Geologic Aspects of Hydraulic Fracturing

An Idaho Emphasis

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Idaho Law Review Symposium

The Presenter: Virginia S. Gillerman

- Economic Geologist (+ 30 years)
  - Metals, Industrials, Energy
- Idaho Geological Survey, Boise (+ 20 years)
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- NOT a lawyer, I do rocks.

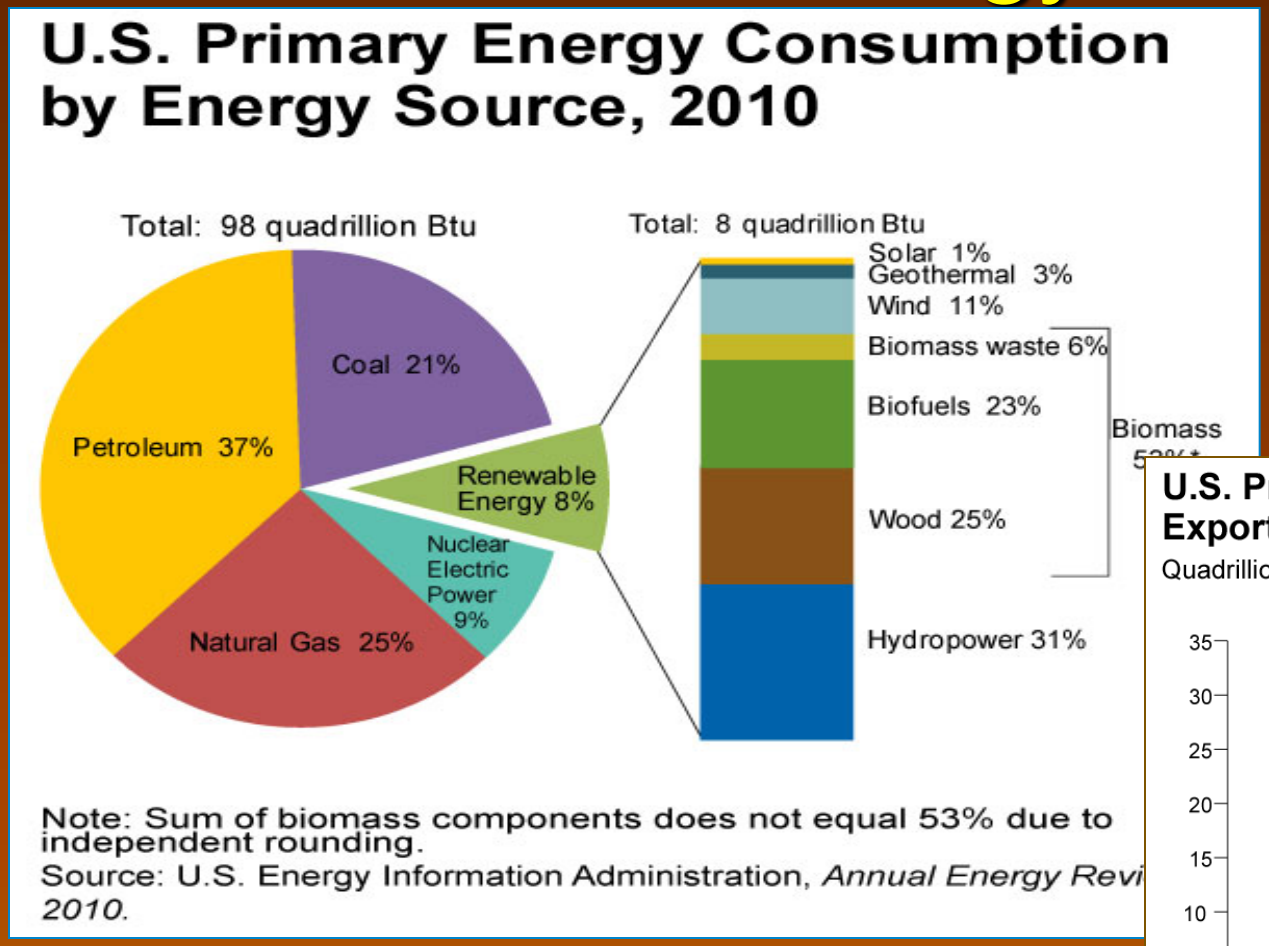
Why are we here to discuss hydraulic fracturing?

22 March 2013

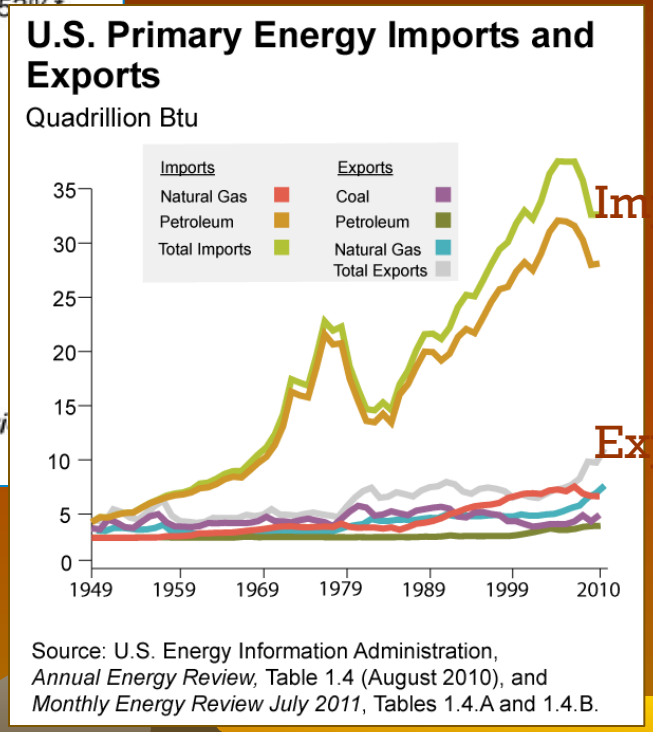
The International Energy Agency (IEA) on Friday 22 March 2013 hosted the inaugural meeting of the IEA Unconventional Gas Forum, which gathered more than 100 officials from government, industry, NGOs and international organisations to discuss best practices for the sustainable development of global unconventional natural gas resources.

“Natural gas is poised to enter a golden age, but will do so only if a significant proportion of the world’s vast resources of unconventional gas can be brought to markets in a manner that is both profitable and that addresses the legitimate public concerns about the associated environmental and social impacts,” said IEA Executive Director Maria Van der Hoeven, who welcomed delegates to the event at the IEA’s Paris headquarters.

Is the U.S. an energy addict? Yes!



US consumes 20% of world's energy, w/ <5% of population.



Per person:

U.S. energy usage: 11.4 kW/h

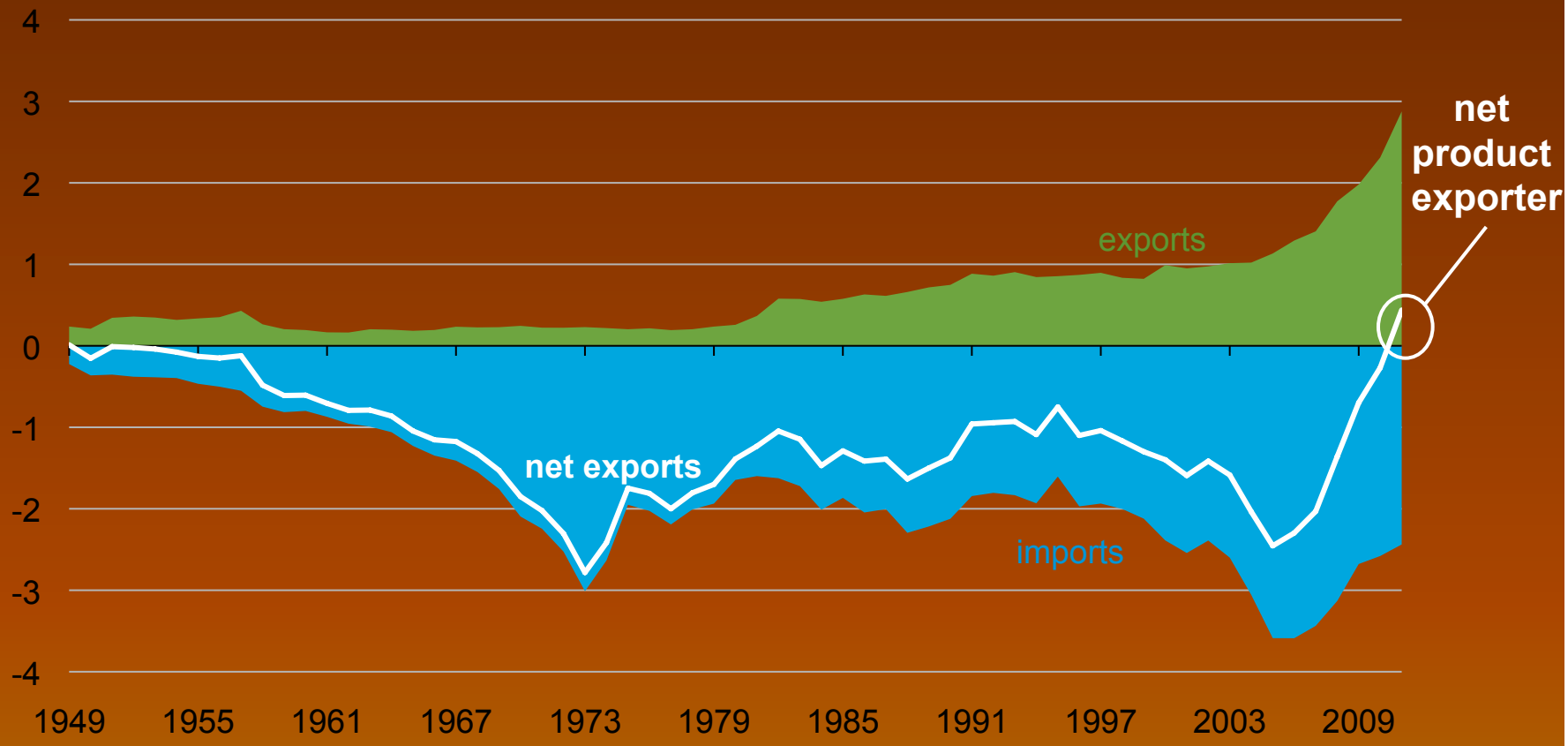
Germany: 6 kW/h

India: < 1 kW/h

1 cubic feet of gas ~ 1030 BTU; 1 BTU ~ 0.3 watt/h

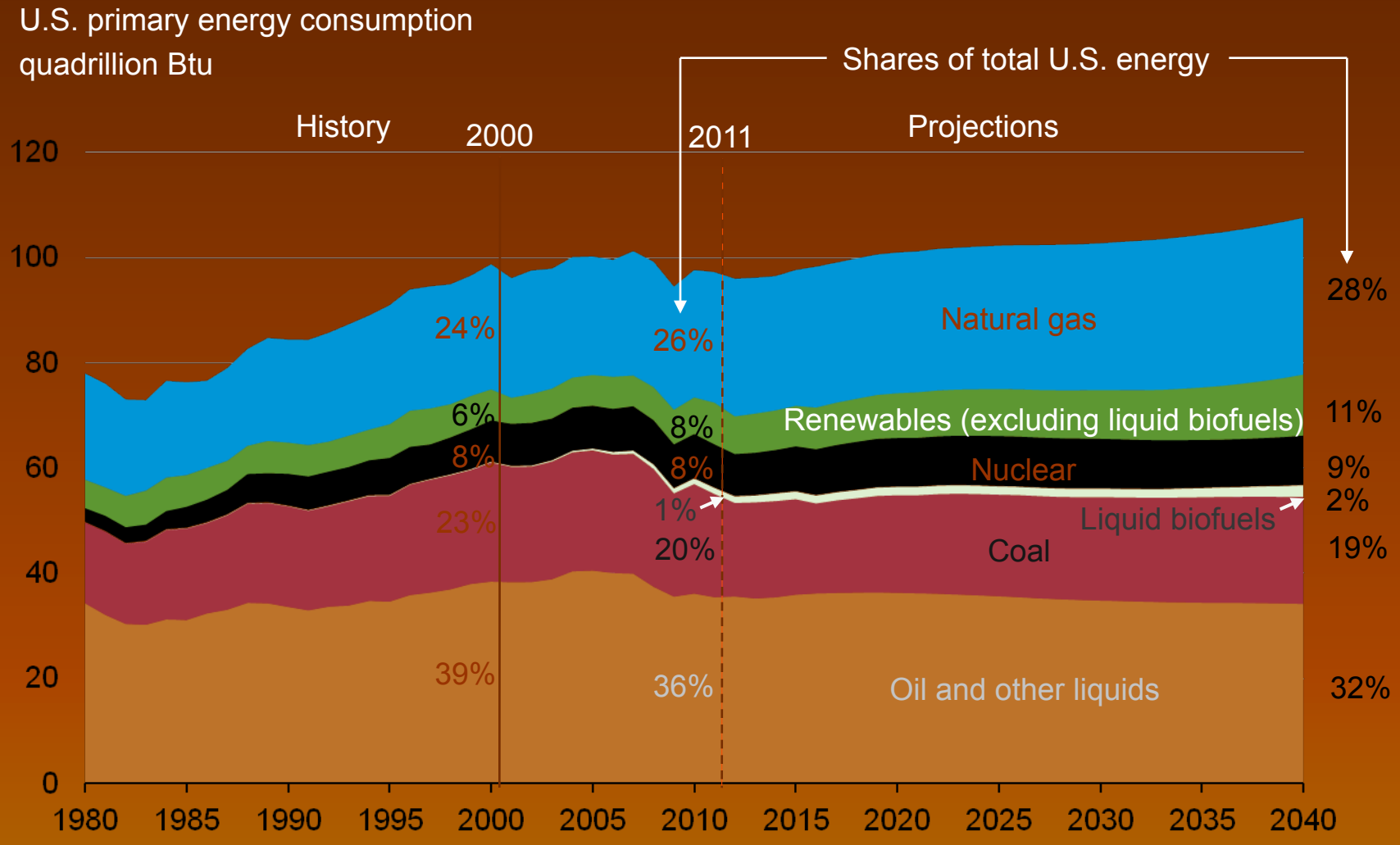
U.S. petroleum product exports exceeded imports in 2011 for first time in over six decades

annual U.S. net exports of total petroleum products, 1949 – 2011
million barrels per day



