IN THE HIGH COURT OF JUSTICE

BUSINESS AND PROPERTY COURTS OF ENGLAND AND WALES

PROPERTY, TRUSTS AND PROBATE LIST (ChD)

B E T W E E N :

(1) UK OIL & GAS INVESTMENTS PLC

(2) KIMMERIDGE OIL & GAS LIMITED

(3) MAGELLAN PETROLEUM (UK) LIMITED

(4) HORSE HILL DEVELOPMENTS LTD

(5) UKOG (GB) LIMITED

Claimants

- and -

PERSONS UNKNOWN WHO ARE PROTESTORS AGAINST THE EXPLORATION AND/OR EXTRACTOR OF MINERAL OIL OR RELATIVE HYDROCARBON OR NATURAL GAS BY THE CLAIMANT(S) AND WHO ARE INVOLVED IN THE FOLLOWING ACTS OR ANY OF THEM:

(1) ENTERING OR REMAINING WITHOUT THE CONSENT OF THE CLAIMANT(S) ON LAND AND BUILDINGS SHOWN EDGED RED ON THE PLANS ANNEXED TO THE CLAIM FORM ("THE LAND");

(2) OBSTRUCTING OR INTERFERING WITH THE RIGHTS OF WAY ENJOYED BY THE CLAIMANT(S) AND EACH OF ITS AND THEIR AGENTS, SERVANTS, CONTRACTORS, SUB-CONTRACTORS, & LICENCEES ("THE PROTECTED PERSONS"), OVER THE PUBLIC HIGHWAY AND/OR THEIR ACCESS TO AND FROM THE LAND.

(3) COMBINING TOGETHER TO COMMIT THE OFFENCES AS DEFINED IN THE ORDER ANNEXED TO THE CLAIM FORM ("THE ORDER") WITH THE INTENTION SET OUT THEREIN.

(4) INTERFERING WITH THE CLAIMANT(S) ECONOMIC INTERESTS BY THE COMMISSION OF THE UNLAWFUL ACTS AS DEFINED IN THE ORDER;

(5) COMBINING TOGETHER USING LAWFUL MEANS WHERE THE PREDOMINANT

INTENTION IS TO INJURE THE CLAIMANT'S ECONOMIC INTERESTS;

(6) WATCHING, BESETTING, INTIMIDATING OR ASSAULTING THE CLAIMANTS) AND

EACH OF THE PROTECTED PERSONS.

Defendants

First witness statement of David K. Smythe

Professor David Smythe will say:

1. RELEVANT PERSONAL DETAILS FROM MY CV

1. I am David Kenneth Smythe, residing at La Fontenille, 1, rue du Couchant, 11120 Ventenac en Minervois, France, since 2004. I am Emeritus Professor of Geophysics in the University of Glasgow. Although I am now a French resident I remain a British citizen, and take an active interest in UK, French and foreign affairs, as well as in various facets of scientific research.

2. My qualifications are: BSc (Hons class 2:1) Geology, University of Glasgow, 1970; PhD (Geophysics), University of Glasgow, 1987; I was made a Chartered Geologist in 1991 on the inception of the title, but this lapsed after 1996. I have in the past been an active member of various professional societies, including: the Geological Society of London, the Royal Astronomical Society, The American Geophysical Union, the Society of Exploration Geophysicists, the Petroleum Exploration Society of Great Britain, the European Association of Geoscientists and Engineers, and the Geological Society of Glasgow. I have published many academic research papers in the journals of these societies and elsewhere, and served as an Editor of the *Scottish Journal of Geology* for a decade.

3. Prior to my taking up the Chair of Geophysics at the University of Glasgow in 1988 I was employed by the British Geological Survey (BGS) in Edinburgh from 1973 to 1987. I was a research scientist, rising to the post of Principal Scientific Officer. My work in the BGS from 1973 to 1986 was funded by the UK Department of Energy as part of a Commissioned Research programme on the geology of the offshore UK region. I also gave geological advice to the Foreign & Commonwealth Office on matters pertaining to UK territorial claims offshore. This was during the exciting phase of early discoveries and development of the North Sea. I led a team of seismic interpreters working mainly on the prospectivity of the western margins of the UK, using the industry seismic and well data supplied to the Department of Energy. As a result I became the UK's leading expert on the deep geology of the continental margin west of the British Isles. Although our interpretation groups in the BGS were never able to commission our own wildcat wells, we had many 'virtual successes', where our independent interpretations were confirmed by subsequent drilling, and where the industry operators were proved spectacularly off-course.

4. In 1985 I was awarded the Lyell Fund by the Geological Society of London, a prize awarded for my contributions to deep crustal seismic imaging and to plate tectonic theory of passive continental margins.

5. In the 1990s I was closely involved in the search for a UK underground nuclear waste repository, and conducted for UK Nirex Limited (the nuclear waste disposal agency) an experimental 3D seismic reflection survey. This took place in 1994. The survey encompassed the volume of the proposed rock characterisation facility (RCF) – a deep underground laboratory planned as a precursor to actual waste disposal. This was a double world 'first' – the first ever 3D seismic survey of such a site, and the first academic group to use this method, which at the time was just emerging as an essential tool of the oil exploration industry.

6. Since my retirement from the university in 1998 I have carried out private research, patented and developed a new method of 3D diagnostic medical ultrasound imaging based on geophysical principles, acted as a consultant to the oil industry for conventional exploration (2002-2011), and maintained an interest in the geological problems raised by nuclear waste disposal, shale gas exploration and coal-bed methane exploration. My tools for this work are up-to-date; I have my own licence for ProMAX 3D (seismic data processing), and currently hold on loan industry-owned licences for SMT Kingdom (seismic and well interpretation) and ModelVision (gravity/magnetic modelling including tensor fields).

2. EXPERTISE OF RELEVANCE TO THIS ACTION

7. My CV shows that I have half a century of experience working in applied and exploration geophysics, much of which has been closely related to oil and gas exploration.

8. In 1995-96 I acted as an Expert Witness for Friends of the Earth Limited against Nirex at the West Cumbria planning appeal into the refusal of Cumbria County Council to permit the excavation of the RCF. I felt obliged to take this action as a result of the complex geology revealed by the pioneering Glasgow 3D survey, and in spite of the fact that it had been funded by Nirex. The inquiry inspector recommended dismissal of the appeal, a recommendation upheld by the Seceretary of State in 1997. The fundamentals of the RCF problem were a misunderstanding of complex geology and the propensity for geological faults to act as conduits for contamination from depth to the biosphere - the same problems as we have today in the case of unconventional hydrocarbon exploration.

9. I may be the only person ever who has sat on both sides of the table at interviews for the award of PEDLs. The first time was in 1984 for the ninth round of offshore licensing, when I was invited by the Department of Energy to assist in interviewing BP. On the second occasion I successfully represented an applicant for a PEDL in the thirteenth landward licensing round. I therefore have some inside knowledge, at least historical, of the requirements for the acquisition of a petroleum exploration licence.

10. During my period as a consultant to the hydrocarbon industry I discovered the potential threat of an unconventional hydrocarbon licence in the Languedoc, in a large region encompassing our home. I therefore read into this relatively new area (of unconventionals), and even gave a couple of public lectures in French to the concerned public. However, the threat of unconventional exploration disappeared in 2011 with the annulment of existing licences, and susequent ban on new licences in French territory.

11. Since around 2012 I have made myself expert in the geological and hydrogeological facets of unconventional hydrocarbon exploration, building on my existing industry and academic expertise in the conventional area. I had ceased consulting for the industry by this time.

12. My particular areas of interest in the unconventional resource exploration field are the structure and tectonics of the ten principal US shale basins, and the shale basins (and coal bed methane prospects) of the UK. I also keep a watching brief on shale basins in other parts of the world. My computer database currently comprises some 99,000 files in 2900 folders, occupying 180 GB of storage. This has become my full-time research work over the last decade.

13. My reason for familiarising myself with the US scene is because the geology of the US shale basins has very little similarity to that of the UK equivalents. In addition, I have discovered that the US unconventional industry runs at a huge and continuing financial loss, after more than ten years of activity. These facts have relevance to the UK as I shall point out later.

14. Rather than writing peer-reviewed academic papers on these topics I have concentrated on studying case histories, often helping objectors to unconventional planning applications by writing detailed reports. For the avoidance of doubt, I have never regarded this as a paying or profitable activity; the honoraria that I have received from several action groups have amounted to £10,000 to date. This is an effective rate of under £1 per hour, less than 1 percent of my hourly rate as a consultant a decade ago. It does not even cover the expenses involved in running equipment, buying data, books and maps, and so on.

15. My reports are designed to be comprehensive and technically robust; they can withstand critical review by experts and industry. Several of them will be referred to later. Their extent can be quantified in the following examples (NB the list is incomplete):

    - Fernhurst, West Sussex (Celtique Energie, 2014): 13,800 words, 20 diagrams
    - Airth, Stirlingshire (Dart Energy, 2014): precognition 12,000 words and 18 diagrams; rebuttal 9600 words, 6 diagrams.
    - Wisborough Green, West Sussex (Celtique Energie, 2014): 18,000 words, 20 diagrams
    - Preston New Road, Lancashire (Cuadrilla): 12,000 words, 4 diagrams.
    - Roseacre Wood, Lancashire (Cuadrilla): 13,000 words, 6 diagrams.
    - Misson Springs, Nottinghamshire (IGas, 2015): 26,000 words, 18 diagrams
    - Broadford Bridge, West Sussex (KOGL, 2017): 6000 words, 5 diagrams
    - Leith Hill, Surrey (Europa, 2018): 14,000 words, 21 diagrams.
    - Arreton, Isle of Wight (UKOG, 2020): 6700 words, 8 diagrams.

