Preston New Road

Planning Inspector Appeals Reference: APP/Q2371/W/15/3134386

- Bowland Shale is heavily faulted; many of these faults penetrate the overlying Permo-Triassic rocks
- Faults mark wide zones of cracks that increase permeability for all types of fluids and gas....they are potential pipelines to aquifers
- Faults are unpredictable in their location and continuity and require detailed investigation to map
- Prof Smythe advises that a well pad should be 5km away from a fault, at PNR it is only 1.5km
- Prof Styles advises that a fault should be minimum of 1km (maybe 5km)away from fracking but at PNR it is only a few hundred metres
- DECC EA and HSE have failed in their regulatory duties even before permission is granted
- There can be no independent review of the plans as the relevant information is C-in-C
- Cuadrilla have deliberately hidden information from you and LCC
- Nowhere is suitable on the Fylde from a geological point of view

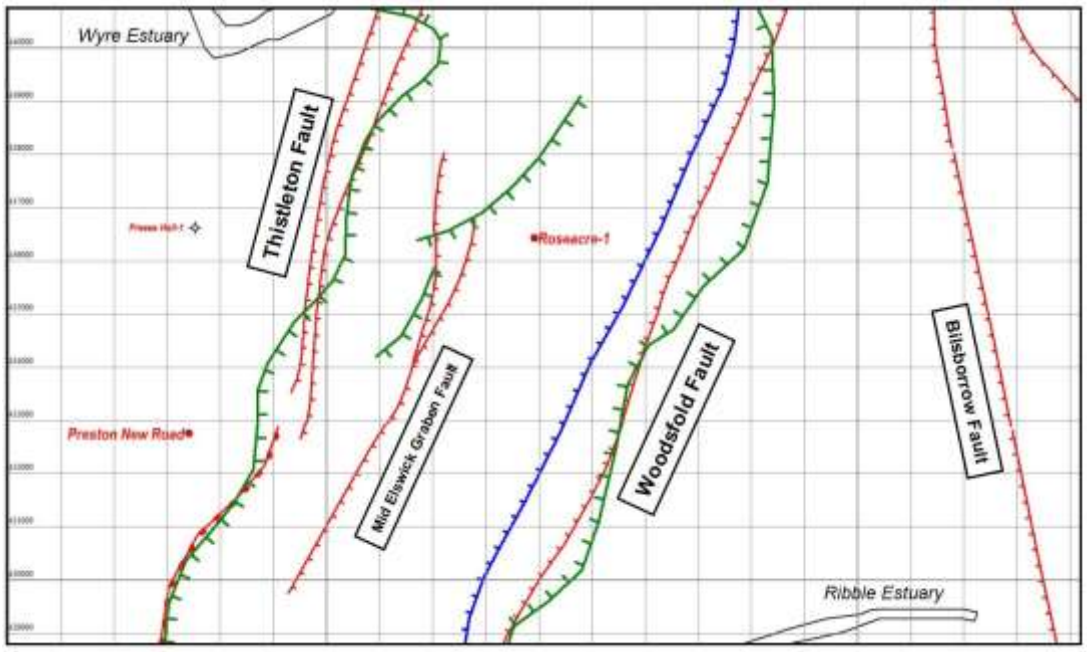

Figure 1 Various interpretations of outcrop of major faults in the Fylde – courtesy of Prof Smythe.

Written Submission to Planning Inspector by Trina Froud

I live in Lytham and my degree was BSc Hons 'Mathematics with Earth Sciences'.

Geology and Geophysics were a revelation to me after Maths, which is quite cut and dried - equations can be solved. Whereas in Geology and Geophysics much remains to be established, and at the time I studied, the theory of plate tectonics was not universally accepted.

Several decades later, a lot still remains to be discovered or explained – the (unpredictable) behaviour of geological faults for instance. We cannot yet predict earthquakes; and we don't even know exactly where the Woodsfold Fault is, the BGS have 3 different interpretations, varying by hundreds of metres, and yet it is one of the major faults in this region.

So my attention was caught 5 years ago, when I heard about Cuadrilla's proposals. I find the subject of great interest, and have met and corresponded with a number of engineers and geologists from the industry, professors from universities and science institutes ever since.