Source: EIA, Petroleum Supply Monthly

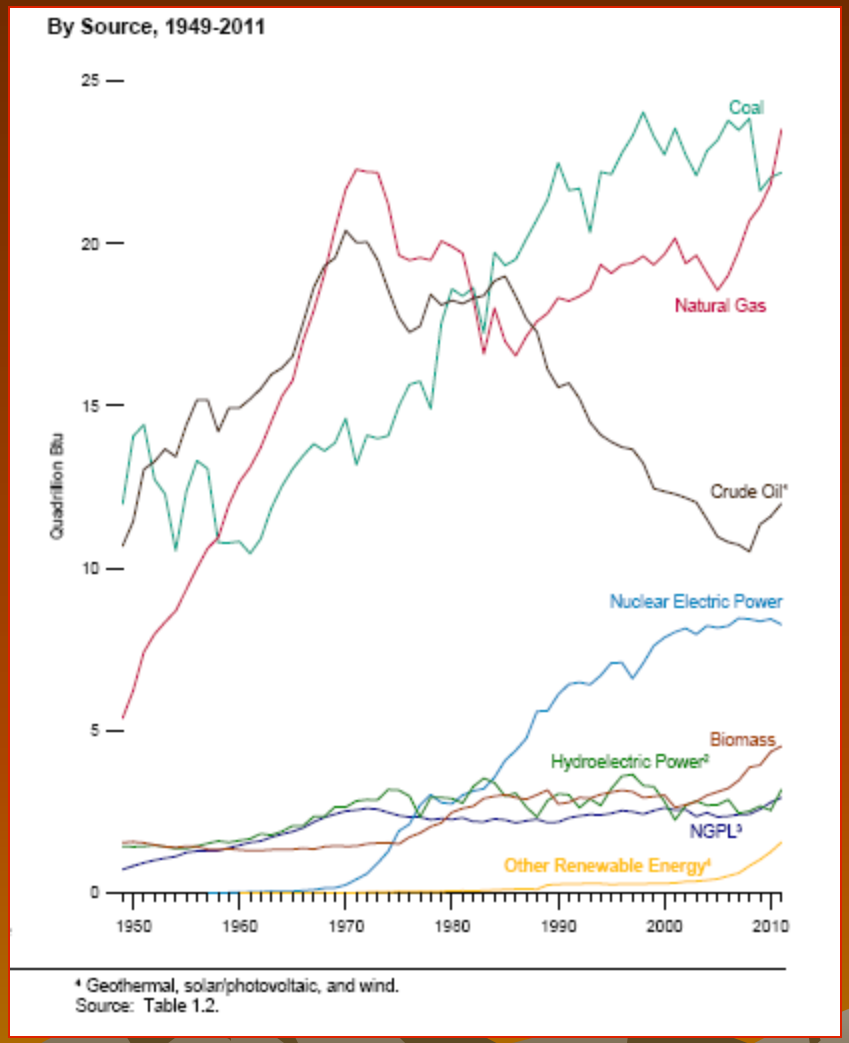
U.S. energy use grows slowly over the projection reflecting improving energy efficiency and slow, extended economic recovery

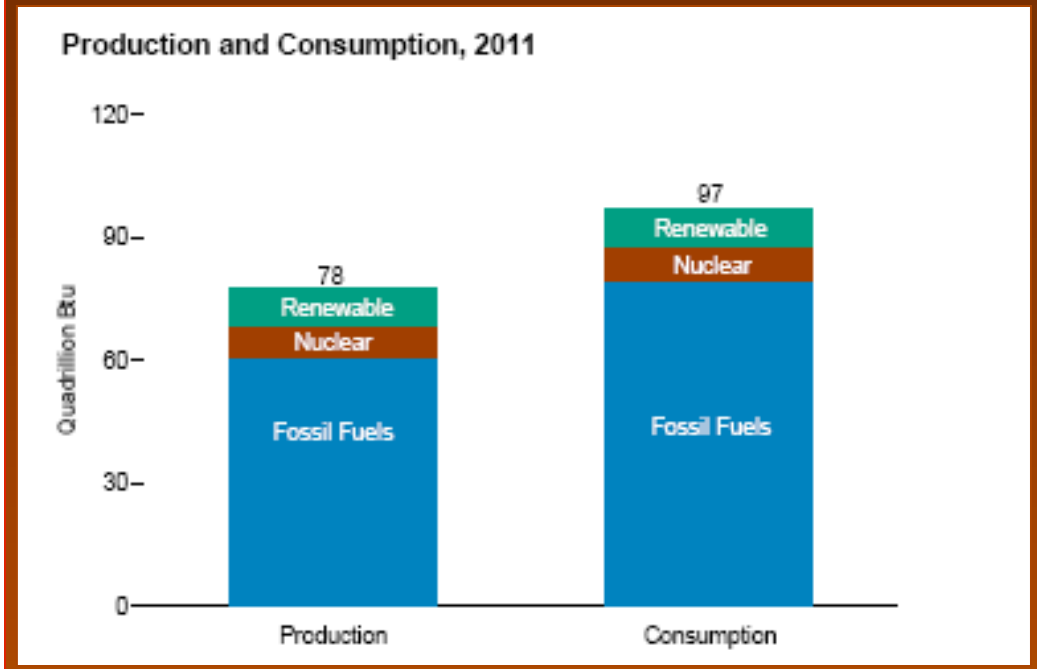


Source: EIA, Annual Energy Outlook 2013 Early Release

FUTURE

2011 and the Past (U.S. Energy Information Administration)

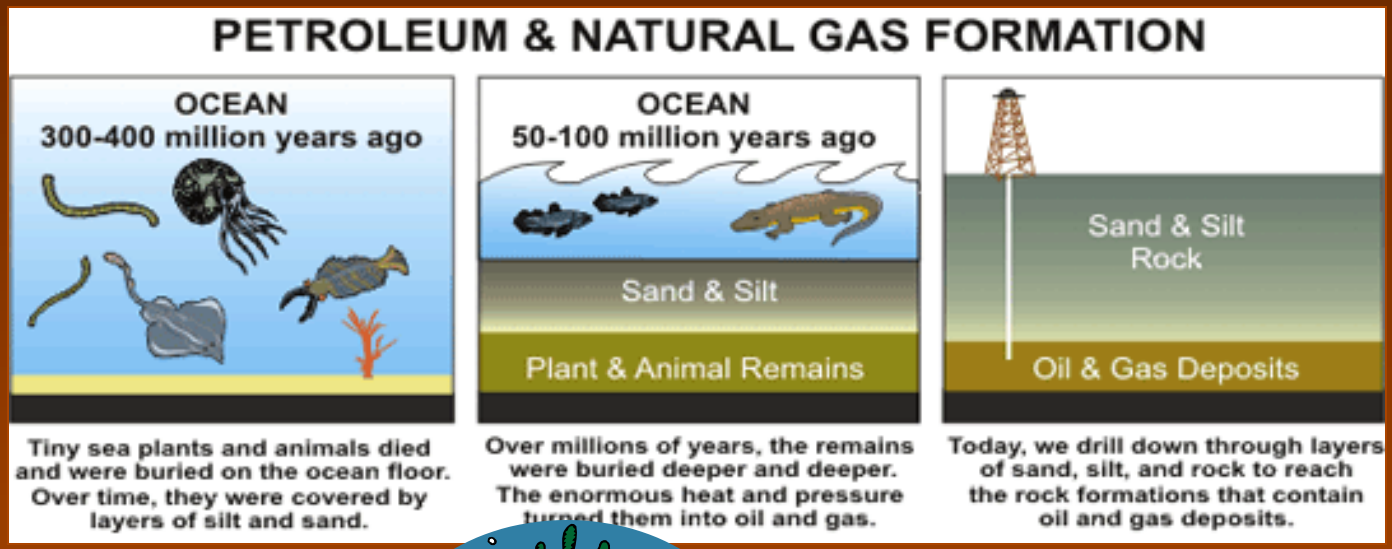




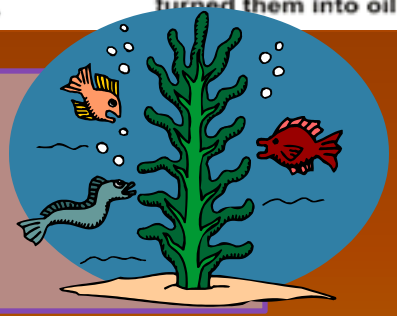
EIA, 2011 Energy Review

Fig. 1.2 Primary Energy Production

What is oil and natural gas?



