FACTS ABOUT FRACKS: RESEARCHING FRACKING IN EUROPE

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INTRODUCTION

If the biggest talking point of UK energy in the last two years can be summed up in a single word, it's probably "fracking". The process of creating permeability in rocks by injecting fluids into them at high pressure, hydraulic fracturing (to give fracking its proper name) has been employed in oil and gas production for many years. However, the technique has come to particular attention during the recent shale gas boom in North America.

Shales (Figure 1) are sedimentary rocks that have been formed by mud accumulating over millions of years and then slowly buried and compressed. If the muds contained a lot of organic matter (the remains of plants and animals) this can be turned into oil or gas during burial. However, as shales are so fine-grained, these hydrocarbons cannot easily escape from the rock. To extract the oil or gas economically artificial permeability must be created, which is where fracking comes in.

... environmental impacts of fracking fluids and shale gas ...

As the first fossil fuel of the internet age, shale gas has attracted plenty of controversy. Many aspects of its discovery and exploitation have provoked public concerns, so it is crucial that scientific research into these topics is carried out. The ReFINE (Researching Fracking In Europe) project, an independent research consortium led by Durham Energy Institute at Durham University, focuses on the risks associated with shale gas and oil exploration and exploitation. These range from whether fracking can cause earthquakes or subsidence, to what the environmental impacts of fracking fluids and shale gas emissions might be.

... recent shale gas boom ...

The first three peer-reviewed studies by the ReFINE team have examined the vertical distance that hydraulic fractures can propagate, the likelihood and magnitude of earthquakes caused by fracking, and the long-term integrity of shale gas wells.

HOW FAR DO THE FRACTURES GO?

Our research into hydraulic fracture propagation (http://refine.org.uk/media/488 6/hydraulicfractures.pdf) shows that natural hydraulic fractures can extend upwards more than 1 km (see Figure 2). However, the maximum vertical distance recorded for a *stimulated* (man-made) hydraulic fracture is 588 m (Figure 2), and our calculations indicate that there is a <1% chance of a stimulated fracture extending vertically more than 350 metres.

Figure 1

Since gas-bearing shales and drinking water aquifers are usually separated by more than 1 kilometre of rock (Figure 2), it is very unlikely that fracking itself

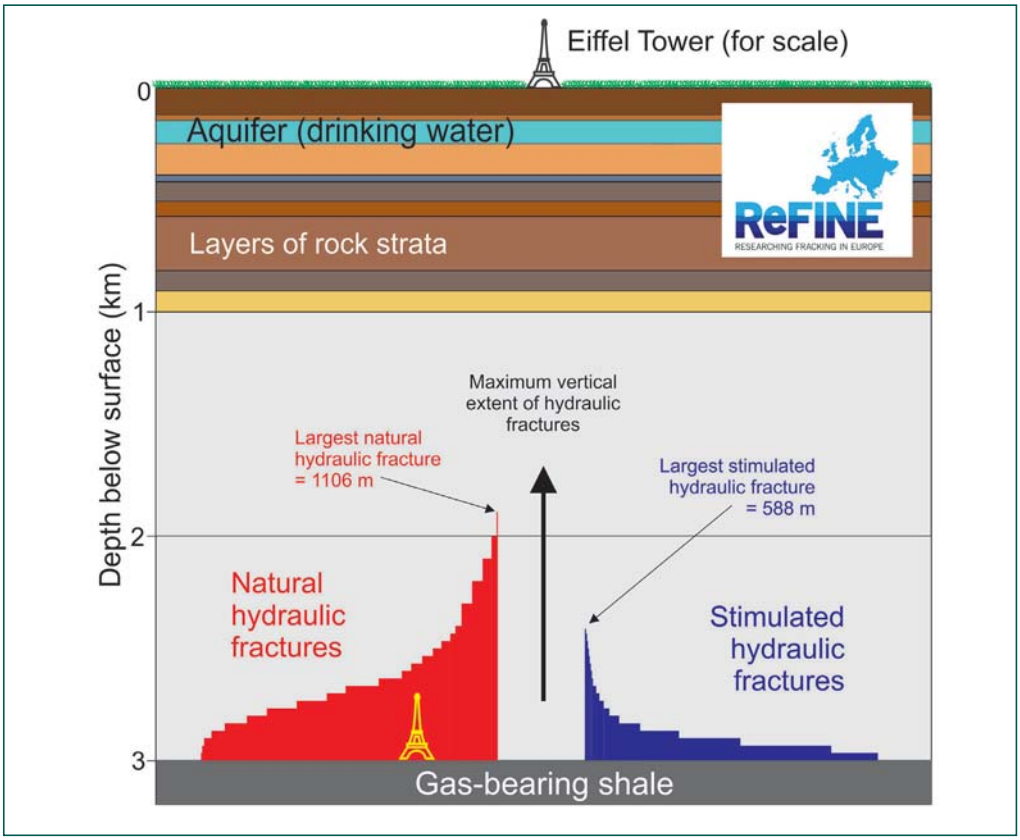

Figure 2

could create a pathway for water contamination. Nonetheless, it is crucial to understand the structural geology of areas in which shale gas fracking is proposed. It would also be wise to impose a minimum separation distance between shale gas intervals targeted for fracking, and the groundwater aquifers above them.

