

The Drillers Are Coming

Companies and regulators are squaring off over a controversial technique that yields natural gas but threatens to pollute water supplies **BY MARK FISCHETTI**

A SINGLE, VAST SHALE DEPOSIT—the Marcellus formation, stretching from Tennessee to New York—might contain enough natural gas to supply the U.S. for more than 40 years at today’s consumption rates, according to recent estimates. Thousands of vertical wells have exploited the shale’s easy-to-reach deposits. But newer technology and improved procedures are making horizontal drilling cost-effective, greatly expanding the amount of gas that can be extracted economically.

Political pressure is increasing to achieve energy independence from overseas suppliers and to use cleaner sources such as natural gas to create electricity, which emits 40 percent less carbon dioxide than burning coal. In response, the

rush is on to capture as much Marcellus gas as possible. Drilling is expanding fastest in Pennsylvania’s extensive reserve. Only two Marcellus wells were drilled in that state in 2005, but 210 were drilled in 2008, and 768 were drilled in 2009, according to the Pennsylvania Department of Environmental Protection (DEP). And every year the portion of drilling permits for horizontal wells has increased significantly, accounting for 75 percent in 2009 and 87 percent so far in 2010. Fewer than 3,000 Marcellus drilling permits were approved from 2005 through 2009, yet “we expect about 5,000 applications in 2010,” says John Hanger, secretary of the DEP. Horizontal drilling is spreading rapidly across Europe as well.

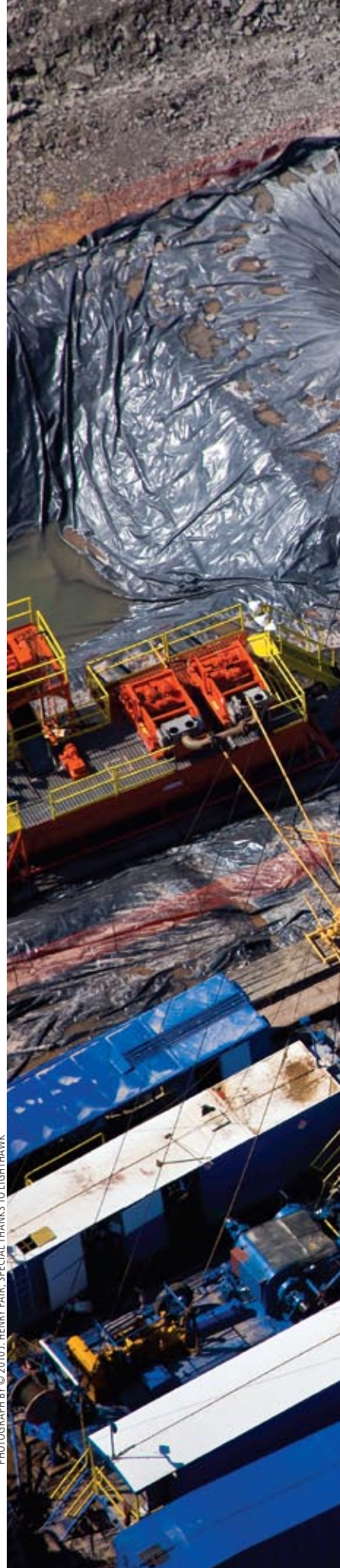
Concern is growing, too: scientists, politicians and public advocates are claiming with increasing urgency that the horizontal process—known as slickwater hydraulic fracturing, or fracking—poses a threat to the environment and people’s health. Enormous volumes of freshwater and chemicals are forced down the wells to break the rock and free the gas, and large quantities of fouled water flow back up.

Residents in states where fracking has been practiced for years have charged that gas production has contaminated air and drinking water. Investigations by state or federal agencies in

KEY CONCEPTS

- The Marcellus shale could potentially supply the country’s natural gas needs for 40 years.
- Critics claim the hydraulic fracturing process that taps the gas can contaminate drinking water supplies, prompting regulators to propose tough controls.
- Full disclosure of chemicals injected into the earth during the fracking process could ease tensions.

—The Editors



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DRILL RIG bores a hole down to the Marcellus shale under Dimock, Pa. Drilling fluid and cuttings are sprayed into a retention pond.

