# Kimmeridge Oil & Gas Limited

# Environmental permit application to drill at

# Broadford Bridge, West Sussex:

# Response to the Environment Agency in the context

# of relevant geology and hydrogeology

**By**

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**Summary**

Kimmeridge Oil & Gas Limited (the Applicant) holds the PEDL234 licence inherited from Celtique Energie Weald Limited in 2016. The Applicant claims that it has also thereby inherited permission to drill and test the Broadford Bridge-1 well, and is seeking a Variation to the Waste Management Permit. The Applicant further asserts that the drilling operation is conventional in nature. Although Celtique Energie's target was conventional (a Triassic sandstone trap mapped below the wellsite), the Applicant's target of Kimmeridgian shales and limestones is clearly unconventional. Any resulting oil production would require fracking. There is no well-defined trap, and indeed, mature Kimmeridgian shales are only found further north within the PEDL area, meaning that the current proposed well is situated at an unsound location for the purpose. A major fault will be drilled through by a 'blind' highly deviated well at shallow depth, and without the normal control of seismic reflection imaging. This work, if approved, carries the risk that shallow Secondary A aquifers may be contaminated.

This response demonstrates that the variations requested by the Applicant are so distant in character from the original planning permit granted to Celtique Energie that an entirely new application needs to be submitted to West Sussex County Council. The information provided in the Applicant's Non-Technical Summary is both incomplete and misleading, so that in consequence the Environment Agency will be unable to comment accurately on the request for variation. The request for a variation to the environmental permit should therefore be rejected.

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**Appendix 1**

## 1 Introduction

Kimmeridge Oil & Gas Limited (KOGL; hereinafter the Applicant) holds the PEDL234 licence inherited from Celtique Energie Weald Limited in 2016. The Applicant claims that it has also thereby inherited permission to drill and test the Broadford Bridge-1 well, and is seeking a Variation to the Waste Management Permit.

The Applicant further asserts that the drilling operation is conventional in nature.

This response demonstrates that the variations requested by the Applicant are so distant in character from the original planning permit granted to Celtique Energie that a new application needs to be submitted to West Sussex County Council (WSCC). The information provided in the Applicant's Non-Technical Summary (document BB-PR-Q02) is both incomplete and misleading, so that in consequence the Environment Agency will be unable to comment accurately on the request for variation.

## 2 The original exploration proposals

Celtique Energie identified the 'Willow Prospect' in 2012. This is a conventional hydrocarbon trap, with the reservoir being prognosed as Sherwood Sandstone (Triassic age) at 7000-8000 ft depth. It lies to the north, and is bounded by, a fault which I call the Broadford Bridge Fault (Fig. 1). The proposed site is one of seven possibilities examined in the Alternative Sites Assessment. Because the trap is finite in extent there is a limited area within which surface sites for drilling may be searched for.

The Broadford Bridge-1 site lies over the trap (Fig. 1). Proposed drilling would have involved a slightly deviated well, such that the bottom of the well would lie some 950 m north of the surface location.

## 3 New unconventional drilling target

The Applicant has acquired the PEDL from Celtique, but now wishes to explore for hydrocarbons in a completely different manner.

Firstly, in contrast to Celtique's well-defined conventional target, the Applicant's target, the Kimmeridge Clay Formation (KCF), is found below the whole of the licence area. There is no geological requirement or justification for using the existing well pad at Wood Barn Farm.

Therefore the Alternative Sites Assessment carried out by Celtique, which is a material part of the planning approval, is superfluous, since the KCF is now the target.

The Applicant has submitted a short document by Barton Willmore entitled *Conceptual Alternative Sites Selection Study of the Weald Basin on behalf of UK Oil and Gas Investments PLC.* This purports to summarise how drilling site selection is carried out in the case of the "*Jurassic tight limestone oil play*". A short digression is required here to explain the differences between conventional and unconventional exploration, and what is meant by 'tight' hydrocarbon plays.

## 4 Conventional and unconventional hydrocarbon plays

Appendix 1 comprises an extract of my submission to the West Sussex County Council minerals local plan consultation of March 2017. Section 4 deals with the definition of conventional and unconventional hydrocarbon resources. The UK Planning Practice Guidance, published in October 2014, states:

> "*Conventional hydrocarbons are oil and gas where the reservoir is sandstone or limestone. Unconventional hydrocarbons refers to oil and gas which comes from sources such as shale or coal seams which act as the reservoirs.*"

This attempt to define the difference between conventional and unconventional hydrocarbons conflates the mineral itself ("*hydrocarbons*") with the process ("*comes from*") and the supposed source or reservoir rock. But the difference between the two terms is fundamentally one of resource extraction method. The guidance fails to recognise this point. The two definitions quoted above are simplistic.

There are various ways of defining the difference between conventional and unconventional hydrocarbon exploitation. In summary, the most important and widely applied criterion is the permeability of the host rock. So-called 'tight' sandstones or limestones are those reservoir rocks which require stimulation treatments such as acidisation and/or fracking to artificially increase the natural permeability, Shale, along with tight reservoirs, is classed as unconventional. Thus the Kimmeridgian micrites of the Weald are also classed as unconventional, because of their low permeability.

Another criterion is whether or not the target is a finite, well-defined volume, or is widely distributed; the former is the case with a conventional reservoir, the latter is an unconventional play. Again, the Kimmeridgian micrites fall into the unconventional category on this measure. Lastly, another criterion is whether the hydrocarbon resource flows naturally or requires stimulation to extract it. Once again, the micrites fall into the category of unconventional, because their permeability is too low to permit the hydrocarbon to flow without treatment of the rock.

Therefore it is misleading of the Applicant to claim that its target is a conventional oil play. If it were indeed conventional, then several dozen existing oil wells drilled in the Weald Basin since the 1980s would already be producing from the Kimmeridge Clay Formation limestones (see the BGS/DECC report of 2014 on the Jurassic shales of the Weald Basin). But they are not.

## 5 Comparison of old and new targets

In 2015 Celtique Energie submitted a geological log prognosis of its proposed drilling (*HSEC-BB-PD-01 Environmental Method Statement Drilling*). The geological column from figure 4.2 of this document is shown in the left-hand side of Figure 2. Depths in feet on the left are driller's depths, i.e. along the somewhat deviated well, and not vertical depths. A complete stratigraphic succession was expected to be encountered, except where the drill would penetrate the Broadford Bridge Fault at around 5000 ft. Some of the Corallian and Great Oolite would be missing, as indicated by the horizontal black line highlighted within the red rectangle.

