



# Shale Development Overview

April 15th, 2013

GOVERNMENT AFFAIRS

**HALLIBURTON**

Water is Life  
PB Area Technology Manager

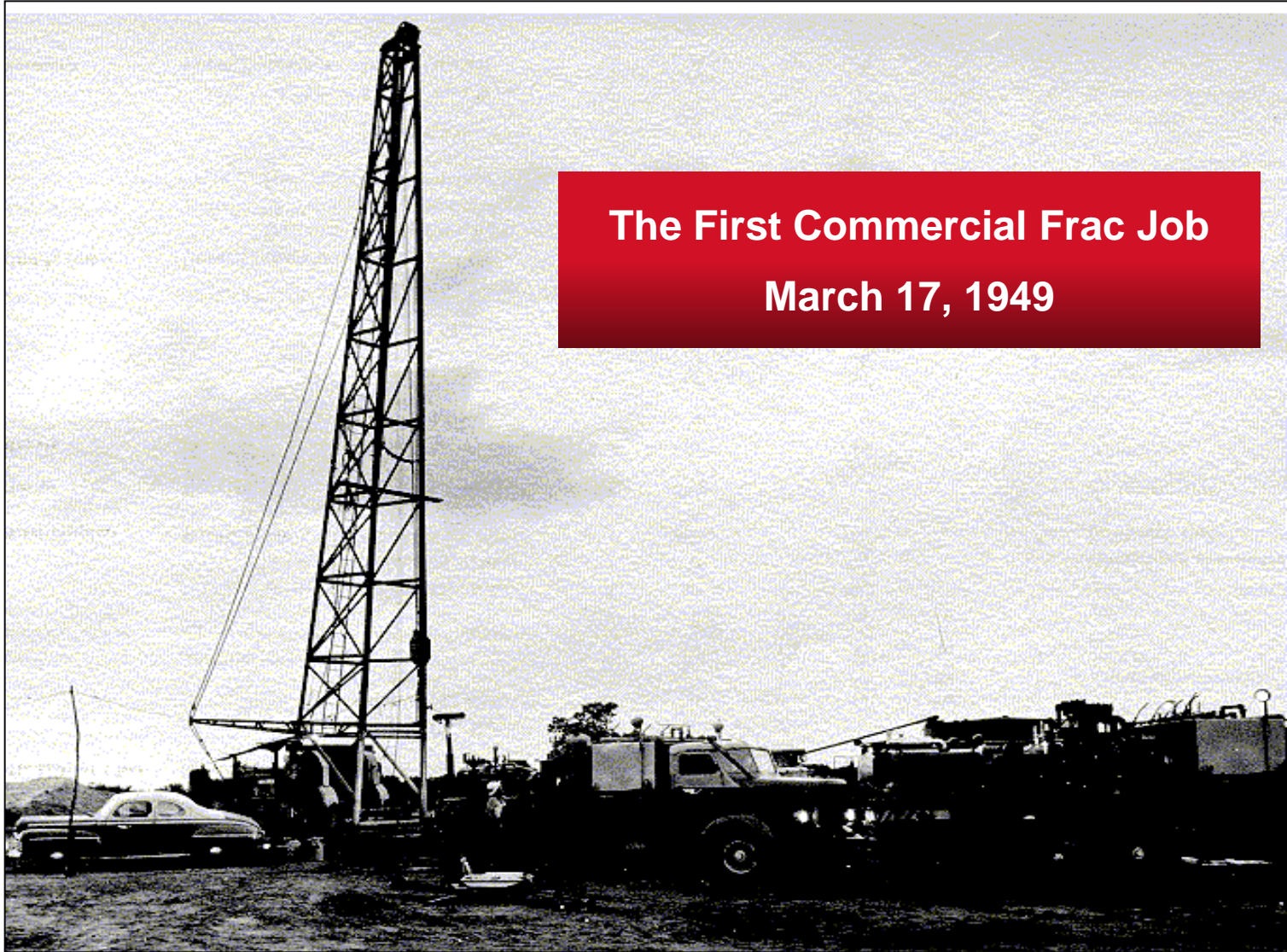
# Northeast - Birthplace of U.S. Natural Gas

- First natural gas well
  - William Hart – 1821
  - Fredonia, New York
- First natural gas pipeline
  - E. L. Drake – 1859
  - Titusville, Pennsylvania
- Early challenges
  - Funding
  - Commercial quantities
  - Storage and transport
  - Technology



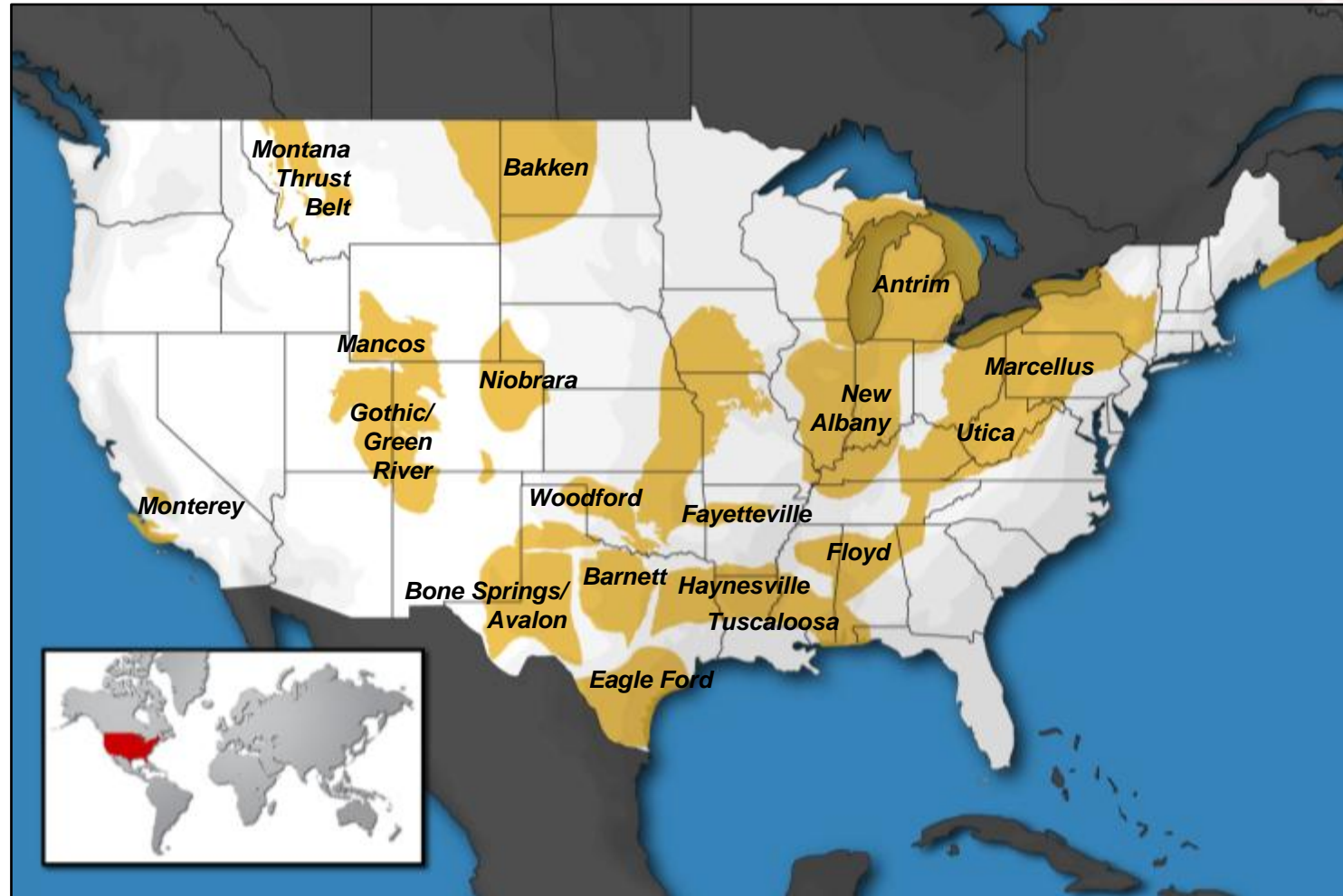
## Natural Gas Evolution Underway

# Velma, Oklahoma





# U.S. Shale Today



[http://www.eia.gov/oil\\_gas/rpd/shale\\_gas.jpg](http://www.eia.gov/oil_gas/rpd/shale_gas.jpg)

# Overarching US Debate

## *Federal Versus State Oversight*

### Federal

Through bills such as the FRAC Act, legislators vie to regulate HF at the federal level



### Diesel Regulation

Waxman inquiry prompts EPA to expand regulatory guidance on diesel use in frac fluids



### Federal Lands

BLM reviewing operations and revising oil and gas regulations on federal lands



### EPA Study

EPA HF study to include water withdrawals, storage, treatment, disposal and recycling



### SEAB

Natural Gas Subcommittee recommendations on improved safety & environment in shale development



### State

State regulators are seeking to maintain primacy over Oil & Gas regulation



# State Regulation *Under Review*

## New York

De facto moratorium awaiting final SGEIS ruling in the late 2012?



