

Critique of Cuadrilla's plans and proposals for drilling near Balcombe, West Sussex

by

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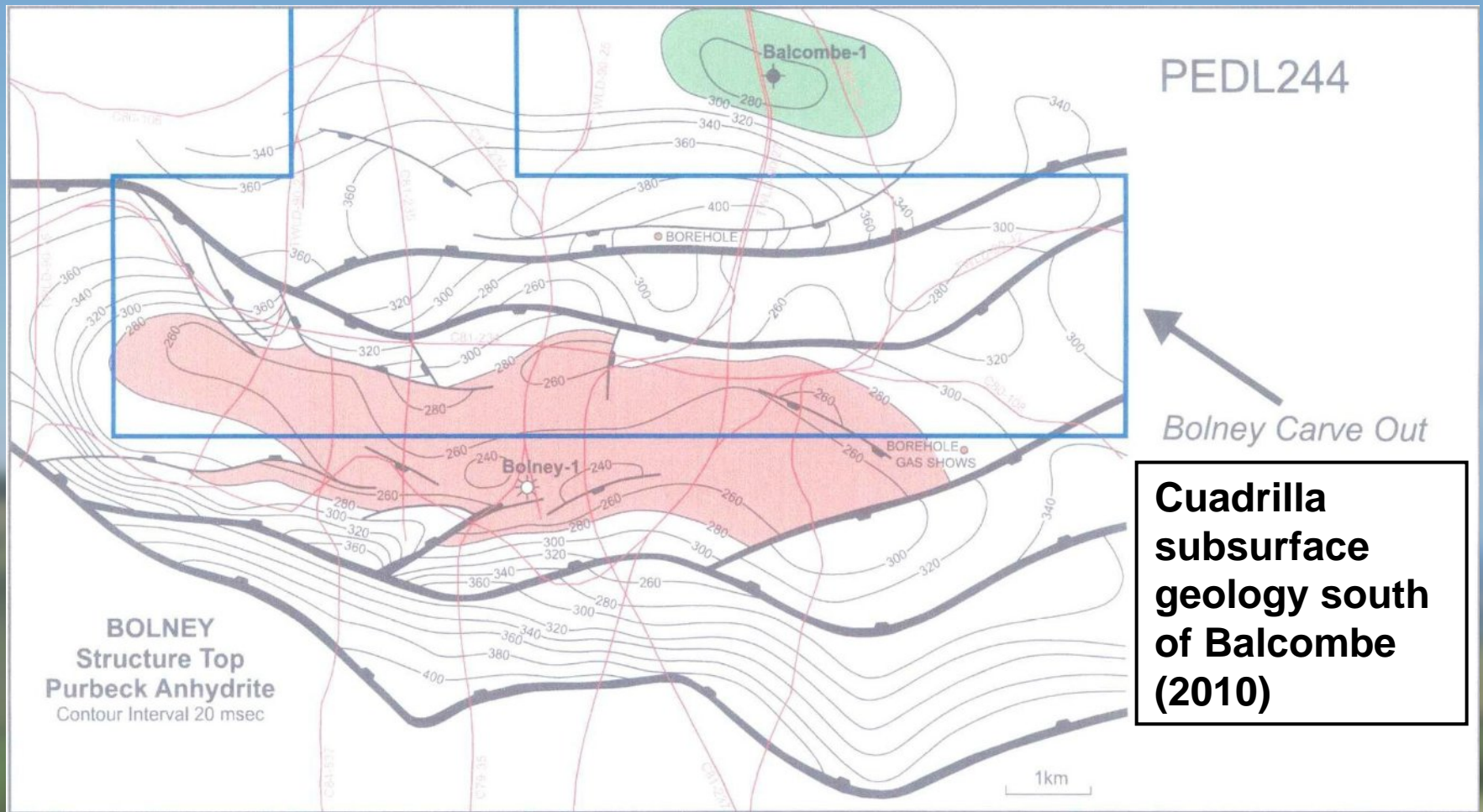
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This slideshow discusses Cuadrilla's published proposals for re-drilling the Balcombe-1 well. Since it is somewhat technical in places, here is a summary:

Cuadrilla's planning application (and subsequent significant changes to it) contain a number of flaws:

