Planning application no. SDNP/1305896/CM by Celtique Energie to drill at Fernhurst, West Sussex:

Comments upon report to SDNPA by Prof. R. C. Selley

By

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8 August 2014

Introduction

Professor Selley has supplied a report to the SDNPA dated 3 July 2014, in response to a request from the SDNPA dated 24 June 2014 (not 26 June 2014, as he states). I wish to comment on a number of contentious points and factual errors made by Prof. Selley, and note, for the record as well as for consideration by the appropriate Planning Committee, the issues upon which he did not respond, or responded in an incomplete manner.

In separate numbered sections, I quote from the report by Prof. Selley, in which he has first re-stated an extract from the SDNPA letter (upright black text), and then followed it by his response in *blue italics*. These pairs of extracts are indented and placed between quotation marks. My comments are in green.

Summary

Prof. Selley is complacent and uncritical regarding the completeness of the information supplied by the Applicant. He has failed to answer the question about whether the same geology can be found outside the licence area, choosing instead to offer some irrelevant information. He is factually in error regarding the Applicant's targets. He is also inaccurate regarding the nature of the Kimmeridgian limestones, and again has failed to answer a specific question asked of him - whether or not the limestones will require fracking.

1. Horizontal well (Selley pages 1-2)

"A key difference between the two, is that the further information submission amends the application by removing the horizontal drilling element, the reason for this is not clear.

I have asked Celtique's CEO, Mr Geoff Davies, for further clarification on this amendment. He replied that such queries should come direct from the SDNPA. Celtique's website states that they are not pursuing with the application for a horizontal well to save time and money. It is possible that the issue of trespass by underground drilling may have been a further factor in reaching this decision. Until this matter is resolved it might cause further delay in the application being processed and a decision reached. Recent pronouncements by Michael Fallon, the Minister for Energy & Climate Change, suggest that the issue of trespass may be resolved speedily to allow horizontal drilling below a depth of 300m to not require the permission of the landowner."

The SDNPA should therefore ask Celtique directly why the horizontal well was dropped.

2. Consistency, accuracy and level of completeness (Selley page 2)

"As part of the critical review, we would like to understand:

a) The consistency, accuracy and level of completeness of the geological information submitted. Is the information submitted with the application consistent with other sources of geological data/research for the Weald Basin?

The geological information of the application is consistent, accurate and sufficiently complete. In particular it is consistent with the definitive published report on the Weald by:

Andrews IJ 2014. The Jurassic Shales of the Weald Basin: geology and oil & gas resource estimates. British Geological a Survey for the Department of Energy & Climate Change. London 79pp.

Swan, G & Munns J. 2003. The Hydrocarbon Prospectivity of Britain's Onshore Basins. Department of Trade & industry. London. 81pp.

The Fernhurst well must regarded as high risk. The reservoir characteristics of the Kimmeridge limestones are unknown. Furthermore the BGS study suggests that only a small thickness of the Kimmeridge Clay source rock may have been heated sufficiently to generate oil."

The bald assertion by Prof. Selley, unsupported by any evidence or argument, that the geological part of the application is "*consistent, accurate and sufficiently complete*" is totally at variance with my submissions:

- **Smythe, D. K. 2014a**. Planning application no. SDNP/1305896/CM by Celtique Energie to drill at Fernhurst, West Sussex: Critique of environmental statement in the context of relevant geology and hydrogeology. Report and objection to SDNPA, 25 January 2014, 60 pp.
- **Smythe, D. K. 2014b**. Planning application no. SDNP/1305896/CM by Celtique Energie to drill at Fernhurst, West Sussex: Additional comments on environmental statement in the context of relevant geology and hydrogeology. Report and objection to SDNPA, 30 June 2014, 34 pp.

It would have been more useful for Prof. Selley to have been asked to comment in detail on these submissions.

The last two sentences, taken together, imply that the Kimmeridge Clay is the source and that the Kimmeridge limestones are the reservoir. This is potentially misleading, because it does not mention the possibility that 'unconventional' treatment of the rocks may well be required (as at Balcombe), for example by acid treatment of the limestone and/or fracking of the larger rock volume including the shales. The basic reservoir characteristics of the limestones are fairly well known, contrary to Prof. Selley's statement. The upper, principal, limestone is 30 m thick at Fernhurst; the limestones have fairly good porosity and very low permeability. In short, they do not constitute a conventional reservoir rock, which, *inter alia*, should have high permeability.

