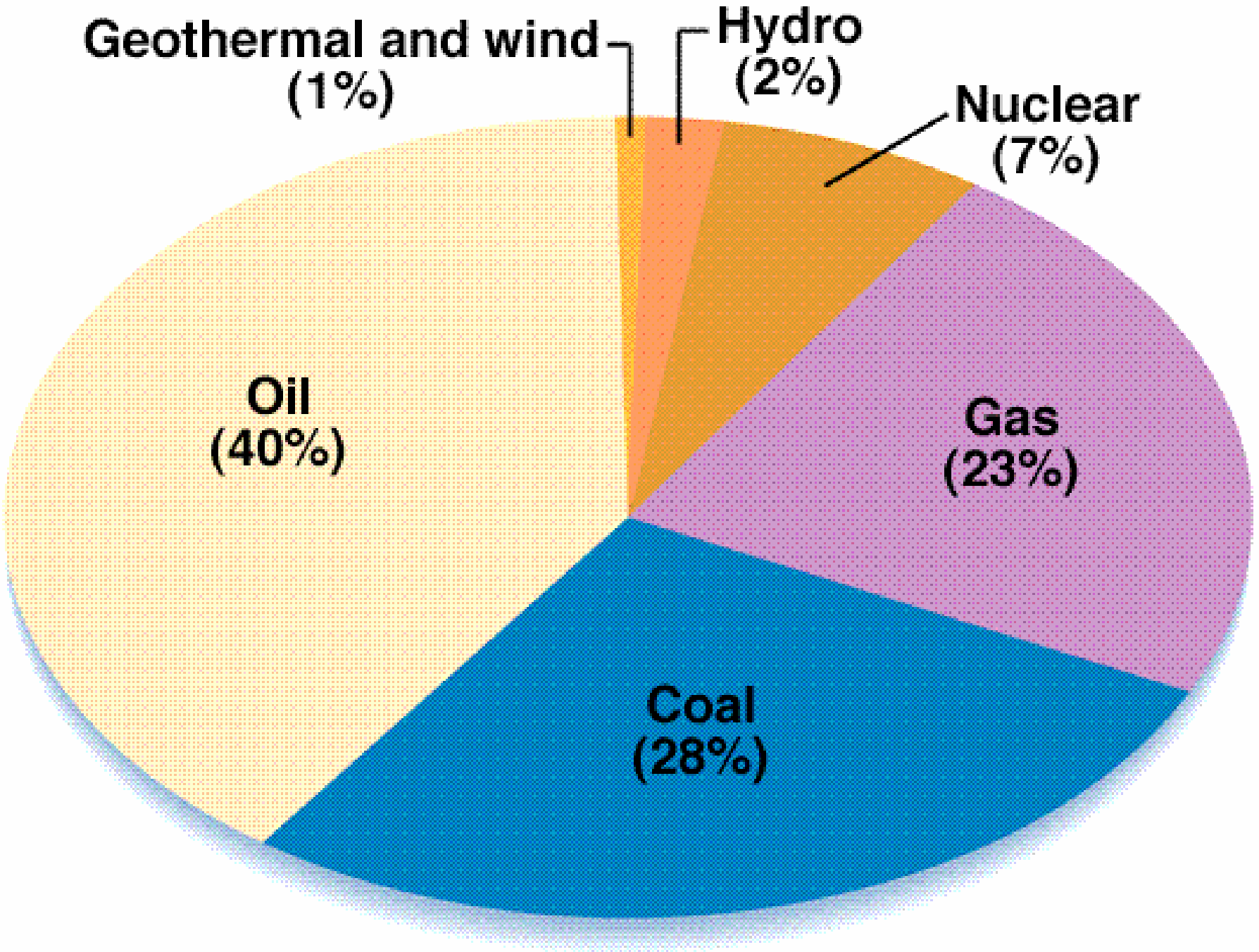
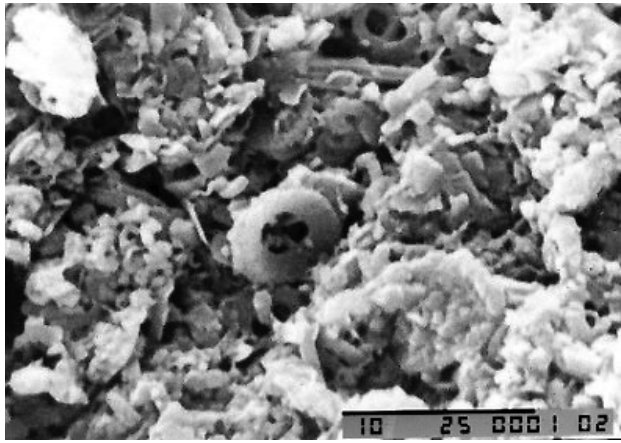
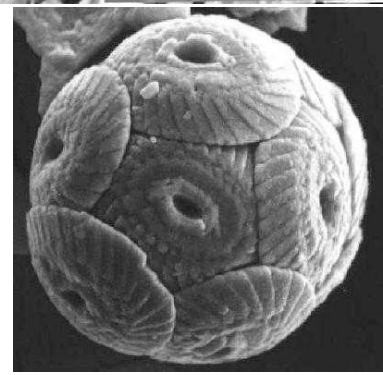
Oil and Gas Basics

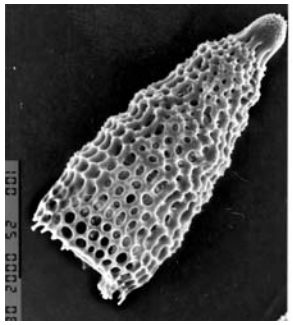
Worldwide commercial energy production.



Today's oil is yesterday's plankton





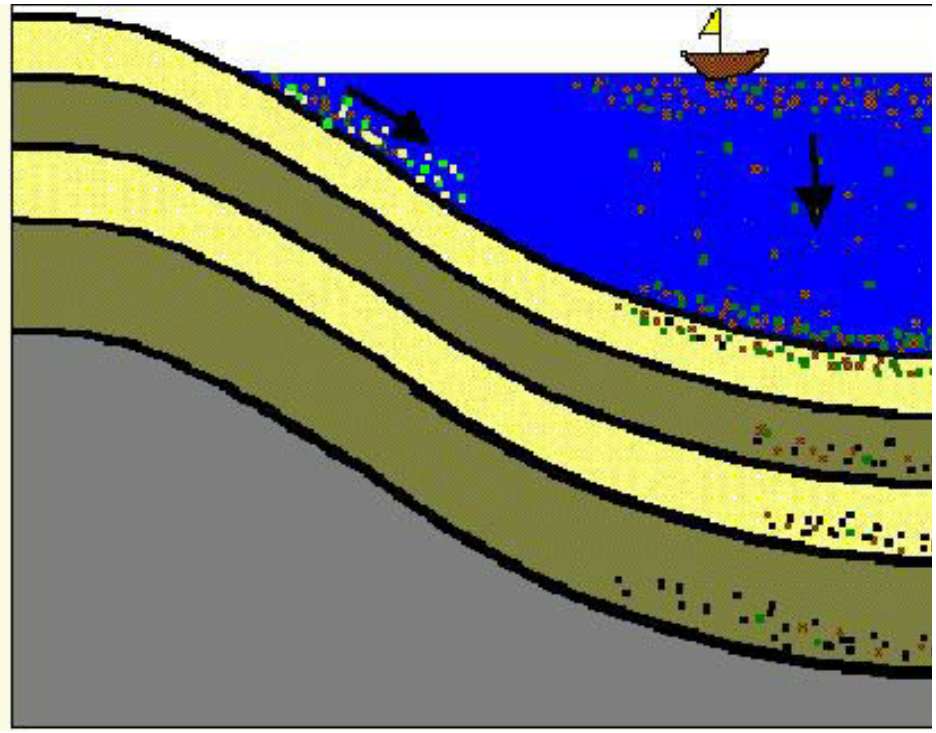


- Small marine and lake organisms live in surface waters
- They die, fall to the bottom and get buried into an organic rich sedimentary layer
- If geologic processes heat and squeeze these rocks sufficiently, they will create crude oil and natural gas (hydrocarbons) from the fossils
- Crude oil and natural gas will migrate toward the surface
- Geologic traps must exist to create an oil field

