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Scientists find new tools for tracing fracking impacts

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Sherlock Holmes used a magnifying glass to trace a fingerprint to its source. Andrew Barron favors miniscule rust particles, millions of gallons of water and a magnet.

Researchers in the Rice University chemistry professor's laboratory have developed nanoparticles that will flow with the fluid used to hydraulically fracture oil and gas wells, slip through rocks and travel wherever the water ends up - in a holding pond at the surface, a tanker on the highway or, in a worst-case scenario, a nearby drinking water well.

The particles, which can bear unique magnetic signatures tailored to each fracking company that uses them, have the potential to clarify the troubled debate over whether and how oil and gas extraction damages water supplies.

View interactive map:

Gas Drilling Complaints Map

"Whether you are Matt Damon or the president of Halliburton, for different reasons you should be interested in this," Dr. Barron said in a lounge off his laboratory on the Houston, Texas campus early this year. "If you're worried about the environment, then for once you might be able to find out if they've really done it and who did it. If you're Halliburton, maybe this is a way of saying, 'You're right, someone contaminated your water. But it wasn't us. It was that guy.'"

Finding conclusive evidence of contaminated groundwater from oil and gas drilling broadly, and fracking-influenced fluids in particular, is a complicated task. Many of the signals of drilling-related pollution like methane, salts and metals can occur and vary naturally; most regions lack robust studies of baseline water quality that can account for fluctuations over space and time.

Scientists and some industry and environmental organizations are seeking more certain and sensitive ways to pinpoint problems or rule them out. Their efforts include testing manufactured tracers, like Dr. Barron's, that can flag pollution if it occurs, identifying natural indicators that reveal proof of a substance's origin near the surface or deep underground, and developing practices to better monitor for changes before and after drilling.

Some oil and gas companies are willing to look closer for signs of contamination because a clean record under tight scrutiny will give the public much more confidence that drilling is done safely, said Andrew

Place, the interim executive director of the new Center for Sustainable Shale Development and corporate director of energy and environmental policy at EQT Corp.

The standards developed by the center, a partnership between industry, charitable foundations and environmental groups, will require companies seeking certification to monitor surface and groundwater around their well sites regularly to demonstrate that their drilling and fracking operations have not caused an impact, instead of responding only if a homeowner raises a complaint.

"All of us want assurance, and the data to back it up, that these operations can be done without groundwater impacts," he said. "No one's served by not knowing the answer to that question."

Ions and isotopes

Scientists looking for natural tracers find them at the intersection of several key questions: What are hallmark signs of the water that flows back from a gas-bearing rock formation like the Marcellus Shale after it is fractured, or "fracked," with a high-pressure mixture of water, sand and chemicals? What is the range of natural variability for elements that occur in a region's groundwater? And what does it look like when the first type of fluid, called "flowback" or "formation water," comes in contact with the second?

"It's hard to tease out the contamination signal from the natural variability," Syracuse University hydrologist Laura Lautz said. "It's even harder to do that when you don't have the baseline water quality data."

Dr. Lautz is part of a team of Syracuse scientists working on Project SWIFT (for "shale-water interaction forensic tools"), an effort to study New York groundwater before Marcellus Shale development begins in the state. They are trying to determine the most potent combination of elements that can distinguish potential contamination from briny shale development waters from pollution caused by shallow saline aquifers, legacy pollution or salted roads. The team has found that studying the quantity and relative concentrations of chloride, bromide and iodide together can be a "very, very powerful" indicator of Marcellus formation water compared to other salt waters, she said.

The problem is that too few people test for them.

Neither bromide nor iodide is included in the Pennsylvania Department of Environmental Protection's recommended list of basic pre-drill water test parameters and they are not among the constituents analyzed during DEP's standard test for post-drilling water contamination investigations. They are also rarely included in historical data sets for regional groundwater.

While Project SWIFT is promoting bromide and iodide as useful forensic tools, the researchers are also investigating if combinations of other, more commonly tested parameters like chloride, calcium and strontium can be revealing, Dr. Lautz said. "If you include the combination of those variables, can they be as powerful as knowing one really key variable like iodide?" Dr. Lautz asked. "I think there is some potential there."

Other scientists have isolated more esoteric natural fingerprints to add precision to their analysis.

Researchers at Duke University study isotopes in water, dissolved salt and gasses for tell-tale signs of formation water or the provenance of methane bubbling at the surface. They have also found promising signals in ratios of elements to help track the sources of fluid or gas.

The strongest indicators come from using tools in combination, said Avner Vengosh, a professor of earth and ocean sciences at Duke.

"The basic chemistry of the water can tell you a lot," he said, especially distinctive ratios of chloride, sodium, bromide, barium and sulfate. "We are trying to develop more novel tools that give more perspective."

Unlike regulators, who generally gauge impacts based on whether substances in drinking water rise above advisory limits set for safety or taste, researchers are looking for subtler indicators.

It is "absolutely" possible to have detectable contamination without any chemical parameters in the water rising above safe drinking water limits, Dr. Vengosh said.

"Good monitoring systems actually identify it at that point," then track any changes, he said. "The way to do monitoring is to be able to identify it in the early stages before it becomes dangerous."

Tracing problems

While some researchers are finding that signs in the water reveal its contamination, others hope to tag the contaminant then engineer a way to trace it.

The process developed by Dr. Barron and his colleagues requires running water through a membrane system to concentrate enough of the rust particles to identify them. The collected particles are then sorted in a magnetic separator and analyzed to find the distinctive signature that distinguishes one company's tracer particle from another.

The process will be tested by an oil and gas company working with the researchers to determine how long after the particles are first injected underground they can still be detected in the water that returns to the surface.

The "limiting factor is time," he said of both his and other proposed benign tracer technologies. "The longer you are away from the time of injection, the longer it's going to take you to sample enough water to get the small amount of material that would tell you whether it's there or not."

It is not a simple process, he said, but it holds the promise of providing more certain answers among murky clues. It also offers a new way to diagnose problems and fix them.

"The important thing shouldn't be the blame game," he said. "It should be finding out the source and making sure it doesn't happen again."

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