Freshwater plankton, algae

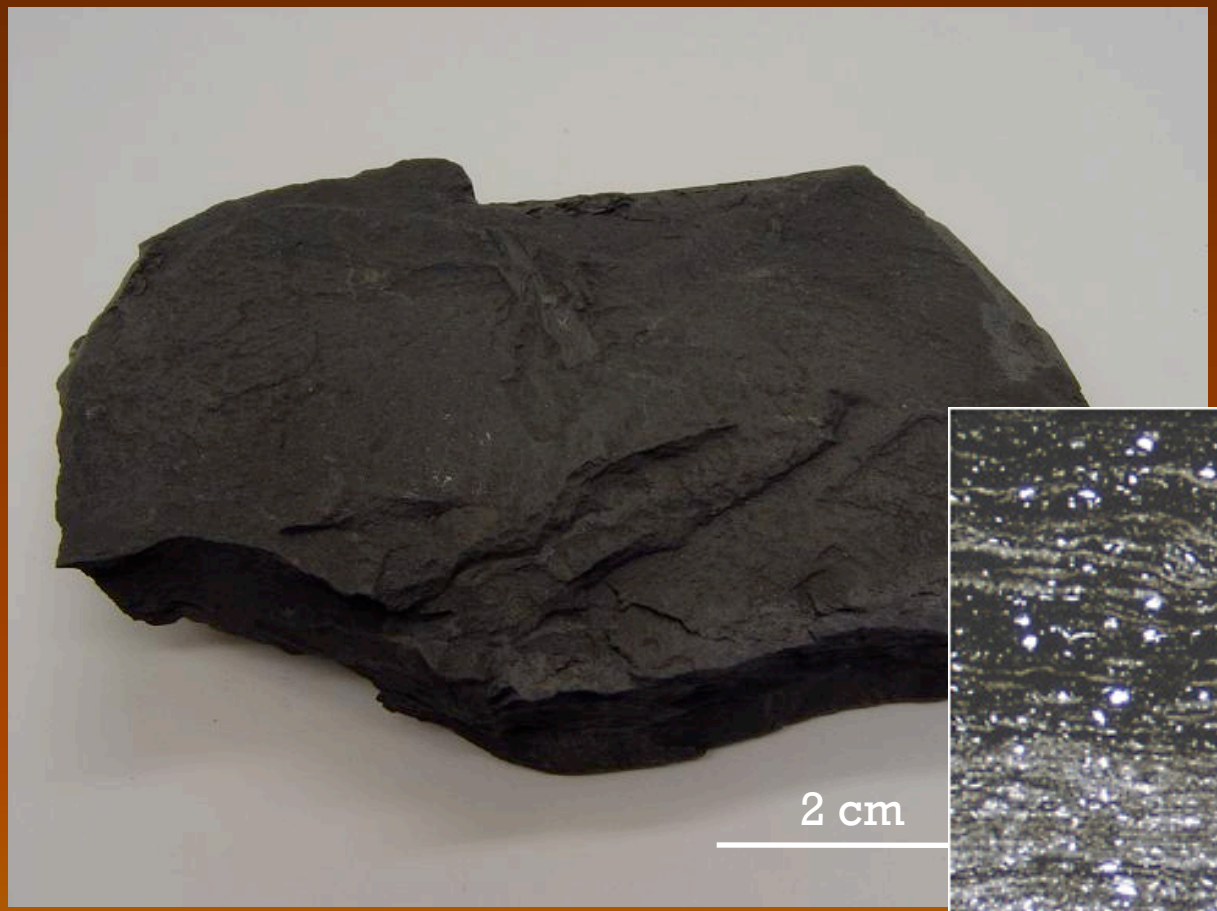


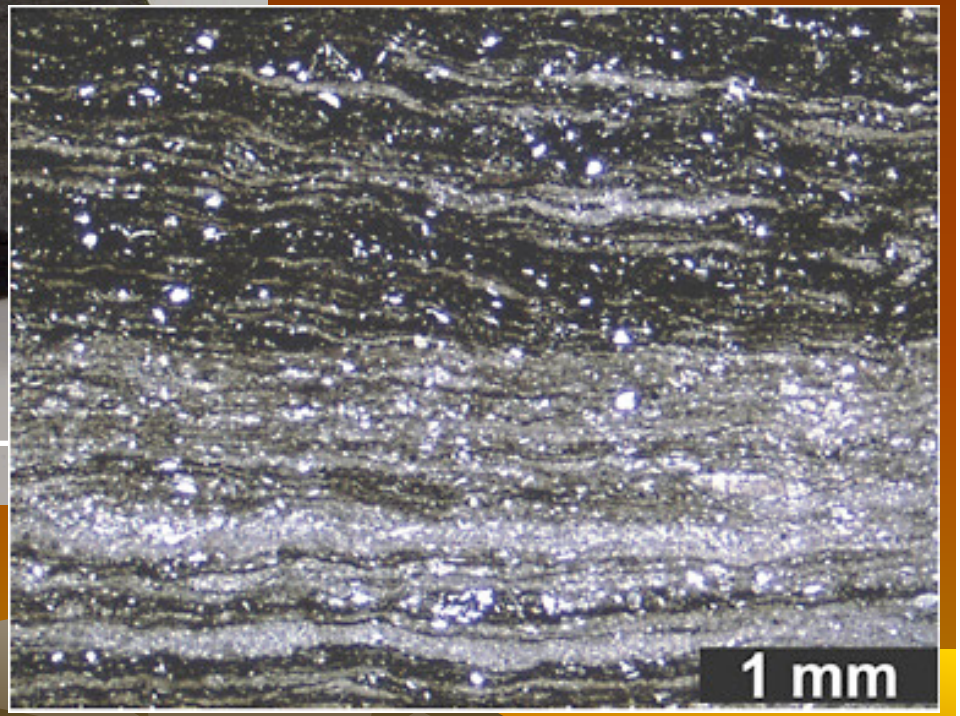
KEROGENS

HEAT !

Natural Gas / Oil

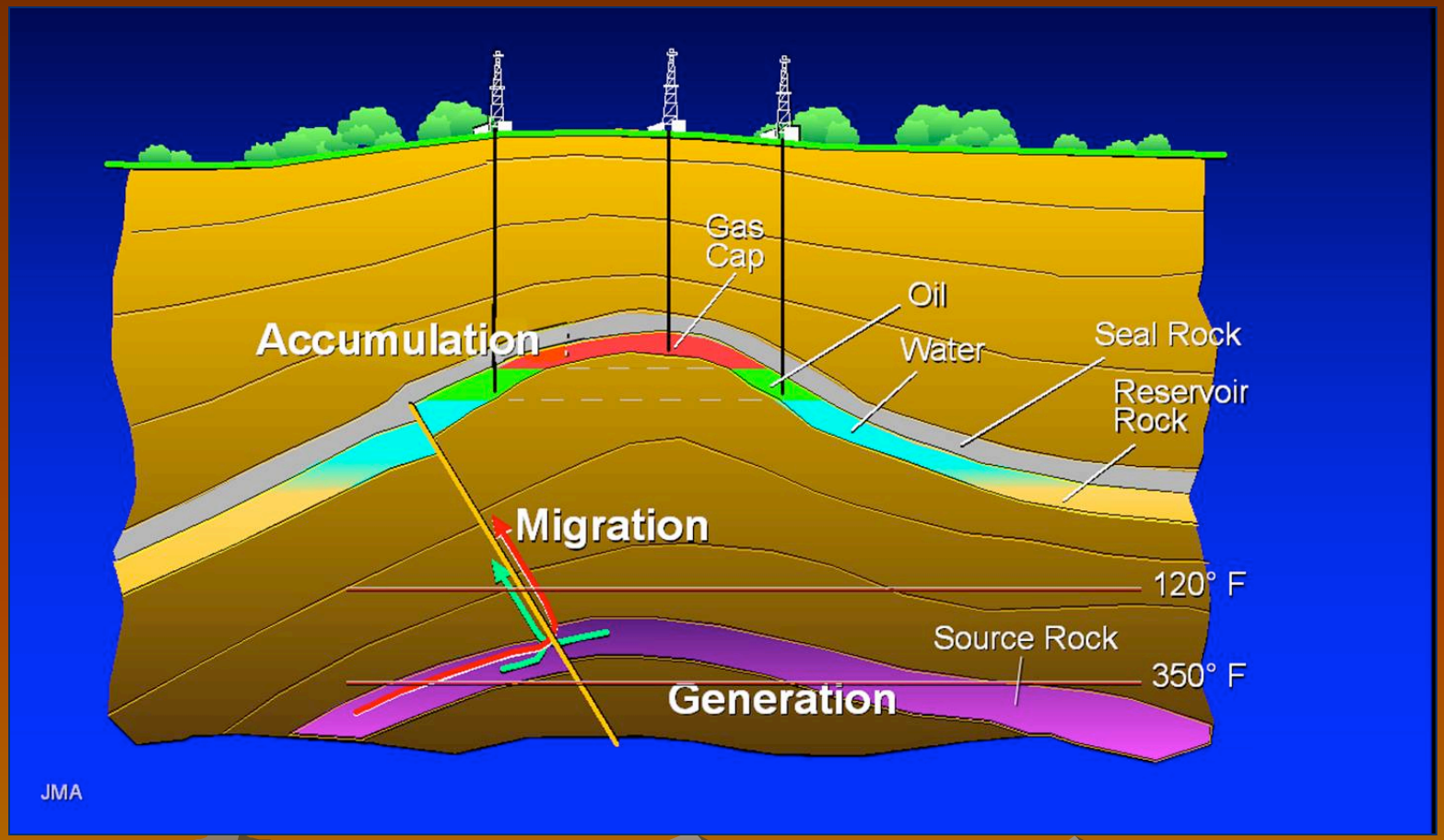
Source rock



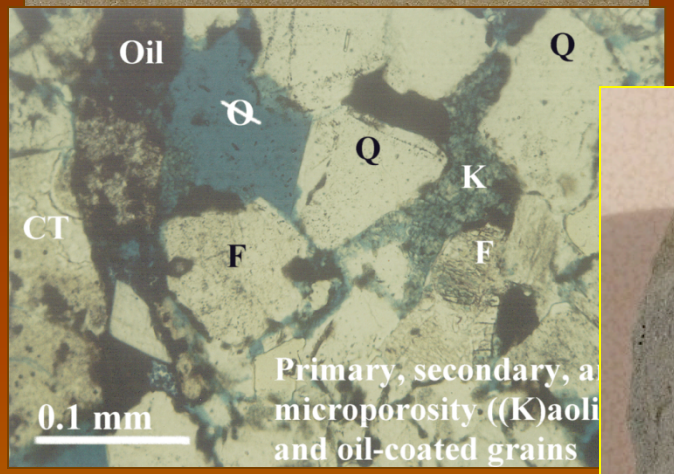


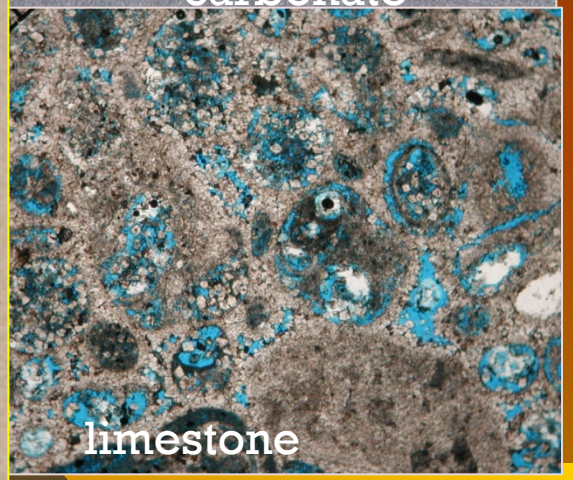
Conventional oil production

- Source, generation, migration, reservoir, trap



Reservoir Rocks



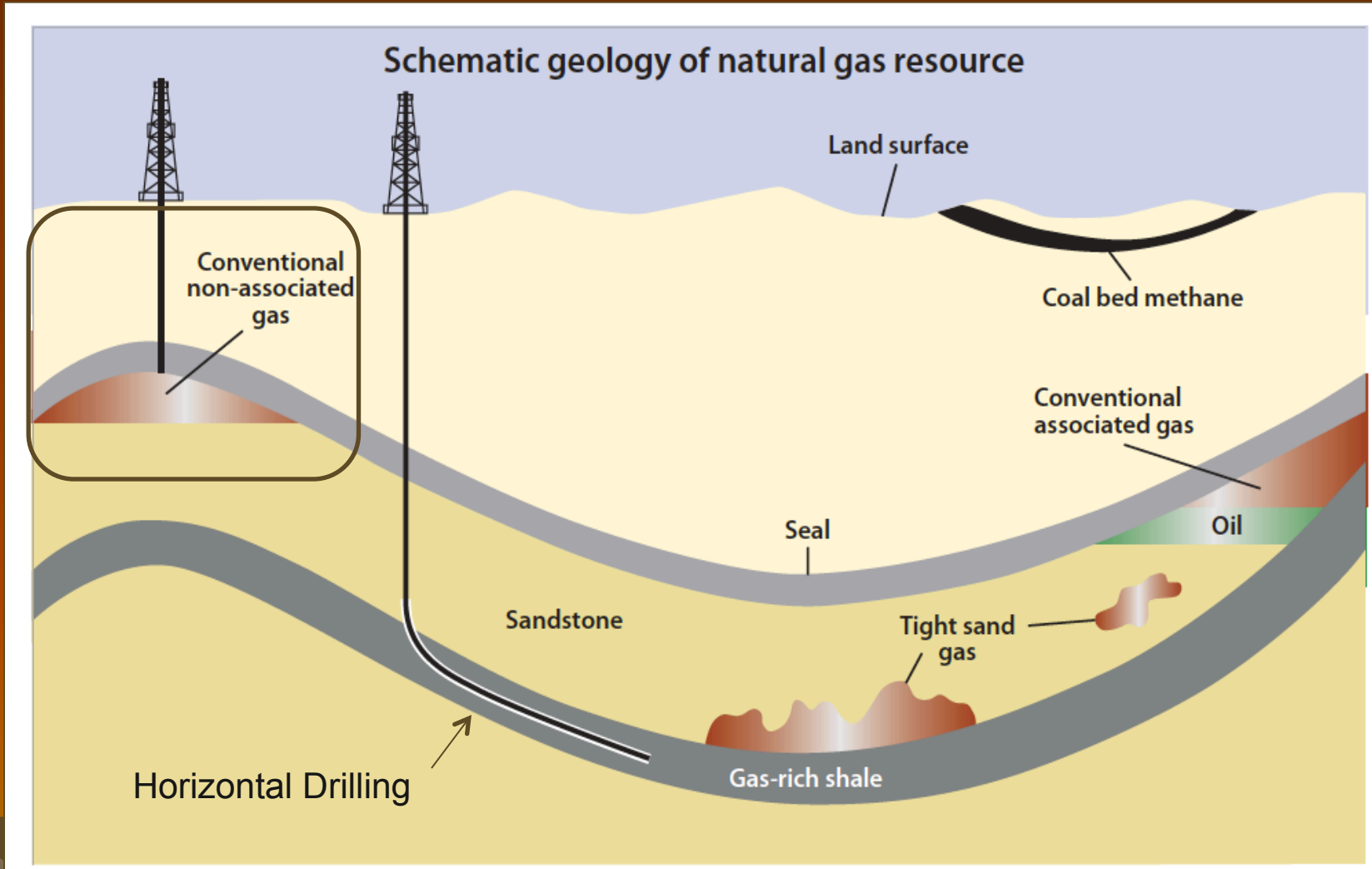


Seal Rock (Cap Rock)