Fundamentally this application depends on the geology and geophysics, it's why we are here; how much gas is in the shale, how much can be extracted and the consequences for us.

This is a Minerals application and you need just as much information about what is happening below ground as you would for a structure above ground.

So I would like to look at the geology, the nature of the exploration practice as allowed by the DECC, and the transparency of the review process.

Geology

The British Geological Survey highlighted the recent publication of 3D maps showing the relationship of potential shale gas source rocks and the overlying principal aquifers in the UK, considering it "an important first step" but said that further work is required to adequately assess groundwater vulnerability. " *The difficulty lies in the fact that below c.200m there is very little information and data on the hydrogeological properties and potential for movement of pollutants through rocks below this depth*"

At the moment everyone is using a geological map (as a representation of a 3D model) that is completely inadequate for the purpose, having been produced over 40 years ago at a very early stage in seismic data availability and processing, when faults less than 30 m could not be recognised.

North of the Fylde in West Cumbria, detailed mapping, borehole and seismic investigations in a similar geological situation were carried out between 1987 and 1997 in the Sellafield area to determine the suitability of the rocks at depth as a potential host for an underground nuclear repository. The large multi-disciplinary team working for NIREX spent a decade establishing a new understanding of the geology onshore and offshore, investigations that showed just how many faults there are, especially onshore e.g. the attached drawing based on the published 1:50,000 scale maps, e.g. the Gosforth sheet available at the following URL

http://www.largeimages.bgs.ac.uk/iip/mapsportal.html?id=1001517

The ongoing debate over the slice of 3-D seismic to identify the location of the Preese Hall fault, demonstrates that it is time consuming and difficult to interpret seismic surveys.

So in the absence of an up to date and public understanding of the Fylde geology, what do we know?

The UK has had a turbulent geological history and as a result, rocks have been tilted and folded and subjected to stress. They are no longer flat, like a pancake, as they are in some American shale basins.

The most striking feature of the Fylde geology, compared to US shale plays, is the complex and pervasive faulting resulting from this history. The Bowland Shales are heavily faulted, having both large faults that extend right up to the surface, smaller ones deep under the surface, and there could be many that we cannot yet detect.

It should be noted that fracking near faults is a very contentious subject, Prof Mike Stephenson, Director of Science and Technology, British Geological Survey said on radio 4:

"What you have to be able to do when you decide you want to hydraulic fracture is make sure there are no faults in the area. That's really very very important"

Faults are of concern because they are complex and unpredictable structures:

- they can slip and cause tremors, as at Preese Hall

- they can create construction problems affecting the integrity of the well

- they can act as conduits (pathways) for fluids to rise, both during and after development, with the inherent risk of contaminating the aquifers

Faults and tremors:

An example of a fault slipping is Preese Hall, where the fracking fluid got into a fault, which slipped by a very small amount, causing 50 tremors; the largest of which, magnitude 2. 3 led to the well itself being deformed over a significant interval. It cannot be used again.

Then there were further aftershocks in August and Nov 2011. These 2 autumn events were used by Prof Styles et al, to determine what had happened in the spring, during the fracturing process. They were tiny tremors - but are *belated* and *related* consequences of the fracking at Preese Hall, several months AFTER the fracking had ended.

The RS/RAE report concentrated on the tremors, and advised the use of a traffic light system to mitigate them, but it should be noted that both Prof Shipton and Dr Westaway have queried this approach.

Dr Westaway says that the TLS might not be triggered at all, as quakes tend to have tremors *after*, not *before* the main one - so we might still get a tremor of 2.3, the magnitude that deformed PH.

And Prof Shipton says *" Magnitude (which is the trigger on the traffic light system) is not the thing we should be worried about – it's vibration frequency ".*

Faults and construction problems:

Cuadrilla is planning to drill through a fault in two locations at PNR and then to frack near a fault.

It is challenging to drill through a fault and a petroleum geologist tells me that it is essential to know precise fault locations in the area of interest, in order that the hole being drilled does NOT penetrate the faults.

- Drilling from one fault block into another laterally requires the operator to re-orientate (steer) the drill in order to penetrate the organically richest shale in the new fault block, such a target is generally only 20-30 cm thick, similar to a seam of coal. Such stratigraphic navigation is quite a challenging process and will take time to perfect.

