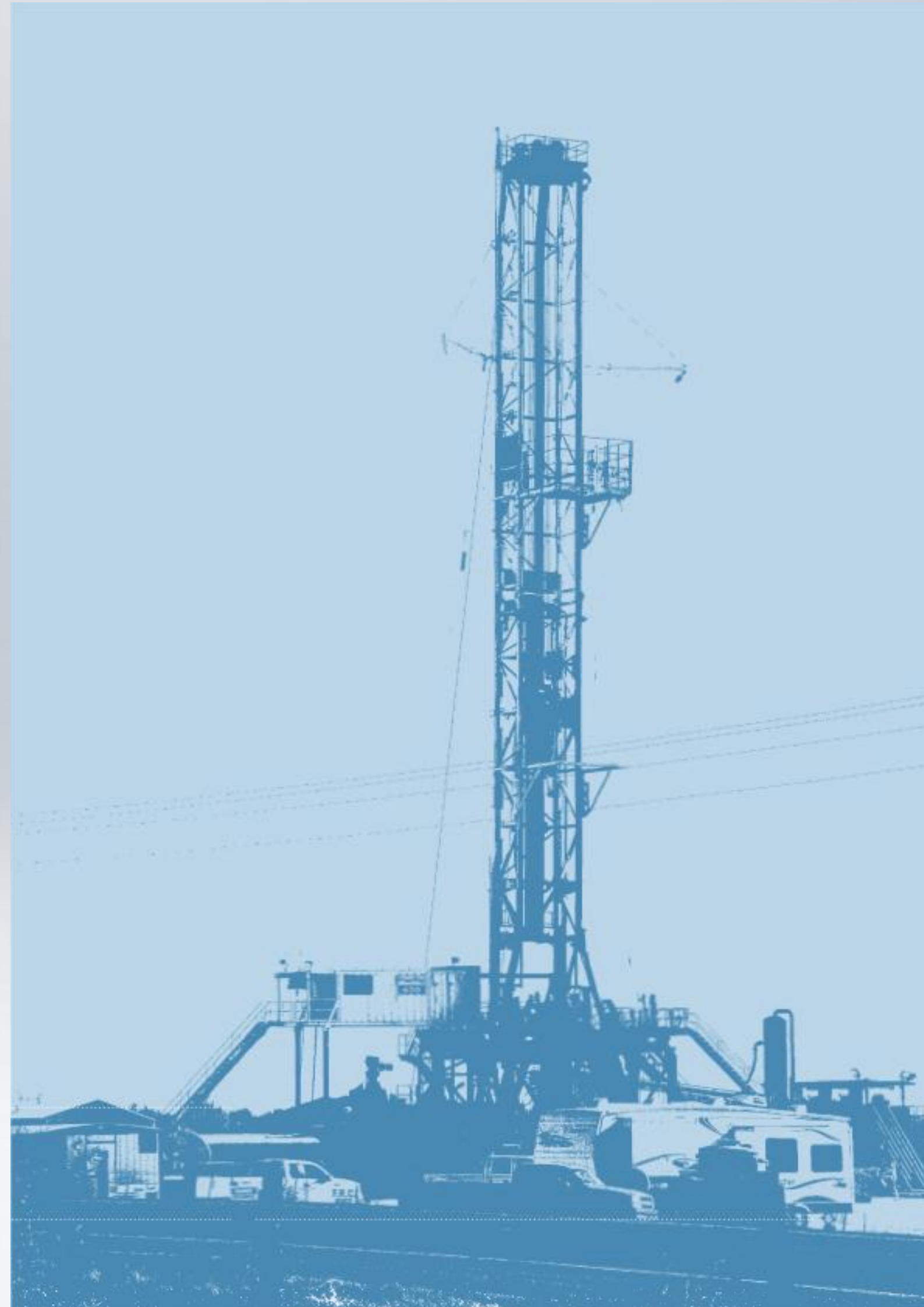


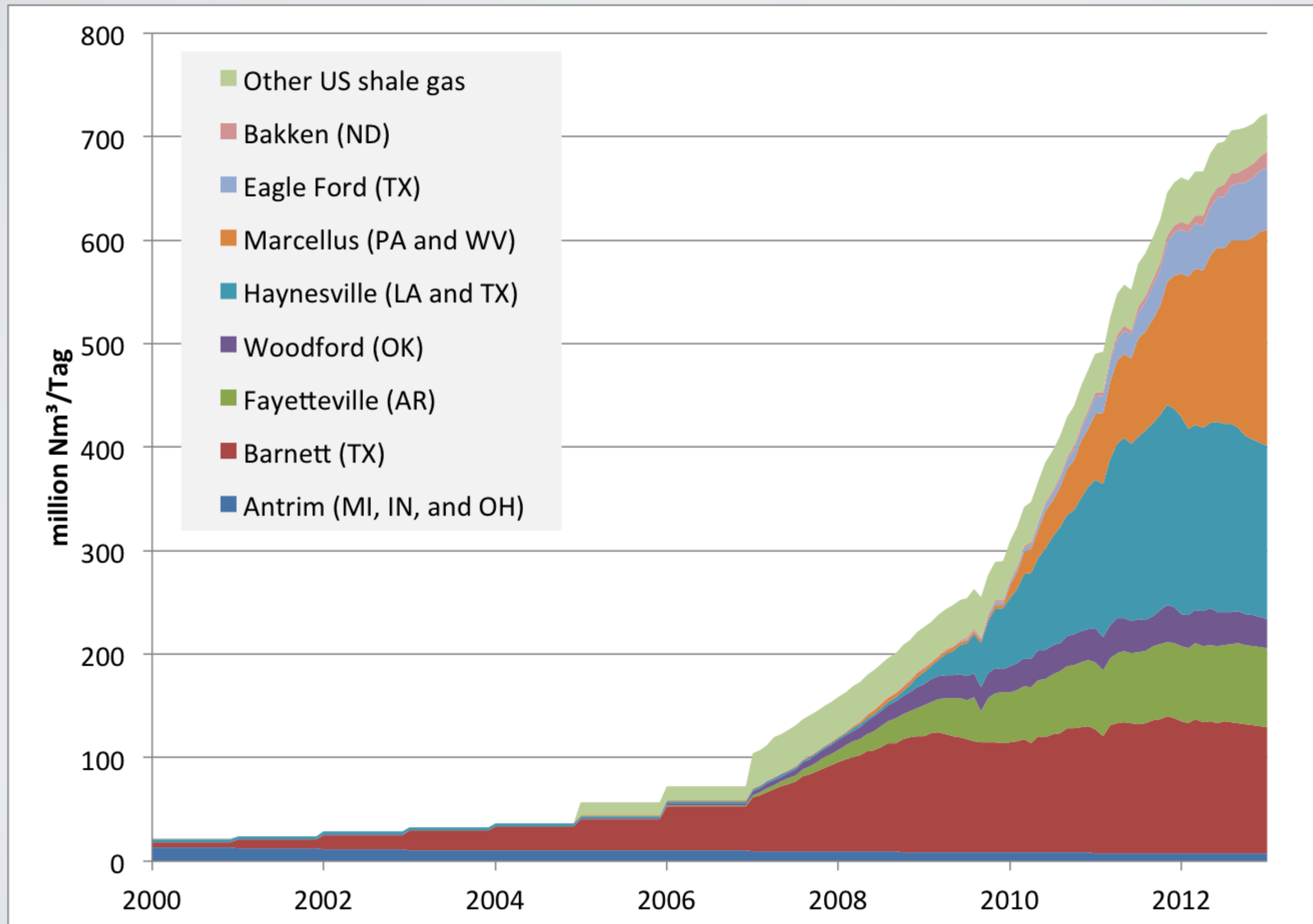
# Shale Gas and fracking

## An Introduction

Markus Hänchen  
ETH Zürich  
1 April 2014