Origin of Hydrocarbons

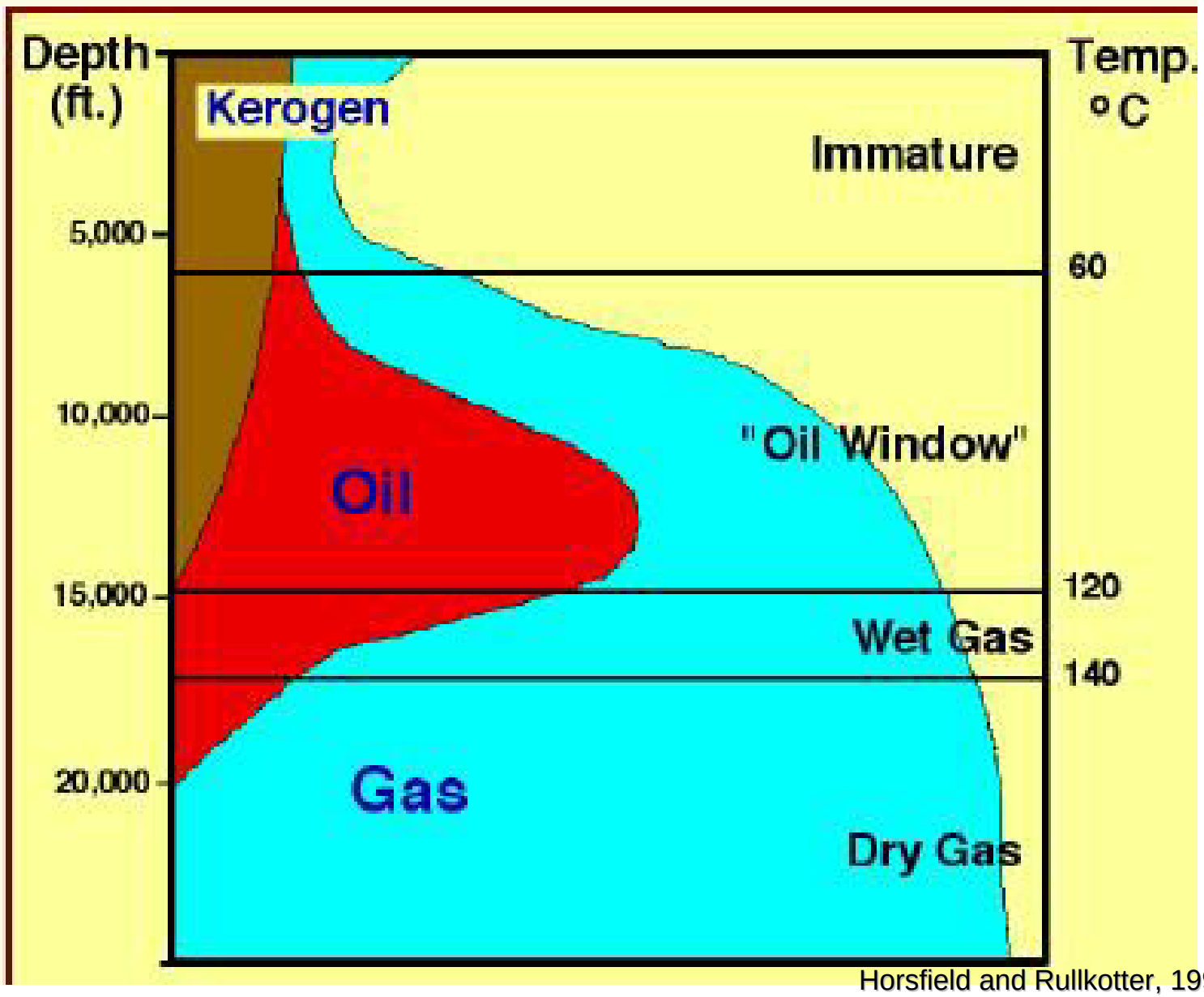
- Accumulation of organic matter (kerogen) and sediments to form a “source rock”
- Generation - Burial of source rock to temperature and pressure regime sufficient to convert organic matter (kerogen) into hydrocarbons
- Migration - Movement of hydrocarbons out of the source rock into a trap
- Accumulation - Hydrocarbons migrate into a trap faster than the trap leaks, forming a reservoir
- Preservation - Hydrocarbons remain in the reservoir and are not destroyed by biodegradation or overheating
- The next slides will present these steps

Accumulation and burial of organic matter



Hydrocarbon Generation

Burial to Greater and Hotter Depths



Horsfield and Rullkotter, 1994

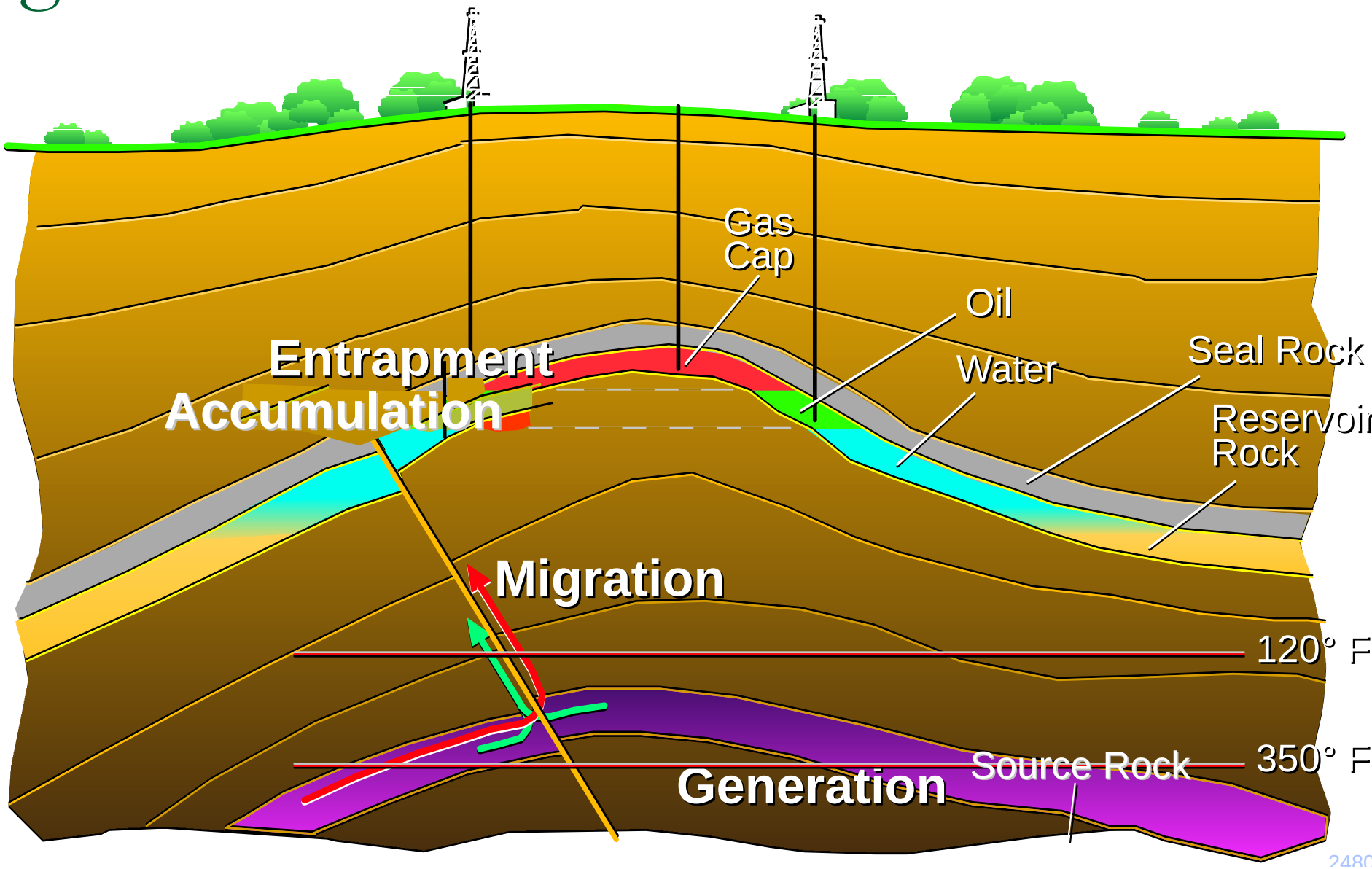
Generation and Maturation

- There is an increase in temperature with depth in the Earth's crust. As organic matter is buried it is heated and progressively transformed into kerogen, oil and gas.
- The most oil is produced between the temperatures of 60 and 120 C, a temperature range known as the "oil window".
- The place where oil and gas are cooked out of the rocks is called "kitchen"

Migration

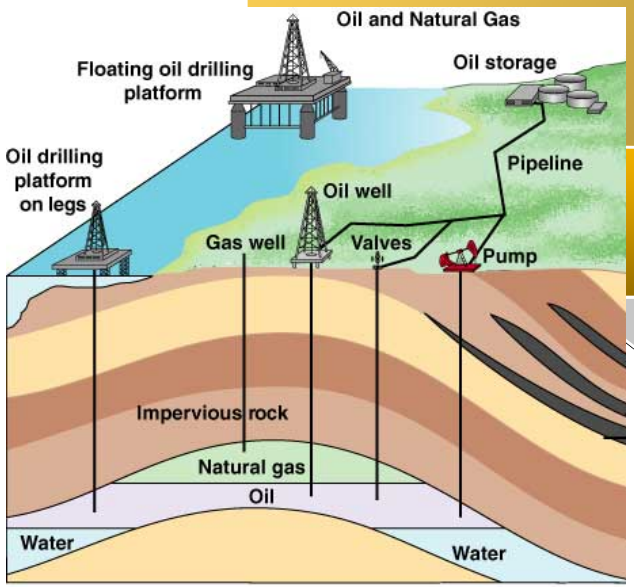
- After hydrocarbon has formed it must migrate out of the source rock and into a reservoir where it can be stored.
- Some hydrocarbons form close to the reservoir but in most cases they migrate many kilometers before coming to rest in the reservoir.
- Petroleum migrates as a mixture of oil, gas and water. In the reservoir these phases separate according to density with the most dense, water on the bottom, least dense gas on top and oil between the two.

