

ONSHORE OIL AND GAS

AN OVERVIEW

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AUSTRALIAN SCHOOL OF PETROLEUM
UNIVERSITY OF ADELAIDE*

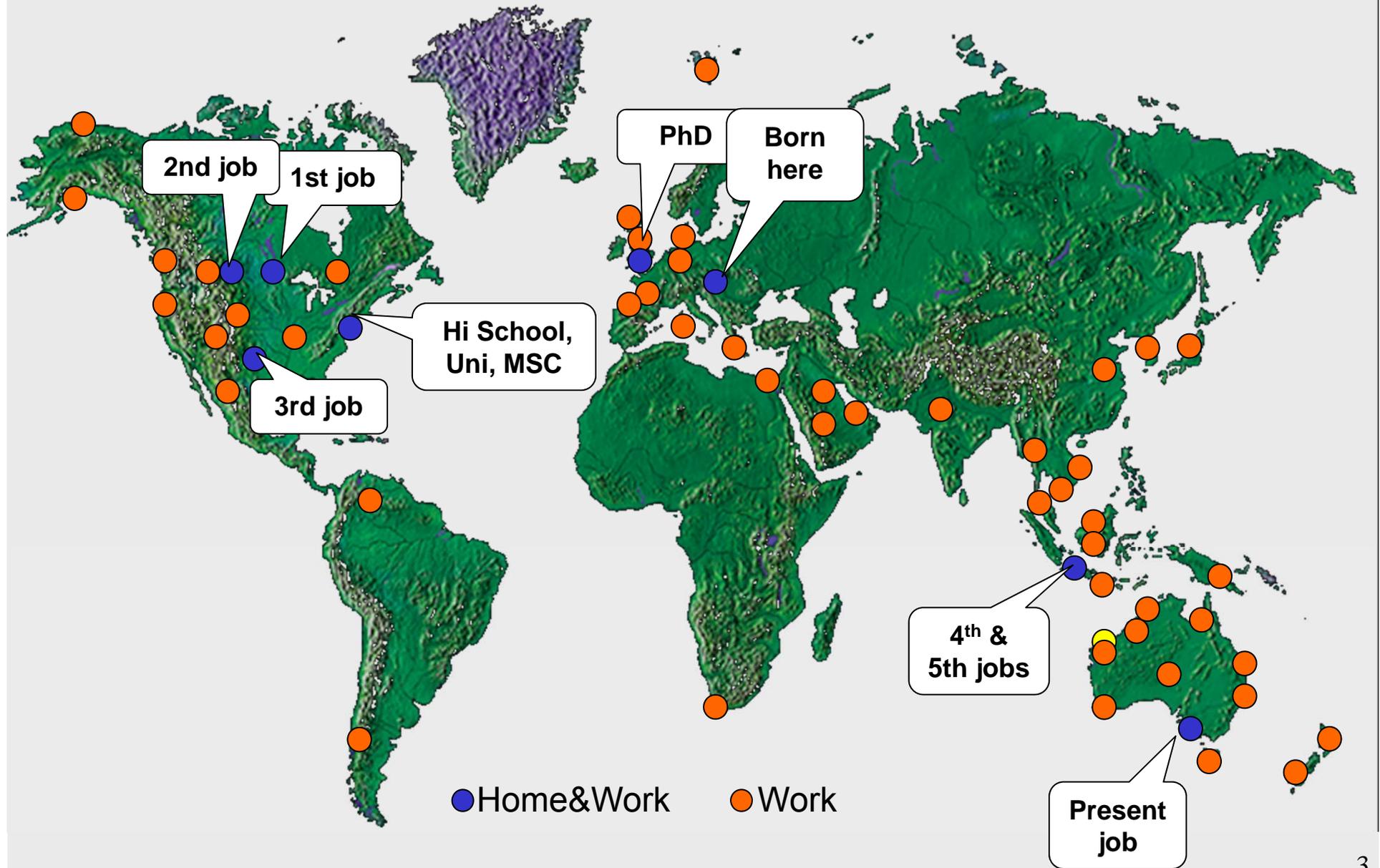




Slide from
Barry Goldstein,
Executive Director – Energy Resources
South Australian State Government

My job is to show you the not-so-simple story

Locations I have lived and worked during my career



Australian School of Petroleum

Opened 2003 with generous grant from Santos
Only University Program in Australia to offer
integrated program in Petroleum Engineering,
Geology, Geophysics and Management

Outline

- Introduction
- Geological conditions for oil and gas accumulation
- Conventional oil and gas
 - Data sources
 - Principle tools
- Unconventional Resources
 - Shale gas
 - US & Australian activities
 - Hydraulic stimulation (Fracking)
- South Australia opportunities

Introduction

Purpose

- To give participants a very basic understanding of the onshore Oil and Gas business and the scientific principles applied to the exploration and production of both conventional and unconventional hydrocarbons

Objectives

- Summarise important petroleum exploration and production concepts and processes
- Introduce basic tools of oil & gas industry
- Review basic principles of conventional oil and gas accumulations
- Review basic principles of unconventional oil and gas development



Structure of the Earth

Plate tectonics

The Earth's crust (lithosphere) is composed of a small number of plates
These are constantly moving, shifting and causing crustal deformation

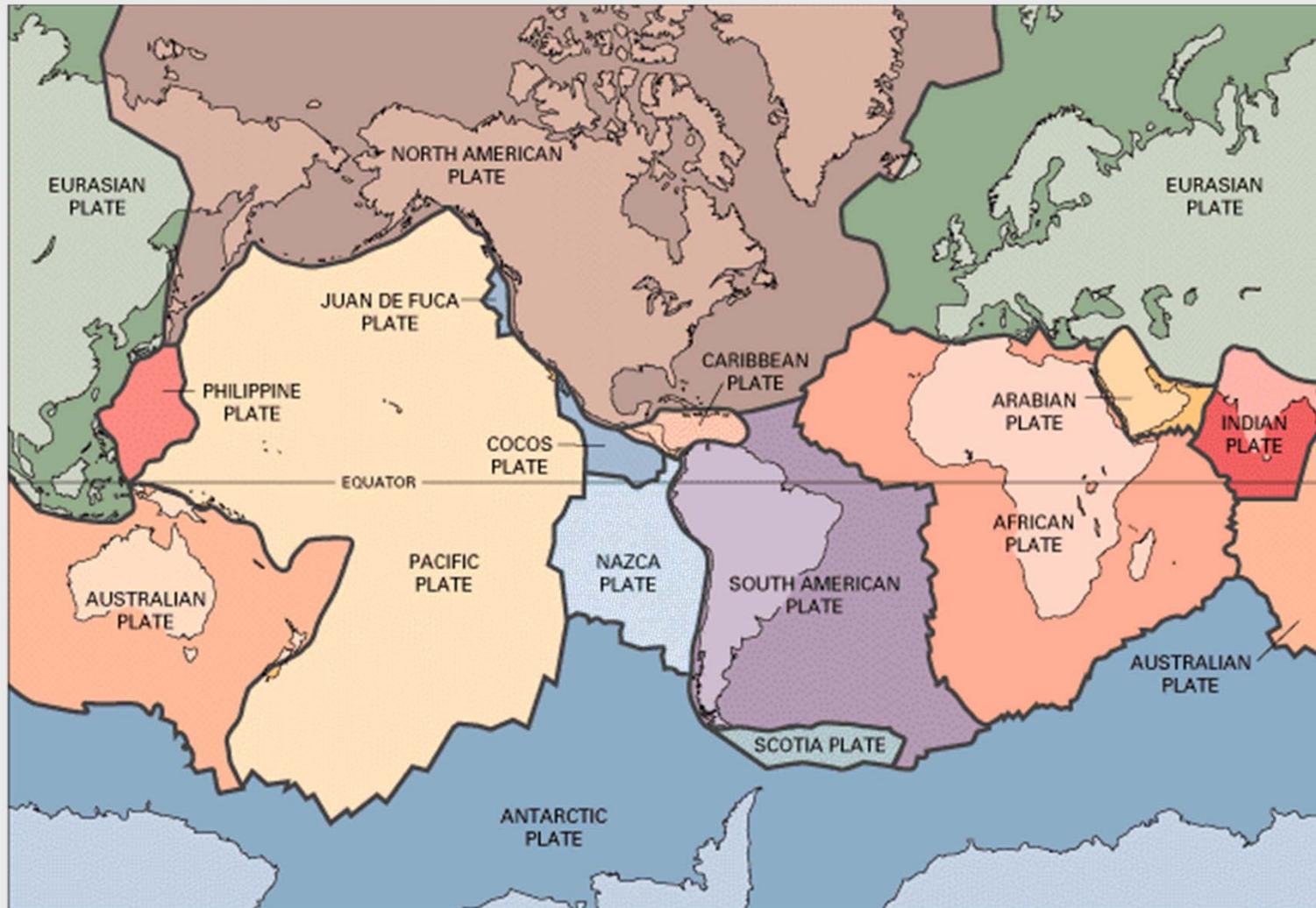
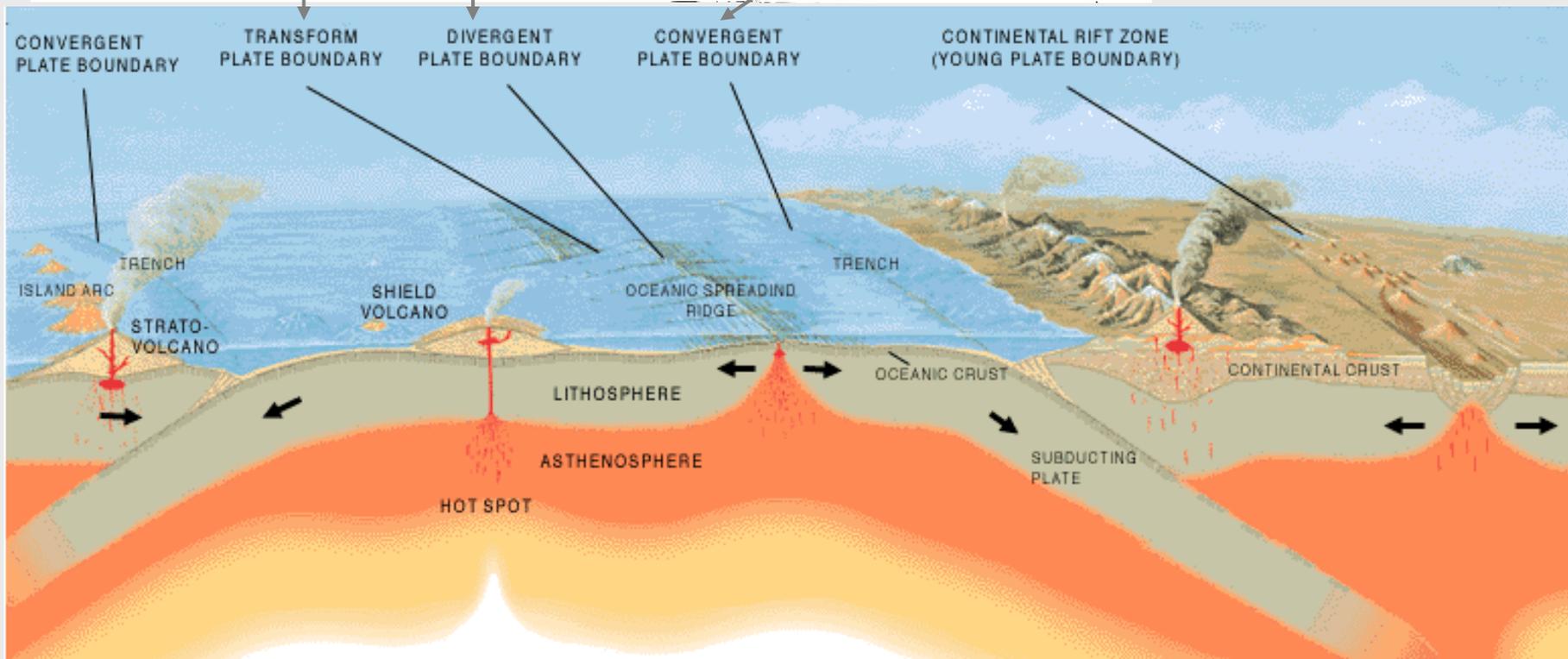
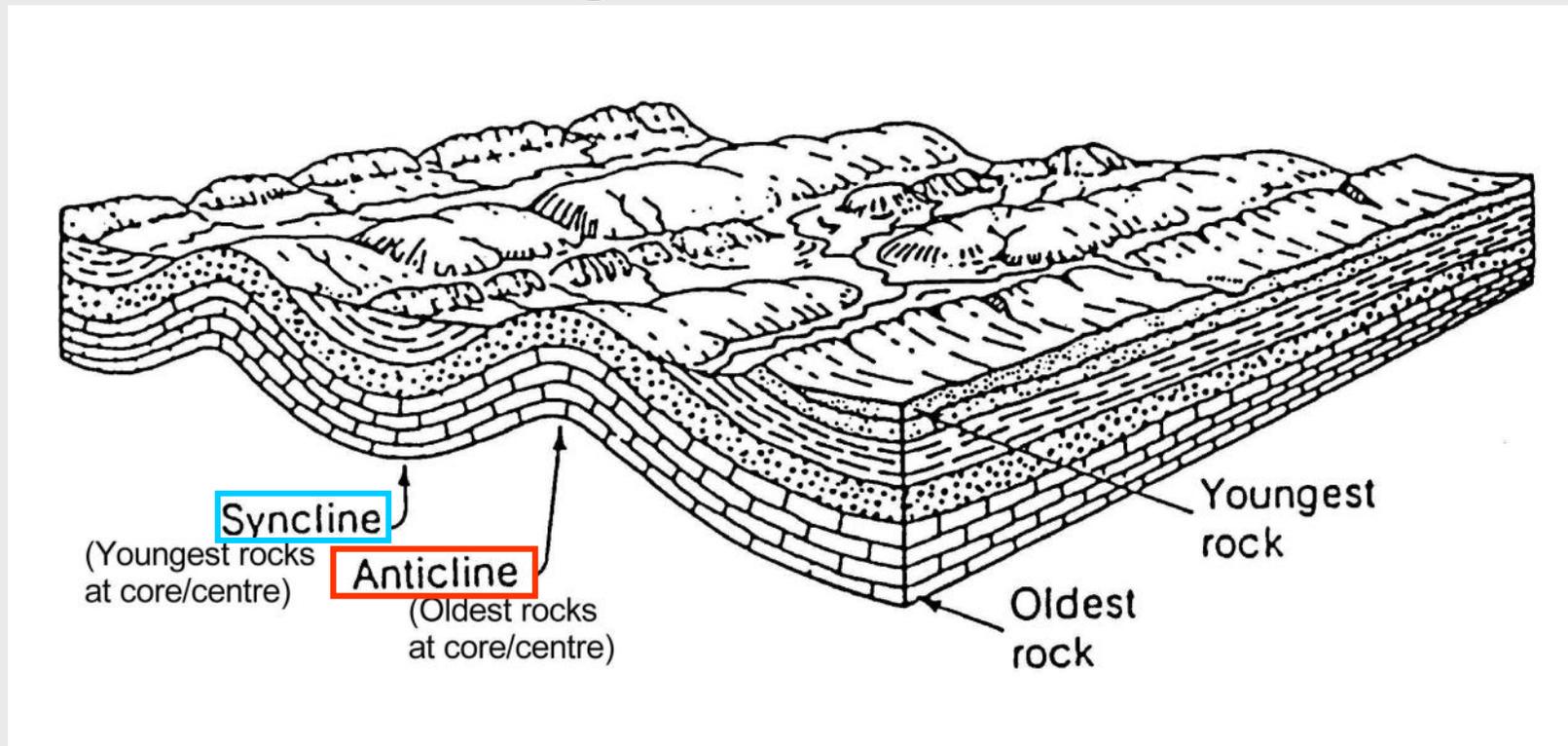


Plate Tectonics

There are 3 basic types of plate boundaries, depending on whether the plates are being pulled apart, pushed together or slid past one another.



Geological Structures



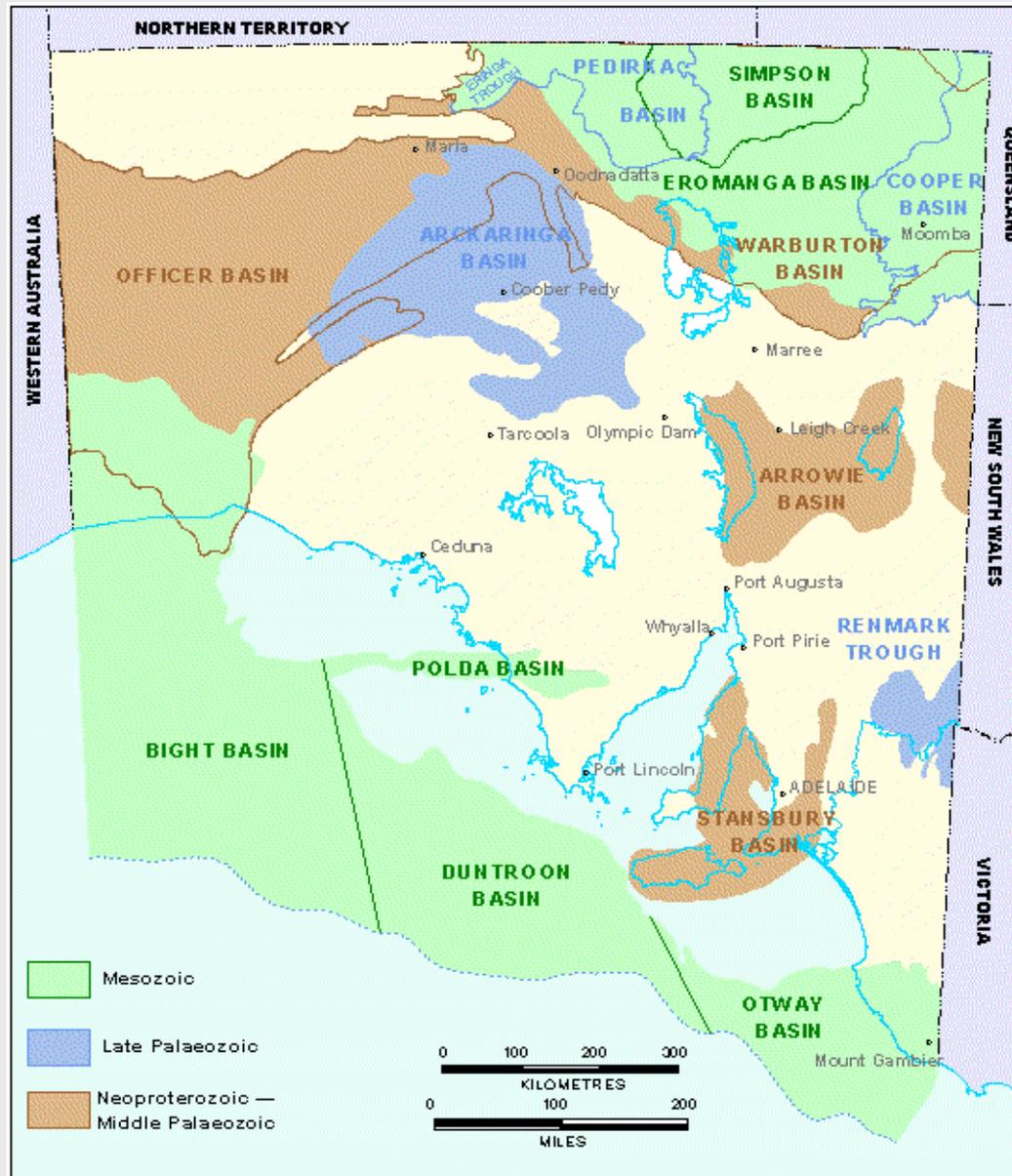
Tectonic stresses cause deformation resulting in FOLDS.

Convex upwards folds are called **ANTICLINES**.
Concave upwards folds are called **SYNCLINES**.

Sedimentary Basins

- Topographically low areas on the Earth's surface (synclines), formed by movements of the earth's crust, are called sedimentary basins
- Subsidence and deposition occur together over a long period to produce a pile of sedimentary rocks in the basins (thickness may be > 10 km)
- South Australian Sedimentary Basins include Arckaringa, Bight, Cooper, Eromanga,, Officer, Otway, Polda, Simpson, Warburton, etc.

