PIONEER
NATURAL RESOURCES

# Hydraulic Fracturing in Coalbed Methane Development Raton Basin, Southern Colorado

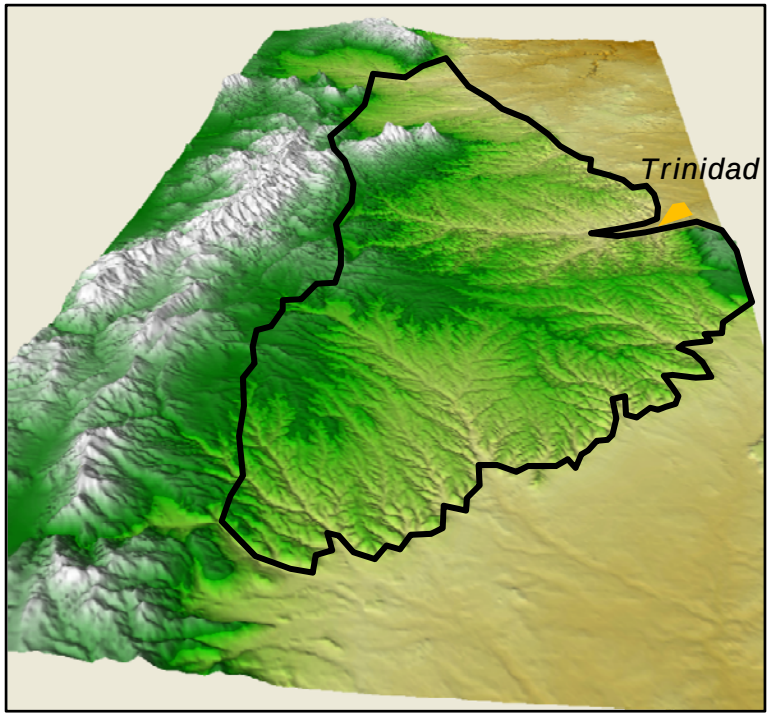
**Hal Macartney**
**Geoscience Advisor – Rockies Asset**

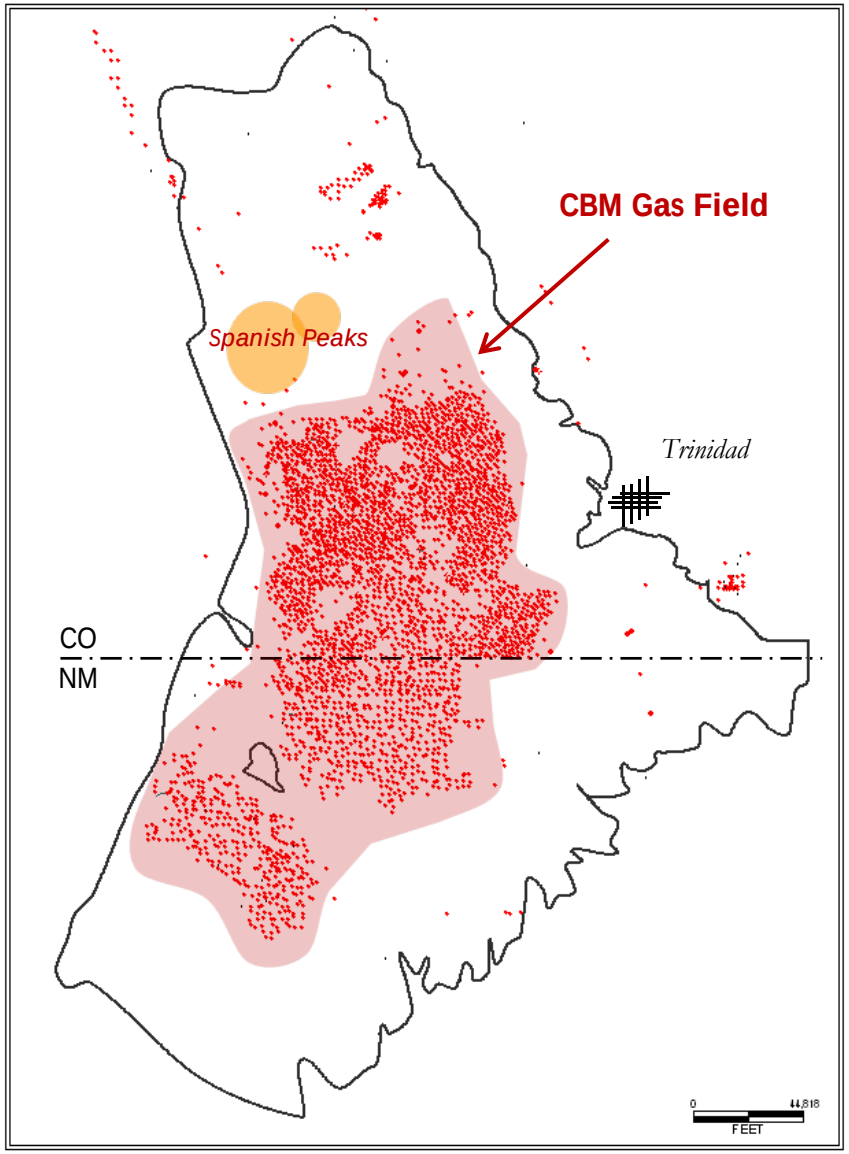
**EPA Hydraulic Fracturing Workshop**
**Arlington, VA March 10-11, 2011**

