The Facts About Hydraulic Fracturing and Seismic Activity

Hydraulic fracturing is a safe, proven technology that has been monitored, researched, and studied for decades.

Hydraulic fracturing is an essential well completion technology for the development of unconventional resources, such as natural gas that is trapped in shale rock formations. It is used to create a fracture network through which oil and gas can migrate to the wellbore. Hydraulic fracturing is accomplished by pumping a mixture of more than 99.5 percent water and sand, with some additives, into dense rock formations deep below the earth's surface. As indicated in Figure 1, multiple fracture sections or "stages" are carefully targeted for controlled stimulation. This process forms a network of narrow (a few millimeters wide) and limited extent (a few hundred feet long) fractures in the rock.

Hydraulic fracturing is accompanied by microseismic vibrations that can be recorded with sensitive listening devices and analyzed with established scientific methods. Microseismic mapping is used to understand and optimize field development, well completions, and stage treatments. This monitoring produces extensive data, thus microseismic activity associated with hydraulic fracturing is well understood.

The process of hydraulically fracturing a well for hydrocarbon development has a very low risk of inducing seismic events that would be felt at the surface. While millions of hydraulic fracturing treatments have been performed over the last 60 years, there have been just a few isolated events of induced seismicity that have resulted in ground shaking, none of which resulted in damage of any significant consequence at the surface.

During hydraulic fracturing, the microseismic events are generally less than magnitude zero to one on the Richter scale as demonstrated by extensive microseismic measurements in several different shale basing in North America.

An Oklahoma Geological Survey study on seismicity near hydraulic fracturing activities concluded that it was "impossible to say with a high degree of certainty whether

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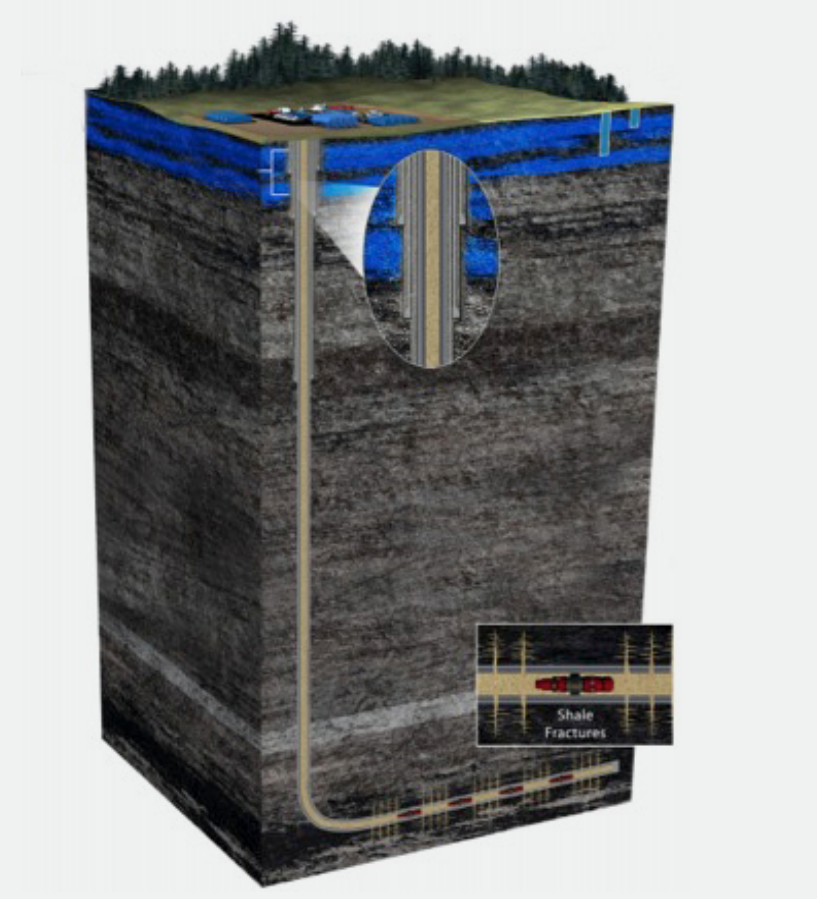
Figure 1. Hydraulic Fracturing Demonstration