Sedimentary Basins in SA



Sedimentary Basins

Importance: Sedimentary basins are where we find

- Source rocks (organic-rich rocks which generate oil and/or gas when subjected to heat and pressure during burial)
- Reservoir rocks (rocks that have porosity and permeability and can hold and produce oil and gas or can be used for gas storage)
- Seals (impermeable rocks which cap hydrocarbon accumulations and stored gas and prevent them from moving)

Origin of Petroleum

- Organic-rich sediments accumulate in sedimentary basins mainly as coals or shales (source rocks)
- Shales: fine-grained detrital sedimentary rock, formed by the compaction of clay, silt, or mud; commonly rich in organic content (TOC > 1-4%)

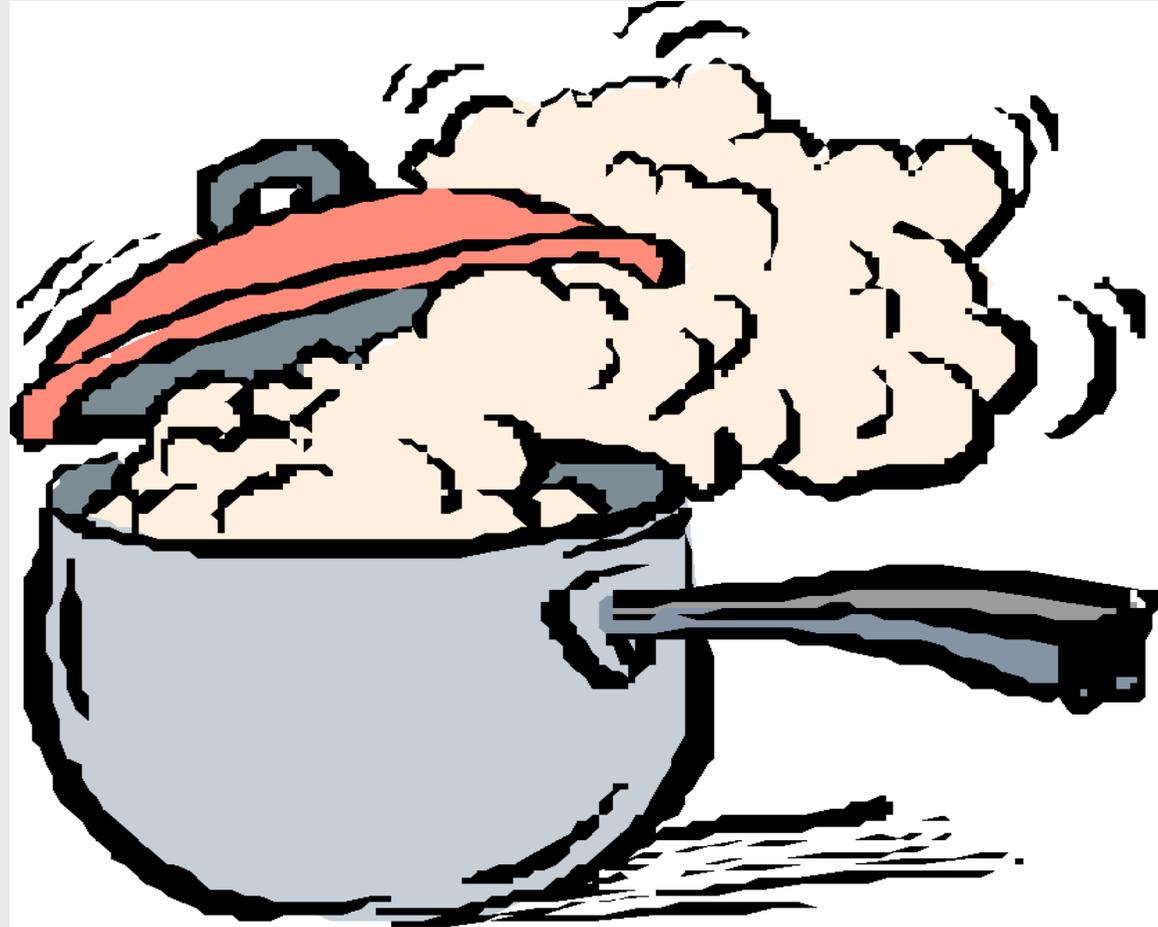


Origin of Petroleum

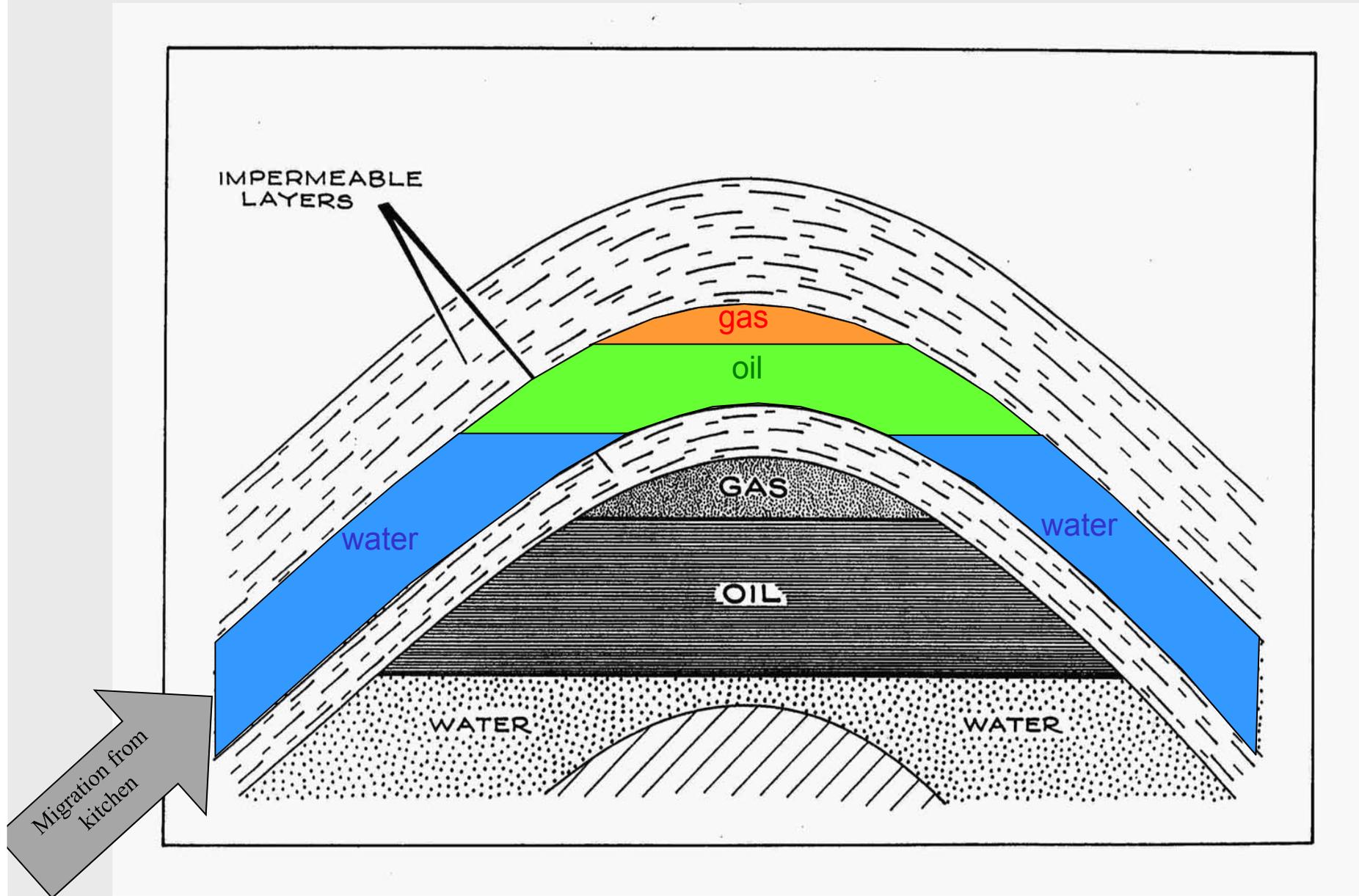
Organic rich source rocks “mature” (“cook”) and generate hydrocarbons

This process requires appropriate temperature, time and pressure (

An area where source rocks have matured (cooked) is often referred to as a “source kitchen”



Simple Anticline Trap

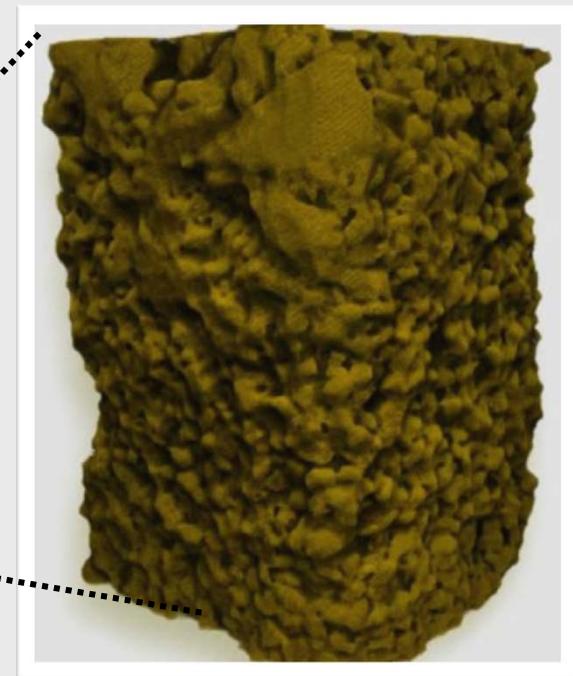
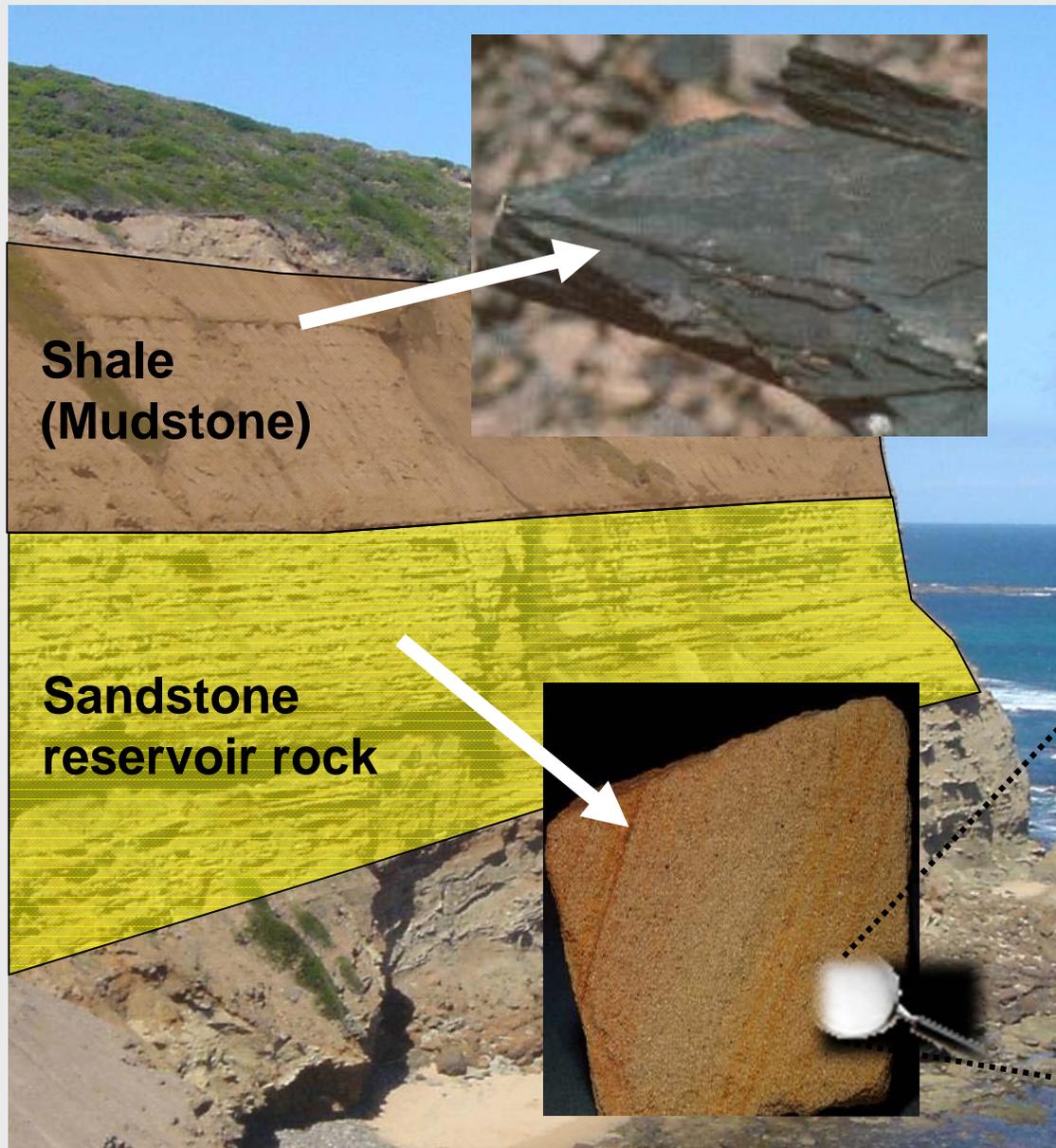


Sandstones and Shales

Conventional Petroleum Systems

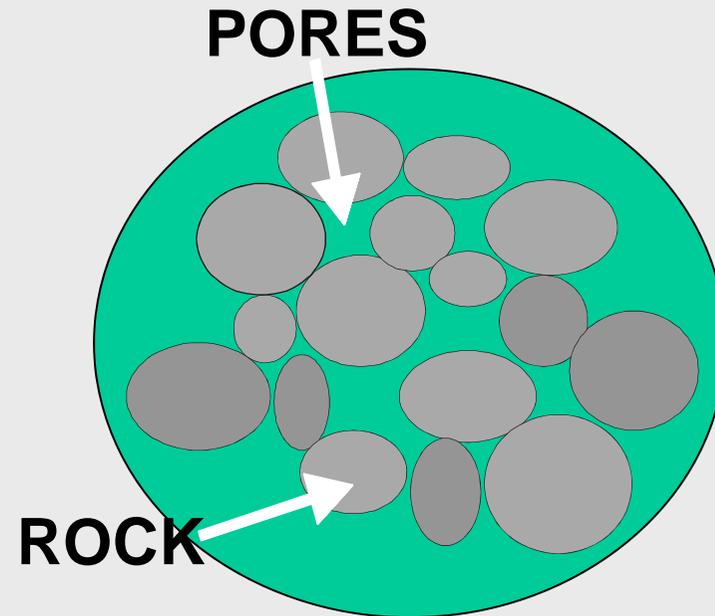
Shale (Mudstone) – non-porous, impermeable, caprock or source rock

Sandstone – porous, permeable, Reservoir rock



POROSITY

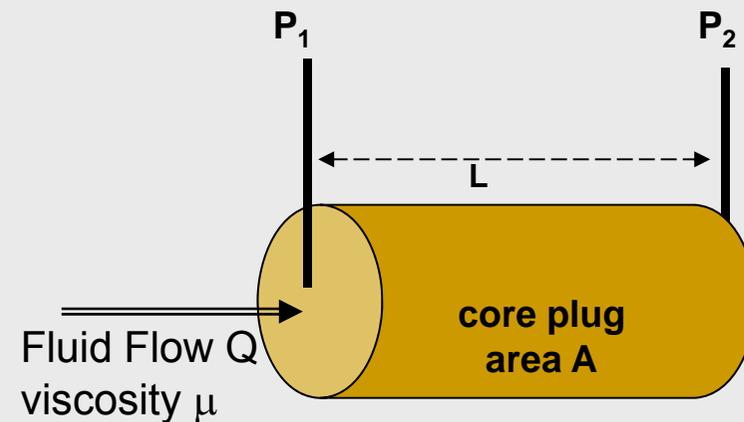
Volume of pore system expressed as a fraction (\emptyset) of gross rock volume



PERMEABILITY

the capacity of a porous rock or sediment for transmitting a fluid; it is a measure of the relative ease of fluid flow under unequal pressure

$$K = \frac{Q \mu L}{A (P_1 - P_2)}$$



Measured in Darcies (D) or millidarcies (mD)

Petroleum Systems: Many 100's to 1000's metres depth

How do we know what's down there?

What data do we normally have?

- Geophysics
 - Seismic; gravity; magnetics
- Drilled wells
 - Rock: Core; drill cuttings
- Wireline logs
- Analogs
 - Outcrops and modern depositional environments
- Models, models, models!

What is Seismic?

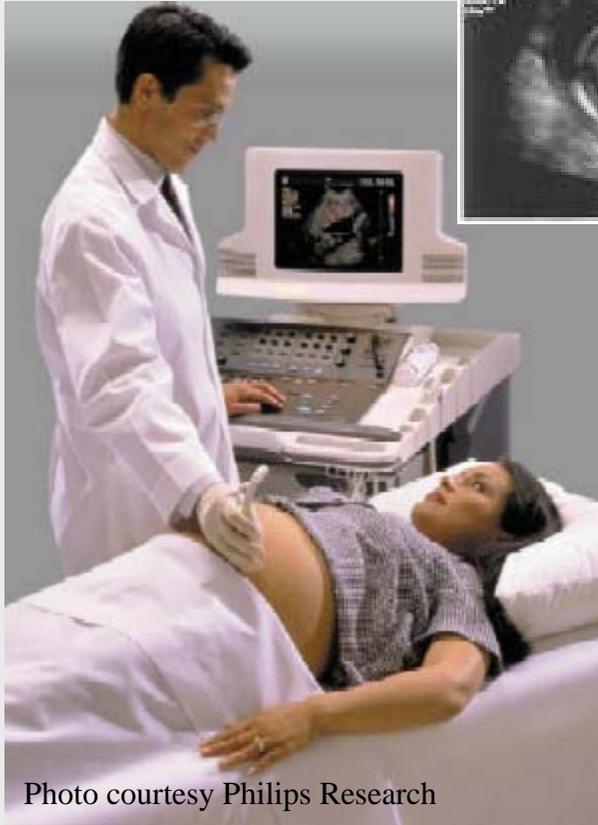
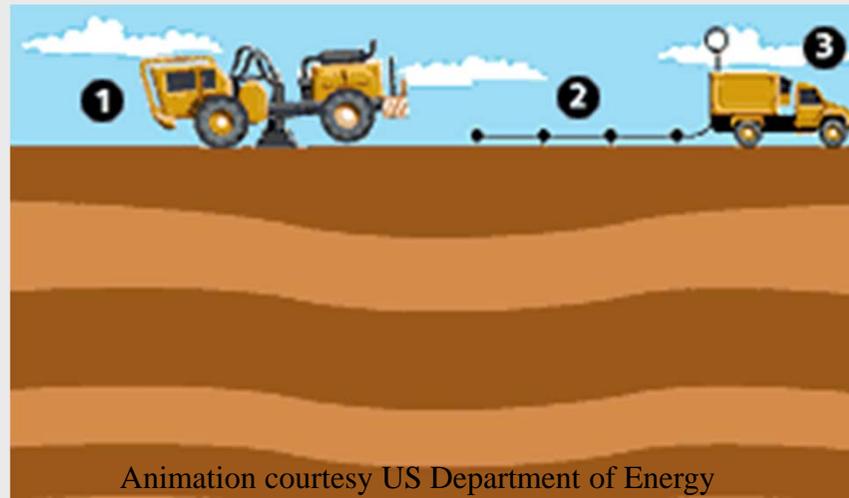
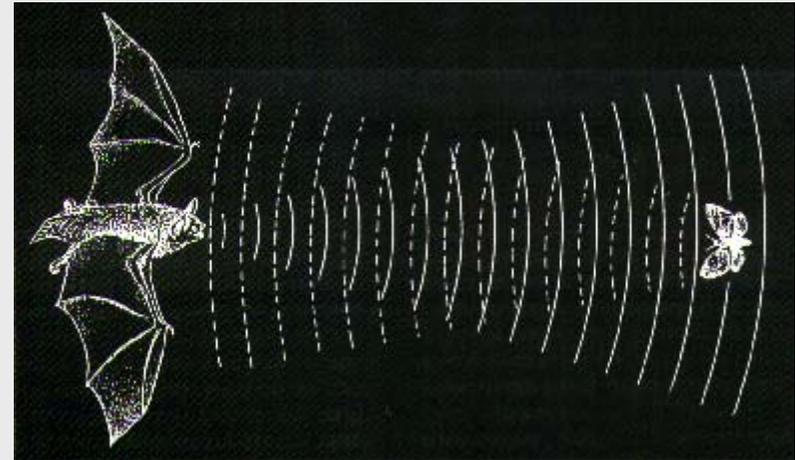


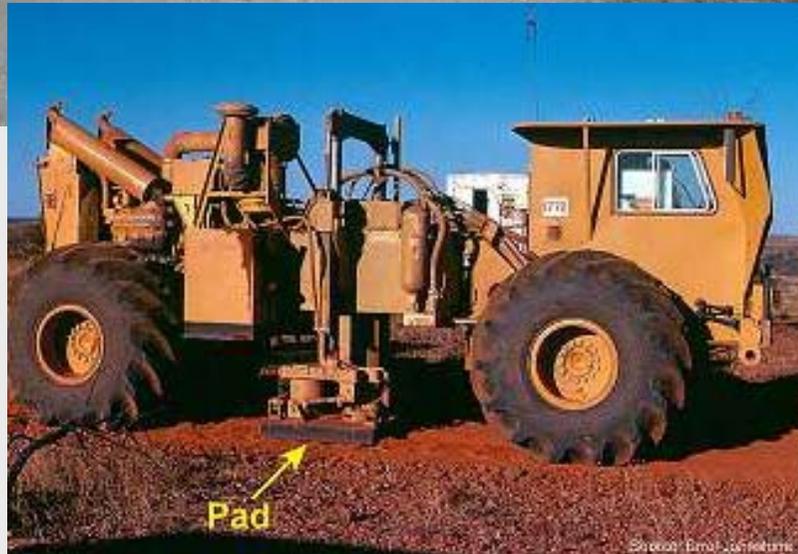
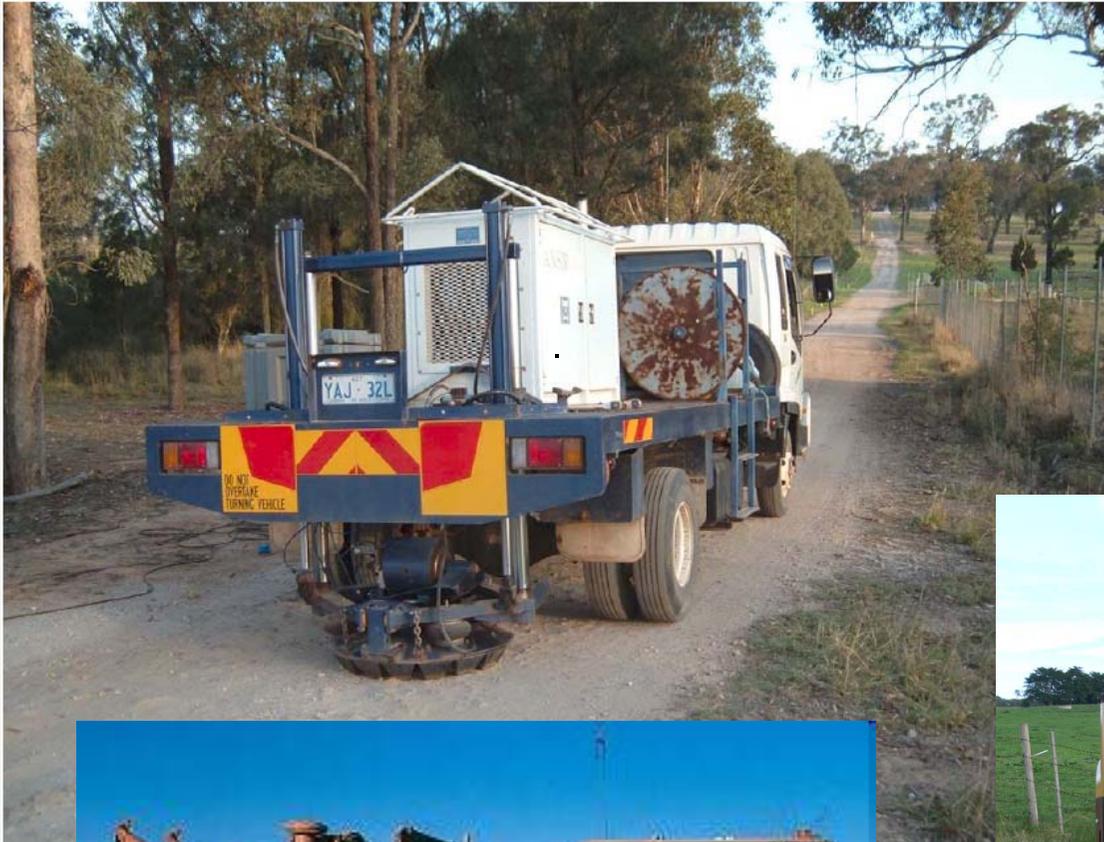
Photo courtesy Philips Research