16. My lengthy review *Inadequate regulation of the geological aspects of shale exploitation in the UK* is about to be published (September 2020) in the oen-access peer-reviewed *International Journal of Environmental Research and Public Health*. It discusses several case histories involving the Complainant, although the emphasis is more on the failures of regulation rather than a critique of the oil and gas industry *per se*.

17. In addition I have submitted many shorter technical objections, responses to parliamentary groups, and so on. I have also published a number of blog articles explaining in non-technical terms (as far as possible) the problems of drilling or interpretation at various locations, including those discussed by the Complainant.

3. REASON FOR MY WITNESS STATEMENT

18. As an experienced physical scientist and technical expert on oil and gas exploration I object to some of the specious, misleading, and at times mendacious technical claims made by the current Complainants, who are:

    (1) UK Oil & Gas Investments PLC

    (2) Kimmeridge Oil & Gas Limited

    (3) Magellan Petroleum (UK) Limited

    (4) Horse Hill Developments Limited

    (5) UKOG (GB) Limited

19. I refer to these hereinafter as the Complainant, jointly and severally. I shall demonstrate why I consider the Complainant to have behaved, and to still behave, in an evasive and misleading manner regarding its exploration activities in the Weald. I shall also demonstrate that the Complainant at times displays a high degree of technical incompetence.

4. *AD HOMINEM* ATTACKS ON MY EXPERTISE

20. Mr Stephen Sanderon, CEO of Complainant no. 1, published online a response in July 2017 to 'frequently answered questions', which is still on the UKOG website[1]. He states:

> *"Through various means, the BBAG* [Broadford Bridge Action Group] *have demanded a full response to 10 questions by a retired academic, David Smythe, who is one of the so-called experts who has served on the BBAG public meeting panel. Most of these questions and their subject matter have been answered in UKOG's prior written responses and during the various on-site visits.*
>
> *As far as we are aware and judging by media reports about his relationship with the University of Glasgow, we understand that, even with his claimed credentials, that David Smythe is not a recognised scientific expert in the field of hydrogeology, petroleum geology or an expert in oil and gas project economics, upon all three of which he has made multiple unsubstantiated assertions. We have been alerted to issues about his description of his current professional status and the consequent adverse reaction of various professional bodies. A description of the dispute(s) is available on his own website.*
>
> *There is also considerable media coverage concerning these disputes, especially that with the University of Glasgow, who seem to wish to distance themselves from him.*
>
> *The bulk of David Smythe's questions seem to relate to UKOG's Kimmeridge Limestone play being uneconomic. That is precisely the purpose of the Broadford Bridge exploration well and subsequent well testing, to establish if economic development is possible or not. That is the purpose of the exploration and appraisal process. Per our latest corporate presentation,*

[1] http://www.ukogplc.com/ul/Your%20Frequently%20Asked%20Questions%20answered%20by%20UKOGs%20Steve%20Sanderson.pdf

available on our website, we clearly state that in the event of success the project has robust economics as it uses conventional drilling and production techniques and isn't reliant on using expensive massive fracking techniques. If the well proves uneconomic or not commercially viable, KOGL will clearly not pursue further development."

21. I shall not respond to Mr Sanderson's self-evidently spurious claims that I am not an expert in the relevant fields. But for the avoidance of doubt, I my legal dispute with the University of Glasgow (2016-2018) was settled amicably, and the new Secretary of the University has stated in a letter to me (5 January 2018) :

"I have no reason to doubt your integrity as a scientific researcher, and hope that you will continue to be as productive in your research as you have been since your retirement in 1998."

22. He has also confirmed that I am free to continue to use the title of Emeritus Professor of Geophysics without hindrance. I remain a member of the College of Science and Engineering, but not attached to any specific school or group within the University, and the views expressed are my own. Professor Paul Younger, who first raised the false issue of my being a Chartered Geologist, took early retirement from the University in March 2017. The previous Secretary of the University Court who instructed that my online links be severed in January 2016 has also departed. My access was restored in full by order of Sheriff Reid at a preliminary hearing in the Sheriff Court of Glasgow in June 2017. The Geological Society of London has been disingenuous in claiming that I need proof of continuous professional development (CPD) in order to continue to be a Chartered Geologist, a title I let lapse in 1996. In fact the CPD requirement only came in less than a decade ago. In any case I have no wish, nor requirement for, the title.

23. It would be more constructive for Mr Sanderson to critique in turn my technical criticisms of the Complainant's exploration work in the Weald, than to resort to feeble and scurrilous *ad hominem* accusations, which I would advise, in view of their potentially defamatory nature, that he now withdraws immediately. The separate question of economics, raised by Mr Sanderson, is discussed below.

5. UKOG AND RELATED COMPANIES

24. I have been unable to find in the Complainant's UKOG web pages any details of the other beneficiaries (interest holders) in the various assets held by UKOG and its partners. This in itself is indicative of an unprofessional attitude to its investors and to the public. The Oil and Gas Authority (OGA), however, reveals the following licences wholly or partly within the Weald Shale Prospective area (see the interactive map[2] provided by the UK Onshore Geophysical Library):

1. PEDL234 (Broadford Bridge wells) 100% Complainant
2. PEDL137 (Leigh-1, Horse Hill-1) 100% Complainant
3. PEDL246 (no wells) 100% Complainant
4. PEDL143 (Holmwood-1 proposed) 67.5% Complainant

25. The exploration history and geology of some of these licences will be dicussed below, preceded by a more general discussion of the definitions of unconventional resources, of fracking, and of acidisation.

[2] https://ukogl.org.uk/map/?e=-131306,6568273,125522,6730320&l=21,269251904,0&sm=true&b=1

6. THE DEFINITION OF UNCONVENTIONAL HYDROCARBON RESOURCES

26. 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."*

27. 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.

28. 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 sandstone, a sandy limestone, or a sand-prone shale. The end-members themselves, for example, 100% pure limestone (chemically, $CaCO_3$, calcium carbonate), 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. The US Energy Information Administration has published a useful diagram[3] showing the various geological settings in which natural gas resources occur. The diagram is similar for oil.
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.
6. There is no mention of the economic aspects of the production process.

29. There is no universally agreed definition of the difference between conventional and unconventional hydrocarbon mineral extraction; various versions in the scientific and technical literature 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.

30. 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. Below 0.1 mD the process required to extract the hydrocarbons is unconventional, whereas above that value it is considered to be conventional. Note

[3] https://www.eia.gov/energyexplained/images/charts/hydrofracturing_lg.jpg

that the measured range of Kimmeridge Clay micrites, between 0.005 and 0.03 mD, unambiguously falls into the unconventional area of the spectrum. A diagram originally published by the Canadian Society for Unconventional Resources illustrating the range of permeabilities and rock types with the dividing line set at 0.1 mD, has been adopted[4] by the Oil and Gas Authority (OGA) and published in June 2017. So the OGA understanding of what is meant by unconventional agrees with the internationally agreed criterion discussed above, but contradicts the government's guidance as set out in its Planning Practice Guidance.

31. 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.

32. 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.

7. THE DEFINITION OF FRACKING

7.1. The legal definition

33. Section 50 of the Infrastructure Act 2015[5], as amended by a direction to the OGA[6] defines hydraulic fracturing ('fracking'), is as follows:

"Section 4A: supplementary provision

(1) "Associated hydraulic fracturing" means hydraulic fracturing of shale or strata encased in shale which—

(a) is carried out in connection with the use of the relevant well to search or bore for or get petroleum, and

(b) involves, or is expected to involve, the injection of—

(i) more than 1,000 cubic metres of fluid at ~~each~~ <u>any</u> stage, or expected stage, of the hydraulic fracturing, or

(ii) more than 10,000 cubic metres of fluid in total."

34. The amendment, which came into force on 29 November 2017, is shown above by the replacement of the word 'each' by 'any', as indicated above.

7.2. Weaknesses in the wording of the definition

35. There are two intrinsic weaknesses in the wording of this definition:

[4] https://www.ogauthority.co.uk/news-publications/publications/2017/southern-north-sea-tight-gas-strategy/

[5] http://www.legislation.gov.uk/ukpga/2015/7/section/50/enacted

[6] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/663909/171129_Direction_to_the_Oil_and_Gas_Authority.pdf

Weakness 1: "*shale or strata encased in shale*", and

Weakness 2: the word "*expected*" (quoted twice).

36. The first weakness is that the phrase in question is almost meaningless. Does it mean that the strata referred to which are not composed of shale, have to lie in direct contact with shale, above, below and all round on all sides? The phrase is unclear. In practice, almost any layer within a sedimentary basin is likely to be 'encased in' shale, excluding the very bottom layer resting on 'basement' rock, and excluding the uppermost layer at the surface of the earth. This is because shale is a very common variety of sedimentary rock, and there are likely to exist layers of shale above and below the stratum in question.