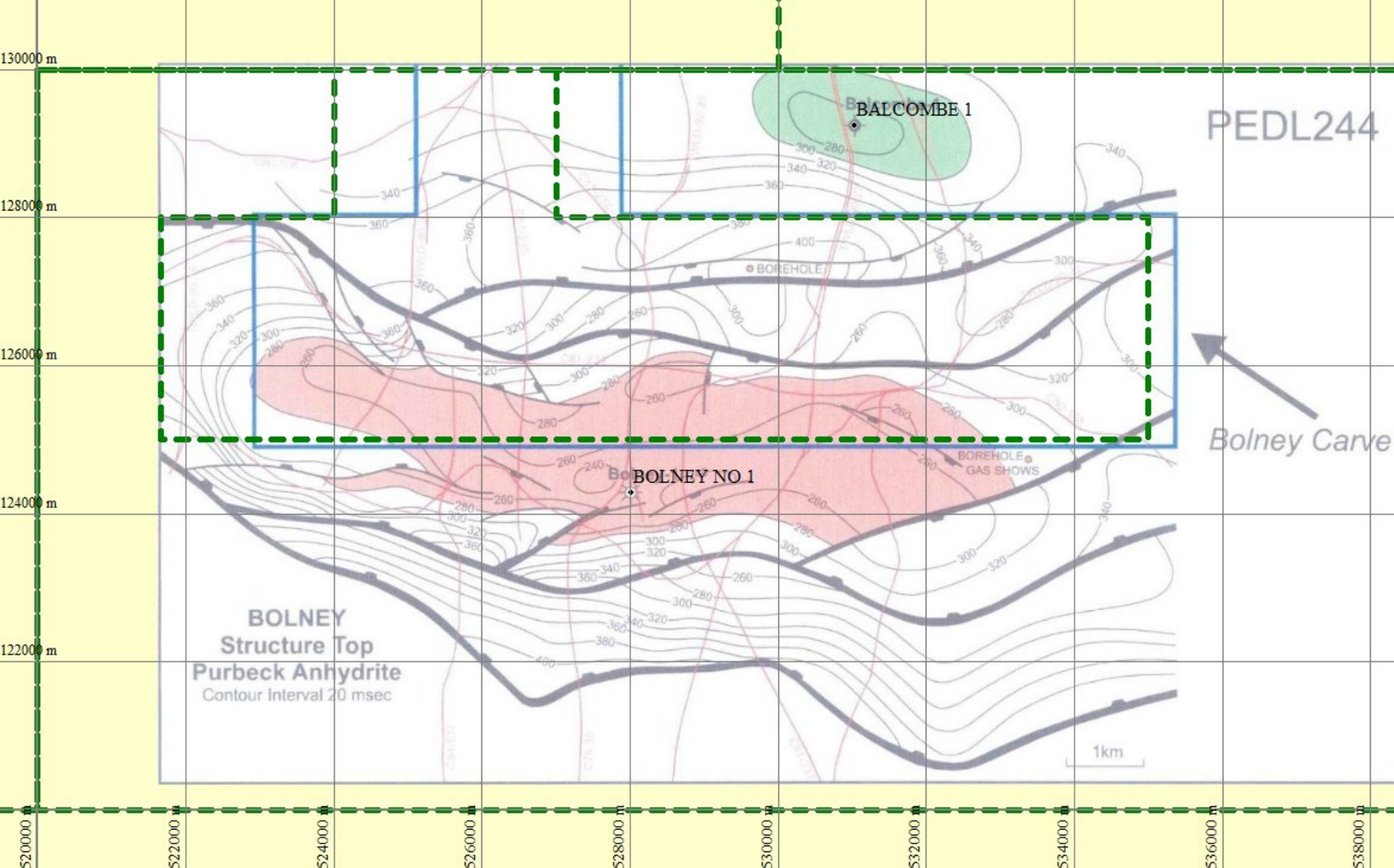
- The boundaries of its licence (PEDL244) are **misplaced by up to 1200 m**.
- The interpretation of the **geological structure is insecure**, as it seems to have taken no account of the published maps of the British Geological Survey (BGS).
- As a result, some of the interpreted **major faults run in the wrong direction**.
- The interpretation omits the faults near the well site**, some of which cut through the existing well.
- Cuadrilla was targeting the 570 m thick Kimmeridge Clay for shale gas, but is now targeting a micrite (muddy impure limestone) layer within the Kimmeridge Clay, supposedly for oil.
- The only subsurface data available, **2D seismic profiles of 1990s vintage, are inadequate for the purpose required**.
- The **micrite is only 33 m thick**, and it is not known how the horizontal drilling can be constrained to keep within this thin layer at 700-760 m below the surface.
- Horizontal drilling cannot reasonably be carried out without a 3D seismic survey** of the district having first been obtained.
- In consequence, **horizontal drilling will probably stray into the Kimmeridge Clay**, which has been identified by DECC as the most important shale gas resource in the UK, after the Bowland Shale of NW England.
- If horizontal fracking is carried out at a later stage in the programme, **any faults intersected may act as fast-track conduits to the surface for contaminated frack water and released methane**.
- It is not yet known whether fracking in an earthquake-free area like the Weald could induce shocks.



This is Cuadrilla's geological map for the top of the Purbeck Anhydrite, a layer about 240 m above the micrite target. The two old exploration wells, Balcombe-1 and Bolney-1, serve to calibrate the depths. Major faults generally running east-west are shown by thick black lines with a comb mark on the side which is displaced downwards. Away from the wells the interpretation depends upon old 2D seismic profiles, shown as thin red lines.

The green oval marks an area of 'closure', that is, a gentle dome-shape under which oil or gas could collect, if present. The red area marks a similar closure around the Bolney-1 well.

