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

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Cowboys and Injuns: a point by point rebuttal of comments made on my Horse Hill-1 analysis by Injuneer

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Posted on 7th October 2017 by Professor David Smythe

Summary

I am responding to a 2500 word critique from a drilling engineer, posted on the Drill or Drop version of my Horse Hill-1 blog. His (or her) evident lack of geological or geophysical experience and training is revealed by the fact that only two minor points out of his 31 points of criticism are valid, and a further two are debatable. Comments from UKOG are still awaited.

Detailed response

It is a pleasure to respond belatedly to this detailed technical comment. I was only made aware of it on 2 October, which is why I had not responded sooner. What particularly amuses me is the effort some poorly-qualified people like Injuneer make to try to refute my arguments, whereas no properly-qualified individual either dares or bothers. The problem with Injuneer's detailed comment, which runs to some 2500 words, is that it fools some others such as Dr Nick Riley (a qualified expert in shale, if not in hydrocarbon exploration generally) into thinking that it is valid, because it has a veneer of expertise.

I note the ongoing lack of response from anyone from UKOG, who would be the most appropriate person to reply, and who were invited by Drill or Drop to do so. Perhaps they are busy re-drawing all their maps, and will eventually publish corrected and non-misleading investor information.

Injuneer's comments are reproduced in italics below, divided into sections for my response.

> *In the interests of full disclosure, let me start by stating that I have spent many years in the oilfield as a Drilling Manager / Superintendent / Engineer.*
>
> *My work has in the past included drilling several Wells Onshore the UK in the late 1980's and early 1990's, but I have been working Overseas for many years and have never worked for any of the Companies currently undertaking drilling campaigns in the Southern UK.*

You are a former oil industry *drilling* engineer, not a reservoir engineer, and neither a geologist nor a geophysicist. So you are expert on drilling, and have clearly picked up some informal expertise and jargon along the way – but that is not the same thing as formal training and practice in geology, geophysics or reservoir engineering. Perhaps you could list your name, qualifications and experience, so that readers can verify your CV. Nevertheless, I shall take your comments on my main article at face value, and comment accordingly.

> *Professor, firstly, your pejorative language E.G. "dog's dinner" & "Pigs ear" in describing UKOG's interpretation is unbecoming of a professional and merely detracts from your argument.*

I used blunt or colourful layman's language in my responses to comments. My guest post, based on a blog of mine, is neither an academic paper nor a consultant's report. The two quoted phrases mean 'a complete mess', which is exactly what UKOG's current interpretations are. Incidentally I heard the phrase 'dog's dinner' on Channel 4 News the other night in the context of the current UK government's handling of Brexit. Is that inappropriate or impolite?

> *As also stated by another poster in this forum, I am used to seeing G&G arguments presented with many qualifiers. To be so definitive in asserting that you are correct, and that they are not, is just wrong.*

I can (and should be) definitive and assertive when I can not only *identify the errors* in the work, and also *account for* why they have been made (poor mis-ties, statics between different survey vintages not thoroughly resolved; not re-mapping the faults from scratch after the well results have come in, etc). If you believe I am wrong, then I stand to be corrected – but I would like the details please, not just denials and counter-assertions.

I have numbered your succeeding technical comments, reproduced in full in italic font, before each of my responses.

> *(1) To go onto your article;*
>
> *You are quoting Euan Mearns out of context. He was actually asking a rhetorical question at the start of what is a very good article he wrote about oil in the Weald Basin and Horse Hill-1 (which he called a 'nice conventional discovery') in particular.*

I am glad you agree with Mearns's analysis. Whether or not his question (about Brits being dumb) is rhetorical or not, his conclusions are clear; that the resources and reserves have been conflated; that the figures are wildly out of line with BGS estimates of oil in place; and that *fracking will be required* to produce from the whole of the Kimmeridge Clay Formation. This last is perhaps the crucial point for the general public, which UKOG is shying away from. I also gave UKOG credit, as did Euan Mearns, for the Portland conventional discovery – but with the proviso that they must remap the trap volume to avoid misleading investors (my conclusions, slide 18)

> *(2) With respect to the knowledge and technology available to BP and the other majors in the 1980's, you are incorrect.*
>
> *Since then, the technology available with respect to – to name a few – drilling fluids, drilling tools, drilling techniques, E-Logging equipment & log interpretation has improved by at least an order of magnitude and we now do things routinely (especially with respect to horizontal drilling) that were simply not possible then.*

I agree that imaging techniques at the logging scale are hugely improved since the 1980s. So have seismic imaging techniques (my own particular speciality – my research group at Glasgow was the first academic group in the world to undertake a 3D seismic survey, in 1994), so it is all the more surprising, is it not, that UKOG is relying on existing 2D surveys from the 1980s. Reprocessing (another speciality of mine) can only make marginal improvements, if any, as I showed in my slides 8-10.

However, the new techniques of the last 30 years do not alter the physical properties of the rock. A shale remains a tight rock requiring unconventional means to physically alter it from being a source rock to a producing reservoir. So, overall, I disagree with you that technology has altered that much since the 1980s – other than the ability now to frack horizontally, which was unfeasible then.