Ultrasound examination during pregnancy

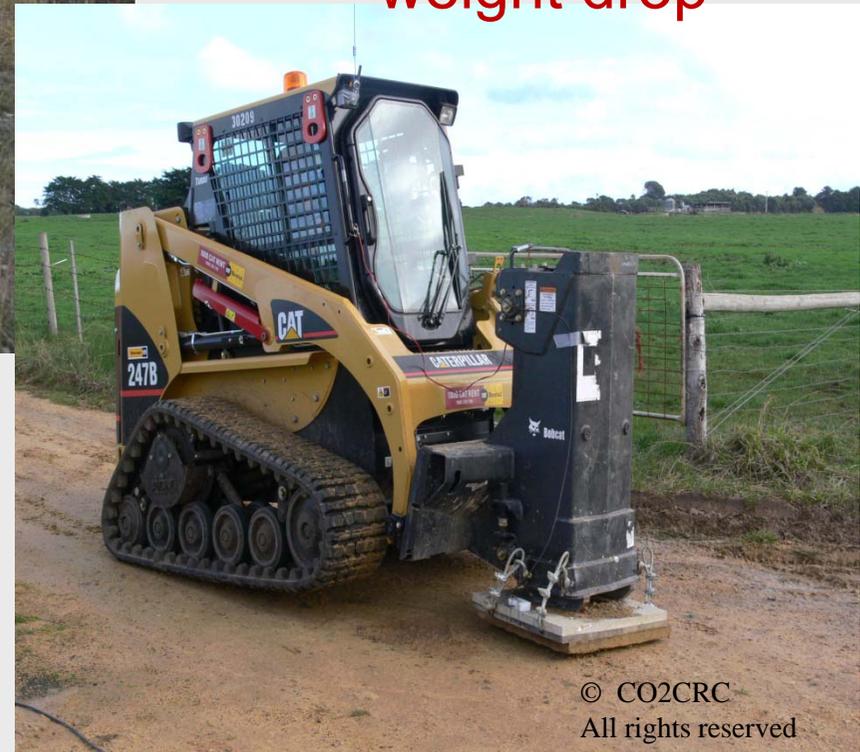


Animation courtesy US Department of Energy
Collecting seismic data on land

Truck-mounted Vibroseis (“Thumper”)



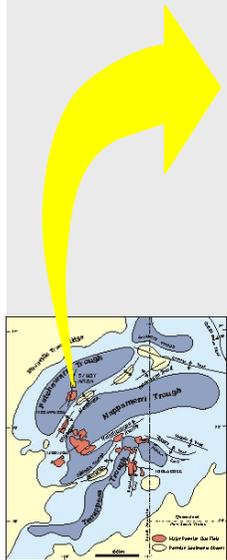
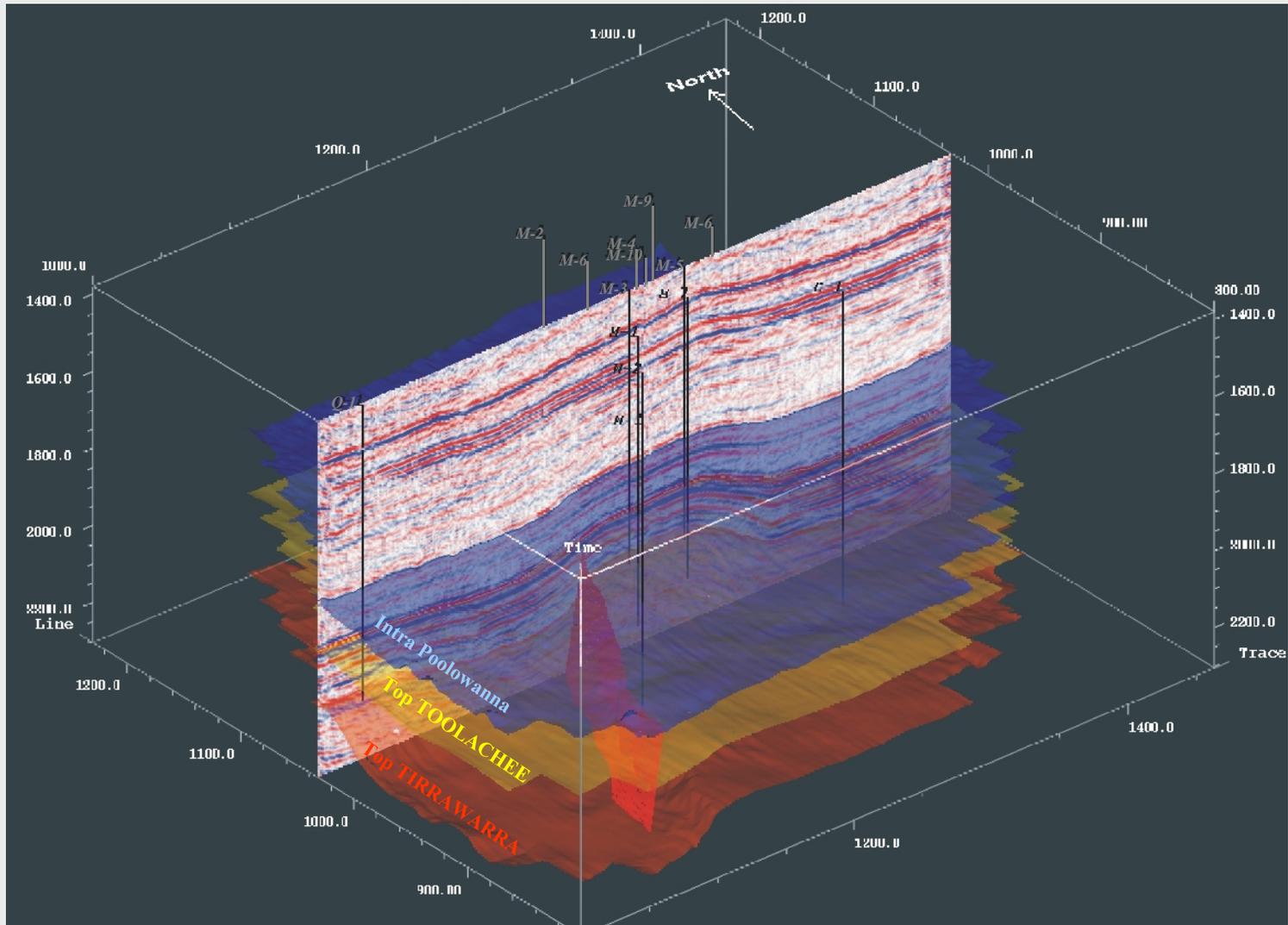
BobCat-mounted weight drop



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3D Seismic Volumes

(example from Cooper Basin)



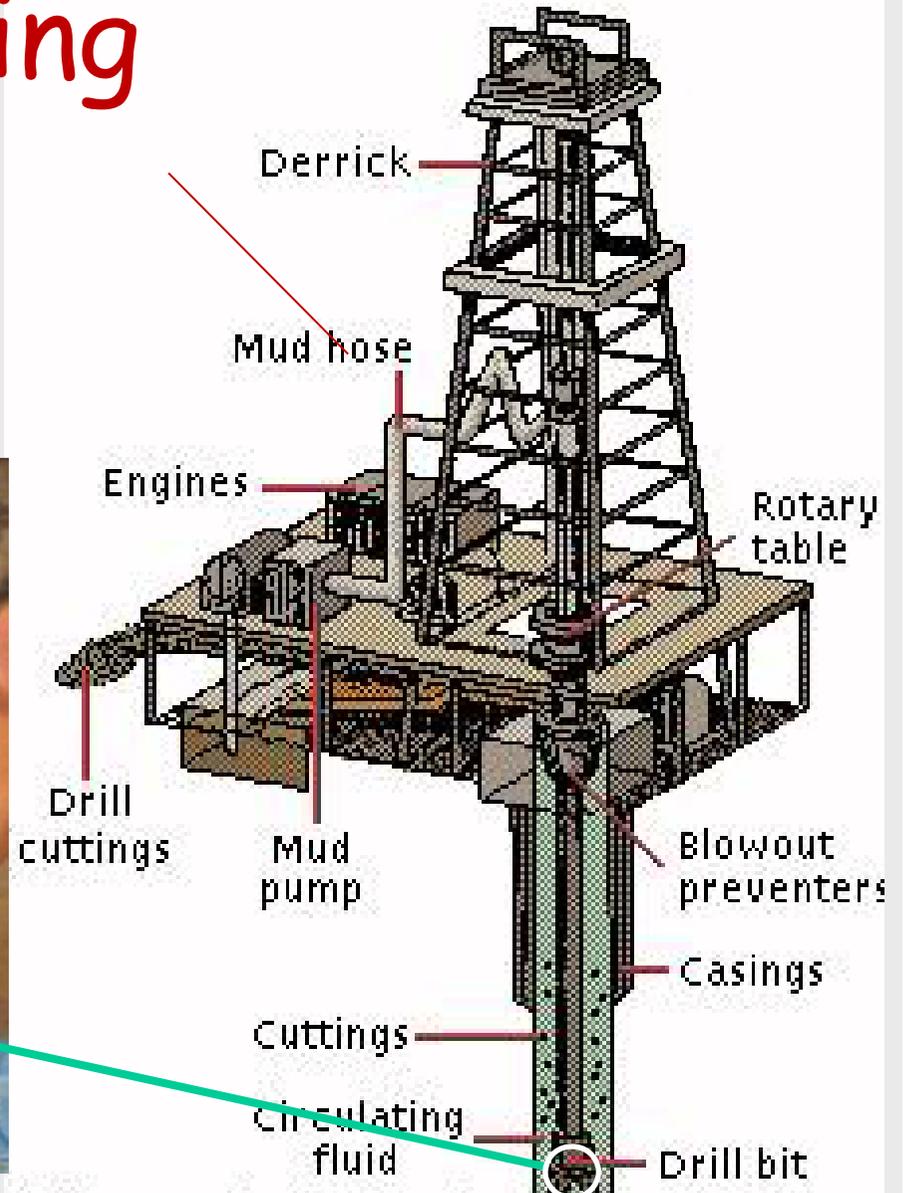
Nakanishi and Lang, 2001

- Technical objectives for drilling:
 - Drill to targeted zone
 - Produce (or inject) fluids/gas
 - Acquire representative core
 - Acquire quality log data
 - Collect other samples (formation fluid, mud gas and cuttings)
- Non-technical objectives:
 - Safe operations
 - On time
 - On budget



Drilling

Tri-cone drill bits



Drilling



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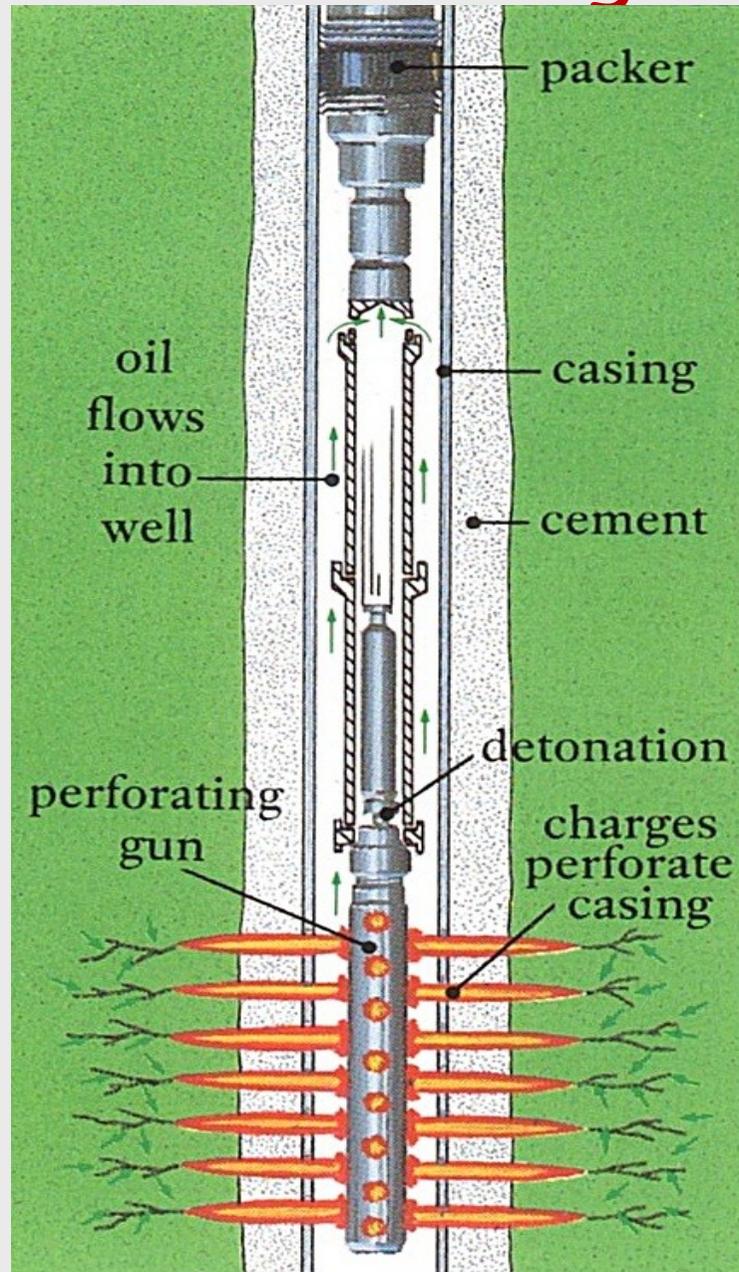
Drilling

Roughnecks on rotary table assemble drill string by connecting pipe stands



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Perforating



Multilateral and Horizontal wells

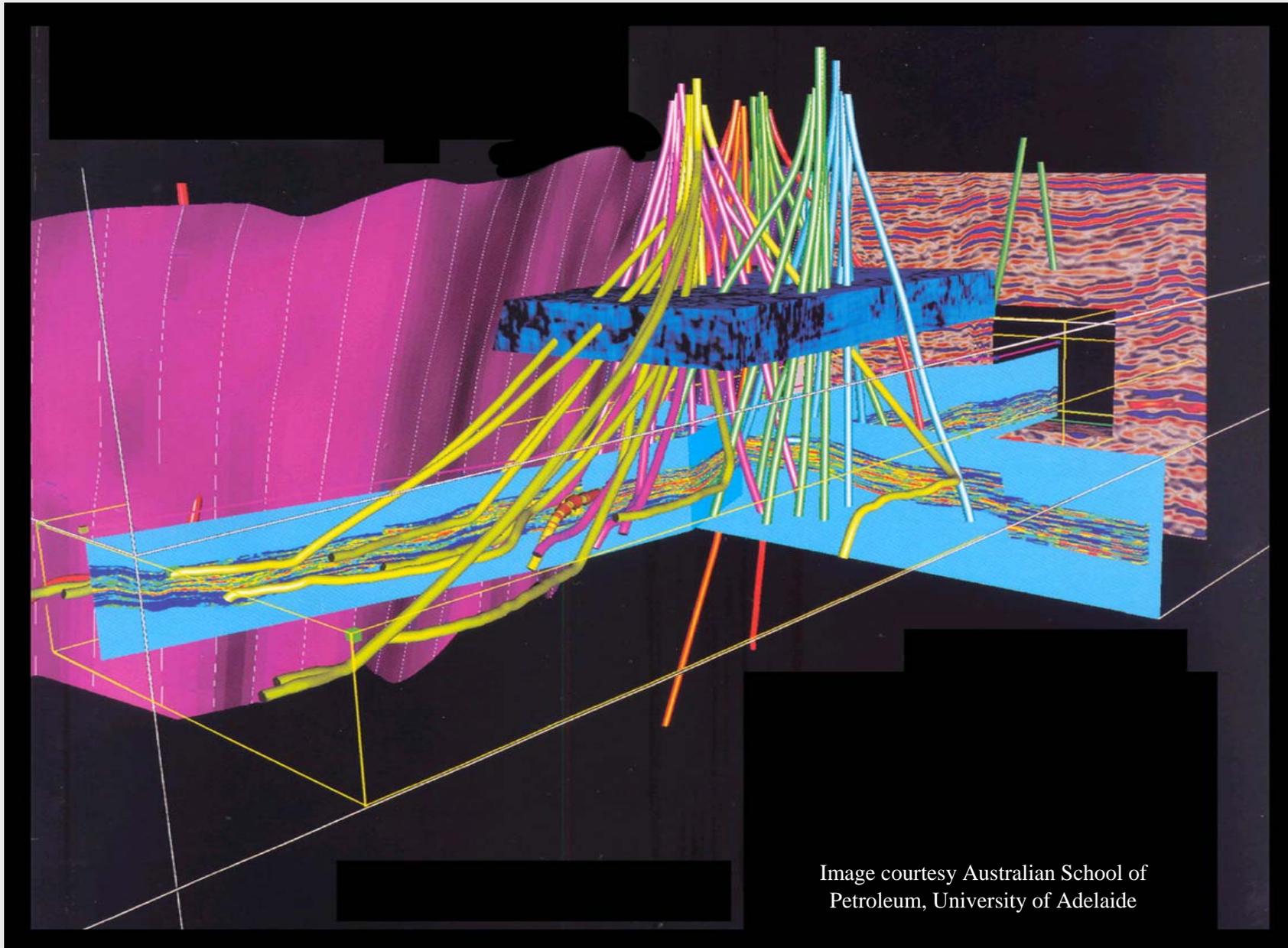
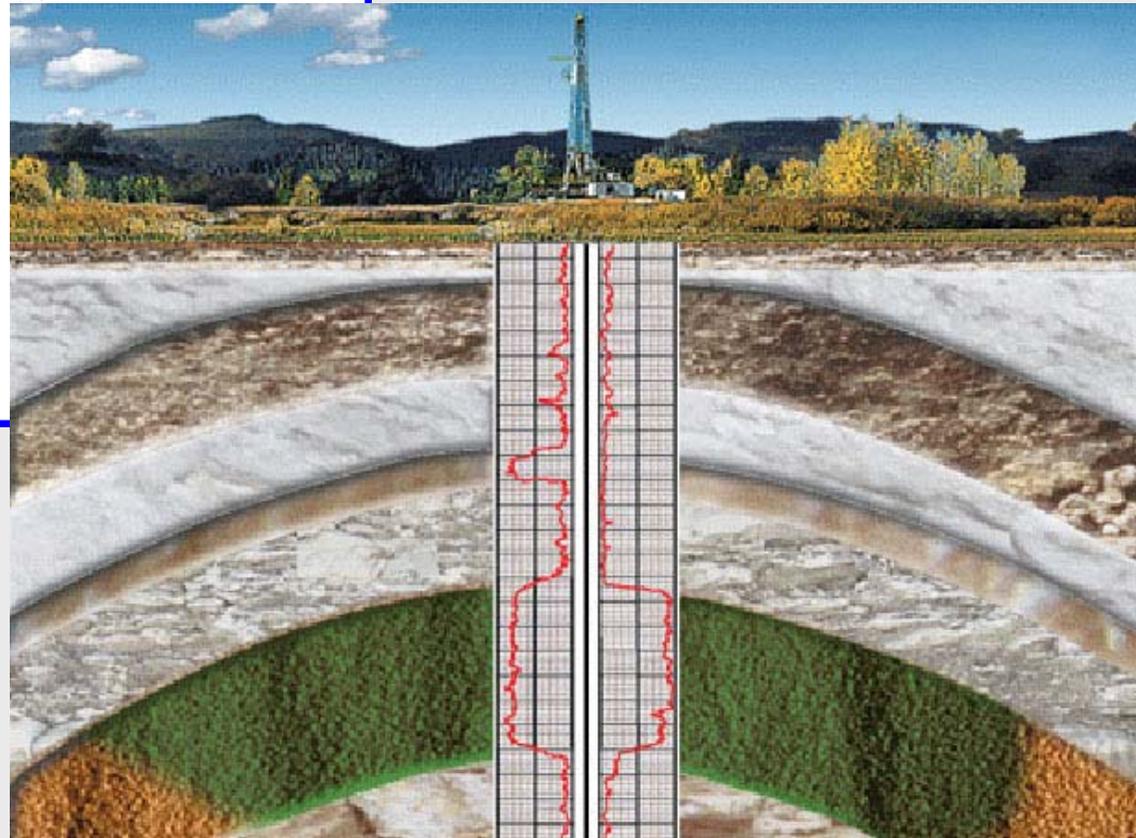
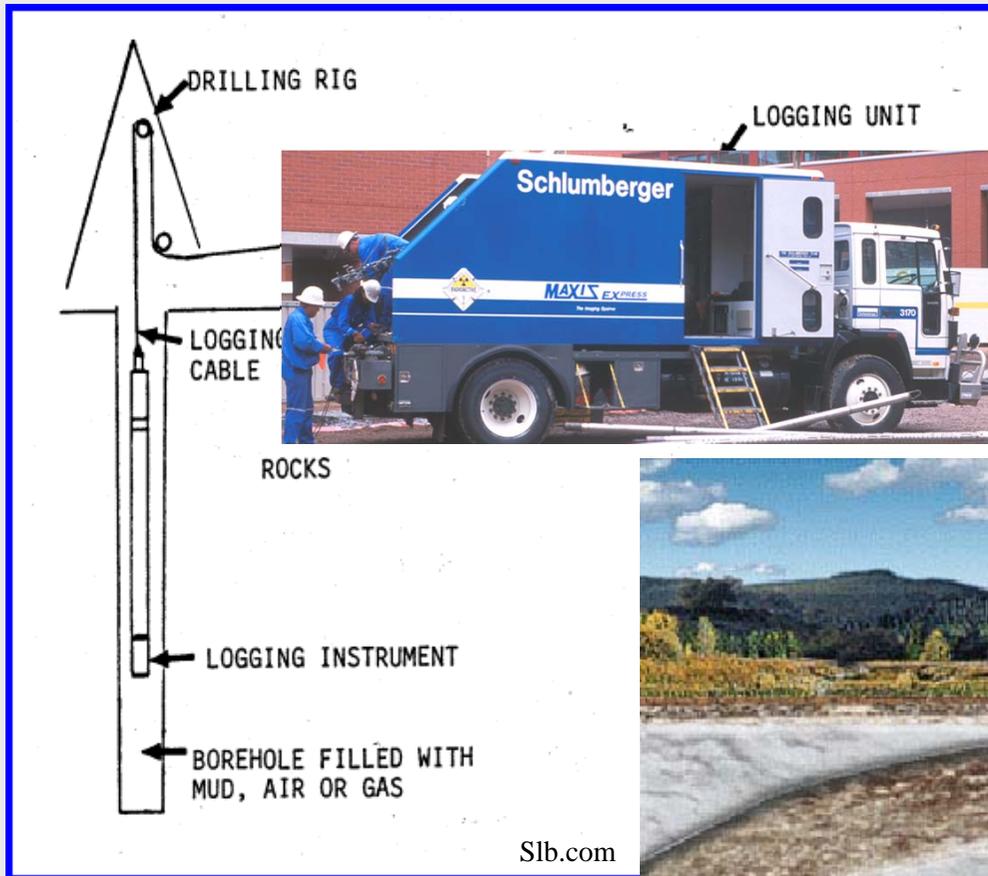


