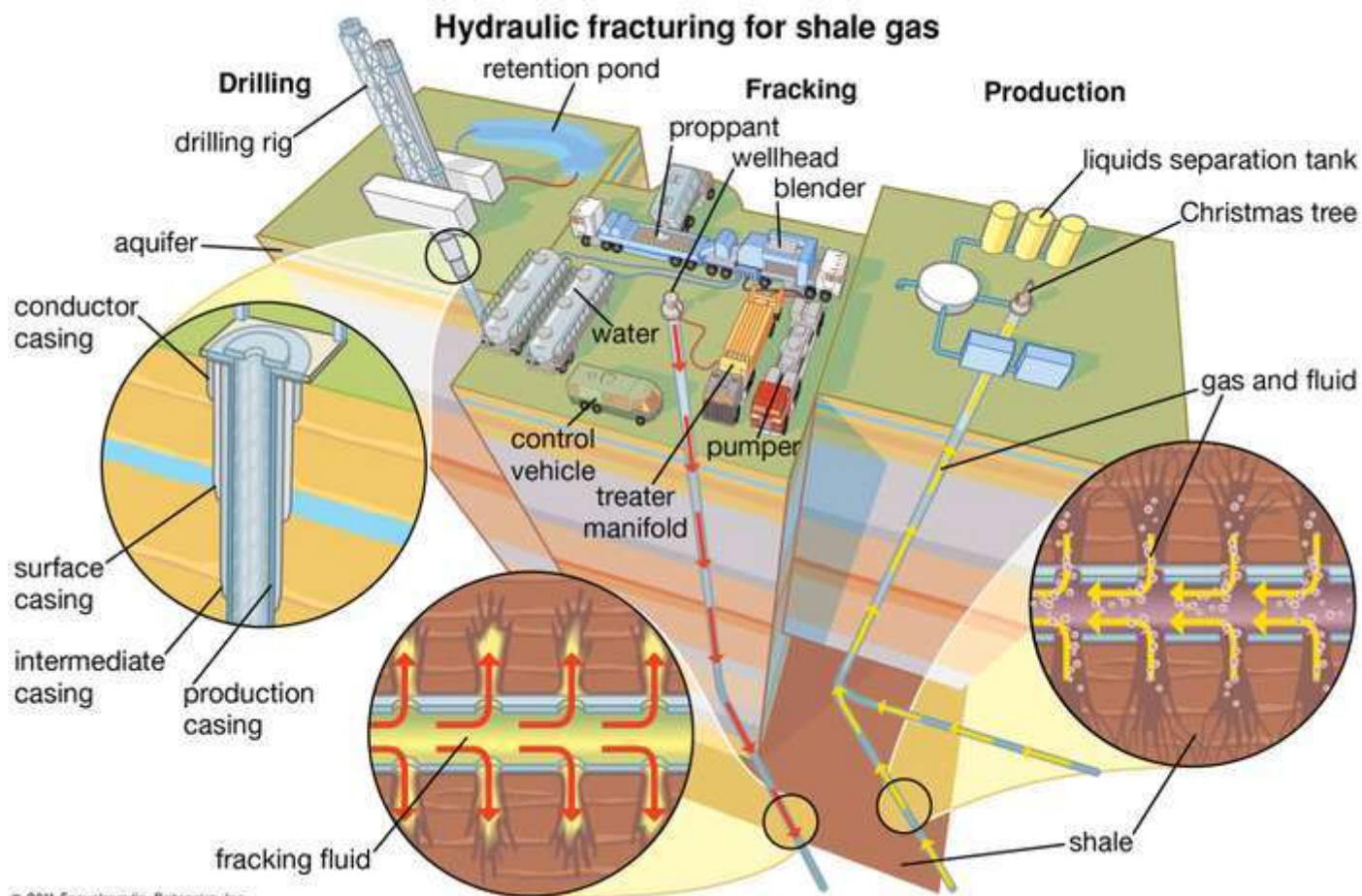


# Fracking

WRITTEN BY

The Editors of Encyclopaedia Britannica

**Fracking**, also spelled **fracing** or **fraccing**, also called **hydrofracking**, in full **hydraulic fracturing**, in natural gas and petroleum production, injection of a fluid at high pressure into an underground rock formation in order to open fissures and allow trapped gas or crude oil to flow through a pipe to a wellhead at the surface. Employed in combination with improved techniques for drilling horizontally through selected rock layers, fracking has opened up vast natural gas deposits in the United States and elsewhere. At the same time, the rapid rise of the practice, frequently in regions with no history of intensive oil and gas drilling, has raised concerns over its economic and environmental consequences.



© 2011 Encyclopaedia Britannica, Inc.

Three steps in the extraction of shale gas: drilling a borehole into the shale formation and lining it with pipe casing; fracking, or fracturing, the shale by injecting fluid under pressure; and producing gas that flows up the borehole, frequently accompanied by liquids.

## **The Rise Of A New Technology**

The technology of fracking has been in use since the 1940s, when liquids such as gasoline and crude oil were injected into poorly performing gas and oil wells in the central and southern United States with the aim of increasing their flow rate. Over the following decades, techniques were improved—for instance, treated water became the preferred fracturing medium, and finely graded sand or synthetic materials were adopted as a “proppant” to hold open the fractures. However, fracking did not enter its current modern phase until the 1990s, when the use of new steerable drill bit motors and electronic telemetering equipment allowed operators to direct borehole drilling and monitor the fracturing process with great precision. Shortly after, a market favourable for natural gas began to be created by high crude oil prices and by environmental regulations that discouraged the burning of oil and coal. In response to these conditions, developers began to open up so-called unconventional gas reservoirs—rock formations that previously had been left undeveloped because, under older production methods, they released the gas contained in them too slowly or in too small a quantity to be profitable.