- *Rocks that are not permeable: does not allow fluids to flow through.*

Conventional vs. Unconventional

Idaho



Source: U.S. Energy Information Administration

Hydraulic Fracturing

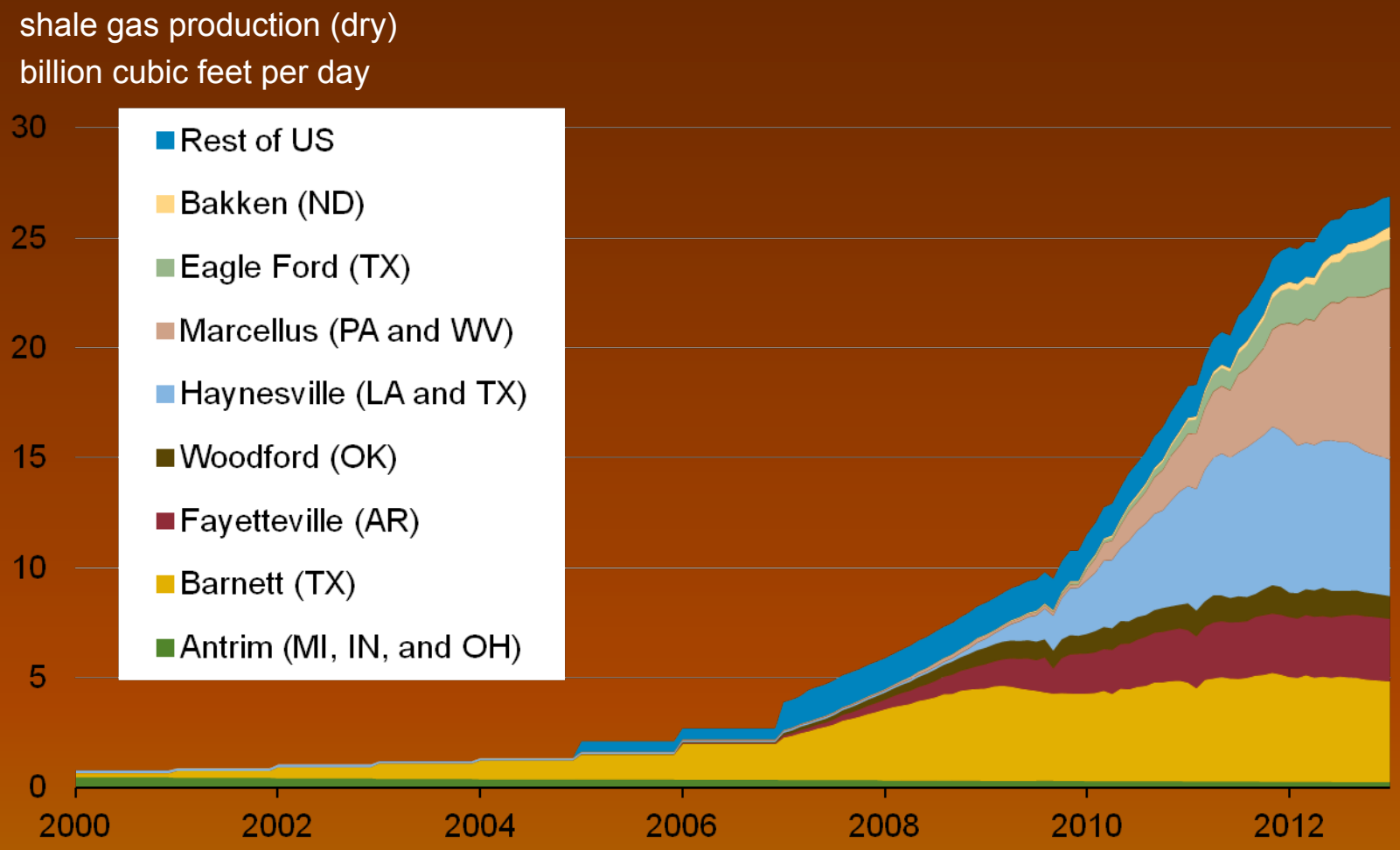
- The propagation of fractures in a rock layer caused by the presence of a pressurized fluid.
- Fluid pressure must exceed lithostatic pressure (weight of rock) plus rock strength.
- Increasing pressure needed as depth increases and as rocks get more cohesive.
- Fractures will close if fluid pressure is removed.

Fracking Areas in North America

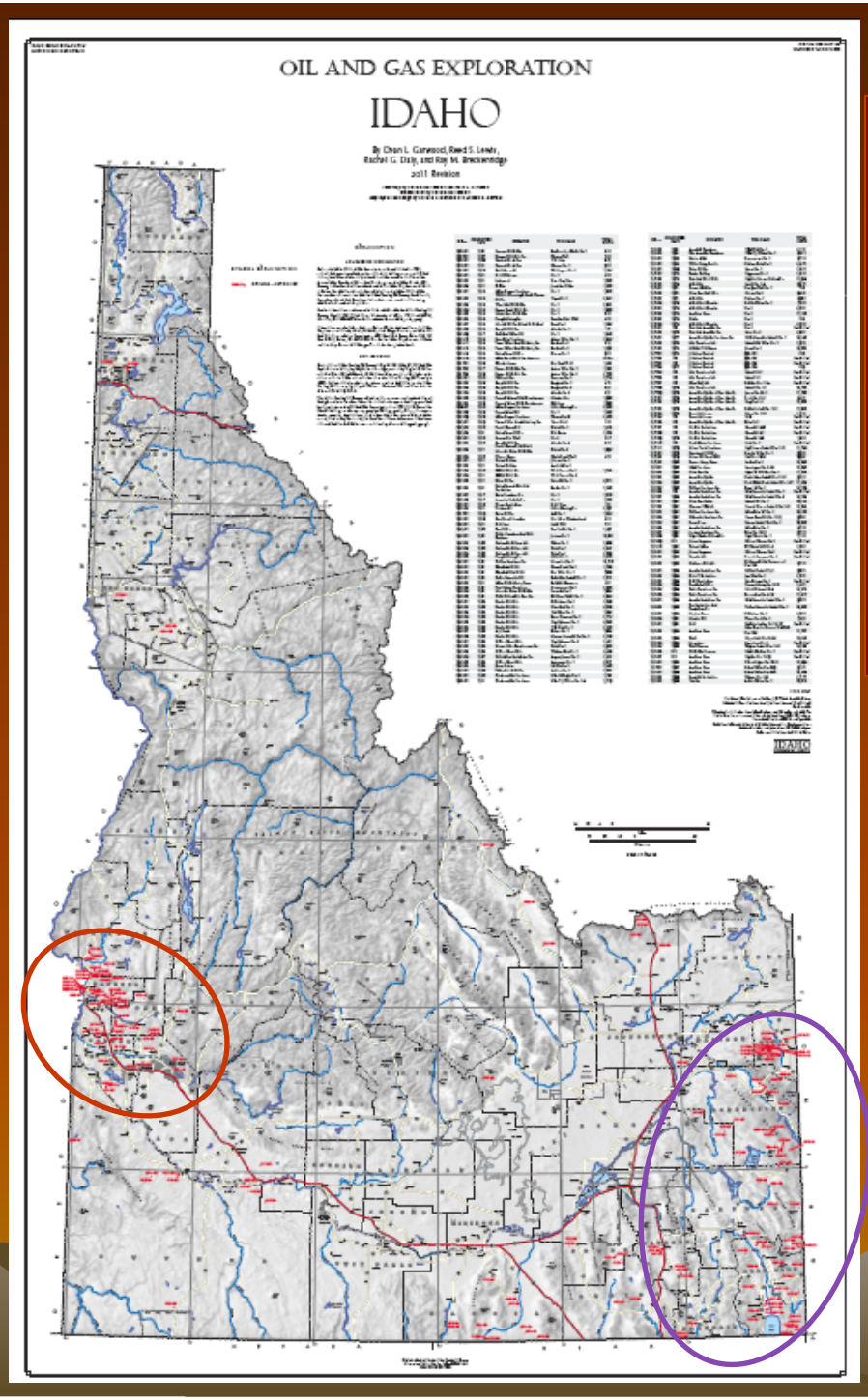
Source: U.S. Energy Information Administration based on data from various published studies. Canada and Mexico plays from ARI.
Updated: May 9, 2011

http://ngm.nationalgeographic.com/2013/03/bakken-shale-oil/fracking-animation-video

Domestic production of shale gas has grown dramatically over the past few years



Sources: LCI Energy Insight gross withdrawal estimates as of January 2013 and converted to dry production estimates with EIA-calculated average gross-to-dry shrinkage factors by state and/or shale play.



Idaho Geological Survey

DWM-142

(2011 revision)

Available at:
www.idahogeology.org

Also see IGS DD-3 Digital database

Western Snake River Plain (WSRP)

Overthrust Belt

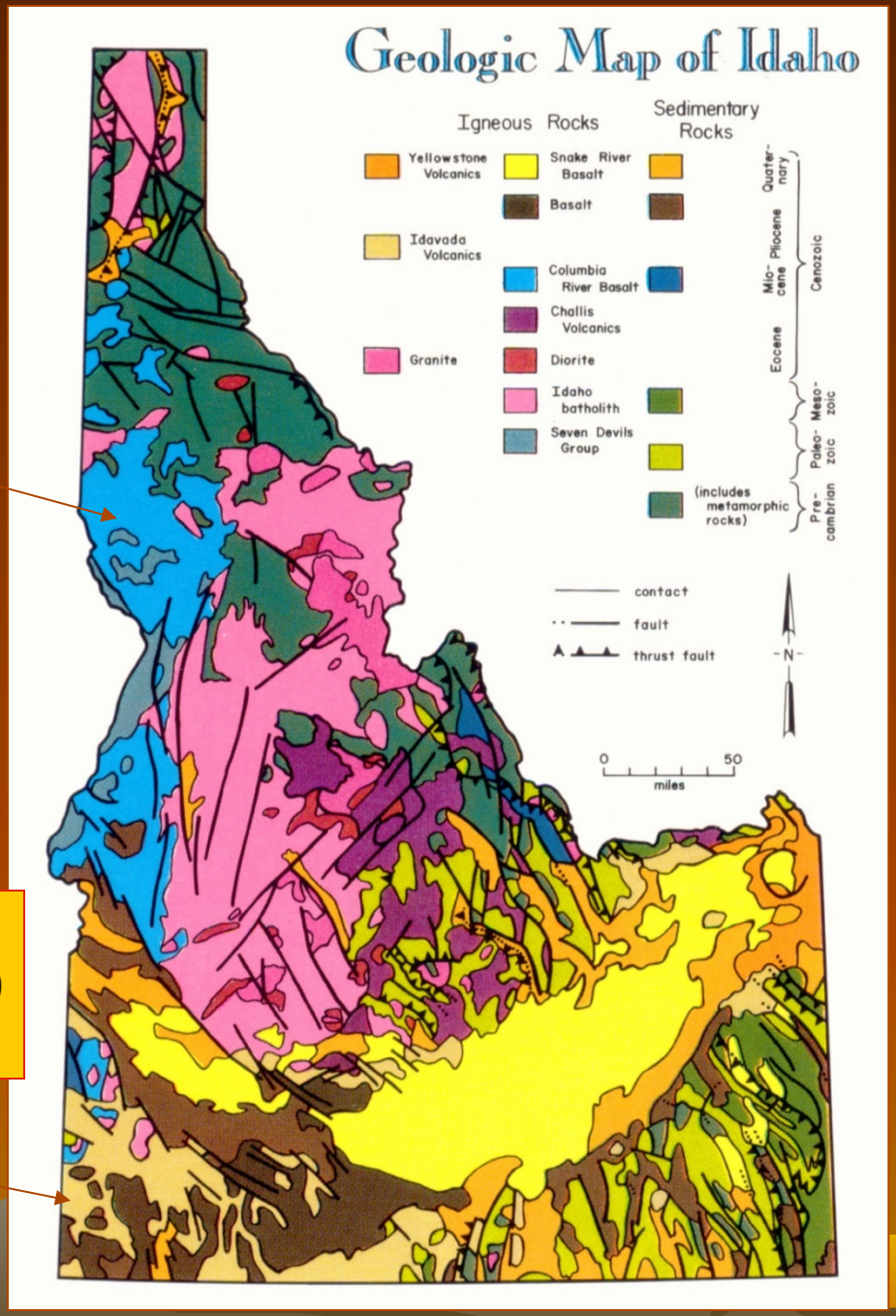
Mid-Tertiary:

Columbia River Basalts (17 – 12 mya)

N-S structures

Western Snake River Plain NW structure (11-9 mya)

Idavada Volcanics – silicic (15 – 9 mya)



NO OIL in PreCambrian or igneous rocks.

Idaho Batholith (granite)= pink

Overthrust Belt (Cretaceous)