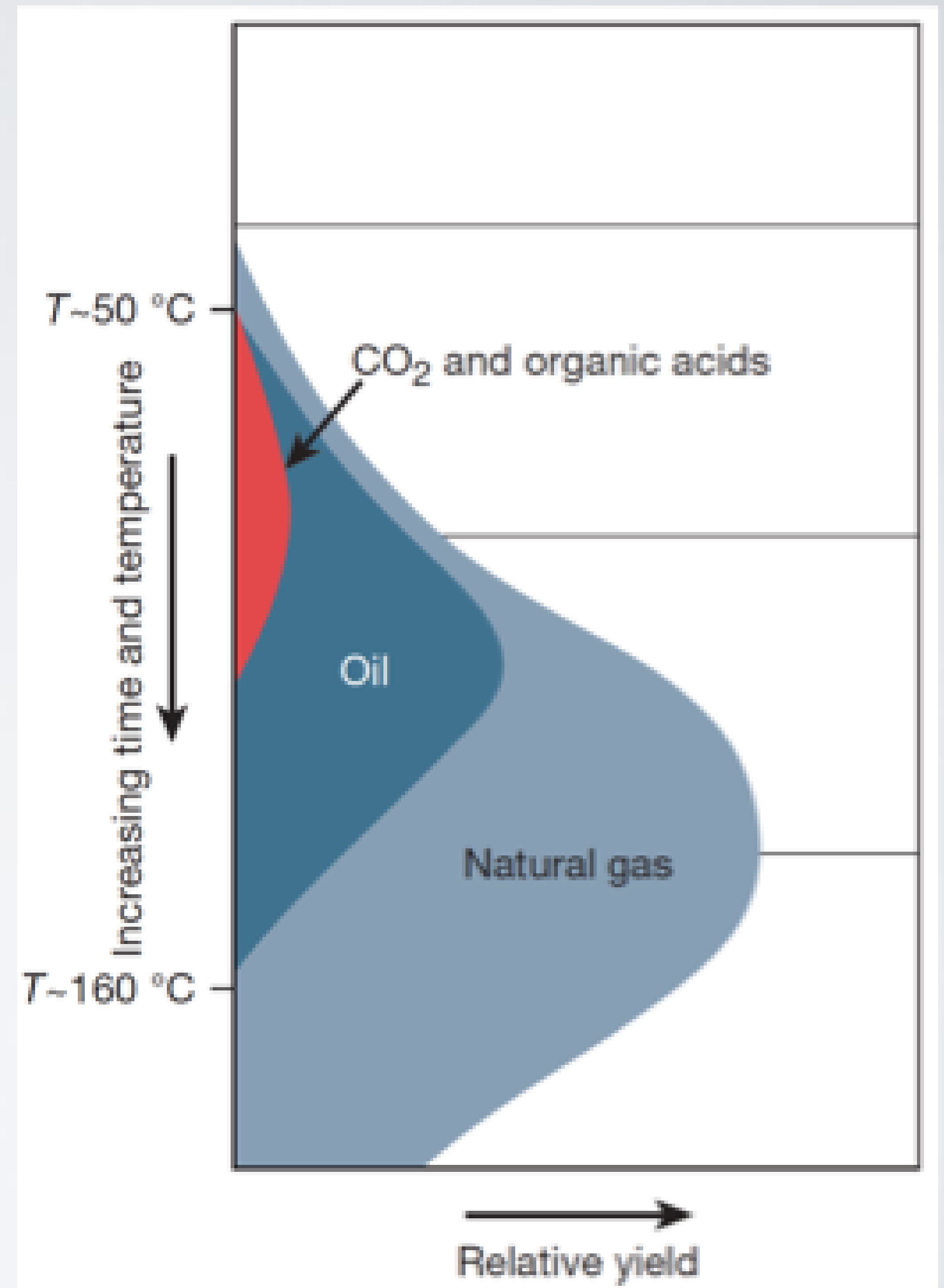
# U.S. Shale Gas Production



39% of total natural gas production in 2013

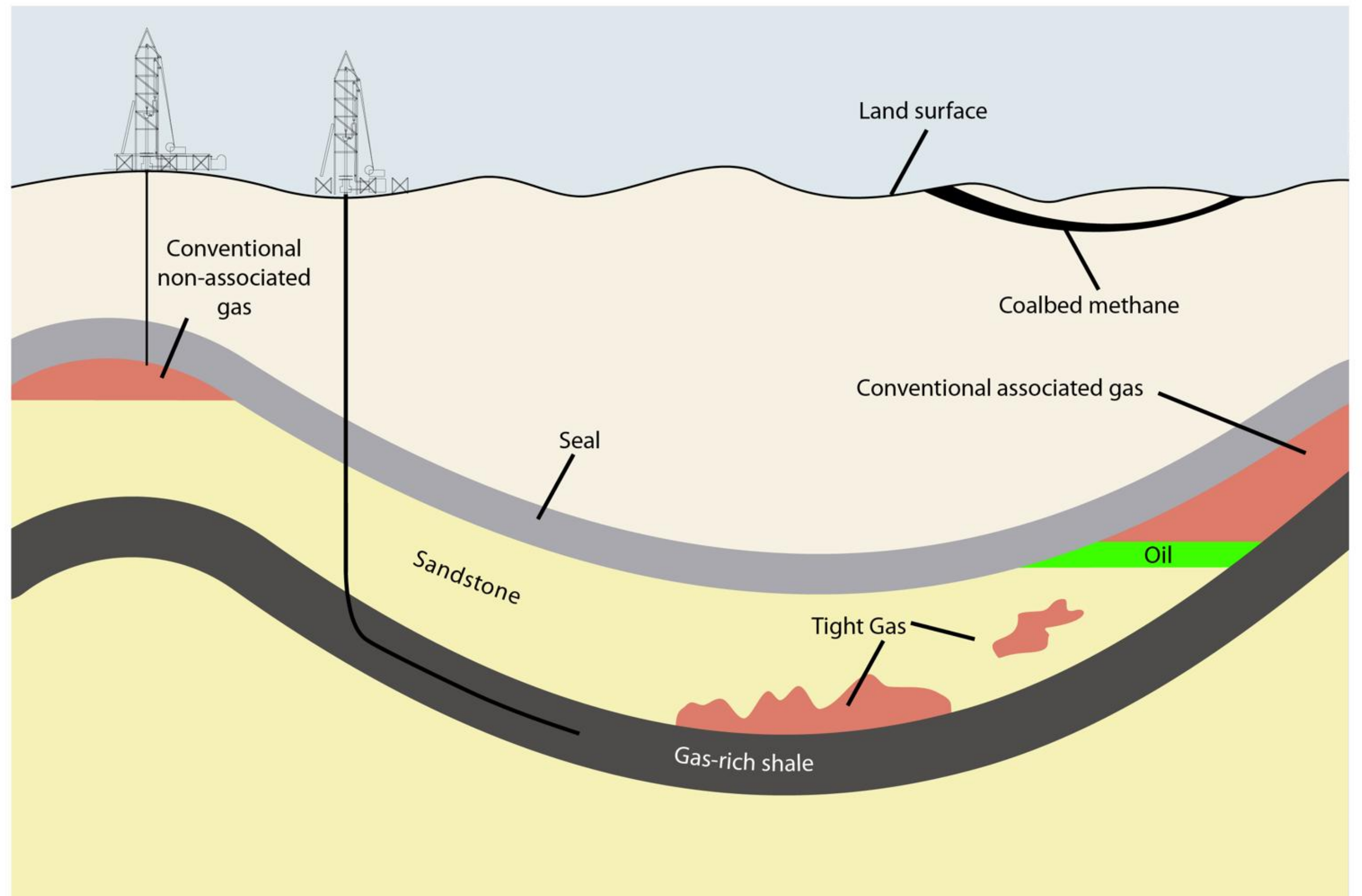
# Formation of Fossil Fuels

- Burial of organic material