Gas from unconventional deposits includes coal bed methane (gas located in the joints and fractures of coal seams), “tight gas” (gas locked into relatively impermeable sandstone or limestone formations), and shale gas (gas incorporated into dense microporous shales). Fracking has been used to recover all these gas types, but it has been practiced most prominently in recovering shale gas.

## **Horizontal Drilling**

Most gas shales are found in extensive seams hundreds or thousands of metres beneath the surface. These seams can be accessed through conventional vertical drilling, but the most productive method is usually horizontal drilling. In this technique a well is begun in the traditional way, with the auguring of a pilot hole usually some 6 to 15 metres (20 to 50 feet) deep. This is lined with a steel pipe some 40 to 50 cm (16 to 20 inches) in diameter, called the conductor casing, that is cemented into place. From there the borehole is drilled straight down, passing through numerous rock layers that may include contaminable freshwater aquifers used for private wells or municipal water supply. This portion of the borehole is lined with a cemented steel pipe called the surface casing. Depending on production needs or environmental regulations, another pipe, called the intermediate casing, may be cemented inside the surface casing.

At a predetermined “kickoff point” (in some cases above the shale formation, in other cases within it), a steerable drill bit is installed, and the borehole is turned to the horizontal. From there drilling continues within the shale, sometimes for another thousand metres or more. When this lateral section of the well is drilled, the entire borehole is lined with yet another pipe called the production casing. In many operations more than one well can be drilled from a single surface site (or “pad”), or more than one lateral section can radiate from a single borehole.

## Fracturing

Once drilling and casing are completed, the production casing down the borehole is perforated by a tool that fires a series of small, aimed explosive charges through the wall of the pipe. At the surface the drilling rig is removed, and the fracking process begins. Typically, a fleet of tanker trucks converges on the pad along with several trailer-mounted hydraulic pumpers, blenders, and chemical-storage tanks, a self-contained control vehicle or trailer packed with electronics, and other equipment.



### Colorado: gas well

Workers at the well head of a fracking (hydraulic fracturing) operation at a natural gas well near Rifle, Colorado, U.S.