CAUSING EARTHQUAKES

Earth tremors and quakes are referred to collectively as seismicity, and occur when a geological fault moves suddenly. Seismic activity in a region reflects the structure of the Earth's crust there, and the stresses being applied to it. If human activities cause a dormant fault to move this is described as 'induced seismicity'.

One of the commonly raised concerns about fracking is the possibility that it could cause earthquakes that would be felt at the surface. Members of ReFINE carried out a global review of published data on induced seismicity (http://refine.org.uk/media/4883/inducedseismicity.pdf). This showed that although fracking has caused earthquakes, they are much smaller in magnitude than those generated by other human activities, such as mining, reservoir impoundment, and conventional oil and gas extraction.

The likelihood of hydraulic fracturing causing felt seismicity is very small, though it is possible that fault reactivation during frackng might cause induced seismicity larger than that recorded to date. Again, a fuller understanding of shale geology can further mitigate against this risk. DECC has also proposed a traffic light monitoring scheme. If shale gas sites record seismicity of magnitude 0.0 or less, fracking can continue (green). If seismicity between 0.0 and 0.5 in magnitude is recorded, fracking can only proceed with caution and increased monitoring (amber). If a magnitude of 0.5 is exceeded, fracking is immediately suspended (red).

WELL LEAKAGE

The long-term integrity of shale gas wells is something we examined in our most recent study (https://www.dur.ac.uk/resources/refine/Publishedversion.pdf). To reach shale gas target horizons, wells have to be drilled down through groundwater aquifers. To prevent hydrocarbons leaking out from the well, barriers such as steel casings and cement are added. If one of these barriers fail, this is termed a *well barrier failure*, but hydrocarbons might not escape as a consequence. However, if all the barriers fail, this *well integrity failure* could create a pathway for pollution and contamination.

Data from the USA indicate that a small percentage of shale gas wells leak, so it is very important that there is assessment of wells, both during their lifetime and after abandonment. Results of such monitoring should be made publicly available, and the appropriate financial and monitoring processes should be put in place, particularly after well abandonment, so that legacy issues associated with the drilling of wells for shale gas and oil are minimized.

CONCLUSIONS

Research by the ReFINE consortium is funded by the Natural Environment Research Council, Shell, Total, and Chevron. The project has an Independent Science Board, led by Professor John Loughhead of the UK Energy Research Centre, to ensure that research is accurate, relevant to the public interest, and free from industry bias.

Current ReFINE studies are examining the risk of subsidence in shale gas sites, methane leakage, and the quantity of radioactive materials occurring in fluids that flow back to the surface after fracking. When it comes to determining what the true risks of fracking are, such scientific research carried out by independent academic experts is crucial. From there, informed decisions can be made on the basis of scientific evidence.

... Results of such monitoring should be made publicly available ...

For more information on the research being carried out by ReFINE, and for resources such as videos and research briefs, visit www.refine.org.uk/research.aspx

SEPARATING FACTS FROM FANTASY IN THE SHALE GAS DEBATE

Huw Clarke
Senior Geoscientist, Cuadrilla Resources

It's been fascinating, and occasionally infuriating, to watch the debate around hydraulic fracturing develop in the UK during the last 18 months.

Cuadrilla has often found itself at the forefront of this debate. Last summer, for example, our exploratory site at Balcombe was surrounded by protesters, many of whom seemed to believe we were about to start fracking for gas within shale rock. In fact, we drilled a 2,700ft exploratory oil well through limestone.

Subsequently, our **actual** plans to undertake exploratory hydraulic fracturing for shale gas, 250 miles away in Lancashire, are attracting considerable interest, as we do our best to separate facts from fantasy.

... focusing our efforts on community engagement ...

Unfortunately, the residents of Lancashire and Sussex, along with people across the UK, have been subjected to a vociferous spread of misinformation from anti-fracking activists.

One of the most famous examples concerns the misleading Gasland documentary, which has been shown many times on TV. One section features Mike Markham from Colorado setting light to his tap water. The State of Colorado's investigation concluded that Mr Markham, in sinking his water bore-hole, had inadvertently drilled his very own coal bed methane well.

... separate facts from fantasy ...

More recently, we have seen outrageous claims that hydraulic fracturing can cause cancer or pollute drinking water, despite the utter lack of evidence to substantiate a single verified case from the hundreds of thousands of fracked wells around the world.