Migration


Gas
Cap
Oil
Water
Seal Rock
Reservoir
Rock
Entrapment
Accumulation
Migration
120° F
350° F
Source Rock
Generation

Migration Anticlinal Theory

Petroleum Accumulates in Structural Closure

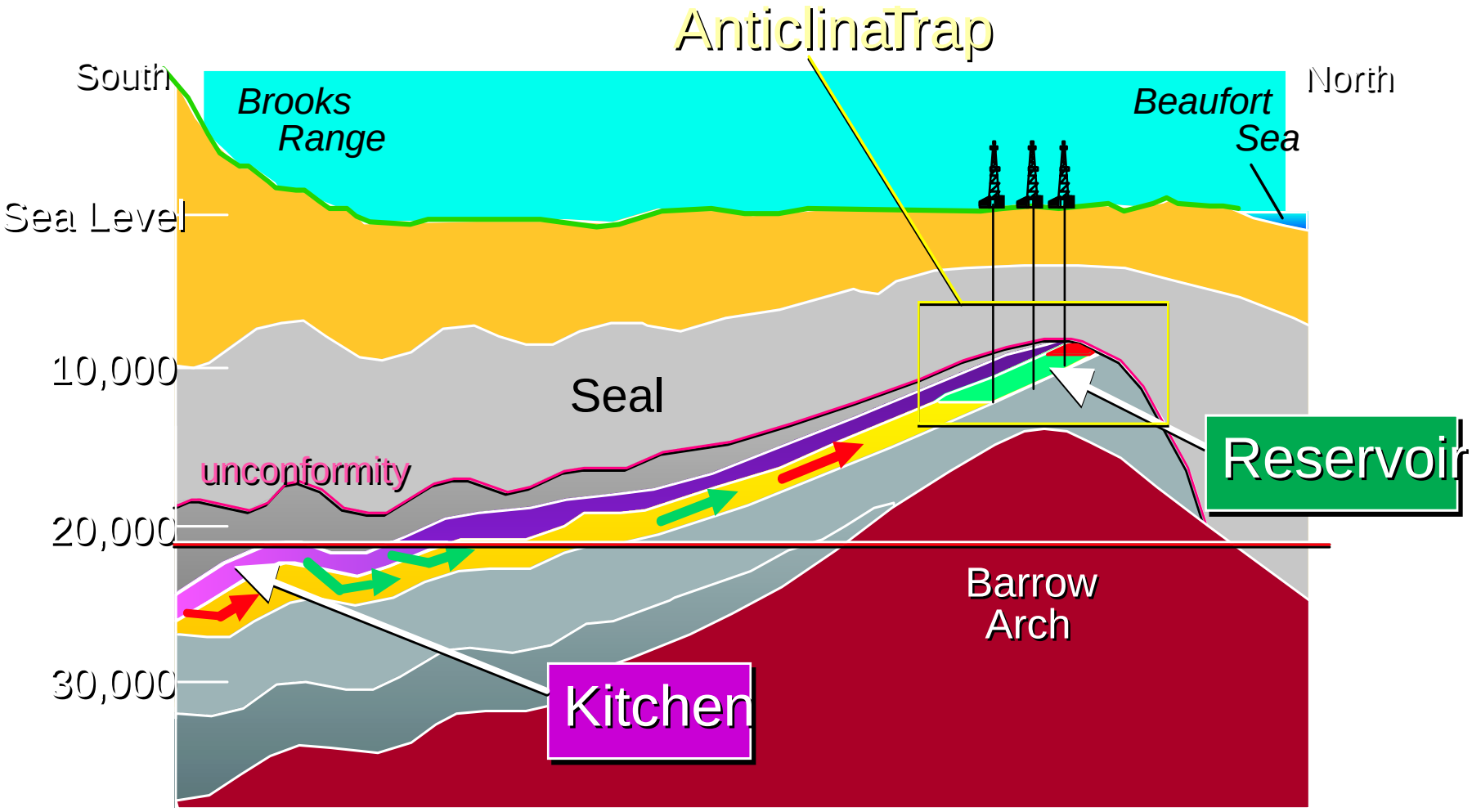


Gas

Oil

Water

Prudhoe Bay Oil Field, Alaska



- Largest North American field
- More than 8 billion barrels recoverable

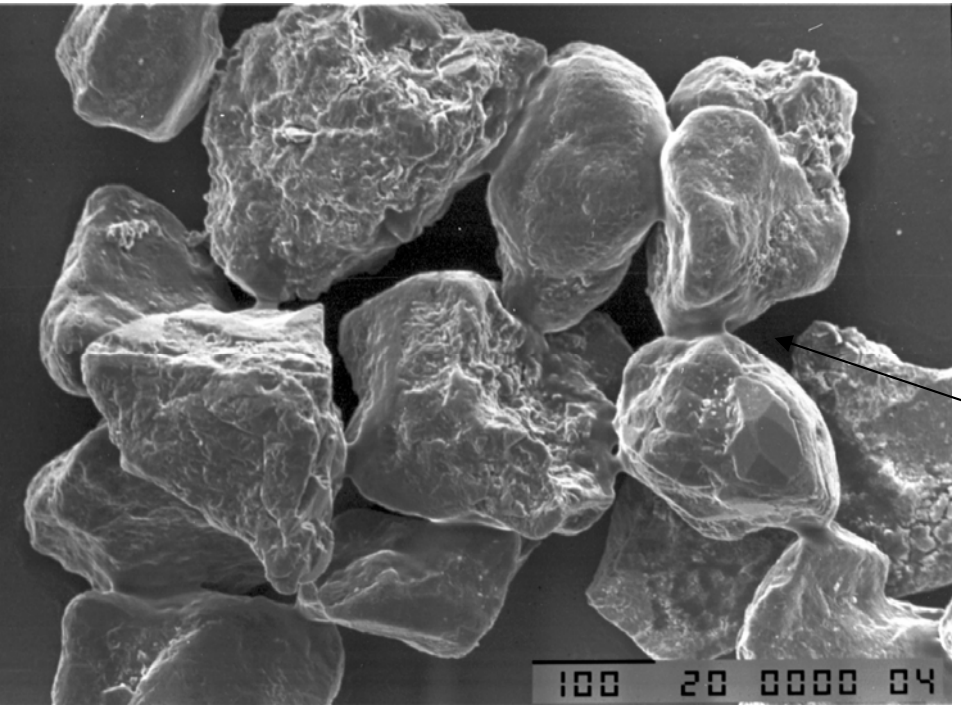
Requirements for a Reservoir Rock

Reservoir Rock - A rock in which oil and gas accumulates, it must have:

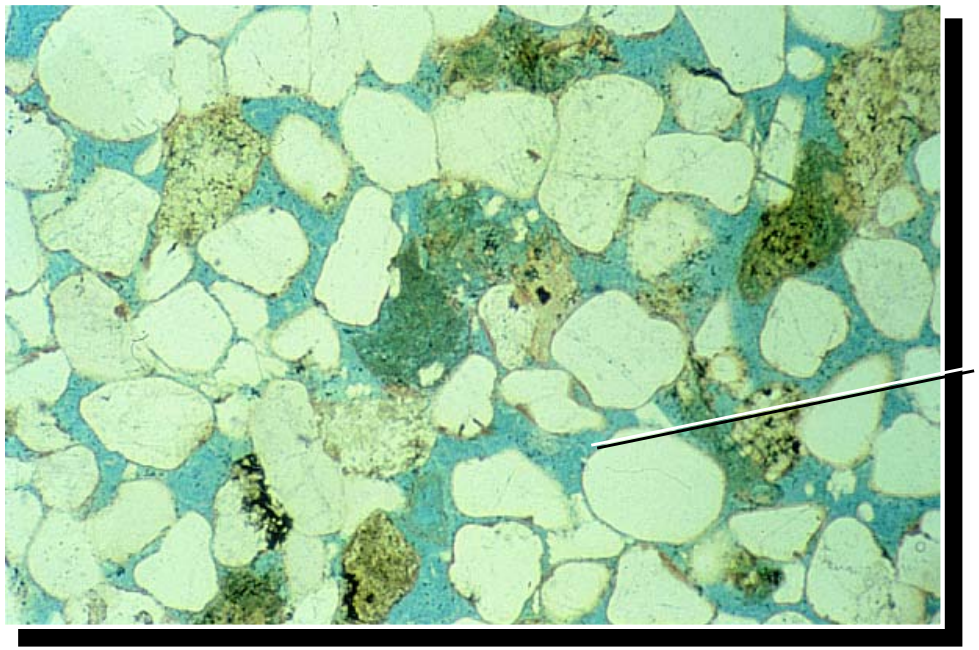
- Porosity - space between rock grains in which oil accumulates.
- Permeability - passage-ways between pores through which oil and gas moves.