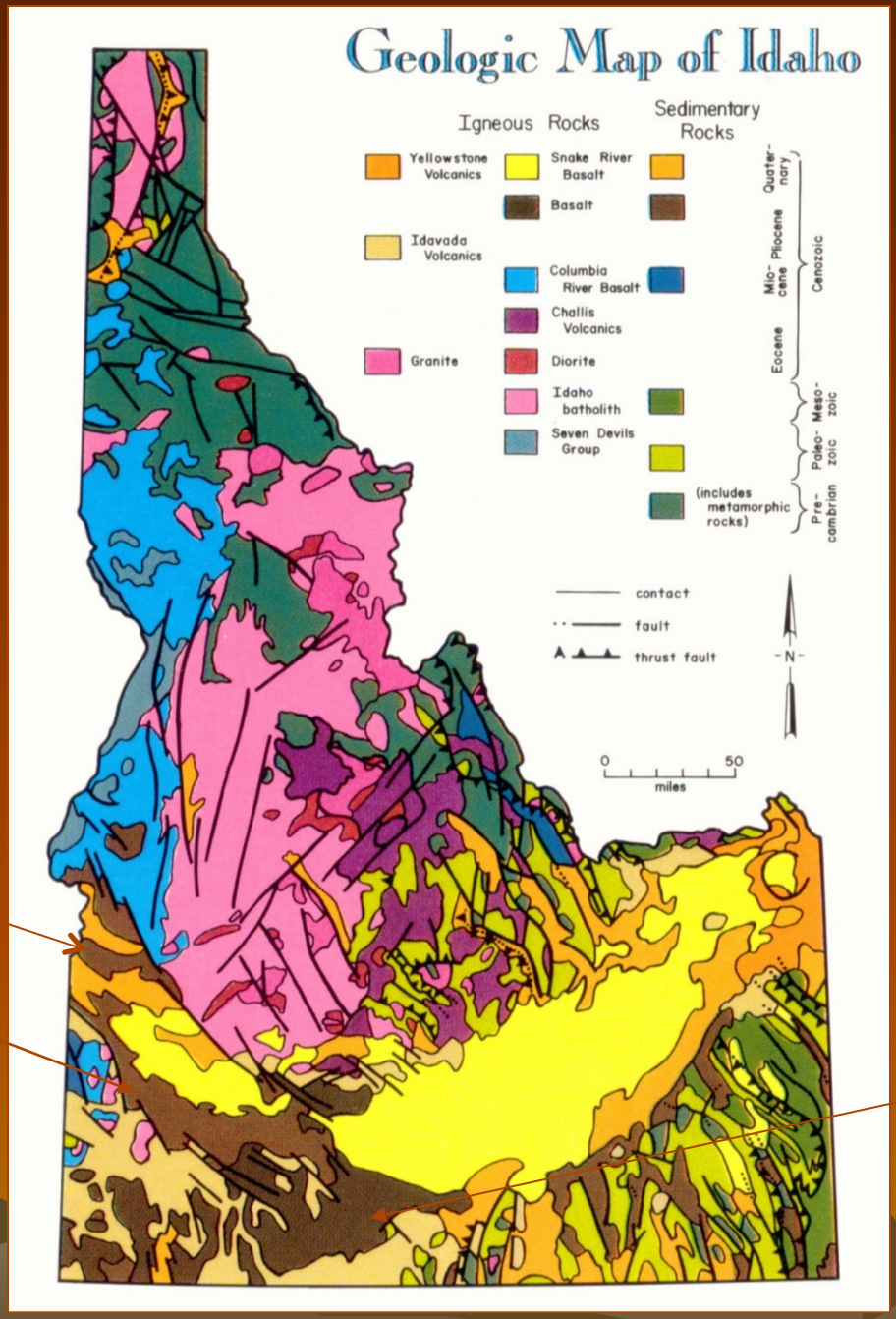
Southwest Idaho

Late Tertiary

Lake Idaho

Lake Sediments with stream deposits

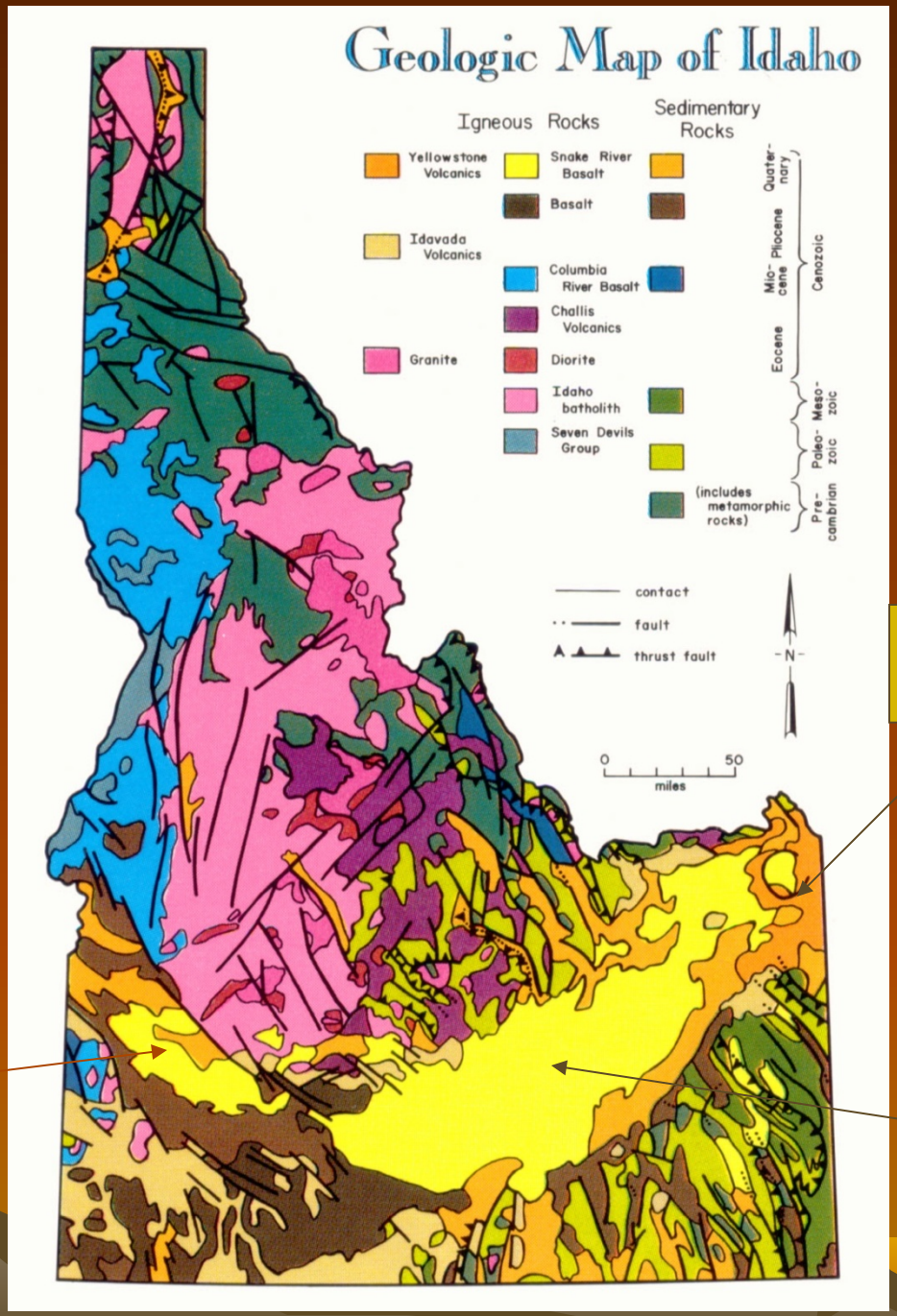
9 - 2 Mya ?



Older Tertiary Basalts and VolcanicTuffs

Quaternary:

2 – 0 mya



Eastern SRP

Yellowstone Calderas (1.2, 0.6 mya)

Western SRP

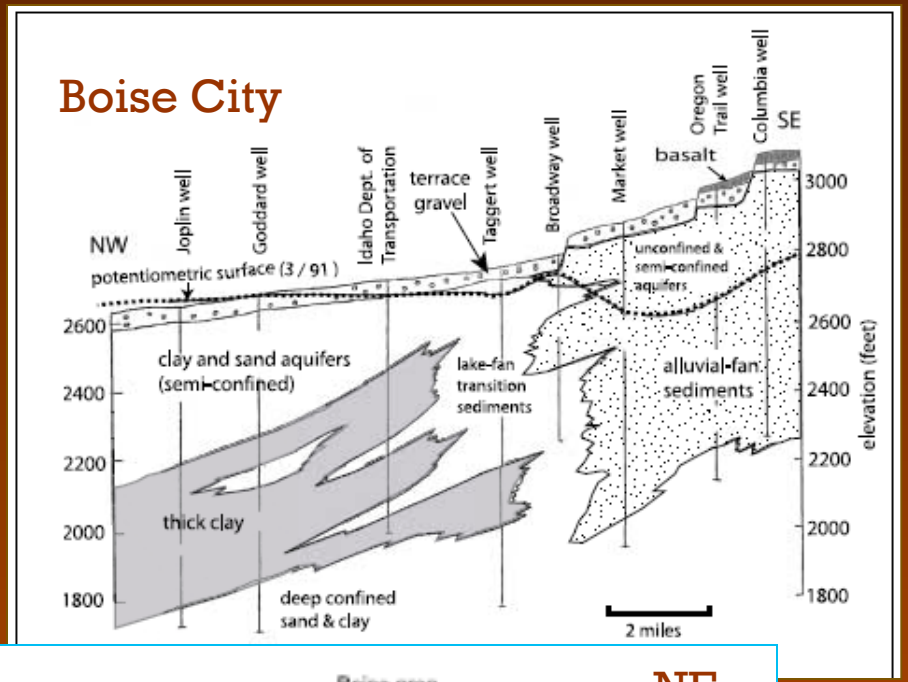
Lake Idaho has drained.

Basalt Volcanoes

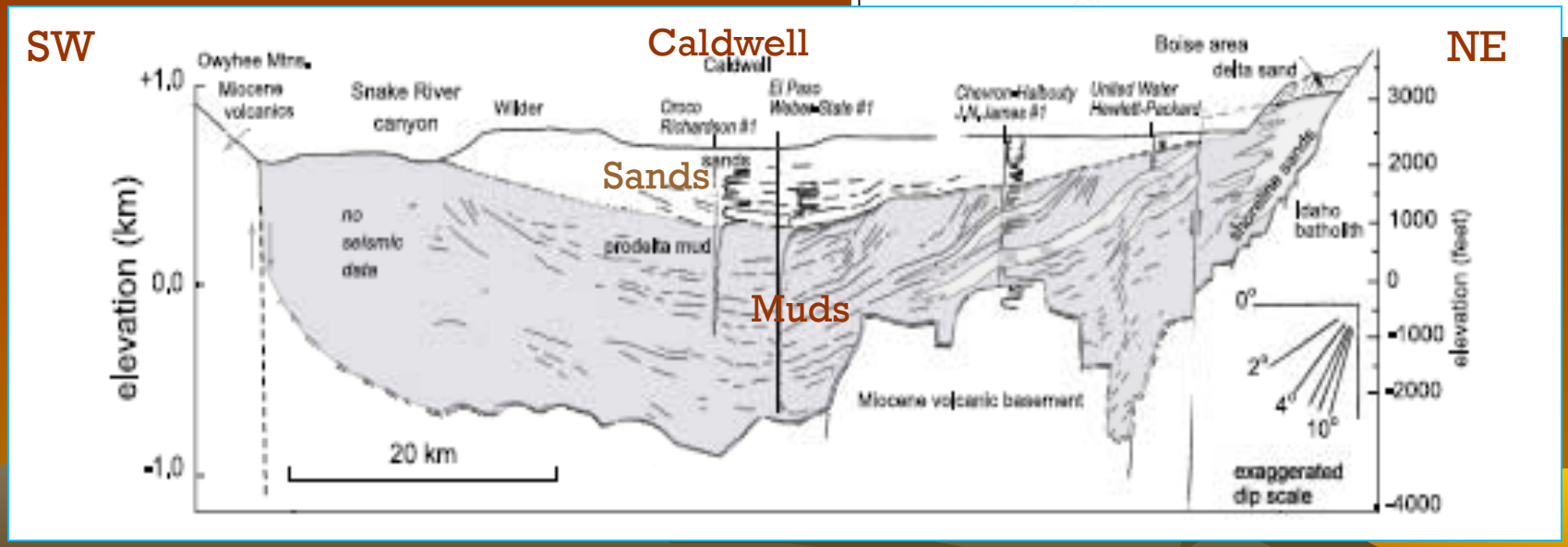
Snake River Plain Volcanics – Basalt Shield Volcanoes

Sediments of Lake Idaho

Wood and Clemens, 2002,
in IGS Bulletin 30

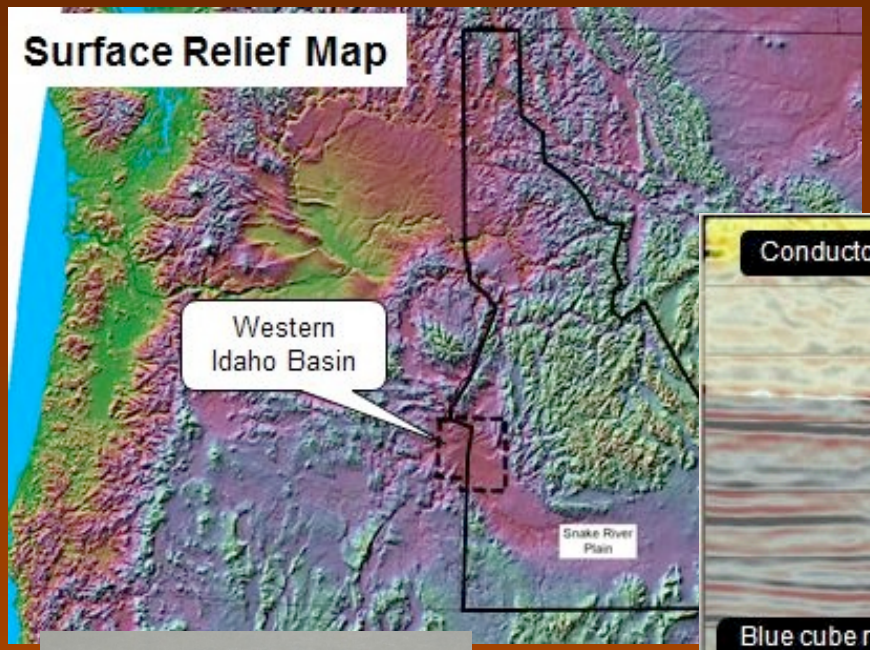


Deeper basin
to west?