NYSE: PXD
www.pxd.com

# Raton Basin

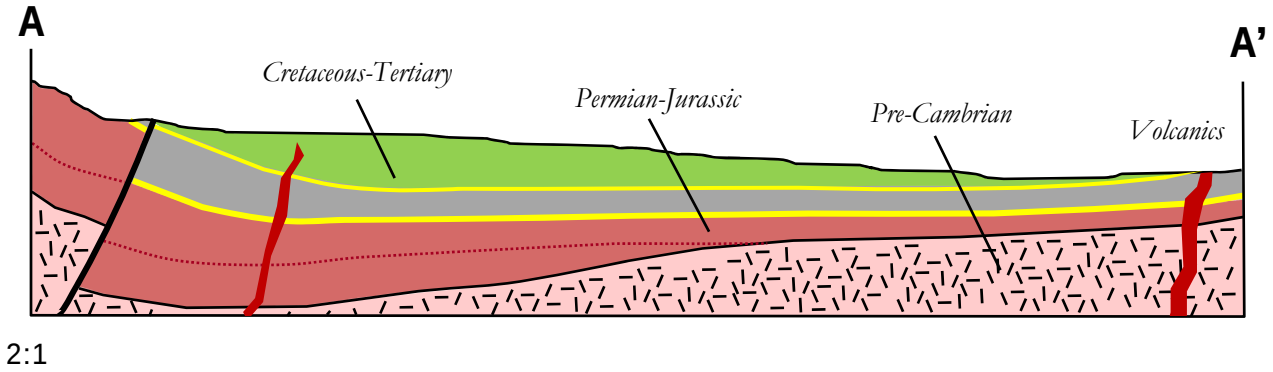
PIONEER
NATURAL RESOURCES

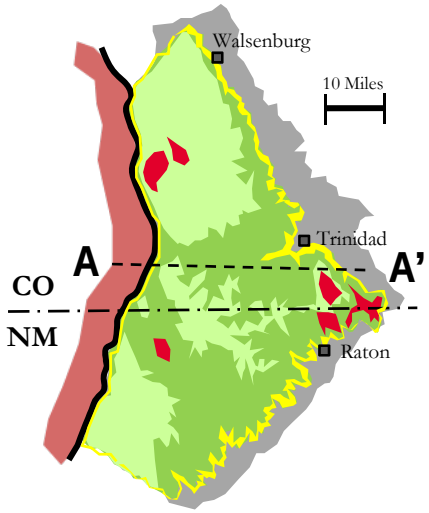



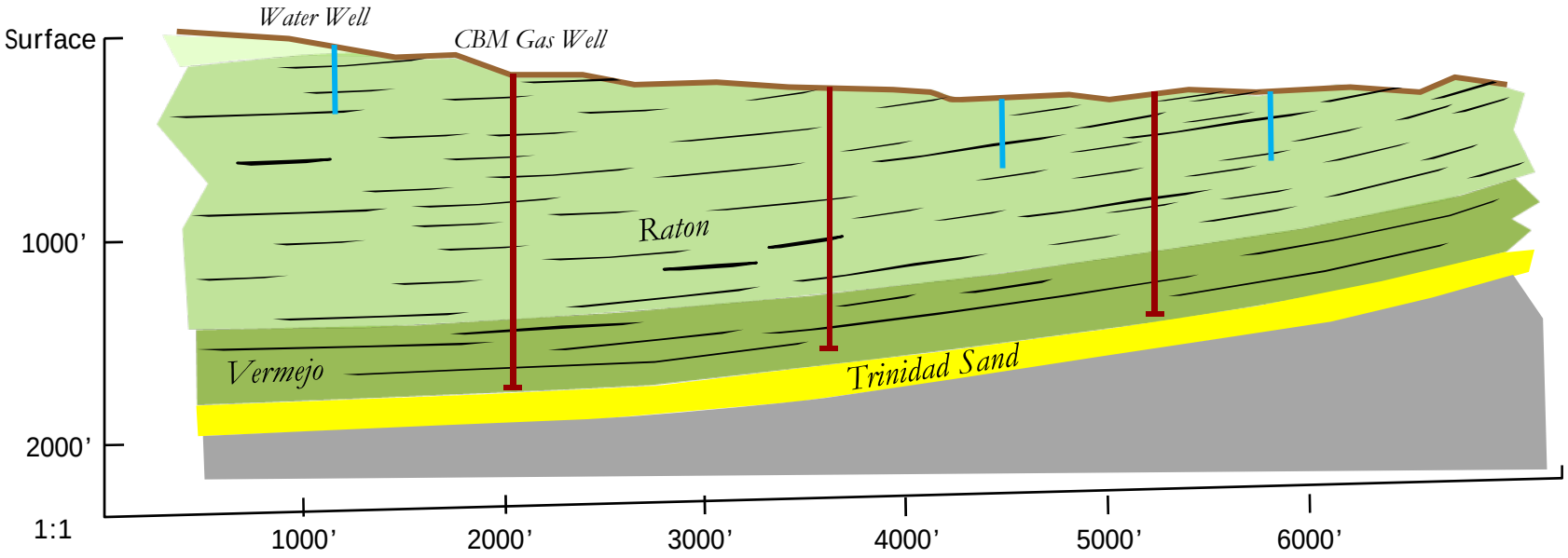



# Raton Basin Geology

PIONEER
NATURAL RESOURCES

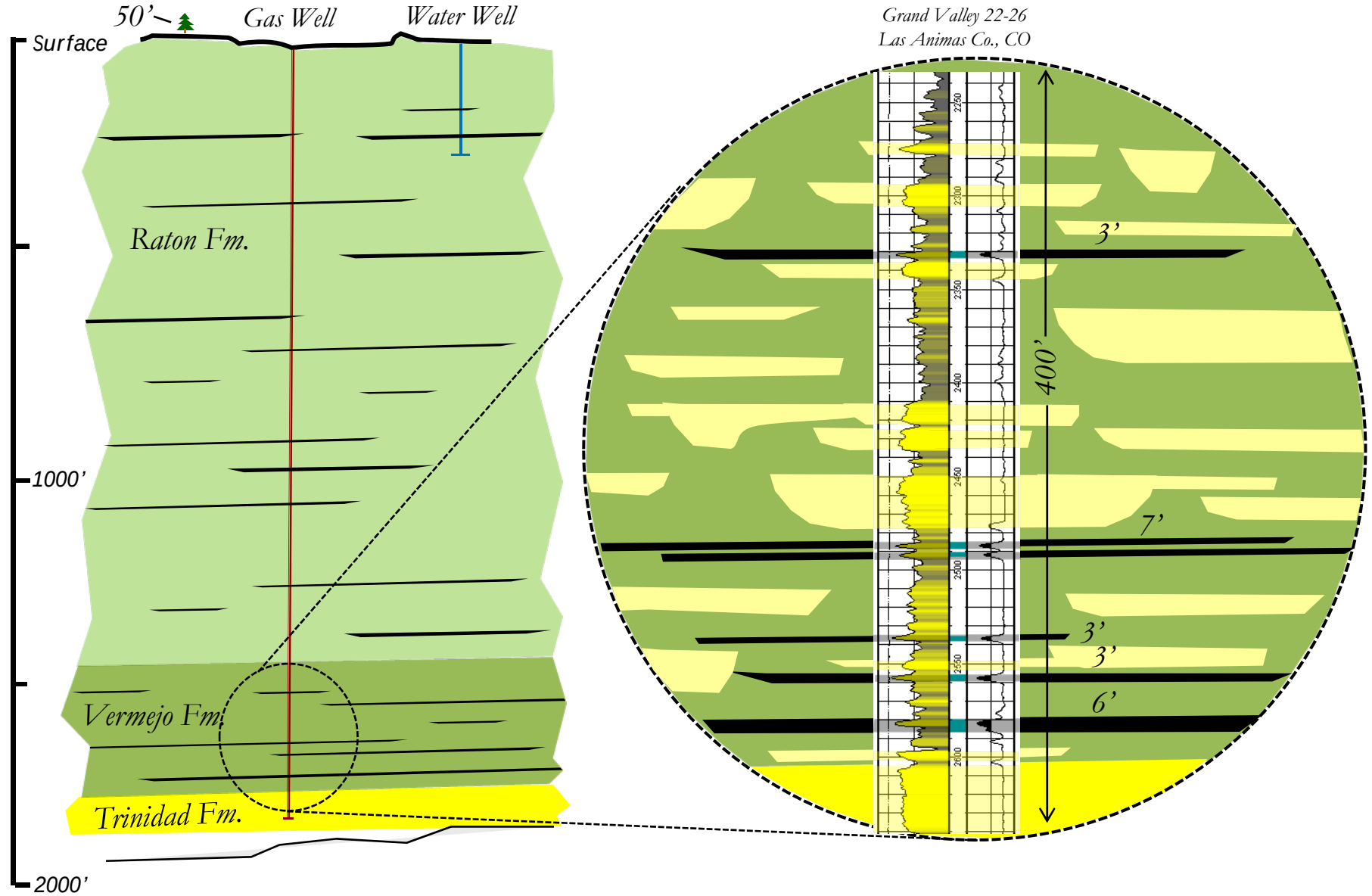