- Prof Smythe notes in a new paper (see reference below) that current UK regulations permit the drilling of faults (if indeed they are identified) either vertically or horizontally, on the way to the fracking zone.

  "This is unacceptable, because cement bonding of the casing, either in the deviation zone or in the horizontal section of the well, is difficult to achieve (Dusseault et al., 2014). The eccentricity of the drill casing with respect to the borehole means that it is hard to flush out drilling mud, and a subsequent cement job may then fail because the resulting cement-mud slurry does not make not a sound bond. "

Prof Smythe gave evidence to LCC last June, using a slice of the 3-D seismic survey, that the Preese Hall well was actually drilled through a fault. And as was demonstrated there, a well that penetrates a fault can also be deformed by tectonic movements triggered by the hydraulic fracturing.
This deformation of the casing and the cement will increase the chance that the integrity of the well bore may become degraded.

Hence the critical need for detailed maps of the area with all possible faults mapped before the design (location, azimuth and length of the horizontal leg) of the proposed well.

Faults as conduits:

Faults are zones of cracks that increase permeability, for all types of fluids and gas....they are potential pipelines to aquifers.

There are natural oil and gas seeps at the surface in West Lancashire, which are directly linked to leaky faults.

The RS/RAE report is often cited, but it is limited in scope because it did not study this issue of faults as pathways, even though that was raised with them by the Geological Society of London.

There has been a lot of research in the last 5 years into the hydrogeology of faults, which is reviewed in a paper newly submitted to the European Geosciences Union by Prof Smythe, Emeritus Professor of Geophysics, Glasgow

http://www.solid-earth-discuss.net/se-2015-134/se-2015-134.pdf

Prof Smythe concludes that "*The major normal faults which cut through the shale to the surface, a universal feature of the UK extensional basins, but absent in the US shale basins, are likely to be transmissive to groundwater"*

Modelling estimates this transit to be in the order of one hour to hundreds of days for gas transit, and from less than ten to a thousand years, in the case of liquid.

But the relative lack of US case histories is due to the fact that the US shale basins do not have through-penetrating faults connecting the shale at depth to the biosphere. In contrast, there are many examples of groundwater and air pollution arising from faulty wells (e.g. Osborn et al. 2011)

Faults are the principle avenues for oil, gas and fluid migration and need to be avoided by wells wherever possible. This is a key safety requirement for the design and location of a well intended for high volume fluid fracturing.

The default position in the hydrocarbon industry is that **faults are leaky unless proved otherwise**.

So how far away should the well be from a fault? CUA/INQ/7

This is the question that you Madam, asked in week 1 and Cuadrilla gave only a partial answer in CUA/INQ/7.

They do start by saying that there is no prescribed or set safe distance, then discuss the ways they hope to mitigate seismicity, and end by stating the distance of RW, from faults at ground level (3km) and at depth.

They do not give any information on these distances for PNR, which is actually much closer to a fault, being only 1.5 km away from the Thistleton Fault (page 21 of CD5.11).

Nor can I find the distances along the lateral between a fault and the fracking stages at PNR. (I have asked the question.)

And they *totally ignore* the possibility of a fault acting as a conduit. In fact they seem to have taken the view throughout the ES that this cannot happen.

Regarding *'there is no prescribed or set safe distance*, true but the advice/research is as follows:

- A desk study shows that there are over 50,000 horizontal fracked wells in the USA but only 20 or so have the drill pad within 5km of an outcropping fault, so the US does not have the potential problem of contamination of groundwater by upwards migration of fluids via faults.

  Therefore Prof Smythe advises that there should be at least 5 km between a well pad and a fault.

At only 1.5km away from the Thistleton Fault, the well pad at PNR is far too close to a major fault.

- Professor Styles advised the Govt last year that there should be a 'respect' distance, an offset, along the lateral well, between a fault and the nearest HF stage. He told me that 900m/1 km was the absolute minimum, (but possibly the minimum should be up to 5 km or more is not known), and he was going to advise the Government of this.

However at PNR, the fracturing stages will be much closer to the faults than this absolute minimum. (see diag in ES page 347)

So Cuadrilla are ignoring advice on suggested safe distances.

The industry avoid faults, and design the lateral section to run *parallel* to the fault plane - as discussed above, it is very challenging to steer the drill bit through the fault, and faults can cause cement bonding problems.