## Wyoming

Chapter 3 regulations address well construction and completions



## Pennsylvania

Chapter 78 regulations address well construction and completions



## Colorado

Rule 205-A ruling sets new standards for HF chemical disclosure – April 1st



## Texas

HB 3328 regulation sets new standards for HF chemical disclosure – Feb. 1st



## California

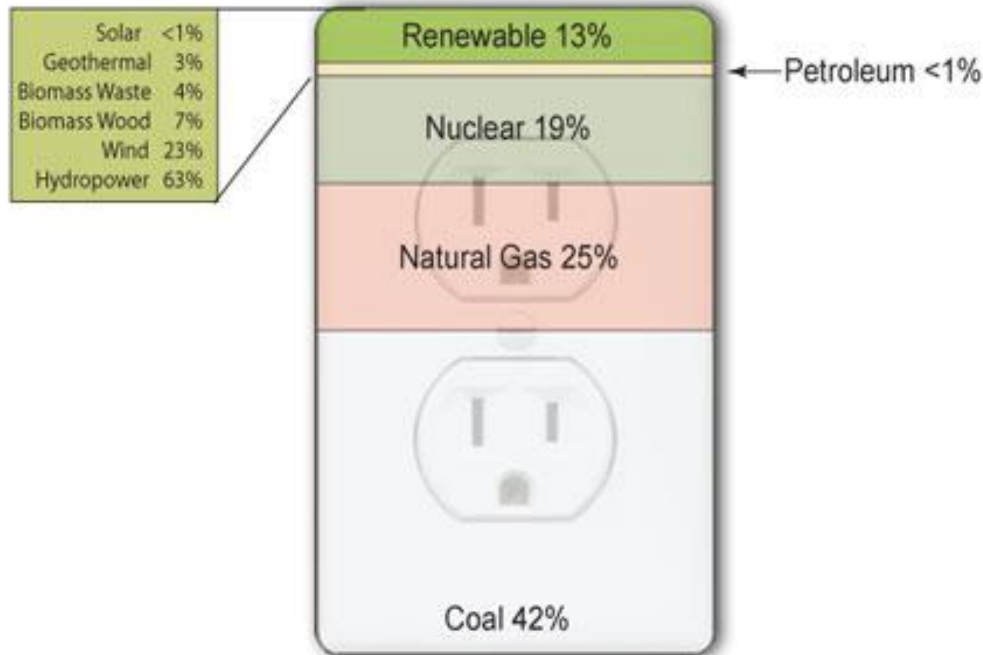
AB 591 proposes new legislation on upstream activities including HF disclosure



# Shale Gas Production

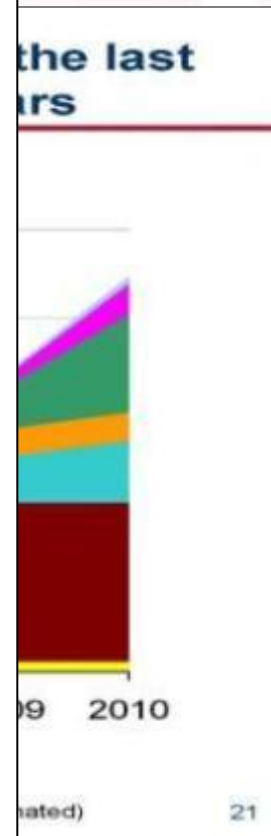
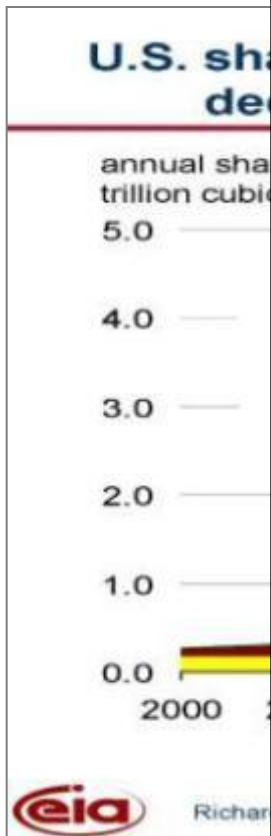
## Game Changer

### Sources of Electricity Generation, 2011



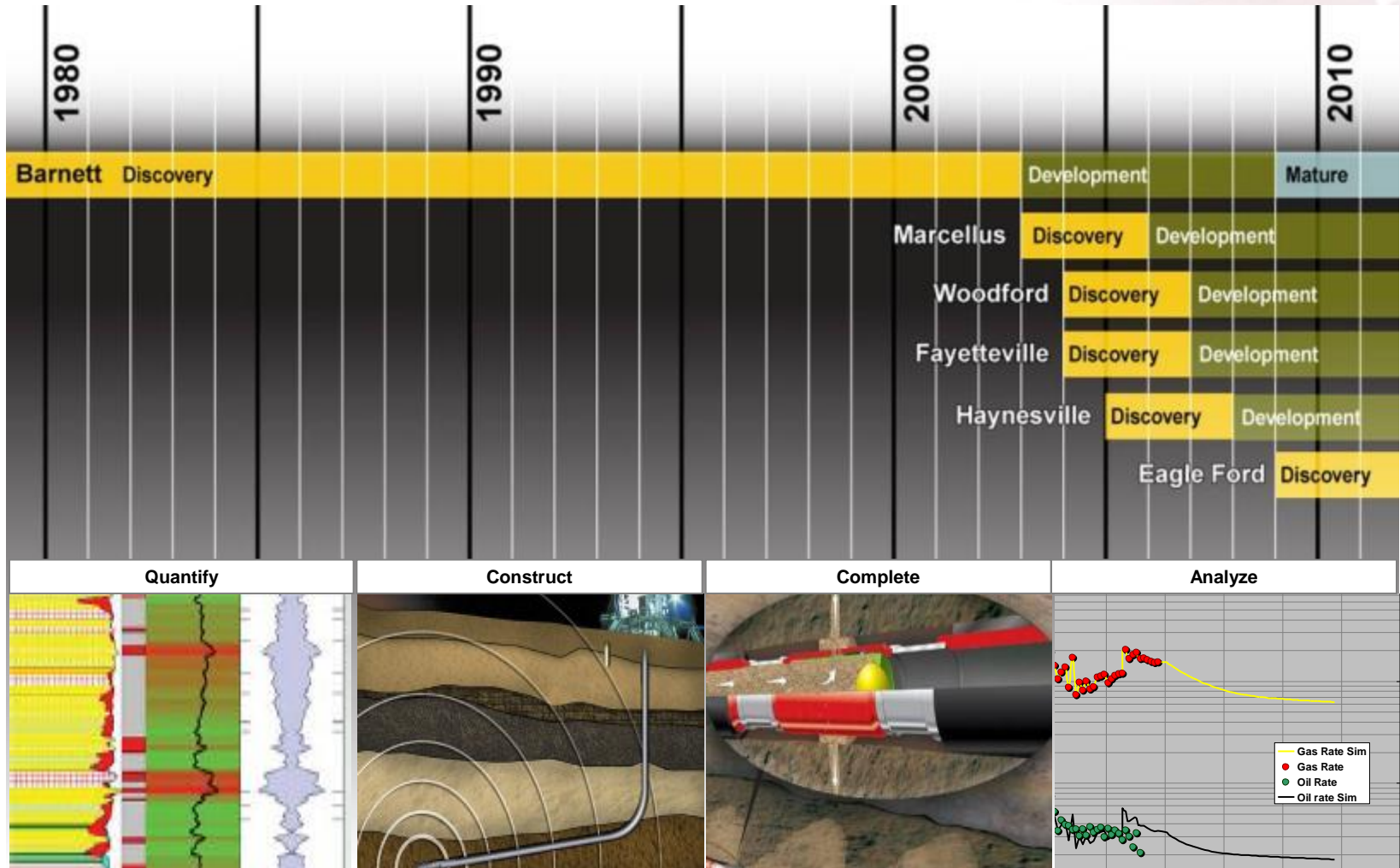
Note: Includes utility-scale generation only. Excludes most customer-sited generation, for example, residential and commercial rooftop solar installations

Source: U.S. Energy Information Administration, *Electric Power Monthly* (March 2012). Percentages based on Table 1.1, preliminary 2011 data.



Richard

# Decades of Shale Development





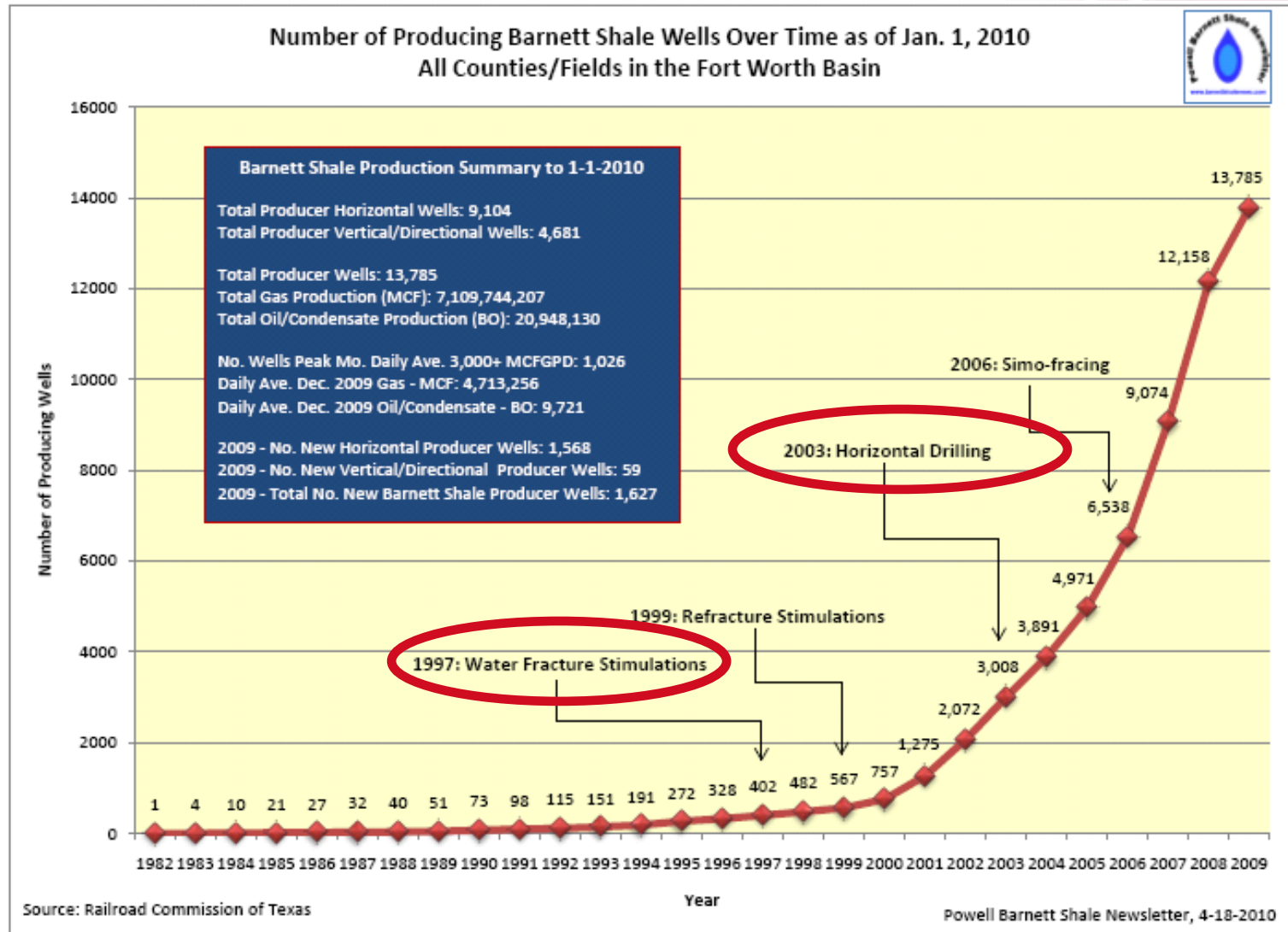
# Barnett Shale



- Set the stage for modern shale gas development
- Learnings leveraged into future operations
- Over 15,000 producing wells today