37. The second weakness, the expectation of a specified threshold volume of fluid, implies a belief that a certain amount will or will not be used. 'Expectation' is not being used in the statistical sense of the word, because the definition refers to discrete operations, occurring one at a time, and not to an aggregate of simultaneous and unpredictable operations for which statistical methods might be appropriate. The question also arises; who is doing the 'believing'?

38. What happens if the expectation that less than the specified amount turns out to be incorrect? The process of hydraulic fracturing involves the insertion of fluid into rock at depth. The volume being inserted is both continuously monitored and controlled by the operator at the surface. Now it may be the case during any one fracking stage, for which planning approval has been granted on the basis that the process will not fall under the definition of associated hydraulic fracturing of shale, that the operator may decide, based upon the perceived progress of the fluid pressure and volume, to insert a greater volume than specified by the threshold. That action implies that the planning consent has been wilfully breached. The alternative, which is under the complete control of the operator, is merely to turn off the fluid supply valve before the threshold is exceeded. This freedom of action applies both for any one stage and for the n'th stage at which the total threshold is in danger of being breached.

39. In conclusion, I can see no justification for someone's belief to be inserted here as part of a legal definition. It implies a discretion on the part of the operator, of whether or not to abide by the planning consent. Such a weak phrasing of the definition may therefore be open to challenge.

7.3. The use of fluid volume as a criterion

40. The definition involves the specification of two alternative minimum fluid volume measures, without qualification. It follows the definition of the European Commission (EC) published in the Official Journal of the European Union dated 8 February 2014. This in turn seems to be based on a consultant's report to the EC by AEA dated August 2012, proposing a figure of 1000 cubic metres for each fracking stage. There is little justification in this report for such a figure, and in any case the scanty research upon which it is based, comprising merely a literature review, has been superseded by the thorough US Geological Survey (USGS) continent-wide study discussed below.

41. Two questions arise from this definition; (a) whether fracking can be soundly defined by such a criterion, and (b) even if this be the case, whether the quoted threshold values are based on sound evidence. Dr Stuart Gilfillan and Professor Stuart Haszeldine, shale gas researchers at the University of Edinburgh, raised both these questions[7] in 2016. They quoted an extensive data compilation

[7] http://energyandcarbon.com/whats-in-a-name-the-risks-of-re-defining-fracking/

from the US Geological Survey (USGS) involving over a quarter of a million fracked oil and gas wells. Because the wells have been fracked, they are, using any reasonable definitions (discussed in section 6 above), unconventional.

42. I have examined the USGS compilation, which yields the following results. Horizontal fracked wells are for gas if the volume of water used is greater than about 2500 cu. m. The equivalent volume for horizontal fracked oil wells is 2000 cu. m.

43. There is also a secular increase in water use in horizontal wells, which is ascribed to evolving drilling and fracking techniques; for example, horizontal wells are generally much longer now than a decade ago. There are significant differences in the mean water use between different shale plays, reflecting, in part, different physical properties of the shale.

44. The results suggest firstly that the figure of 10,000 cubic metres chosen in the Infrastructure Act definition is too large by a factor of at least four. Secondly, the utility of having such a definition in the first place could be considered unsound. As the USGS authors conclude:

> *"Because hydraulic fracturing is not a one-size-fits-all operation, assumptions and generalizations regarding water use in hydraulic fracturing operations and the potential for environmental impacts should be made with caution."*

45. The Edinburgh researchers suggest that strain rate may prove to be a better criterion than simply fluid volume; this is a measure of how fast the rock cracks up when fracked, and involves the applied fluid pressure and the rate of flow, as well as the total volume. But they question why such a definition is needed at all.

46. The attempt to define hydraulic fracturing by any minimum threshold water volume criterion is unsound. In addition, the volume figures selected as discrimination criteria are contrary to established evidence, by being far too high, and the wording of the definition itself has weaknesses which render it unsound in a legal sense. Fracking remains fracking if it artificially enhances permeability in rock, whether the method used is (a) fluid under high pressure or (b) dissolution by acids. Fracking type (a) is hydraulic fracturing; fracking type (b) is chemical fracturing. Both types of permeability enhancement fall under the umbrella of 'unconventional' fossil fuel exploitation.

7.4. The possibility for evasion

47. Professor Haszeldine and I have pointed out the implications of the current definition in a letter[8] published in *Nature* in August 2017. We stated:

> *"Current exploratory drilling in the United Kingdom's Weald Basin is registered as 'conventional' because the hydrocarbon licensees are testing thin limestone layers in the shale and are not yet fracking. Assuming the UK licensees start HVHF, they can then in principle claim that it is conventional hydrocarbon production by keeping the fracking fluid volume to less than 10,000 m3 per well, which would evade environmental obligations specified in the 2015 UK Infrastructure Act".*

48. The Complainant has stated[9], regarding Horse Hill:

[8] https://www.nature.com/articles/548393a

[9] http://www.horsehilldev.co.uk/our-responsibilities-detail/3194294-horse-hill-1-flow-test-programme

"the three Horse Hill-1 flow tests all took place above the current UK-wide ceiling of 1,000m (3,300ft) below ground level, above which massive hydraulic fracturing (fracking) is not permitted by law. Therefore, the flow test zones cannot be fracked.

Note: hydraulic fracturing is currently defined by UK law (the Infrastructure Act 2015) as involving the total aggregate injection of more than 10,000 cubic metres (approximately 2.2 million Imperial gallons) of water into a rock formation at a pressure above the fracture gradient of that rock formation. This limit corresponds to the minimum injected fluid volume typically required to enable hydrocarbons to flow commercially from shale rocks."

49. The Complainant will hardly be unaware that it needs merely to ensure that less than 10,000 cu. m of water is used per well, and that each frack stage uses less than 1000 cu.m. For example, a well of ten stages, each of 990 cu.m water use, totalling 9900 cu. m, will legally not be classified as high volume hudraulic fracturing.

50. UKOG's portfolio page[10] states:

UKOG's portfolio has a good balance of low risk, stable production and conventional development assets, together with higher risk higher reward exploration and tight oil development assets offering further upside potential.

51. Note the mention of tight oil.

8. ACIDISATION: THE NEED FOR FRACKING DEFERRED

52. The Complainant and its partners are promoting the concept of acidisation of the Kimmeridgian micrites. First of all, the difference between an acid wash and an 'acid squeeze' needs to be discussed. The latter term is unusual, because it occurs neither in industry usage nor in common definitions to be found in the relevant pages of websites such as those of Halliburton[11], Schlumberger[12], PetroWiki[13], or Rigzone[14]. It should not be confused with a squeeze job[15]. However, an acid squeeze is referred to in the context of unconventional, low permeability carbonate stimulation treatments, for example by Rees et al. (2001)[16] and by Vasquez et al. (2015)[17].

53. The concepts behind acidisation and the need for legislative rewording in the UK are discussed in a briefing paper[18] prepared by Brockham Oil Watch with lawyers, in the context of Weald unconventional exploration activity, and submitted to BEIS in late 2019.

[10] http://www.ukogplc.com/page.php?pID=3

[11] http://www.halliburton.com/en-US/ps/stimulation/acidizing/default.page

[12] http://www.glossary.oilfield.slb.com/Terms/a/acid_job.aspx

[13] http://petrowiki.org/Matrix_acidizing

[14] https://www.rigzone.com/training/insight.asp?insight_id=320&c_id=

[15] https://en.wikipedia.org/wiki/Squeeze_job

[16] https://www.onepetro.org/conference-paper/SPE-71692-MS

[17] https://www.onepetro.org/conference-paper/SPE-174270-MS

[18] https://brockhamoilwell.files.wordpress.com/2019/11/acid-stimulation-fracking-by-stealth_rev14-2.pdf

54. The Environment Agency (EA) defines an acid wash and an acid squeeze as follows:

> *"An acid wash is defined as the application of acid under low pressure and will be used primarily to clean the near wellbore environment to remove damage from drilling activities. This activity will precede any further acid squeeze.*
>
> *Acid squeeze is defined as the application of acid under pressure that does not exceed the fracture pressure of the formation. The pressure that the acid can be applied at, so that it does not exceed the fracture pressure of the formation will be established by pressure testing during drilling operations. The acid squeeze is designed to clean the natural pores and fractures of the near wellbore environment (i.e. 1m radius from the well) which may have been damaged by drilling operations. Depending on the extent of existing fractures within each formation acid may pass beyond 1m radius of the borehole, but will be recovered as production water when pumped back to the surface."*

55. The definition (and need for) an acid wash is not in contention, because it is routinely used in conventional production. However, the definition given above of an acid squeeze states that it is merely a further cleaning process in the near-wellbore environment of a formation "*which may have been damaged by drilling operations*". No improvement of the intrinsic permeability of the formation is implied.

56. The so-called 'acid squeeze', as defined above, is identical to matrix acidisation, which, according to PetroWiki[19], has two distinct purposes; (1) to remove damage, and (2) to enhance productivity. The mechanisms used for these two purposes are the same, and what they have in common is that the pumping pressure is below the fracture strength of the rock. According to the PetroWiki account they can be differentiated because the latter procedure requires a "*large volume of acid*" to "*improve*" the formation permeability, whereas, in contrast, acidising to remove damage, which is the stated purpose of the acidising in the present application, merely "*restores*" permeability. So the volume of acid, allied to some extent with its rate of injection, is the crucial criterion.