The right-hand side of Figure 2 shows that the Applicant has simply re-used the same diagram, but with different depth figures shown on the right. There are two columns; the true vertical depth, and the driller's depth measured along the hole, on the left and right, respectively. Analysis of these figures shows that the Applicant is planning a highly deviated hole. It also expects to penetrate a fault zone, where it states (as highlighted in the red rectangle of Figure 2) "*Lower Purbeck, Purbeck Anhydrite and Portland beds expected to be faulted out*". These layers, shown in light blue, crimson and yellow in the middle of the geological column, should therefore have been omitted from the column. In contrast, the rock layers correctly omitted by Celtique in its column on the left (within the lower red rectangle) should properly have been included in the column on the right.

The result of the analysis is shown in Figure 3, which is a Celtique Energie cross-section with the new proposed well track added. The Celtique well penetrates nearly vertically to about 5000 feet, then passes through the Broadford Bridge Fault into the footwall side on the north.

The traversing of this normal fault accounts for the missing section (along the wellbore) between the upper Corallian and the Upper Lias. The well path then turns nearly vertical again to attain its target of the Sherwood Sandstone (the yellow stippled layer).

The Applicant's well is proposed, in contrast, to deviate significantly from just below the surface, and then pass through the Broadford Bridge Fault at a much shallower depth than the Celtique proposed wellbore. It then penetrates the Kimmeridge Clay Formation (KCF), with its two thin so-called limestone beds, at an oblique angle.

We do not know where it is then directed, because, according to the well prognosis in Figure 2, it should then proceed to penetrate the Oxford Clay or Lias. On the upthrown (north) side of the fault this would be at a depth of 6500 ft – implying an abrupt vertical depth jump of 2500 ft. In short, the well prognosis by the Applicant does not make sense below the KCF.

## 6 Tracking the wellbore during drilling

How is the Applicant going to keep track of the geology and structure encountered while drilling? This is crucial for setting wellbore casing, cementing the bore, and so on. There is no problem in identifying, to a precision of better than 1 m in three dimensions the position of the drillbit while it is drilling. Such geo-location is done acoustically by listening to the drillbit noise. But the question is how to identify correctly the geology that is being drilled through.

Figure 4 shows a map of the proposed well location, with generalised seismic lines shown by the thick dotted green lines. Several of these tracks have multiple seismic lines along them, dating from different epochs. A couple of very early seismic lines, dating from 1962, have been omitted, as they are of such poor quality as to be useless. The nearest line to the wellpad is the recent Celtique Energie line CE-11-02. It passes 500 m to the west of the surface location of the well.

A three-dimensional picture of the geological structure can be constructed form the 2D seismic lines by interpolation. Celtique Energie did so in making the structure map of its target (Fig. 1). This method is effective when the target structure is well-defined, the geological structure is fairly simple, and the exploratory well(s) to be drilled are vertical or near-vertical. But the method cannot work effectively if the well is to follow a highly-deviated path through a fault zone, as the Applicant plans to do.

Not only will the Applicant's well start at 500 m east of the nearest seismic line, but it will follow a northward trajectory, passing through the Broadford Bridge Fault zone, and only crossing one other seismic line, which runs NW-SE at about 800 m north of the drillpad. So the Applicant will be drilling 'blind', relying on (i) drill cuttings and (ii) a set of directional gamma-ray detectors to determine the geology at any moment. These two tools work passably well when the geology is simple, and one knows in advance what layering to anticipate, but will fail if a fault is traversed.

## 7 The target rocks

The new target zone that the Applicant wishes to test is the Kimmeridge Clay Formation (KCF) on the north side of the Broadford Bridge Fault (Fig. 3). In particular, it wishes to test the two so-called limestone layers, commonly referred to as micrites, within the shales of the KCF. These are depicted in Figure 3 by the light-blue layers. The micrites of the KCF are very impure limestones, being composed as much of shale or mudstone as of carbonate, and thus they could equally well be termed calcarous mudstones. There are three or four of these thin layers (of 30 m or less in thickness) throughout the KCF. Within each layer there is a varying percentage of limestone.

These so-called micrites of the Weald do not feature in the BGS lexicon of recogised rock types. They can be traced eastwards on well logs from the classic Kimmeridge Bay outcrop on the Dorset coast, where the equivalent formation is seen in cliff faces as an interbedded layering of shales (including oil shale) with thin (sub-metre) bands of limestone. The micrites can be recognised in the subsurface on well logs by the divergence of gamma ray, which decreases, and sonic velocity, which increases, relative to the shale above or below; however cuttings and sidewall cores often fail to recogise the micrites explicitly. This is due to the mixed shale/limestone nature of the rock.

Drilling at Balcombe illustrates the difficulty of characterising and following a micrite layer. The upper, or I-micrite, was identified by Conoco in its Balcombe-1 well as 110 ft (33.5 m) thick, whereas the BGS, using the same well data, considers it to be 25% thicker, at 42 m. These figures demonstrate that the definition of the layer is somewhat arbitrary. Cuadrilla Balcombe Limited drilled the vertical well Balcombe-2 in 2013, and then side-tracked from this into a horizontal well, Balcombe-2z, in 2014. It drilled blind, as the Applicant intends to do, in a westerly direction, with no seismic image as control. Cuadrilla claims to have successfully drilled horizontally along the I-micrite without problems for a distance of about 750 m, but the evidence suggests otherwise.

Figure 5 shows a detail of the lithology log from the deviated well Balcombe-2z in the zone where the wellbore is 'landing' (flattening out into a horizontal inclination) in the I-micrite. The portion reproduced is driller's depth in feet, from 2300 ft to 3100 ft (701 m to 945 m). This is not vertical depth, but distance along the curved wellpath. Cuadrilla has simply marked the top of the I-micrite at 2640 ft (green arrow in Fig. 5). This is clearly imprecise, by ±40 m or so. At 2700 ft the wellbore is inclined at 15° to the horizontal. The dip of the geological layering is near zero.

The lithology log shows a gradational change from 100% clay to 100% micrite over 55 m of the inclined wellbore, but the gradation is repeated below 2700 ft, this time over about 34 m. It is possible to explain the repetition by assuming that two separate logging runs were made and then poorly spliced together; the coincidence of the repeated section with the liner suggests this. Cuadrilla explains the apparent repeat by the drilling out of the cement shoe, the cement comprising the white lithology marked just below 2700 ft, but that explanation fails to account for the presence of clay just below 2700 ft, with the gradual build-up to 100% micrite some 34 m further on. An alternative explanation is that the wellbore went through a normal fault with a downthrow to the east (wellhead side); however, that calls for the presence of the liner and drilled-out shoe to be just coincidentally at the same place as the fault. A third possibility (which I currently favour) is that the repeat drilling, going through the cement shoe, encountered a thin band of clay or shale within the micrite layer, and then gradually descended very obliquely into 100% micrite again.

The Balcombe drilling history illustrates that simply to drill through the micrite layers obliquely, and to identify them correctly, is far from straightforward in the absence of seismic reflection data.