> *(3) The Kimmeridge was well known as a source rock, but it was not well recognized (if at all) that the Limestones could be a potential reservoir. Indeed, from a drilling perspective, they were far better known as a potential lost circulation zone which needed to be bridged off with lost circulation material.*

You are wrong about the limestones not being recognised as potential reservoirs in the 1980s. At Balcombe-1 in 1986 Conoco tested the two principal Kimmeridgian limestone layers (micrites) for their reservoir properties, because oil and gas shows were noted in the upper, but not the lower. I only mention that example because I have all the logs for Balcombe-1.

On the subject of lost circulation zones due to limestone, that appears to be precisely what has happened at Broadford Bridge-1, where the deviated well crossed the Broadford Bridge Fault at the Purbeck limestones. KOGL (subsidiary of UKOG) has had to sidetrack the problem zone and plug and cement the washout zone. Another case of poor well design, I would say.

> *(4) The Electric Logging technology that was available back then was very poor at identifying natural fractures – I don't actually recall ever running the imaging tool that might have been able to do so.*
>
> *The conventional E-Logs available lacked the resolution to tell what type of fluid would be in the matrix porosity of the Limestone, and any natural fractures would have been clogged up by us Drilling types with LCM, thus distorting the E-Log responses…*

Again at Balcombe, Conoco reported fractures in the upper micrite, from sidewall cores, not logging, and concluded that the oil was in fracture porosity. So UKOG's 'discovery' is thirty years old. My own simple calculations of permeability from Balcombe porosity measurements yield 0.2 and 0.05 mD, respectively, calculated by two different methods. This compares with UKOG's 0.005 at Horse Hill-1 and 0.02-0.03 mD for three micrites at Brockham-1. The last figures are of the same order as the measured permeability of the Kimmeridge Clay.

The point is that little has changed since 1986 regarding the micrite poroperm. It is as tight as the shales (the Kimmeridge Clay) above and below. Acidising was routine, so why did Conoco (or other majors) not exploit the micrites then? What has changed are not the rocks, but the technology – the possibility of HVHF in horizontal wells.

> *(5) As an aside, on that subject, UKOG will indeed have new information available that you do not – specifically the E-Log Sonic (and VSP, if one was run) data from the HH-1 Well. This will no doubt have been used in their new structure model.*

You are implying, I think, that better time-depth interconversion is available to UKOG than to which I have access. Indeed so, but it will make little or no difference to my analysis of the flaws in UKOG's structure maps, and my correlation from Collendean Farm-1 to Horse Hill-1, unless there is some huge and unprecedented velocity anomaly over the 800 m between these two wells (my slide 15). But such an anomaly is very unlikely, given the practically flat layering seen on the V-shaped seismic tie between the two wells, where the undulation (in two-way time) over the 2600 m horizontally is of the order of 30 ms (about 40 m) in amplitude.

> *(6) The first horizontal Well was not drilled Onshore the UK until around 1991 – long after the Majors had left the Weald Basin due to the oil price collapse.*

You *might* be correct. The two BP papers I have on Wytch Farm discuss the long-reach laterals starting in April 1993. I agree that the Weald was finished by then due to the oil price collapse. But Dr Nick Riley (whose comment follows yours) talks about being involved in experimental horizontal drilling in the UK in the 1980s, i.e. during the Weald exploration activity. So either he is right and you are wrong, or vice-versa.

> *(7) Even so, horizontal Wells were still a niche technology until the late 1990's when drilling horizontal Wells in the Austin Chalk in the USA really developed the tools and techniques needed for horizontal drilling to enter the mainstream.*
>
> *In fact, development of the Austin Chalk would be a direct analogy to a potential development*

in the Kimmeridge Limestone – drilling horizontal wells to penetrate as many naturally occurring fractures as possible.

I disagree here about the Austin Chalk being a direct analogy, even if that formation was indeed used for developing long-reach drilling. The better analogy for the Weald play, quoted by UKOG, by Schlumberger, and previously by Celtique Energie, is the Bakken. Schlumberger states, in its summary report for UKOG dated 4 June 2015:

"*The upper two micrites could have a conventional pore system encased within the organic facies of the Kimmeridge. This would be a system akin to the Bakken Shale in North America.*"

The Bakken, of course, requires fracking to extract oil from the shales above and below the naturally fractured limestone. Without fracking the Kimmeridge play will be limited to the tiny amount of oil in the micrites; but fracking is implied both by the UKOG figures analysed by Euan Mearns, discussed above, as well as by Schlumberger.

(8) With respect to the PEDL's issued by the OGA, does a 'conventional' license classification mean that frac jobs or acid washes cannot be performed?

Since returning to the UK, I must admit to have been very surprised at the outcry over fracing here. Are people really not aware that around 200 Wells Onshore the UK (including some in Sussex and Hampshire) have already had frac jobs performed on them? And that many Wells (probably a majority) in Sussex and Hampshire have had acid washes? But I digress.

So, the statement that there is no new technology available to UKOG is fundamentally incorrect.