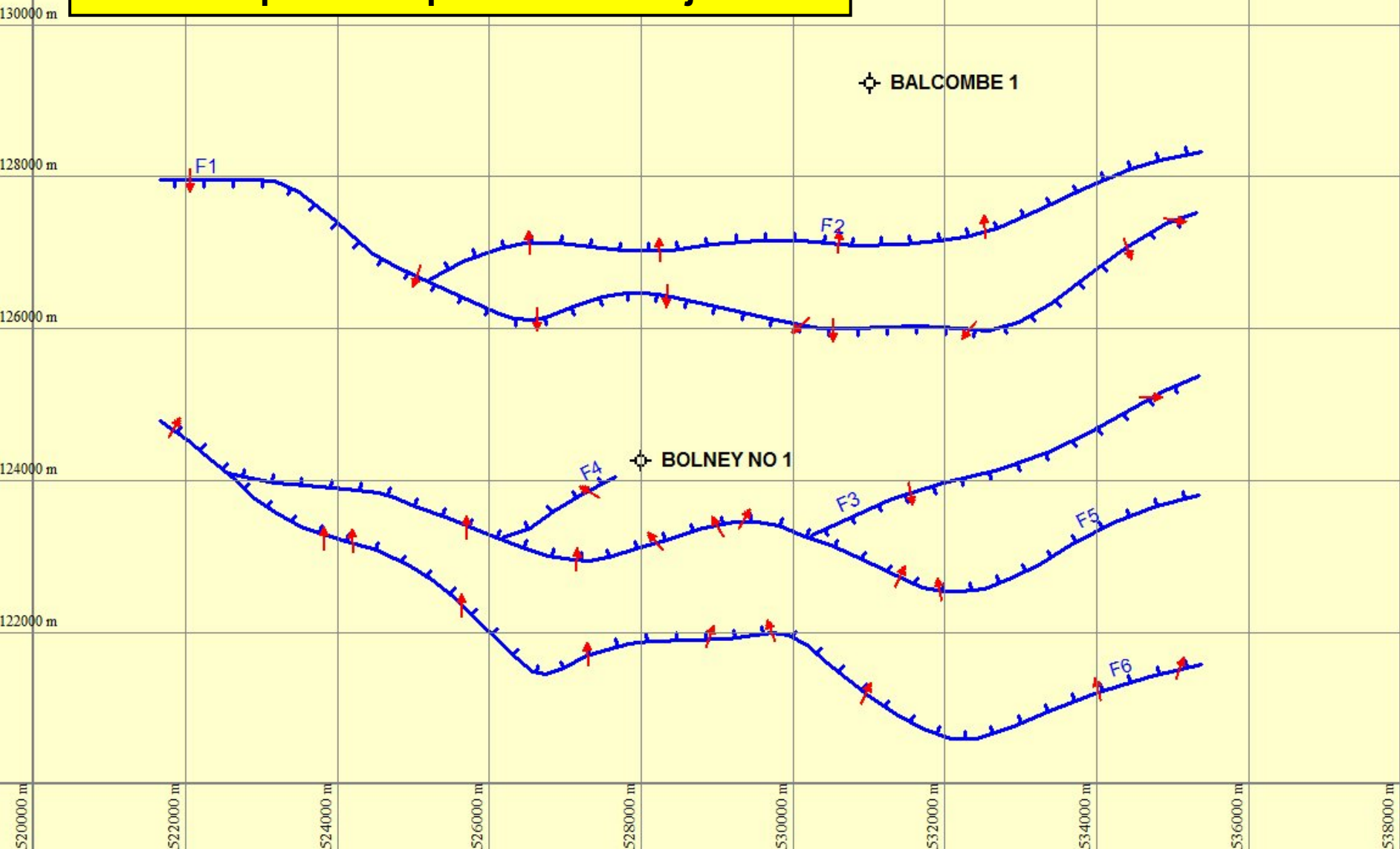
The blue polygon labelled 'Bolney carve-out' is an area *excluded* from the much larger PEDL244 licence area, but this area is wrongly positioned.