- First: biogenic methane production
- Thermogenic oil and gas production
- Oil and gas window



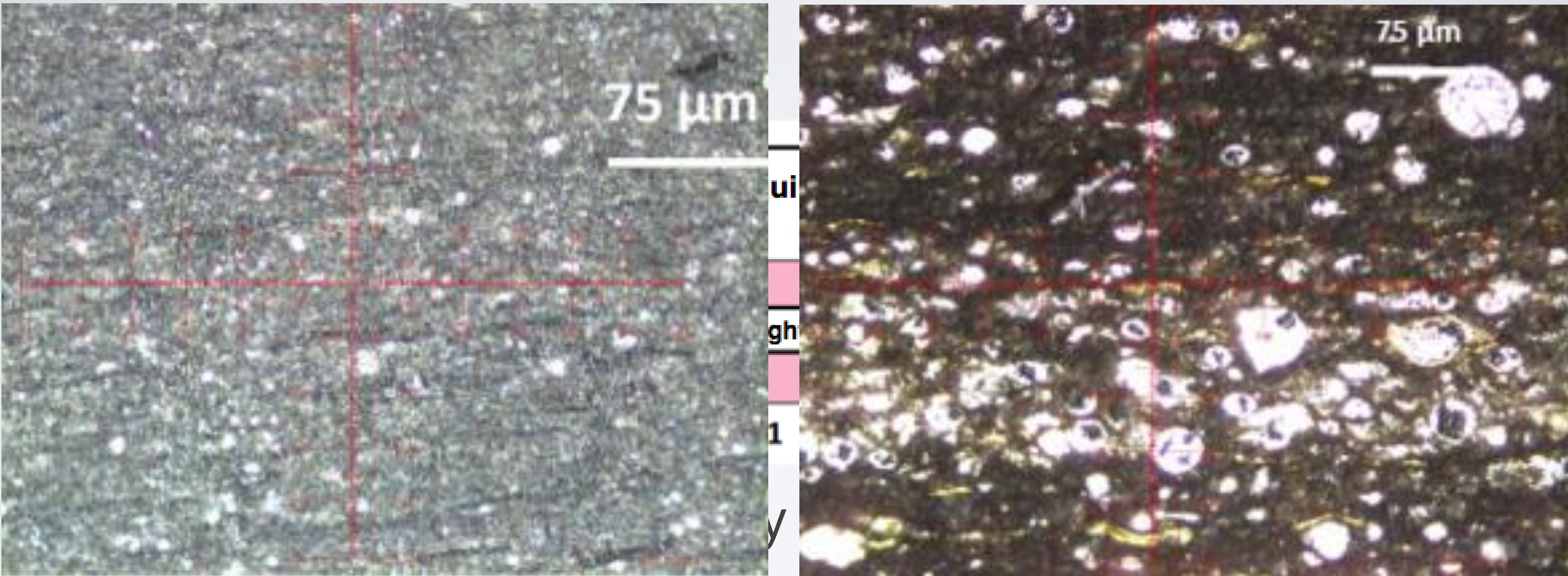
# Unconventional Natural Gas

- Upward migration from source rock
- Conventional gas: Accumulation under structural traps
- Tight gas: Trapped in low permeability rock
- Shale gas: Remains trapped in source rock