*Brennan Linsley/AP*

The amount of fresh water used in fracking a single shale gas well varies greatly, depending on the size of the well and the amount of fracturing that has to be done to release the gas: industry and regulatory sources give figures that range from approximately 7.5 million to 20 million litres roughly equivalent to the water contained in three to eight Olympic-size swimming pools. Environmental groups argue that, in new areas where fracking may grow dramatically, such consumption may represent an unsustainable use of the region's fresh water.

In response, the shale gas industry insists that fracturing for shale gas consumes less water per thermal unit than is used in coal and even conventional oil production. The water is obtained from sources determined by the market and regulations—e.g., purchased from the municipal water supply, pumped from local rivers or streams, reused from previous frack jobs. Sometimes it is piped directly to the pad, and often it is stored there in steel tanks or in large, shallow ponds that have been excavated out of the ground and lined with plastic.

Using fresh water, a mixture of liquid and proppant is blended that consists of some 90 percent water, less than 10 percent sand, and 0.5–2 percent chemical additives; these latter include gelling agents, borehole-cleaning acids, corrosion-preventing stabilizers, and petroleum-based friction reducers—all combined to produce a “slickwater” judged to be right for the particular job. The precise formulas for these fracturing fluids are well-guarded company secrets, though the types of chemical compounds employed are generally known.

In a series of closely monitored operations, the fluid is pumped down the borehole and through the perforations in the production casing under great pressure, powerful enough to enlarge and prop open existing tiny fissures in the shale. Once fracturing is complete, production tubing is inserted into the well. Gas freed from the fractured rock enters the tubing and flows to the surface, where the fracking equipment is replaced by a network of valves at the wellhead called the “Christmas tree.” Fracking fluid returns along with the gas and in some cases brines from the shale formation. These liquids are diverted to the settling ponds or tanks for further treatment and disposal. A finished production site eventually may be denuded of all previous machinery and structures, leaving little more than the Christmas tree (or trees), connections to a gas pipeline, tanks for storing condensed liquids, and support and maintenance equipment. Unused settling ponds are filled in.

## **Environmental Concerns**

### **Freshwater contamination**

Gas wells are often drilled through or near aquifers, and complaints about polluted well water are not uncommon.

A typical frack job is done at depths of 1,500 to 2,500 metres (5,000 to 8,000 feet). Between the shale deposit and the floor of an aquifer (which is normally found no more than a few hundred metres below the surface) are numerous layers of rock that would prevent the infiltration of gas and liquid—though some scientists believe there is a chance, in some geologic formations, that liberated shale gas may be able to follow existing faults and fractures upward to the water table. A more likely scenario suggested by some scientists might be the diffusion of shale gas through old, disused wells that have not been adequately cased or plugged. One frequently documented cause of local pollution is defective casing in the portion of an active gas well that passes through an aquifer, allowing production gas and liquids to pass into the water supply.

In 2010 *Gasland*, an American documentary film critical of fracking, created a sensation with its footage of a kitchen faucet spewing flames in Fort Lupton, Colorado. The success of the film inspired a number of imitation videos on the Internet. Such events might indeed be traceable to drilling, which on many occasions has disturbed previously unknown pockets of gas located close to aquifers, enabling methane gas to permeate well water in concentrations higher than normal. However, such disturbances can be created by drilling of almost any kind, whether for gas, oil, or even well water. For this reason, industry officials, while conceding that drilling procedures should be held to strict standards, nevertheless insist that explosive conditions almost certainly would not be caused directly by the hydraulic fracturing of shale deposits deep underground.

### **Wastewater pollution**

Drilling and fracking consume large quantities of fresh water, and they return that water in a highly polluted state. Recovered fracturing fluid, or flowback, contains not only the original additives (some of which are carcinogenic if consumed in raised quantities over time) but also salty subsurface brines as well as minerals brought up from the formation that may include toxic elements such as barium and radium. Despite myriad disposal regulations, the handling and transport of contaminated water, additives, and sludge are inevitably punctuated by mishaps and negligence. Occurrences such as leaking pipes, breached settling ponds, and even intentional and illegal discharge into rivers and streams periodically arouse the ire of residents, regulators, and anti-industry activists over the release of pollutants into waterways.