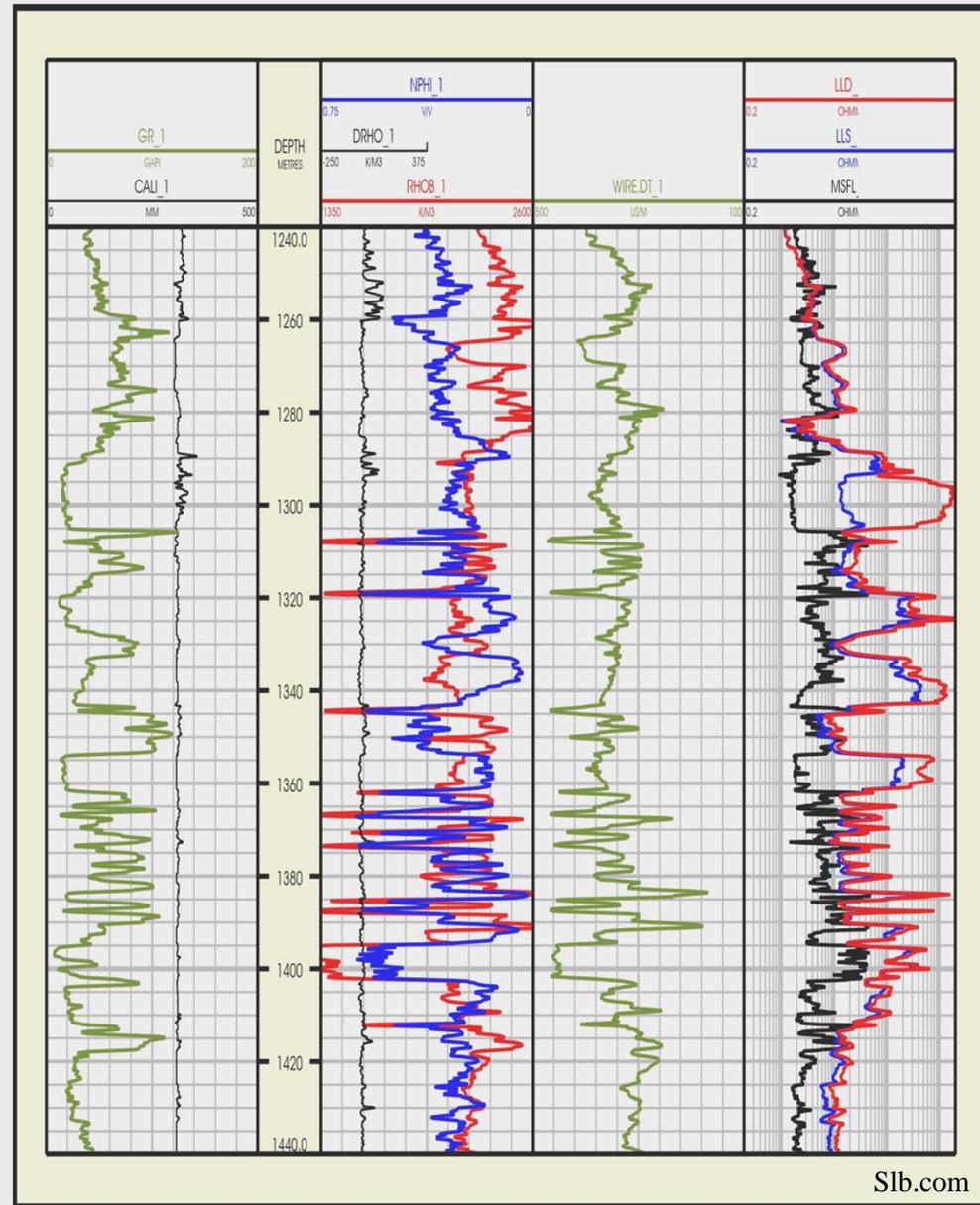
Image courtesy Australian School of
Petroleum, University of Adelaide

Wireline Well Logging

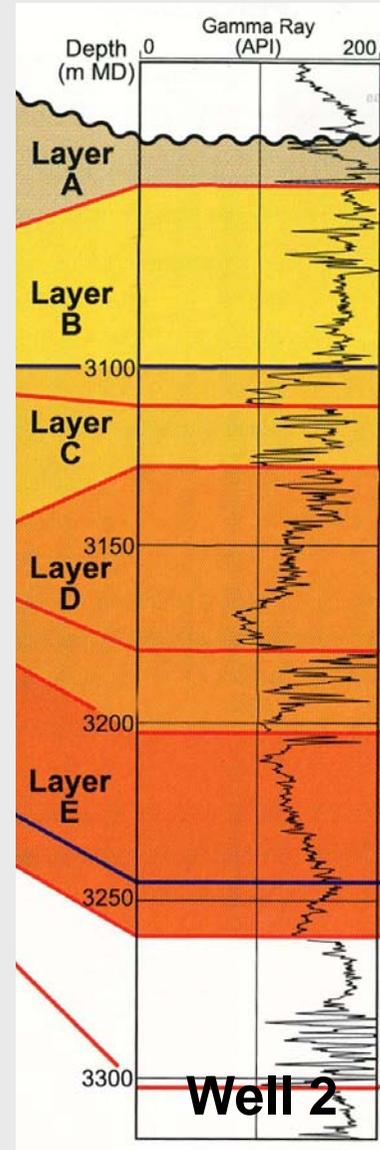
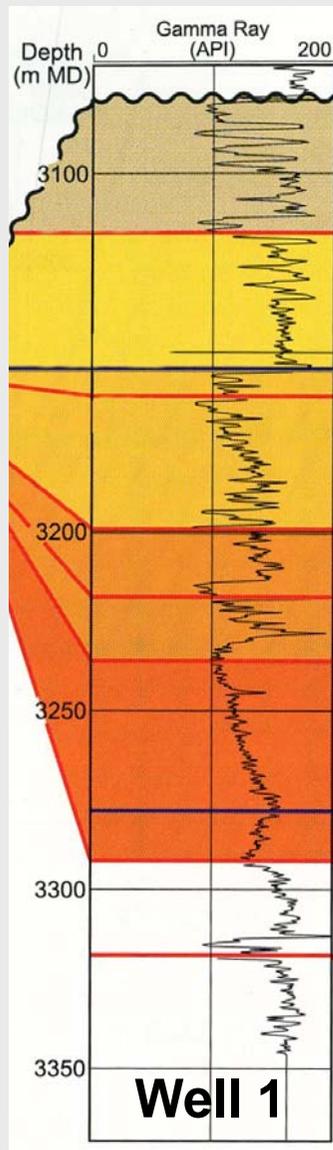


Well Logs

- Logs are measurements of various physical properties of the rocks and fluids as a function of depth in a borehole.
- Different types of measurements are made to give information on different aspects of the rocks, and independent estimates of the same properties. No single log measurement gives the full picture.



Wireline well log data

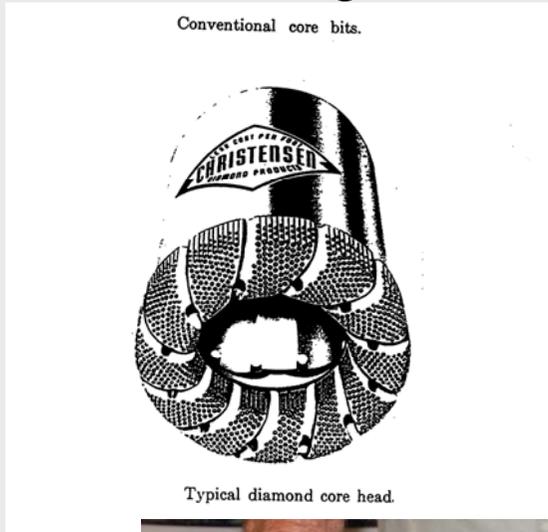


Wireline log data
(interpolated between wells)

← 10 km →

Core

“Hollow” bits for cutting core

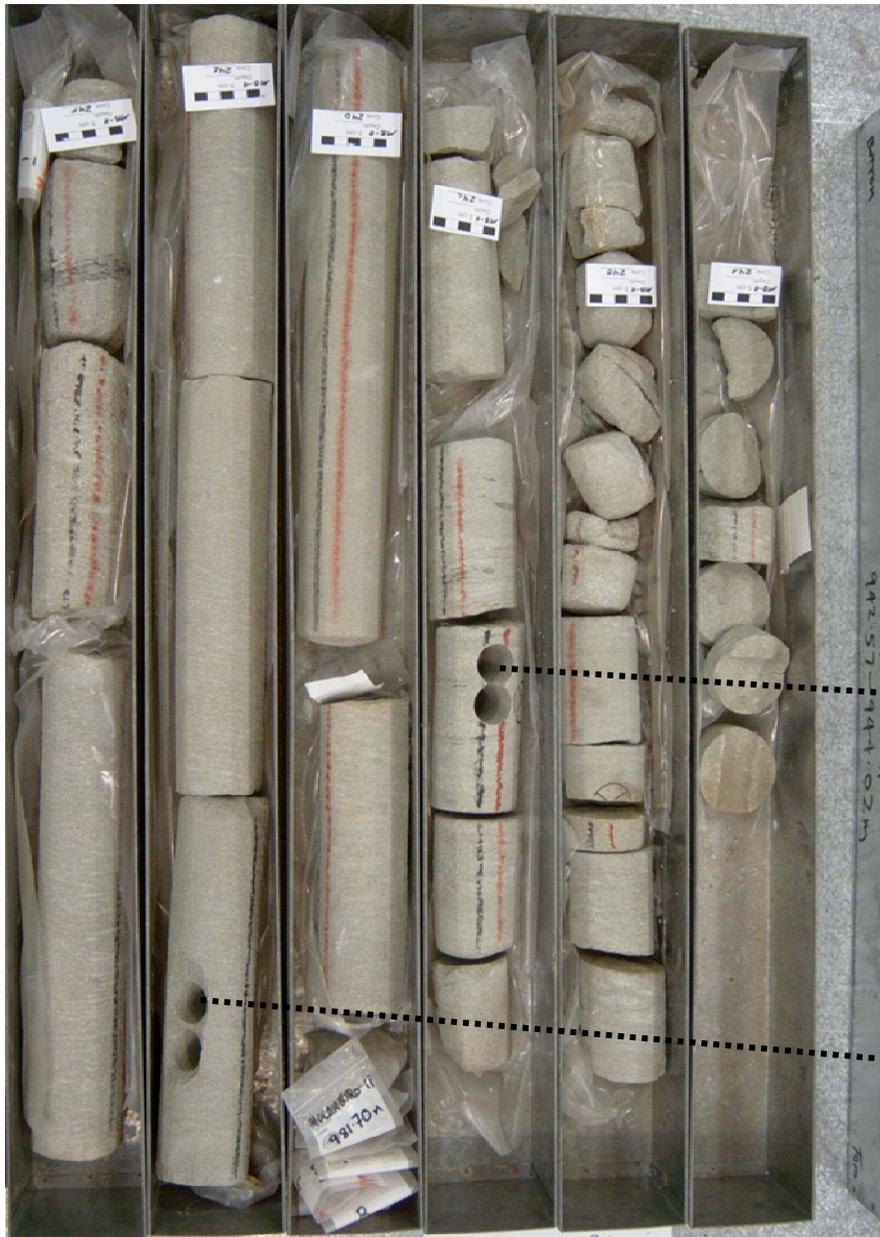


Core retainer

Fibreglass and aluminium core barrels



Core



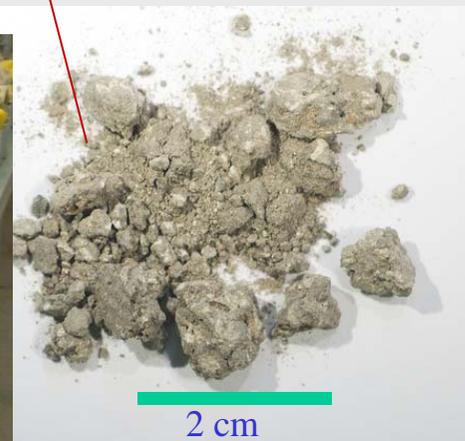
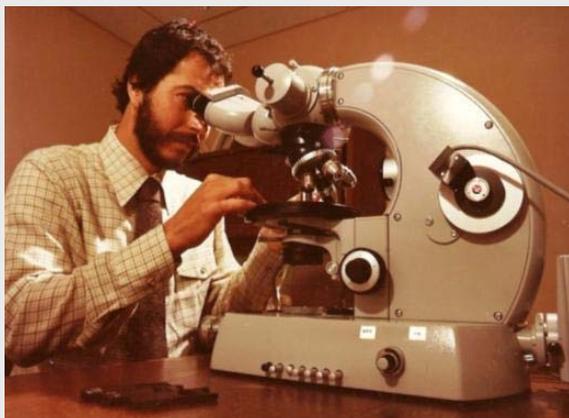
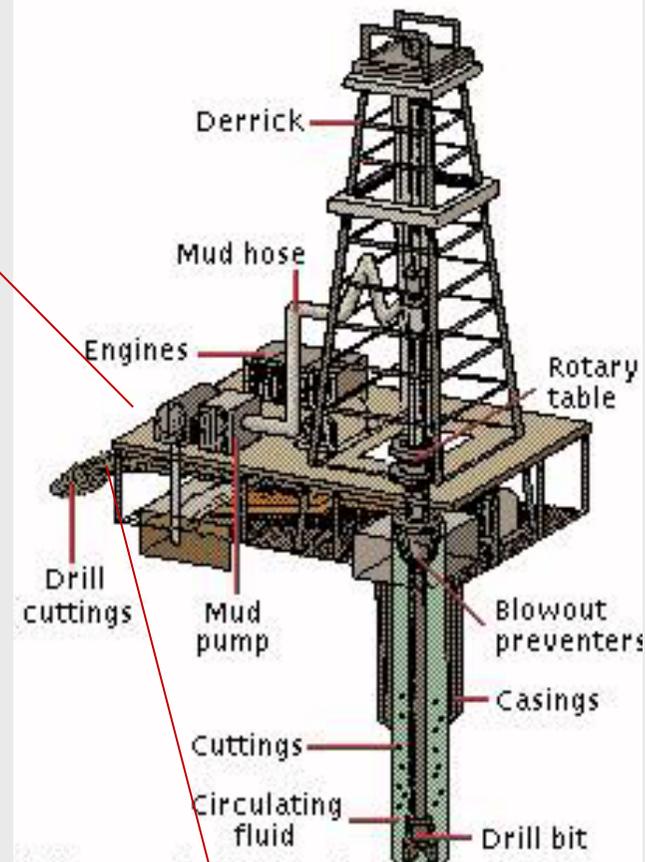
Describing the core: It is important to know original depositional environment to determine reservoir geometries, orientations, trends.

Plugging the core: The core must be analysed for porosity, permeability and grain density (Routine core analysis); Sometimes, Special Core Analyses (SCAL) is performed. For these tests, small samples (core plugs) are drilled



Cuttings

Shale shaker removing cuttings from mud



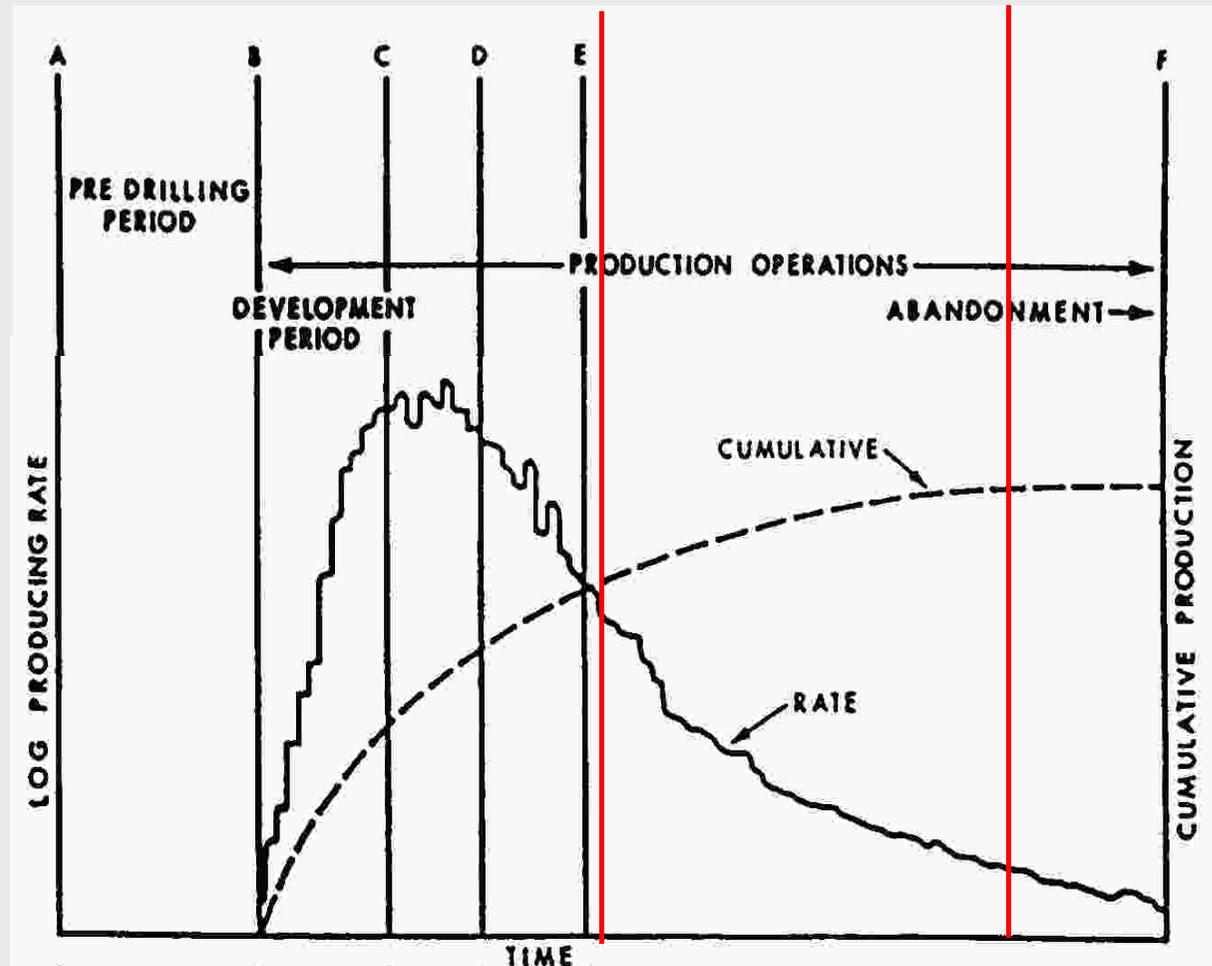
Typical Production Profile

Typical Field / Basin Production Profile

Rate increases rapidly as development wells are drilled and come on stream (B-C).

Rate then plateaus for some time (months to years) (C-D).

Rate then declines gradually until production is uneconomic, and field is abandoned (D-F).