Reservoir Sandstone

Porosity is the amount of void spaces in a rock



Pores



Pores (blue)

Permeability is how easy fluids move through a rock

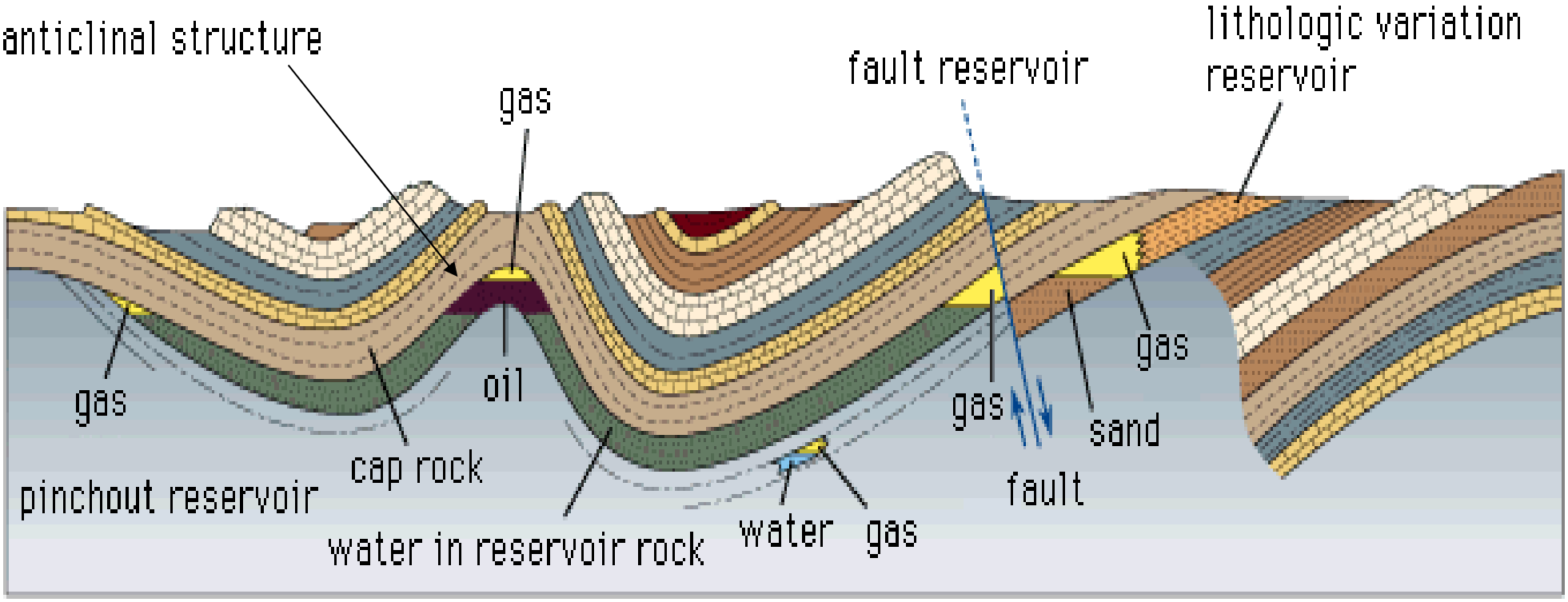
Requirements for Traps

Traps are porous rocks covered by impermeable rocks, that isolates the fluid from the surface.

Main types of traps are:

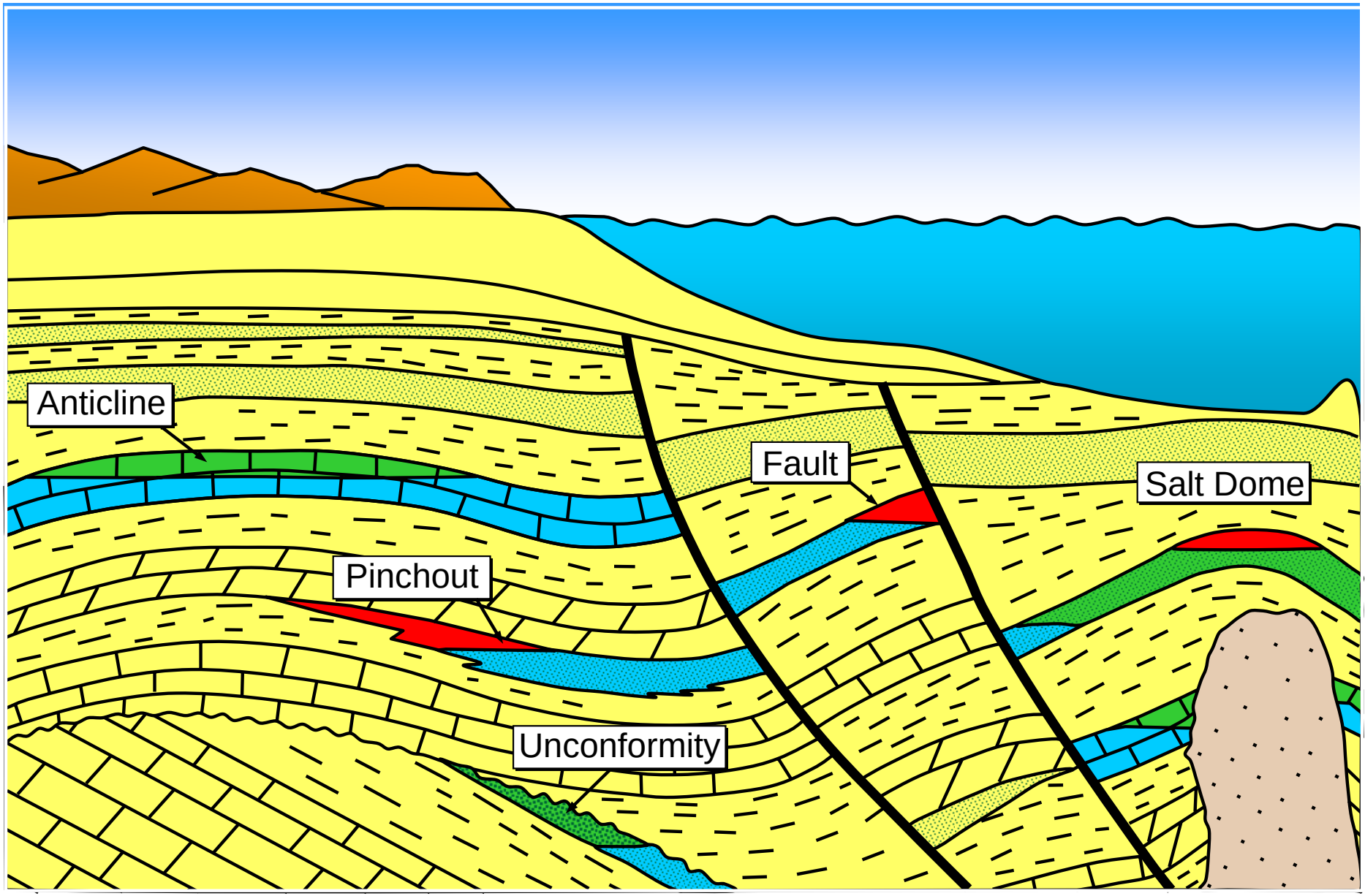
- Anticlinal - Rock layers folded into a dome
- Stratigraphic - Rock layers changing from a good reservoir to non-reservoir due to change in rock type.
- Fault - Offset of rocks such that oil and gas accumulates in reservoir rock

Trap types

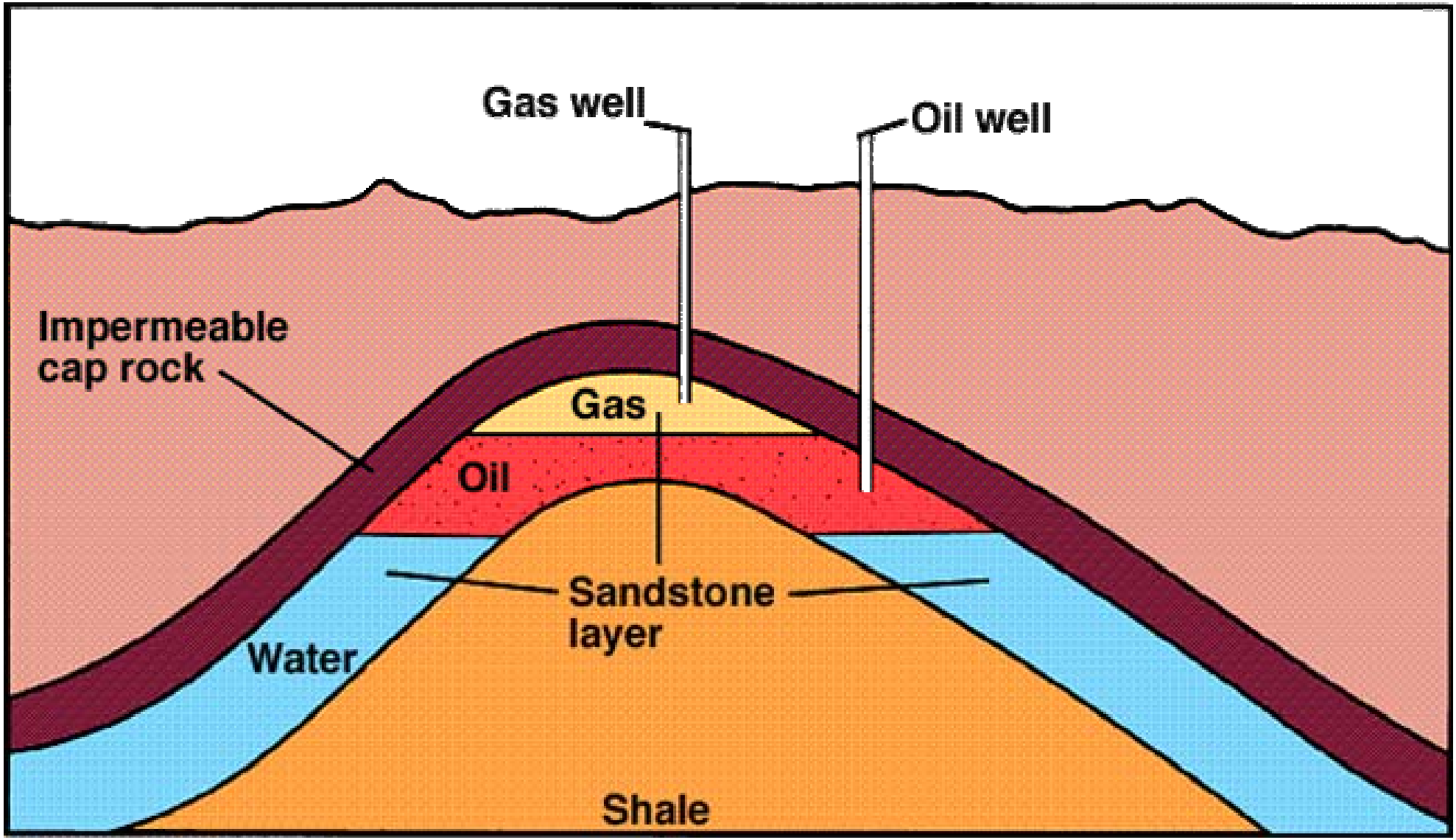


The pinchout and lithologic variation reservoirs are examples of stratigraphic traps