A study of hydraulic fracturing related seismic activity in England in 2011 found that the combination of geological factors necessary to create a higher-than normal seismic event was "extremely rare."[1]

or not these earthquakes were triggered by natural means or by the nearby hydraulic-fracturing operation." The study did note, however, the events under examination were "small earthquakes with only one local resident having reported feeling them. The earthquakes range in magnitude from 1.0 to 2.8."[2]

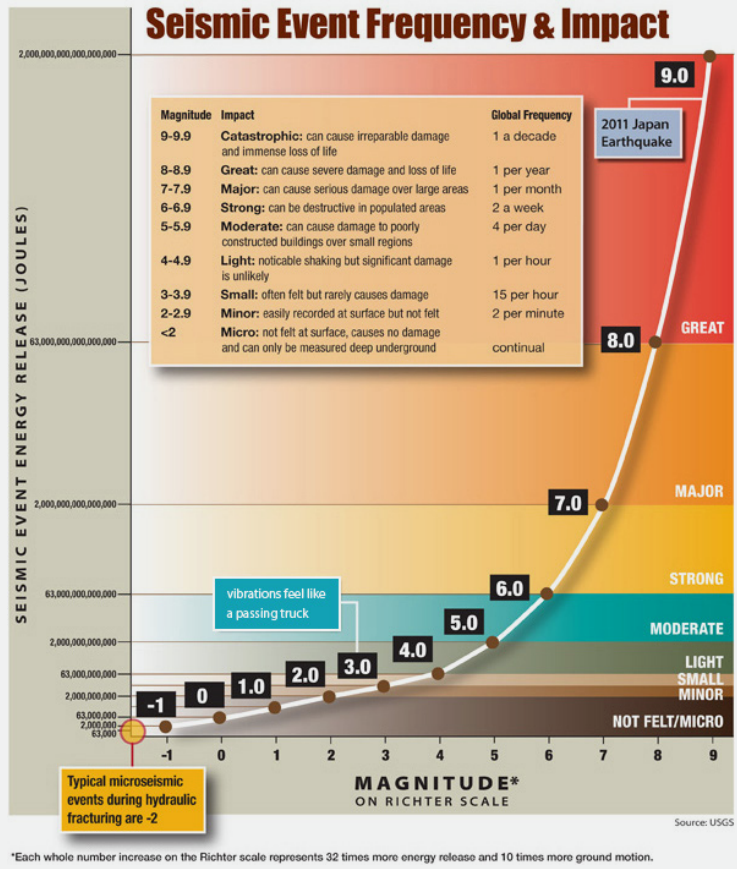
USGS estimates that there are approximately 1.3 million naturally-occurring earthquakes between 2 and 2.9 every year and an additional 130,000 between 3 and 3.9.4[4]

For reference, a magnitude three earthquake is described by the United States Geological Survey (USGS) as causing "vibrations similar to the passing of a truck."[3]

As shown by the extensive experience, seismicity induced by hydraulic fracturing represents minimal risk to humans, animals, structures or the environment. Nonetheless, the industry has made safety a top priority and invests heavily in modeling and mapping the earth's subsurface to constantly improve its understanding of fault lines and other geological structures.

Hydraulic fracturing is a safe, proven technology that has been monitored, researched, and studied for decades. Microseismic analysis has been used extensively for monitoring fracture behavior and is well-documented in the geoscience literature. The continued development of monitoring and modeling capabilities to improve the process will provide ongoing assurance of the safety and effectiveness of this critical well-completion procedure.

Figure 2. Seismic Activity Demonstration



Graphical Representation of Seismic Events as Recorded on the Richter Scale. Source: http://www.powerincooperation.com/EN/Pages/triggered-seismicity.html#sthash.XzYixVrC.dpbs.

[1] "The Geo-mechanical Study of Bowland Shale Seismicity": http://www.cuadrillaresources.com/news/cuadrilla-news/article/press-release-geomechanical-study.

[2] Examination of Possibly Induced Seismicity from Hydraulic Fracturing in the Eola Field, Garvin County, Oklahoma: http://www.eenews.net/assets/2011/11/02/document_pm_01.pdf.

[3] USGS Earthquake web site, 2012: http://earthquake.usgs.gov/learn/topics/mag_vs_int.php.

[4] USGS Earthquake: http://earthquake.usgs.gov/earthquakes/eqarchives/year/eqstats.php.