Cooper B.
Conv Gas

Cooper B.
Conv Oil

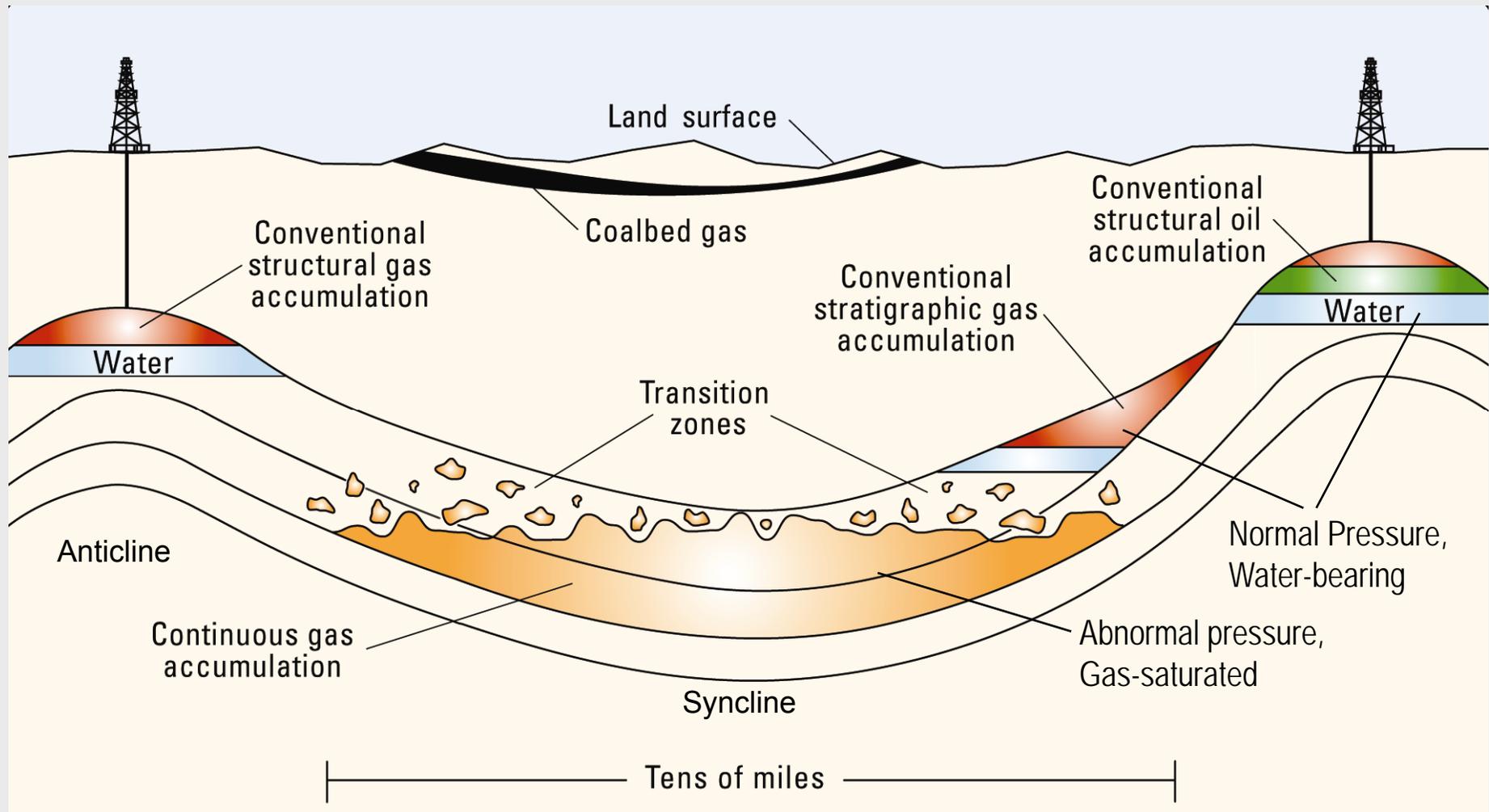
Unconventional Resources

- Not what we used to explore for or produce.
- Oil and gas accumulation not controlled by buoyancy within a reservoir.
- Wide geographic extent – not limited to discrete “fields”.
- Difficult to extract.
- Low permeability; oil and gas do not flow easily towards a well.
- Requires some sort of stimulation.

Unconventional Resources

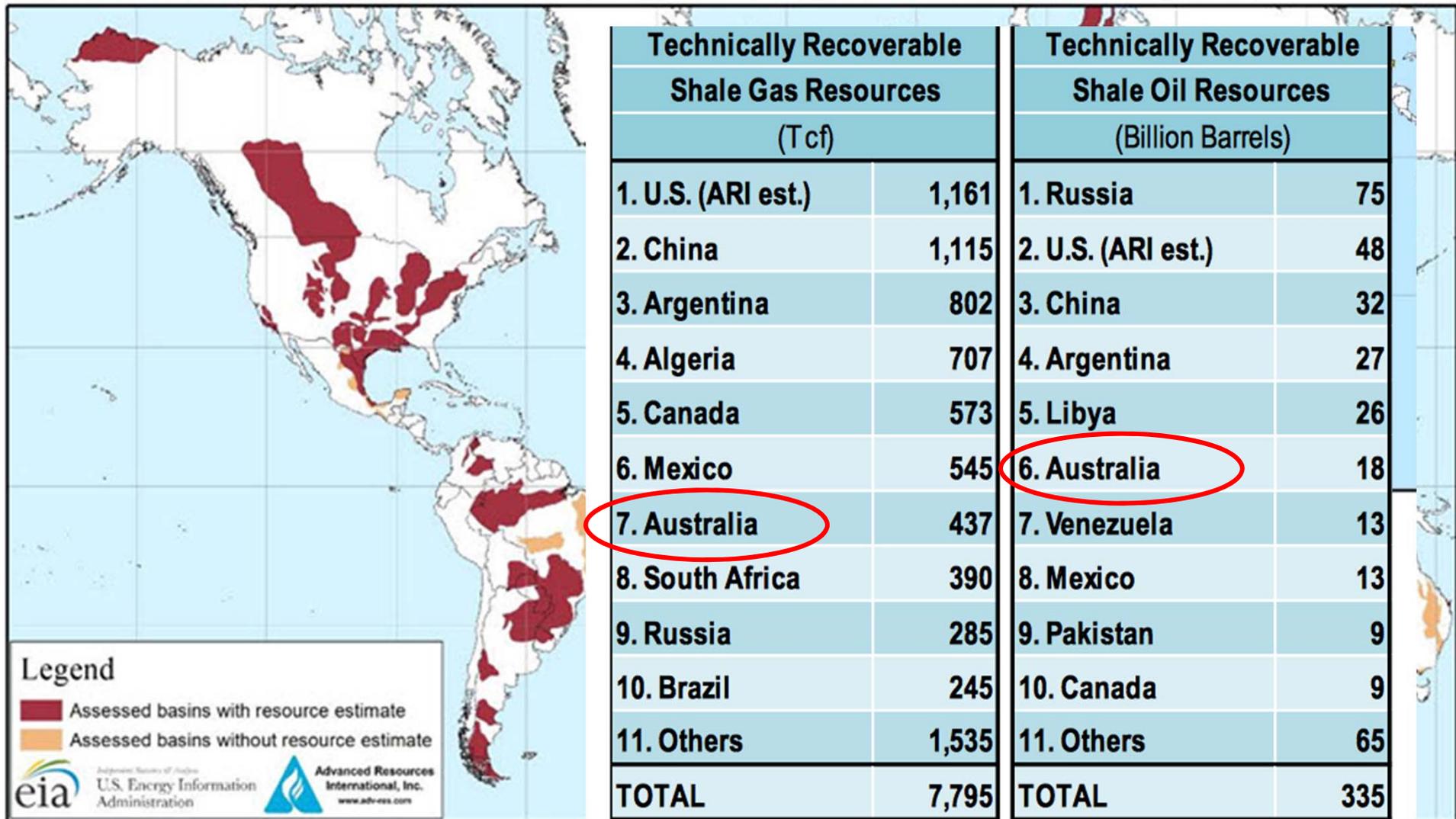
- Coal seam gas (CSG, CBM)
- Tight gas
- Shale gas (basin-centered gas)
- Shale oil
- Oil shale
- Oil sands (tar sands)
- Gas hydrates

Conventional & Unconventional Petroleum Systems



Modified from C.J. Schenk et al., USGS DDS 69-B, 2003

Figure 1. Map of basins with assessed shale oil and shale gas formations, as of May 2013



Source: United States basins from U.S. Energy Information Administration and United States Geological Survey; other basins from ARI based on data from various published studies

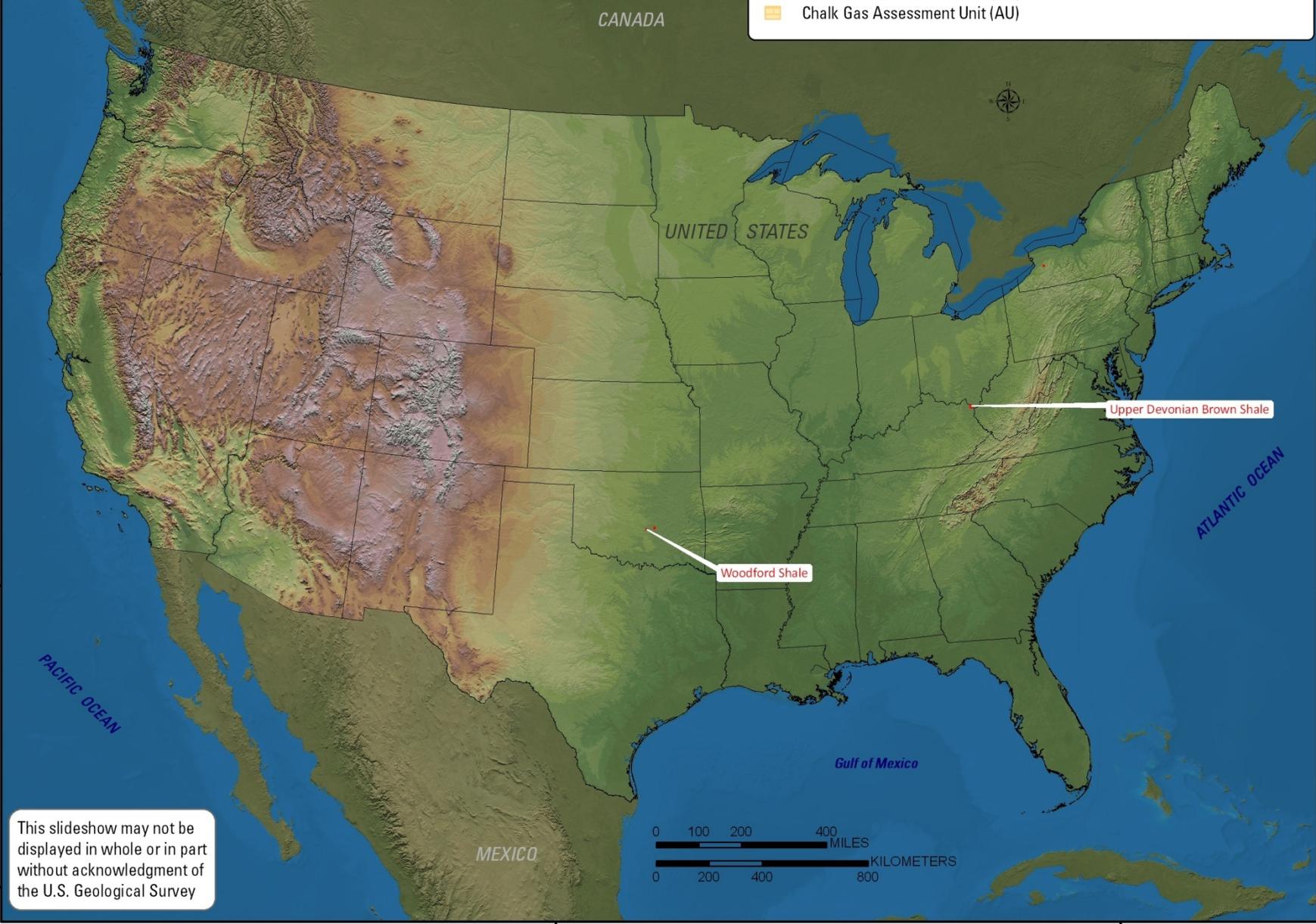


Digital Data Series 69-Z
Version 1.0

1930

Explanation

- Square-mile cells represent shale gas-producing wells (size exaggerated)
- Shale Gas Assessment Unit (AU)
- Chalk Gas Assessment Unit (AU)



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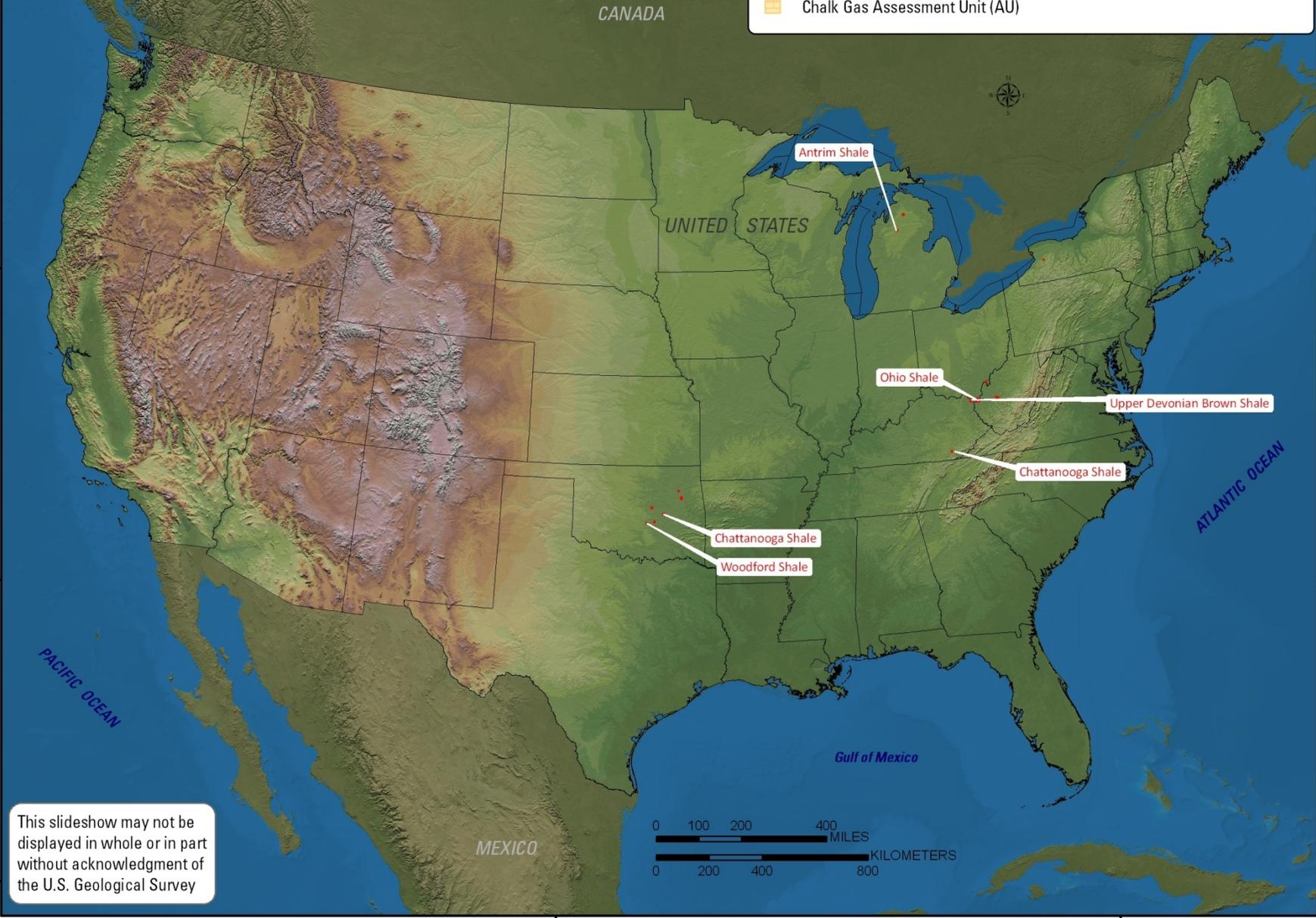


Digital Data Series 69-Z
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1940

Explanation

- Square-mile cells represent shale gas-producing wells (size exaggerated)
- Shale Gas Assessment Unit (AU)
- Chalk Gas Assessment Unit (AU)



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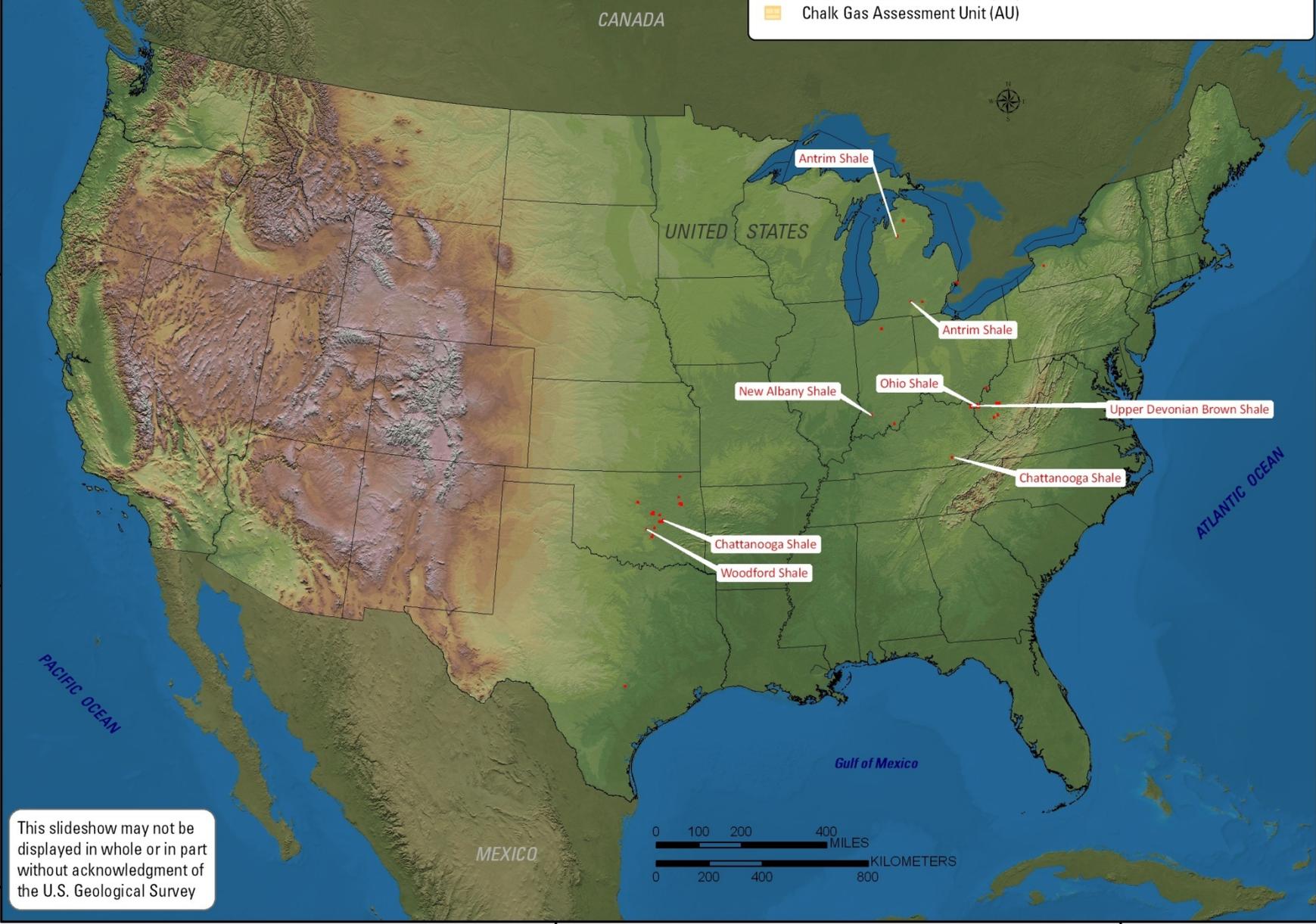


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1950

Explanation

- Square-mile cells represent shale gas-producing wells (size exaggerated)
- Shale Gas Assessment Unit (AU)
- Chalk Gas Assessment Unit (AU)



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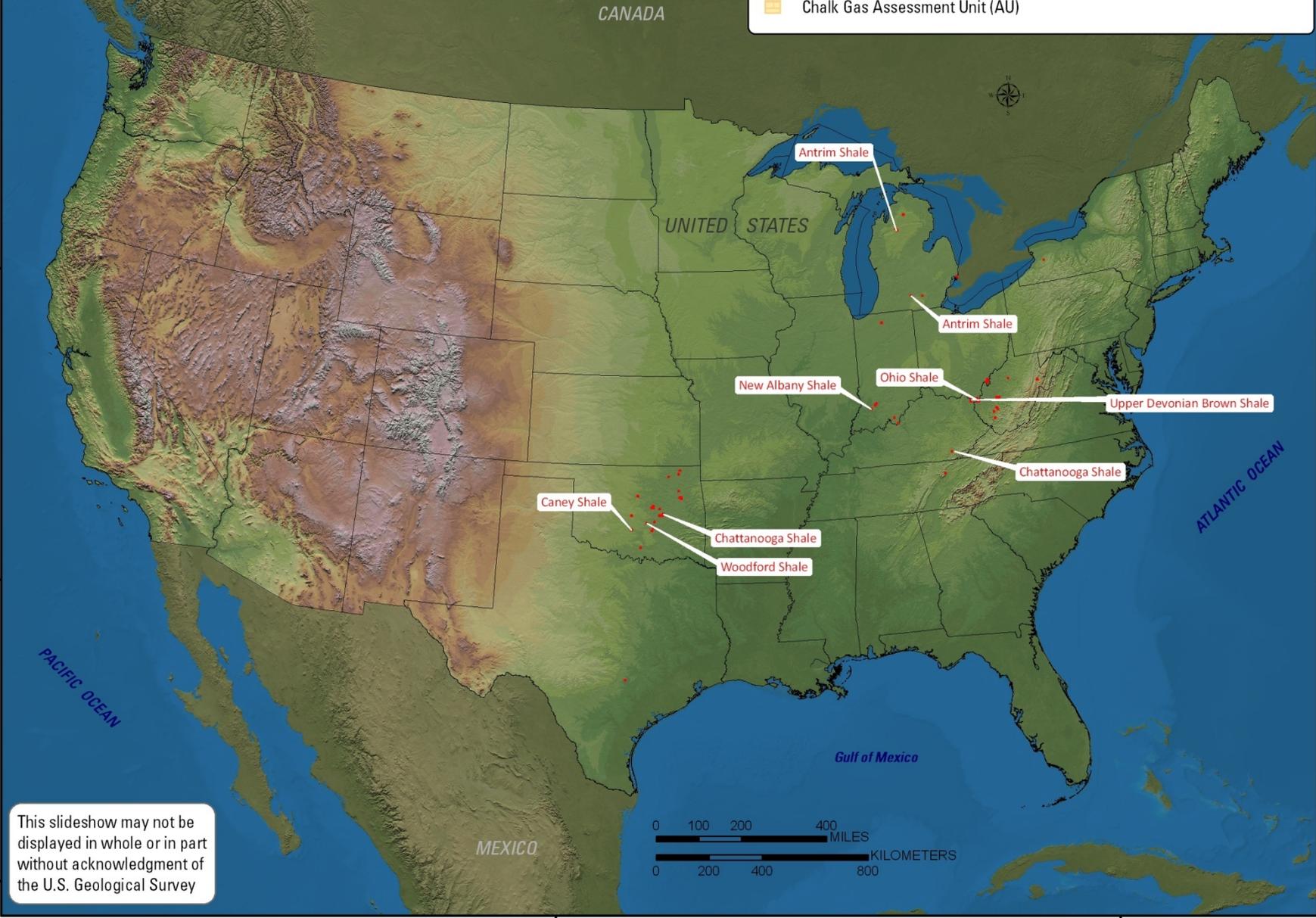