Incidentally the correct noun and verb in Europe is 'frack', not 'frac'. You raise the question of onshore frack jobs. But you do not appreciate the huge quantitative difference between small-scale (usually vertical well) fracking, and High Volume Hydraulic Fracturing or HVHF. If UKOG et al. in the Weald start fracking their horizontal wells by HVHF, they will be able to say, legally, that it is not fracking, as long as they restrict the water usage to less than 10,000 cu. m per well. This is an artificially high threshold set by the UK government. As I pointed out in a letter in *Nature* in August, the scientifically defined threshold (if water use is to be used as the criterion for the HV in HVHF) is 2000 or 2500 cu. m, for oil and for gas, respectively, based on the evidence from 263,000 fracked wells of all types in the USA.

So the sleight of hand being planned here, with the connivance of the OGA, is that UKOG will 'stimulate' its so-called 'limestone' wells, eventually using HVHF to free up the oil in the shales, but it will be able to deny that it is actually fracking. By 'not-fracking', they can thereby evade their environmental risk assessment obligations, and, furthermore, the 1000 m minimum depth requirement for fracking will not apply. George Orwell would have been proud of the government's fracking Newspeak.

(9) UKOG didn't refer to the Jonah Field – they originally took a generic field development diagram that has been applied to many field developments all over the world – it was YOU who specifically tied it into the Jonah Field.

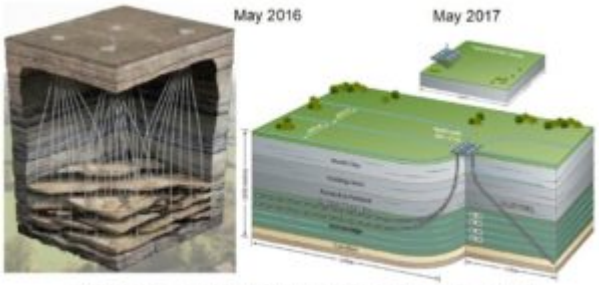
It could equally have been titled 'Forties Field' or 'Welton Field', or any one of a thousand other fields in Production around the World.

Wrong – UKOG very likely used the Jonah Field model (which I reproduced in my slide 17 from their Oil Shale World presentation dated 19 May 2016 slide 9; an almost identical image is shown in their Investor presentation dated 25 April 2016 slide 13) because it is onshore, and it shows the multiple deviated wells from each pad producing from the vertical legs each passing through stacked tight sandstone lenses. The giveaway is UKOG's ridiculous picture (which I politely called "*curious, geologically unrealistic*") of the

Kimmeridge as a ‘stacked chappati’ set of isolated lens-shaped reservoirs. Such geology has nothing whatsoever to do with the Weald Jurassic, and further demonstrates UKOG’s deep ignorance. If you can find me another onshore analogy image similar to that used by UKOG, other than Jonah, then please provide it.

> *(10) However, it is irrelevant, as you should have used the slide (No. 15) from UKOG’s most recent presentation (May 2017) on their Website.*
>
> *http://www.ukogplc.com/ul/Corporate%20Presentation%20May%202017.pdf*
>
> *This clearly, and correctly, shows that horizontal and high inclination Wells would be used to develop a Kimmeridge Limestone Field.*
>
> *It has been available on the UKOG website for over three months, so why didn’t you use it?*

In any case, the Jonah field picture is *not* irrelevant because that is what UKOG was showing its investors just one year earlier. It demonstrates that UKOG really has little clue about what it is going to do, because within 12 months it completely changed its production strategy.



UKOG: Schemes for multiple deviated wells from one wellpad

UKOG change of drilling schemes between May 2016 and May 2017.

It is true that I could have used the later UKOG image. I downloaded that presentation on 2 June, but then simply forgot about it. However, can you tell me how much oil UKOG will extract from their deviated well shown above? Precious little, I would say – another half-baked idea to suck in investors, but with little or no sound production technology behind it.

> *(11) Even though the Kimmeridge Limestones are at a relatively shallow depth, current drilling technology means that horizontal legs of 2,000+m should be easily obtainable. This greatly increases the areal extent that each Well Pad could cover, thus significantly reducing their number.*
>
> *The testing of Broadford Bridge-1, plus the drilling and testing of Holmwood-1 and other Wells by Angus Energy will go a long way to establishing if this indeed a valid play concept for the Weald Basin.*
>
> *Until then, people can speculate all they want – but speculation is all it is and claiming that HH-1 is commercially barely viable is far too premature.*
>
> *In the meantime, trying to equate potential development projects in the Kimmeridge Limestone with fracing is, at best, being disingenuous.*

It is not I that is speculating – it is UKOG, with its ridiculous claims of estimated resources (or is it reserves – they don’t seem to know the difference, do they?) designed to bring in the investors and pump the share price.

I repeat; this is not a ‘Kimmeridge Limestone’ play, it is an unconventional Kimmeridge Clay play – a

shale play with close analogies to the Bakken. No-one in North Dakota tries to claim that the Bakken is a conventional limestone play, do they? They merely use the limestone as a good brittle layer to frack in, but with the frack growth going well beyond the bounds of the limestone.