Cuadrilla mapping error

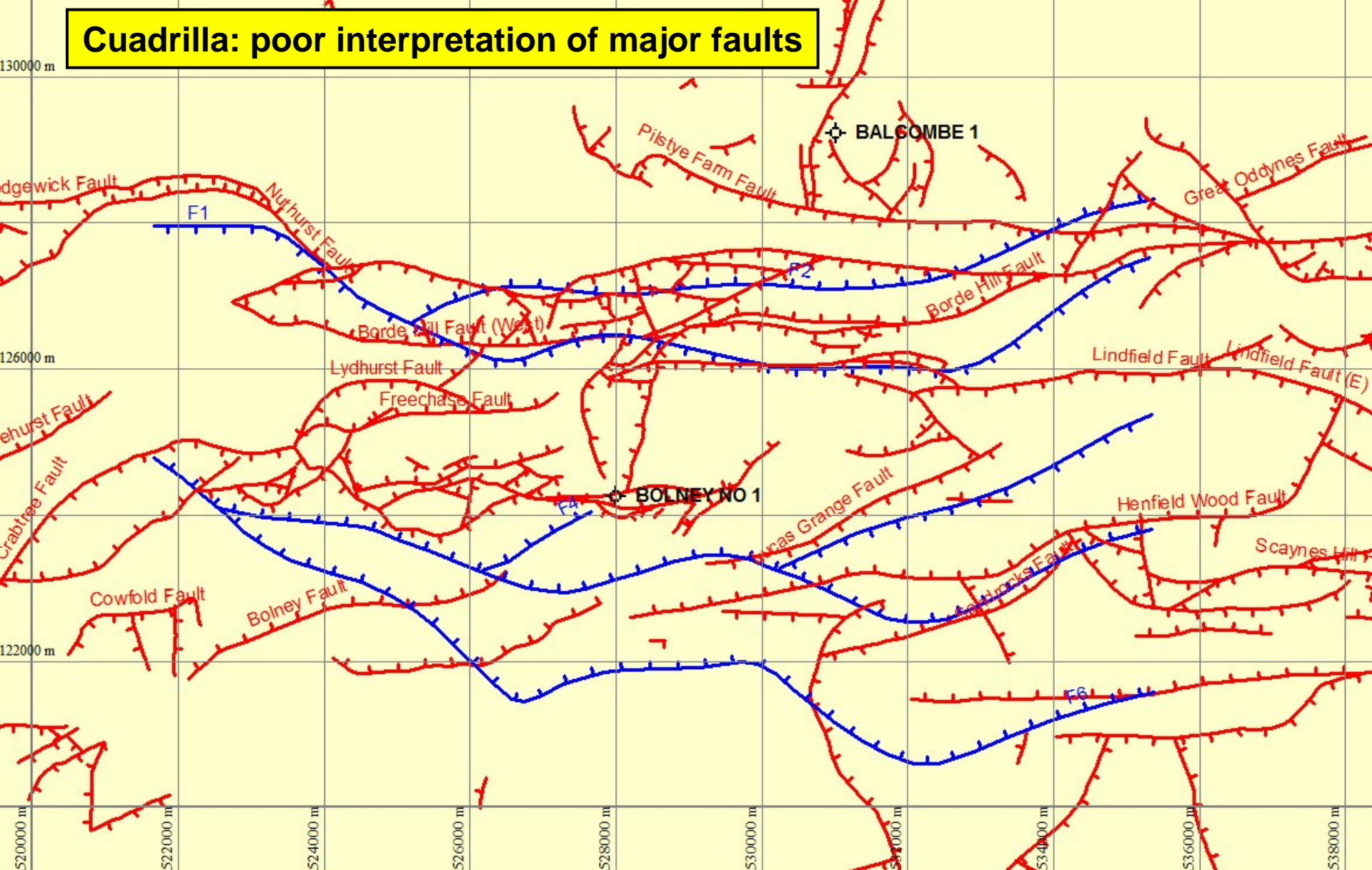
The Cuadrilla licence application map has been merged into a digital mapping program by registering it using the two wells, whose digital position is shown. A further check is that the seismic lines (red) now match the government database (not shown). But note how the DECC licence boundary (green dashes) mismatches that on the Cuadrilla map (blue) by up to 1200 m.

Cuadrilla: poor interpretation of major faults



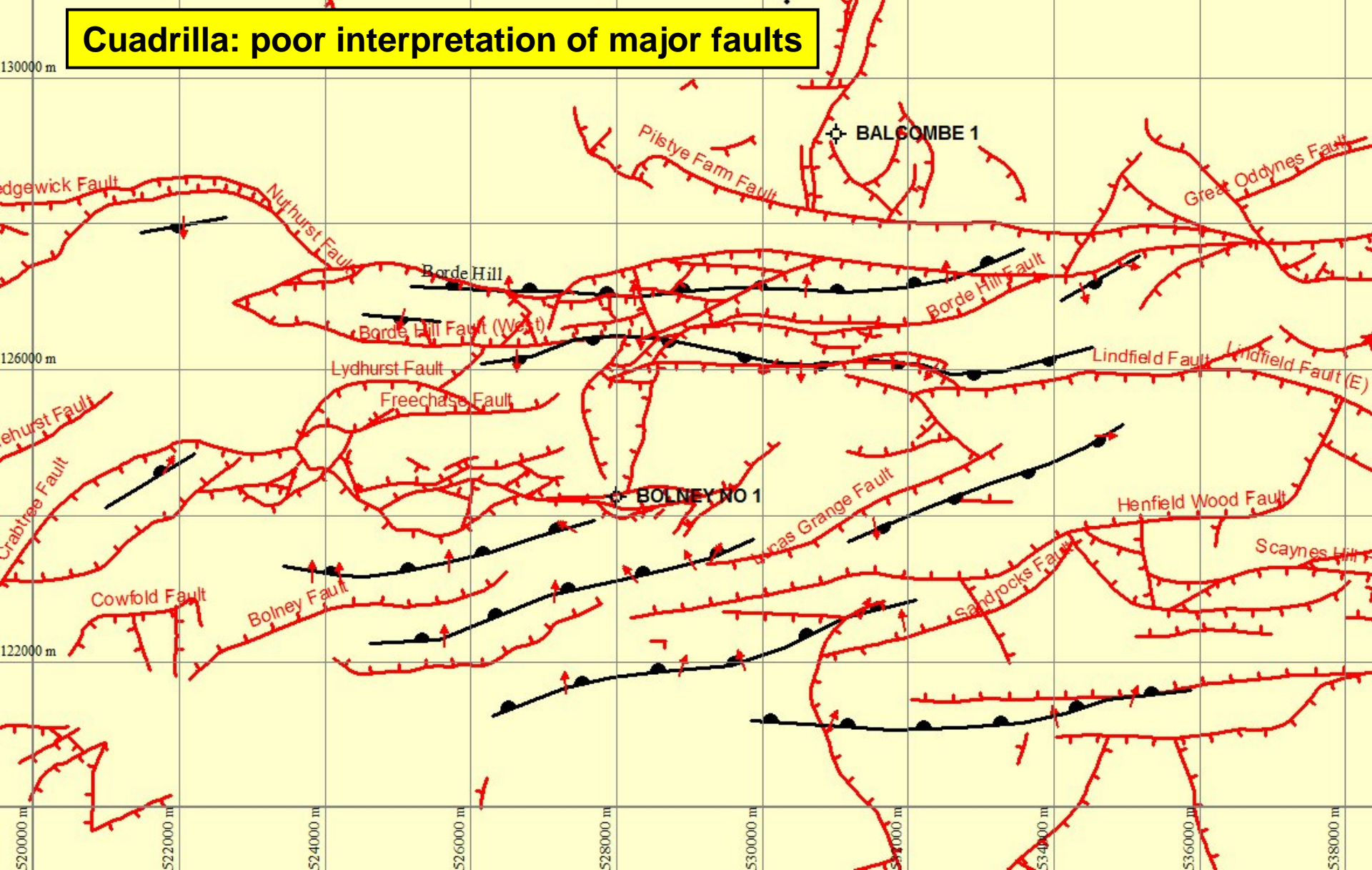
The major faults mapped by Cuadrilla are in blue, with control points from 2D seismic lines shown by red arrows. The direction of arrow is along the seismic line, pointing to the downthrown side of the fault (shown by the comb marks on the faults).