## 8 Drilling through faults

The Applicant intends to drill through the Broadford Bridge Fault at around 2500 ft depth (Fig. 3), but at a location some 500 m east of the nearest seismic line. The interpretation of the geology by Celtique Energie, shown in Figure 3, is based on the new seismic line CE-11-02 which they acquired in 2011. But it should be noted that such an interpretation is far from being a fully accurate cross-section of the geology. The raw data for this line are shown in Figure 6, which I have mirror-imaged so that it matches the geological interpretation, with north placed on the left. The vertical scale is in milliseconds of two-way reflection travel time (TWT), with zero being at sea level. The base of the seismic data of Figure 6, at around 1300 ms, corresponds approximately to the 10,000 ft depth of Figure 3. A scaling from reflection time to depth can be routinely accomplished if the seismic velocities of the rock layers are known or can be estimated.

Figure 7 shows my interpretation of faults on the seismic line CE-11-02 of Figure 6. I have not tried to mark the geological layering. However, I have graded the thickness of each fault line according to its likely perceived throw (offset). Accompanying each of the two principal faults there are subsidiary faults. It can be seen that correlating geology even across the small faults may be prone to error. The nearest existing wells to which a tie may be made for correlating the geology to the seismic are Ashington-1, some 5 km to the SE, on the downthrown (south) side of the Broadford Bridge Fault, and Southwater-1, some 9 km to the NE, on the upthrown side of the fault. Errors and uncertainties will be introduced in correlating from these wells to the proposed wellsite, due to the limited quality of the existing seismic database.

The upward continuation of the Broadford Bridge Fault is unknown. The seismic data do not exist shallower than about 250 ms (300 m depth). The published BGS geology map does not show a fault at outcrop at the expected location, but that may be due to lack of adequate exposure rather than an absence of faulting at the surface. The fault certainly cuts all three of the Secondary A aquifers within the Hastings Beds subgroup. The horizontal uncertainty in the position of the fault at around 500 ms TWT is of the order of ±100 m, and this uncertainty will be greater because the wellbore will intersect the fault some 500 m east of the plane of the seismic section. The danger exists that if the well is not properly cased through the fault zone there could exist a conduit for contamination of the groundwater resources, running from the wellbore and up the fault.

## 9 Discussion

The Wood Barn Farm wellpad is a poor location for testing the KCF, because it lies 1.2 km south of the limit of mature Kimmeridge shale as defined by the BGS. The Applicant appears to have simply refurbished and modified the original drilling plans submitted by Celtique Energie, when new diagrams, including the well design, are required.

The only reason for the Applicant to apply to continue work at Wood Barn farm seems to be the presence of the existing wellpad prepared by Celtique Energie. This is not a rational basis on which to pursue exploration work granted by the extension of the PEDL period, which rightly should have expired in June 2016.

The Applicant stated in a Stock Exchange press release (RNS no. 2127D, 5 July 2016):

> "***Broadford Bridge ("BB") PEDL234*** *(Company interest 100% via ownership of Kimmeridge Oil and Gas Ltd): A two-year extension of the Initial Term of the licence to June 30th 2018. The Licence contains a constructed well pad and regulatory permissions to drill the BB-1 Kimmeridge Limestone well, a look-alike Kimmeridge prospect to the Horse Hill-1 Kimmeridge Limestone oil discovery.*"

This statement may have been misleading shareholders and the public. No permission has been granted to drill a so-called 'Kimmeridge Limestone' well. The Applicant has merely taken the previous well prognosis of Celtique Energie, intended for a completely different hydrocarbon type and target, and has pasted on a new set of depth figures, as I have shown in Figure 2. It then expects the regulatory agencies, including the EA, to sign off this fundamental change of exploration plan as if it were a trivial amendment. I consider this to be irresponsible and technically incompetent.

Alongside the Applicant's well schematic (KOGL Non-Technical Summary, document BB-PR-Q02, page 5) there is drawn a well construction schematic, and at the bottom of the diagram there is a proviso:

> "*The above casing design is subject to change following a review of the formation tops and a casing design being carried out and signed off as part of the basis of well design*"

But all the contingent work on formation tops and casing design referred to above should have been carried out before the request for variation. At present the EA is being asked to approve in advance an ill-conceived and internally inconsistent drilling plan, which may or may not be revised (if the Applicant chooses to see fit) at some future date. This is unacceptable.

Similarly, there is no evidence that the Applicant has even made the effort to undertake a preliminary study of the local and regional geology, for example, by tying the well data from the two nearest wells (discussed in the previous section) to the proposed wellsite. This kind of work is an essential prerequisite to drilling, and is normally carried out before planning applications to drill are submitted.

## 10 Conclusions

The Applicant has tried to hide behind the now-defunct plans of Celtique Energie for a conventional exploration drilling programme, when in fact its new proposals are for unconventional extraction. Given that the Kimmeridge Clay Formation, with its tight thin semi-limestone bands, is an unconventional target, it will require fracking to exploit at full scale, even if no fracking is carried out at the test stage.

The Applicant has failed to demonstrate that the existing pad at Wood Barn Farm is the most suitable site for testing the KCF, which exists throughout PEDL234. In fact a more suitable location, where the shale is mature for oil, would be somewhere within the northern half of PEDL234.

The Applicant has misconstrued its well prognosis plan, which is merely an annotated version of Celtique Energie's plan. It is internally inconsistent, in that it does not take into account the different geology to be encountered by the new wellbore.

The Applicant proposes to drill a highly deviated well northwards from the pad, with no seismic control. This is irresponsible, since it will have a poor grasp of the geology it encounters along the wellbore.

The Applicant, should, if it wishes to persevere with its proposals for testing the KCF, acquire additional 2D seismic data, or preferably 3D seismic, and interpret them before deciding upon a suitable location for exploratory drilling. This location is unlikely to be at Wood Barn Farm.

The prior existence of a drill pad inherited from the previous licensee is no justification for using the same pad for a substantially different exploratory aim.

In conclusion:

- The history of the transfer of the PEDL, the granting of an extension period, the request for a variation, the subterfuge of conventional exploration, and the evidently incomplete, technically sub-standard nature of the request, is reminiscent of a hasty and speculative operation, which should not be permitted.
- A new planning application for exploratory drilling within PEDL234 needs to be drawn up and submitted to WSCC.
- The Environment Agency should therefore refuse the current environmental permit, because the information supplied is incomplete and misleading.