# Barnett

## Historical Evolution



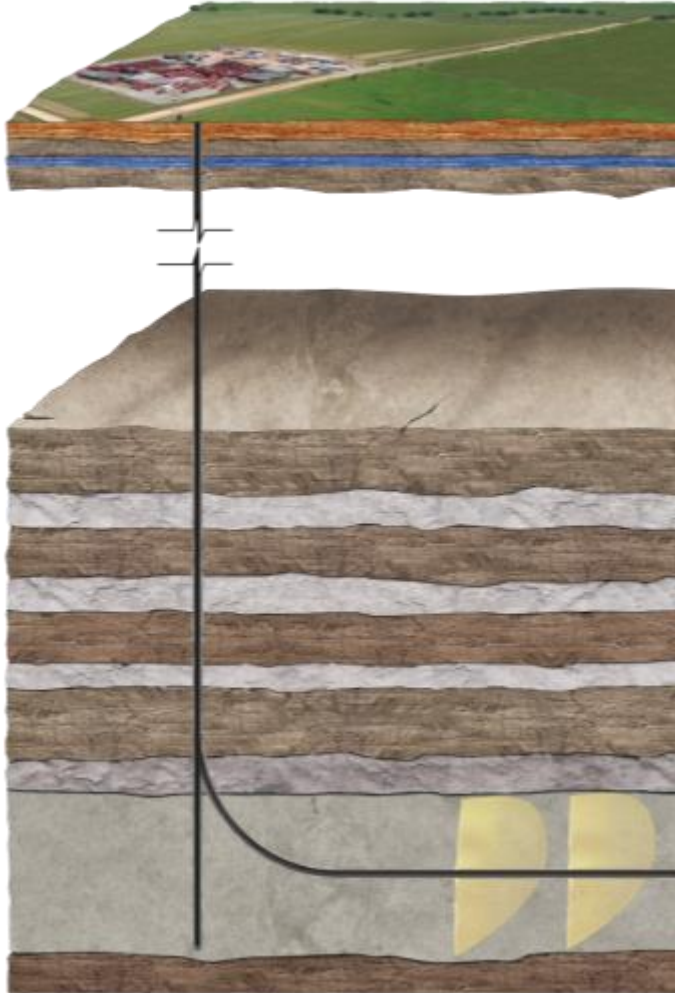
# Austin Chalk

## *Horizontal Drilling and Hydraulic Fracturing*



- Extensive use of horizontal drilling & hydraulic fracturing since 1985
- Long laterals and large volume fracturing safely utilized
- Processes are proven and well understood

# What is “Hydraulic Fracturing?”

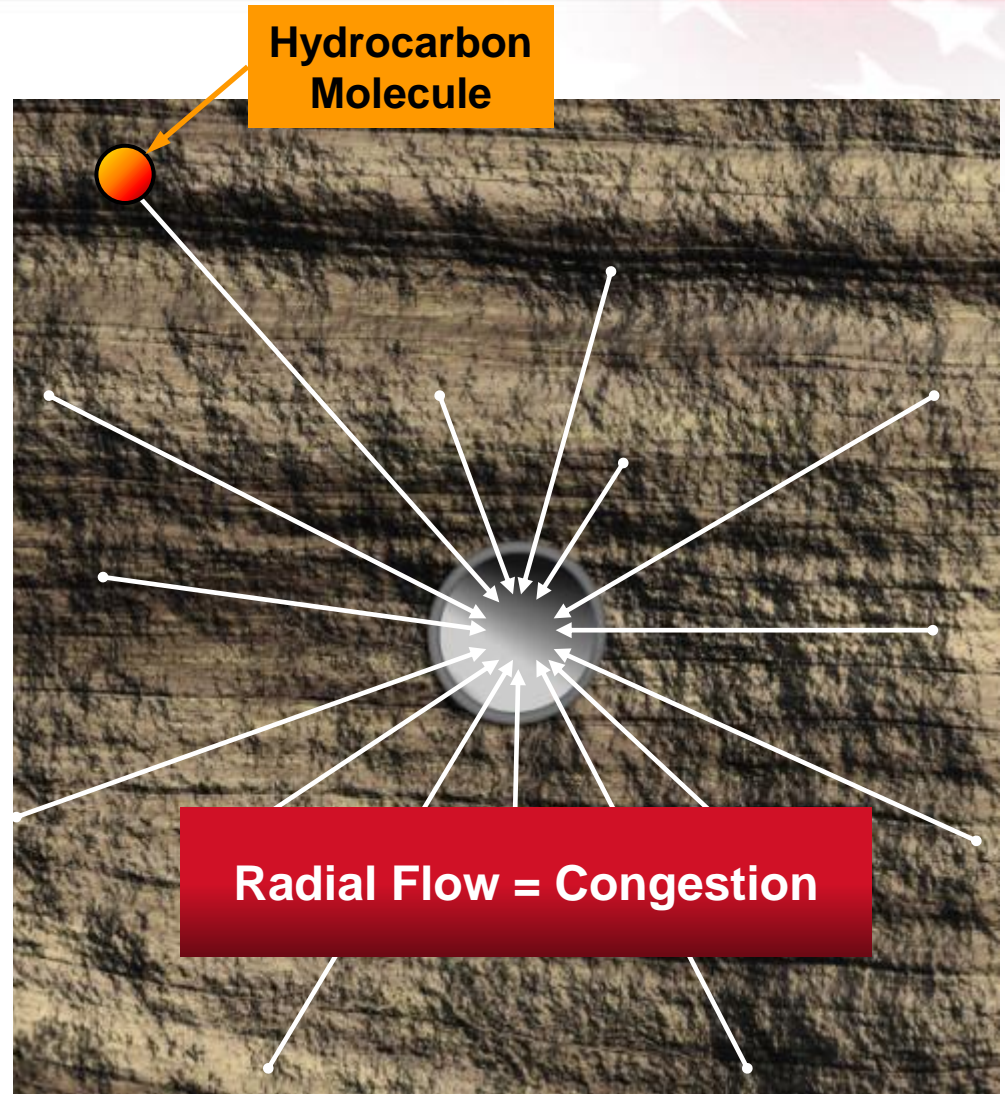
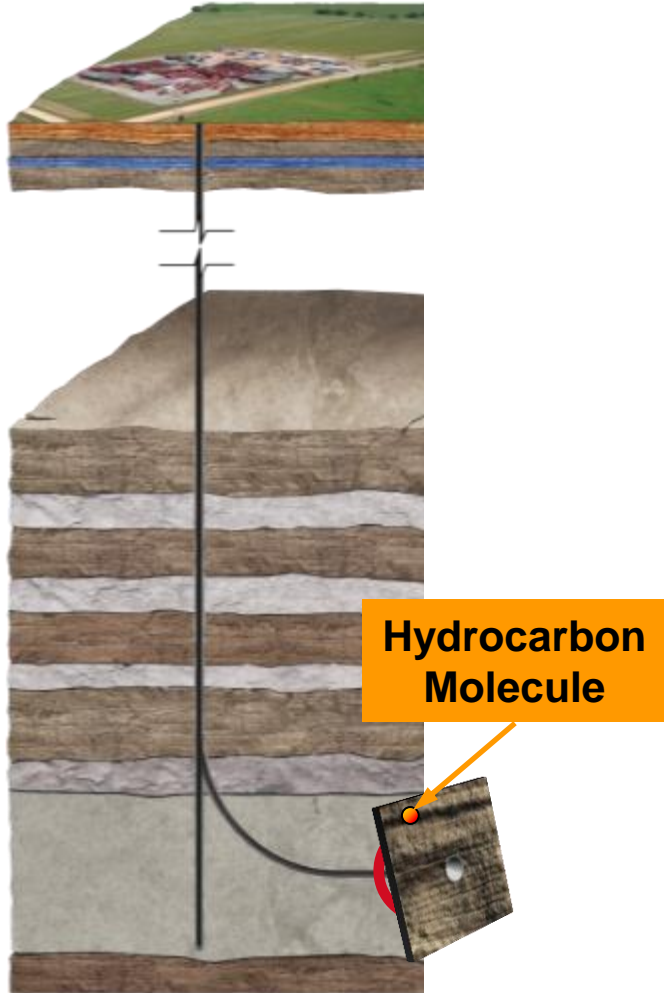


- Hydraulic Fracturing:
  - The use of fluids to create a pathway to the wellbore
  - The placement of small granular solids into the pathway to ensure that it remains open after the hydraulic pressure is removed
- Objective:
  - Increase the rate at which the well is capable of producing oil or gas
  - Increase the economically recoverable reserves for a well