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1960

Explanation

- Square-mile cells represent shale gas-producing wells (size exaggerated)
- Shale Gas Assessment Unit (AU)
- Chalk Gas Assessment Unit (AU)



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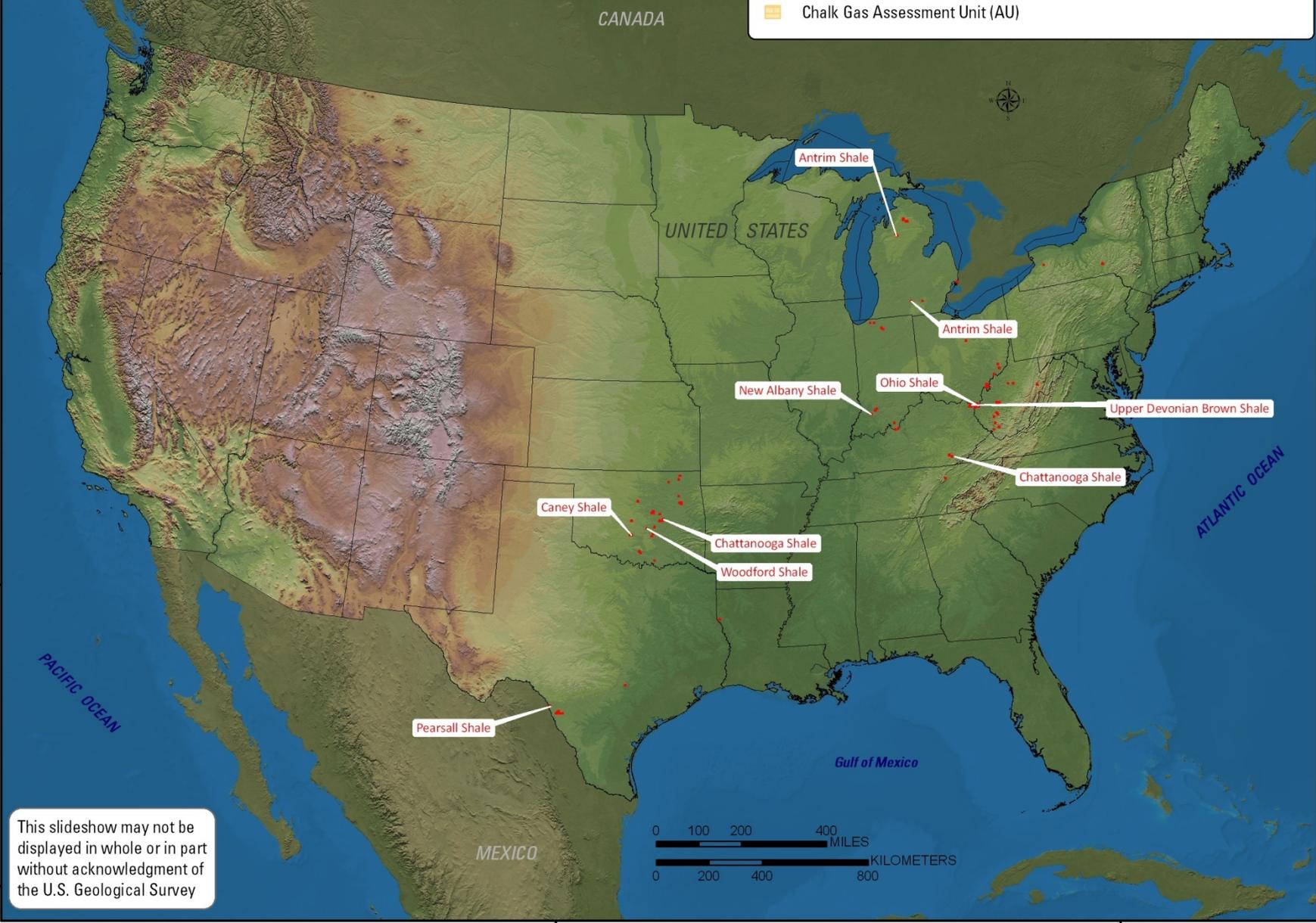


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1970

Explanation

- Square-mile cells represent shale gas-producing wells (size exaggerated)
- Shale Gas Assessment Unit (AU)
- Chalk Gas Assessment Unit (AU)



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1980

Explanation

- Square-mile cells represent shale gas-producing wells (size exaggerated)
- Shale Gas Assessment Unit (AU)
- Chalk Gas Assessment Unit (AU)



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1990

Explanation

- Red square-mile cells represent shale gas-producing wells (size exaggerated)
- Red shaded area represents Shale Gas Assessment Unit (AU)
- Yellow shaded area represents Chalk Gas Assessment Unit (AU)



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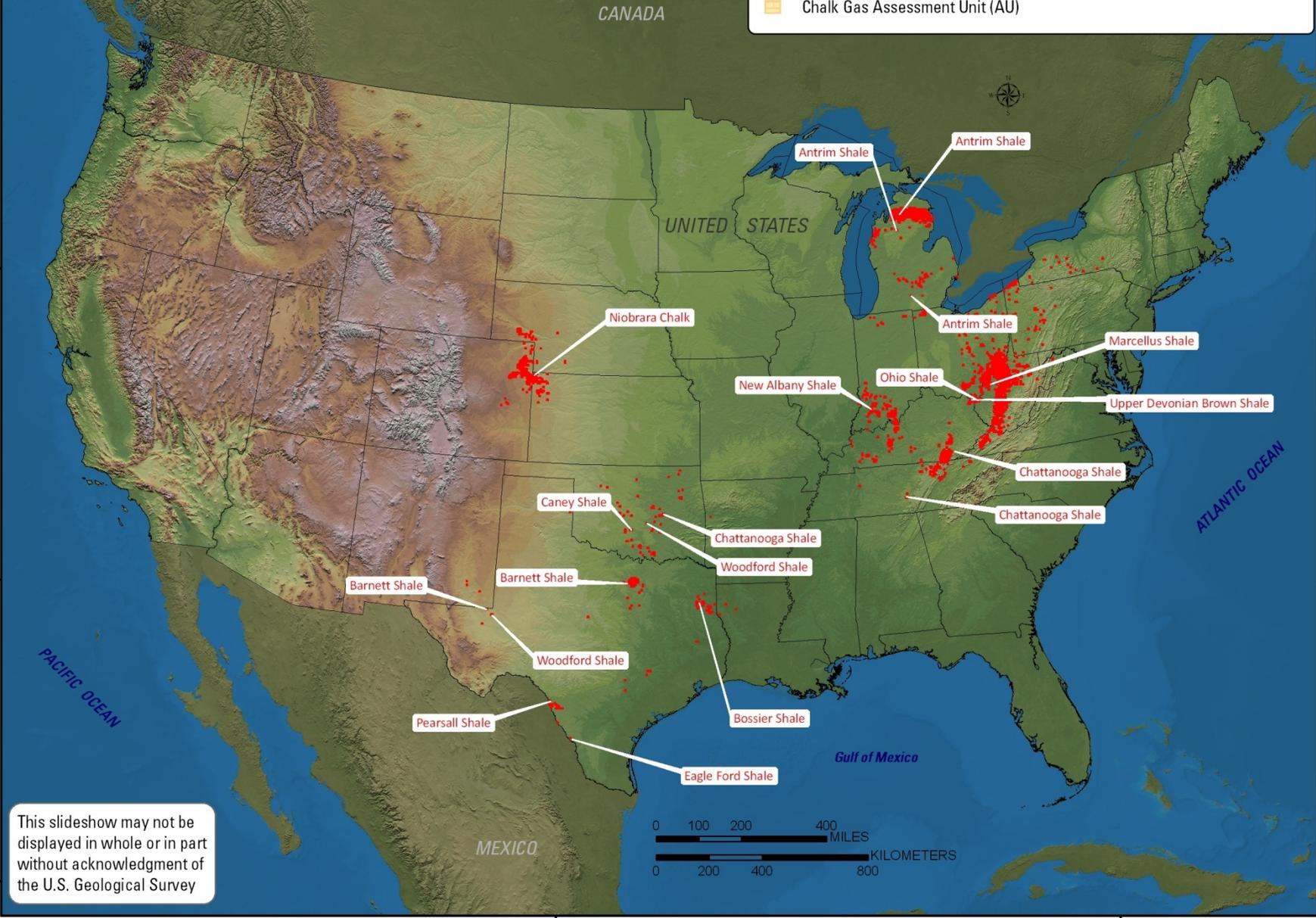


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2000

Explanation

- Square-mile cells represent shale gas-producing wells (size exaggerated)
- Shale Gas Assessment Unit (AU)
- Chalk Gas Assessment Unit (AU)



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2010

Explanation

- Square-mile cells represent shale gas-producing wells (size exaggerated)
- Shale Gas Assessment Unit (AU)
- Chalk Gas Assessment Unit (AU)



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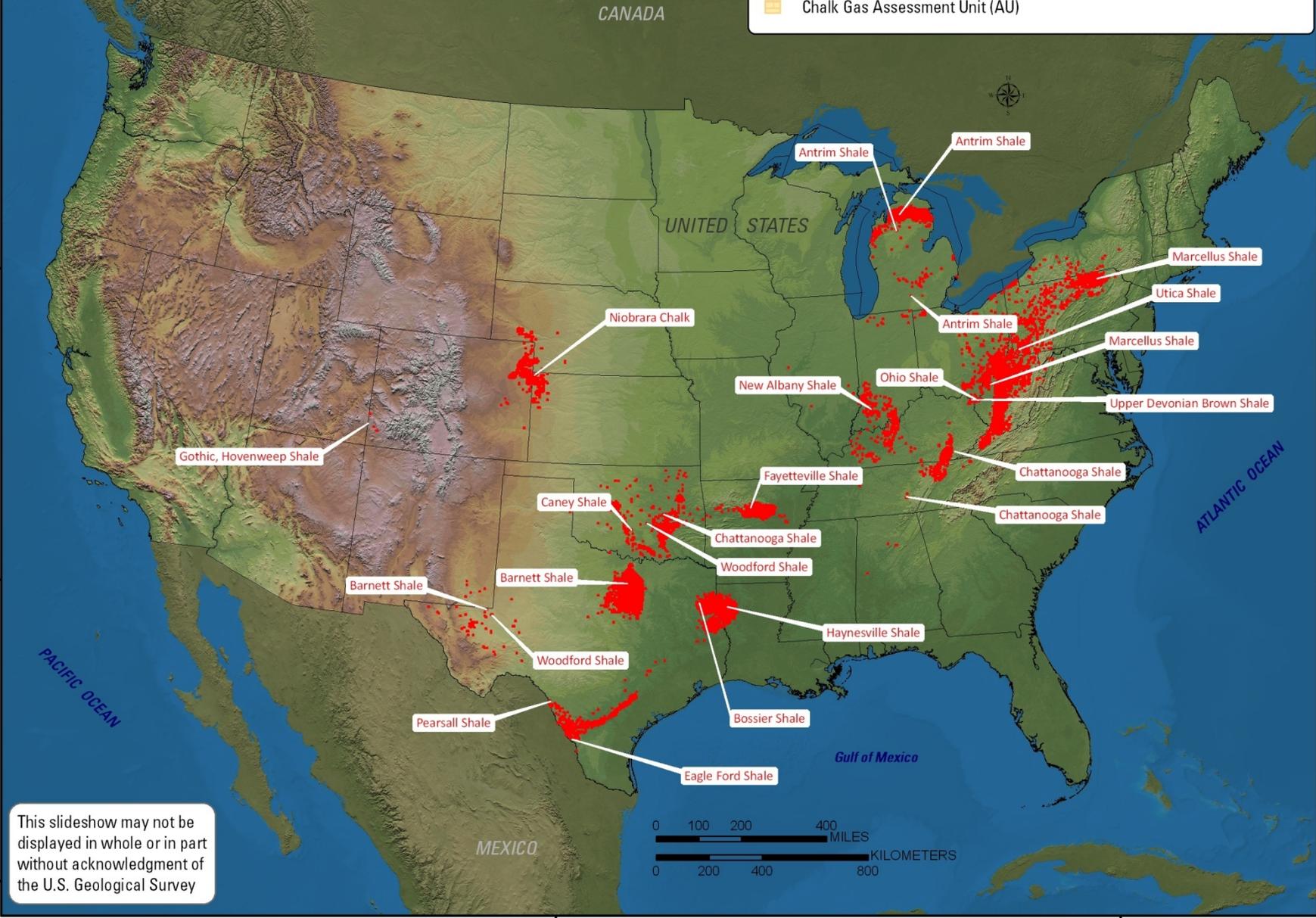


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2012

Explanation

- Square-mile cells represent shale gas-producing wells (size exaggerated)
- Shale Gas Assessment Unit (AU)
- Chalk Gas Assessment Unit (AU)



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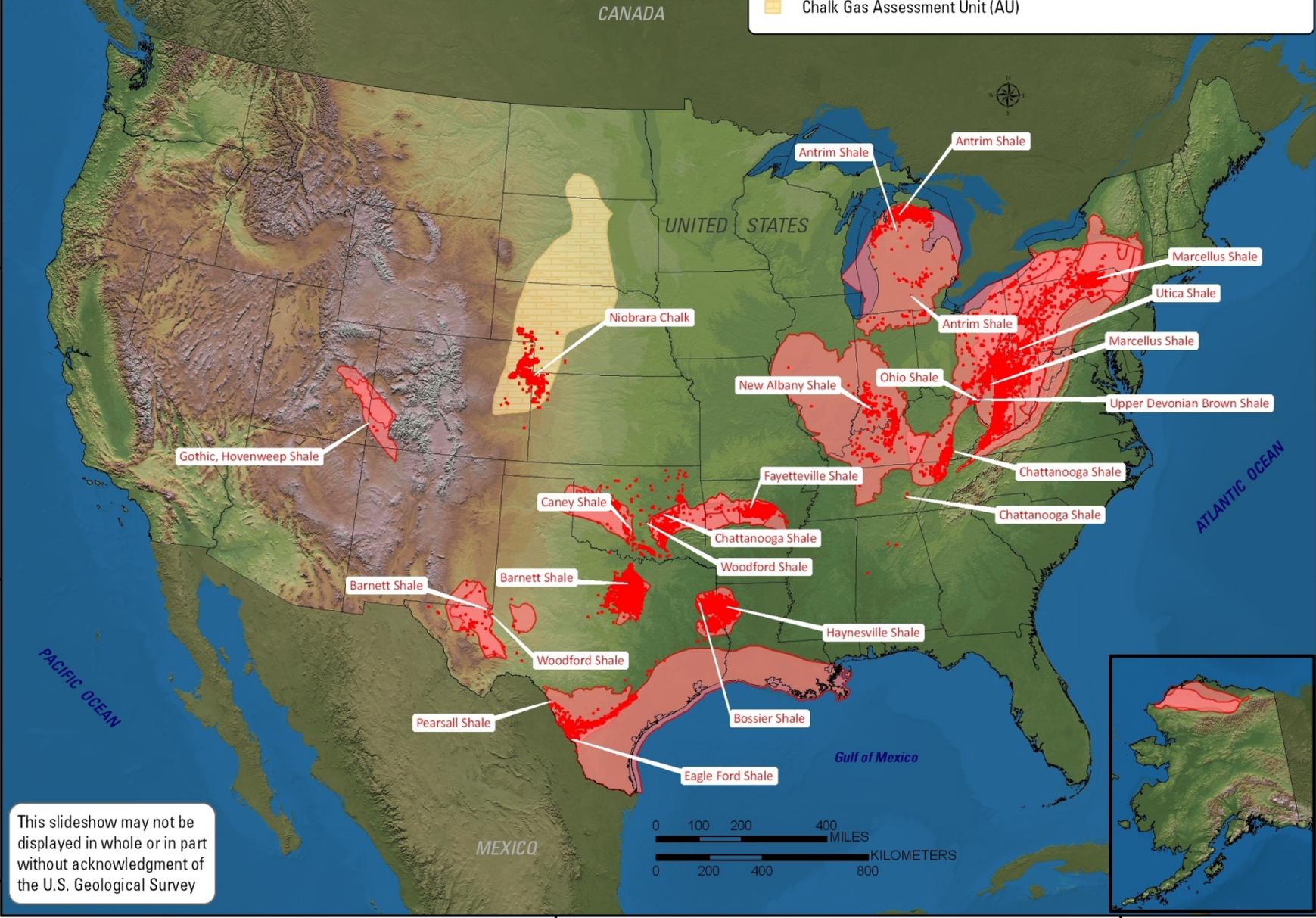


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2012

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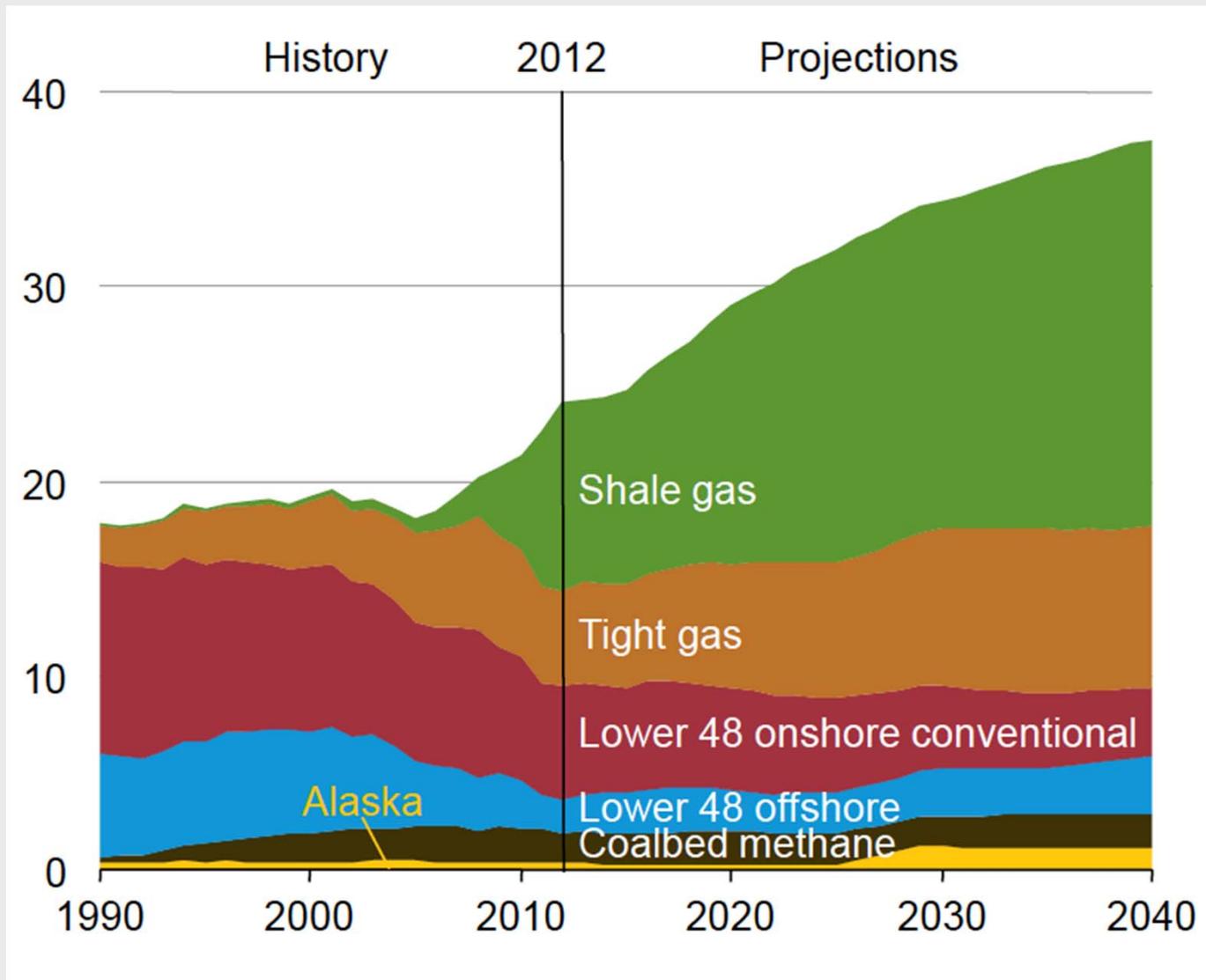
- Square-mile cells represent shale gas-producing wells (size exaggerated)
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- Chalk Gas Assessment Unit (AU)