> *[Finally Professor, you claim that none of the posts have challenged your model.*
>
> *Well, here you go (this also includes a rebuttal of some of the other statements made in your article and posts);]*
>
> *(12) Page 1*
> *'Geological analysis of the Horse Hill prospect'. In fact, your presentation should be more accurately titled 'An alternative Geophysical model'. It is certainly not a geological analysis and if anyone had come into my office with such a presentation and tried to pass it off as such, they would have been given very short shrift indeed.*

You are talking as if you were an exploration manager, which you never were. You were a drilling engineer and manager; as such your expertise would have had little relevance in evaluating a prospect.

> *(13) Page 2*
> *'The predicted closure area is based on just three 2D Seismic lines'. No, the other seismic lines were also used to define the limits of the closure area.*

Yes, the overall context is based on a dozen or more lines, but the actual local structure is defined only by three lines. That is why Magellan highlighted and labelled those three in red.

> *(14) Page 3 & 4*
> *The fault interpretation is described as very different when in fact they are remarkably similar. In addition, you are referring back to the Magellan prediction of 2009, whereas UKOG produced a revised version in* [your text seems to be incomplete here]

My main point, that you have failed to grasp, is that even after drilling HH-1, UKOG is sticking closely (February 2015) to the old pre-drill Magellan model.

> *(15) Page 5*
> *You describe the apparent throw of the fault changing from one direction to another and back again as being highly unusual. Perhaps it is just the areas I have drilled in, but I have seen exactly this several times during my career. I would agree it is not common – but that doesn't mean it did not happen here.*

I said that such normal fault behaviour is highly unusual, except in strike-slip terrains. Just another half-baked (false?) memory on your part. We really need evidence. Where are the papers discussing such strike-slip behaviour in the Weald? I have found none. Let UKOG (or Dr Nick Riley, commenting in your support) provide links to them, for all to see.

> *(16) I should point out that both the interpretations (also on page 6 of your presentation) hangs on the apparent top of Portland being 18m deeper on HH-1 than on CF-1. Without access to all the CF-1 data, I would point out that there are several potential errors on the quoted top Portland for CF-1.*
>
> - *A) Is the depth referenced quoted as TVDMSL, MDMSL, TVDRT or MDRT? I have seen many instances in old well records where we were unable to definitively identify what the datum used for depths quoted actually was.*
> - *B) Does the top Portland quoted in the CF-1 Well refer to the Portland Limestone, Portland Sandstone or possible even the top of the Portlandian, which actually includes some of the Purbeck Group? I recall this was always a topic of discussion in*

the 1980's when I was involved in drilling some Wells in the Southern UK. There was also some discussion about whether or not the Purbeck Anhydrite should actually be called the Portland Anhydrite for just this reason.

Part A. Sorry, nice try, but you are wrong again. As you should know, the contour map reproduced in slide 6 will almost invariably have a subsea datum because it is based on seismic TWT, depth converted in this case to feet. Here are the well details:

Collendean Farm-1: Top Portland Sandstone 1753 ft subsea (tops from UKOGL).

Horse Hill-1: Tops from the Nutech report for UKOG; Top main Upper Portland Sst 621.2 m MD; subtract KB to datum of 71.1 m = 550.1 m SS ≡ 1805 ft SS.

However, the figures I note in slide 6 are based on my interpolating the contours, which would (or should) have been constrained by the well tops. These are 1755 ft for CF-1 (i.e. 2 ft deeper than the top) and 1815 ft for HH-1 (10 ft deeper than the top). If you don't like the 10 ft discrepancy between the 1805 ft top and the 1815 ft contoured depth, then I suggest you should ask UKOG to account for it. Another error on their part perhaps?

My conclusion, that HH-1 came in 60 ft deeper (or is it 52 ft deeper?) than CF-1 still stands. Remember that the prediction was that the 'Top Portland Target' (my slide 9) would be 80-100 ms *shallower* than at CF-1, that is, around 100 m, or over 300 ft shallower. Recall also that the prospect was supposed to be a horst block, with HH-1 on the horst and CF-1 off it, so evidently the new well would be shallower.

Summary: HH-1 prediction: >300 ft shallower than CF-1; actual result: 60 ft deeper. A severe failure of mapping, I would say, and, furthermore, I have explained why.

I cannot comment on possible differences in stratigraphic interpretation between CF-1 and HH-1, as I don't have the composites for these two wells; however, what UKOG calls the Top Portland Target, as picked in yellow on their seismic (my slide 9), should be internally consistent. So any discussion here about which flavour of 'Portlandian' has been mapped (your point B above) is irrelevant. UKOG should have sorted all that out before presenting their maps.

(17) Page 7
I would point out that the throws associated with the fault (as marked by yourself on page 6 of your presentation) are actually quite small – certainly in the vicinity of the apparent change in direction of fault throw, such small throws are very difficult to definitively image on 2D seismic of this vintage – there may not even be anything there at all.

You are inadvertently confirming (not questioning, as you think) two of my main points:

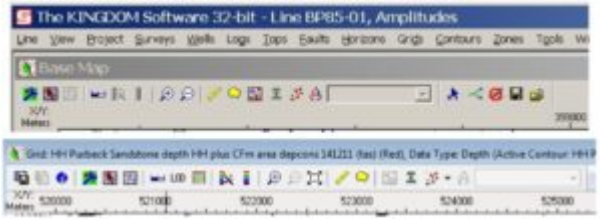
(a) The vertical throw of the UKOG version of the Collendean Farm Fault does indeed diminish to zero locally – i.e. it is not there! Of course, you might argue that it is still present as a strike-slip fault, with no vertical component of throw, but since we are in a no-data zone between seismic lines along the fault trace of some 1500 m, you can hardly argue that, based on no evidence.