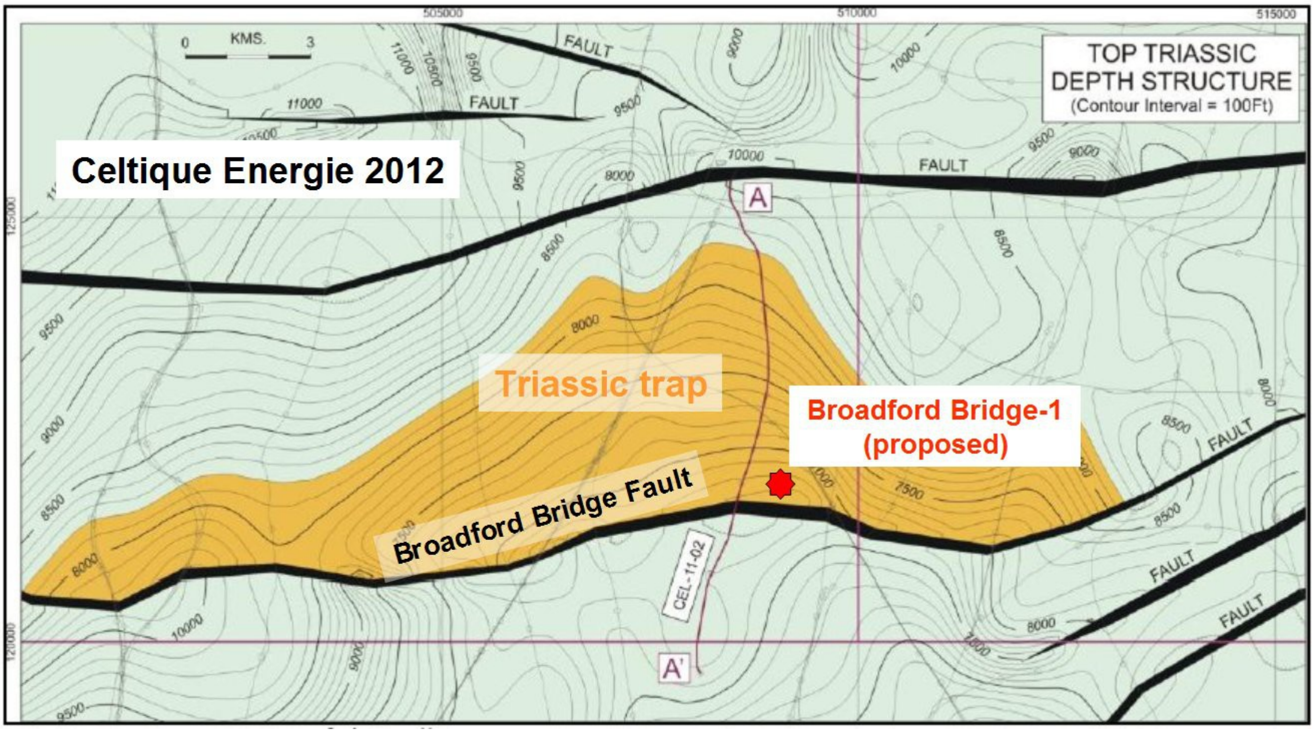



*Figure 1. Celtique Energie conventional Triassic sandstone target trap at Broadford Bridge.*

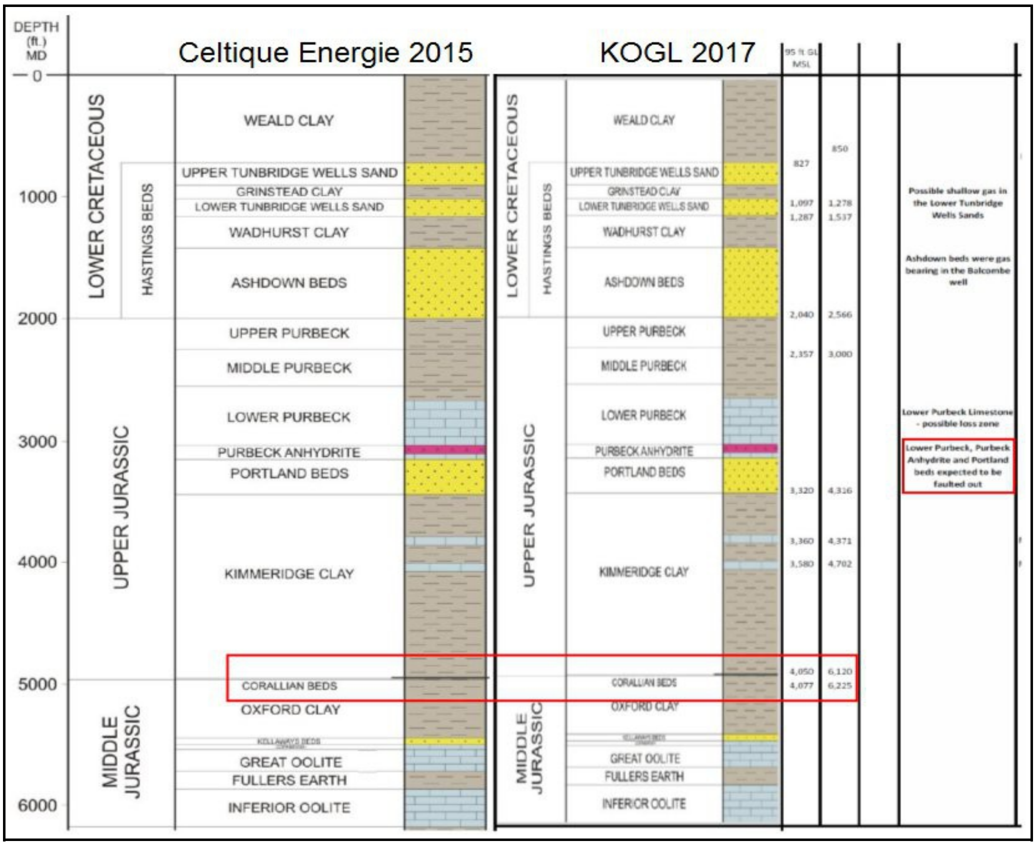



*Figure 2. Comparison of the original Celtique Energie well prognosis with the Applicant's prognosis. Red boxes indicate (a) the fault zone predicted by Celtique where section will be missing, and (b) text on the right where the Applicant expects to penetrate a fault zone.*

