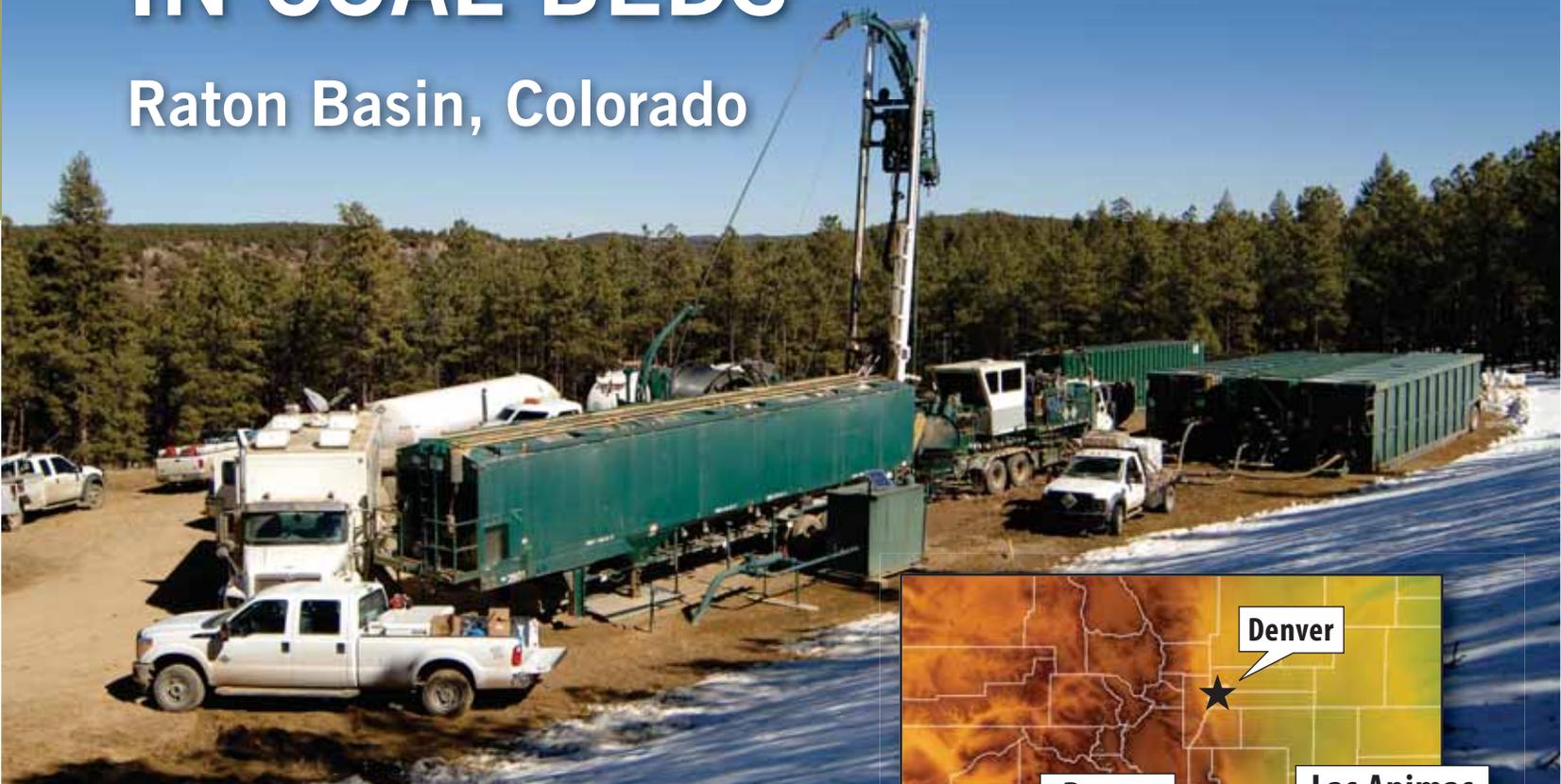


# HYDRAULIC FRACTURING IN COAL BEDS

Raton Basin, Colorado



## Unlocking Natural Gas from Coal Beds

Hydraulic fracturing, also commonly called fracing, is a proven process which has been used in the U.S. since 1949. Advances in this technology have allowed the U.S. to increase production of natural gas. Use of natural gas reduces carbon dioxide emissions and particulate pollution, and it decreases our reliance on imported fuel. Developing the natural gas held in coal beds helps address America's energy needs and supports its economic renewal.