Cuadrilla: poor interpretation of major faults



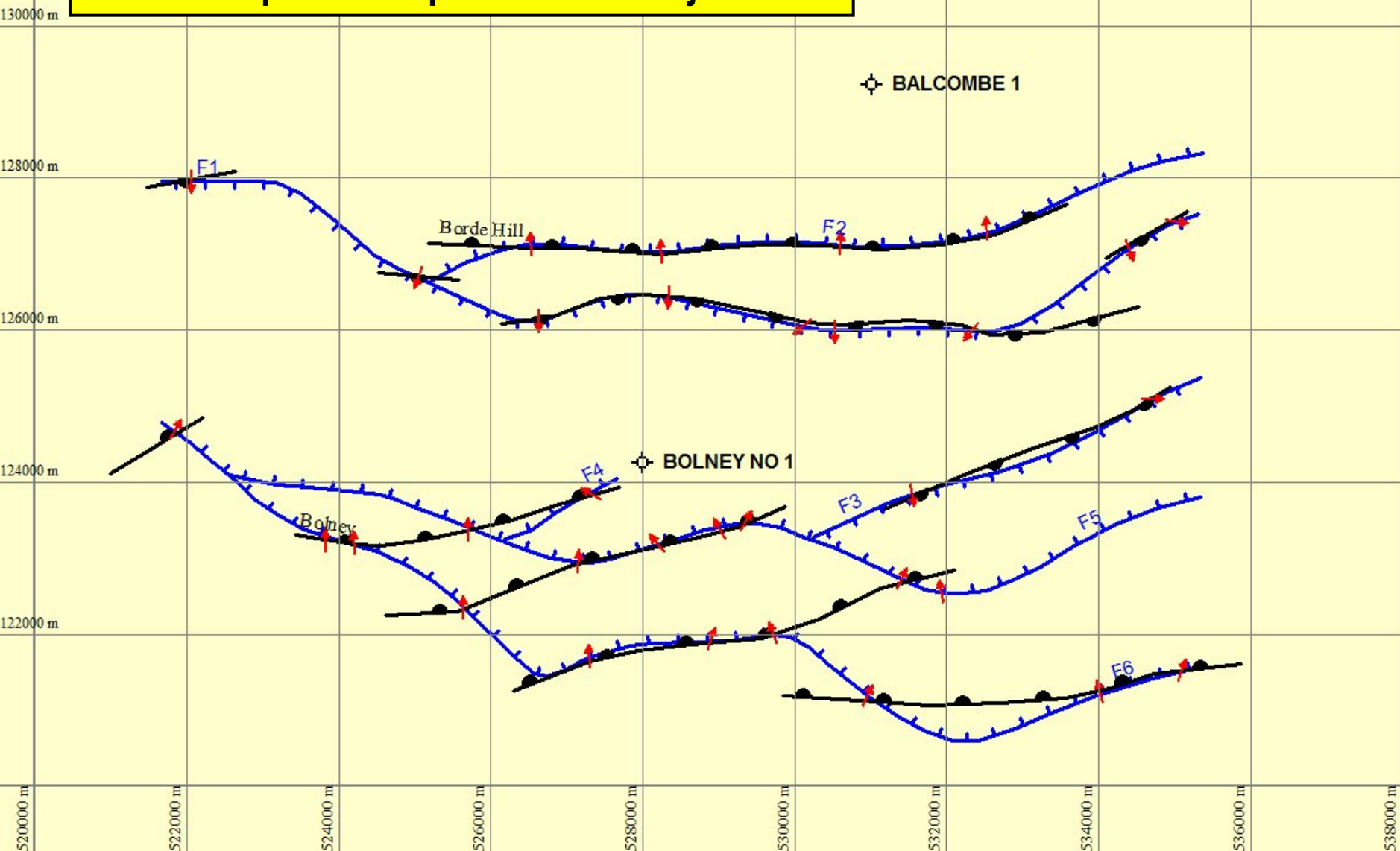
In the southern part of the interpretation the Cuadrilla faults at around 500 m depth have poor correlation of trend compared to the surface faults (red) as mapped by the BGS.