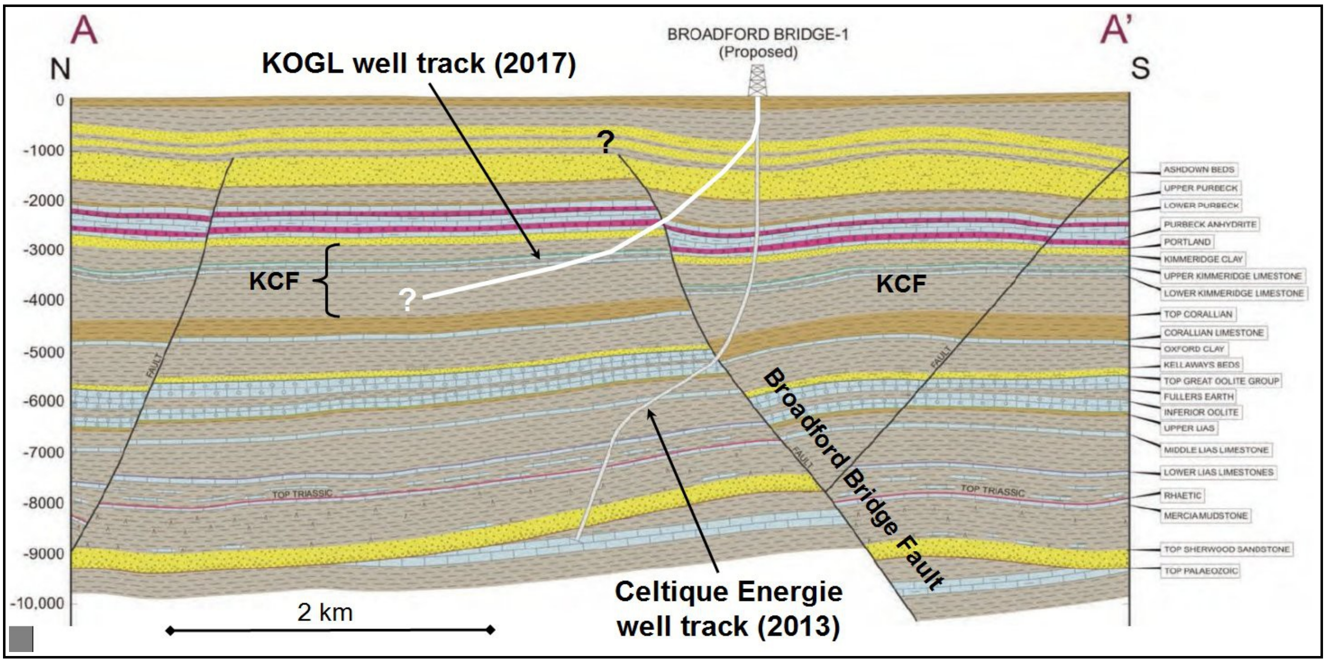



*Figure 3. Celtique Energie interpretation of geology along section AA' (Fig. 1) showing original well track and new welltrack proposed by the Applicant. KCF – Kimmeridge Clay Formation.*

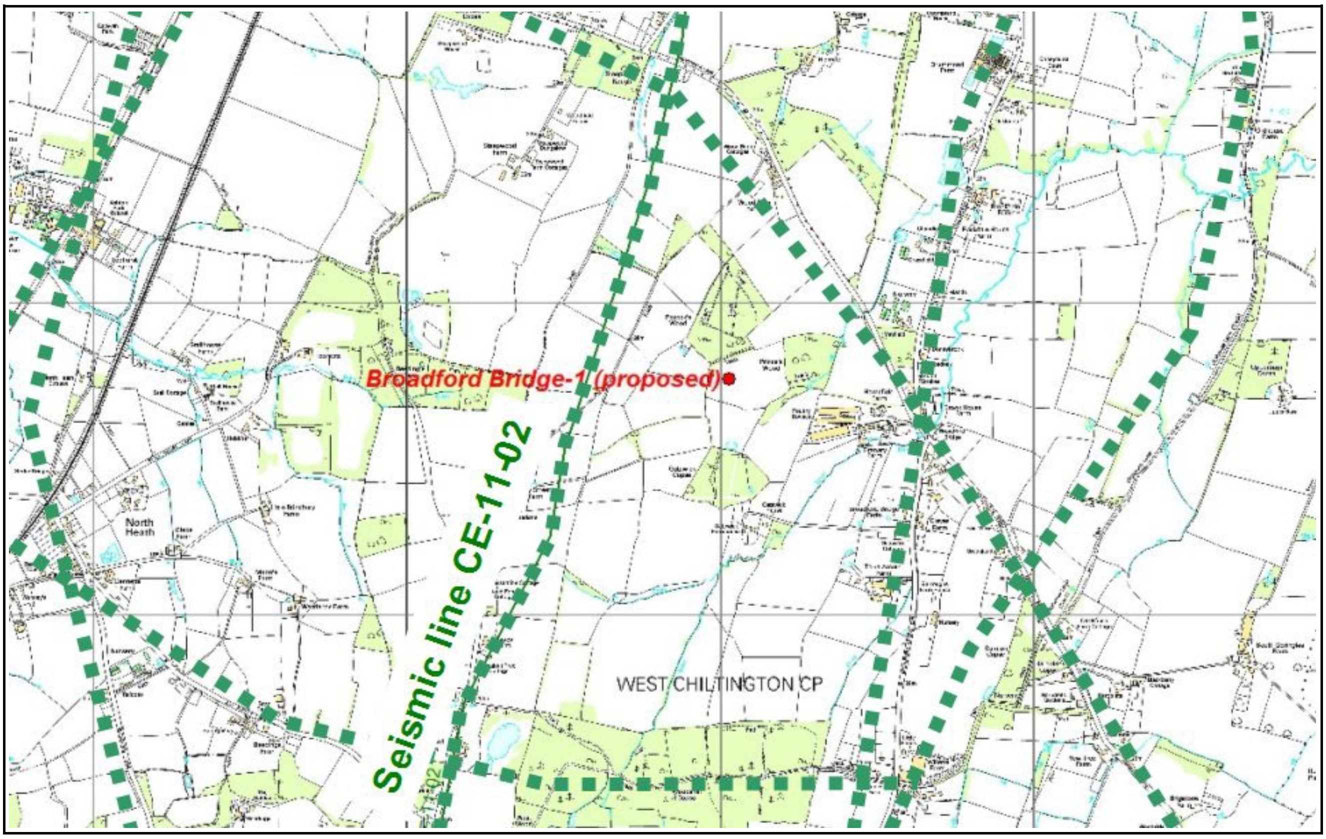



*Figure 4. Generalised locations of seismic reflection data (dotted green lines) around Broadford Bridge-1. Grid is at a 1 km interval. OS map base copyright acknowledged.*