Prof. Selley's last sentence is unclear, and I do not see its relevance. If Prof. Selley is referring to the whole area of the BGS study, then the area identified by the BGS in which mature Kimmeridge Clay occurs is only one-twelfth of the total area studied. But within the latter mature area, most or all of the existing thickness of Kimmeridge Clay is indeed oil-mature; that is, it is likely to have generated oil.

3. Similar geology outside PEDL231 (Selley pp. 2-4)

> "b) To understand the target formations within PEDL 231 and how they compare to those outside the PEDL boundary, but within the Weald Basin. Can the same geology be found outside PEDL 231?

The general geology of the Weald is very well known after nearly 200 years of research. The surface geology has been mapped both by the British Geological Survey, by academic and amateur geologists ***(Figure 1.).***

The subsurface geology of the Weald is less well known, obviously, though many wells have been drilled across the basin since the Netherfield wells in 1875. The Weald is a basin of sedimentary rocks (limestones, sandstones & mud rocks) deposited layer on layer over many millions of years. Surface mapping and subsurface boreholes show that the main rock units are laterally continuous across the Weald ***(Figure 2)*** *though there are some minor changes in rock type across the basin.*

[Figs. 1 and 2 here]

Figure 3 *shows the producing oil & gas fields of the Weald that provide information of known source rocks and reservoirs, and can be used to predict their distribution. Some variations in source rock and reservoir quality have been observed.*

[Fig. 3 here]"

Figure 1, reproduced from a guidebook published by Prof. Selley, is irrelevant because it portrays the landscape evolution of the Weald, involving just the younger rocks from Ashdown Sands upwards, and not the deeper rocks of hydrocarbon interest.

Figure 2 is a 52 km long cross-section. It is potentially more useful than his figure 1, because it implies that the geology is similar from end to end, albeit with the layers of interest being somewhat thicker within the central Weald area. However, Prof. Selley does not discuss this figure.

Prof. Selley then states, regarding figure 3, that there are "*some variations*" in source rock and reservoir quality. But he does not conclude by answering the question, which should have been stated in the affirmative; yes, the same geology is found outside the bounds of PEDL231.

4. Basic terminology (Selley pp. 5-6)

"c) Some of the basics behind petroleum geology and terminology (e.g. Is the Weald Basin a 'prospect' and if not, what is the difference between a 'prospect' and a 'target horizon'?)

Figure 4 *is a stratigraphic column that shows the sequence of rocks to be encountered across the Weald. This figure also shows the rock strata which are petroleum reservoirs for the various oil & gas fields of the basin. In the petroleum industry the term '****prospect'*** *is applied to a location where*

*it is possible that petroleum may be trapped and that merits testing by drilling. The term '**prospective**' is applied to an area where evidence suggests that petroleum may be trapped.*

[Fig. 4 here]

*Thus the Weald basin is known to be **prospectiv**e because it contains many producing oil and gas fields. A **prospect** has been identified beneath Nine Acre Copse that merits drilling.*

*A **target** horizon is a layer of rock, generally sedimentary (sandstone or limestone), that may contain petroleum, i.e. has the potential to be a petroleum reservoir, i.e. has porosity (pore spaces to hold petroleum) and permeability- the pores are interconnected, enabling petroleum and water to flow through the rock. Thus there are two **targets** for the Nine Acre Copse **prospect**: the Kimmeridge Limestones (Upper Jurassic) and the Great Oolite (Middle Jurassic).*

The Great Oolite is a major petroleum reservoir across the Weald basin producing oil in many fields such as Singleton, Storrington and Lydsey. The Kimmeridge Limestone target is not yet a proven reservoir in the Wessex Basin. This was the target for Cuadrilla's well at Balcombe."