However the well pad is too close to a fault at the surface and both the horizontal and vertical wells at PNR will be drilled straight through fault planes, and too close to them, according to current research advice.

This is flying in the face of industry wisdom.

I was told at a Cuadrilla roadshow '*It is to see if they can.'*

Nature of the exploration practice as allowed by the DECC:

A petroleum geologist of 35 years' experience with Shell, has told me that a Good Exploration Practice has a 5 year plan in place, before fracking starts, of research and seismic and taking core samples, where each stage is independently evaluated.

Cuadrilla did at one point have plans for an exploration well (not to be fracked) at Clifton, which would have enabled them to correlate the actual geology with their seismic survey; and allowed them to find out more about the volumes of gas present and how readily it would flow. However this plan seems to have been dropped.

The industry tells me that any resource assessment programme should have **prescribed** steps that evaluate the potential resource in a way that minimises the risks to health, safety and the environment. And the steps of this Work Programme should be independently audited.

For example:

If permission had been granted to drill a vertical well, it is then drilled, sampled and logged, and there would be a long period, *up to a year*, when this new data is incorporated into the subsurface model.

A proposal could then be made to drill a deviated well from the vertical and permission would only be granted when independent technical advisers were satisfied that all the risks had been evaluated. (eg faults) .

Data from the deviated well leg is then gathered, analysed, in particular for where the well bore has penetrated any "unknown" faults, and used to update the subsurface model.

Based on this update, then permission *is separately* sought for perforating sections of the cased well bore that avoid all the faults in preparation for a HVHF pilot test.

Cuadrilla is not going to do this necessary research - they plan to drill both legs quickly and to frack immediately afterwards.

The current DECC License policy is non-prescriptive, so even before the drill hits the ground, the councillors at LCC cannot be 'satisfied' with the regulatory framework.

So what is the nature of the review process for the well in relation to the geology ?

Geological Review

If this were a structure above ground, then everyone could visualise it, independent architects and building engineers could review it and comment. But it isn't, it is a well that is being sunk through complex geology, and will interact with it. It requires an independent specialist, to review the plans in relation to the geology and faults.

- The DECC is not involved in proposals for the location of wells or the acquisition of geophysical data, nor is it independent.

- The HSE review the well design, and the DECC review the hydraulic fracturing plans .According to the ES
  " A Hydraulic Fracturing Programme (HFP) will be submitted to DECC for review and approval after drilling is completed and before any fracturing starts. DECC require the HFP to include: A map showing faults near the well and along the well path, with a summary assessment of faulting and formation stresses in the area and the risk that the operations could reactivate existing faults;
  But neither body is independent and seemingly neither do this in the context of the seismic survey.

- The BGS hold cores, well logs, the 3D seismic survey results and are capable of carrying out a review of the plans. I asked Prof Stephenson if the BGS had such a role but he said "*No. We aren't a licensing or regulatory body. We're a science institute. "*

A county council planning department, as MPA, has to decide if the application is based upon sound geological data and interpretation.
It is unlikely that county councils have the in-house expertise to make such judgments, or time and resources to employ a specialist,
If they did they would be able to establish more of the queries that needed to be answered before giving permission. They would know what is missing from plans or being hidden.
However they have to rely wholly on what the applicant chooses to present, and this can be flawed.

Regulatory Review

In Feb 2015 Andrew Quarles of Cuadrilla said that there is over a million gallons of fracking fluid left below ground in the damaged Preese Hall well and *"No one know exactly what is going on or where the water goes or where the final resting place is".*

Given this information, the EA has issued a permit which does not comply with the EU Mining and Waste Directive.

In Alberta the State's Energy Board records - for all wells - the design and life history of the wells and in particular the results of tests on integrity, that are done before abandonment. The research paper says that a certain % of wells do leak (full integrity failure, rather than well barrier failure).

The UK does not seem to have any equivalent database of wells or tests to aid the design approvals, (and the HSE and EA certainly are not checking for leaks in the long term after the well has been abandoned.)

So the MPA cannot be satisfied by either the EA or HSE regulatory agencies before (or after), commencement of operations.

Independent Review

In order to have a transparent and independent review process, as for a structure above ground, information has to be available publicly. However this is not the case.