# Why We Need Fracking



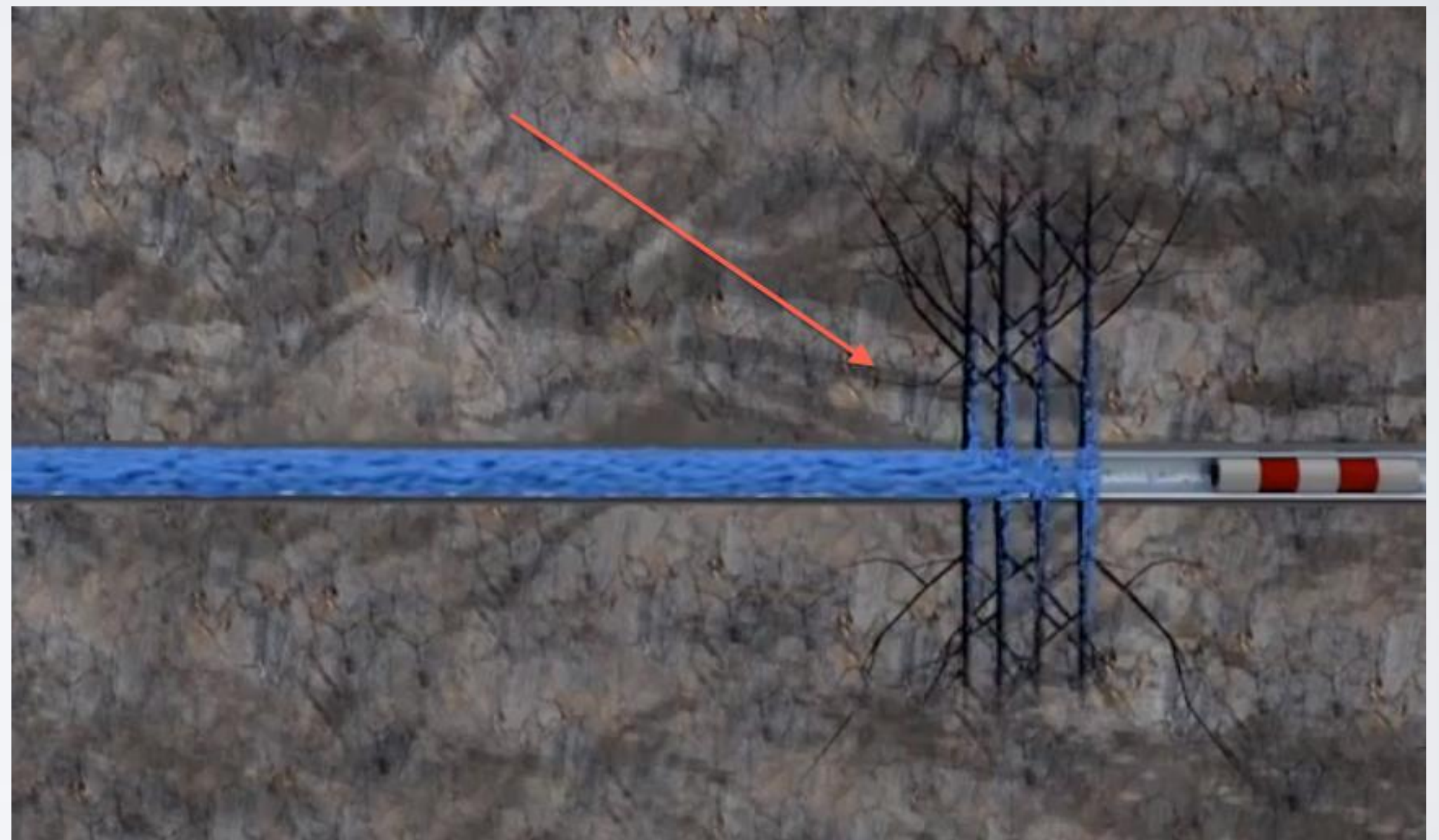
Thin section photograph of shales -- small, unconnected pores

[Pierce \(USGS\), 2012](#)



# Hydraulic Fracturing

- Pumping large volumes of water with sand and additives
- 10 m<sup>3</sup>/min, 500 bar, 10'000 m<sup>3</sup>/well
- Sand prevents closure of fractures after pressure reduction
- 5 to 80% returns mixed with highly saline formation water (incl. heavy metals, NORM)