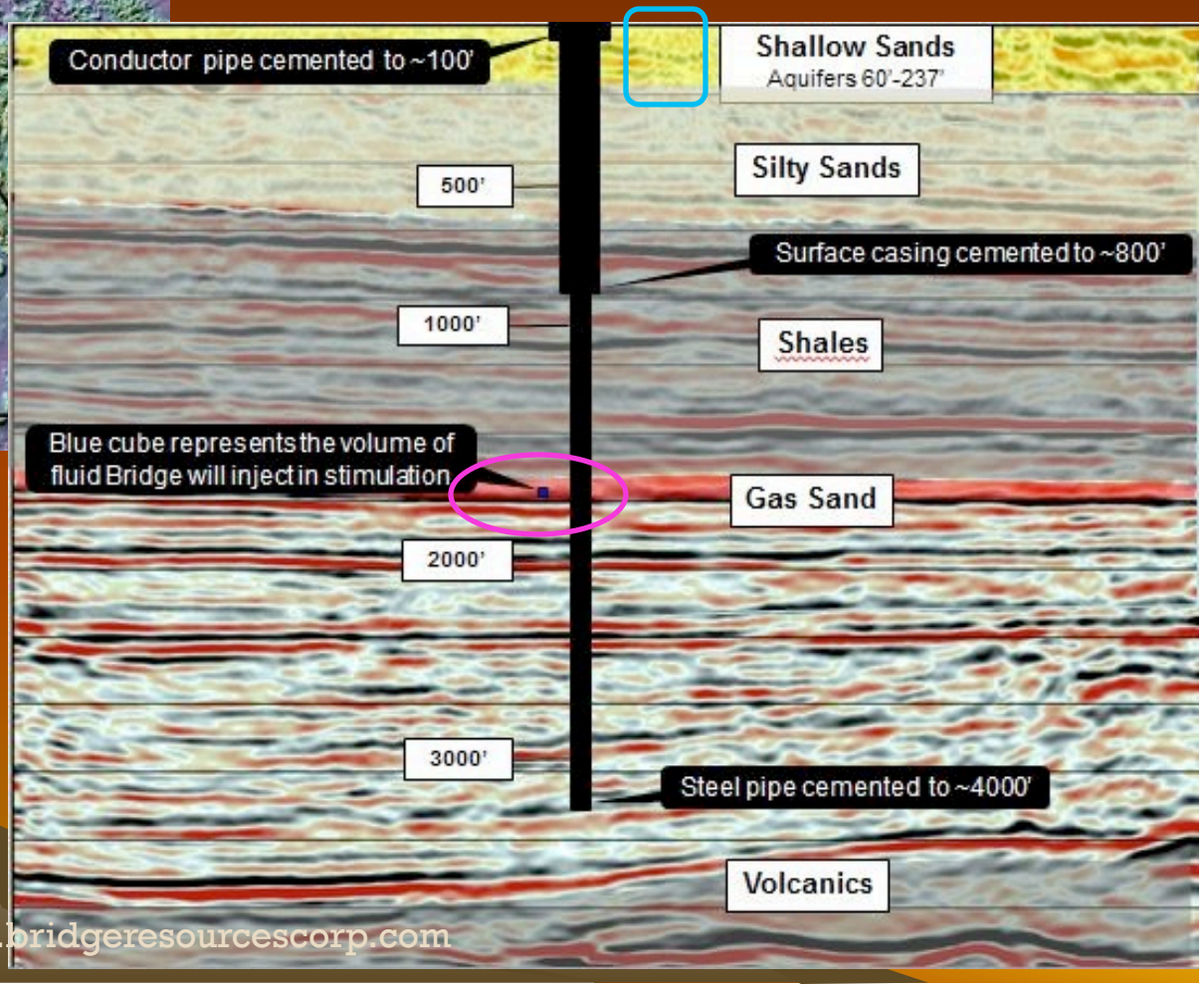


Methane in well water – long known in WSRP

Gas in Payette Co., Idaho

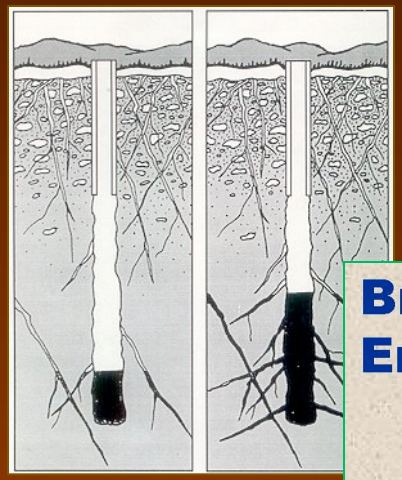


Drilled 11 wells, 7 have potential
Reserves 35-235 BCF gas



Shale/siltstone

http://www.bridgeresourcescorp.com



Mini Fracking

Bridge Energy

WHAT IS A FRAC?

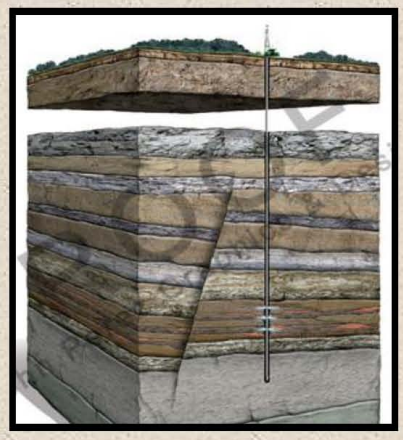
Injecting fluid + proppant (sand) into formation under pressure to restore or create pathways for gas to flow to well bore

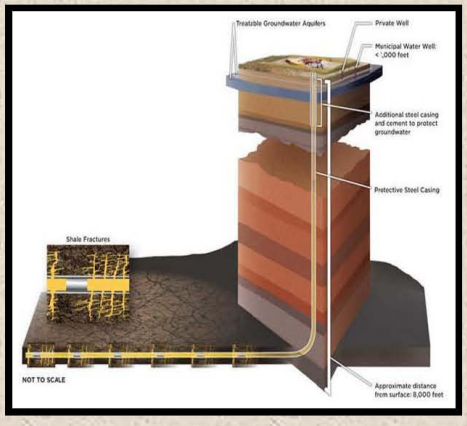
SMALL — LARGE

"Mini frac"
Rock = Conventional Sandstones
Objective = Clean out near borehole to restore existing permeability
•Vertical well, 6-26' treated
•150' fracture radius
•714 bbls fluid @ <1000 – 2400 psi
•6-8 trucks on location, ½ to 1 day

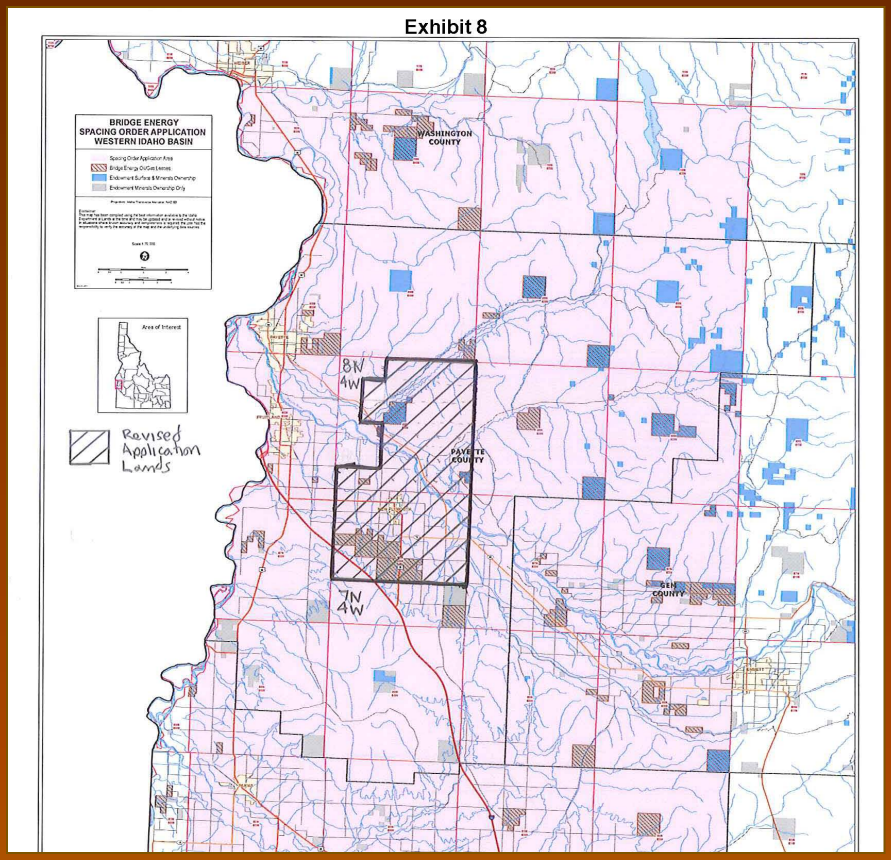
3%

"Shale Frac"
Rock = Unconventional reservoir (shale)
Objective = Create pathways for locked up Gas/oil to flow
•Horizontal well, 1000s of feet treated
•5000' fracture radius
•25,000 bbls fluid? @ 10,000 psi
•40-50 trucks on location, 7 days, 20 stages





Idaho's Gas Field, Payette Co.