Cuadrilla: poor interpretation of major faults



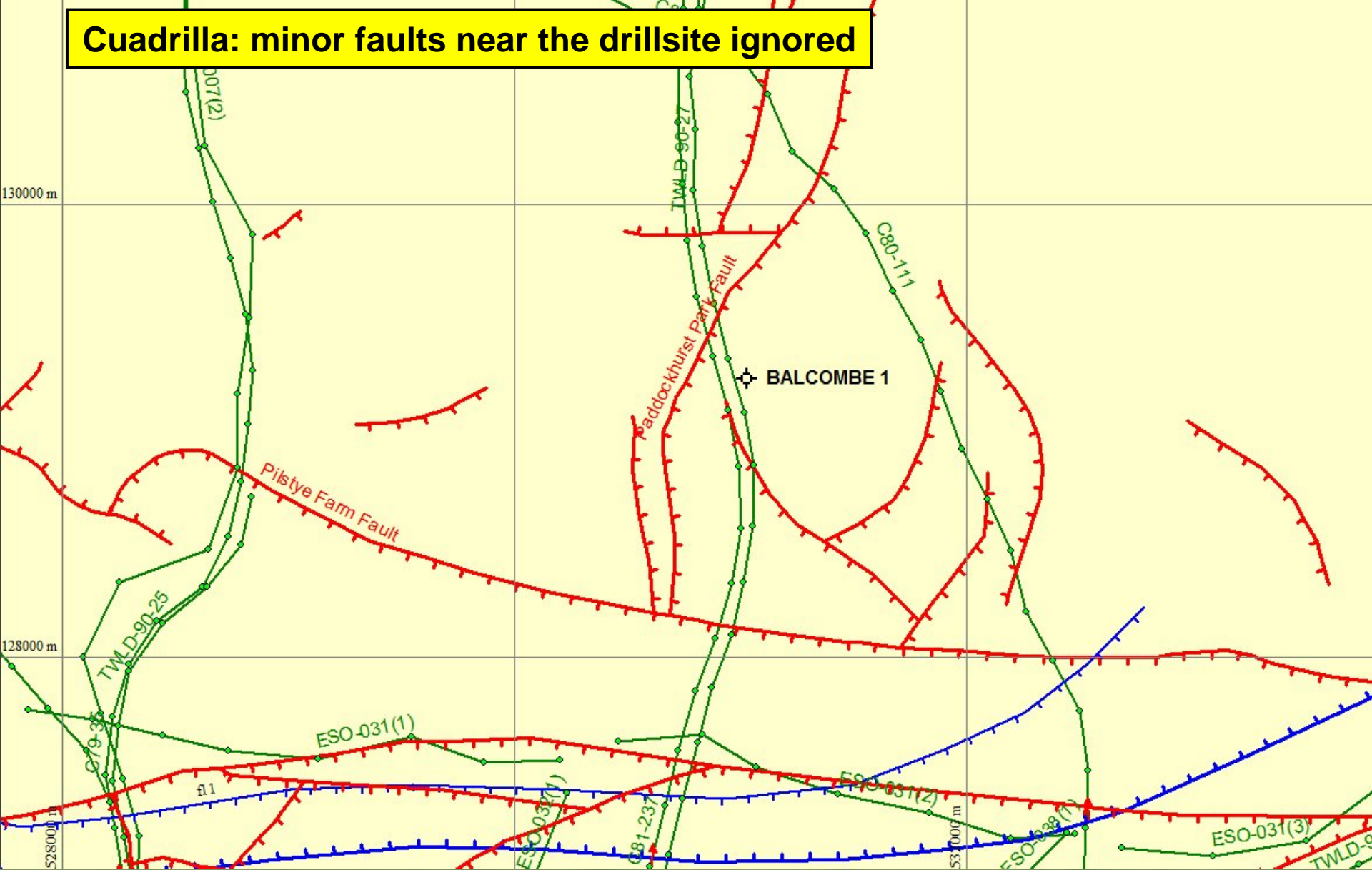
The black lines with half-moons are my re-interpretation of the major faults at depth, honouring the control points (red arrows) and also the general trend of the surface faulting.