Texas, Colorado and Wyoming have raised anxiety. An August 2009 air-quality study in Dish, Tex., by the state's Commission on Environmental Quality found that benzene, xylene and other toxins exceeded legal limits. Isolated incidents do not constitute scientific proof that gas production is systemically perilous. On the other hand, the recent oil disaster in the Gulf of Mexico makes an eloquent case for caution. Does fracking pose too big of a threat? The answer is not clear.

HEIGHTENED SCRUTINY

SAFETY DISAGREEMENTS between industry and citizen groups boiled over into national news earlier this year. Because the Marcellus formation underlies the watersheds that supply more than nine million people in the New York City area and another 200,000 upstate in Syracuse, the New York Department of Environmental Conservation announced in April that it would require drilling applicants to meet tough, site-specific environmental reviews—procedures that would be so time-consuming and costly that industry would walk away. “We’re not going to go to New York because of that,” acknowledges Mark D. Whitley, a senior vice president at Range Resources in Fort Worth, Tex., one of the biggest Marcellus drillers.

A month before the New York announcement was made, the U.S. Environmental Protection Agency had begun a two-year study of the horizontal drilling process, from site selection to the disposal of fracking fluids. In e-mail responses to questions from *SCIENTIFIC AMERICAN*, the agency writes that anecdotal evidence indicates potential adverse impacts on drinking water, but “there is a lack of scientific information to verify these concerns.” The study, the EPA notes, is intended “to resolve the scientific uncertainties.”

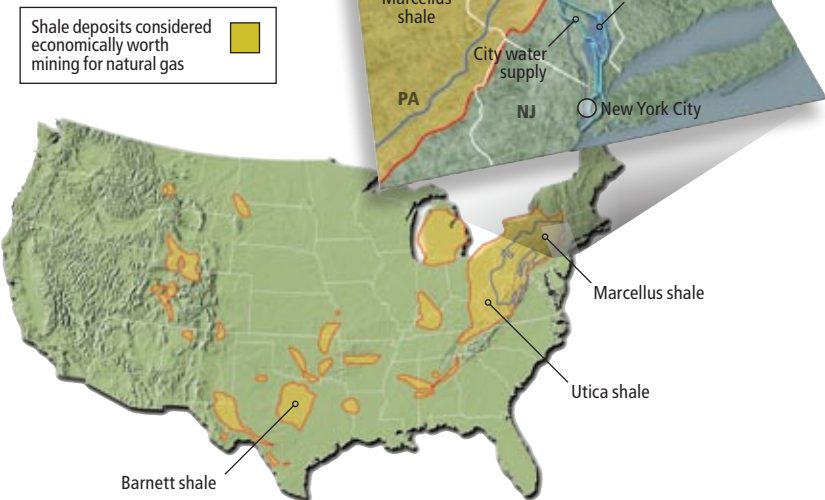
Some legislators have said the pace of land leasing and drilling should slow down until such examinations are completed. But Kathryn Z. Klaber, president of the Marcellus Shale Coalition, an industry group in Pennsylvania, says drillers will not ease up, other than possibly in New York. Whitley adds, “I don’t see the EPA study having any impact” on expansion plans.

DOWN THE HOLE

CONCERNS STEM LARGELY from chemicals used in the fracking process. After four or five acres of land are cleared, a well is drilled to the shale layer, typically 3,000 to 8,000 feet below the surface. The layer is usually only a few hundred feet

[THE RESOURCE]

VAST SUPPLY, WORRIED EYE



Huge underground shale formations (*gold*) could provide the U.S. with natural gas for years. But concerns that drilling into deposits could contaminate freshwater sources has prompted New York to fight extraction in regions of the Marcellus that underlie drinking water supplies.

thick, so the drill bit gradually turns about 90 degrees and continues horizontally through the layer for up to a mile. Steel pipe is then inserted the length of the bore and encased in cement.

Shale is fracked in stages of about 1,000 feet each, beginning at the far end of the pipe. For each stage, huge pumps force a million or more gallons of fluid through holes in the pipe at up to 6,000 pounds per square inch, fracturing the shale. Subterranean pressure pushes the fracking mixture back up the pipe; this “flowback fluid” picks up other compounds from the shale, including salts, heavy metals and naturally radioactive materials. The fluid is stored in a holding pond or tanks. Gas later rises through the pipe.