### What Is Hydraulic Fracturing?

Fracing is the process of creating fissures in underground formations to allow natural gas to flow. In the Raton Basin, fracing occurs in coal beds up to 3,500 feet deep, releasing a natural gas commonly referred to as coal bed methane (CBM). During fracing, water, nitrogen, sand and several additives are pumped under pressure into coal beds to create fractures.

## Coal Bed Methane Frac Fluid Components

The standard coal bed frac fluid is made up of 54.90% water, 34.94% nitrogen and 9.88% sand. Guar, soap (often called surfactant), enzymes and/or breakers (fluid thinners) are less than .28% – approximately one quarter of 1% of the total volume of the frac mixture.

The percentages vary slightly, depending on the coal seam properties. Sand is added to the frac fluid in varying quantities to prop open existing fractures and support new fractures. Nitrogen, an inert gas found in the atmosphere, is used because it reduces the fluid density and helps to lift out the frac fluid after the fracturing treatment, enhancing gas flow.

Pioneer uses water produced from its coal bed methane wells in fracturing the coal seams.

## CBM Frac Stages

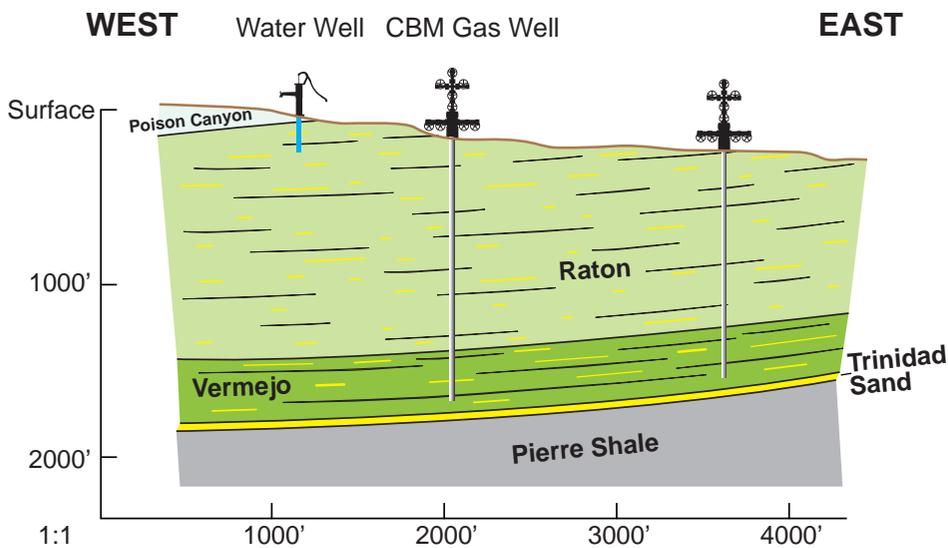
Each wellbore could have from one to more than a dozen two-foot to ten-foot thick coal seams that each require a hydraulic fracture treatment. When there are multiple coal seams, each seam is isolated with special equipment, and the frac fluids are pumped only into the individual coal seam that appears productive. Each of these zones constitutes a frac stage.

## Geology of Coal Seams

Coal seams in the Raton Basin are lenticular or "pod-like" in shape, which means the coal seams are generally thin and discontinuous. Coal seams in the Raton formation are thinner and shorter than seams found in the Vermejo Formation (see diagram below).

Methane gas occurs naturally in shallow formations too, even ones intersected by some water wells, and is unrelated to the gas produced from deeper zones.