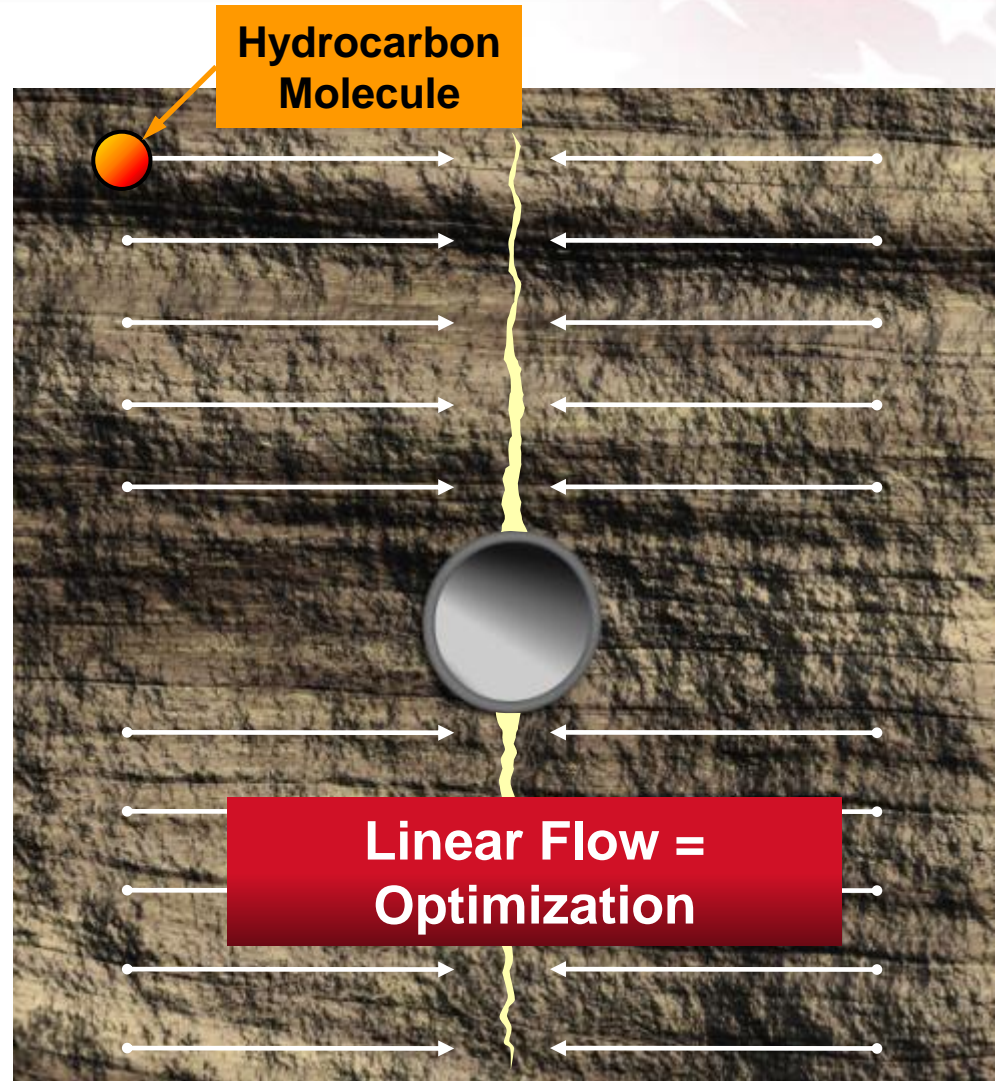
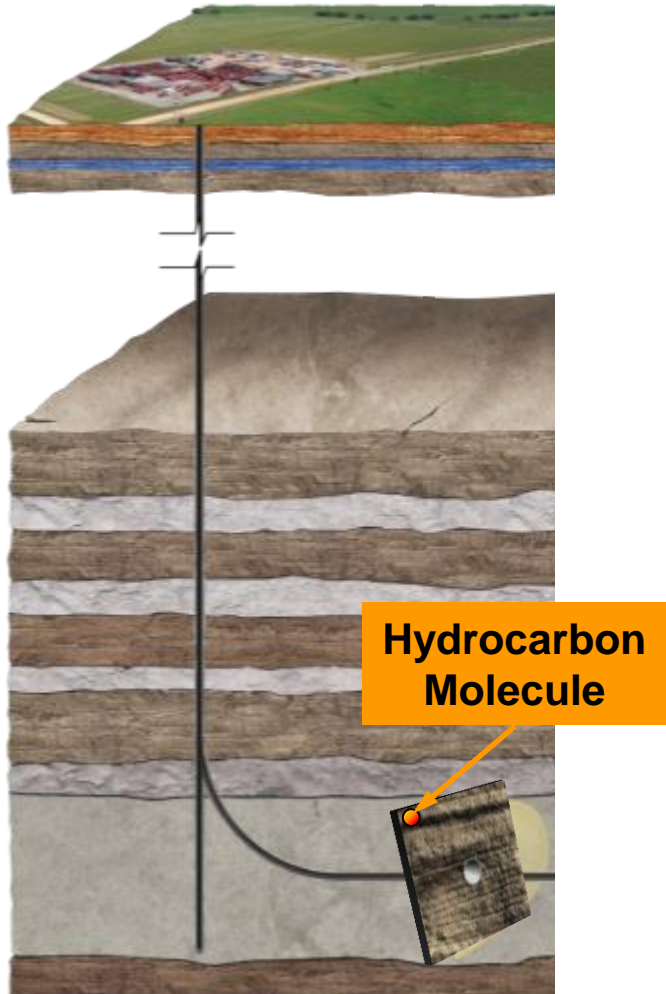
# Why We Frac

## *Radial Flow*



# Why We Frac

## Linear Flow



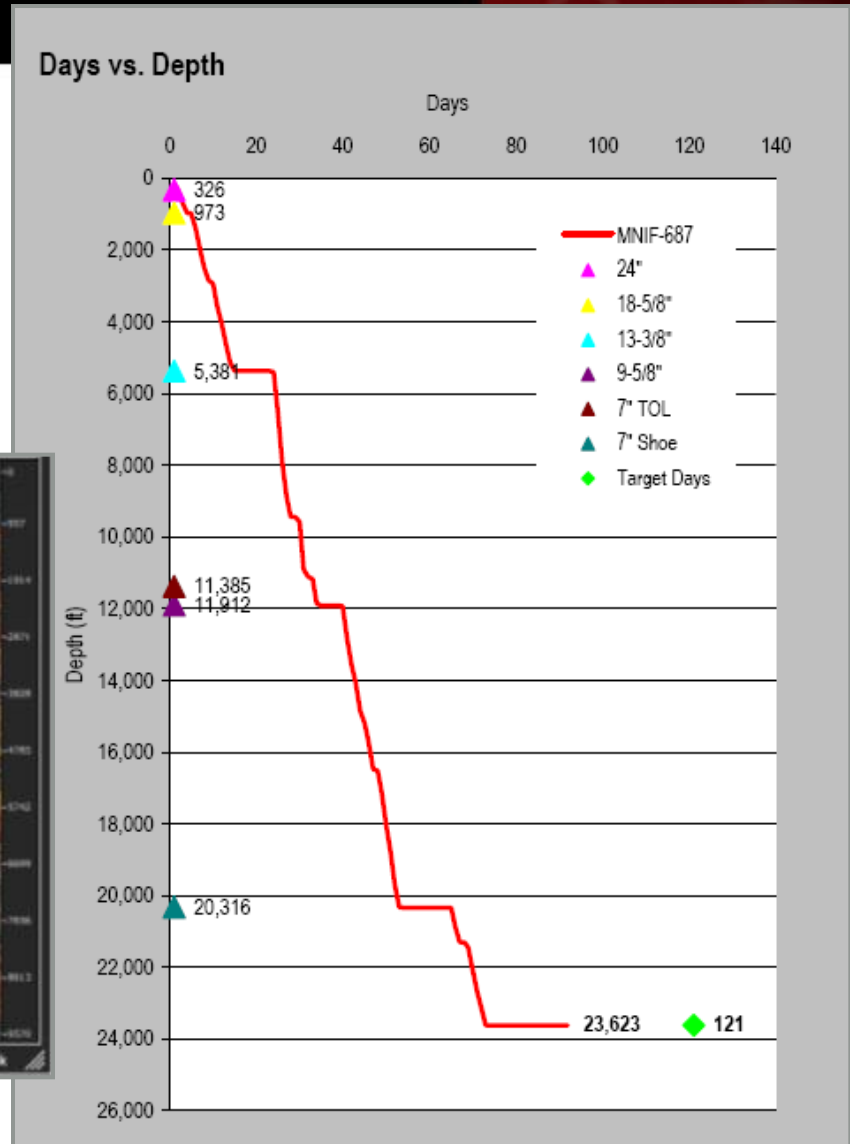
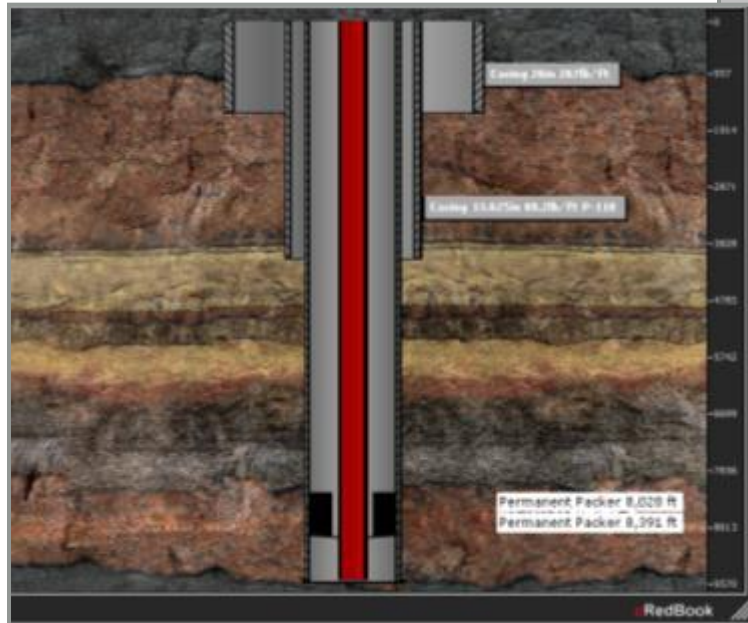
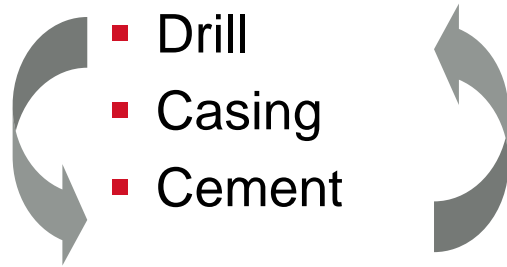