Going down, the fluid is about 99.5 percent freshwater and sand and 0.5 percent chemicals. The sand props open the fractures so gas can escape. Drilling companies use a proprietary mix of up to 10 or 12 chemicals in a well, including a friction reducer to help the mixture flow, a scale inhibitor to prevent rust, acid to clean the perforations, bactericides to kill microorganisms that can inhibit some chemical actions, and more. Among the dozen “fracturing solutions” used by Halliburton, one of the nation’s largest fracking companies, are hydrochloric acid, ethylene glycol and the bacteria killer glutaraldehyde. BJ Services’s list includes methanol and petroleum distillate blend. Although 0.5 percent

sounds small, that fraction of one million gallons is 5,000 gallons of chemicals.

Over time, five frackings would be done across the mile stretch. And up to 12 horizontal bores may be drilled from one well over several years. Ten bores, each with five stages, would require 50 million gallons of freshwater and 250,000 gallons of chemicals.

Geologists say it is highly unlikely that the chemicals could find their way up to groundwater, which typically lies a few hundred feet below the surface, because the shale is below impermeable rock. But the flowback fluid can leak at the wellhead. “The high pressures can cause malfunctions at the surface,” Pennsylvania’s Hanger says. Although the pipe is encased in cement to prevent such leaks, “the space between the wider bore and the narrower pipe is not uniform,” notes Anthony R. Ingraffea, a professor of engineering at Cornell University who has a Ph.D. in rock fracture mechanics and whose research has at times been supported by the gas industry. The bore intersects voids, fractures and cracks, “and sometimes cement doesn’t fill those features.”

It is also unclear how long the cement will last. And the drilling may cross pockets of methane, allowing the gas to rise up the borehole to groundwater. Another problem may involve leaks from poorly built or lined holding ponds. Up to 40 percent of the water and chemicals sent down the hole returns in the briny flowback fluid. “The companies are trying to do it right,” says J. Scott Roberts, deputy secretary for mineral resources management at the DEP. “But we do find the occasional individual who forgets what the priorities should be. Or a company runs short of money and does dumb things.”

CHEMICAL TRANSPARENCY

WARINESS ABOUT which chemicals are used where stems in part from a legal maneuver that excludes fracking from having to meet the “underground injection control” provisions of the Safe Drinking Water Act, which protect underground drinking water sources from contamination. The exemption, written into the 2005 Energy Policy Act, was dubbed the Halliburton loophole because it was supported by then vice president Dick Cheney, former CEO of Halliburton. In 2009 New York State Representative Maurice Hinchey introduced the FRAC Act to repeal the exemption. As of May, the act was in committee, with no timetable for action. Klaber says the legislation is pointless, “a solution that doesn’t have a problem.”

[HOW IT WORKS]

FRACK, BABY, FRACK

Hydraulic fracturing, or fracking, releases natural gas from shales. A borehole is drilled down to and through the shale, a pipe is inserted and a cement slurry is injected around the pipe to encase it. The drill rig is then removed, and rock is fractured in several stages (one of which is shown, bottom right).

The Occupational Safety and Health Administration requires a company to list on-site chemicals on a “material safety data sheet” that must be available to first responders, so if an accident occurs they can evaluate possible injuries. But Josh Fox, who produced the 2010 documentary *Gasland*, about potential health problems experienced by residents across the U.S., says in the film that gas companies refused to tell him, and abutting homeowners, which chemicals were used at particular sites.

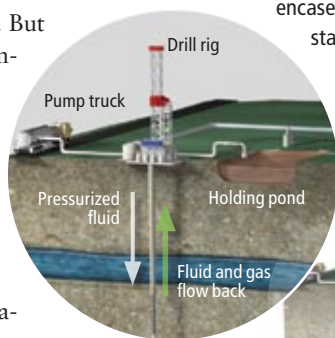
Klaber says local regulators can obtain the data sheets and can disclose that information to the public. The sheets do not list the concentrations of the chemicals, which the EPA notes “are necessary to determine toxicity.” The DEP’s Roberts says the sheets do not disclose “the recipe” of how chemicals are mixed or used: “That’s considered intellectual property.” One issue is whether mixing of chemicals or their reactions with compounds down in the shale create other compounds that could be harmful.