The 3-D seismic is confidential, the well design is confidential and the Hydraulic Fracturing programme is confidential.
Even the depth of the 2 legs of the well at Grange Hill has been withheld for 4 years; it became available only a few days ago.

So it is impossible for an independent specialist (say from the industry or from a science institute) to review, the info is commercial–in-confidence, there's no transparency

And very hard for an individual to establish any of the detail of what has happened, questions are often either ignored, or are only answered by government 'spiel'.

Other Observations

(1) PI note on site selection CUA/INQ/11

Refers to the' high-graded geology' but there is no evidence provided, nothing to back up this claim.
They describe these 2 sites as 'the most suitable geology for initial exploration wells'.
Which begs the question that if these are the best sites, the others are less good - worse geology apparently, and less gas?
So how and why would they want to continue?

(2) Industrial site on coast

Speakers for Roseacre and Treales have suggested that Cuadrilla could site the pads on an industrial area of the Fylde coast, and using long laterals would be able to access gas under all of the Fylde.

This idea is completely mistaken, it shows a lack of understanding of the complex Fylde geology, and complete ignorance of the difficulties and risks inherent in drilling through even minor faults.
(This idea would necessitate drilling through a major fault - the Thistleton Fault.)

If this was a viable option, Cuadrilla would surely have taken it.

(3) Missing information

When I spoke to LCC Feb 2015, re a planning application for the Grange Hill well, I commented there was very little detail given – of the faults or the well, and that it did not say in which of the two wells GH1 or GH1Z, the testing would be carried out. A councillor queried the two wells of which I had proof on the DECC wells spreadsheet https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/466843/LANDWELLS9Oct2015.xls but Mr Perigo the planning officer, had been kept in the dark by Cuadrilla and told the Development Control Committee that I was wrong, that there was only 1 well.

When Mr Hopwood asked Mr Matich about the problems with this well, at this Inquiry, Mr Matich dodged the question, saying only that the well reached Total Depth.

I have since received a letter from the DECC, (see attached), giving the depths of these 2 legs : *Grange Hill 1 was drilled to a total measured depth of 6478 ft (6400 feet true vertical depth) …Grange Hill 1Z was drilled from this point to a total depth of 10775 ft measured depth (10709 feet true vertical depth).*

So it was the second well, i.e. Cuadrilla's second attempt at drilling here, that achieved TD.

I have been unable to establish exactly why they had a problem, though there do seem to have been problems because of the geology. And have asked DECC on two or three occasions : *Do you know what caused the problem at Grange Hill that necessitated the drilling of a second leg e.g. was it equipment or the geology?* (*If covered by confidentiality when will it be released and by whom?)*

It shouldn't be down to ordinary people such as myself, to chase DECC to find out what Cuadrilla have hidden from LCC and the Inquiry.

I note that the lack of a geoscientist available to LCC, allowed Cuadrilla to hide the existence of the 2nd well from the Planning Officer, and they are being evasive with you too.

Summary

- A structure above ground, multi storey car park, shopping mall, can be pulled down in 30 years and the land and environment will be restored - as if it had never existed.

  When a well is abandoned it is not 'restored' as the QC suggested, yes the well is capped off and yes the farmers field will look the same as it did before, but below ground the well is there forever with the fluids, now released from the shale.

  The EA analysis of the flowback fluids at Preese Hall showed it contained heavy metals (including lead, arsenic, chromium, cadmium) and naturally occurring radioactive material.

  http://webarchive.nationalarchives.gov.uk/20140328084622/http://www.environment-agency.gov.uk/static/documents/Business/6th_Dec_-_Shale_gas_-_North_West_-_Monitoring_of_flowback_water_-_update_(2).pdf

  Because of the faults in the Fylde this fluid, poses an inherent risk to groundwater, which could take decades to travel to the surface.

  If the groundwater becomes contaminated then it cannot be undone, it is not 'reversible'.

- There is no possibility of independence in the review process and there is little overall subsurface review.

- The operator has not been open with LCC or indeed you at this Inquiry.

- There is insufficient geological information provided in the application to allow you or an MPA to proceed

- When I was at university I was taught that you *Survey first, drill last.* But Cuadrilla didn't do this, they drilled 4 wells and fracked one of them before doing/having to do, a 3D seismic survey.