# Well Construction Protecting Ground Water

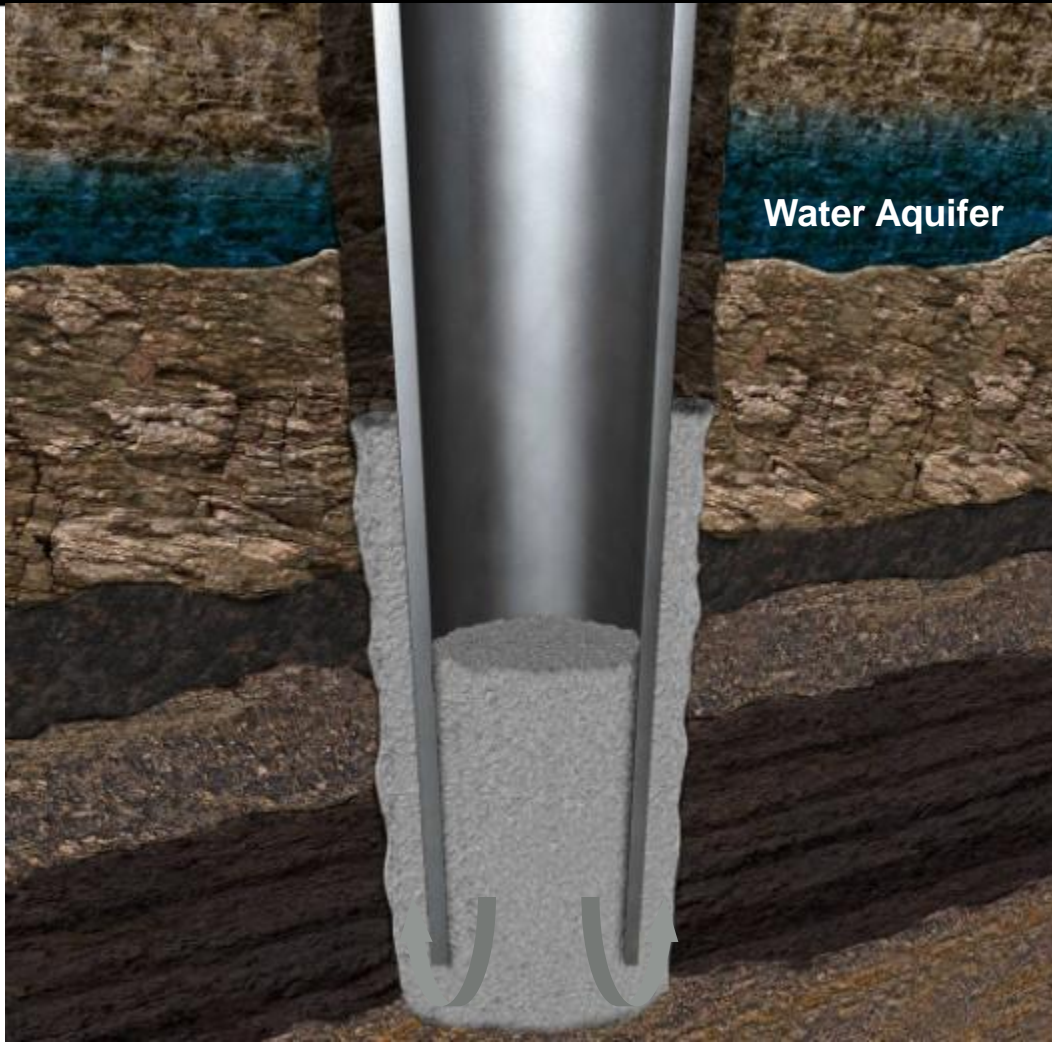
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# Well Design





# Cementing Operation



## Well Cementing :

- The process of designing & mixing a slurry of cement, water and additives.
- Then pumping the slurry down through steel casing to critical points in the annulus between the casing and in the open hole.

# Why Oil and Gas Wells Are Cemented



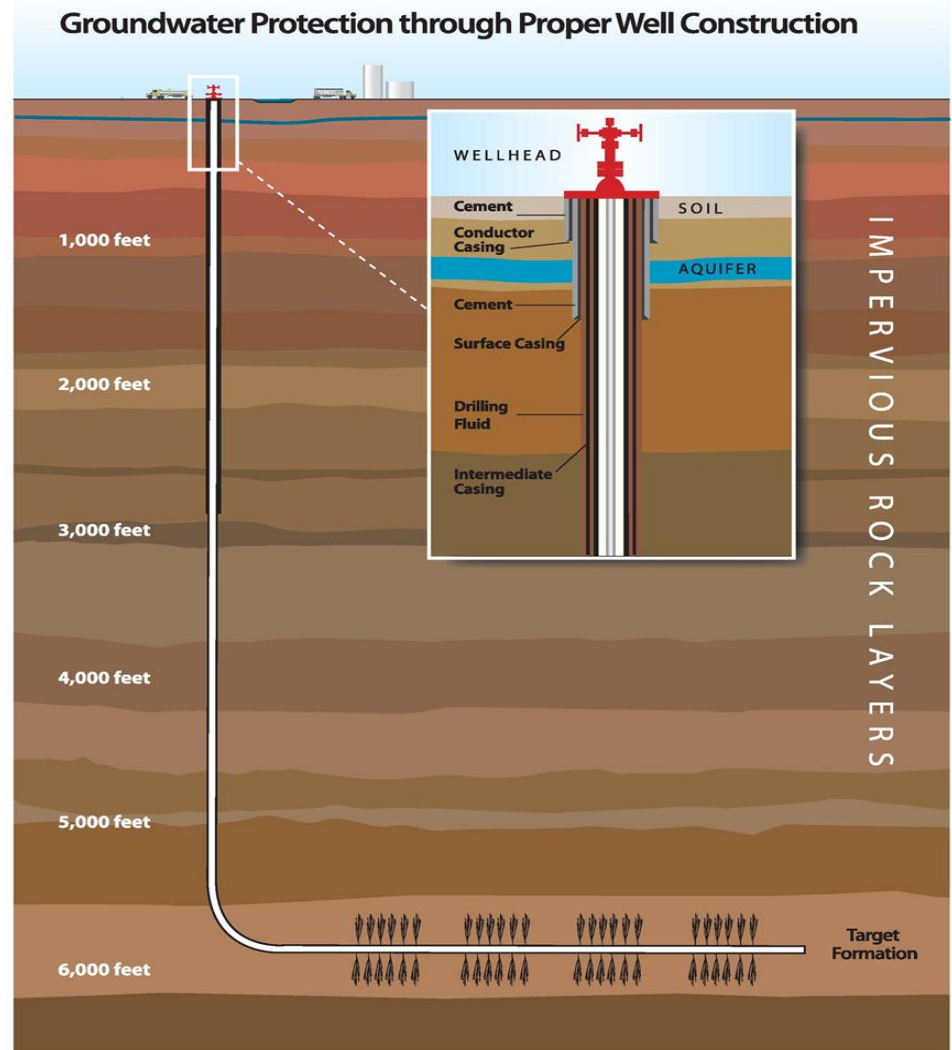
## Purpose of Cementing

- Protects ground water
- Bonds and supports the casing
- Restricts fluid movement between formations

Society of Petroleum Engineers, Cementing Monograph Volume 4, 1990

# Steel Casing - Multiple Layers of Protection

- Casing Objectives
  - Zonal Isolation
  - Well Control
  - Pressure Containment
- Casing Specifications
  - API Standards
  - Life Cycle





# Completions

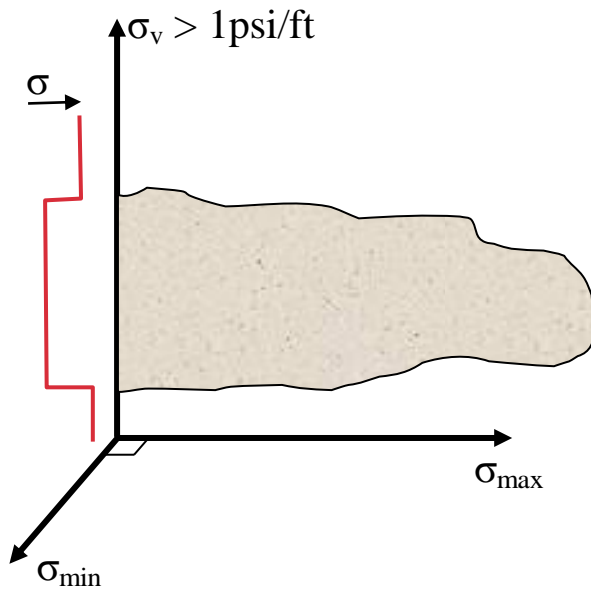
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# Hydraulic Fracturing

## An Engineered Process

### Hydraulic Fracturing Equation



$$\sigma_{min} = \left[ \begin{array}{c} \nu \\ 1 - \nu \end{array} \right] \left[ \sigma_z - \alpha_1 P_R \right] + \alpha_2 P_R + \sigma_{Tec}$$