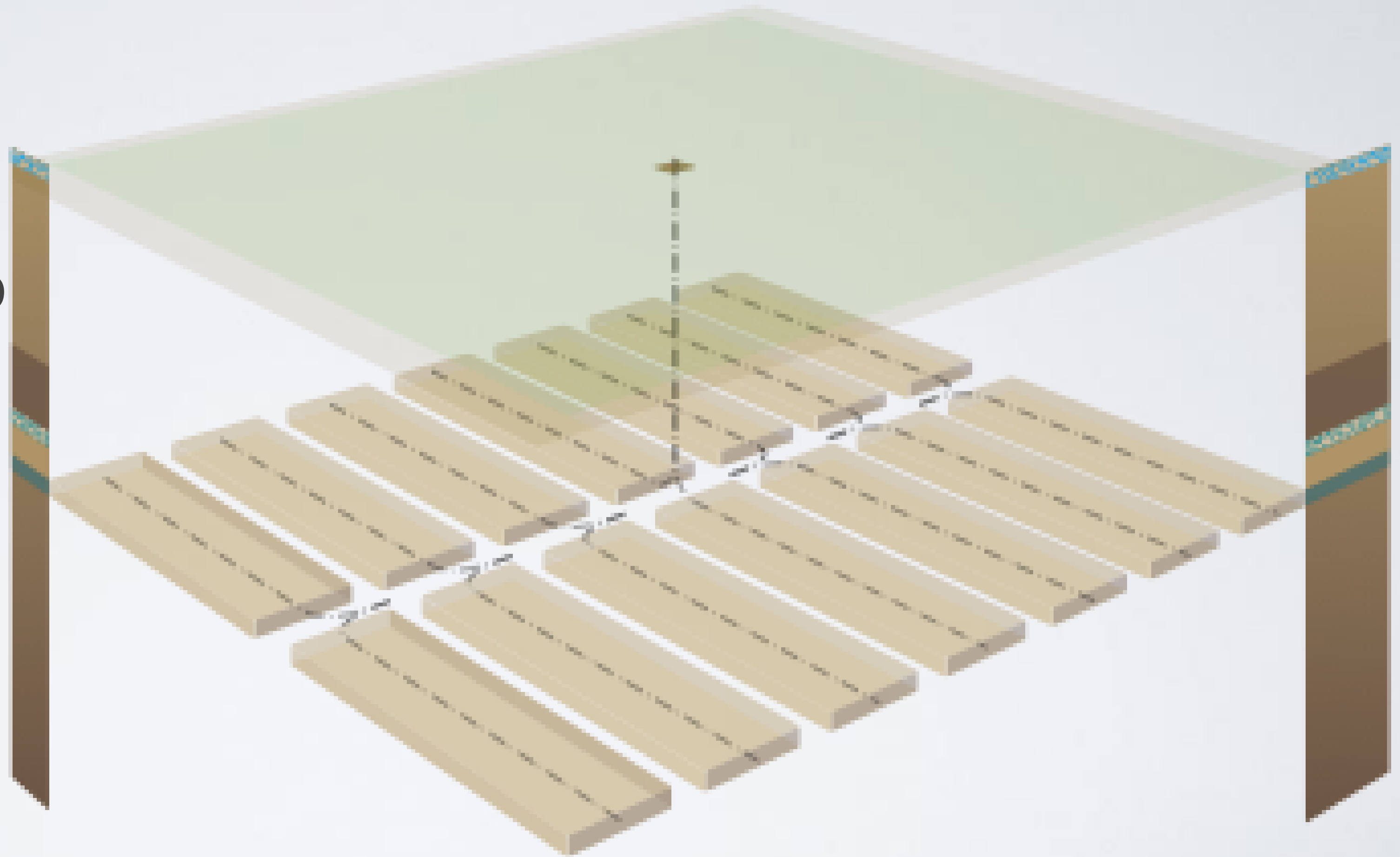
# Well Construction

- Multiple concentric steel casings encased with cement
- Typically four casings with three casings in the freshwater layer
- Depths of 1000 to 4000 m, lateral length of 1 to 3 km



# Well Layout

- Multiple wells (up to 30+) drilled from one well pad
- One pad can cover an area of 3x3 km or larger



