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ReFINE Briefing Note

Fracking and aquifers: how far up can a frack go?

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This research brief is based on the review article: 'Hydraulic fractures: How far can they go?' by Richard J. Davies, Simon Mathias, Jennifer Moss, Steinar Hustoft, and Leo Newport, published in Marine and Petroleum Geology, 2012, and available for free download at www.refine.org.uk

Hydraulic fracturing, better known as 'fracking', is a process in which rocks are deliberately broken open by the injection of fluids under high pressure. The role of fracking in the extraction of shale gas and oil has generated much recent controversy and has become associated with many environmental fears. Perhaps the greatest of these is that hydraulic fractures could create a pollution pathway linking the gas- or oil-producing zone to a drinking water source. It is therefore vital to understand to what distance hydraulic fractures can propagate. Research led by Durham Energy Institute indicates that there is a less than 1 per cent chance of a stimulated hydraulic fracture propagating upwards for more than 350 m, and that the maximum recorded distance of such a fracture is less than 600 m.

What is hydraulic fracturing?

When fluids force their way through buried rocks at high pressure, cracks called **hydraulic fractures** are formed (Fig. 1). They grow, or propagate, until the build-up of pressure has been released. Hydraulic fractures can be formed naturally, by processes such as volcanic activity or the escape of water from deeply buried rocks, or artificially.

Artificial or **stimulated hydraulic fractures** are those produced by human activities, such as during injection of water into geothermal boreholes, by an uncontrolled 'blowout' of gas or oil under high pressure in an underground well, or by fracking for shale gas.

Relatively little has been published on the maximum distance a hydraulic fracture can propagate upwards, particularly in shale gas and oil systems. To investigate this, our study analysed the size of thousands of natural and stimulated hydraulic fractures.

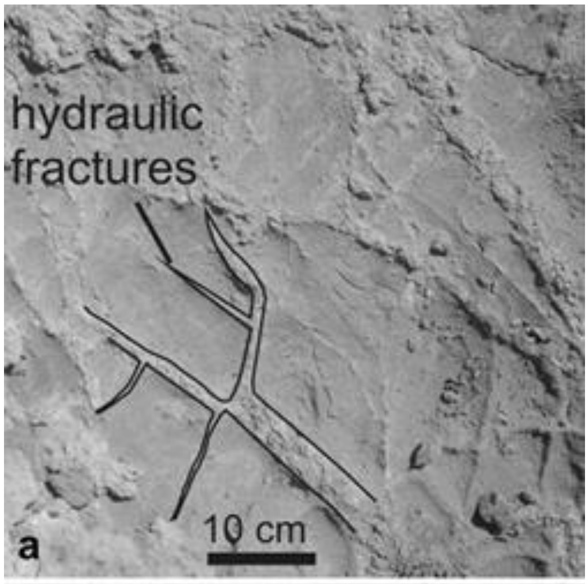

Figure 1: Natural hydraulic fractures in shales from Azerbaijan (image taken from Davies et al., 2012).

What is shale gas fracking?

Shales are very fine-grained rocks formed of compressed mud, and often contain oil or gas trapped in the pores between the mud particles. As these pores are not connected, shales have very **low permeability**. Hydraulic fracturing is used to free the trapped gas or oil. To do this, a well is drilled vertically down and then horizontally into the gas- or oil-bearing shales.

Steel casing is installed in the well and once in place water, sand and chemicals are injected into the well at high pressure. These highly pressurized fluids flow through holes in the well casing, causing millimetre- sized cracks to open up in the shales. Sand particles within the fluid then hold the cracks open. This allows the gas or oil to flow into the wellbore and up to the surface where it can be collected.

Hydraulic fractures: how far can they go?

A number of recent stories have suggested that shale gas fracking can cause contamination of drinking water aquifers. Of particular concern has been the potential that methane could get into tap water. Gas-bearing shales typically occur at considerable depths below aquifers. To assess this it is critical to know how far upwards stimulated hydraulic fractures can extend.

Our study examined thousands of natural and stimulated hydraulic fractures. For **natural fractures**, analysis of 1170 examples from offshore Norway, West Africa and Namibia showed the maximum reported height to be 1106 m (Fig. 2). For thousands of **stimulated** hydraulic fractures in shale gas fields the maximum reported height was 588 m (Fig. 2). Mathematical analysis of the datasets indicates that the likelihood of a natural hydraulic fracture extending vertically more than 350 metres is about 33 per cent. For hydraulic fractures stimulated by shale gas fracking, the likelihood of them extending more than 350 m is less than 1 per cent.

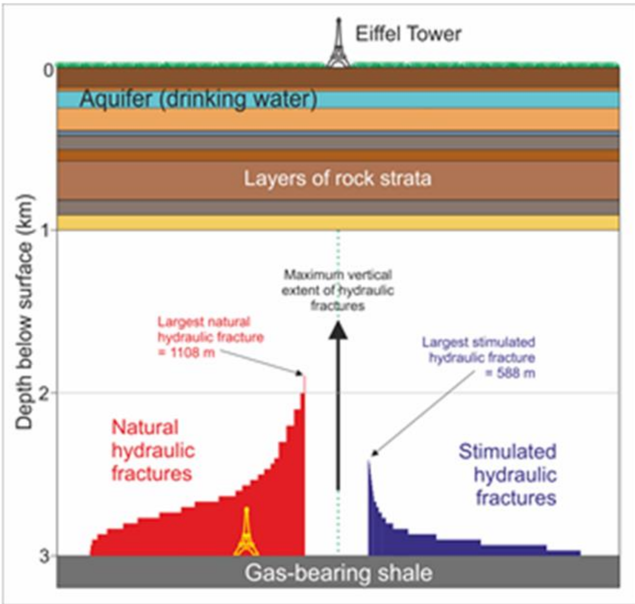

Figure 2: Comparison of the vertical extent of natural (red) and stimulated (blue) hydraulic fractures, based on data from Davies *et al*. (2012). Gas shales typically occur at depths of 2-3 km, and drinking water aquifers at 200-300 m. The Eiffel Tower is 300m high.

What can we conclude?

Based on the data analysed, natural fractures have the potential to grow upwards further than man-made ones. This is probably because they develop over much longer time scales and under the pressure of much greater volumes of fluid. The data indicate that very few stimulated hydraulic fractures propagate more than 350 metres. With drinking water aquifers typically being about 300 m below the surface, and most fracking occurring at depths of 2 to 3 km, it is extremely unlikely that a stimulated hydraulic fracture could connect the two zones.

However, our research highlights the need for caution when developing shale gas or oil reserves and the importance of geological understanding. Based on the maximum recorded height of a stimulated hydraulic fracture, regulators should consider setting a distance limit of at least 600 metres between aquifers and shale gas targets, especially in new areas where fracture data is incomplete or absent.

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