Hydrocarbon Trap Types



Production : to produce hydrocarbons, we have to find and drill into the reservoir

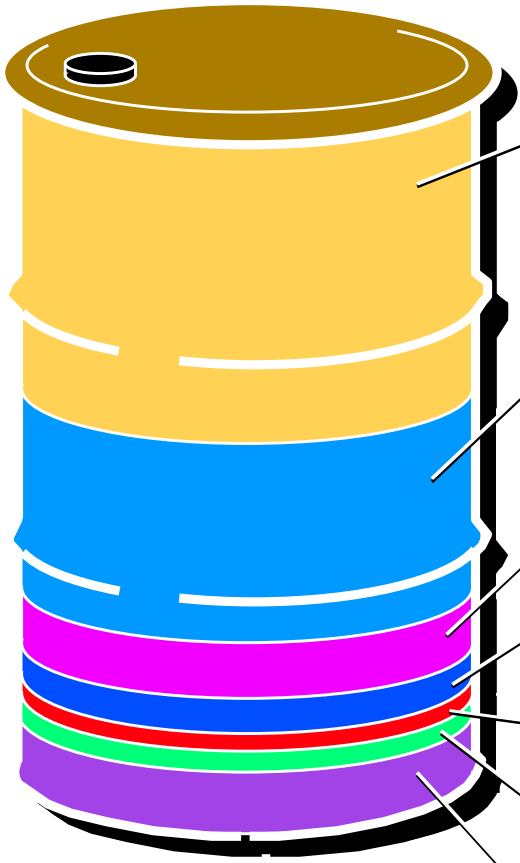


Enger /Smith. Environmental Science. 6th ed.
@1998 McGraw-Hill

Petroleum Products

A Barrel of Crude Oil (Light Texas Crude) Provides:

One Barrel = 42 gallons



Gasoline - 19.5 gallons

Fuel Oil - 9.2 gallons

Jet Fuel - 4.1 gallons

Asphalt - 2.3 gallons

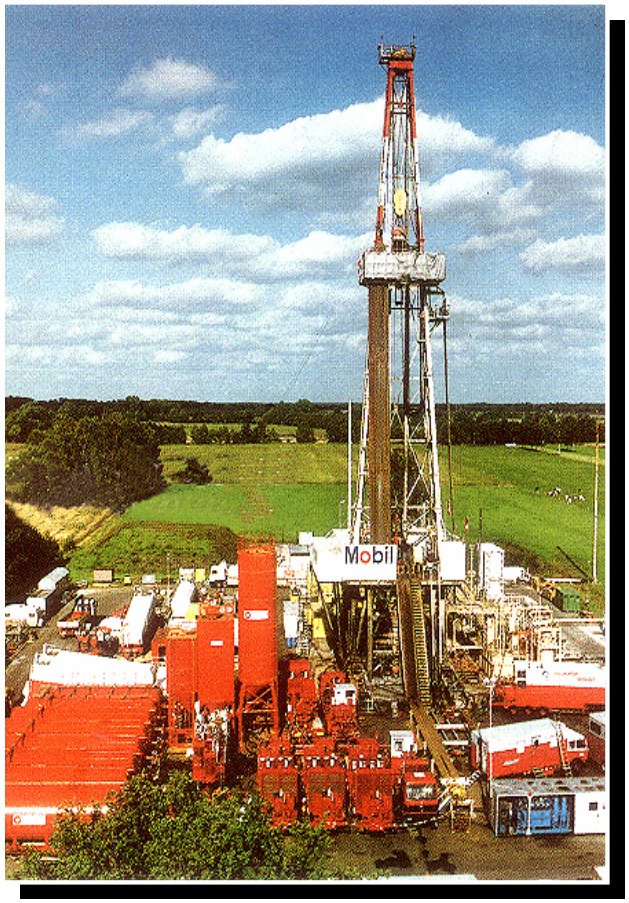
Kerosene - 0.2 gallons

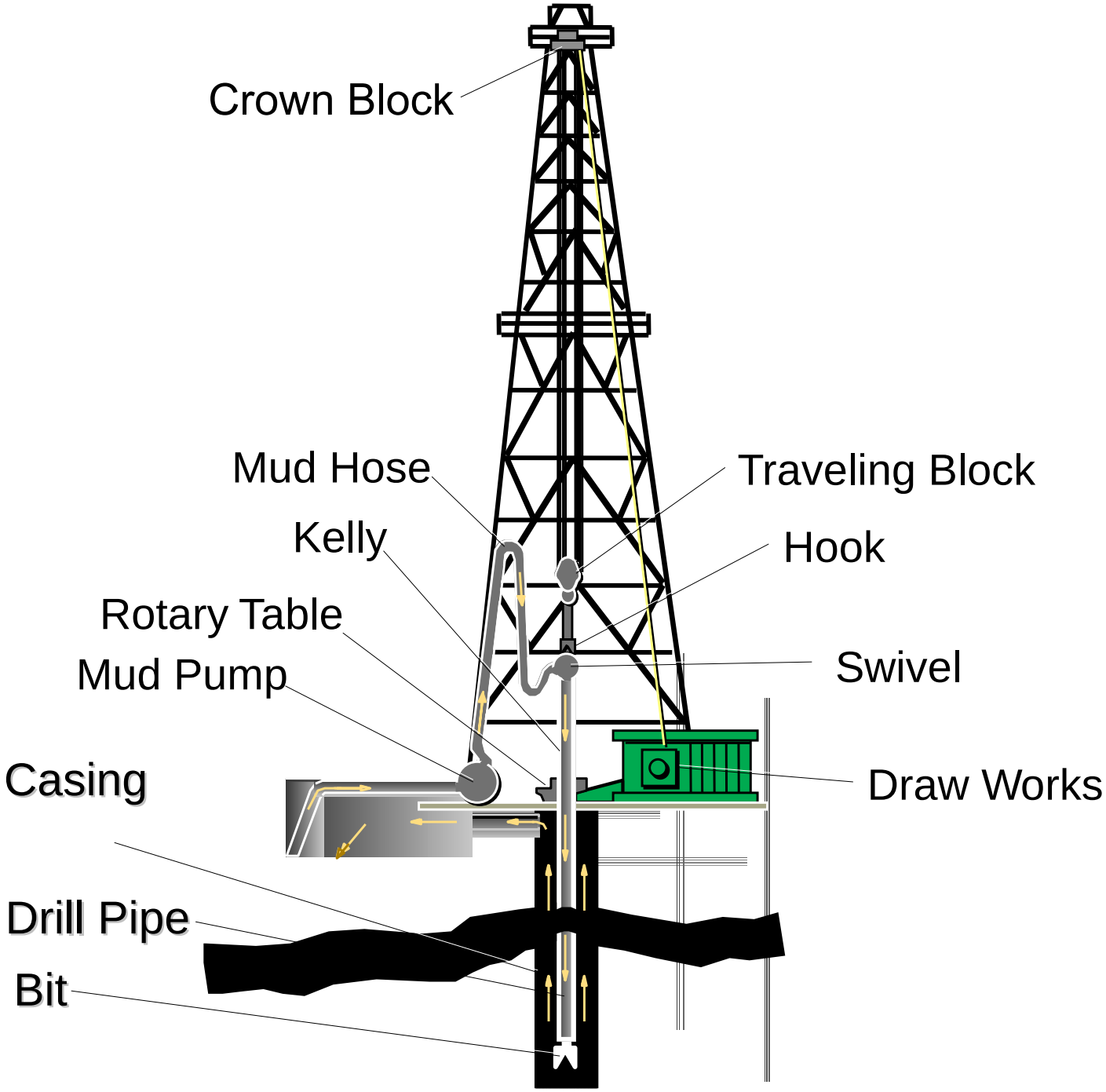
Lubricants - 0.5 gallons

Petrochemicals, other products - 6.2 gallons

American Petroleum Institute, 1999

Drilling Rig





American Petroleum Institute, 1999

Drilling

Rock Bit

Cuttings

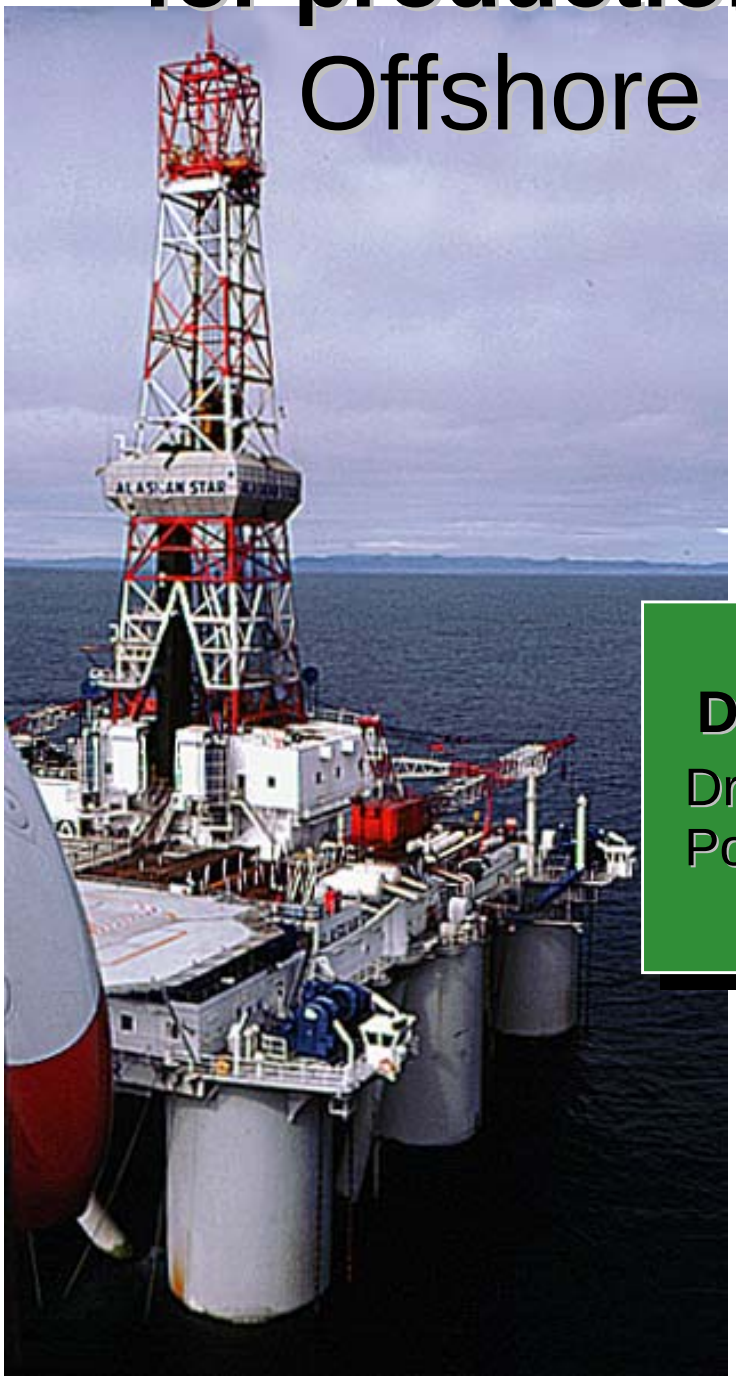
Core (Diamond) Bit

Core

American Petroleum Institute, 1999

Production: Two different environments for production rigs

Offshore



Offshore
Daily Rig Cost

Drillships:Dynamically Positioned: $148,672

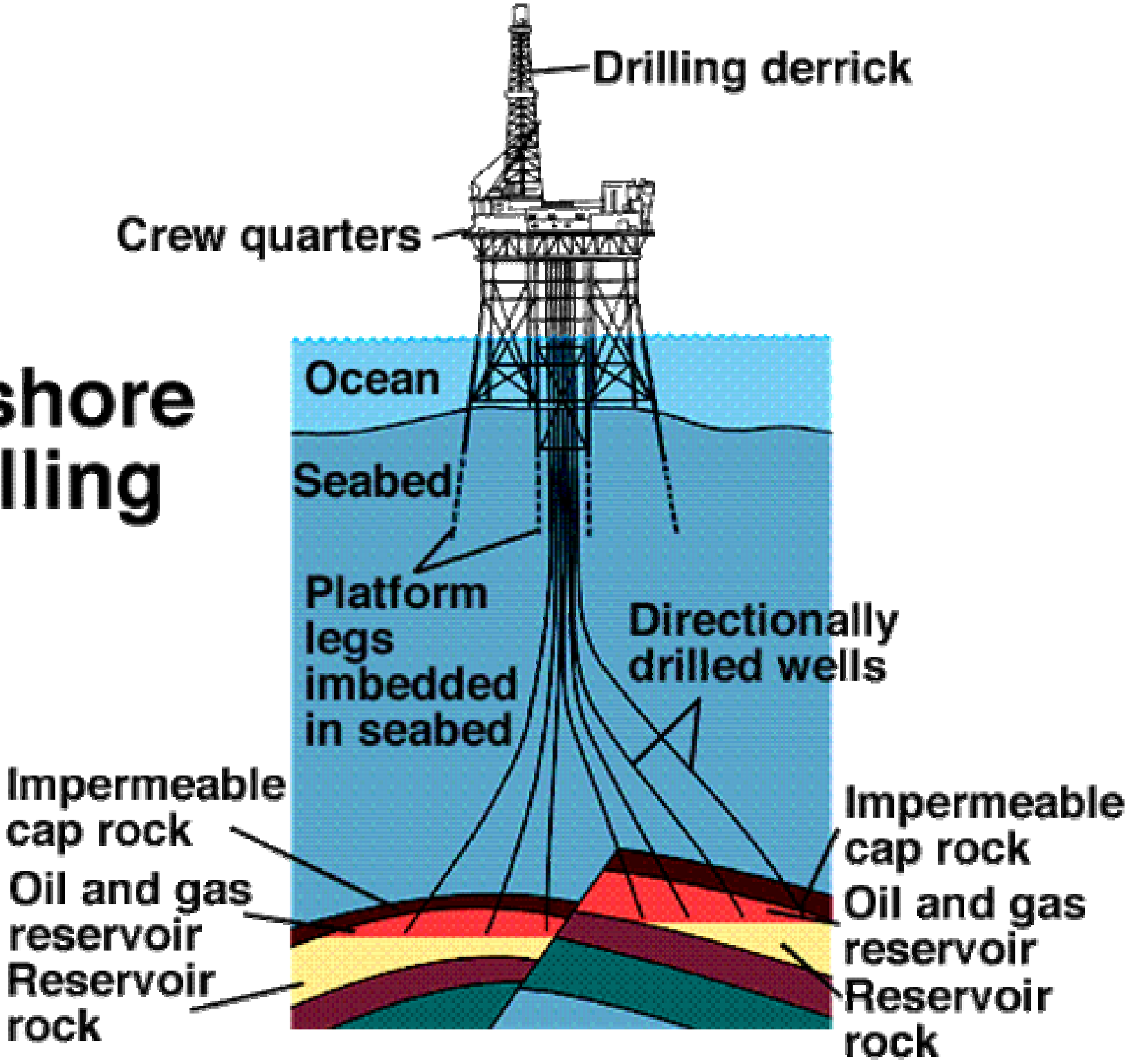
Onshore

Daily Rig Cost

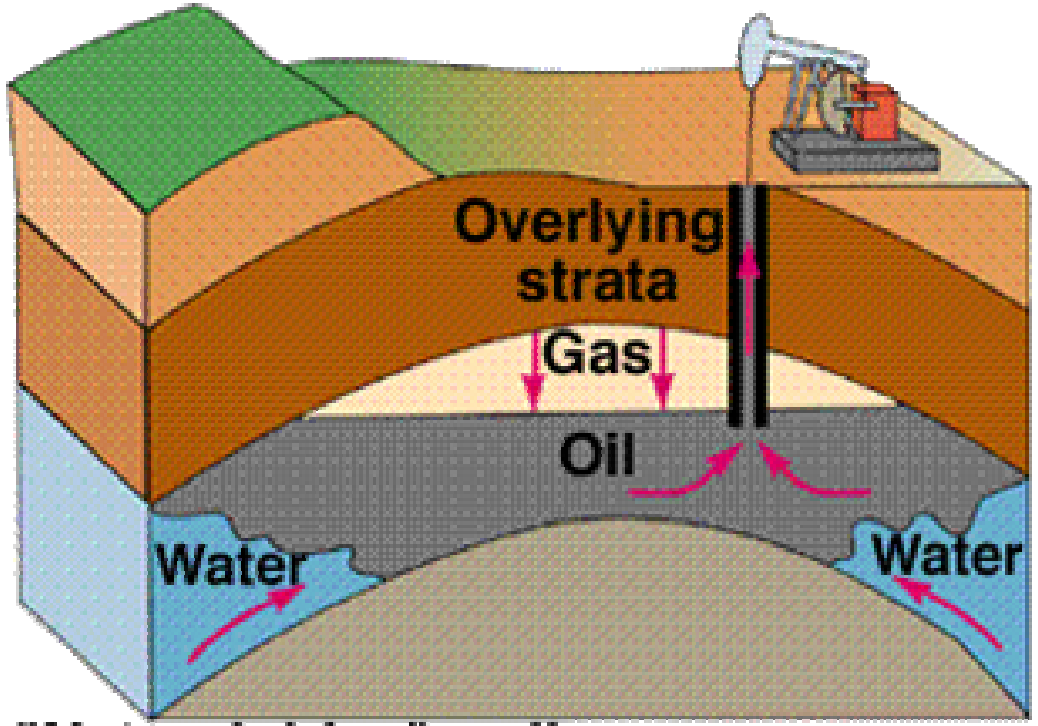
1999 $30,000
(Single year contract)