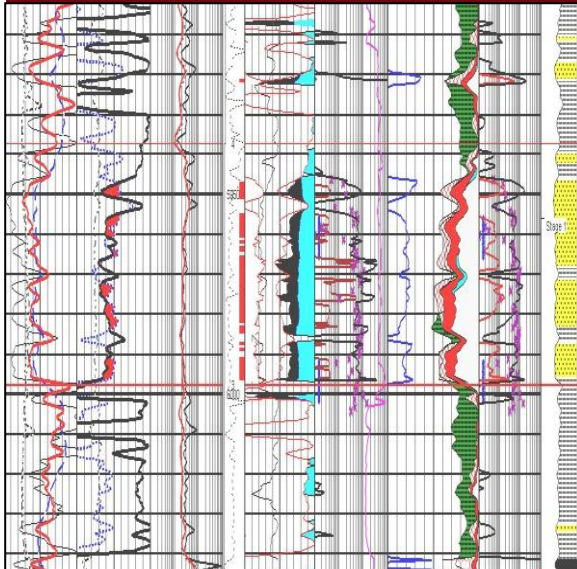
### Fracture Design Pump Schedule

Stage #	Flow Path	Fluid System	Prop Type	Stage Time (min)
1 - 1	Shut-In			0
1 - 2	In	20# Water Frac G		39.3
1 - 3	In	20# Water Frac G	SAND - PREMIUM - 20/40, BULK, SK (100003678)	17.82
1 - 4	In	20# Water Frac G		6.39
1 - 5	In	15% Hydrochloric Acid		1.06
1 - 6	In	20# Water Frac G		16.46
1 - 7	In	20# Water Frac G	SAND-CRC PREMIUM-20/40, BULK (101357961)	7.02
1 - 8	In	20# Water Frac G	SAND-CRC PREMIUM-20/40, BULK (101357961)	10.32
1 - 9	In	20# Water Frac G	SAND-CRC PREMIUM-20/40, BULK (101357961)	8.96
1 - 10	In	20# Water Frac G	SAND-CRC PREMIUM-20/40, BULK (101357961)	6.31
1 - 11	In	20# Water Frac G		10.37
1 - 12	Shut-In			0
<b>Total</b>				<b>124.01</b>

# Fracture Design

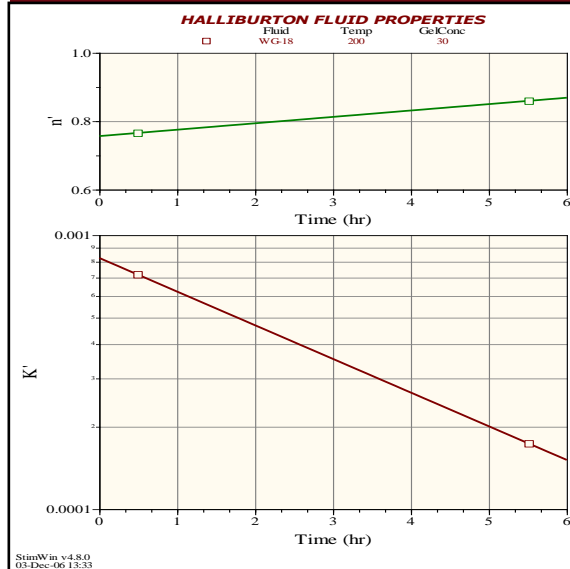
## Detailed Data Required

### Petrophysics Formation Properties



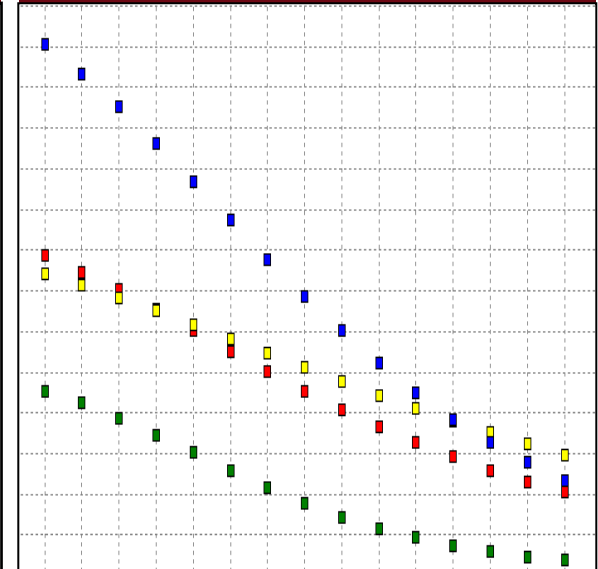
$k$ ,  $\Phi$ ,  $v$ ,  $E$ ,  $\sigma$ ,  $P_p$ , BHT

### Fluid Properties



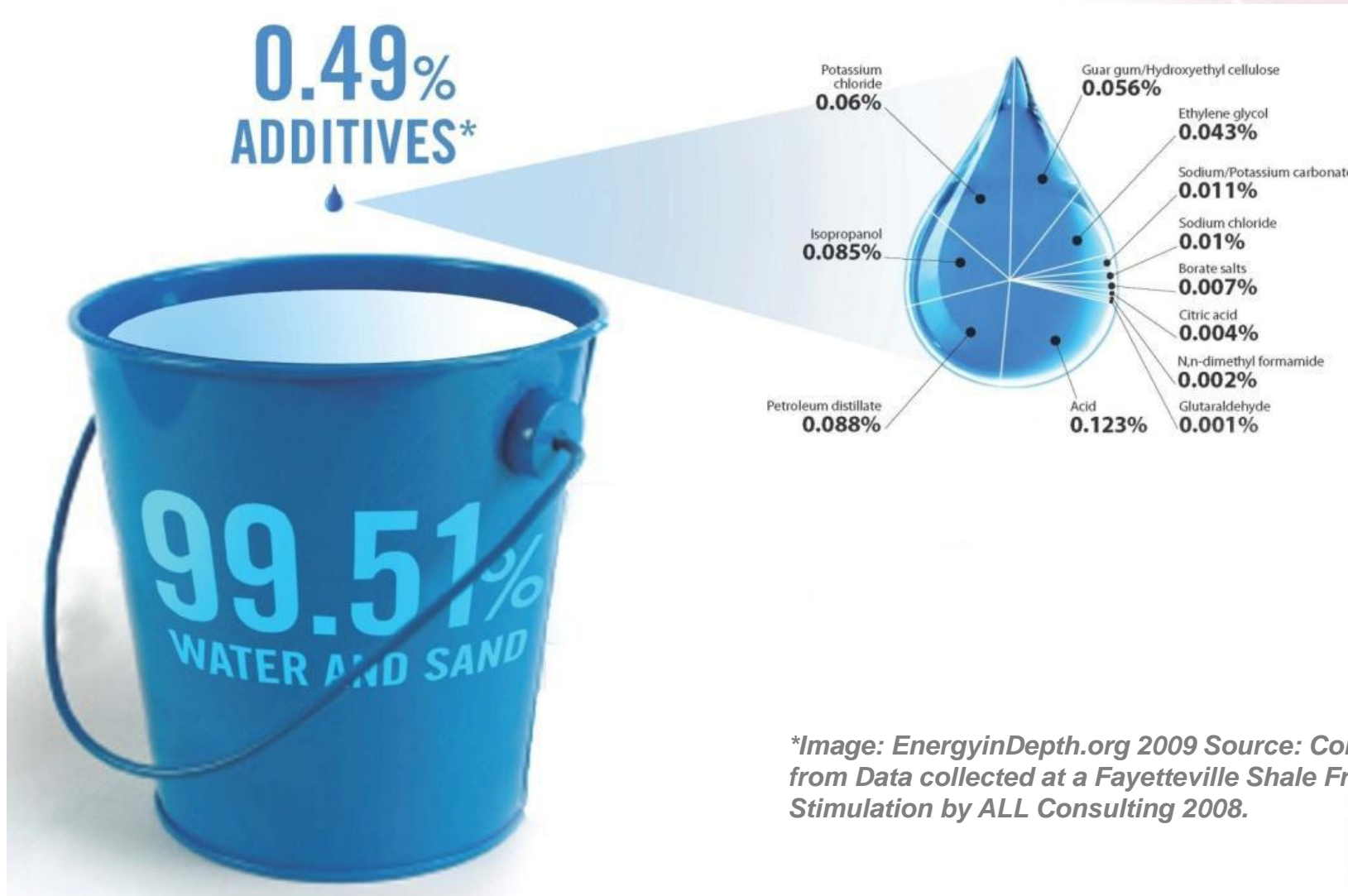
Multitude of fluid types  
 $n'$ ,  $K'$ ,  $\mu$ , break profile,  $P_f$