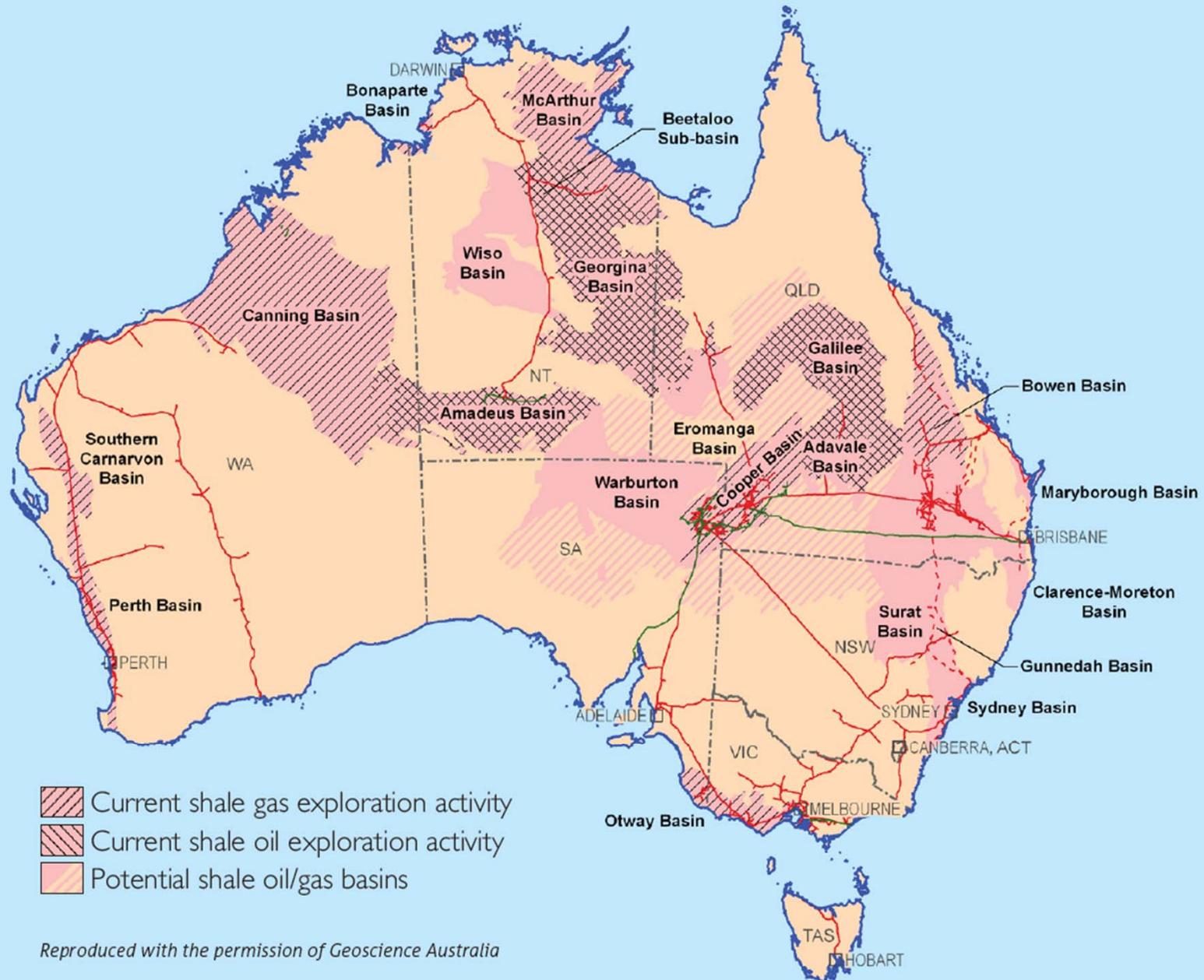
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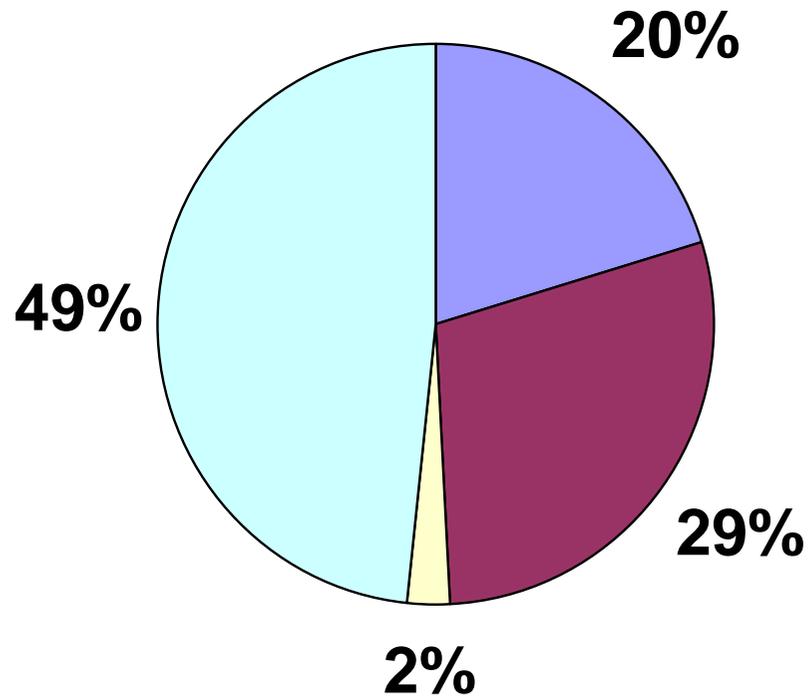
U.S. Natural Gas Production



AUSTRALIAN BASINS WITH SHALE GAS POTENTIAL



Total Australia gas resources



**Unconventional gas -
80% of total gas
resources in Australia**

■ Conventional ■ CSG ■ Tight Gas ■ Shale Gas

Resources – identified, potential and undiscovered.
Source: Geoscience Australia, 2012

Hydraulic stimulation: aka hydraulic fracturing ("*Fracking*")

- Technology for development of unconventional resources
- Has created notoriety, scrutiny, and a new regulatory environment for oil and gas industry
- What are potential environmental and social issues associated with the process
- What are the impacts to oil and gas exploration and production

Why Hydraulic Fracturing?

- In order to produce oil or gas from tight rocks (rocks with a very low permeability), it is necessary to increase the permeability to enable oil or gas to flow to the well bore.
- Open fractures in the reservoir rock increase the reservoir surface area that is connected to the wellbore and increase the flow of oil or gas to the well can.

Hydraulic-fracturing

- a general term, for which there are numerous trade or service names, for the fracturing of rock in an oil or gas reservoir by pumping in water (or other fluid) and sand (or other granular material) under high pressure.
- The purpose is to produce artificial openings in the rock in order to increase permeability.
- The added pressure opens cracks and bedding planes, and a proppant is introduced into these cracks to keep them open when the pressure is reduced.

Proppant

- Sand-sized particles mixed with fracturing fluid to hold fractures open after a hydraulic fracturing treatment.
- naturally occurring sand grains,
- man-made or specially engineered proppants,
 - resin-coated sand
 - high-strength ceramic materials (eg sintered bauxite,

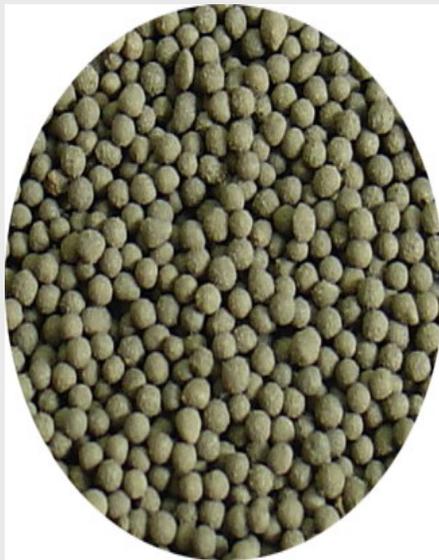
Types of Proppants



Frac Sand



Resin Coated Sand

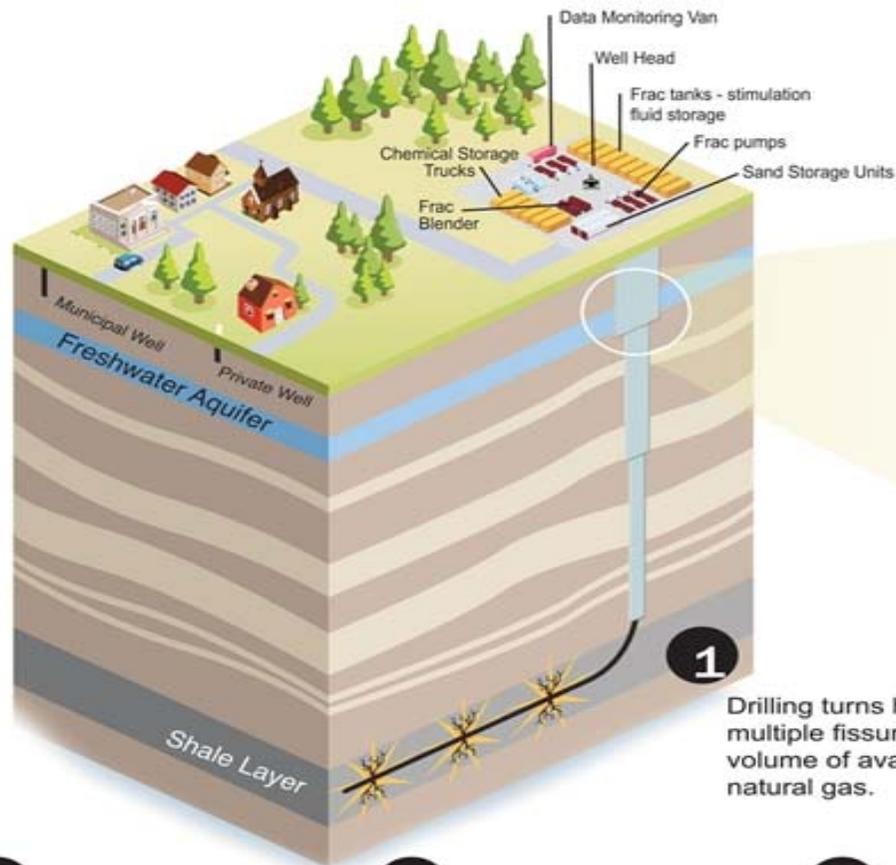


Ceramic Proppant



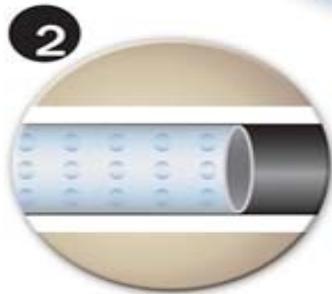
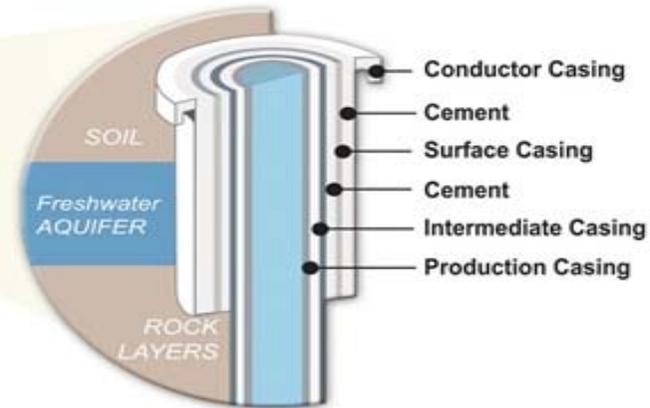
Sintered Bauxite

Images courtesy Ray Johnson

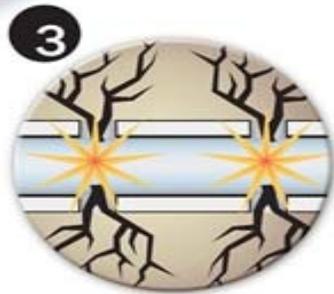


1 Drilling turns horizontal, hitting multiple fissures and increasing volume of available oil and natural gas.

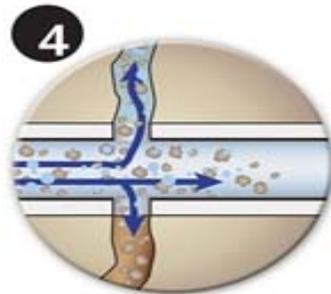
Cement casing protects aquifer.



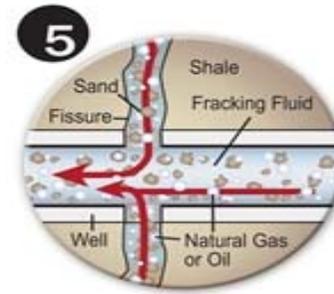
2 Production casing inserted into borehole, then surrounded with cement.



3 Casing is perforated blasting small holes through pipe, cement, and shale.



4 After drilling, the well is hydraulically fractured. A mixture of water, sand, and chemicals (fracking fluid) is pumped into the well at high pressure.



5 The fluid generates numerous small fissures in the shale, freeing trapped oil and gas that flow back up the pipeline to the wellhead. The sand keeps the fissures open to increase the flow of oil and natural gas.

Illustration Not to Scale.
Tip of the Mitt Watershed Council, 2013.
www.watershedcouncil.org

Fracking: a big job, requiring big equipment (and lots of it)

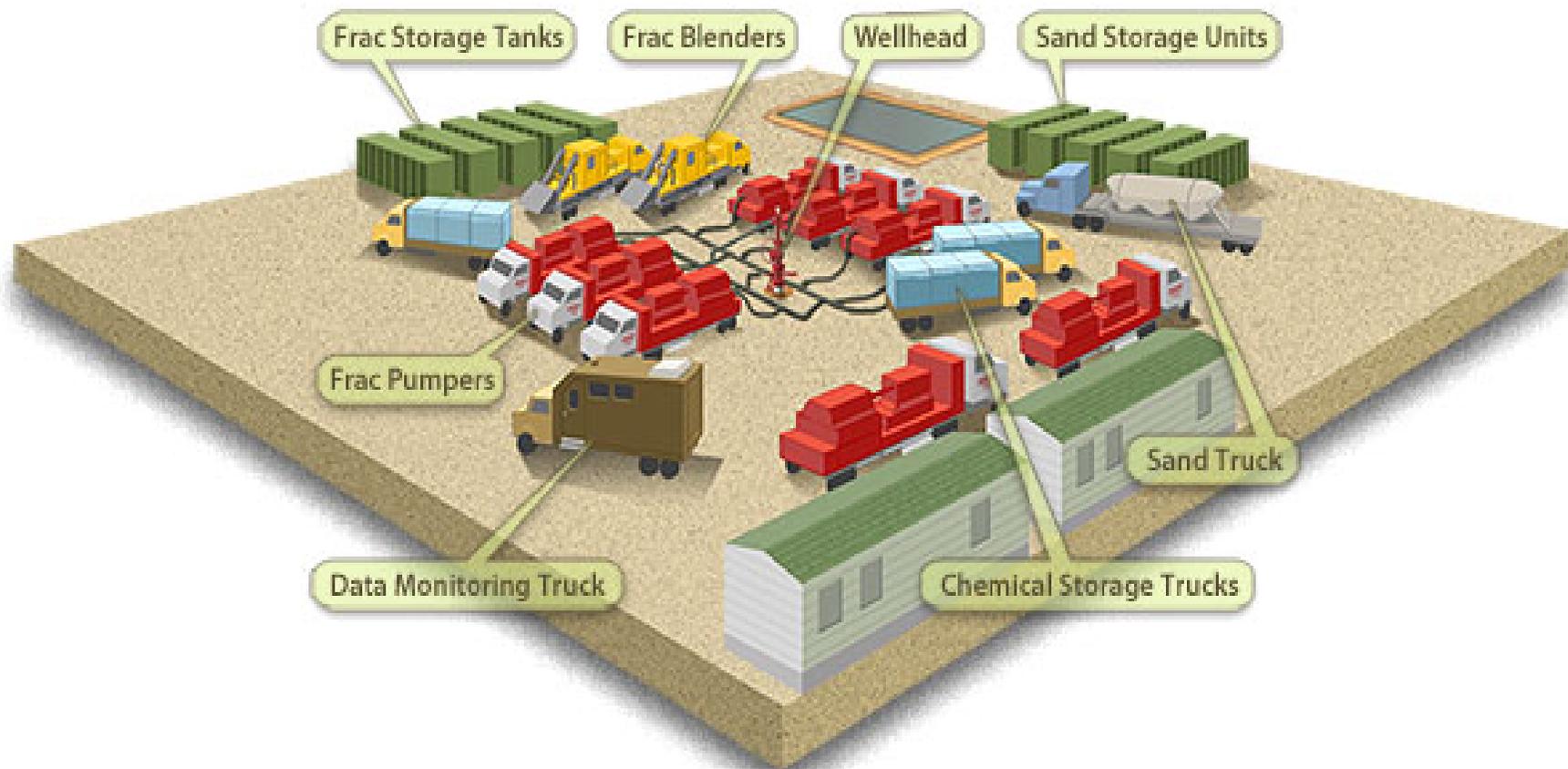
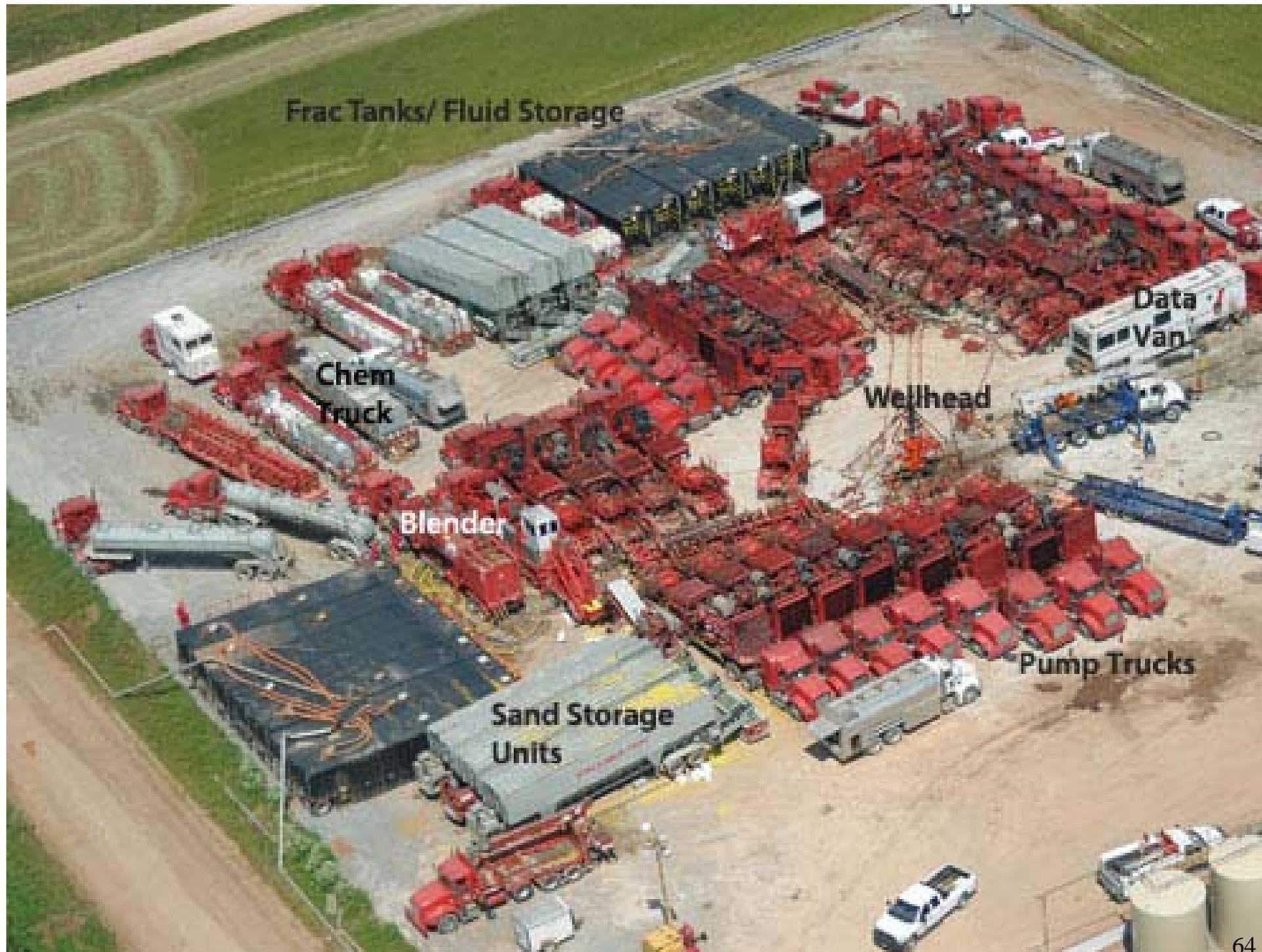