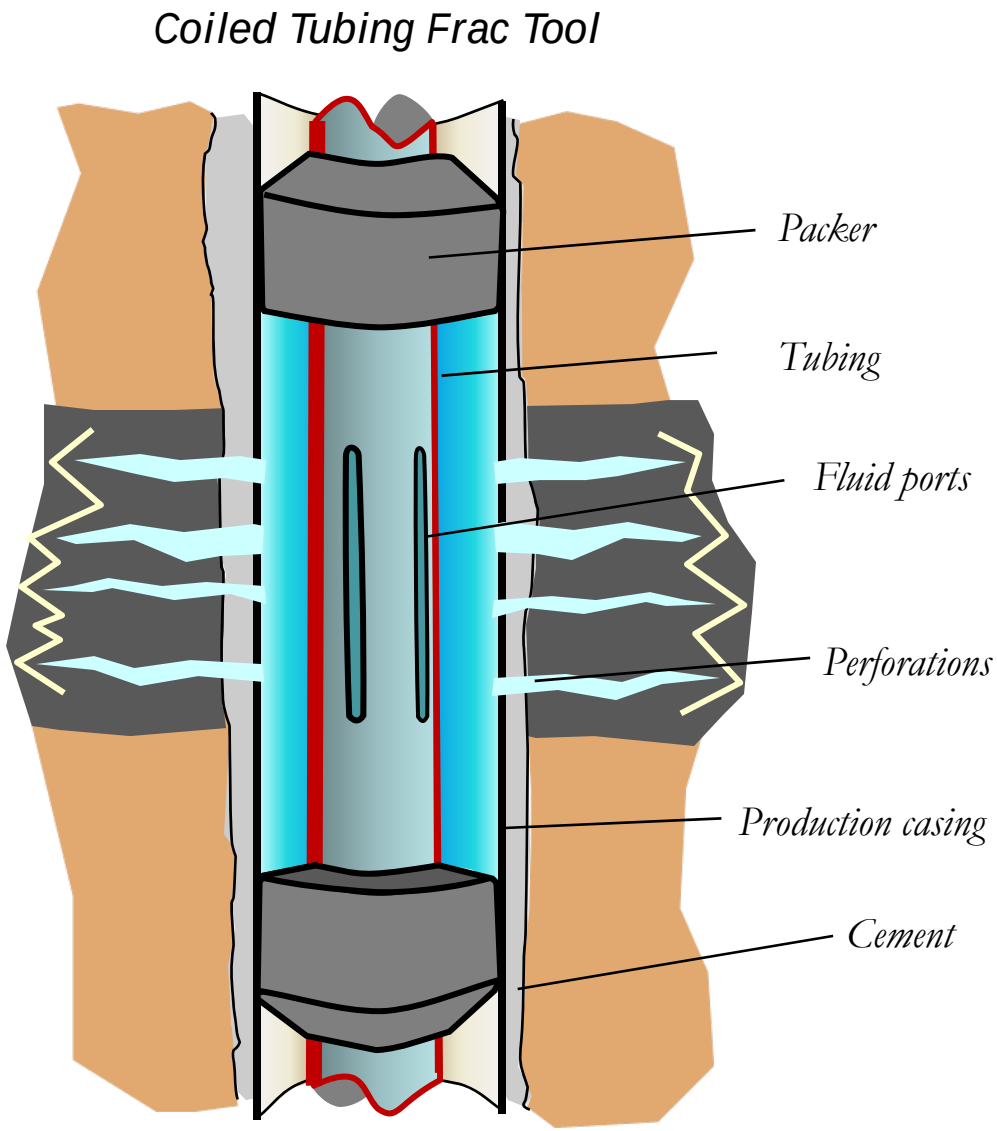
# Geology – Coalbed Methane Well

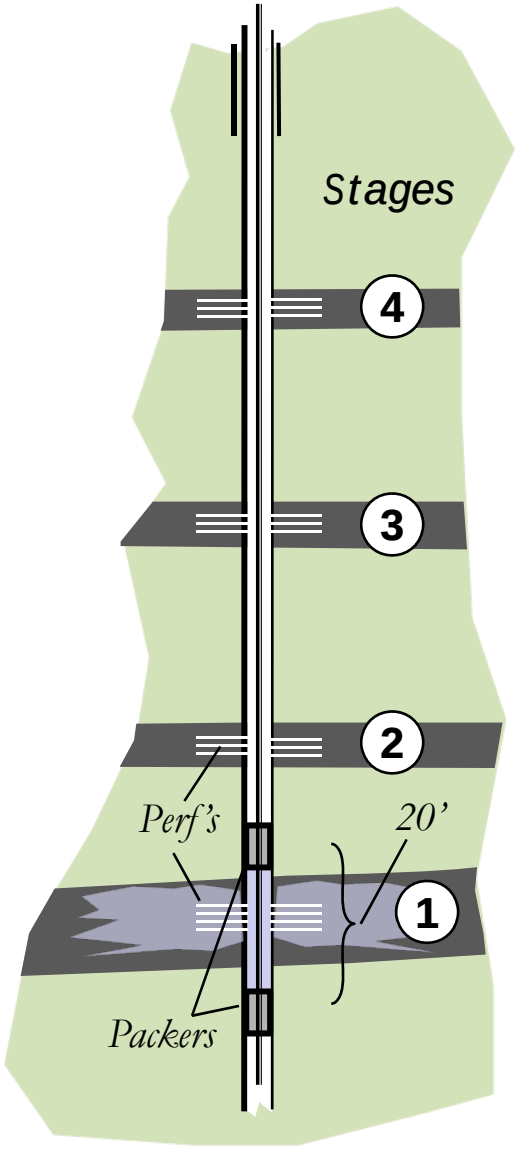
PIONEER NATURAL RESOURCES



# Hydraulic Fracturing in Coal Beds

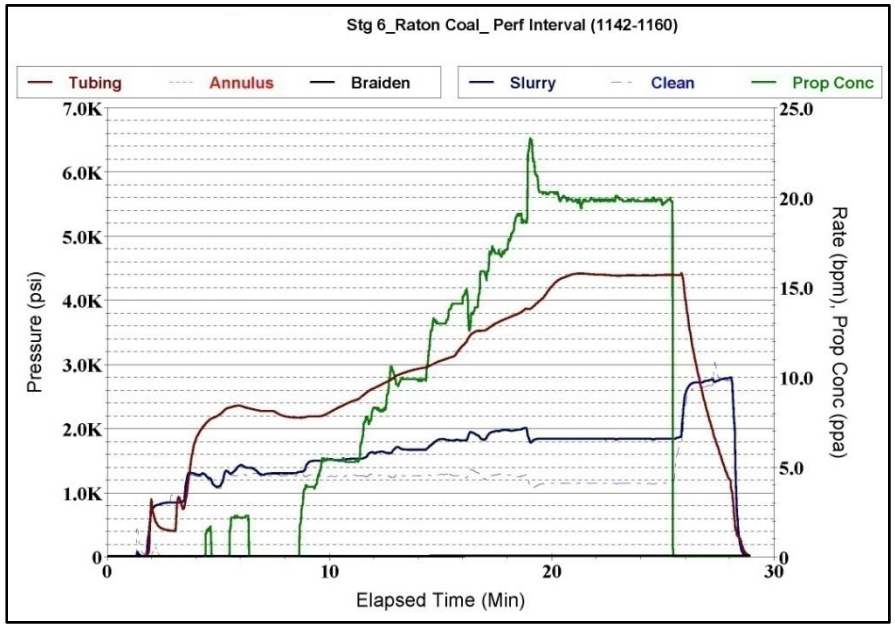
PIONEER
NATURAL RESOURCES

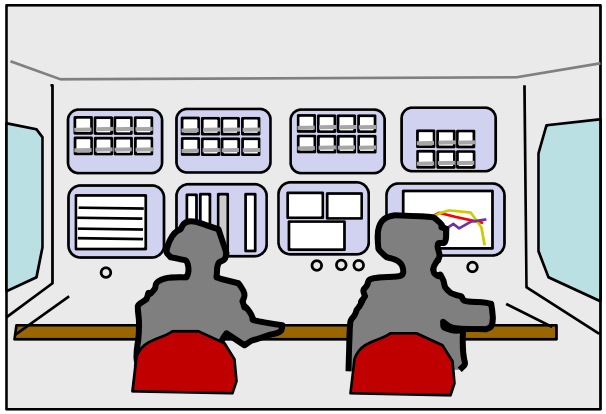