Cuadrilla: poor interpretation of major faults



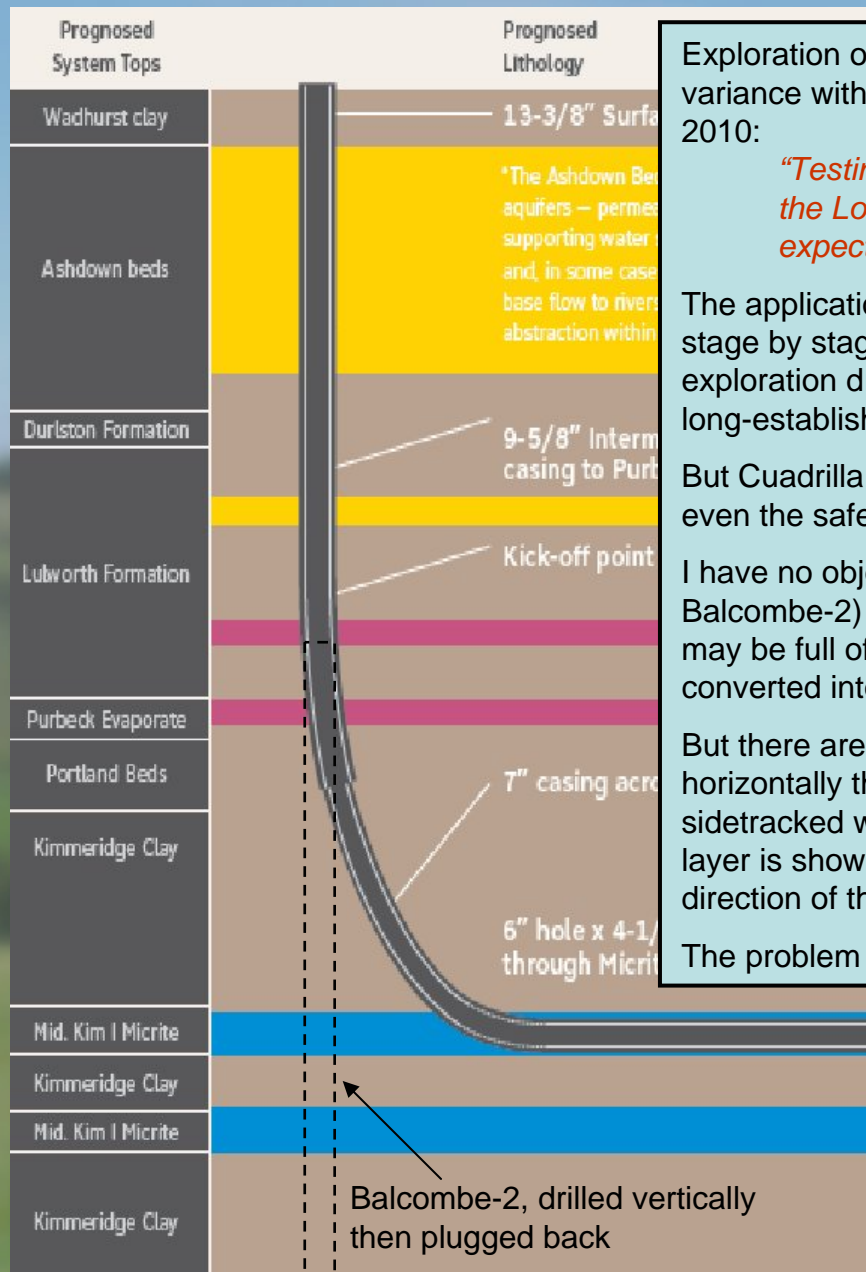
The Cuadrilla interpretation (blue lines) is satisfactory only north of 126000N and from 526000E to 534000E. Everywhere else their fault correlations lead to trends that are 40° or more away from what should be expected from the surface geology. The black lines are a better interpretation.

Cuadrilla: minor faults near the drillsite ignored



Detailed map around the Balcombe-1 drillsite. BGS faults in red, seismic lines in green, Cuadrilla-interpreted faults at depth shown in blue. The plans for exploration at the well seem to have ignored the many faults around it. The north-south Paddockhurst Park Fault passes 200 m west of the well, and has a throw (displacement of one side vertically relative to the other) of 30-40 m. This fault may intersect the well. The National Grid is shown at a 2 km interval.

Cuadrilla: substantial changes of target rock and drilling intentions



Exploration of the micrite layer for oil, which is Cuadrilla's current intention, is at variance with Cuadrilla's stated intentions in its original planning application of 2010:

"Testing the shale layers (known as stages) will be the main purpose of the Lower Stumble exploratory drilling operation ... The Company are expecting to encounter between three and six shale stages"

The application goes on to describe a hydraulic fracking process carried out stage by stage on the vertical well, all within the 28-day period of the exploration drilling. Note that this kind of 'stimulation' test is a relatively safe, long-established process, and requires only small amounts of water.

But Cuadrilla now denies (May 2013) that it will employ any kind of fracking, even the safe vertical stage-by stage stimulation, in this round of exploration.

I have no objection, technically, to the drilling of the vertical well (called Balcombe-2) to target the 33 m thick micrite. If Cuadrilla is lucky, the micrite may be full of oil and flow easily. Therefore the exploration well can be converted into an oil production well.

But there are severe technical problems, because Cuadrilla now wishes to drill horizontally through the micrite, but not to frack it (at this stage). This sidetracked well will be named Balcombe-2Z. The deviation into the micrite layer is shown in the diagram on the left, which is not to scale. The compass direction of the deviation is expected to be between NW and SW.

The problem is illustrated in the next slide.

Cuadrilla: keeping the drill string within the micrite

Balcombe-2

West

No subsurface data between seismic lines about 2 km apart

East

PPF

Ground surface

Offset layer

Where does the Paddockhurst Park Fault (PPF) intersect the well? It will displace the micrite vertically by 30-40 m.

This cross-section shows the near-impossibility of keeping the horizontal drilling within the 33 m thick micrite. All that is known is that the micrite is about 60 m deeper as shown by the seismic line 2 km to the west.