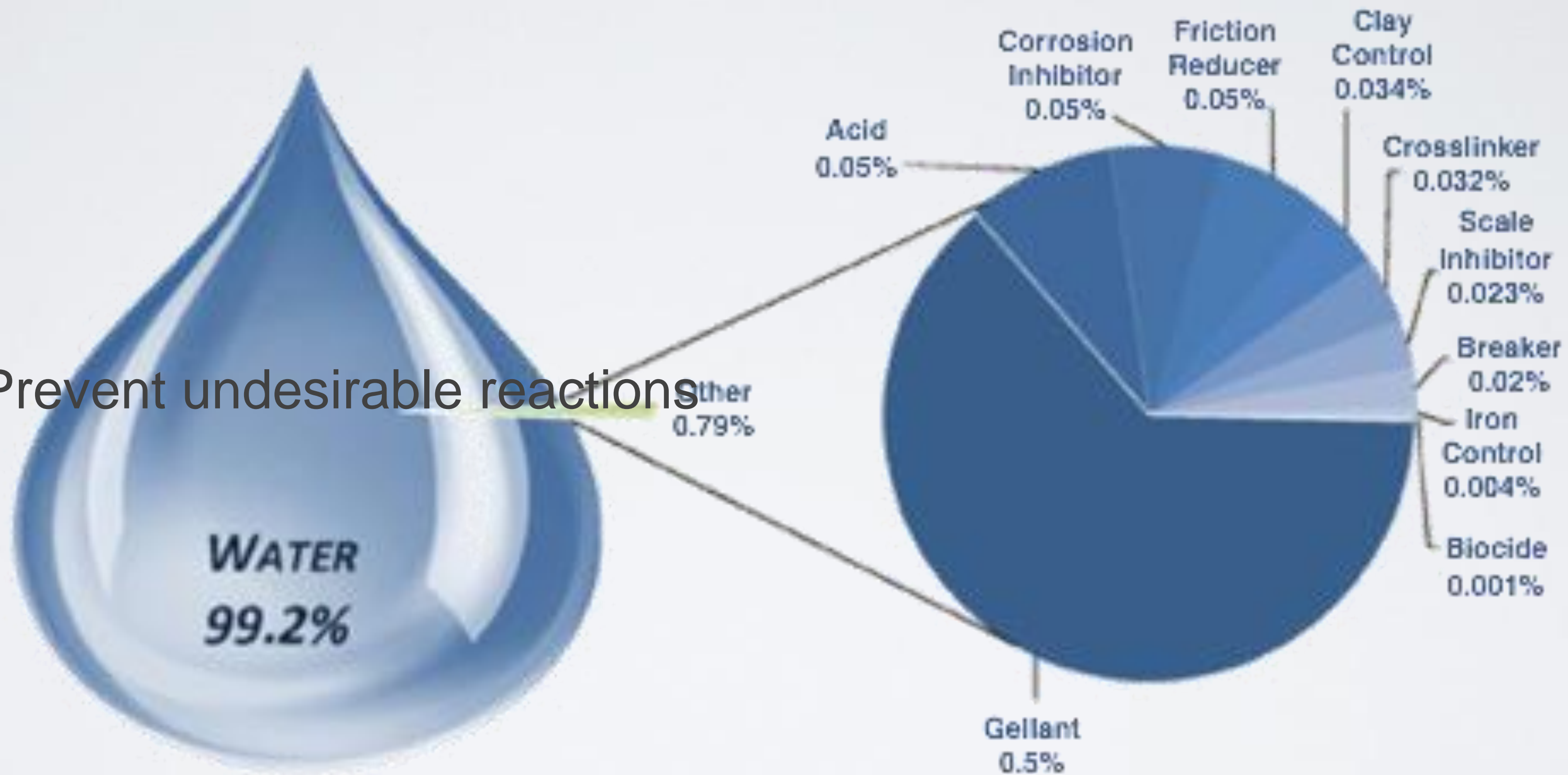


# Frac Fluids

(1) Modify fluid properties

- 
- 
- 
- 
- 
- 
- 
- 
- 
- 

(2) Prevent undesirable reactions



[fracfocus.org](http://fracfocus.org), August 2012

(3) pH adjustment

# Frac Fluids

## (1) Modify fluid properties

- Friction reducer
- Gellant
- Crosslinker
- Breaker
- Surfactant

## (2) Prevent undesirable reactions

- Biocide
- Corrosion inhibitor
- Anti-scaling agent
- Clay stabiliser
- Iron control

## (3) pH adjustment

- Strong acids, bases, buffers

Frac Fluids rarely  
contain  
components from  
all additive groups



# Examples of common additives

## (1) Modify fluid properties

- Friction reducer > Polyacrylamide
- Gellant > Guar Gum
- Crosslinker > Sodium Perborate
- Breaker > Sodium Peroxidisulphate, Cellulase
- Surfactant > Nonyl Phenol Ethoxylate

## (2) Prevent undesirable reactions

- Biocide > Glutaraldehyde
- Corrosion inhibitor > Isopropanol
- Anti-scaling agent > Ammonium Chloride
- Clay stabiliser > Potassium Chloride
- Iron control > Citric Acid

## (3) pH adjustment

- Strong acids, bases, buffers > Hydrochloric Acid, Acetic acid



# Frac Fluid Developments

## FracFocus 2.0

HUNDREDS OF COMPANIES. THOUSANDS OF WELLS.

**Welcome to FracFocus 2.0!** We're excited about our latest upgrades designed to dramatically enhance the site's functionality for the public, state regulatory agencies and industry users. Our user-friendly 'Find A Well' chemical disclosure registry now includes more extensive search options.

FracFocus continues to evolve and expand, adding more participating companies and reported wells from across the country. Our continued success is the result of nationally recognized organizations working with state governments and the oil and natural gas industry to provide public transparency.

[FIND OUT MORE >](#)

[Welcome](#)

[Hydraulic Fracturing](#)

[Casing & Cement](#)

[State Regulations](#)

[Chemical Use](#)

Looking for information about a well site near you?