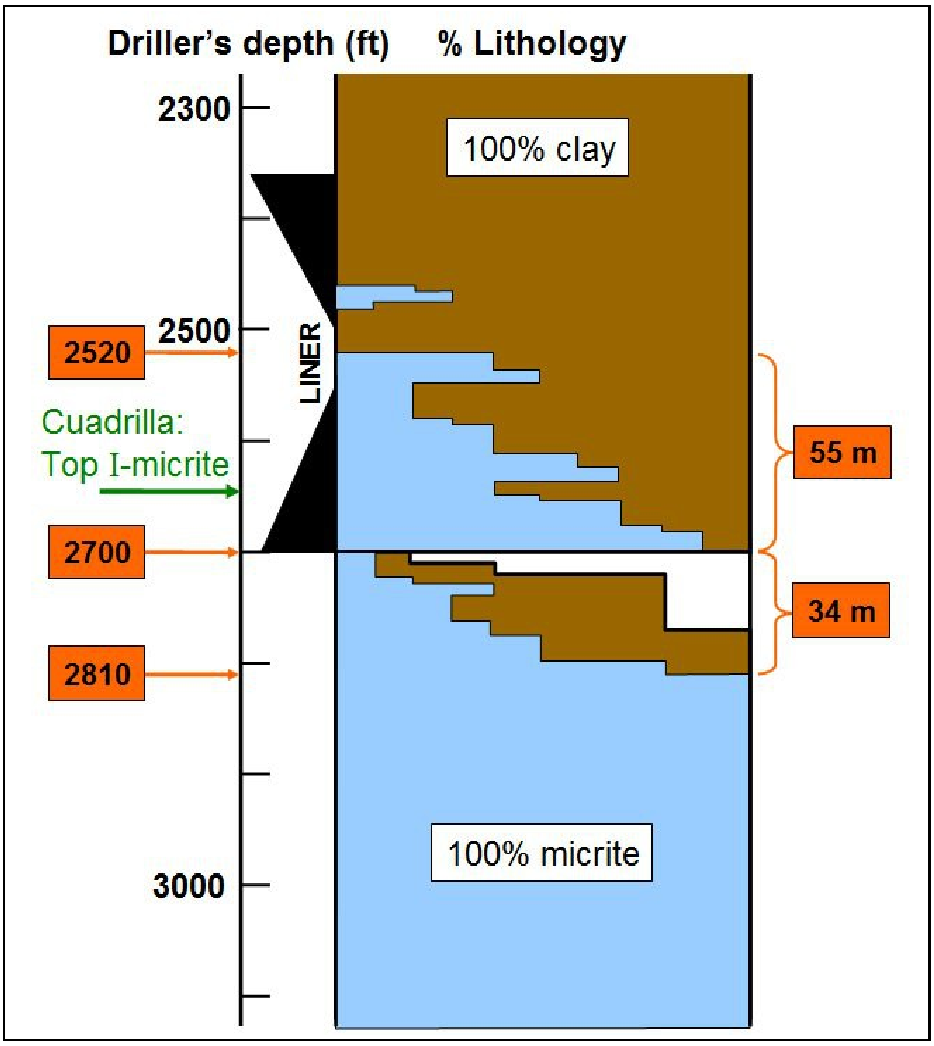



*Figure 5. Detail of lithology log from deviated well Balcombe-2z in the zone where it lands in the I-micrite. Driller's depth in feet is distance along the curved wellpath. At 2700 ft the wellbore is inclined at 15° to the horizontal. The dip of the geological layering is effectively zero (actually about 3°). The log shows two gradational changes from clay to micrite, not the one as would be expected.*

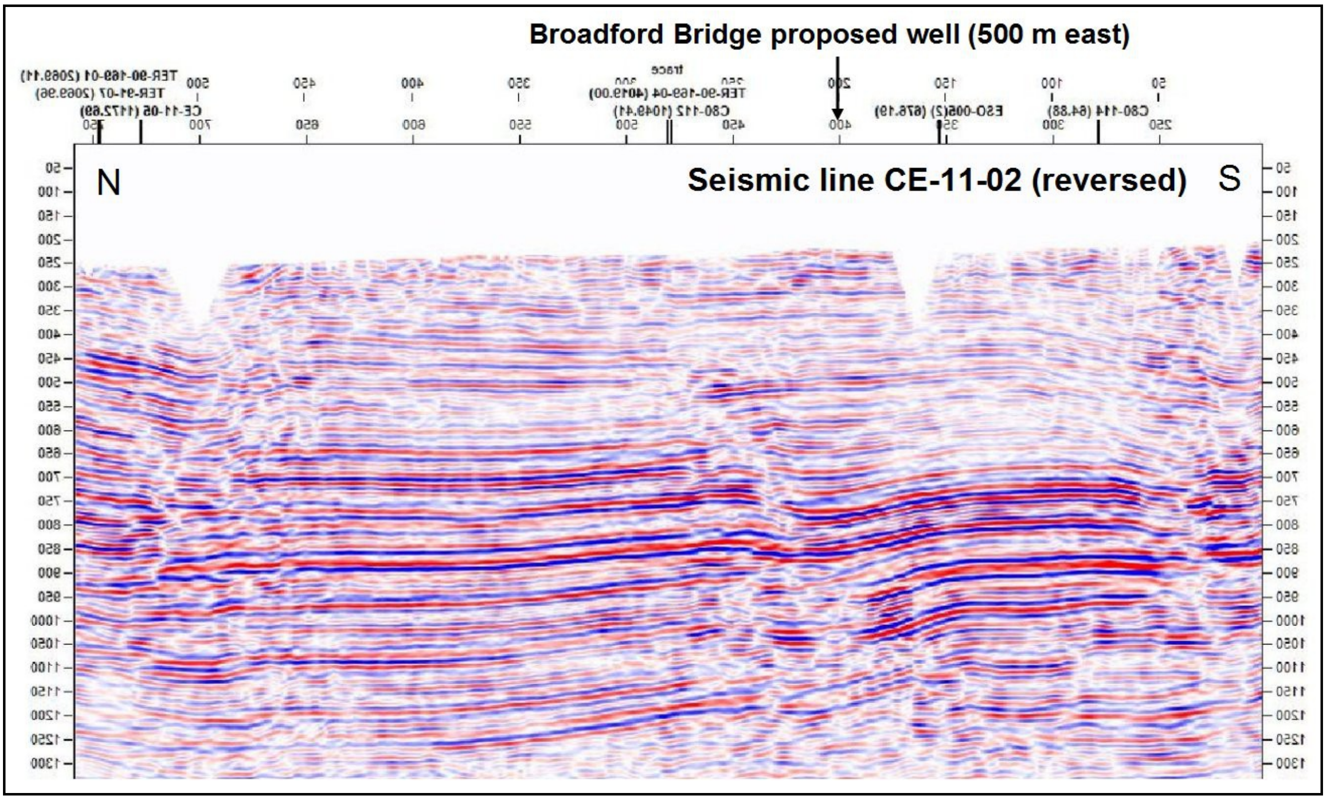



*Figure 6. Raw seismic reflection section CE-11-02, located by line AA' in Figure 1. The image has been mirrored to place north on the left.*