This is not to say there are no concerns with shale gas, rather that we should form opinions from peer-reviewed facts, instead of relying on sensational "most viewed" You-Tube clips or ill-informed scaremongering.

Looking ahead, the primary focus for Cuadrilla is continuing exploration work within the Bowland Basin and specifically our 1,200km^2 licence area in north-west England.

In February, we announced our intention to apply for planning permission to drill, hydraulically fracture and test the flow of gas from up to four exploration wells on two sites – one at Preston New Road and the other at Roseacre Wood. Since then we have been focusing our efforts on community engagement and consultation as well as preparing an Environmental Impact Assessment for both sites.

Separate applications will also be made to install two seismic arrays that would be used to monitor the hydraulic fracturing process. Seismic activity above the level of 0.5 magnitude (m), which can only be detected at surface by extremely sensitive equipment, will mean fracturing jobs will be halted; immediate flow back of the fracture water will commence alleviating the stress on the rock. This traffic light system in place for seismicity provides confidence that any seismic events created by our engineering works will be

far below the threshold of even superficial structural damage and further more greatly decrease the likelihood of detection from human perception.

The Bowland Basin is one of a number of lower-carboniferous (320 million years old) extensional basins that lie onshore within the UK. Compared with similar basins such as the Gainsborough Trough or Edale Gulf, the Bowland Basin has undergone deeper burial and greater inversion meaning greater thermal maturity pushing the rocks further into the gas window. Cuadrilla was drawn to the Lancashire region by a combination of large open acreage, a small unconventional producing gas field (Elswick) and the rather more substantial East Irish Sea gas field. The gas in Elswick and that in the East Irish Basin have long thought to be sourced by the deeper carboniferous Bowland Shales. The Elswick 1 well, drilled in 1990, is of great importance to the hydraulic fracturing

... water aquifer contamination ...

discussion. It is one of a number of onshore gas wells within the UK that have undergone hydraulic fracturing treatments and have shown to be a productive safe gas well with no adverse effects. Opponents of shale gas often state that hydraulic fracturing is a poorly understood new technology, it is important to note that the first commercial fracturing treatment was carried out in 1947.

At community engagement meetings, by far the most frequent question I am asked is with regard to groundwater pollution. This covers a wide range of misinformation with the most common being that hydro-fractures will grow from the depth of the gas reservoir all the way up through the crust into the water aquifer. I will address this assertion head-on as it needs to be put to bed.

... great importance to the hydraulic fracturing discussion ...

Geo-mechanical theories disproving this concern are robust. They include the energies required to make such a gigantic fracture height, the rocks layers that act as fracture growth barriers containing vertical height growth, and the fracture evolution direction, which is controlled by maximum stress direction. These are peer reviewed accepted theories but anti-scientific anti-fracking blogs often claim otherwise. We hope that with micro-seismic imaging showing fracture evolution during fracturing operations we will physically demonstrate the true reality.

As an industry we do not deny that water aquifer contamination can occur as a result of drilling oil and gas wells, but these cases are few and very far between. But it is lack of well bore integrity that leads to water contamination by thermogenic gas, not the process of fracturing. Well bore integrity is critical to all oil and gas wells (hydraulic fractured or not); poor isolation of the gas zone can result in gas channelling to a water aquifer. Cuadrilla spends a vast amount of time on ensuring well integrity to mitigate any water contamination. As a control we drill three to four shallow monitor wells around the perimeter of the drill pad prior to drilling for shale gas, monitoring background levels to ensure methane in ground water remain unaffected by our operation.

Other concerns include toxic chemicals mixed in with the fracture fluid, the use of large quantities of water, flow back water, land subsidence, negative property prices, air pollution, increased traffic volume, noise and light pollution from the drilling itself. One concern, raised at a recent public meeting regarded the risk of damaging the geopathic stress of the earth, left me perplexed. As a scientist it is not easy to accept that the feng shui of the ground should be a determining factor! These concerns amount to a great deal of anxiety attached to shale gas extraction. A benefit from the US experience is most of those anxieties that are valid have been addressed and solutions found which we in the UK have already adopted.

Cuadrilla's approach to public concern is one of openness and transparency. Our public information evenings in Lancashire countryside work well to allay residents' concerns, empowering local people with real information regarding Cuadrilla's operations. Time spent listening to concerns and explaining our operations is time well spent.

The benefits from shale gas are obvious: employment, taxes, lower gas prices for a greener natural gas compared with what we currently import and most importantly, security of supply. The challenge lies not in the extraction of the gas or the environmental management as solutions are already in place, but rather persuading the communities in which we work that the industry can be trusted.

... benefits from shale gas are obvious ...

From the opinion polls we've conducted in Lancashire, we've found that most people have open minds when it comes to shale gas exploration. It's crucial that we continue providing local communities with as much information as possible concerning our plans, so they can make decisions on facts instead of rumours.