In basins in the southern United States, where oil and gas drilling have been practiced on a large scale for almost a century, recovered fracking water is routinely transported to existing disposal wells and pumped into formations deep underground. In new areas where infrastructure for underground disposal does not exist, the water is commonly brought like any other industrial wastewater to treatment plants. This raises the issue of wastewater disposal. In most cases, treated wastewater is released into surface waters while still containing contaminants at tolerable levels set by local pollution standards. Environmental activists note that many standards do not even address some of the chemicals present in fracking water. As a result, the release of even treated wastewater that included fracking fluids may be endangering life in aquatic ecosystems. Partly in response to environmental regulations, gas producers are developing various methods for treating and reusing flowback from fracking operations.

In the United States the refusal of drilling companies to disclose the formulas of their fracking fluids is a major point of contention. Local and state laws could require drillers to disclose their formulas, but at the federal level fracturing fluid is explicitly exempted from regulation under such laws as the Safe Drinking Water Act of 1974. The gas industry maintains that regulation is unnecessary, since the chemical additives in fracturing fluid are safe and are not injected anywhere near aquifers. Environmentalists, on the other hand, question the gas industry's motives in refusing to divulge their formulas and insist that the industry will never be trusted so long as it refuses to do so.

## **Seismic activity**

The injection of recovered fracking water into underground disposal wells raises another environmental concern: human-induced seismicity. All frack jobs produce vibrations that can be detected by sensitive instruments, but on occasion a larger-than-usual number of small tremors and even light earthquakes of magnitude 4.0 or higher have been recorded in some areas where shale gas is being developed. In some cases this has led to a suspension of fracturing activity. However, a more serious threat, according to geologists, is the underground disposal of huge quantities of drilling and fracking fluid, which may alter pressure balances or even lubricate existing faults in rock formations that are already liable to slip. In some areas of known fault lines, underground disposal has been banned.

## **Regulation**

Environmental concerns such as those outlined above have called increasing attention to the practice of hydraulic fracturing, especially as its use has grown and moved beyond areas where oil and gas exploration has been practiced for generations. Nowhere is this more the case than in the Marcellus Shale, a vast and rich shale gas deposit lying mainly under Pennsylvania but also extending northeast into New York and southwest into Ohio and West Virginia—a region blanketed by the scenic Allegheny Mountains and home to consumer and environmental movements that were well established long before fracking entered the area in the early 2000s. Using records kept by the Pennsylvania Department of Environmental Protection, conservation organizations found that gas drillers in that state had been cited for violations of environmental regulations more than 1,600 times from January 2008 to August 2010. In July 2011 the New York Department of Environmental Conservation (DEC), citing concerns about freshwater use and wastewater disposal, issued a report recommending that horizontal drilling and high-volume hydraulic fracturing be banned anywhere within the watersheds supplying drinking water to New York City and Syracuse. The DEC also recommended that drilling not be allowed within a specified distance of any primary freshwater aquifer and that the purchase and drawing of water for drilling and fracturing be strictly regulated. In 2014 New York Gov. Andrew Cuomo announced a statewide ban on fracking, making New York the first state with proven reserves to ban the practice. North of New York, in Canada the Quebec Ministry of the Environment called for a halt to all fracking operations within the Utica Shale along the St. Lawrence River, pending further investigation of risks to the environment and the population.

In France the test drilling of shale formations in the picturesque southeast part of the country and in the densely populated north around Paris provoked such a strong reaction by environmentalist groups that the government was prompted to put the issue to a vote in parliament. In June 2011 France became the first country in the world to ban the exploration and extraction of gas and oil by hydraulic fracturing.