The definitions given here of prospect and target are acceptable. However, Prof. Selley is wrong about the targets for the Fernhurst well. It is agreed that the Kimmeridge Limestones are a target, but he has omitted the Kimmeridge Clay and the Middle Lias shales, and his mention of the Great Oolite is misleading, because it is not a target. The other secondary targets are the Oxford Clay, Kellaways Beds and Cornbrash (see Smythe 2014b, sections 2.4 and 2.5 for a full discussion).

In addition, Prof. Selley's statement that a prospect has been identified beneath Nine Acre Copse, a small locality, is misleading, because the prospect is described by Celtique in a letter to DECC as *"laterally extensive"* (see Smythe 2014b, section 1.4 for a discussion of this letter).

5. Porosity and permeability of the targets

"d) To understand the porosity of the primary target; Kimmeridge Limestone formation and the secondary target; Great Oolite formation and the likelihood of whether the oil would be free flowing or trapped and require fraccing.

*The **Kimmeridge** Clay is a thick formation that is largely composed of mud that contains within it thin layers of fine-grained limestone. The Kimmeridge Clay has a high content of organic matter. This has generated petroleum in some areas, notably the North Sea, where it is the main source rock for North Sea petroleum. Within the Weald basin the thin limestone beds are particularly well*

–developed forming the rock unit that is termed the Kimmeridge Limestone. It must be understood that this is not a bed of solid limestone many metres thick but a sequence of thinly inter-bedded limestones and clays. The limestones have negligible porosity and permeability, but they are brittle and naturally fractured due to earth movements. Petroleum can migrate from the organic rich clay beds into the intervening naturally fractured limestones. Colloquially Americans call this the 'Oreo cooky' model (An oreo cooky is a biscuit composed of alternate layers of crisp biscuit and viscous sugary confection) ***Figure 5.*** *This situation produces petroleum in the Franciscan cherts of California and the Bakken shale of Illinois. When the shale gas industry began in 1821 production was solely from natural fractures. The artificial fracturing of conventional reservoirs (sandstones and limestones) began in the late 19th century. For many decades explosives were used, more recently the less exciting and more environmentally friendly hydraulic fracturing was developed in the 1940's, first for conventional reservoirs and then for shale in the late 20th century.*

[Fig. 5 here]

The ***Great Oolite*** *is a limestone with good porosity and permeability. It is a type of rock that is a major petroleum reservoir around the world and in Arabia in particular. In some cases the carbonate grains are completely un-cemented, but generally there is some mineral cement that infills pores and thus diminishes both porosity and permeability. In such cases the rock is hydraulically fractured and flushed through with acid to leach out some of the carbonate and thus increase flow rate. The Great Oolite is a major producer of petroleum across the Weald basin in the Storrington, Singleton, Humbly Grove, Stockbridge, Baxter's Copse, Lidsey and Goodworth fields (Refer back to Figure 4)."*

Prof. Selley's description of the 'Kimmeridge Limestone' is inaccurate and over-simplified. In the Weald there are two distinct limestones, the I-micrite and the J-micrite, correlatable from well to well throughout the basin. There is also a lower K-micrite of more limited extent, which is not present below the SDNP.

The Bakken play is not in the state of Illinois, as stated by Prof. Selley, but lies some 1200 km to the NW, in NW North Dakota and NE Montana, and continues north of the 49th parallel into Canada. Prof. Selley fails to make explicit that the Bakken, a good analogue to the Kimmeridge limestones of the Weald, was a failure as a conventional oil target between 1952 and 1980, but only began to become productive in oil after the advent of fracking in about 1980.

Prof. Selley's description of the Great Oolite as an important reservoir for the oilfields that have been developed around the fringes of the Weald Basin is irrelevant, because this limestone is *not* a target of the current proposal (Section 4 above). Coring is to be be confined to Middle and Upper Jurassic layers *above* the Great Oolite, and the Middle and Upper Lias *below* the Great Oolite. However, it raises an interesting point, which is that had Celtique been investigating a conventional target at Fernhurst, the Great Oolite would be a prime candidate for detailed investigation by coring. This is additional evidence that the Applicant is seeking unconventional plays.

Prof. Selley has not answered the principal question here, which is whether or not the limestone has low permeability and will need fracking. But he has not provided any new information to suggest that these limestones will contain oil which will flow freely without stimulation.