## Raton Basin Geology

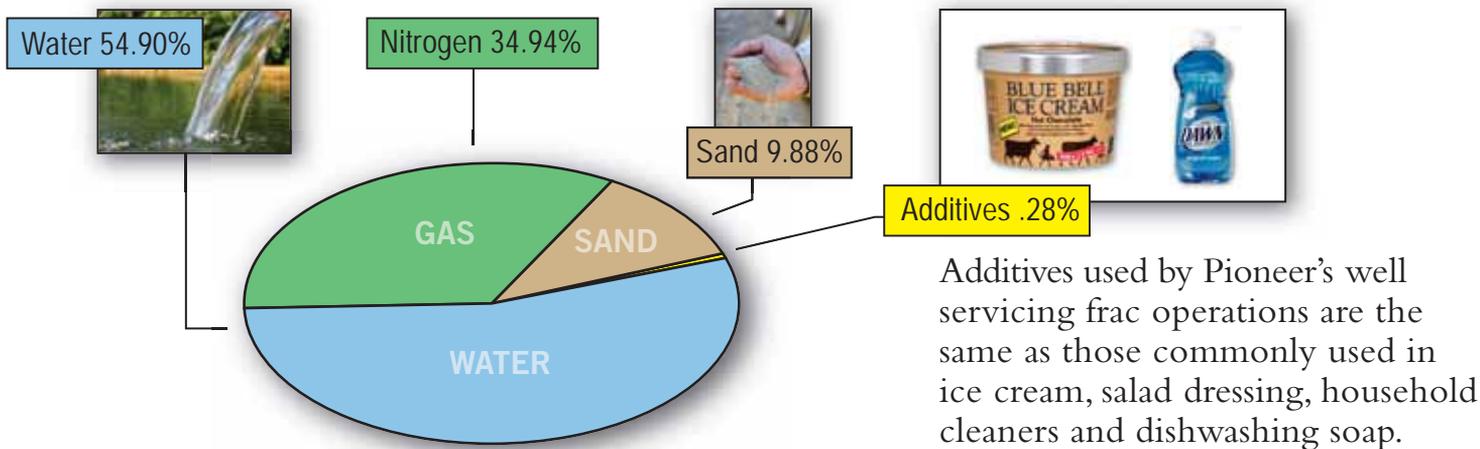


## CBM Fracing vs. Shale Gas Fracing

CBM fracing is different than fracing in a shale gas zone, where larger amounts of water, higher pressure, potentially more ingredients and more sand are used. Generally, shale gas fracing occurs at depths more than a mile below the surface of the earth. CBM fracing occurs in coal beds up to 3,500 feet deep.