Possible other faults displacing micrite

The micrite layer is not horizontal

Well deviated
horizontally to
follow micrite

Initial
vertical
well

Depth
(m)

Vertical exaggeration 5:1

Known level of micrite layer

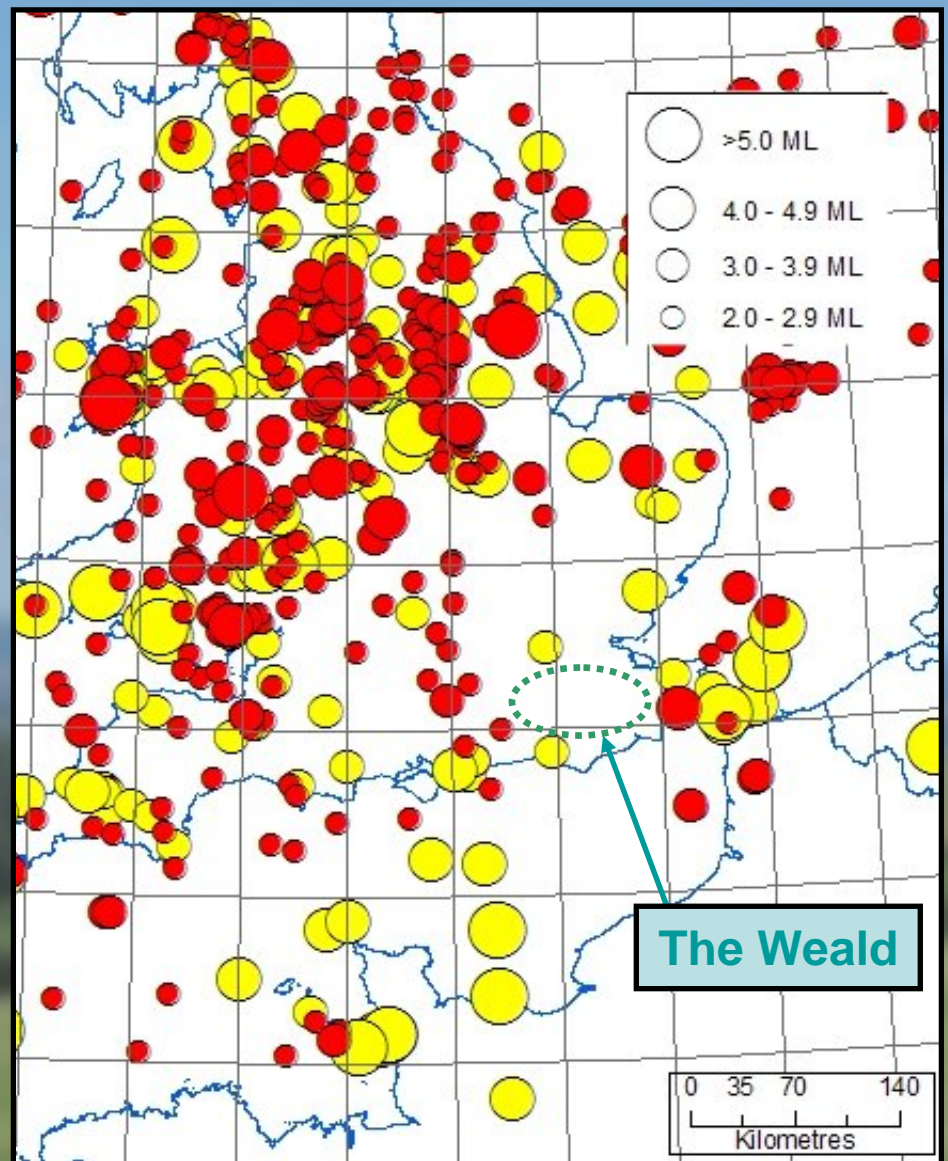
Cuadrilla: comments and questions on the horizontal drilling

- It will be all-but impossible to keep the drill string within the 33 m thick micrite layer, due to insufficient geological information.
- The drilling will therefore almost certainly transgress into the Kimmeridge Clay, either above and/or below the micrite.
- Before any horizontal drilling was permitted, a full 3D seismic survey should have been carried out, as Cuadrilla has already done in Lancashire.
- Given the stated purpose of the well in the initial planning application of 2010, is the recent proposal to investigate oil in the micrite a cover-story for investigating the shales?
- If, as seems likely, the horizontal well enables sampling of both the micrite and the shales, will Cuadrilla submit a new planning application to frack the shales?

Could fracking trigger earthquakes?

This BGS map of historical earthquakes from 1832 to 1970 shows that the Weald has been completely earthquake-free for 170 years.

Earthquakes in previously non-seismic zones can be triggered by injection of fluids into wells, but it is *not yet known* whether fracking in an area like the Weald, which is cut by many faults, could trigger shocks.



Documents and data sources

Minutes of meeting between Balcombe Parish Council and Cuadrilla Resources Ltd, 3 May 2013.

Cuadrilla Resources Ltd. Lower Stumble Hydrocarbon Exploration Site Planning Application [January 2010]. Appendix B. Seismic interpretation.

Cuadrilla Resources Ltd. Lower Stumble Hydrocarbon Exploration Site Planning Application [January 2010]. Appendix C. The drilling operation.

Cuadrilla Resources Ltd. Balcombe Environmental Method Statement. Version 1, issued 30 June 2013

DECC. UK onshore well locations, shapefile July 2013.

UK Onshore Geophysical Library. Onshore seismic reflection navigation textfiles in UKOOA format.

Edina Digimap. Maps and geospatial data for UK Higher Education. Ordnance Survey topographic maps, digital elevation models, BGS geology maps and outlines.

British Geological Survey 1993. Geology of the country around Horsham. HMSO, 130 pp.