(b) The whole prospect was based on inadequate seismic coverage. The coverage that exists comprises three-decade old 2D seismic, some of it reprocessed more recently. The PEDL should not have been granted by DECC/OGA without at least requiring 30-50 km of new 2D seismic to be shot, as a condition.

(18) Question – are you sure that the UKOG G&G group (or their subcontractors, if the work has been farmed out) are still using the old IHS Kingdom program? I'd be surprised if they are.

Yes, I am sure. I have a (borrowed) licence for Kingdom 8.6, and I recognise the icons on menu bar of the

UKOG image, which are identical to those on my version. The ‘version 7.5’ on the UKOG image refers to the contouring software package, not the Kingdom version itself.



Kingdom menu bar from 2009 (top) and from UKOG, c. 2014 (bottom). Note the identical icons.

> *(19) Also, it would be more correct for you to state that “in my view, the mapping of the CFF is fundamentally flawed”, as there is clearly more than one interpretation and it is not possible to say which (if either) is the most accurate.*

I am not saying that my version is necessarily the only plausible version, so you are misinterpreting me. However, I stated, with two arguments, why the UKOG mapping is indeed “*fundamentally flawed*“. The ‘in my view’ phrase that you seem to desire is redundant, because I have signed the piece; the comment is self-evidently ‘my view’. What matters is the substance behind it.

> *(20) Page 8*
> *You make the statement that most of the mauve faults are not credible, but do not state your reasoning behind this. It can certainly be seen that there is a lot going on in the SP 240 – 300 area and so it’s difficult to definitively state if any particular fault is there or not.*

The particular UKOG mauve fault I mentioned cuts across strong continuous reflectors from about 500 ms depth to 1100 ms, where it follows the projected path of CF-1 shown by the vertical dotted line. This can be seen more clearly on slide 10, where CF-1 (projected) is at CDP 258. No seismic interpreter would put a faultline through this group of reflectors, unless the 2D line runs at a low angle to the fault trend, and it could then be inferred that the seismic data are showing reflections from both the hanging wall and the footwall. Even then, the only feasible place for the main fault is where I have marked it on slide 10. This is CDP 267 at Top Portland depth, about 9 CDPs or 225 m north of the UKOG position (horizontal scale is 1 CPD = 25 m).

So, as I said, most of the UKOG mauve fault interpretations on slide 8 are not credible – the data have been over-interpreted. The only plausible fault is the main red one, which is more or less coincident with my version.

> *(21) Page 10*
> *You make the claim that your revised fault interpretation shows that Well CF-1 lies on the upthrown side of the CF Fault. Yet you ignore that SP 250 looks busy from 300ms downwards, and that there is good reason to suspect a fault – possibly the main CF Fault – extends diagonally from SP 250 at 400 ms TWT, down to SP 270 at 600 ms. This would potentially put the CF-1 Well on the downthrown side of the fault, as per UKOG’s interpretation.*

This is the first time I have come across a drilling engineer dabbling in seismic interpretation. Your alternative interpretation is untenable because it cuts across reflectors between 300 and 500 ms. I put in a possible small fault between those depths, marking the northern limit of reflector continuity, and converging downwards with my main Collendean Farm Fault. That small fault, with an undetermined throw, still lies north of CF-1.

So I reject your unfounded alternative explanation, which seeks only to try to retain the UKOG version. I could go into more detail as to how exactly I have positioned my fault between 500 and 700 ms TWT,

involving the diffractions occurring off the terminations of a fault on unmigrated data, but I don't see why I should have to teach you elementary seismic interpretation. Why not take a course in the subject if you are sufficiently motivated?

> *(22) Page 11*
> *Considering how 'busy' the area is, it looks like there actually is little difference between UKOG and your placement of faults – just the interpretation of how they are connected between the seismic lines.*

Wrong again. Surely you realise that the correct location of CF-1 on the nearest seismic line (albeit offset by 135 m from the line, as I show in slide 13) is of paramount importance.

> *(23) Page 12*
> *The Esso line is not used by UKOG – I suspect because they QA/QC'd the data and were not confident in its validity. They certainly did not 'forget it' as you claim. However, if you are confident, why not use it instead of line C80-130 try try and cross-correlate? Although it is a little further from the CF-1 Well than line C80-130, the intersection between it and line BP-85-74 is 1km closer to HH-1 and therefore much more valid.*

