Sulfide-producing bacteria dominate hydraulically fractured oil and gas wells

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Researchers have found that the microbes inhabiting a hydraulically fractured shale formation produce toxic, corrosive sulfide through a poorly understood pathway. The team's findings, published this week in *mSphere*, an open-access journal of the American Society for Microbiology, reveal that the oil and gas industry may need new ways to monitor and mitigate sulfide-producing bacteria in fractured shales.

"This is a pretty inhospitable environment of high pressure, salinity and temperature some 2,000 meters underground. You'd think that microbes introduced during the fracturing process would die, but some of them make a good life for themselves," says Mike Wilkins, an environmental microbiologist at The Ohio State University in Columbus and senior researcher on the study. "The industry spends a fair amount of money trying to keep microbes out of these systems."

Hydraulic fracturing, also known as "fracking," involves the high-pressure injection of water, sand, and chemicals into shale formations to create fracture networks that release oil and gas, which are pumped back to the surface and recovered. Practiced for only the last decade, not much is known about the microbial ecosystems in the fracture networks.

Sulfide-producing microbes cause multiple problems for drilling operations. Hydrogen sulfide can "sour" a well and must be separated from oil and gas in an expensive process. Sulfides can be toxic to the workers on the drilling pad and can also corrosively degrade metal pipelines. The microbes themselves can gum up the extraction process by filling in the tiny fractures with either biomass or excreted precipitates.

Wilkins' team had previously found that one bacterial family in particular, Halanaerobium, dominated fractured well ecosystems. These bacteria can convert thiosulfates found in the environment to sulfide. The team, along with collaborators at West Virginia University and Pacific Northwest National Lab, decided to track sulfur cycling catalyzed by the microbial community found in a Utica shale formation well near Flushing, Ohio. [image of drilling rig in Ohio that was sampled for study. Credit: Rebecca Daly]

"The well continually pulls up fluids that have been sitting in the fractures for months, so it's a good way to get a chemical and biological look at what's going on down there," says Wilkins. His team collected fluid samples during a 120-day period to measure both the sulfur-containing chemicals and the bacteria species present.

They found that, within 10 days after pumping and sampling of well fluids began, Halanaerobium reached nearly 100% dominance of the bacterial community and remained so for the next 100 days. The team then scoured the genes present to find possible enzymes capable of catalyzing sulfur reactions. They found multiple copies of rhodanese, an enzyme that can reduce thiosulfate to sulfite and elemental sulfur, and anaerobic sulfite reductase, an enzyme that reduces sulfite to sulfide. If Halanaerobium species used these two enzymes together, the microbes could be using environmental thiosulfate to produce sulfide.

To confirm this, the team cultured Halanaerobium isolated from well samples. The lab-grown bacteria produced both enzymes and when fed thiosulfate in the culture media, produced sulfide. Finally, the team measured a particular sulfur isotope that microbes prefer to consume and saw that it decreased in the well samples over time. "That's a sign that the sulfur cycling seen in this well is a microbial process, rather than an abiotic one," says Wilkins.

Current industry tests monitor for sulfide-producing microbes by detecting sulfate reduction activity only. "Sulfate-reducing bacteria are super common in seawater and groundwater and convert sulfate to sulfide," says Wilkins. Halanaerobium, however, convert thiosulfate to sulfide. So today's tests of this well, Wilkins notes, would mistakenly lead a well operator to think no sulfide is produced.

"Knowing which microbes are doing potential damage is important so that well operators can target them better," he says. Halanaerobium have been found to dominate fractured well ecosystems from Texas to Pennsylvania, Wilkins says, so improved monitoring of their sulfide production could be key for well productivity nationwide.

Provided by American Society for Microbiology

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