Map from Spacing Order, IDL

9/2012

Oil and Gas Well Construction

Shallow Sands to ~270 ft

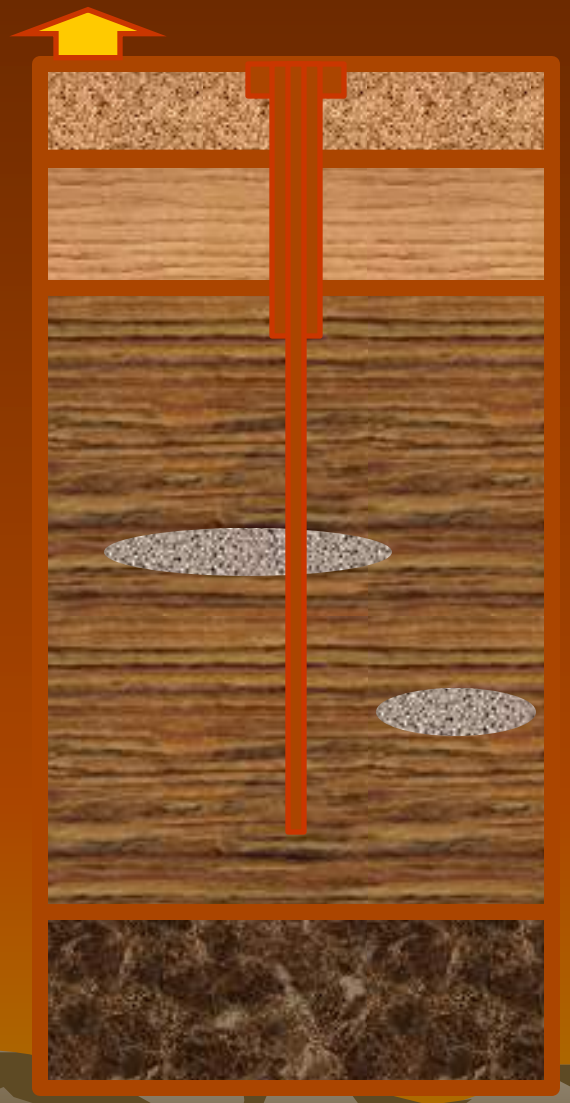
Silty Sands to ~550 ft

Shale to ~4500 ft

Sand lenses 1800+ ft

Shale to ~4500 ft

Volcanics 4500+ ft

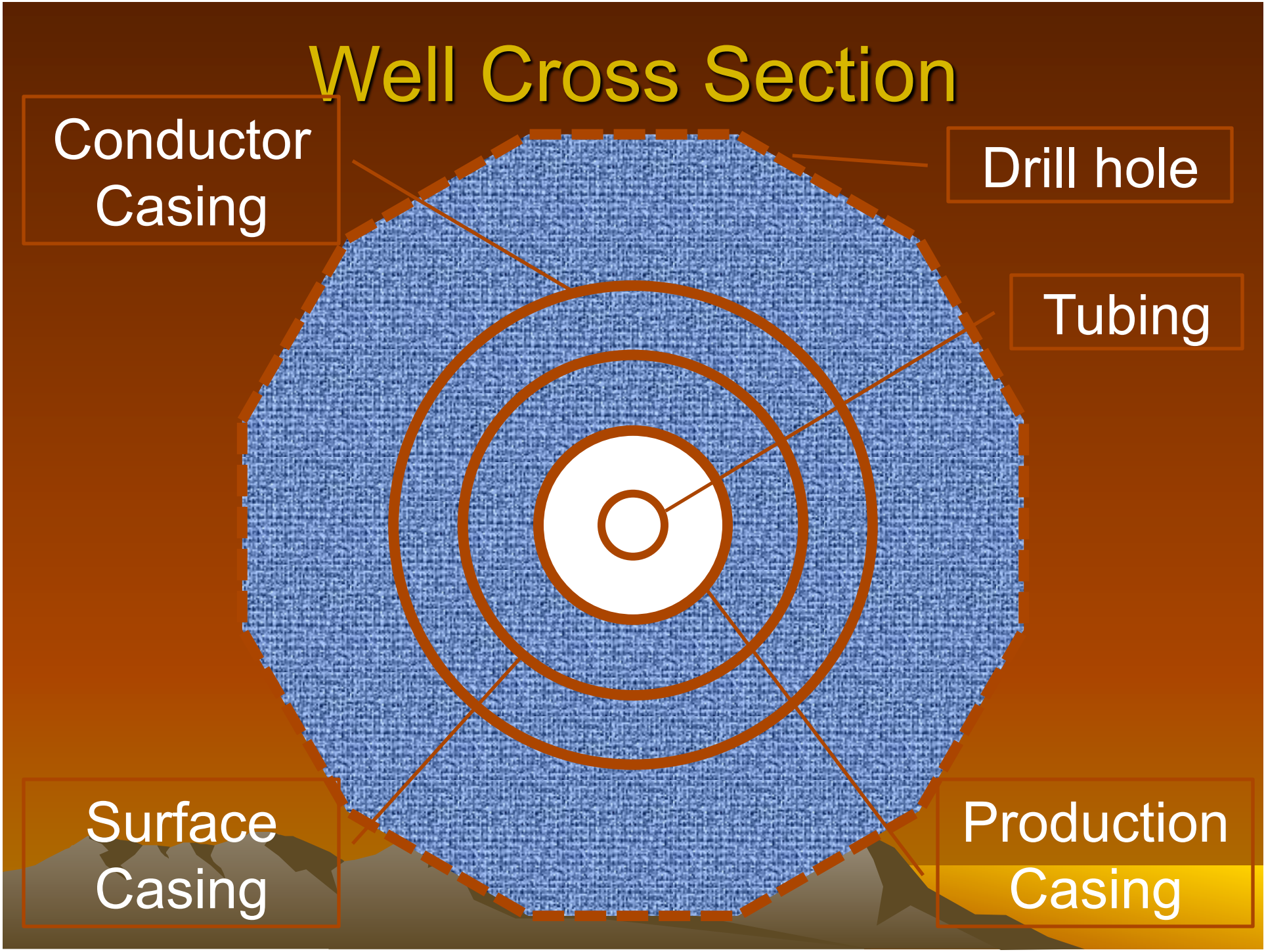


12” Conductor Casing to ~100 ft

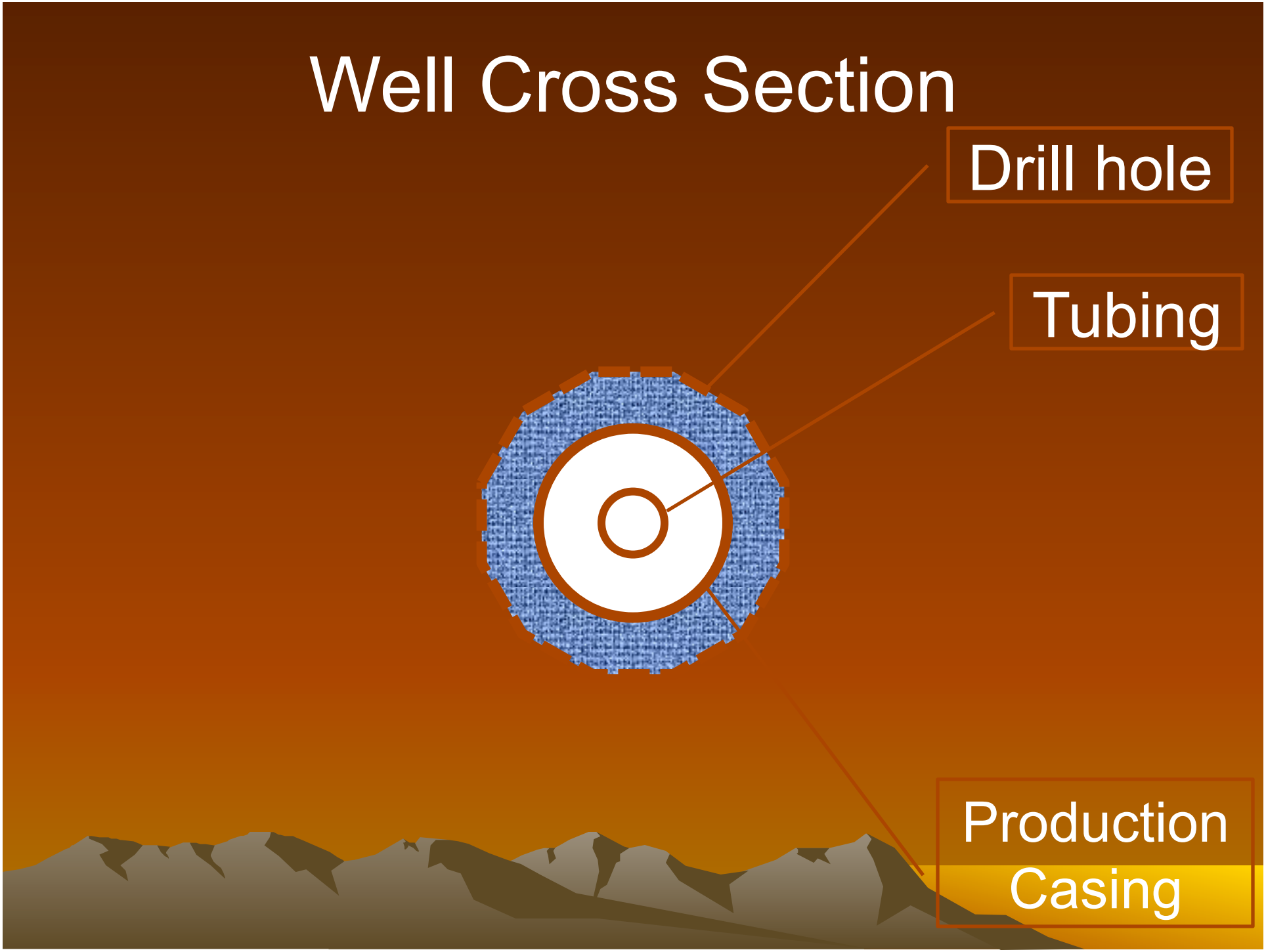
8 $^{5}/_{8}$” Surface Casing to ~800 ft

4 $^{5}/_{8}$” Production Casing to ~4000 ft

Well Cross Section



Well Cross Section



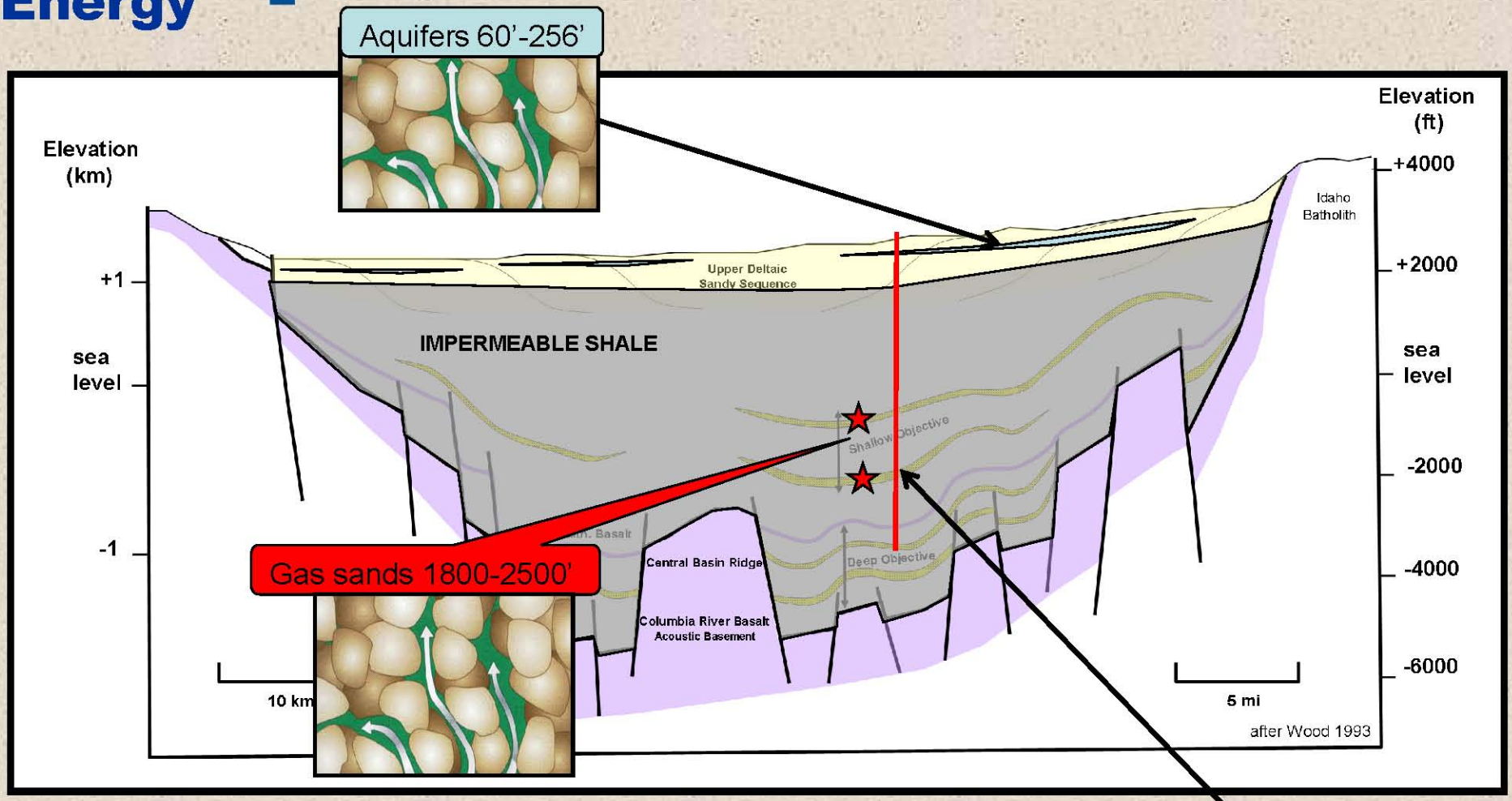
Main Idaho (IDL) Concerns

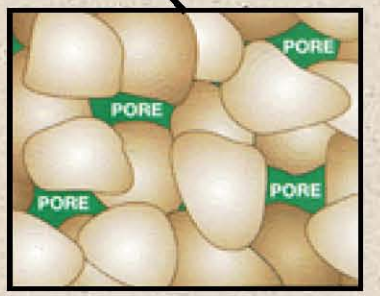
1. Allowing Responsible Resource Extraction
2. Protecting Water Quality
   - Well Integrity
   - Fluid Containment on Surface
   - Disclosure of Fluids
   - Proper Disposal of Fluids

(E. Wilson, IDL)

Bridge Energy

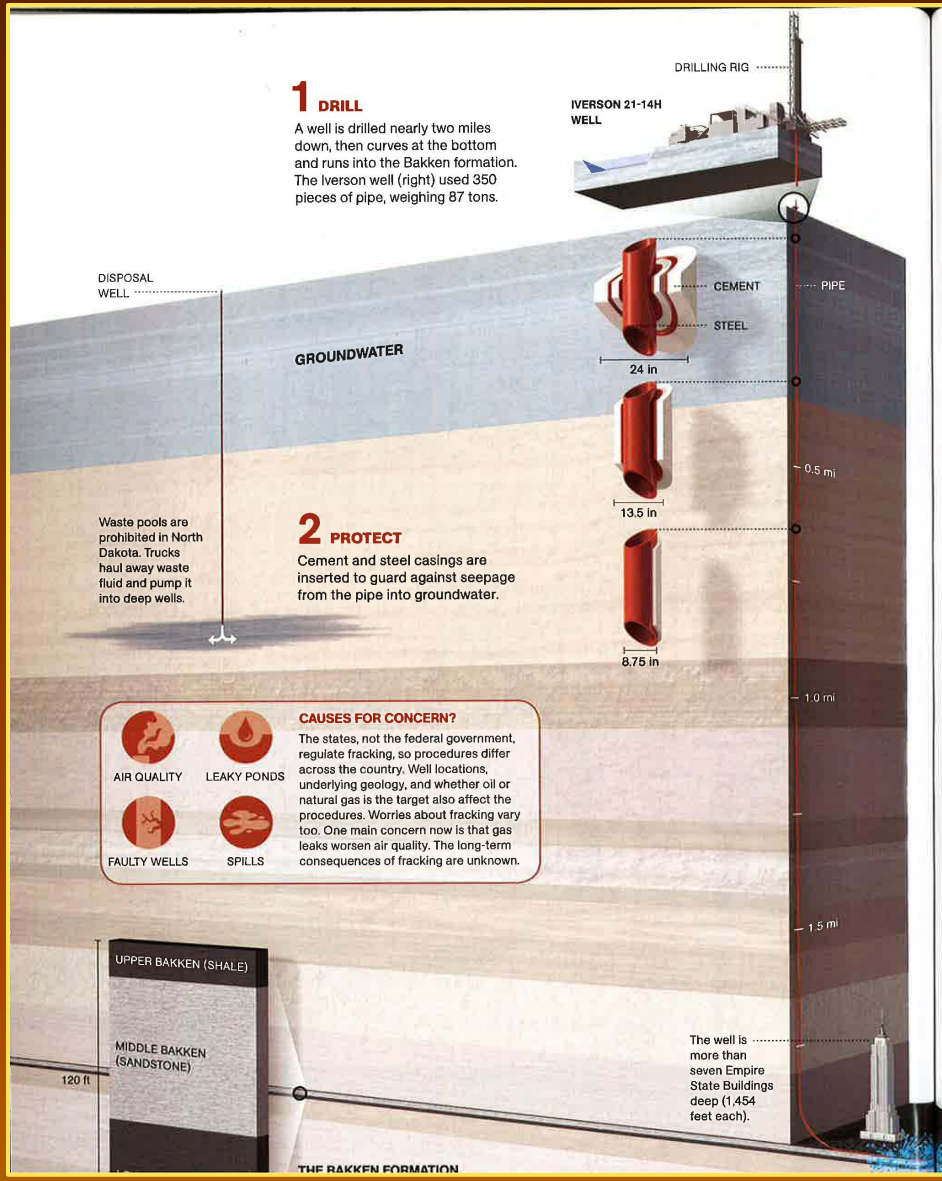
BASIN CROSS SECTION





show rocks

Drilling process can block pathways in a zone nearest the borehole.