American Petroleum Institute, 1999

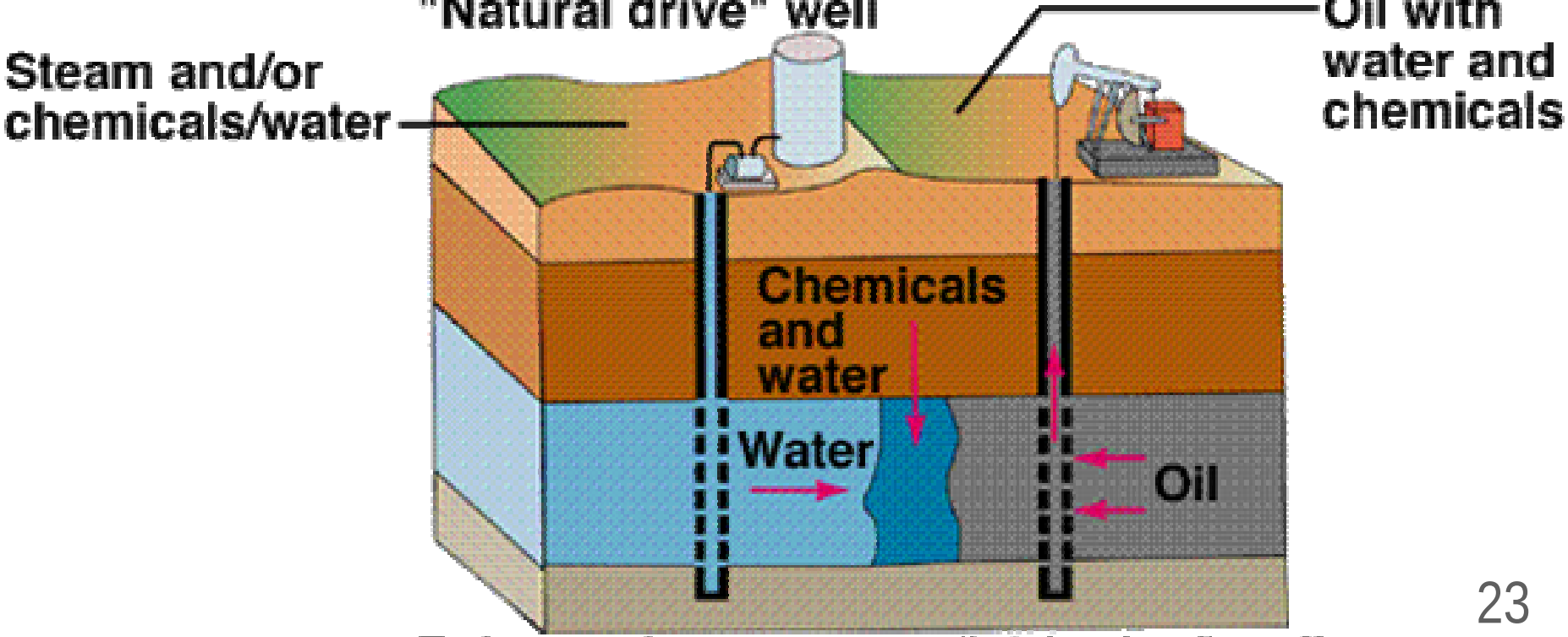
Offshore Drilling



Recovery process for petroleum.