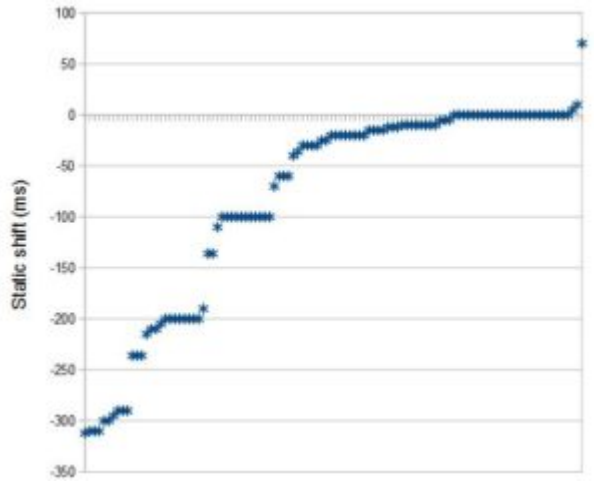
I too would preferentially omit the old Esso line from the interpretation, unless a particular problem arose, as it has here, and nothing else was available. But once again you misunderstand the problem. The satisfactory nature of my correlation is that you can tie the two wells by going SW from CF-1 on C80-130, then east on BP-85-74 (my slide 13) by proceeding around the end of the Horse Hill Fault, last identified at H on slide 15. So there are no faults to have to correlate across on that path.

Using your suggestion, we would first have to jump-tie from the well, offset by 285 m from the line (slide 12), then go south on old data, then try to correlate across the CFF at H, which would be very doubtful (slide 14) then tie from SP 1666.5 to the BP line at CDP 125 (see slide 13 where the intersection is marked) and hence to HH-1. This path is much more uncertain than the one I chose to use.

If you are not familar with the difference between SP numbering, as used on the old single-fold Esso dynamite data (and why there are no common-depth points), and the CDP numbering system used on the more modern data, then again I am not going to teach you here. Read up on it please.

> *(24) Page 13*
> *A static correction of +25ms has been added to the BP line. Why? This is quite large considering how shallow the top Portland SST is. If the static correction is removed, then the correlation is poor.*

I made the relative static correction to match the two lines of different vintages, having first checked their polarity, phase, and datum. In my work for a client in the Wessex Basin seven years ago I applied static shifts to 107 lines from 25 different surveys. These lines are similar in client, contractor, epoch (1968-1985), acquisition, processing and geology to those in the Weald. The static corrections varied from -312 ms to +70 ms, with only 25 out of the 107 having a zero static.



Static corrections for 107 lines in the Wessex Basin, ordered from low to high.

So the static I applied to the BP line at Horse Hill is not unusual. On the contrary, it would be unusual if the raw stacked data from two different surveys *did* match without a static correction being necessary. If such statics have not been correctly applied then the seismic interpretation will be a mess.

> *(25) Page 14*
> *You admit that data quality from the Esso line is poor (which is likely to be the reason why UKOG did not use it), and I feel a case could be made for the same error in scalloping of the reflectors could have happened in trace 440 – 460 and trace 520 – 540. However, you use this seismic data to pick two major and two minor faults.*
>
> *You and I both know that I could give this same Seismic data to ten G&G personnel and get back ten very different interpretations of where the faults are.*

I have noticed that the labels of the two principal faults on slide 14 are in the wrong sense. They should be interchanged, with the Horse Hill Fault (HFF) being the more southerly, and vice versa. But that labelling error makes no difference to my analysis.

I disagree with your apparent observation of scalloping of reflectors in the area of the two main faults. The offset (downthrow to the north) of groups of reflectors is clear below 400 ms, especially for the Collendean Farm Fault. The reflector offsets are particularly evident between 500 and 800 ms at all four marked faults. None of this can be ascribed to what I called scalloping due to under- or over-correction of these single-fold data.

As to your ten different subjective interpretations from ten different interpreters, I can only plead superior expertise. This started with my own PhD fieldwork acquiring single-fold onshore land dynamite data in 1971, and progressed over the 46 subsequent years through 2D interpretation, deep seismic, 3D seismic acquisition, high-resolution shallow seismic, processing and interpretation of 2D and 3D, and so on.

> *(26) Page 15*
> *This is your interpretation. You state that the UKOG interpretation is untenable, but from the data in your own presentation it is relatively simple to make a case for a fault running along C-I-J-K as per the UKOG interpretation.*
>
> *I am not saying that they are correct and you are wrong. It is just that cases can be made for both and it is therefore incorrect to definitively state that one is untenable.*
>
> *In any case, depth based contour lines are really needed to produce a valid map. I am sure you are aware that time/depth conversion using Sonic log and VSP data sometimes means*

that formation tops on one Well may appear higher than another Well when presented in time format, but are actually deeper due to velocity changes across the field and/or faults.

No valid or convincing case could be made for your C-I-J-K fault correlation, not least because that path would make an unrealistic sharp Z-bend just within the no-data zone (how convenient!), while leaving the fault at H isolated. My interpretation has the merit of the two faults being relatively rectilinear, following the regional trend of N80°E or so.

In any case a C-I-J-K fault interpretation would still demonstrate that UKOG's mapping is in error.

Your comment about velocity anomalies affecting time-to-depth conversion and resulting contouring is irrelevant here, because the data for the two wells tie without problem both in depth and time (slide 13). See also my response to your comment no. 5 above.

(27) Page 16
As above, it is not correct to state that UKOG's interpretation of this particular field (it is no longer a prospect, as oil has been found) is untenable – just that you have a different interpretation.