# Environmentally Friendly CBM Frac Fluid Components



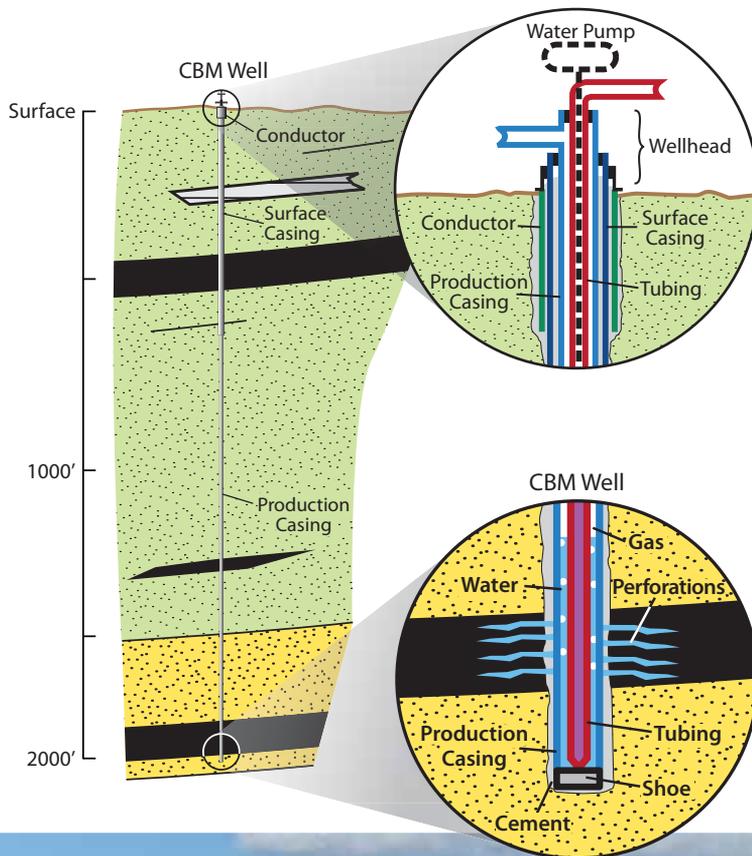
## Fracing in Coal Beds

Fracing of the thin stringers of coal beds in the Raton Basin is done in vertical wellbores. Continuous monitoring during each frac stage shows that fractures in coal beds generally extend horizontally no more than 200 feet with little to no vertical fracturing. Fracturing is limited in vertical extent due to the layering of tighter shales and siltstones above and below the coal seams and because of the overburden pressure. Compared to shale gas fracing, CBM fracs are small and used mainly to improve and enhance existing pathways.

The average depth of a producing coal seam in the Raton Basin is approximately 1,300 feet. The vast majority of water wells are at shallower depths, generally less than 200 feet below the surface, putting the fractured zone far below the majority of producing water well zones or aquifers.

## Protecting Groundwater

State oil and gas regulatory programs are in place to protect groundwater. The Colorado Oil and Gas Conservation Commission (COGCC) regulations require that multiple layers of protective steel casing, surrounded by cement, be installed to protect freshwater aquifers and isolate methane-producing zones. The regulations require verification that the cement has been placed in the wellbore and that the cement job is solid.



**Pioneer Natural Resources Joins Frac Disclosure Registry Website:** A new landmark web-based national registry was recently unveiled by the Ground Water Protection Council and the Interstate Oil and Gas Compact Commission. The new website, [www.FracFocus.org](http://www.FracFocus.org), features information about hydraulically fractured wells nationwide. Categories include location, operator, state and county in which the well is located, *as well as descriptions of the chemicals used, their function in the process and registry numbers for each of the additives.* Pioneer was one of the first oil and gas exploration and production companies to step forward to volunteer information on the chemical additives used in hydraulic fracturing in new wells drilled starting in 2011.

## Coal Bed Frac Facts:

- **Local, accessible record of chemicals:** All operators must maintain Material Safety Data Sheets (MSDS) for any chemical product brought to the wellsite for use onsite or down hole during drilling, completion and workover operations, including fracing.
- **Chemical inventory:** Operators must maintain an additional inventory of all chemical products and fuel in any amount exceeding 500 pounds that has been used or stored cumulatively during any quarterly reporting period.
- **Disclosure of chemicals:** Detailed information on the exact chemicals used is available when requested by COGCC or by a doctor in the event of concern of a health issue.
- **State fracing regulations:** Fracing is regulated at the state level by the COGCC.
- **CBM frac composition:** Frac fluids are generally 99.9% water, nitrogen and sand with less than .28% additives such as guar, soap, enzymes and/or breakers.
- **Water source for fracing:** Generally, small amounts of coal bed methane (CBM) produced water is used in fracing the coal seams.
- **Aquifer protection:** Surface casing is set to depths below nearby producing water wells and must be surrounded by cement.
- **Water well testing:** With landowner permission, water wells in the vicinity are tested before and after fracs occur, based on COGCC rules.
- **2003 EPA Frac Study:** The Agency study concluded that the injection of frac fluids into CBM wells poses minimal threat to underground sources of drinking water. The EPA did not find confirmed evidence that drinking-water wells have been contaminated by frac fluid injection into CBM wells. The study report and details are available on the EPA website.

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## About Pioneer Natural Resources

Pioneer is a large independent oil and gas exploration and production company, headquartered in Dallas, Texas, with operations primarily in the United States.