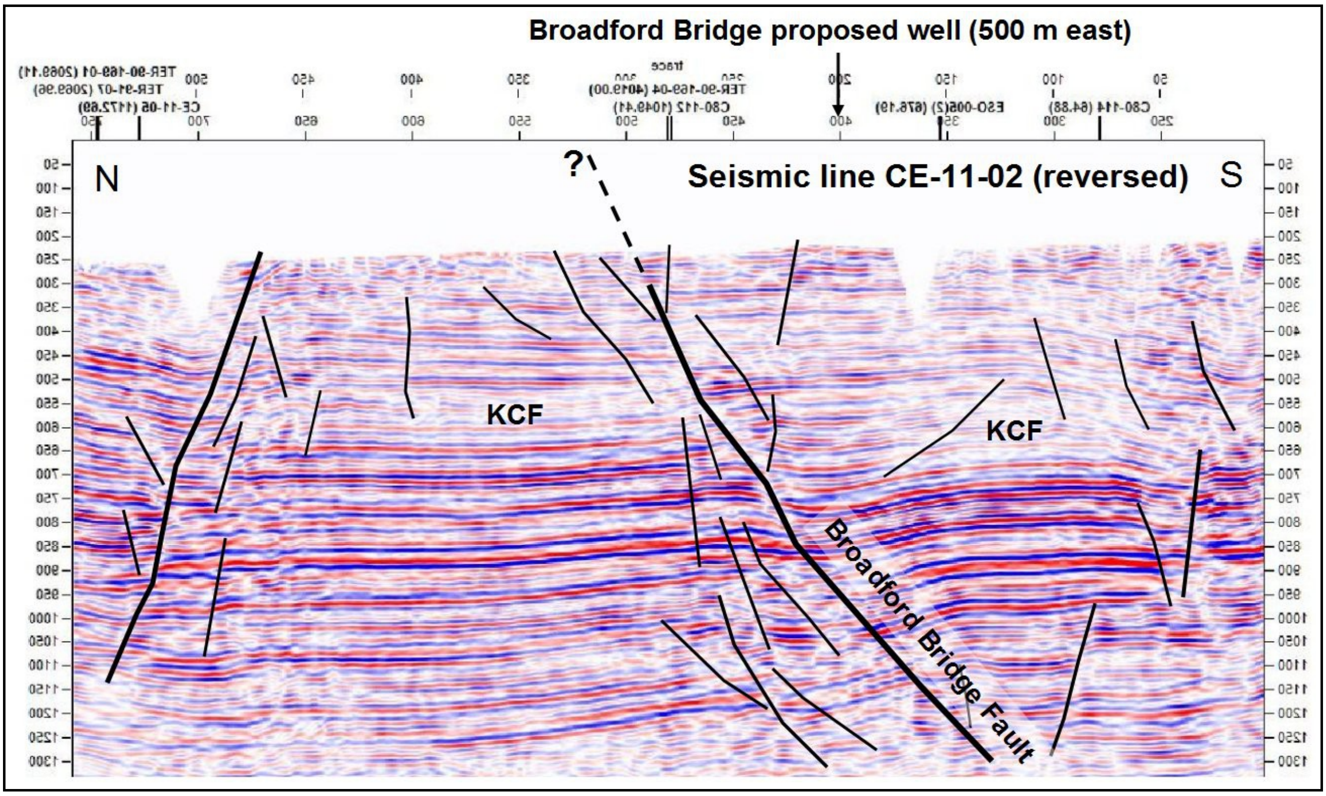



*Figure 7. Faults interpreted on seismic line CE-11-02.*

**Appendix 1**

**Extract from**

**West Sussex County Council**

**Minerals Local Plan consultation submission**
**David Smythe**
14 March 2017
[This version contains the diagrams and internet hyperlinks omitted from the online version submitted on 13 March 2017. Extra links added 15 March (v. 1.4)]

## 4 The definition of conventional and unconventional hydrocarbon resources

### *4.1 National planning practice guidance*

The terms 'conventional' and 'unconventional' hydrocarbons are defined in the Minerals Background Paper no. 2 at paras. 4.24 - 4.26. The source of the definitions is not explicitly stated, but it can reasonably be assumed that the definitions are taken from national planning practice guidance. The Minerals section of Planning Practice Guidance, published on 17 October 2014, states:

> "*Conventional hydrocarbons are oil and gas where the reservoir is sandstone or limestone. Unconventional hydrocarbons refers to oil and gas which comes from sources such as shale or coal seams which act as the reservoirs.*"

This attempt to define the difference between conventional and unconventional hydrocarbons conflates the mineral itself ("*hydrocarbons*") with the process ("*comes from*") and the supposed source or reservoir rock. But the difference between the two terms is fundamentally one of resource extraction method. The guidance fails to recognise this point.

The definition is unsound for the following reasons:

1. It uses overly-simplistic rock types to differentiate between the two resources - "*sandstone*", "*limestone*", "*shale*", "*coal seams*" - without defining them properly. Such nomenclature is too black and white; in practice, there are gradations between end-member rock types; for example, geologists can describe a muddy themselves, for example, 100% pure limestone, are rather rare in nature.

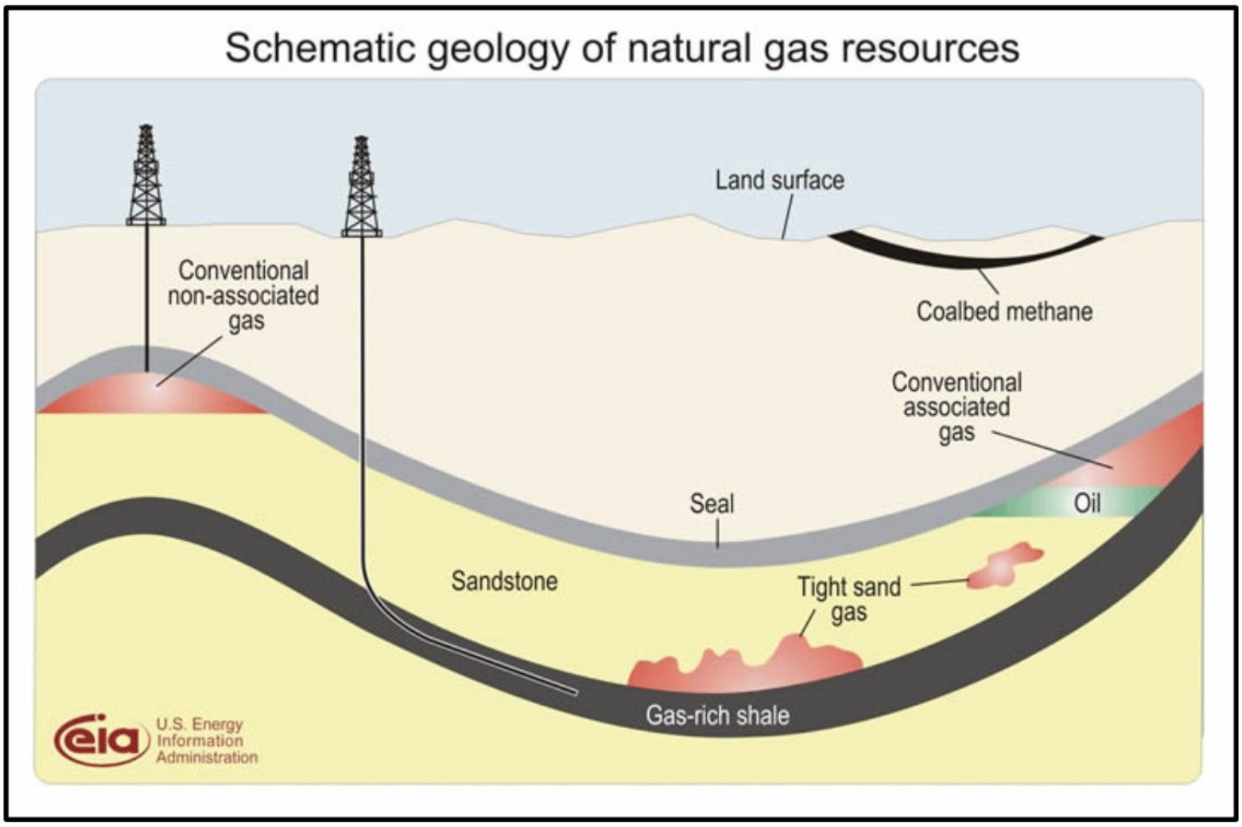
2. There is no mention of the geological context within which any of these rock types occur, for example, basin position, trap geometry, layer thickness, etc., nor the source where the hydrocarbons have been generated.