57. The EA "*does consider matrix acidisation to be a form of stimulation. Matrix acidisation does treat the geological formation, with the aim of stimulating flow in the oil and/ or gas reservoir.*" The volume of acid used is of potential environmental concern, because hydrochloric acid (HCl) is known to attack the cement sheath between well casing and rock, and degrade it (see for example Aghajafari et al. 2016)[20].

58. A PetroWiki article[21] shows the linear relationship (a straight line) between the pumping pressure of the fluid being injected and the rate of acidising injection. The hydrostatic pressure, or 'normal' pressure, is the pressure due to an equivalent column of slightly saline water. The zone of interest along this line runs from the normal pressure up to the fracturing pressure.

59. At the typical depth of interest, the Kimmeridgian micrites are about 1000 m deep, and the hydrostatic pressure is approximately 1500 psi. The formation pressure, also known as pore pressure, is often somewhat higher than hydrostatic pressure. The drilling mud used will have been designed with a density to balance the formation pressure; however, this rule only applies to

[19] http://petrowiki.org/Matrix_acidizing#Acidizing_to_remove_damage

[20] https://www.sciencedirect.com/science/article/pii/S240565611630030X

[21] http://petrowiki.org/Matrix_acidizing

permeable formations, so that in drilling the Kimmeridge Clay Formation a drilling mud of little more than hydrostatic density will suffice. It follows that the pressure required for an acid wash, to clean out around the drill string and hole, will be of around the same magnitude as the mud pressure used to drill the hole. This implies that the acidising injection rate lies towards the origin (bottom left-hand corner) of the line.

60. The zone of matrix acidisation lies further up the injection rate line, but in practice this may overlap with the acid wash zone. Now if the Complainant's use of matrix acidisation going to be merely for cleaning up damage, and not for enhancing permeability (because it claims that the prospect is conventional), how can we differentiate between the two actions? We can further ask, why is there a need for the so-called 'acid squeeze' at all? The only feasible solution to this problem, to ensure that the Applicant does limit its activity to near-wellbore damage repair, is to limit the permitted volume and concentration of HCl to values that will suffice for cleaning.

61. A California Department of Conservation paper (SB 4 well stimulation treatment regulations. Discussion of calculated acid volume threshold, 5 pp., 2014) discusses and defines an Acid Volume Threshold, below which the acid treatment will not be classed as a stimulation. The reason for the paper is stated as follows:

> *"Although Public Resources Code section 3158 expressly identifies acid matrix stimulation as a form of well stimulation treatment, the statute calls for a threshold volume of acid, below which an acid matrix stimulation treatment is not subject to regulation because it does not pose a significant risk."*

62. The basis for the threshold is the volume of rock surrounding the wellbore which is to be treated, together with the rock porosity. Such a threshold is necessary in the UK regulatory framework, because at present there is a contradiction between the EA's understanding of matrix acidisation, which it correctly defines as a form of stimulation, and the Complainant's assertion that its Kimmeridge micrite so-called 'Continuous Oil Deposit' is conventional in nature. We can circumvent this contradiction by defining a threshold volume for acidisation, below which the process may be assumed to be for purposes of wellbore cleaning only , and not for rock formation stimulation.

63. The California paper states:

> *"The amount of acid used in the well can be used as an indication of the design and purpose of the use of acid in the wellbore. Acid used to increase the permeability of the formation must come into contact with the formation and is designed to alter the formation, typically to dissolve constituents in the formation, in order to increase the formation's permeability. Therefore, the amount of acid used is directly related to the area that is anticipated to be altered, i.e. the more acid placed in the well for every treated foot, the larger the area that will be impacted by the acid."*

64. The paper goes on to conclude, based on various research sources, that the radius of formation damage is empirically known to be between 20 and 50 inches, and then conservatively selects 36 inches as the threshold radius. In the UK framework we can assume 1.0 m as an approximate equivalent. For every meter length of wellbore, the void space in the 1 m radius from the well is simply πr^2 x ϕ, where r is the radius (= 1 m, measured outwards from the hole) and ϕ is the porosity, minus the volume of the wellbore itself. The porosity ϕ of the Kimmeridgian micrites is 0.1 (and often less). Assuming a borehole diameter of 8-1/2 inches and a porosity ϕ of 0.1 yields an acid threshold volume of 0.35 cu. m per linear metre, so for a 30 m thick micrite the threshold acid volume will be 10.5 cu. m.

65. In conclusion, if the so-called 'acid squeeze' is justified at all for well cleaning purposes, the volume of acid used should be limited to what is required to clean the Kimmeridgian micrites, by applying the California paper principles. The volume required should also be limited to the lesser concentration of 7%, which is all that is required for an acid wash. Any greater requirement than that volume and concentration of HCl amounts to a tacit admission that the Complainant is in fact intending matrix acidisation to enhance the existing low natural permeability of the micrites.

66. The NUTECH report of 8 April 2015 on Horse Hill-1 for the Complainant divided the Kimmeridge Clay Formation (KCF) into eight layers; 5 mudstones and three 'limestones' (micrites). The calculated oil in place for the whole KCF amounts to 114.9 MMBO (million barrels of oil), of which 18.7 MMBO lies in the three micrites, i.e. 16%. But all the promotion by the Complainant of its so-called discovery assumes that the entire KCF will be exploitable, not just the three micrites. The report goes on to make comparisons with the Bakken play of North Dakota, amongst others, stating:

> *"From a geological, reservoir engineering and possible future operational perspective, the interbedded naturally fractured carbonate and mudstone reservoirs encountered in the HH-1 are analogous to the Middle Bakken limestone of the Williston Basin".*

67. The Bakken play is a wholly unconventional oil play. The plays in the Permian Basin of western Texas, also referred to, are mixed conventional and unconventional. The Complainant's portfolio page states[22]:

> *"UKOG's portfolio has a good balance of low risk, stable production and conventional development assets, together with higher risk higher reward exploration and tight oil development assets offering further upside potential."*

68. A comprehensive report by Ms Kathryn McWhirter, dated November 2016, on the relationships between acidising and fracking of unconventional resources, notes the following statement by the CEO of the Complainant:

> *"Whether industry chooses to call the acidising process conventional or unconventional, fracking or not fracking, ancient or modern, acidised wells will need to be drilled 'back to back' across the Weald if companies are to exploit their PEDL areas to the full. ''You have to drill a lot of wells close to each other (…) almost back to back so that it becomes like an industrial process,' according to Stephen Sanderson, CEO of UKOG (https://www.youtube.com/watch?v=5zBAD-EJHyk)."*

69. Therefore it is amply clear that the Complainant intends to exploit the full potential of the oil in the whole KCF. This oil is unconventional. But production cannot be achieved by matrix acidisation alone; high volume hydraulic fracturing will be required to access and release the 84% of the potential oil which is trapped in the shale (mudstone) layers of the KCF.

70. The Complainant is thus being disingenuous in claiming that it can achieve its ends simply by drilling and acidising the Kimmeridgian micrites alone. It will need to frack the KCF. It will use the micrites as a mechanically suitable layer, just as has been done with the Bakken, in which horizontal wells will be drilled for fracking, but the fracks (the artificially created fractures) will pass upwards and downwards into the shales. The improper reference to the micrites as 'limestones', and the assertions that economic production can be achieved by acidisation of these alone, are a

[22] http://www.ukogplc.com/page.php?pID=3

smokescreen, to avoid referring in public to the need for fracking. In any case, the quotation (above) by the CEO of the Complainant implies that the Wealden countryside is going to become industrialised, whatever techniques of stimulation are employed.

9. TECHNICAL INCOMPETENCE, EVASIONS, OMISSIONS AND BREACHES BY THE COMPLAINANT

9.1. Horse Hill

71. PEDL137 was awarded to Magellan Petroleum in the 12th onshore licensing round in 2004. A planning application to drill Horse Hill-1 was submitted Surrey County Council (SCC; Mineral and Waste Application RE10/2089) in 2010. Planning permission to drill was granted by on 16 January 2012 following a favourable Officer Report dated 9 November 2011. The Officer Report summarised the geology behind the proposal as follows:

> "*The Horse Hill Prospect has been identified through seismic survey and interpretation of the drilling from Collendean Farm 1. Drilling would target the Portland Sandstone, Corallian Beds in the Jurassic Formation and the deeper Triassic Formation, which has a predicted top of formation at 7,300 ft True Vertical Depth Sub Sea (TVDSS). It is proposed to drill to a total depth of 7,483 TVDSS. The applicant has stated that the Portland Sandstone and Corallian Beds have been shown elsewhere as productive in relation to oil and that gas flows have been recorded from the upper Triassic Formation*".
>
> and:
>
> "*The current application involves the drilling of a well to potential target areas: the Portland and Corallian sandstones which the applicant expects to be oil bearing at this location and the Triassic which the applicant expects to be gas bearing*".
>
> and
>
> "*The applicant does propose a deviated well to access three target areas: The Portland, the Corallian and the Triassic at approximately 499 m, 1143 m and 2143 m depth respectively. The initial geological target, the Portland Target, is relatively shallow and therefore the well deviation would not begin until close to the base of the Portland Sandstone at approximately 671 m. From that point the borehole would build angle, but to minimise the chance of difficulties with the wellbore, the build rate is programmed not to exceed 3.0° per 30.5 m up to a maximum angle of 22.6°*"*.*

72. None of the planning documents mention unconventional exploration, nor is the Kimmeridge Clay Formation mentioned. However, there were no particular conditions attached to the planning permit in regard to drilling to the targets specified above.