Even unmixed, the chemicals may be toxic. The River Reporter, an advocacy group in Narrowsburg, N.Y., sent a list of 54 data-sheet chemicals to the Endocrine Disruption Exchange for analysis. The exchange, led by Theo Colborn, a former EPA science adviser, determined that the chemicals fell into 14 categories of potential health concerns, including possible damage to the lungs, liver, kidneys, blood and brain.

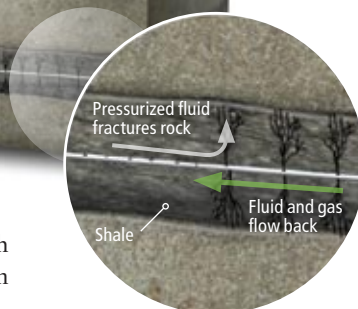
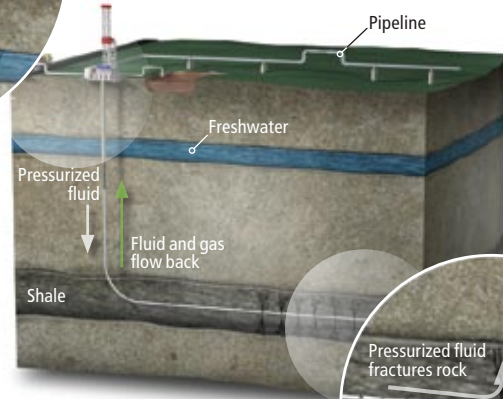
GROUNDWATER CONTAMINATION

INDUSTRY LEADERS, including Range Resources’s Whitley, point out that no cases of groundwater contamination due to the fracking process have ever been documented. Some regulators agree. Critics say that phrasing refers only to injected fluids rising back to groundwater level. They note that when the entire fracking operation is considered, including wastewater holding ponds, hundreds of contamination incidents have been documented. In Dimock, Pa., for example, the DEP cited Houston-based Cabot Oil & Gas for spilling fracking fluid and diesel.

Most violations cited by regulators do not involve fracking chemicals, however. Both the industry and the critics “are being a bit disingenuous” in their statements, says Terry Engelder, professor of geosciences at Pennsylvania State University, whose research is also in part supported by the gas industry. “New York, in particular, is being hypocritical; they are happy to heat with natural gas drilled around the water



After the rig is removed, fracking fluid is pumped down the pipe; when it returns, it is stored in a holding pond or tanks. Later, gas will flow through a well-head (not shown) into a pipeline.



For each stage, a gun blasts perforations through the cement-encased pipe. A mixture of water, sand and chemicals is forced through the holes at high pressure, breaking the rock. The fluid, and later the gas, flows back up the well.

supplies for Pittsburgh.” Hanger concurs: “Both sides are trying to win a position, and truth can be a casualty.”

The EPA study, due in 2012, could add scientific clarity. Also, in July the EPA plans to announce results of an investigation into contamination of residential wells in Pavillion, Wyo.

GOING FULL BORE

REGARDLESS OF WHAT the EPA reports say, fracking seems destined to increase. In May, for instance, Statoil Natural Gas signed an agreement to send up to 113 billion cubic feet of Marcellus gas a year, for 20 years, from Ellisburg, Pa., to Toronto. Ironically, in March, Statoil also agreed to pipe gas to New York City.

Tension over fracking will likely continue. At a May 3 forum at Duquesne University, Hanger called for a severance tax on producers to cover the cost of sealing wells that might be abandoned and to remediate other damage. Operators pay severance taxes in 28 states. Klaber warned that too many impediments could discourage more drilling in Pennsylvania, which she said created 107,000 jobs in the prior year. The industry, she says, does not want to “miss an opportunity as a country to reap the benefits that come with domestic natural gas.” The country certainly needs energy. It also needs drinking water. Whether it can have both remains an open question. ■

MORE TO EXPLORE

Riverkeeper’s watchdog Industrial Gas Drilling Reporters, covering action in New York State and Pennsylvania, can be downloaded at www.riverkeeper.org/campaigns/safeguard/gas-drilling

Information from the Marcellus Shale Coalition is available at www.pamarcellus.com

A video of Anthony R. Ingraffea explaining fracking can be seen at www.mefedia.com/watch/28577813

To track the documentary *Gasland*, go to www.gaslandthemovie.com