Fracking the Prairie

There are three basic steps in hydraulic fracturing, or fracking, the pumping of fluids at extreme pressure into rock deep beneath the Earth's surface to extract the embedded oil. The oil well depicted here is the Iverson 21-14H, in western North Dakota. It plunges 10,500 feet to frack sandstone and shale in layers of rock called the Bakken formation. The area produces some 660,000 barrels of oil daily, which has created a boom for the state but has also given rise to concerns about the environmental costs.

THIS WELL'S FRACTURING FLUID

80.5% WATER

19% PROPPANT

Proppant is a combination of natural quartz sand and man-made ceramics. It props open fractures in the rock so oil can flow more freely.

0.5% CHEMICALS

Additives, many toxic, are used to inhibit bacterial growth, minimize friction, and increase viscosity.

WHERE DOES THE USED FLUID GO?

80% DISPOSED OF

Most is pumped into injection wells at least 2,500 feet below potable water.

20% RECYCLED

PRODUCTS USED IN LIFE OF ONE WELL

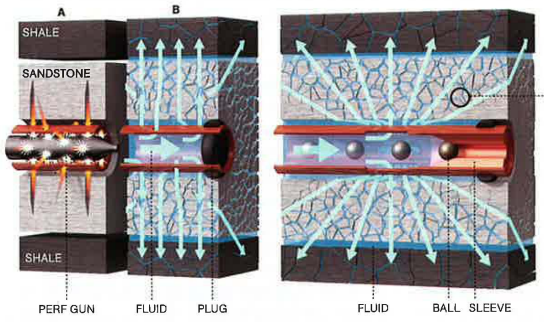
2 MILLION GALLONS OF WATER

4 MILLION POUNDS OF PROPPANT

350+ BARRELS OF CHEMICALS

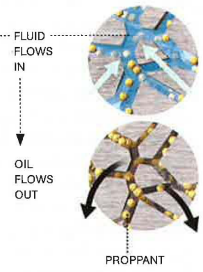
3 FRACTURE AND OIL FLOW

Fluid is pumped under high pressure down the well and into the rock to the end of the pipe, fracturing the rock in stages to release the oil. Two methods are used, with the sliding sleeve (below right) employed first.



PLUG AND PERFORATION A plug blocks off a section of pipe, and a "perf gun" blasts small holes in the sandstone (A). Fluid is pumped in at high pressure (B), releasing the oil.

SLIDING SLEEVE Plastic balls are forced down the pipe, pushing open sliding sleeves to expose holes in the pipe. Fluid shoots out through the holes, fracturing the rock.



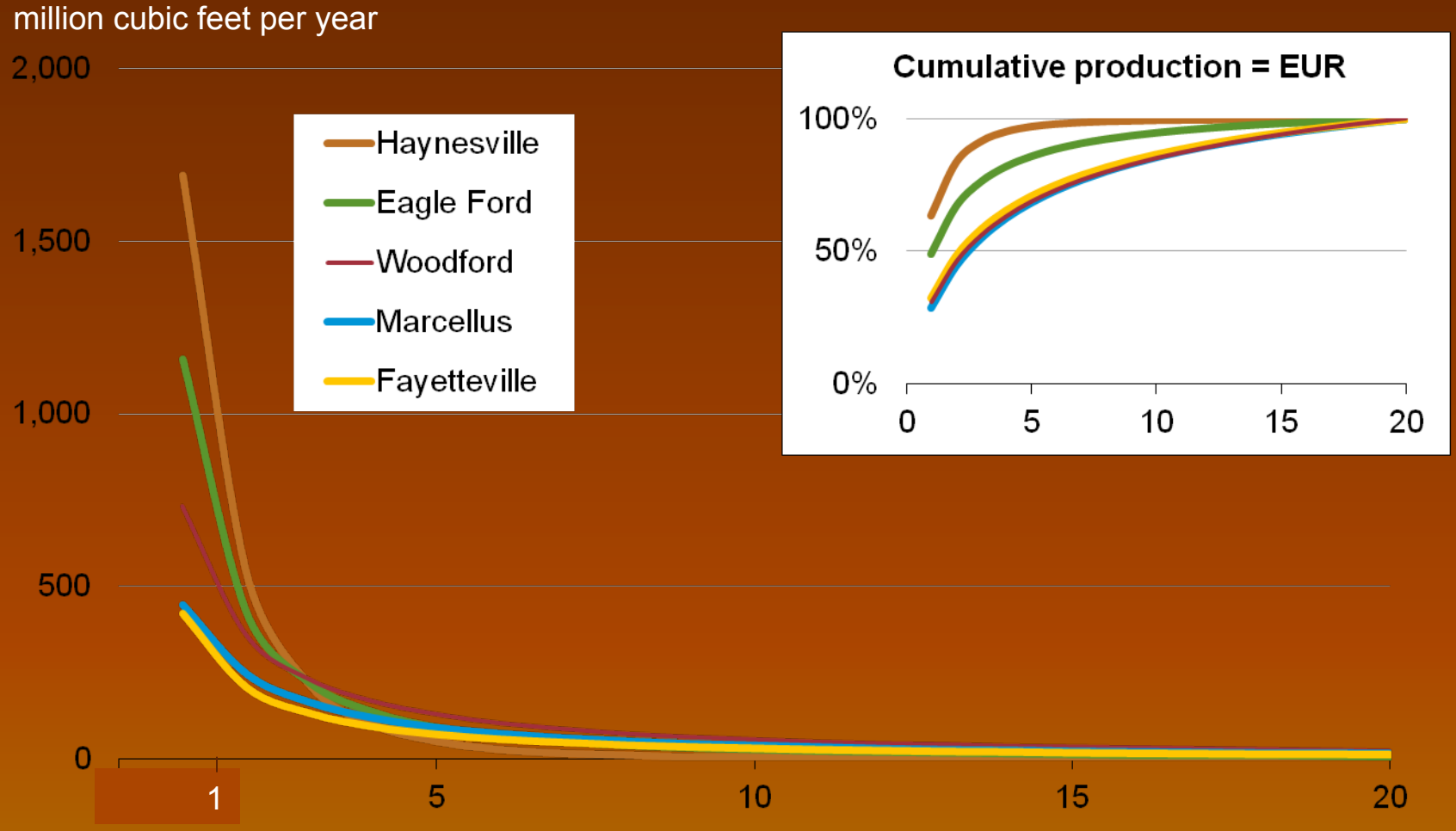
Fracking fluid expands cracks in the rock, releasing oil, which flows back up the well.

PLUG AND PERFORATION ◄ | ► SLIDING SLEEVE

North Dakota

(National Geographic, March 2013)

An average well in shale gas and other continuous resource plays can also have steep decline curves, which require continued drilling to grow production

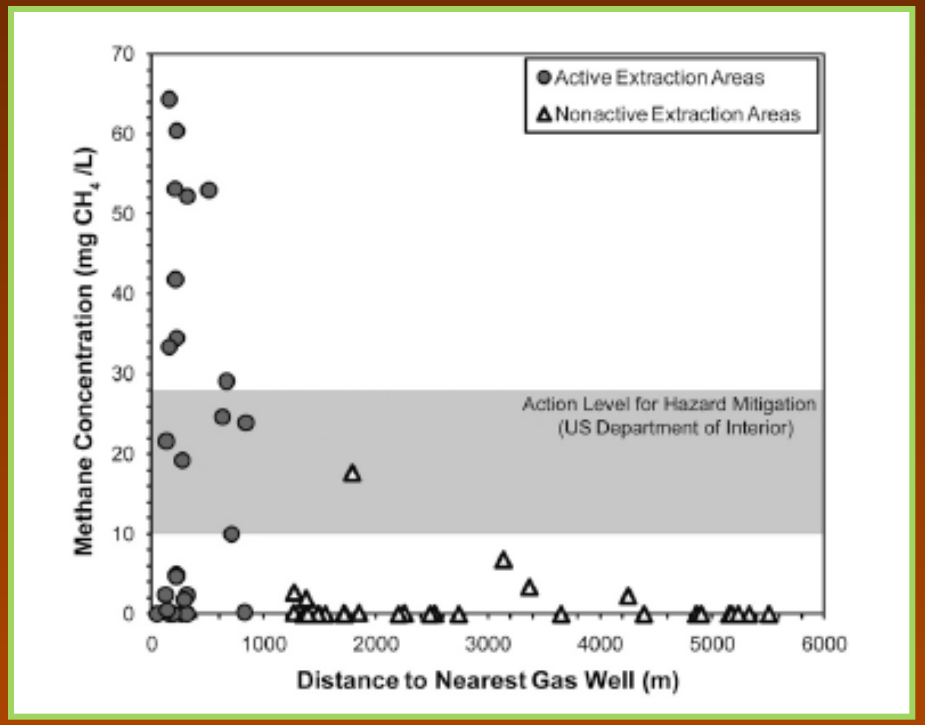


Source: EIA, Annual Energy Outlook 2012

Shale Gas Drinking Water Concerns

Contamination
Volume Usage

- Methane in shallow aquifer?
  - Yes, present locally, pre-fracking.
  - Probably natural swamp gas.
  - Need isotopes & C analyses to determine origin.
- **Wastewater Storage**
- **Wastewater/Fluid Injection**

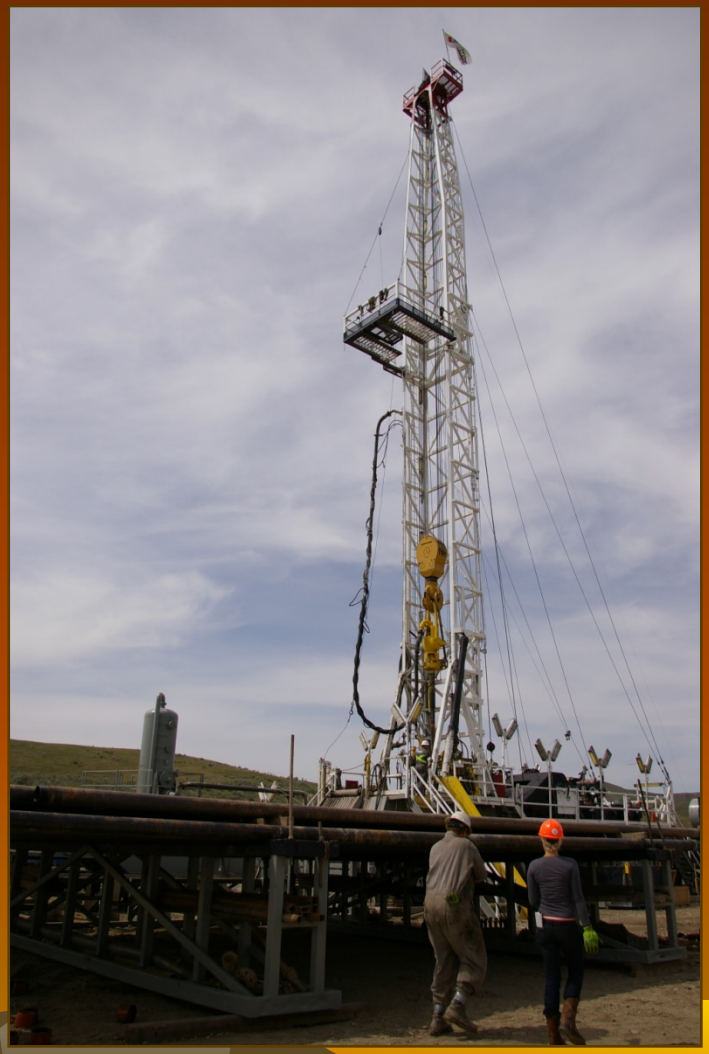


From Osborn, et al., 2011, study of methane in wells near fracing of Marcellus shale in NY, PA. Field produced by horizontal fracing in hard, tight Paleozoic shales. It is not similar to Idaho's WSRP.

Natural methane ubiquitous!

Potential Issues with Legal Implications

- Surface Ownership/ Split Estates
- Business Aspects, Royalties
- Regulations – State, Local, Evolving
- Environmental/Water Use (chemical additives)
- Social & Community



Geologists Recommend:

- Data: Lithologic and geophysical logs released to state (post-confidentiality period and pre-drilling studies.
- Proper use of BMPs.

- Protection of groundwater and drinking water - must know local geology and hydrogeology. Every site and operation is different.
  - Stringent state regulatory monitoring on-site by experienced personnel of operations including drilling, cementation, surface waste water facilities, injection operations, etc.
  - Disclosure and prior approval of fracing fluid (FracFocus).
  - Reasonable water use and management.
  - Adequate bonding and enforcement – as required in mining and other land use activities.
  - Sensitivity to local land use/public opinion, but development location does ultimately depend on geology.

- **Idaho has advantage in being able to develop regulations prior to hydrocarbon production and fracking since we are late to the game.**

- Thank you

New State Geologic Map
www.idahogeology.org