73. I published a blog article[23] in August 2017 analysing the Horse Hill-1 'discovery' by the Complainant, drilled in PEDL137. It was accompanied by a more detailed technical analysis[24] published on my website. The blog article was republished on Drill or Drop[25], leading to an attempt by an anonymous

[23] http://www.davidsmythe.org/frackland/?p=398

[24] http://www.davidsmythe.org/fracking/Smythe%20Horse%20Hill%20analysis%20v1.1.pdf

[25] https://drillordrop.com/2017/08/29/guest-post-by-david-smythe-the-geology-and-oil-potential-of-horse-hill/#comments

commentator to criticise it, based on his or her alleged experience as a drilling engineer. I responded[26] to this critique, showing that only two minor points out of the 31 points of criticism might be considered valid. My response also enabled me to expand further on the anomalous results from Horse Hill-1. Here follows a modified summary of these articles.

74. For nearly five years the press and the penny-investor bulletin boards had been excited by the alleged finding of a potential oilfield in the Weald Basin, bigger than the North Sea in oil content, below Surrey, Sussex, Kent and Hampshire. It started with the oil flow testing results reported from Horse Hill-1 (HH-1) - the so-called Gatwick Gusher - drilled by the Complainant in the summer of 2014.

75. What is surprising is that the 'discovery' implies that the traditional oil majors, including BP, Amoco, Shell, Texaco and Conoco, somehow collectively failed to find this gigantic Weald reserve during their exploration of the Weald in the 1980s. As Euan Mearns[27], an experienced oil industry observer, put it in early 2016 "*How could we Brits be so dumb as to miss 100 billion barrels just waiting to be pumped from under the home counties?*". Furthermore, this was during an era of high oil prices: $60 to $120 per barrel (adjusted for inflation) between 1980 and 1986.

76. The majors drilled right through the Kimmeridgian many times; they tested it; they had the long-reach horizontal drilling technology (witness BP's Wytch Farm development in Dorset and out under Bournemouth Bay - the biggest onshore oil field in Europe); so why did they all miss the oil? It seems to have been left to a small investment group (the Complainant), plus a few related minor hydrocarbon exploration companies, to unearth this alleged bonanza.

77. The Complainant had interpreted the geology as comprising a higher-standing block called a horst, bounded to the north and south by faults. It also said that the old BP well Collendean Farm-1 (CF-1), dating from 1964, lay off the edge of the horst block. BP had drilled in the wrong place, according to the Complainant. HH-1 was planned to be drilled into the horst block. The Top Portland Sandstone was predicted to be about 100 m shallower here than at CF-1. But it turned out to be 18 m deeper.

78. After the results of HH-1 were available the Complainant made the fundamental mistake of retaining the prior fault pattern instead of discarding it and re-mapping the geology from scratch. The Complainant bodged up a re-interpretation, while retaining two faults running ESE from CF-1. But the more southerly of these now has an alternating sense of displacement (the downthrow), which is geologically untenable except in certain geological terrains which do not apply in the Weald. Going from west to east, the fault downthrows to the south, then to the north, then back to the south again.

79. I re-examined the seismic data to see where the faults lie. There is a southerly Horse Hill Fault running E-W about 60 m north of HH-1, but dying out to the west. The crucial evidence comes from a vintage 1962 seismic line very near HH-1 which the Complainant had omitted from its database. It is of poor quality, but does the job required of positioning the faults.

80. CF-1 lies just south of what I call the Collendean Farm Fault. BP did not drill on the 'wrong' side of the fault, as wrongly claimed by the Complainant. There is in fact unfaulted geological continuity from CF-1, traced on seismic data round the western termination of the Horse Hill Fault, then back

[26] http://www.davidsmythe.org/frackland/?p=435

[27]http://euanmearns.com/the-gatwick-gusher/

east to HH-1. The seismic continuity of the nearly flat layers west of HH-1 fits perfectly with the fact that HH-1 is deeper than CF-1 by 18 m.

81. So the two re-interpreted faults of my remapping are parallel and distinct; they run ENE-WSW, following the regional pattern. Despite its shambolic re-interpretation, the Complainant has indeed made a minor discovery of conventional oil in the Portland Sandstone, but it will need to re-map the geological structure from scratch, to then explain to its investors whether or not this is worth exploiting commercially.

82. What of the huge Kimmeridge 'discovery'? The Complainant leans on calculations made for it by Schlumberger, an oil service company, which estimated that in the whole Kimmeridge Clay Formation there was 176 million barrels of oil in place per square mile, by extrapolation from the HH-1 flow results. The Complainant further declared initially that this oil would be exploitable over the whole licence block by a curious concept of multiple deviated wells from each pad, following an unusual concept which I recognised had been borrowed from the Jonah oil field of Wyoming; however, the Complainant later changed its exploitation concept to a more commonly used one involving multiple stacked lateral wells. The radically changing concepts over a few months demonstrate a flimsy grasp of the technology by the Complainant.

83. As for the supposed huge reserve of KCF oil below the Weald; the oil in place has been estimated by Schlumberger on a per square mile basis. But how much area of a fractured fault zone can actually be drained from this single well? In addition, one certainly cannot extrapolate the anomalous fault zone flow results from HH-1 to the Weald generally. Using Schlumberger's figure above, and a produceable reserve from the fractured tight KCF formation of 1% of the oil in place, HH-1 might be able, optimistically, to produce 177,000 barrels from the fault zone. In other words it might make enough to recover the costs of its exploration and development. This sort of figure might also be applicable along this and other fault zones.

84. Oil production from Horse Hill is running at about 200-250 bbl per day, which comes from the Portland, not from the the KCF. This is a respectable result for a very minor oil field. However, these results prove that the Complainant has grossly exaggerated its estimates for the Kimmeridge.

85. In conclusion, the Horse Hill-1 results are anomalous because the Complainant drilled a fault zone. It is irresponsible and misleading to apply those local flow results to the wider geology outside of that and other similar fault zones, i.e in the 95% or more of the KCF which is not affected by a fault zone. There will be no KCF bonanza in the Weald - unless the countryside is indeed industrialised to permit wholesale fracking of horizontal wells throughout the region, with a 1-3 km well pad spacing similar to, say, NE Pennsylvania, or to the Bakken shale play of North Dakota.

86. The Complainant has never challenged my geological analysis of Horse Hill, preferring instead to fall back on character assassination (section 4 above). I conclude that its geological understanding is technically deficient, and, furthermore, it is failing in its fiduciary duty to keep its investors properly informed.

9.2. Broadford Bridge

87. The Complainant drilled the Broadford Bridge-1 well in 2017, followed by a side-track 1z well, in its PEDL234 licence block. These wells reveal two deficiencies in the Complainant; firstly, its breach of planning permissions, and secondly, its further technical incompetence. I submitted a consultation

response[28] to the Environment Agency in April 2017 regarding the EA permit, before the drilling started, and followed it up with a note[29] to West Sussex County Council in August 2017. In December 2017 I published a blog article[30] about the results of the drilling. What follows is a summary and update of these documents.

88. The Complainant holds the PEDL234 licence inherited from Celtique Energie Weald Limited in 2016. The Complainant claimed that it had also thereby inherited permission to drill and test the Broadford Bridge-1 well, and was seeking a Variation to the Waste Management Permit previously issued to Celtique by the EA.

89. The Complainant further asserted that the drilling operation would be conventional in nature. This is untrue, because the tight micrites to be targeted require stimulation to make any oil flow.

90. Celtique Energie had 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. The proposed site was 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. 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.

91. The Complainant claimed, in a letter addressed to Mr Nick Herbert MP dated 28 May 2017, that it had all the necessary permissions in place from the four relevant authorities. This assertion is misleading and untrue. The permit awarded by West Sussex County Council to Celtique Energie on 11 February 2013 stated as follows:

> *"... they PERMIT the following development, that is to say :-*
>
> *The siting and development of a temporary borehole, well site compound and access road including all ancillary infrastructure and equipment, on land at Wood Barn Farm, Broadford Bridge, for the* ***exploration, testing and evaluation of hydrocarbons in the willow prospect****. At Wood Barn Farm, Adversane Lane, Broadford Bridge, Billingshurst, West Sussex"* [my highlighting].

92. But the Complainant did not target or drill to the structure (the 'Willow Prospect', as above) for which consent was granted; it drilled from the same pad in an entirely different direction. This is a clear breach of the consent.

93. The target rocks (Kimmeridge Clay Formation; KCF) are completely different, and the end point of the UKOG drillhole is 1500 m shallower vertically and about 1000 m away horizontally from Celtique's approved end point. Furthermore, in Celtique's application documents the only mention made of the KCF was in drilling through it, to specify that the drill casing of a certain size would be cemented into the hole to isolate the KCF. There was no suggestion anywhere that the shales (Kimmeridge and Lias, with their limestone layers) might be an alternative target.