### Proppant Properties



Variety of proppant types  
 $\beta$ , sg, size, CD

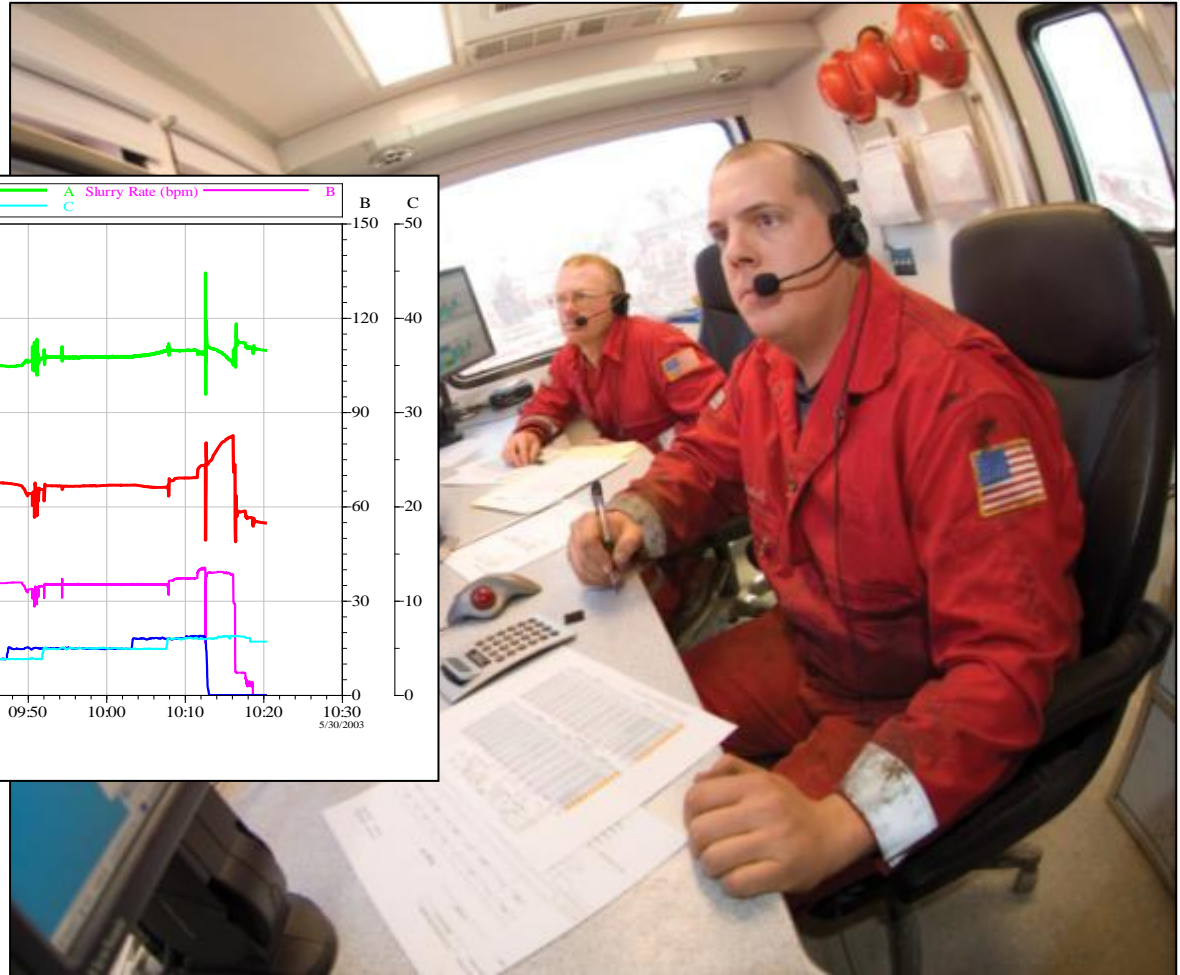
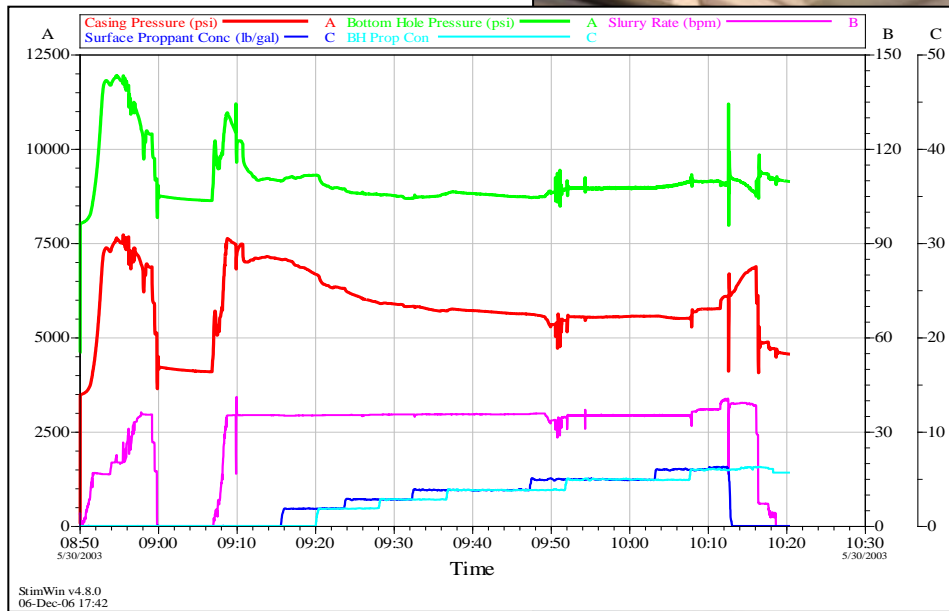
# Fluid Composition



*\*Image: EnergyinDepth.org 2009 Source: Compiled from Data collected at a Fayetteville Shale Fracture Stimulation by ALL Consulting 2008.*

# Fracture Treatment

## *A Managed Process*

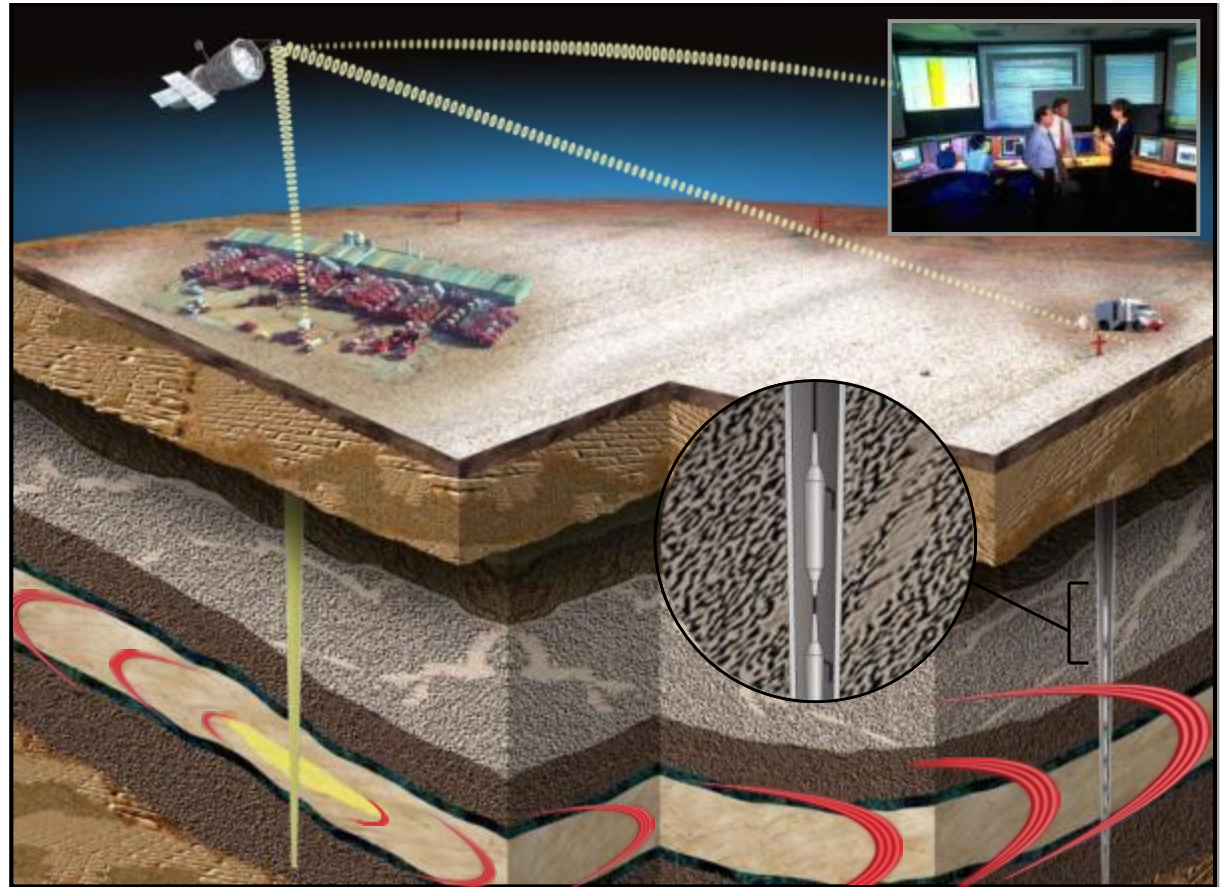




# Fracture Evaluation

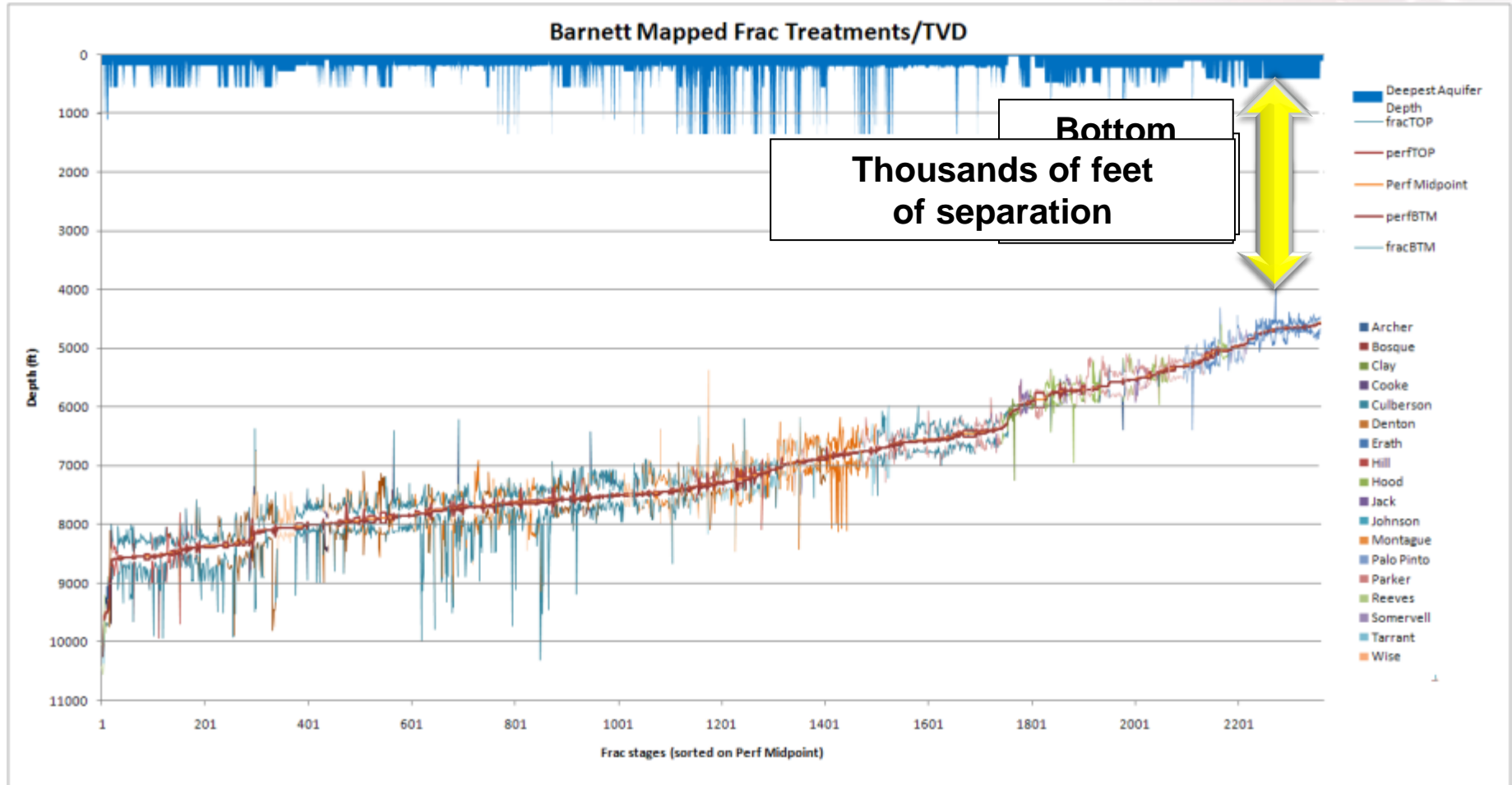
## *Microseismic Monitoring*

- Fracturing process generates “nano” level microseismic events
- Geophones in monitor well identify and map precise location of events