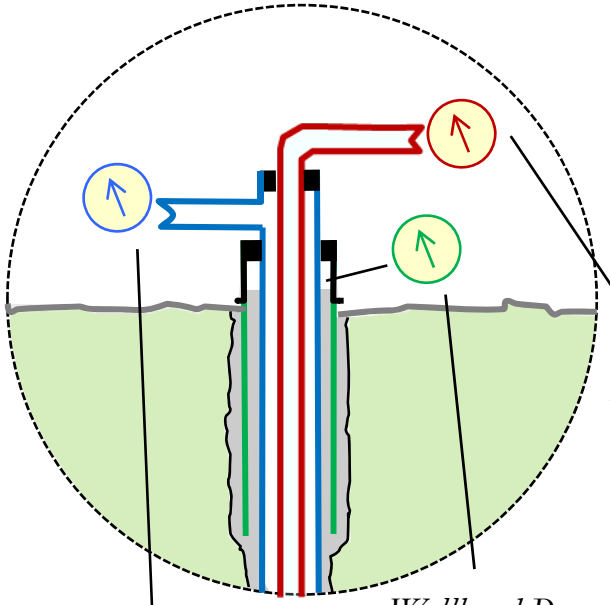



# Monitoring Hydraulic Fracturing

PIONEER
NATURAL RESOURCES



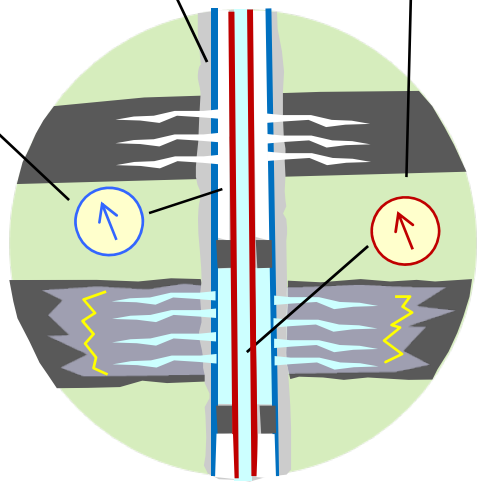





*Tubing Pressure (frac fluids)*

*Wellhead Pressure (behind casing)*

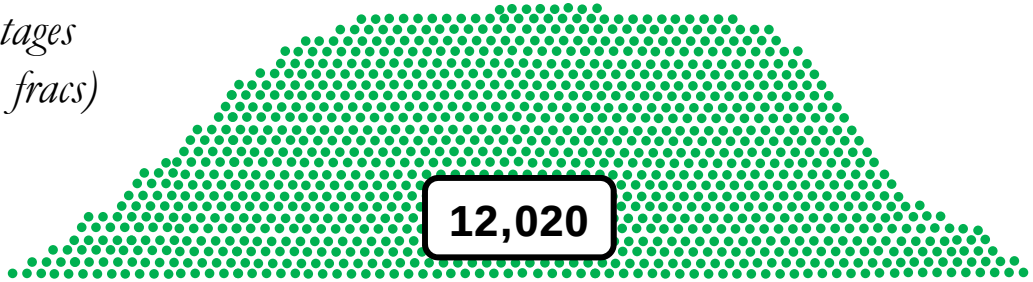