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[28] http://www.davidsmythe.org/fracking/Smythe%20EA%20consultation%20submission%20v1.1.pdf

[29] http://www.davidsmythe.org/fracking/Smythe%20WSCC%20objection%20to%20amendment%20by%20KOGL%20v1.0.pdf

[30] http://www.davidsmythe.org/frackland/?p=468

94. The use of the existing drill pad (at Wood Barn Farm) for the target drilled by the Complainant negates the validity of the Alternative Sites Assessment carried out by Celtique, which should have been a proper part of planning consent. More suitable drilling locations for KCF oil prospecting are to be found to the north of the PEDL234 licence block, west and north of Horsham, and not in the very south where the pad is situated.

95. The Complainant has tried to hide behind the now-defunct plans of Celtique Energie for a conventional exploration drilling programme, when in fact its exploration is for unconventional extraction. 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.

96. In contrast to Celtique's well-defined conventional target, the Complainant's target, the KCF, is found below the whole of the licence area. There is no geological requirement nor 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.

97. Given that the KCF, 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 test stages would require acidisation, a form of stimulation, to incease the oil flow

98. The Complainant 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.

99. The Complainant misconstrued its well prognosis plan, submitting to the EA and WSCC merely an annotated version of Celtique Energie's plan. The well plan is therefore internally inconsistent, in that it does not take into account the different geology to be encountered by the new wellbore.

100. The Complainant proposed to drill a highly deviated well northwards from the pad, with no seismic control. This was irresponsible, since it would have a poor grasp of the geology it would encounter along the wellbore. My prediction that it would encounter severe geological problems, due at least in part to the lack of proper seismic control, turned out to be correct.

101. After the drilling of the main well and its sidetrack, the Complainant reported its results in a curious manner. Firstly, it claimed that it had now identified a "*Continuous Oil Deposit*" (COD), which it claims underlies the entire Weald. It interpolates the results from the two wellpads, Horse Hill and Broadford Bridge, drilled some 27 km apart, to postulate its COD. 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.

102. I have tried to make sense of the drilling progress figures issued by the Complainant, over the last few months of its activity at Broadford Bridge. They are very confusing and seemingly contradictory. 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.

103. The original well Broadford Bridge-1 (BB-1) encountered problems when drilling through the Broadford Bridge Fault. 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, the Complainant 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.*"

104. The 'plugging' referred to above means drilling mud getting into fractures and clogging them up, thereby reducing flow. This is, in my view, is more evidence of the incompetence of the Complainant. Ironically, had the Complainant 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.

105. The difference between the different numbers of micrite layers recognised within the KCF is partly one of interpretation. The Complainant sees four micrites, not three, not only in the Balcombe-1 log, but also elsewhere, over the entire Weald. How far is one prepared to stretch the definition of micrite, especially when the Complainant then proceeds to label them as limestone?

106. The target of interest to the Complainant at Broadford Bridge is the sequence of four so-called limestones within the KCF, numbered KL-1 to KL-4, from the bottom up (KL being Kimmeridge Limestone), embedded in shale. Further confusion arises in the numbering scheme because the Complainant has previously identified the uppermost two micrites as KC Lst 1 and 2, respectively, counting from the top down.

107. The Complainant claims that four discrete limestone layers are found within the KCF right across the Weald Basin from north to south. It illustrates this with a 'fence' diagram (a grid of lines connecting geological layers across a series of wells).

108. The British Geological Survey (BGS) study of the Jurassic shales of the Weald Basin[31], dated May 2014, and carried out for the Oil and Gas Authority, includes a comprehensive set of such fence diagrams, linking 63 wells hung along six separate fences. Each well is portrayed as a geological column 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. In contrast to the Complainant, the BGS recognises only two micrites over the whole basin (the thickest and uppermost two of the Complainant'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 its geological columns in light blue, the conventional colour used for limestones, and sensibly uses lime green instead.

109. Not content with seeing four micrites over the entire Weald, the Complainant has now identified a fifth so-called Kimmeridge Limestone at Broadford Bridge. Its understanding of the geology seems now as remote from reality as an Enid Blyton children's adventure story. I have tried to analyse what is actually going on in the geology, as identified by BB-1 and its sidetrack BB-1z.

[31] https://www.gov.uk/government/publications/bgs-weald-basin-jurassic-shale-reports

110. 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 the Complainant that there is a fifth micrite. I have assumed flat layering, and have inserted four micrite layers using the proportions taken from the nearby Wineham-1 well. The appearance of a fifth micrite, as claimed by the Complainant, 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 SW of where BB-1 hits the top of the KCF. I have shown the fault as vertical, but it could dip to the 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, it goes through the Complainant's KL-4 micrite twice. This accounts for the total of five micrites. There must be either folding or faulting to account for the depth figures quoted by the Complainant. However, if there are errors in these figures, or else an entirely different solution exists, then I look forward to learning of it. To date the Complainant has not responded to my explanation.

111. The RNS announcement[32] of 15 November 2017 on the initial tests carried out on KL-1 stated that:

> *"Although these two KL1 zones are hydrocarbon bearing, the Company concludes that sustained commercial flow rates from the shale dominated KL1 could likely only be obtained via reservoir stimulation beyond the scope of its existing regulatory permissions."*

112. This is tantamount to admitting that fracking would be needed. The Complainant went on to promise that testing would move upwards into the KL-2 - KL-5 zones. It finally reported[33] on 20 February 2018 that testing of KL-3 and KL-4 produced "*no sustained flow*". It added that the current test of KL-5 "*straddles a discrete naturally fractured limestone interval close to the top of KL4*". This seems to corroborate my view that KL-5 is merely a repeat of KL-4, but on the south (hanging wall) side of the fault zone.

113. According to the RNS update[34] of 29 March 2018:

> *"A* [sic] *further BB-1z sidetrack and/or alternate completion and reservoir stimulation techniques are under consideration to help deliver higher sustainable rates and possible future commerciality at BB-1/1z. A further BB-1z sidetrack and/or alternate completion and reservoir stimulation techniques are under consideration to help deliver higher sustainable rates and possible future commerciality at BB-1/1z."*

114. Work stopped in March 2018 and the well was suspended. In July 2020 a third time extension was granted by the MPA for two more years, during which UKOG said it would not carry out any new work, but would compare the Broadford Bridge results with its other sites in Surrey.

115. Any future efforts will be doomed to failure unless the Complainant gains a proper understanding of the geology. In doing so it will need to address my technical criticisms and re-interpretations, instead of resorting to *ad hominem* attacks.

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[32] http://irpages2.equitystory.com/websites/rns_news/English/1100/news-tool---rns---eqs-group.html?article=26702149&company=ukog

[33] http://irpages2.equitystory.com/websites/rns_news/English/1100/news-tool---rns---eqs-group.html?article=27088001&company=ukog

[34] http://www.lse.co.uk/share-regulatory-news.asp?shareprice=UKOG&ArticleCode=450tur86&ArticleHeadline=Update__Broadford_Bridge1

116. In conclusion, the so-called Continuous Oil Deposit (COD) of the Weald Basin Upper Jurassic is just CODswallop. The drilling history of the Complainant at Broadford Bridge shows that it operates in a technically incompetent manner, with mendacious reporting.

9.3. Leith Hill

117. The Complainant has a 67.5% interest in PEDL143, wherein lies the Holmwood prospect, and has taken over operatorship from Europa Oil & Gas Limited. Although the Complainant was not the operator, it nevertheless has a fiduciary duty to its shareholders to take an active part in, and to correct if when necessary, the technical failings of the previous operator. I submitted a consultation response in April 2018 to the Environment Agency, pointing out that the operator's application for a permit has the following serious weaknesses and problems which needed to be addressed:

1. Use of out-of-date geological mapping information.
2. Problems of shallow faulting from old and new BGS information not considered or reconciled.
3. Poor understanding of shallow geological structure of the Hythe Formation principal aquifer below the wellsite, leading to misleading conclusions on groundwater flow directions.
4. Proven hydraulic continuity *via* Lower Greensand formations and unconsolidated deposits from the wellsite to public supply wells at Dorking.
5. Shallow geological structure includes poorly-understood faulting, with a thrust fault near the wellsite.
6. Conductor casing too short and does not penetrate into the Weald Clay.
7. Hastings Beds cut by a fault in vicinity of the wellbore.
8. Insufficient seismic reflection information properly to define the faulting and target structures.
9. Lack of evidence presented to justify geological structures.
10. Lack of justification for seismic ties to existing wells.
11. No evidence presented for time to depth conversion of the seismic data.
12. Two promised seismic reflection lines never obtained.
13. Equidimensional and complex faulted nature of the target structures necessitates a 3D seismic survey for accurate characterisation.
14. Redesigned wellbore at the very limit of technical capacity, with no leeway for manoeuvre.
15. Likelihood of cement bond failure along wellbore at shallow angle.
16. Unconventional (tight, low permeability) target micrites added to the work programme at a late stage despite claim that prospects are conventional.
17. Confusion between acid wash to clear borehole and stimulation of unconventional formations to enhance flow.

118. The information supplied by the Applicant for the permit (the operator of the Holmwood-1 site) was incomplete and misleading. The problems summarised above lead to the inescapable conclusion that the Applicant had a poor understanding of the geology, and of the technical problems that it was likely to encounter in drilling. In turn, its understanding of the hydrogeology was seriously defective. In consequence there was a serious risk that the drinking water aquifers in the district might be contaminated by the Applicant's proposed activities, both in the short term and in the long term. However, the EA refused to consider the risk to the Dorking public water

boreholes, falling back on the supposed adequacy of Europa's plans to "*mitigate the risk*", despite its evidently inadequate and out-of-date geological interpretation.