Figure courtesy Ray Johnson



Frac Tanks/ Fluid Storage

Chem Truck

Blender

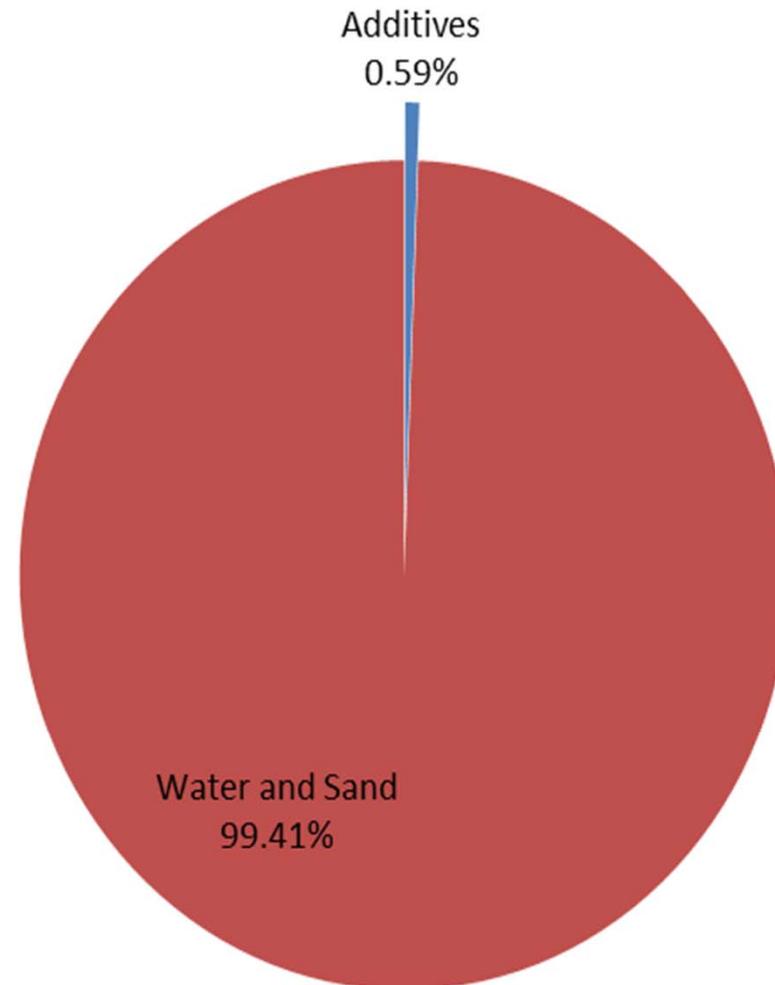
Sand Storage Units

Wellhead

Data Van

Pump Trucks

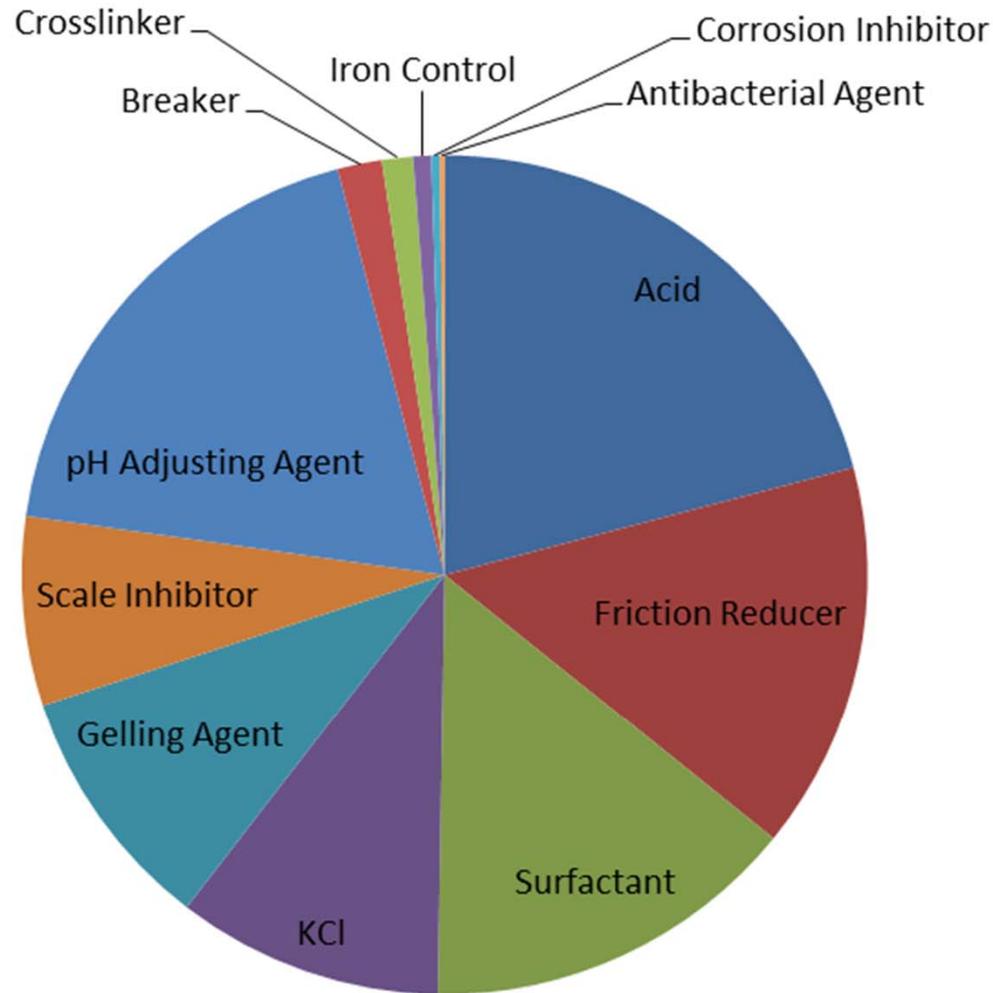
Composition of Frac fluids



Typical Fracturing Fluids

Figure courtesy Ray Johnson

Typical Composition of Frac fluid additives

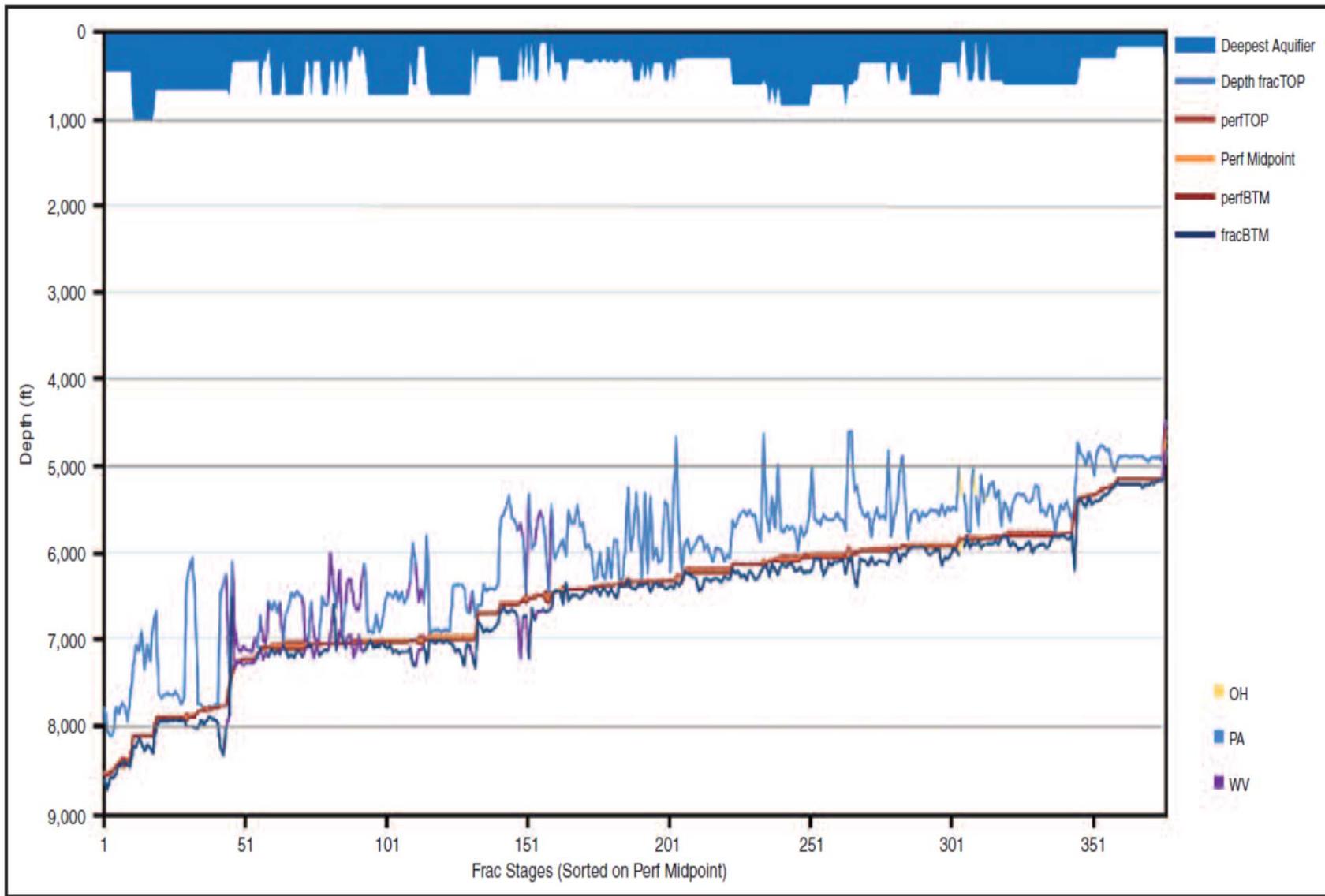


Typical Fracturing Additives, about 0.6%

Figure courtesy Ray Johnson

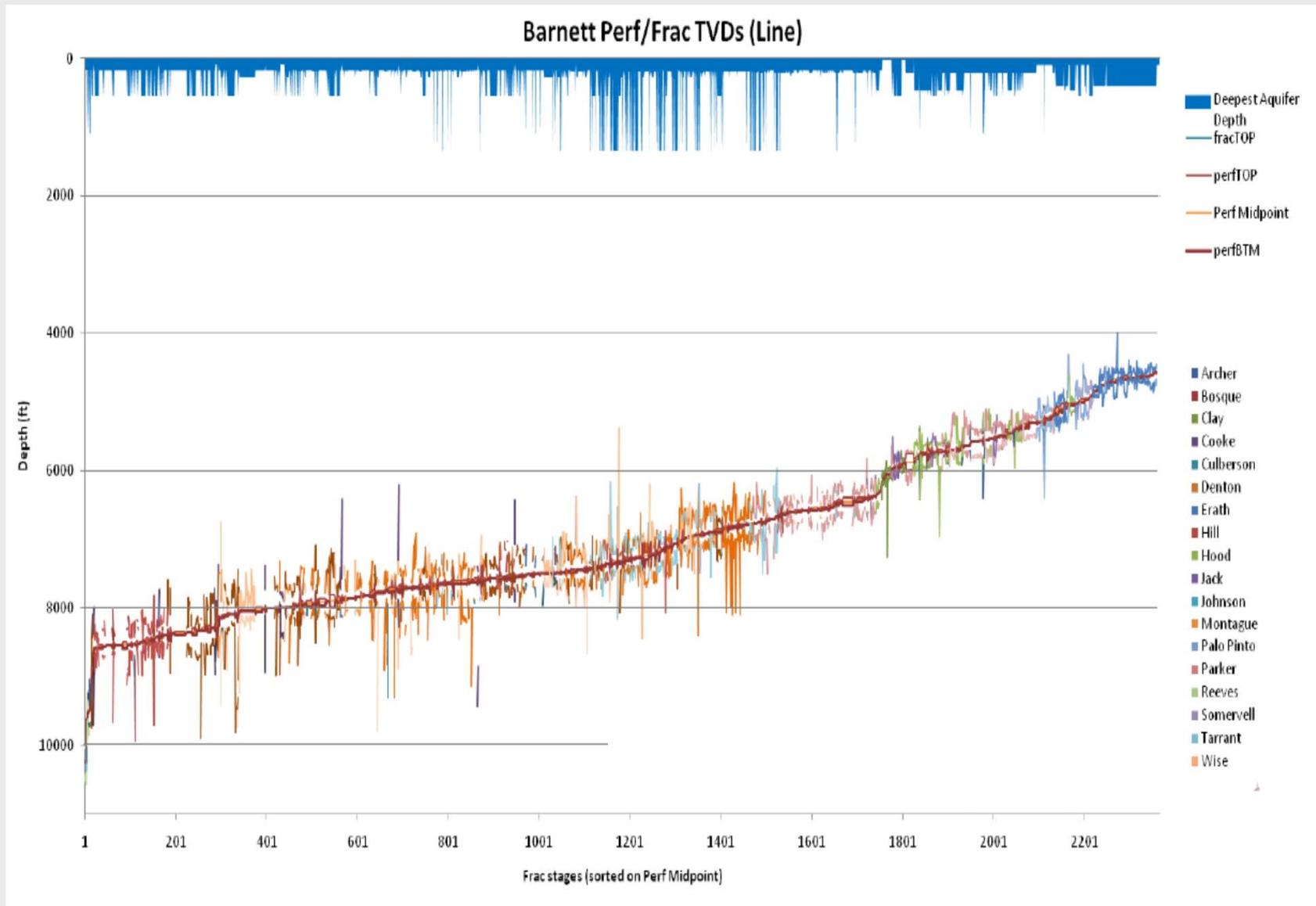
Do frac affect potable aquifers?

Marcellus Shale Mapped Fracture Treatments (TVD)

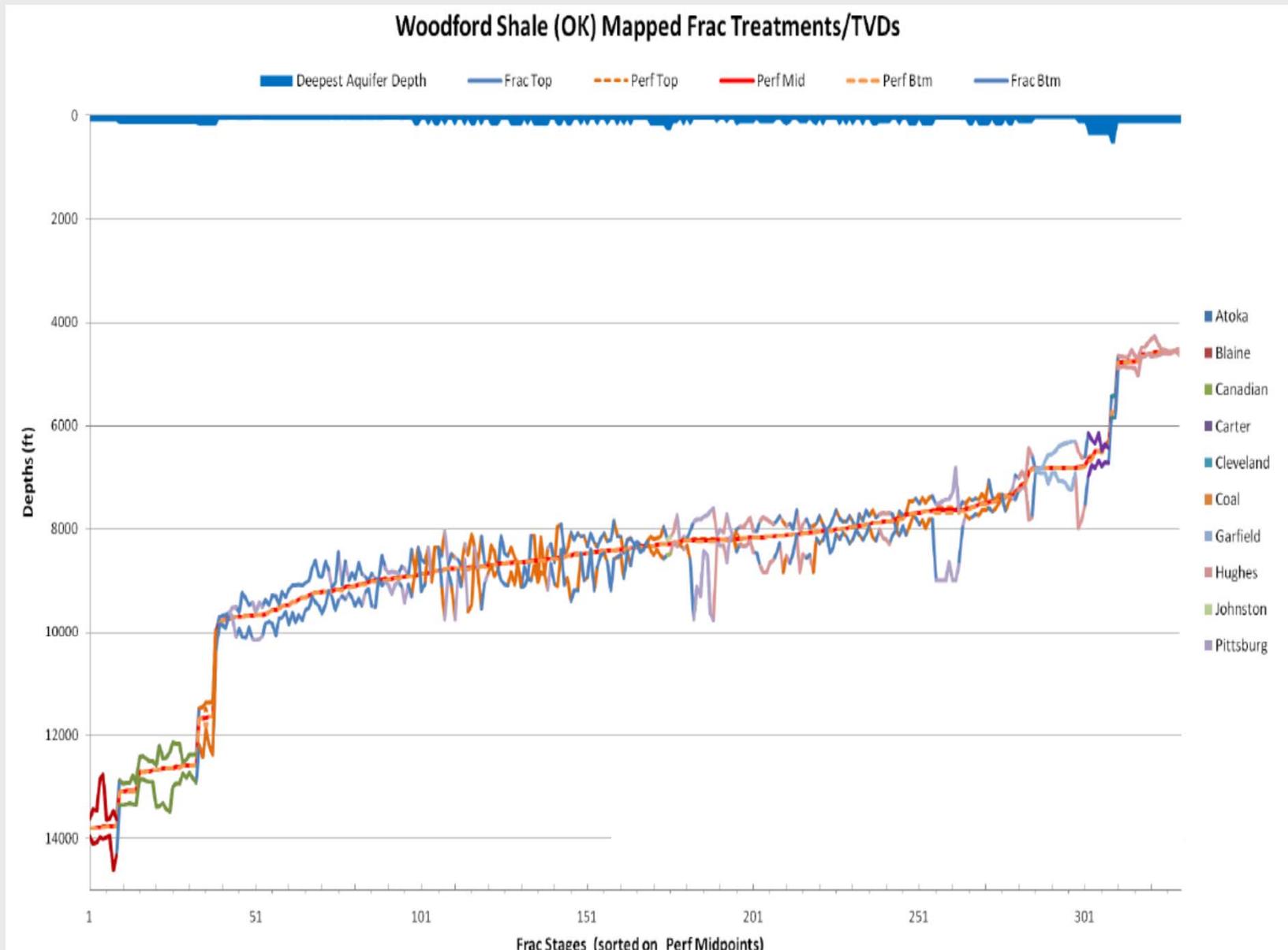


Source: www2.epa.gov/hfstudy/measurements-and-observations-fracture-height-growth

Do fracs affect potable aquifers?



Do frac affect potable aquifers?



Source: www2.epa.gov/hfstudy/measurements-and-observations-fracture-height-growth

Hydraulic Fracturing (“Fracking”)

- Used for decades in NYS
- Formations are thousands of feet below surface and groundwater
- Does not occur until after the ground water zones are sealed and drilling completed
- All oil and gas states surveyed – not one instance of drinking water contamination in over one million frac jobs



Hydraulic Fracking Video

- <http://www.youtube.com/watch?v=VY34PQUiwOQ>

Who is Looking at Unconventionals in SA?

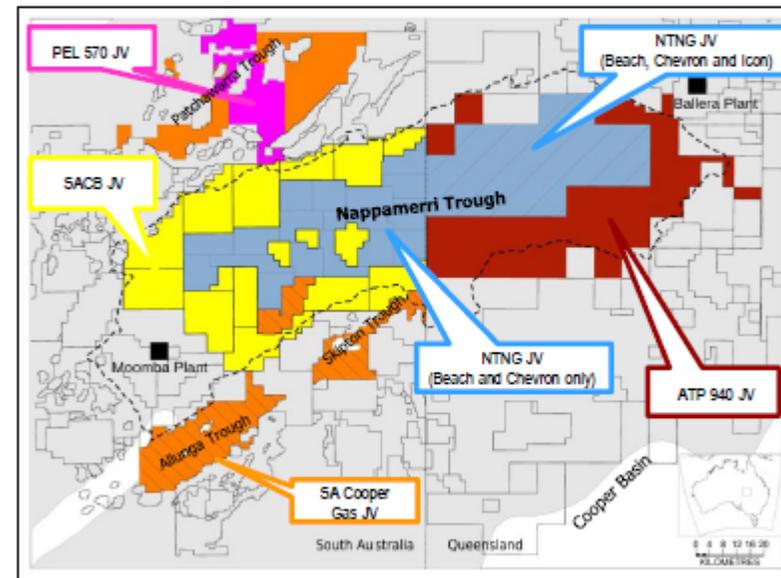
Several major joint ventures are currently assessing the unconventional resource potential of the Nappamerri Trough and surrounding acreage

Cooper Basin Unconventional Participants

SACBJV (Santos – Operator, Beach and Origin)	<ul style="list-style-type: none"> Most experienced operator in the Cooper Basin with long standing unconventional assessment program
NTNG Joint Venture (Beach – Operator, Chevron and Icon Energy ¹)	<ul style="list-style-type: none"> 18 wells drilled to date within the Nappamerri Trough
Central Unconventional Fairway ATP 940P Joint Venture (Drillsearch Limited – Operator and BG Group)	<ul style="list-style-type: none"> First obtained large regional high spec 3D survey and have now commenced an initial four well drilling program
SA Cooper Gas Joint Venture (Senex Energy – Operator and Origin)	<ul style="list-style-type: none"> Newly formed JV (February 2014) primarily focused in and around the Patchawarra and Allunga Troughs
PEL 570 Joint Venture (New Standard Energy – Operator, Ambassador Oil and Gas)	<ul style="list-style-type: none"> 3D seismic planned for 2014 with drilling commencing in 2015 Drillsearch announced intention to acquire Ambassador (key asset PEL 570) and has since responded to a counter offer by NYSE-listed Magnum Hunter Resources
Other Smaller Acreage Positions (e.g. Strike Energy)	<ul style="list-style-type: none"> Generally lower activity targeting niche areas and plays

¹ Icon Energy only a participant in the Queensland portion of the NTNG JV acreage

Major Unconventional Focus Areas



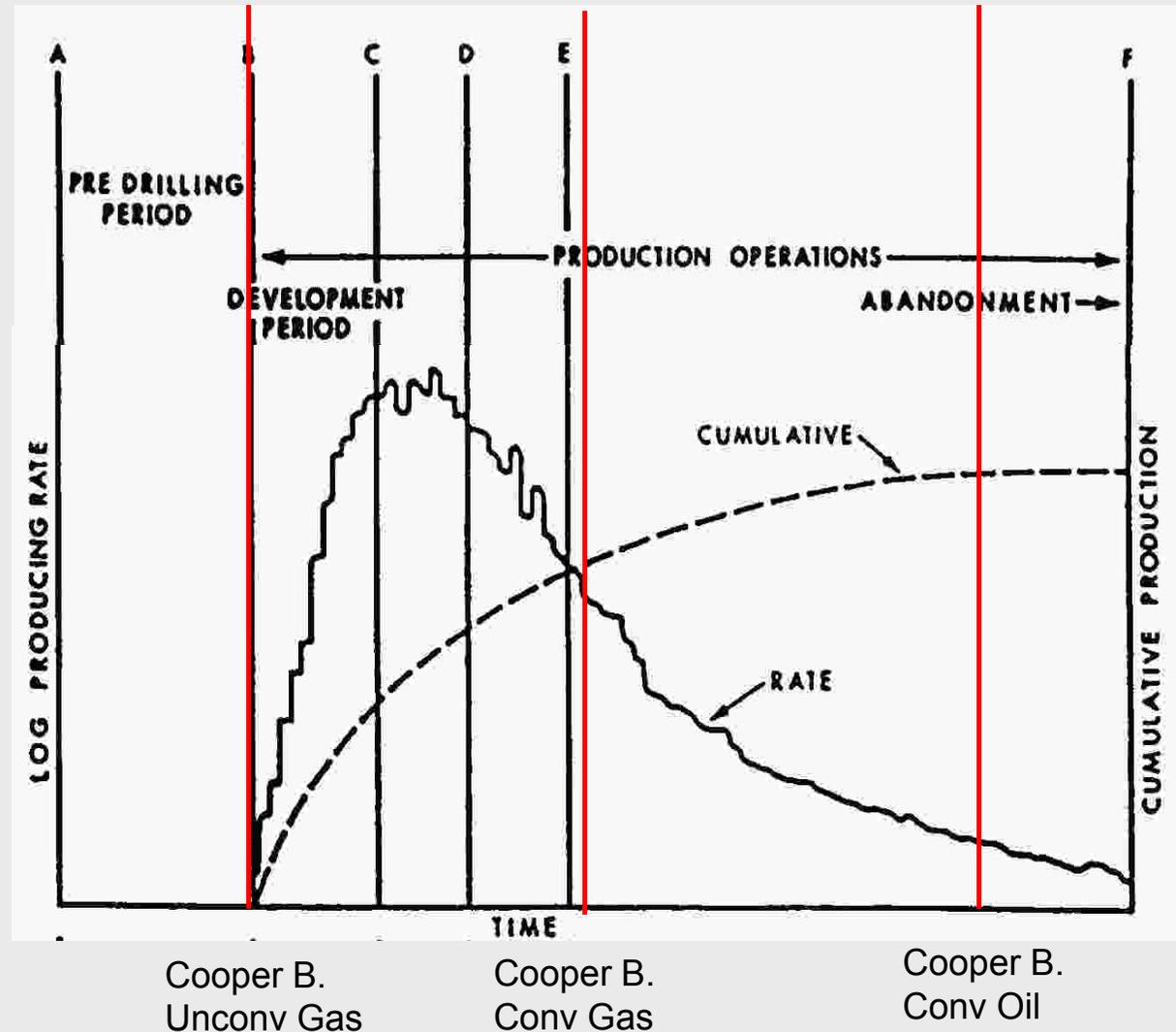
The E & P Process

Typical Field / Basin Production Profile

Rate increases rapidly as development wells are drilled and come on stream (B-C).

Rate then plateaus for some time (months to years) (C-D).

Rate then declines gradually until production is uneconomic, and field is abandoned (D-F).



Stakeholders: all of us in this room

Need to be

- engaged in the identification of issues
- Willing to share data / learnings
- Participate in joint industry learning programs / R&D efforts



Not another lecture series



To a generally confused & frustrated audience



But genuine technical engagement and partnerships

Stakeholders: all of us in this room