*Casing Pressure (above top packer)*



# Frac Stages & Interruptions

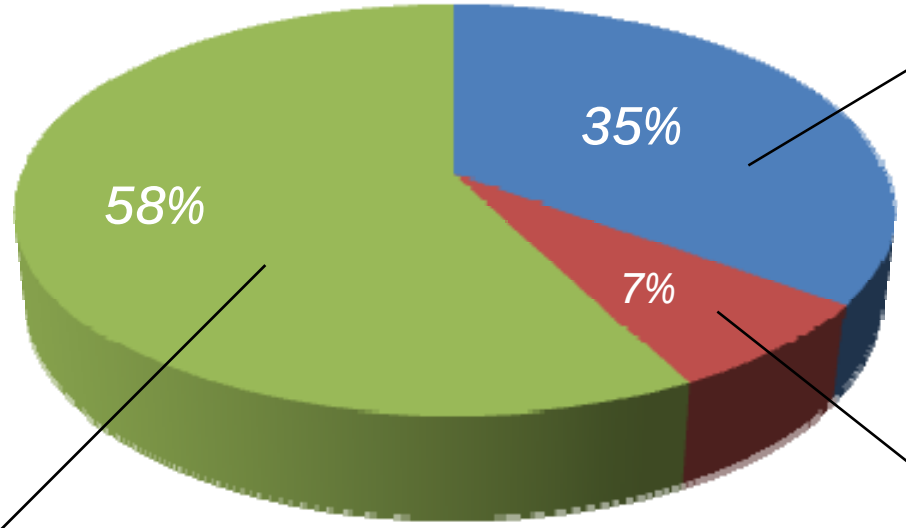
PIONEER NATURAL RESOURCES

*Total Stages (in 2273 fracs)*




*Interruptions**


## Interruption Causes:




**Pressure Loss**

**Materials & Mechanical**

**Pressure-out / Screen-out**

**Operator shut-down*

# Summary

PIONEER
NATURAL RESOURCES

- **Pioneer Natural Resources has performed hydraulic fractures on 2400 shallow CBM wells in the Raton Basin with no impact to drinking water.**
- **Why no effect?**
  - Fracs propagate horizontally – very little height growth
  - Coals and sands are discontinuous
  - Frac volumes and energy rapidly dissipate
  - Real-time monitoring of frac pressures and fluids

# Hydraulic Fracturing in Coal Bed Methane Development, Raton Basin, Southern Colorado, USA

Hal Macartney
Pioneer Natural Resources USA, Inc.