That the UKOG Geologists have modified their pre-existing fault maps with new data is unsurprising. I have seen this in virtually every Exploration Well I have been involved in, as it is only human nature to use the model that you have started with and only change it when confronted with sufficient data to show it is fundamentally flawed ("The bloody XXXX Formation came in 1,000m high – your model is BS!!!!"....).

Agreed – the Portland is a discovery, no longer just a prospect. But the same is not true of the Kimmeridgian micrite oil shows, which, however, UKOG is claiming as a discovery.

UKOG has tinkered with the old pre-drill Magellan fault map, but has not adequately modified it. You seem to be confirming that human nature accounts for this resistance to throwing out the old model and starting again. Unfortunately human nature often conflicts with rigorous science.

(28) While a discovery has been made in the Portland, it is not correct to try and call it a minor (or anything else) discovery until, at the very least, flow testing has better established the potential reservoir limits.

Further clarity on the reserves could then be gained by revisiting the model with this information and – later on, by a combination of drilling another Well, side-tracking the current HH-1 (unlikely – I'd keep it as a producer), reprocessing current seismic data with the computational power and new velocity information from HH-1 available and, finally, possibly shooting more seismic over the structure.

Agreed – but I am not disputing the Portland conventional discovery in principle, just arguing that the mapping needs to be re-done from a clean sheet of paper.

As I stated above, new 2D seismic should have been required as a condition of the licence. It is a bit late suggesting it now. The investment by UKOG of, say 30 km at £10K/km = £300K would have been amply repaid – 10% of the drilling cost, let us say. But cowboy companies like UKOG are trying to do everything 'quick and dirty', and seem to be more interested in premature and outrageous press and investor announcements than in serious exploration.

(29) In the third paragraph on page 16, you state that the flow from the Kimmeridge is due to drilling HH-1 close to the HH Fault; it is the fault that has enhanced the fracture permeability (technically you should state 'the number of fractures and their size') and it is just a local effect.

This is nonsense. In my experience, any rubble zone that may exist around a fault is very small (just a few m in diameter) and HH-1 is not close enough to see this effect.

Indeed, if a rubble zone of the magnitude you imply existed around the HH Fault, then any oil in the structure would have migrated out long ago – especially along such a near vertical fault.

In any case, there does not need to be a fault close by for a natural fracture network to exist in a formation.

Wells frequently fail to identify faults. Balcombe-1 is a good example, which I use as a proxy for Cuadrilla's Balcombe-2. Cuadrilla failed to notice that the BGS geology map indicates a mapped fault, which I predicted would be intersected in the vertical section of the wells. My subsequent analysis of the gamma ray and sonic logs, comparing them with unfaulted Southwater-1, duly identified the fault at 620 m depth, albeit with a throw of only 10 m, and not the 30-40 m I predicted.

You are unfamiliar with the wider research on fault structure. Damage zones on each side of a relatively impermeable fault core zone (up to 50 cm width) can be up to 100 m wide, as shown here.

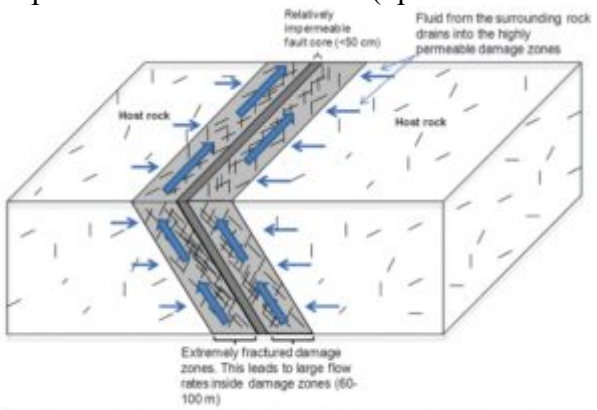


Figure 1. A schematic of a fault zone showing the relatively impermeable fault core surrounded by the highly fractured damage zone. In a fractured, low matrix permeability reservoir, fluid from the fractures in the surrounding rock mass drains into the highly permeable damage zones.

Flow into and up fault damage zones (from Johri et al. 2014. A fault scaling law to characterize fault-damage zones at reservoir depth, Bull. Am. Assoc. Petrol. Geol. vol. 98 no. 10).

You should also be aware that good 3D seismic, specially processed, can actually image the upward migration of hydrocarbons. This would not be possible if what you call the 'rubble zone' was a mere few metres in diameter – see the special volume on imaging of seeps and gas chimneys, published in 2013 (Aminzadeh, F., editor: Hydrocarbon seepage: from source to surface. Geophysical Developments no. 16, Society of Exploration Geophysicists).

Having said that, you do make an ostensibly valid point about the possible prior escape upwards of hydrocarbons if the fault zone were indeed a zone of enhanced permeability. That argument would only be true if the oil prospect was conventional, trapped somewhere, and with the fault acting as an 'escape' pathway out of the trap. But the Kimmeridgian Clay Formation overall (away from fault zones) is evidently a tight, unconventional play (refer to the permeability measurements quoted in my response to point no. 4 above, and the accepted definition of 'tight' being <0.1 mD). Furthermore, the local high free (i.e. conventional) flow in the short-term test (1365 bopd) at HH-1 is only from the two upper micrites. I argue that there is a local cause for this free flow – the fault zone. The trapping mechanism could be the lower permeability of the shale above each limestone layer, which, although having an enhanced permeability near to the fault, could be nevertheless low enough to prevent flow up the shale damage zone. This is explained by the diagram below.