119. The EA also failed to see that the proposed conductor casing was too short, at 50 m, to protect the Hythe Formation and the underlying Atherfield Formation, simply reiterating that it was:

> "*satisfied with the proposals to install the conductor casing into the top of the Weald Clay, at approximately 50 m true vertical depth*".

120. Other issues were not adequately taken into account by the EA. In conclusion, the EA's understanding of the geology, based upon what was presented to it in my consultation submission, is severely limited.

121. The Complainant should bear a share of responsibility for the deficiencies in the application for an EA permit by its partner at Leith Hill. Had the drilling proceeded, it is probable that the same severe technical problems would have arisen as at Broadford Bridge (see Section 9.2 above), due to the very shallow angle of the deviated well when transecting faults. Such a possibility was also ignored by the EA. However, the lease of the Bury Hill well pad expired in September 2018 and was not be renewed, so Europa closed the site, and in March 2019 transferred the operatorship of PEDL143 to UKOG.

9.4. The Complainant's licence on the Isle of Wight

122. An additional licence of interest is PEDL331 on the Isle of Wight, operated by the Complainant, with a 95% beneficiary interest. This licence has two features; firstly, it illustrates how the Complainant talks up its data on an apparently conventional prospect, and secondly, what it tells us about the Kimmeridge Clay Formation, the target in the Weald Basin.

123. There are two existing wells within PEDL331. Arreton-1 was drilled by Darcy Exploration Company Ltd (later to become BP) in 1952. Nearby Arreton-2 was drilled by Gas Council Exploration Ltd. (later to become British Gas) in March 1974. The composite log header, which can be viewed on the UKOGL website[35], labels its status as 'dry and abandoned'. I studied this area a decade ago as a consultant for the previous licensee. We had a team of four consulting earth scientists, all highly experienced, with myself as the geophysicist in charge of the seismic reflection data. We identified in passing an elongate structural high below the Arreton well locations, but dismissed the Portland Limestone as a prospect, because (I believe from memory) it was too tight (low permeability), although it had oil shows. DECC described the wells thus in 2010:

> *"The Upper Jurassic Portland Beds are largely represented by limestones in the Wessex-Channel Basin. They have minor shows in the Arreton wells on the Isle of Wight."*

124. But now the Complainant has re-analysed the 30- and 40-year old data and announced that it has a "*discovery*". It has come up with optimistic estimates of oil in place and 'prospective resources'. No mention is made of the unconventional nature of the oil in the 'limestone' - i.e. that it was found in the wells, but did not flow. This is an abuse of the process of technical appraisal.

[35] https://ukogl.org.uk/map/php/images.php?subfolder=wells\compositeLogHeader&filename=1905-clh.jpg

125. Secondly, the logs of the Kimmeridge Clay Formation below the Portland in Arreton-2 display the characteristic pattern of the two micrites, as mapped by the BGS over the Weald area. However, the composite log lithology for the upper layer is marked merely as a marl, whereas the lower layer is marked by three limestone bands of between 3 and 4 feet in thickness, within shale and subsidiary marl, over the 70 feet thickness of this layer. This lithological interpretation corresponds in general to the layers seen at outcrop in Kimmeridge Bay, Dorset, photographed in the detailed online field guide[36] by Dr Ian West. The offshore well 98/13-1, drilled in 1991 just west of the Isle of Wight in Freshwater Bay, confirms this picture, although the lower layer in question is marked with a mixed symbol depicting argillaceous dolomitic limestone over an interval of about 38 feet. In conclusion, there is no justification for calling these micrite layers (an informal industry term for argillaceous tight limestone or calcareous shale) 'limestone'.

126. The Arreton-2 well was drilled at a time when the oil price was between $8 and $18 (years 1974-1978), which, after adjusting for inflation, is equivalent today to a range of $40-60[37]. So the fact that the price at the time of drilling or shortly after is comparable to recent prices (up to 2019) suggests that it was not economics that led the operator in that era to classify and abandon the well as 'dry'. I presume that the techniques (horizontal drilling and fracking) for exploiting an unconventional reservoir such as the Portland Limestone were either not available at that time, or else were uneconomic.

127. The Complainant has submitted an application to drill at Arreton. It contains numerous inconsistencies regarding whether the directional drilling is towards the SW or to the SE. There may have been a change of strategy during the application process, because certain diagrams were never updated and are inconsistent with others. The geology is far less certain than implied by the Applicant's cross-sections, and the 2D seismic coverage on which it is based is rather sparse and out-of-date. The complex Purbeck – Isle of Wight Fault zone runs E-W just to the north of the proposal. Accommodation faults splaying off this main structure are present, but hard to map. Drilling a well which is deviated from the vertical to the horizontal frequently leads to problems in cementing the gap between the production casing (a hollow steel tube) and the rockface of the hole, so that well integrity is compromised. Failure of well integrity may in the long term lead to leakage and contamination of the primary aquifer at the surface. The splay faults, unrecognised by the Complainant, may also connect the new wellbores to the Arreton-1 and -2 wells, which are now 68 and 46 years old, respectively, and which may have suffered loss of integrity through rusting of the casings. Drilling new wells near to these old wells constitutes a further environmental risk. I have submitted (31 July 2020) a formal objection to the proposal, detailing these technical failings.

128. In conclusion, the Complainant misleads (by omission) in not declaring that the Arreton so-called 'discovery' will require unconventional methods to be exploited. It is also likely to encounter the same serious technical problems as it found in the Weald.

9.5. The Newdigate earthquake swarm

129. The OGA hosted a one-day seismicity workshop on 3 October 2018 to investigate the Newdigate earthquake swarm in Surrey. The area is cut by normal faults with displacements of the order of tens to hundreds of metres. There has been no active tectonism in the region since the mid-

[36] http://www.southampton.ac.uk/~imw/Kimmeridge-Bay.htm

[37] https://inflationdata.com/articles/charts/inflation-adjusted-oil-prices-chart/

Miocene uplift and tectonism related to Alpine compressional events. The swarm had abruptly started on 1 April 2018, as felt events causing visible damage, after centuries of aseismicity in the area. The invited attendees included four BGS scientists, five academics, eight government employees, three industry representatives including the Complainant, plus a representative from the MPA, Surrey County Council. The OGA report of the workshop concluded[38] that:

> "*based on the evidence presented, there was no causal link between the seismic events and oil and gas activity although one participant was less certain and felt that this could only be concluded on 'the balance of probabilities' and would have liked to see more data on nearby oil and gas surface activity over the past two years …*".

130. The Officer Report for the SCC planning meeting of 11 September 2019, recommending approval of the development, failed to address various problems, including the possible link of drilling to the new earthquake activity, the proximity to a fault, the use of acidisation to stimulate the KCF, and the many errors in the scanty cartoon-standard geological interpretations by UKOG. At the planning council meeting which approved the development, the deputy planning development manager assured councillors that the county council was obliged to rely on the finding of the OGA that the earthquakes were "natural" (not human-induced).

131. The OGA report discounted the hypothesis presented by Edinburgh University researchers[39] that surface operations at Horse Hill may have had an almost immediate physical effect in the subsurface, namely, the release of the wellhead pressure by opening of a valve on, or just prior to, the first earthquake of 1 April 2018. According to the operator, the HSE holds records of all well integrity tests carried out between 2016 and 2018, spanning the period when the earthquake swarm began. But the HSE has denied holding these documents.

132. The documentation, or logs, of activity and operations at the Horse Hill well pad during 2018 should have been made available to allay the suspicion of cause and effect postulated by the Edinburgh researchers. The fact that UKOG has chosen to keep them secret increases the suspicion that either they do not exist, or else that they would prove that the relevant valve was indeed opened to release the build-up of wellhead pressure over the previous two years, *before* the first earthquakes of 1 April 2018.

133. Instead of being transparent about its actions at Horse Hill before and during the period of earthquake activity, the Complainant threatened the senior Edinburgh University researcher with legal action, should the University proceed with publication of its hypothesis. However, the hypothesis, which I consider to be perfectly reasonable, and backed up by a detailed analysis[38], has been published, in the form of its initial presentation to the OGA by the OGA itself. In my view the legal threat by the Complainant is not only futile, because the hypothesis is already in the public domain, but it tends to confirm that the Complainant has something to hide. The release of the aforesaid documents could dispel this suspicion, and at the same time refute the cause-effect hypothesis of well depressurisation proposed by Edinburgh.

[38] https://www.ogauthority.co.uk/media/5174/2018_11_23-newdigate-workshop-summary-finalv3.pdf

[39] https://editor.ogauthority.co.uk/media/5173/10-weald-basin-earthquakes-induced-oga-workshop-haszeldine-cavanagh-oct-2018-low-res.pdf

10. WIDER ISSUES

10.1. Cuadrilla at Balcombe

134. Cuadrilla Balcombe Ltd stated in its planning application documents, dated January 2010 (Appendix C. The Drilling Operation):

> *"Both the porosity and permeability within the Lower Stumble structure are considered to be poor to good but the natural fractures are expected to be good to very good ie the wells should flow unstimulated.*
>
> *....*
>
> *There may be a need to stimulate a stage which flows gas/oil but at a low rate to ascertain if the gas was being held back by poor porosity or permeability or lack of natural fracture or a combination of all three. Stimulation is carried out by pumping water under pressure into the natural fractures in the shale formations to open them up to allow the gas to flow more freely. In some cases silicone* [sic] *sand is then pumped in to hold open the fractures once the water is removed."*

135. This is a clear reference to contingent fracking. However, Cuadrilla later said (January 2014) that its plans would exclude hydraulic fracturing.