# Fracture Location Determination

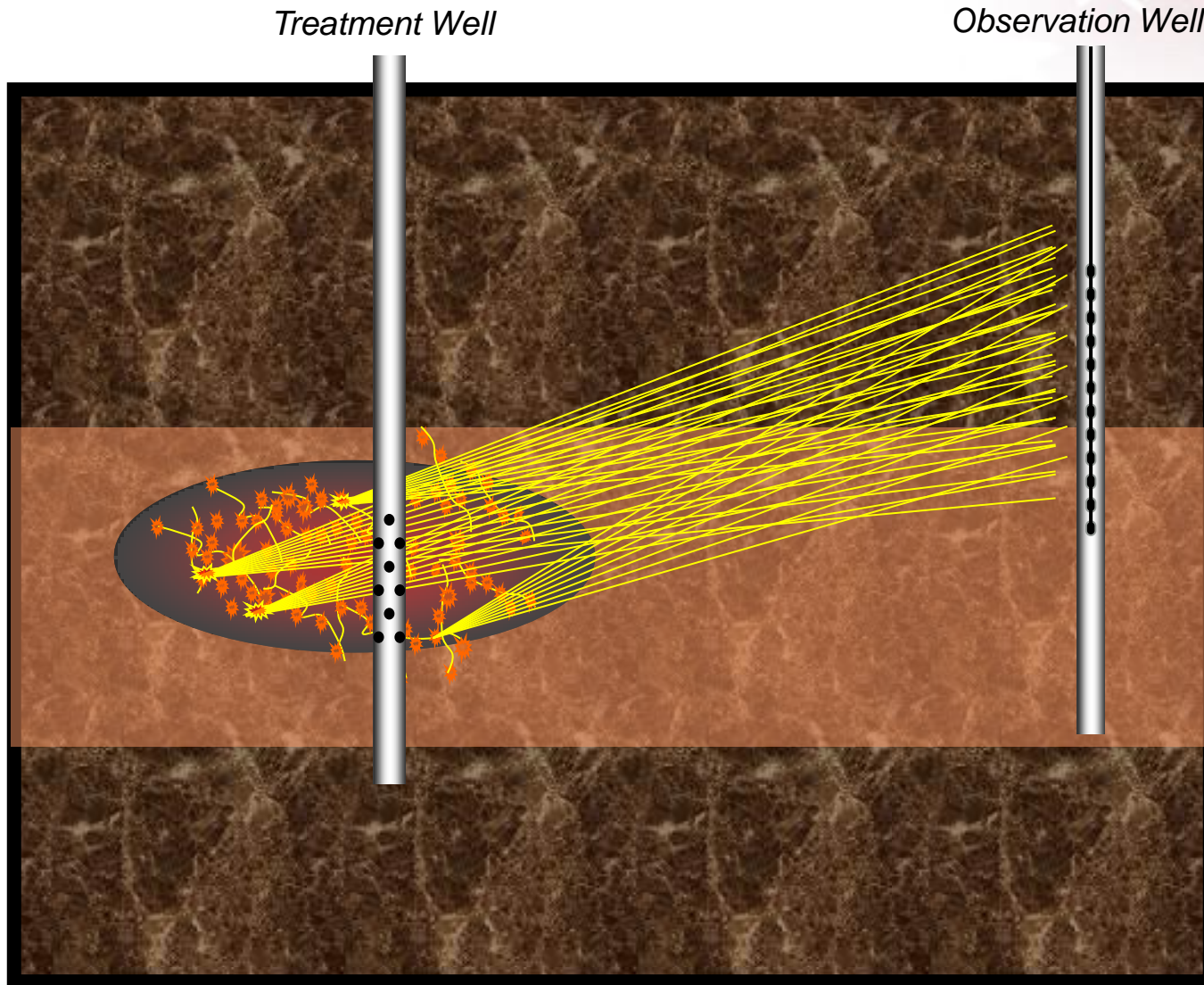
## Barnett Study



Kevin Fisher, "Data Confirm Safety of Well Fracturing,"  
The American Oil & Gas Reporter – July 2010

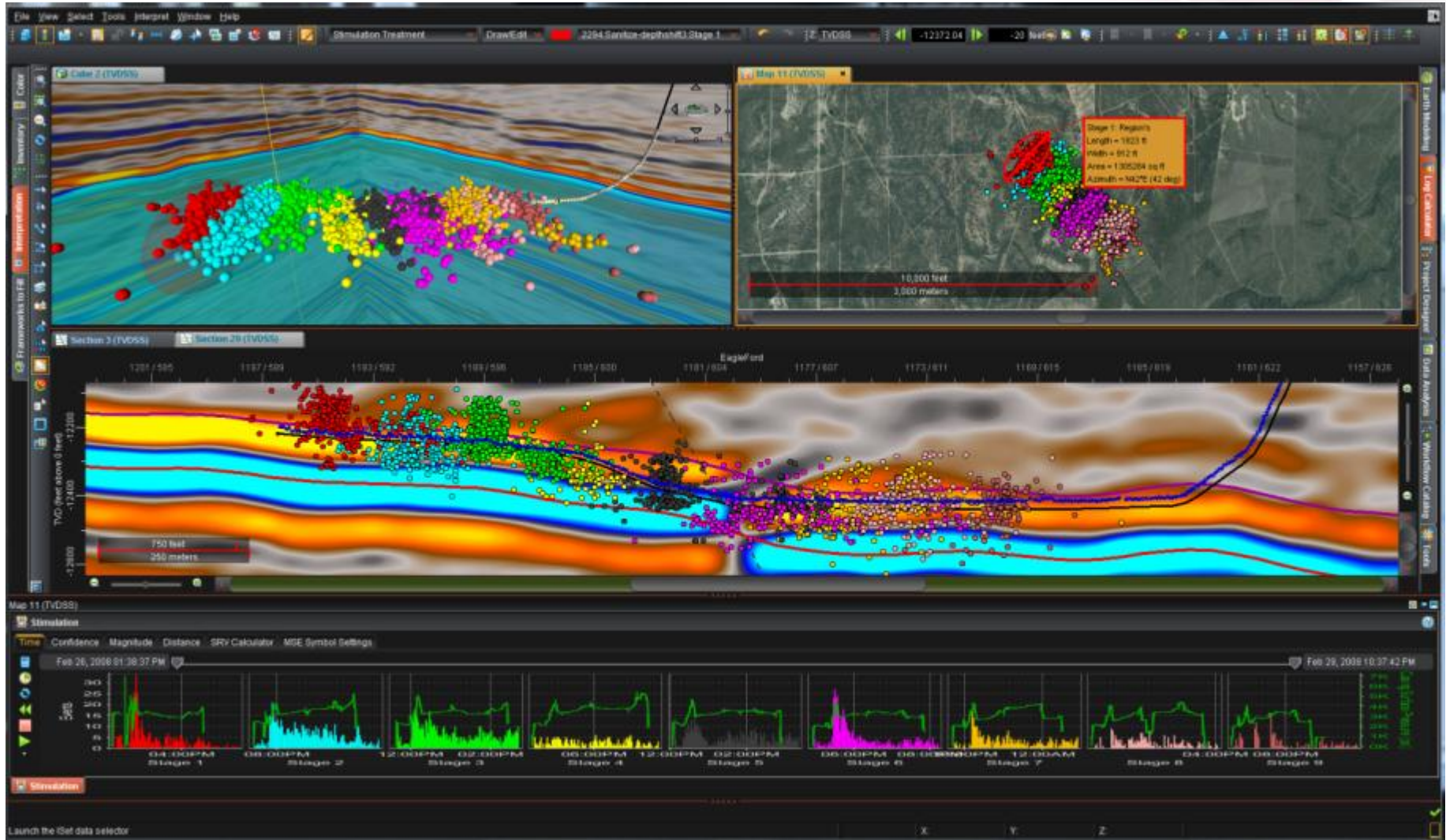
# Closer Look

## *Microseismic Monitoring*





# Visualization a Mile Away





# Sources of Information

## STRONGER

In-depth peer review of the HF regulatory programs in OH, PA, OK, LA and CO  
[www.strongerinc.org](http://www.strongerinc.org)



## API

Detailed Guidance Documents and Recommended Practices for industry  
[www.API.org](http://www.API.org)



## IOGCC/GWPC

FracFocus website adopted by states providing well by well information to the public  
[www.FracFocus.org](http://www.FracFocus.org)



## Energy In Depth

Energy In Depth launches new grassroots initiatives in northeast PA, southern NY and eastern Ohio  
[www.Energyindepth.org](http://www.Energyindepth.org)



## Halliburton

Hydraulic Fracturing microsite contains detailed fluid information and educational material  
[www.Halliburton.com/HydraulicFracturing](http://www.Halliburton.com/HydraulicFracturing)



# TRUTH LAND



- Truthland has been viewed more than 30,000 times on YouTube
- More than 40 screenings have already been scheduled in states across the nation



[www.Truthlandmovie.com](http://www.Truthlandmovie.com)

Thank You!