*The statements made during the workshop do not represent the views or opinions of EPA. The claims made by participants have not been verified or endorsed by EPA.*

Pioneer Natural Resources USA, Inc. operates a natural gas field in the Colorado portion of the Raton Basin, a field containing approximately 2400 wells and producing 200 million cubic feet of gas per day from coal beds. Many of these wells were hydraulically fractured by Pioneer's own personnel and equipment. There have been no instances of damage to underground sources of drinking water from these operations, and no more than 20' of height growth in induced fractures.

The Raton Basin is located between the Rocky Mountains and the high plains to the east, and it straddles the Colorado-New Mexico state line. The target formations for coal bed methane are the Tertiary-aged Raton and Cretaceous-aged Vermejo, both characterized by intermittent thin coals, sands, silts and shales. Both of these formations are at the surface in portions of the basin. Naturally occurring gas seeps are common, and coal is actively mined for industrial consumption.

Pioneer's coal bed wells are vertical and produce from depths from 450' to 3500', and from as many as 20 coal seams varying from 1'-8' in thickness. Coals are hydraulically fractured in stages using a coiled tubing tool which enables multiple stimulations in one hole-entry. Cased boreholes are pre-perforated in all the target coals and stimulation proceeds up from the lowest, with each zone isolated for its treatment.

Pressures are closely monitored during the frac in three critical areas:

1. In the tubing delivering the fluids and pressure to the frac tool
2. In the open space above the frac tool, inside the casing
3. In the well-head at the surface, outside casing and inside surface casing

Tubing pressure(1) indicates the delivered pressure to the rock underground and is used to gauge job performance in breaking down the formation and delivering fluid and sand into it. Casing pressure (2) monitors any fluid communication from the treatment zone to open perforations above the top packer; any such pressures terminate pumping.
The well-head pressure (3) indicates if any fluid or pressure has migrated behind casing to the surface.

The casing pressure(2), gives us practical and unequivocal evidence of how high our fractures are growing; perforated zones that are too close will communicate. From experience, 20' is the safe margin for interval spacing and therefore the upper limit of height growth. It is estimated from performance, volumetrics, and computer models, that our lateral fracture growth is from 120-200'.

In a typical hydraulic fracture stage will use 150 barrels (6300 gallons) of foamed fluid, consisting of 70% nitrogen, 30% water (recycled water produced from coal bed wells), 60lbs. of a natural guar gelling compound, 4 gallons of an organic enzyme to break down the gel, and 15 gallons of a mild detergent to create foam. Around 8000 lbs. of sand proppant is placed for every foot of coal stimulated.

Analysis of data from 2273 Pioneer frac jobs since late 2001 shows that more than 12,000 individual hydraulic fracture stages were executed. Of these, approximately 10% were interrupted before the end of the pumping because of high pressures (inability to initiate or finish pumping sand), materials or mechanical difficulties, or because of pressure loss. These last events have dropped to near zero in recent years with broader interval selection.
To date, with more than 12,000 stages pumped, there have been no instances where Pioneer's hydraulic fracture fluids or pressures impacted underground sources of drinking water. This is due to a number of factors. Mechanically, the fractures propagate horizontally with very little height growth and frac volumes and energy rapidly dissipate in the formation. Geologically, the coals and sands are discontinuous and lack through-going natural fractures. Operationally, real-time monitoring of frac pressures and fluid volumes informs us of out-of-zone loss and results in early shut-in. Finally, there is a competent seal all the way to surface provided by cement and casing.

Pioneer continues to model and improve its hydraulic fracture processes, applying experiences gained in the Raton Basin to its operations in other active plays.