10.2. Economics

136. Mr Stephen Sanderson, CEO of the Complainant, has stated (see section 4 above) that I am not an "*expert in oil and gas project economics*", about which I have made "*multiple unsubstantiated assertions*". This statement is incorrect, because I have never sought to discuss individual hydrocarbon project economics. I have, however, been following the general economics and financing of unconventional hydrocarbon exploitation in the USA, and have realised that in that country it has been a giant Ponzi scheme.

137. I have followed industry commentators such as Art Berman[40] (a highly experienced geologist and analyst of the US industry), and read business articles in the *Wall Street Journal*[41], Bloomberg[42], and similar serious sources. I also follow statewide sources such as MarcellusGas.org[43], which provide useful data on drilling progress, lease costs, etc. (that example being for the Marcellus Shale of Pennsylvania). My only original contribution to this discussion has been to collate official figures for overall US gas revenues and costs for the period of the shale gas bubble, which are as follows:

[40] http://www.artberman.com/

[41] https://www.wsj.com/europe

[42] https://www.bloomberg.com/europe

[43] https://www.marcellusgas.org/

US gas wells: 2007- 2016 inclusive

Description	$billion	Source
Historic income (gas sales)	324	1
Drilling/completion cost	[368]	2
Royalties, leases, interest etc.	[74]	3
Issuance of debt - junk bonds	[227]	4

138. Costs are given in square brackets. The sources of the information are:

1: EIA monthly averages of Henry Hub price × volume;

2: 46,000 wells @ $8M each (range $6M-$10M);

3: Assume 20% of the drilling cost;

4: Thomson-Reuters + Bloomberg, 2010 to Q3 2017 – assume 50/50 gas/oil split of $455B debt

139. There is no great economic skill or experience required in producing these figures, merely access to the appropriate information, plus some arithmetic. An additional *proviso* is to recognise that most of the wells were over five years old at the end of the survey period. They have a severe decline rate, meaning that most of the production occurs in the first eighteen months or two years of the well's life, and that they are effectively dead after between five and eight years. So the raw gas income quoted above is nearly the total income that the wells will ever provide. In round terms, the table above shows that the cost of producing the gas has been about double the historic income produced.

140. I have not yet carried out a similar calculation for US unconventional oil wells, because in some plays such as the Permian Basin it is difficult to separate the conventional from the unconventional. However, I have no reason to believe that the economics of unconventional oil in the US are fundamentally different for those of gas. The Permian Basin oil production is now in severe decline.

141. UK Onshore Oil and Gas (UKOOG) represents the onshore oil and gas industry. The Complainant is a member of UKOOG. On fracking of tight formations, UKOOG states[44], under heading 4 - Production:

> *"This initial three- to five-month investment has the potential to deliver a well that will produce oil or natural gas for 20 to 40 years, or more".*

142. This statement has remained essentially unaltered in its website since at least before October 2013, when it was stating:

> *"This initial three- to five-month investment could, however, result in a well that will produce oil or natural gas for 20 to 40 years, or more."*

[44] http://www.ukoog.org.uk/onshore-extraction/drilling-process

143. Such statements are seriously misleading, both for potential investors in the industry and for the general public.

144. My views on the faulty economics of the US unconventional hydrocarbon industry are supported by, for example, the SRSrocco Report[45], as well as by the sources cited above. Naturally, expert commentators like Art Berman, cited above, take a more nuanced view, highlighting, for example, that there do exist certain 'sweet spots' or localities such as parts of the Permian Basin, where the break-even price may be surpassed (i.e. the unconventional prospect may be profitable). However, his overall view of shale is summarised in the statement on his home page:

> *"Shale is not a revolution–it's a retirement party. Shale plays were not some great new idea. They became important only as more attractive plays were exhausted".*

10.3. Likely UK economics of shale production

145. UKOOG has admitted that UK shale costs may be two or even three times higher than those in the USA. Given that US unconventionals are overwhelmingly loss-making, it is therefore difficult to see how an indigenous UK industry can ever be profitable. This negative view of the nascent industry has been corroborated and quantified by a study[46] by University of Manchester researchers for the case of shale gas. It is worth quoting their highlighted summary points, as follows:

- UK shale gas is 2 times more expensive than LNG and 3 times more than US shale gas.
- Nevertheless, it is still more competitive than most other sources of electricity.
- Shale gas would have little effect on energy prices and consumer bills.
- The contribution to the GDP is small, an order of magnitude lower than in the US.
- The economic success of shale gas in the US may not be replicated in the UK.

146. I have not analysed this paper in detail, but I conclude, from a preliminary study, that some of the numerical values assumed are optimistic; for example the estimated ultimate recovery (EUR) is based on a well lifetime of 30 years, which is far too optimistic, and the estimated costs of drilling, taken from US data only up to 2007, seem to be very low.

147. There are no compelling economic arguments for developing unconventional fossil fuels in the UK; on the contrary, the US financial experience should serve as a warning. An indigenous unconventional fossil fuel (UFF) industry can never be a 'transitional' energy source because it will clearly take too long to develop. The cost of indigenous UFF will be so much higher than in the US that any such industry would require heavy subsidy, and/or penalise the consumer by the application of severe import tariffs, or even import bans.

10.4. Environmental implications

148. The same Manchester researchers mentioned above have also published a paper[47] on the sustainability of a putative UK shale gas industry. The highlighted summary points are as follows:

[45] https://srsroccoreport.com/u-s-shale-oil-industry-swindling-stealing-energy-stay-alive

[46] https://www.research.manchester.ac.uk/portal/files/65318663/Economic_viability_of_UK_shale_gas.pdf

[47] https://www.sciencedirect.com/science/article/pii/S0048969717331984

- Shale gas ranks between the fourth and eighth relative to other electricity options.
- To become the most sustainable option, large improvements would be needed.
- This includes a 329-fold reduction in environmental impacts.
- A 16-fold increase in employment would also be needed.
- An electricity mix with less rather than more shale gas is more sustainable.

149. One of the environmental indicators (which are ranked rather than quantified) studied by the team is the global warming potential. A salutary warning of what is already happening to global temperatures, exacerbated by the onset of the US shale industry, has been made in a non-technical video lecture[48] by Professor Anthony Ingraffea. He and his former team at Cornell University have pointed out the danger to the atmosphere caused by methane leaks from US fracked wells - methane being a far more potent greenhouse gas than CO_2. Ingraffea, a mechanical engineer, is also an expert on the mechanics of leaks from all types of deep wells.

11. CONCLUSIONS

150. I have been asked, if my calculations on the uneconomic nature of US unconventional gas production are valid, how is it that the industry continues? I respond that it continues because it makes a few business persons - those who run the gas companies - very rich. All they need to do is to carry on persuading investors to supply the company with money. This normally takes the form of selling debt - high-risk, or junk bonds - which offer an exceptional dividend. But after the typical six-year term of the bond expires, the company, unable to repay the bonds, either goes into liquidation or 're-structures' its debt, for example by offering shares in place of the bonds. This cycle has now restarted, with the surviving companies offering junk bonds with an up to 15% dividend instead of the previous 6%. In addition, the new drilling activity since 2016 was confined mainly to a few areas like the Permian Basin, but is now once again in serious decline.

151. It is my belief, founded on the evidence supplied above, that the Complainant intends to hydraulically fracture the unconventional tight oil shale sequence known as the Kimmeridge Clay Formation. The Complainant intends to shelter behind the unscientific and faulty government definition of high volume hydraulic fracturing, by keeping the volumes of water required for the process to just under the threshold at which fracking is defined. The Complainant will thereby be able to avoid its obligations such as providing a hydraulic fracture plan; furthermore, it can ignore the minimum 1000 m depth below ground level limit, above which fracking is forbidden.

152. I have produced ample evidence to show that the technical quality of the work carried out by Complainant is deficient. The Complainant appears to be failing in its fiduciary duty to its shareholders by failing to provide true and prompt accounts of its technical progress and results from its several current projects.

153. The Complainant is misleading the public by: providing mendacious accounts of its work plans; avoiding mention of the fact that its Weald exploration is mainly unconventional; mis-using basic geological terms like 'limestone'; avoiding the use of the word 'shale'; avoiding all mention of possible future fracking; and exaggerating the size of its so-called 'discovery' in the Weald.

[48] https://www.youtube.com/watch?v=PGfIjCG-zB4

154. The alleged benefits for the UK of the exploitation of oil resources in the Weald, whether on a large or small scale, are nugatory, and in any case far outweighed by the disbenefits to the world at large from continuing exploitation of fossil fuels and its concomitant effect in contributing to global climatic warming. The Complainant seems to be seeking only private profit for itself and its shareholders; even on that narrow criterion it is evidently failing, as indicated by the current share price.

155. I believe that the facts stated in this witness statement are true.

[Signed by the witness and dated]

DKSmythe

18 September 2020