If I know to survey first, then they do too, they took a chance, a risk and it rebounded on them.
They are continuing to take risks, e.g. not doing Clifton well, and not taking the time and steps necessary to prove to you or themselves that their borehole prognosis is justified, at PNR, they have not followed 'good industry practice'.

- More sophisticated seismic imaging methods need to be developed for onshore, e.g. to identify faults in shale with throws as small as 4-5m. We need to bring it up to a similar standard to that of marine 3D seismic.

- Everyone I have spoken to – even academics who are in principle pro-fracking, have expressed a concern about some aspects: regulation, geology, geography, competence.

- In 2011 the University of Montpellier-2 published two explanatory documents on the risks of potential fracking in the south of France and as a result France banned shale fracking of shale in July 2011, and in October of that year cancelled all the unconventional exploration licences.
  A large German study of the environmental risks of fracking advises that the **method be banned from use i**n any area which is faulted.

- Simon Toole, Head of Licencing at DECC, has worked in the industry and after a meeting in StA in2012, he told me that the risk to be concerned about is of ground water contamination. (which could be via Faults and Engineering failures too)

- The overwhelming message from scientists is that this is a new industry and they are eager to study it, and the message from industry professionals is two-fold : accidents happen and Cuadrilla has gone about this exploration in completely the wrong way,

- The BGS have recently announced a programme of monitoring to characterise and quantify the risks *for the future.*
  In other words we don't yet know what all the risks are, so cannot mitigate yet them. An example of this is the seismicity at PH – it was completely unexpected.

- And the EU has just commissioned scientists at Edinburgh University to conduct further studies into the risks associated with hydraulically fracturing.
  http://www.ed.ac.uk/news/2015/fracking-121115
  They say : "***The risks associated with shale gas recovery by fracking are to be assessed in a new project by EU scientists.***
  "Experts say existing regulations for oil and gas recovery are not suited to fracking.
  Regulations specific to the emerging technology should be developed, they add.
  Scientists will make recommendations to EU member states to develop legislation that mitigates the likely impacts of gas exploration and recovery"

Conclusion

A Global Environmental Quality Manager for fracking sites, now retired and living in Lytham St Annes, told me that spills are a key risk, both on and off site. He spoke of the risks of spills and explosions and asked if the Fylde had an Evacuation Plan?

He was shocked when he saw the PNR site, saying *he did not know of anywhere in the world that fracking would be carried out in such a location*.

And at a personal level, that is more than enough for me to ask you to turn down this appeal.

Construction of a well is a complex engineering task and the consequences of getting it wrong can be significant.

Cuadrilla have had serious problems with all 4 of their wells (geological, technical problems) and these vertical wells are relatively simple to construct, compared to the horizontal wells they are proposing. How can we reasonably expect them to construct the much more complicated horizontal wells, without further serious problems?

No horizontal (lateral) wells in shale, have yet been fracked in the UK using high volumes of low-viscosity water under extremely high pressures, a treatment termed 'super-fracking' (Turcotte et al.) This would be a first.

No industry is risk free; and Geology and Geophysics cannot be controlled or regulated. So it is **vital** to minimise these risks.

Despite this, Cuadrilla are proposing to drill through a fault in 2 places at PNR, both the vertical and horizontal wells will go through a fault, and they propose to frack close to the faults.

Prof Styles advised the Government that there should be a **minimum** distance of approx. one km between fracking and a fault, but Cuadrilla plan to frack within that 1 km,

and Prof Smythe advises that there should be at least 5 km between a well pad and a fault, but there is only 1.5km.

This must not be allowed.

We need a proper understanding of the geology here which can only be achieved by an independently verified period of detailed seismic investigation and interpretation *prior* to any drilling, and then wells drilled to verify the new interpretation *all before* any exploration and exploitation takes place.

In order to minimise risks to health safety and environment we need much better regulatory control.

You are being asked to make a decision on a new industry with inadequate geological information, and with inadequate assessment of the risks

So I believe that you must refuse this appeal.

Figure 2 Bowland Shale[1]

[1] The photo (Figure 2) appeared in the DECC Bowland shale report: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/226874/BGS_DECC_BowlandShaleGasReport_MAIN_REPORT.pdf