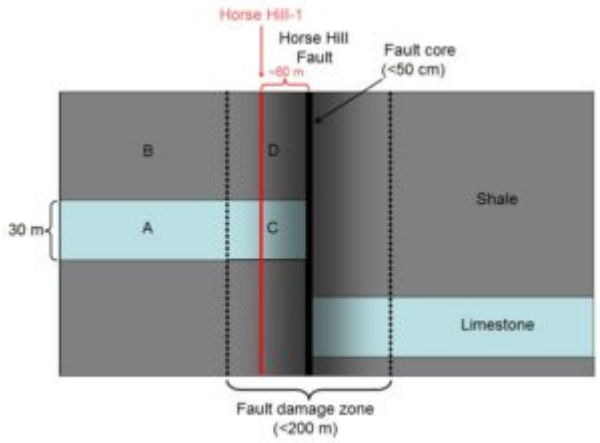


Diagram (not to scale) of four permeability regimes adjacent to the Horse Hill Fault at a Kimmeridge limestone. A – fractured limestone; B – shale; C – highly fractured limestone in the fault damage zone; D – fractured shale in the fault damage zone. D can be a caprock for the free-flowing quasi-conventional oil in zone C.

(30) With regards to the last paragraph on page 16, you use a lot of qualifiers used to come up with a potential 170,000 bbls produced from this Well (in other words, you are implying it is sub-economic), and I am afraid this is also nonsense.

Any Reservoir Engineer would wait until the test data was available before trying to estimate the fracture volume being drained, and from that work out potential recoverable reserves. The reserves recoverable not only depend on the extent of the fracture network, but also the matrix porosity and permeability of the fractured formation.

In some of the hugely prolific fields in the Middle East, similar Wells have produced for years. But if there is a water leg in the field (and no apparent evidence of that yet at Horse Hill), they may water out after only a few months of production.

It is Schlumberger (for UKOG) who came up with the 68 MMBO/km^2 of oil in place for the entire Kimmeridgian section. The empirical experiments of testing the Kimmeridgian to see whether there is free oil flow anywhere within it have already been done. They comprise the 55 or so wells drilled through the Kimmeridgian in the wider Wealden area (see the BGS Weald report of 2014, appendix F, for the log correlations of these 55 wells). None of these, to my knowledge, had free-flowing oil anywhere in the Kimmeridgian. So the idea that the unusual localised (and probably short-term) high flow at Horse Hill-1 can be extrapolated across the whole region, as UKOG is implying, is both geologically untenable and is misleading investors.

So my estimate, albeit rough and ready, of what might realistically be produced from a fault zone – the only feasible explanation I can think of for the localised high flow – is indeed just to demonstrate that this so-called discovery is clearly sub-economic. But UKOG is building a whole fantasy world around this one well.

[Page 17
See earlier comments.]

(31)Page 18
Your conclusions are, quite frankly, wrong.

Irrespective of which fault model is correct, you clearly do not understand the nature of natural fracturing and how it can be used to exploit the gas or oil present in a structure, and you reference a development model which UKOG are not going to use.

On the contrary, Injuneer, I understand fracturing and fluid flow quite well enough, thank-you, to have

been able to demonstrate that UKOG has been over-hyping its so-called Kimmeridgian *"continuous oil deposit"*, which it claims will magically not require extensive fracking, despite the fact that fracking is implicit in the definition.

I concede the following points, based on your critique:

- I agree that the Portland is now a discovery and not a prospect, because oil has been found.
- UKOG is now planning to use a more orthodox scheme of horizontal drilling than the Jonas Field analogy they promoted up till 15 months ago.
- It is debatable when, exactly, horizontal drilling came of age in the onshore UK.
- So it is also debatable whether the new technology in drilling and imaging, developed since the earlier round of Weald exploration, is a game-changer or not.

In conclusion, your limited relevant experience as a drilling engineer, during which you appear to have have acquired some of the lingo of hydrocarbon exploration, does not make you an expert. Your 31-point critique (my numbering) is riddled with errors of geology, seismic interpretation, mapping, fault and fracture zones, irrelevant examples, the difference between classic fracking and HVHF, and so on, that it is difficult to take it seriously. I have only made the effort to refute it all, point by point, because the superficially technically expert nature of your commentary seems to have fooled at least one person who should know better, Dr Nick Riley. He is a geologist of the stratigraphic/ palaeontological variety, the world expert on the Bowland Shale of Lancashire, very knowledgeable about the Carboniferous System in general, but he is in no way an exploration geologist. Dr Riley described your comment as a "*thorough and informed technical response*". I hope he reconsiders that view.

I still await detailed comments on my analysis from UKOG itself, and/or from real exploration earth scientists who can discuss, and if needed find fault with, my interpretation in the true technical detail it deserves. In the meantime – investors beware!