3. There is no mention of the physical properties of the rock types, such as permeability and porosity.

4. It omits mention of the physical and chemical properties of the "*hydrocarbons*" themselves, e.g. viscosity, API gravity (oil), or alkane (gas).

5. It omits to mention the processes by which the hydrocarbon is extracted, in particular the difference between hydrocarbons which are extracted from the rock with little or no treatment, *versus* those requiring extensive treatment to make them flow - e.g. steam heating, acidising, or hydraulic fracturing, or whatever forms of

reservoir stimulation.



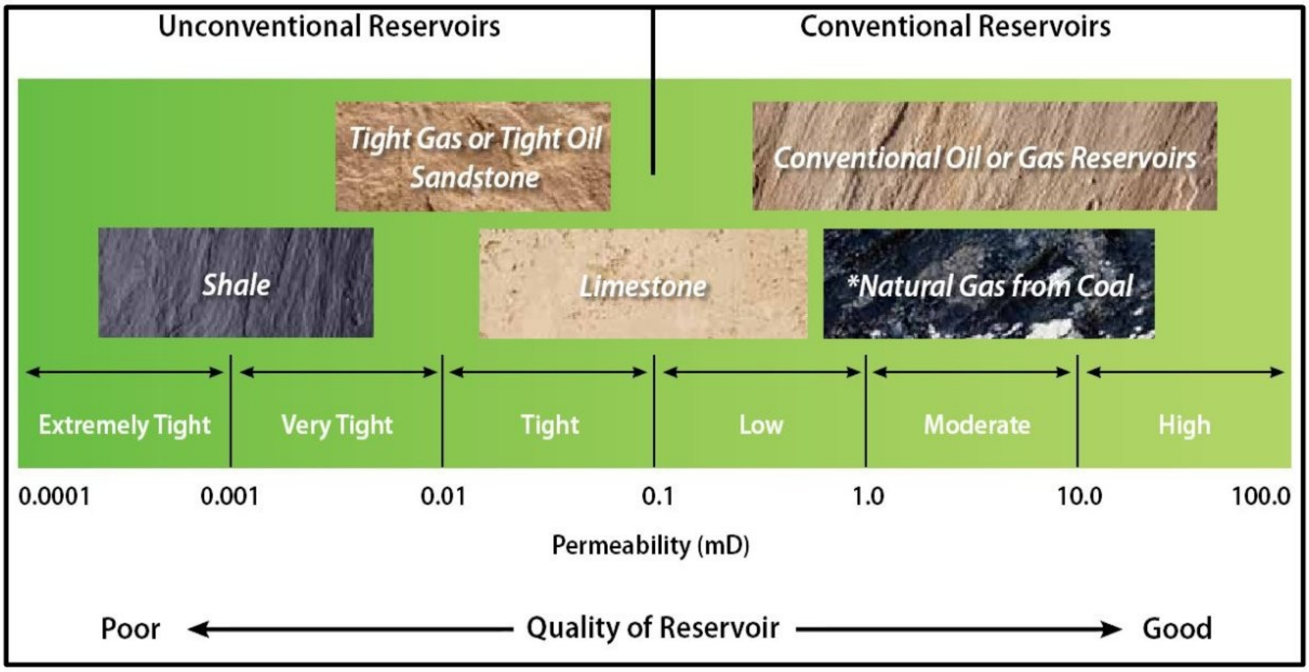

*Schematic geology of gas resources, from US Energy Information Administration.*

6. There is no mention of the economic aspects of the production process.
I have written to the Department of Communities and Local Government asking for the information to justify its definition, but await a reply.

### *4.2 Other definitions*

There is no universally agreed definition of the difference between conventional and unconventional hydrocarbon mineral extraction; various versions in the scientific and technical literature (see section 7 below) emphasize different aspects mentioned in points 1-6 above. However, all reasonable definitions that I am aware of include, either implicitly or explicitly, the permeability of the host rock.

The figure of 0.1 mD (milliDarcies) for the host rock is generally agreed to differentiate between the two extraction procedures, although the Society for Petroleum and Coal Science and Technology of Germany defines a higher value of 0.6 mD. Given the vast range of possible permeabilities and the limited precision in estimating permeability, the scale is usually presented in logarithmic form, so that units (decades) on the scale are 0.001, 0.01, 0.1, 1, 10 ... mD and so on. Below 0.1 mD the process required to extract the hydrocarbons is unconventional, whereas above that value it is considered to be conventional.




*Spectrum of permeabilities to differentiate between unconventional and conventional reservoirs (Canadian Society for Unconventional Resources).*

Next in importance to a quantitative definition using permeability comes the geological setting in which the hydrocarbon-bearing rock occurs. Thus conventional resources are found in finite and well-defined traps, whereas unconventional gas or oil is distributed throughout a widespread layer with no clear-cut boundaries.

Along with the two criteria above, the process of extracting the hydrocarbons is important. It is variously described as fracking, acidising, massive stimulation, additional extraction or conversion technology, or assertive recovery solution. Although different in detail, what they all have in common is the aim of making the hydrocarbon flow when it would otherwise not do so.

### *4.3 Discussion and conclusion*

No definitions of which I am aware (see list below) regard so-called "sandstone" or "*limestone*" reservoirs as automatically conventional, as simplistically defined by the national planning practice guidance. On the contrary, many sandstone and limestone reservoirs are called 'tight', meaning that unconventional extraction methods are required.

Given the unscientific and imprecise nature of the definition, it would be justifiable for the MLP to ignore it as being unsound.

[end of Appendix 1]