Search for nearby well sites that have been hydraulically fractured to see what chemicals were used in the process.

TOTAL WELL SITES REGISTERED

6 8 3 1 4

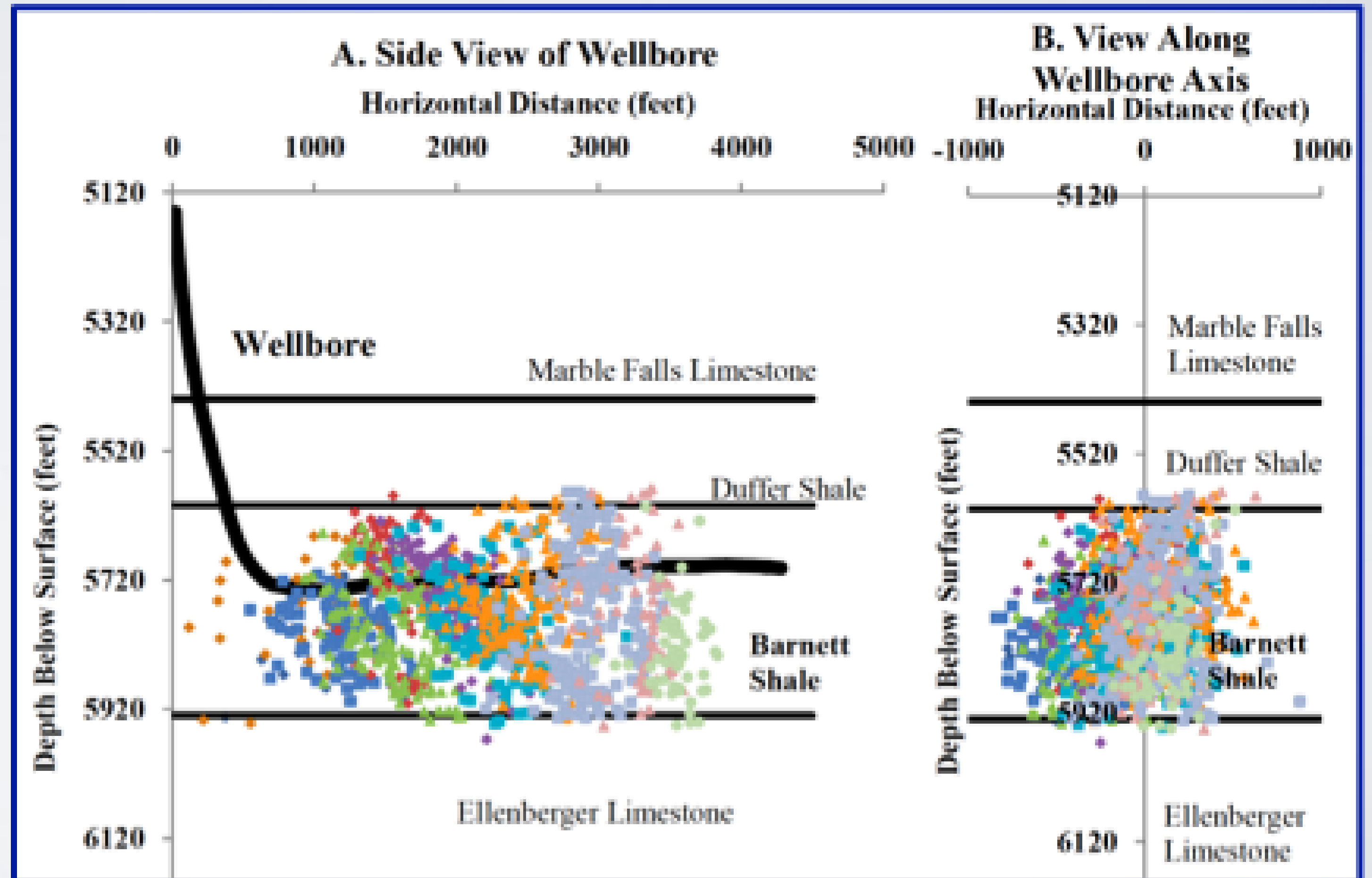
since  
2011

[fracfocus.org](http://fracfocus.org), April 2014



# Fracturing Monitoring

- Pressure-flow rate response
- Microseismic
- Tiltmeter



# What Can Be Problematic

- Methane in groundwater (more sampling)
- Surface or near surface spills of frac fluid or backflow (reduce toxicity of additives, stricter procedures)
- Migration from deep underground (very unlikely)
- Disposal of backflow (mostly re-injected, increased recycling)
- Methane emissions during well completion (technically solvable: Green Completions, required in the US now)
- Freshwater needs (only in arid areas)
- Induced seismicity (mainly from backflow re-injection)
- Land use, noise, light (mainly in undisturbed nature)