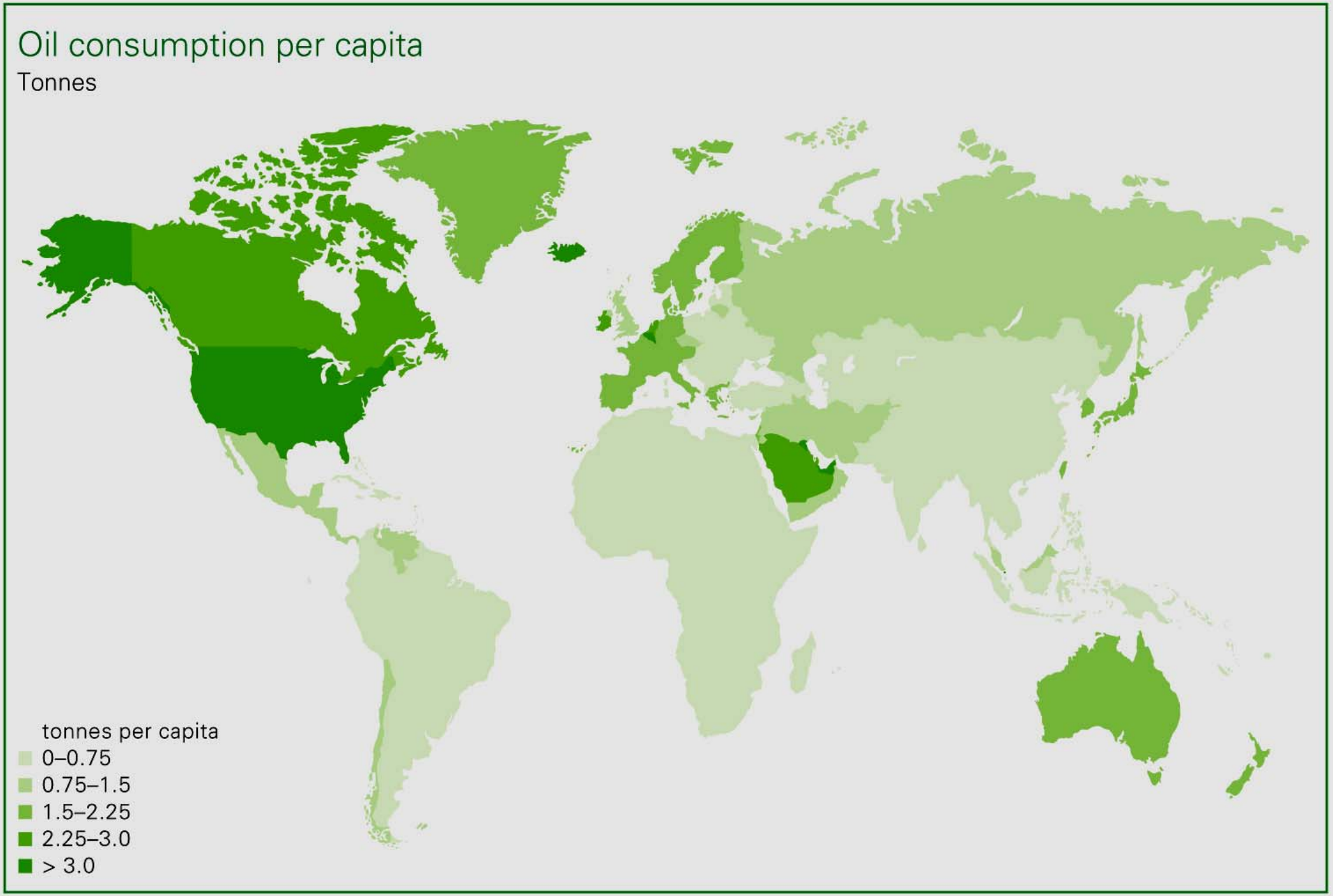
"Natural drive" well



Enhanced recovery or "stripping" well

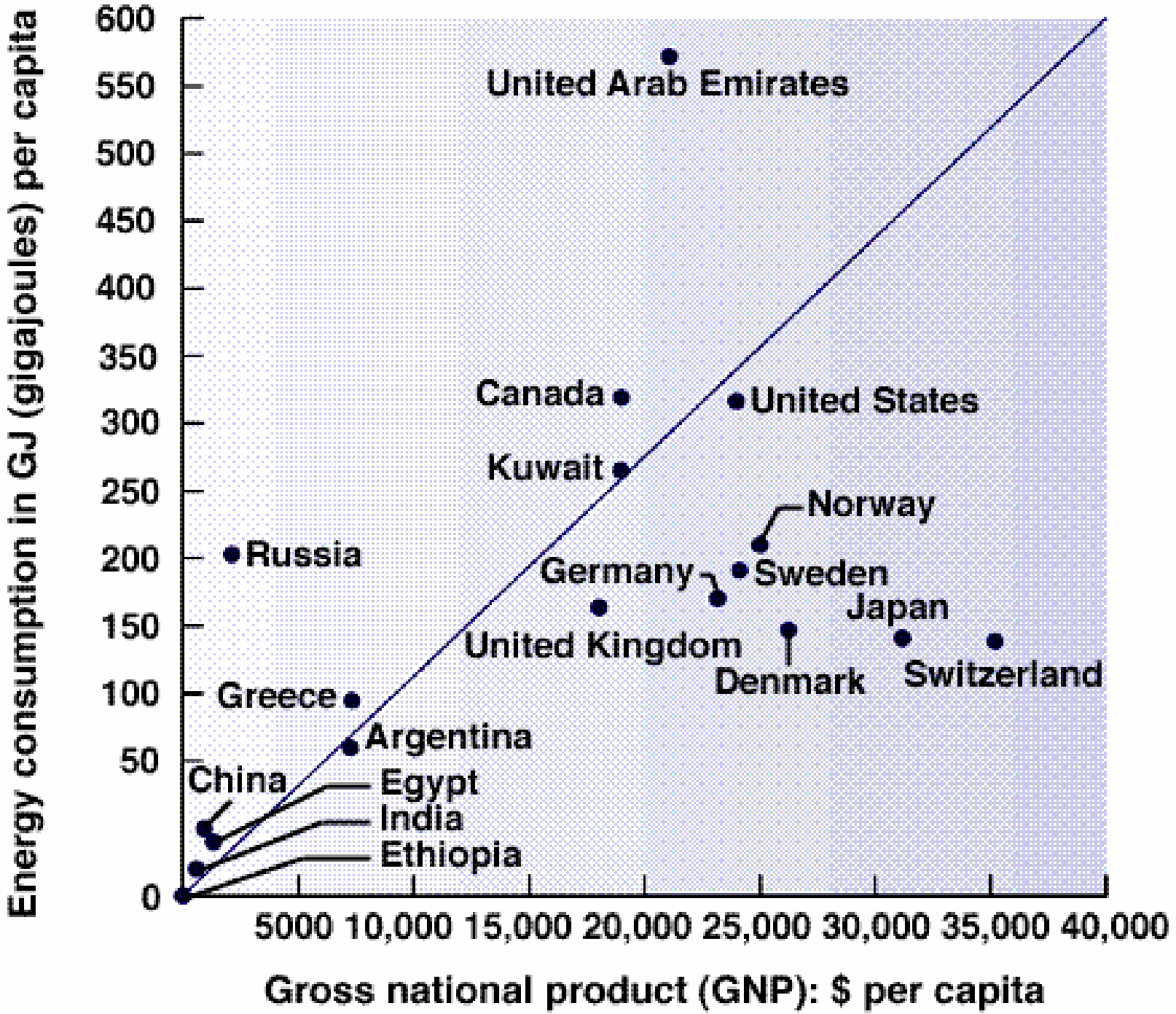
Demographics of Energy Use

- The 20 richest countries consume
  - 80% of natural gas
  - 65% of oil
  - 50% of coal
- U.S. and Canada have 5% of world population, use 25% of available energy



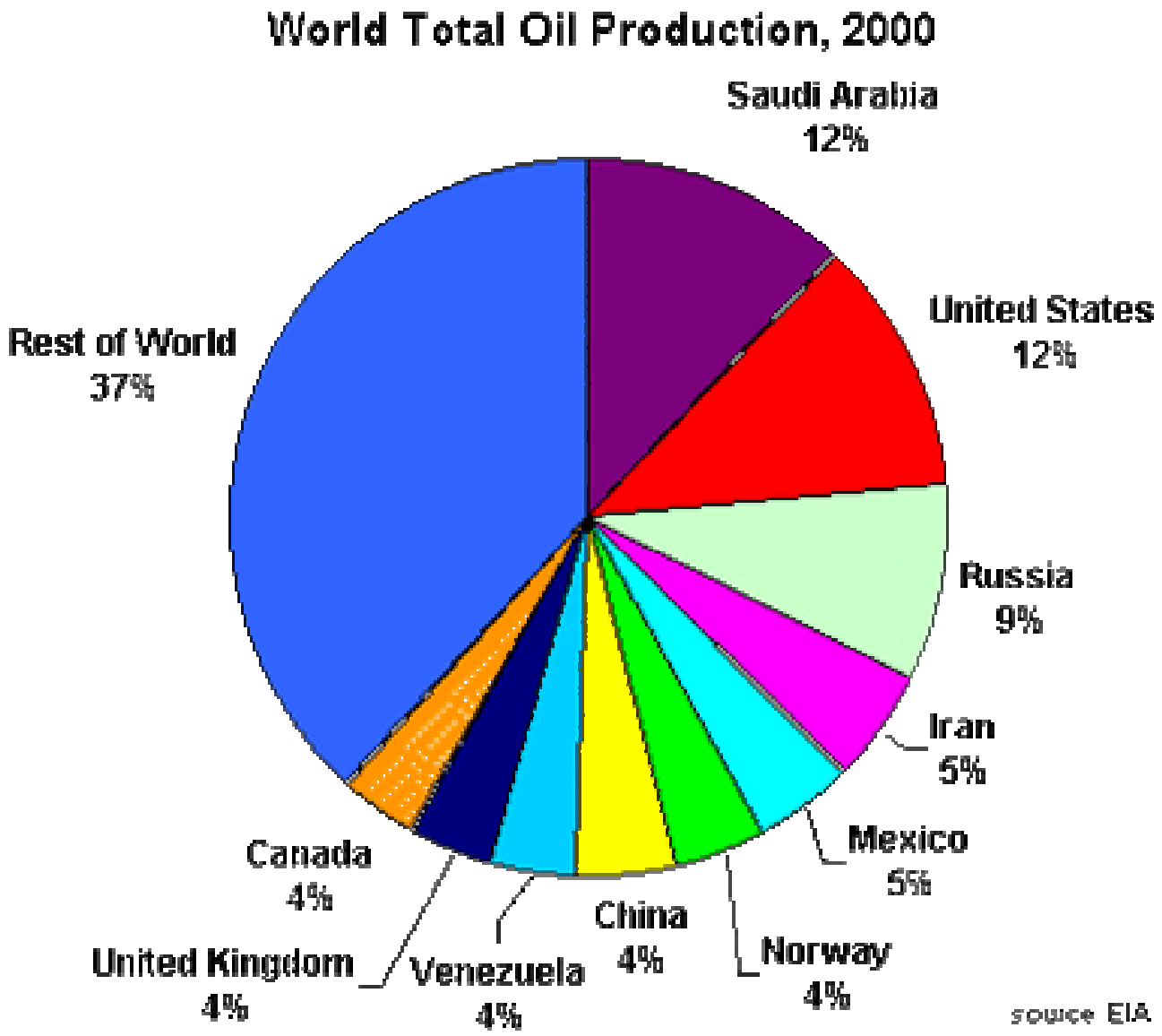
BP statistical review of world energy 2003

Per capita energy use and GNP.



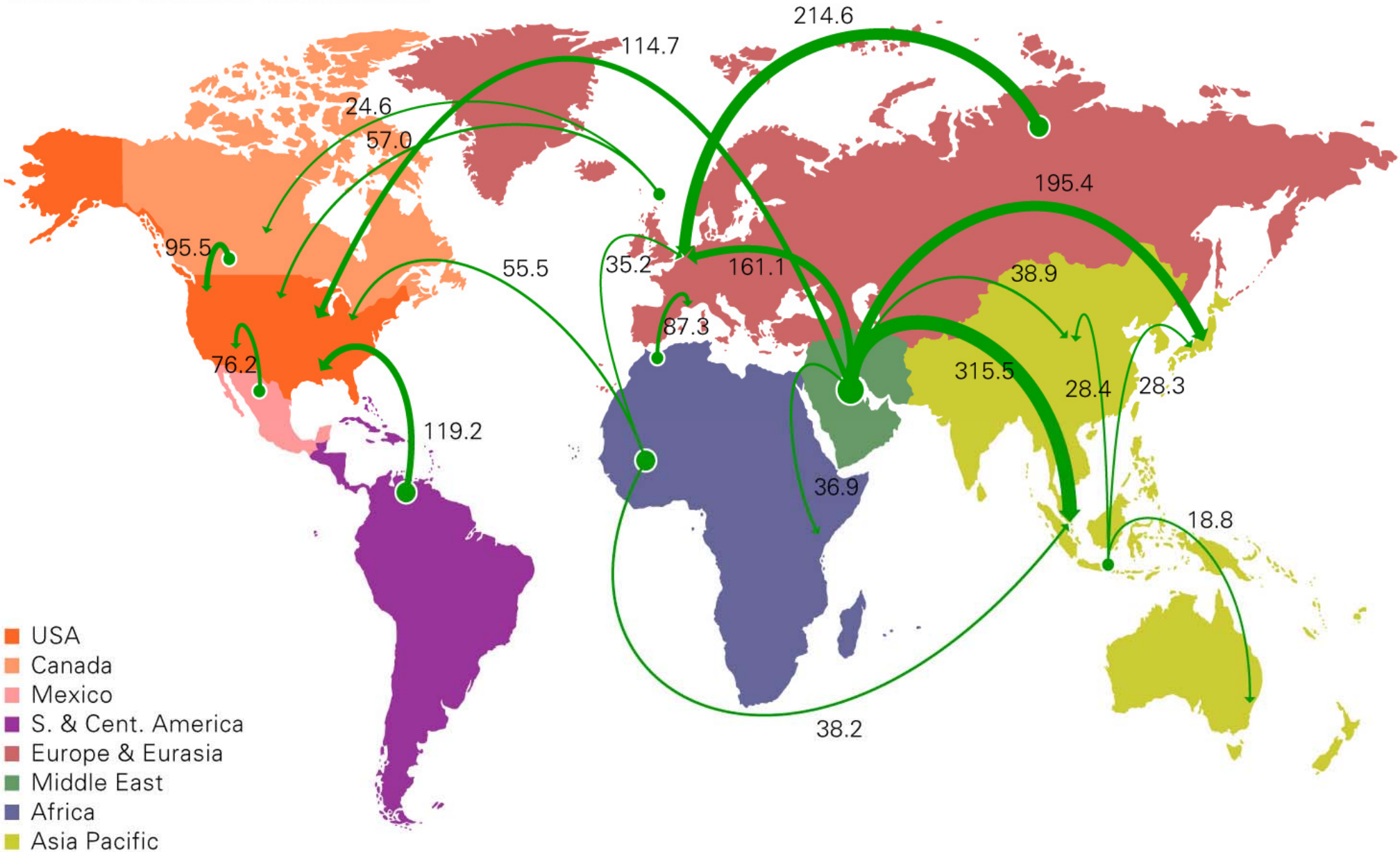
HOW LONG WILL OIL AND GAS LAST?

World Oil Supply Today



Major oil trade movements

Trade flows worldwide (million tonnes)



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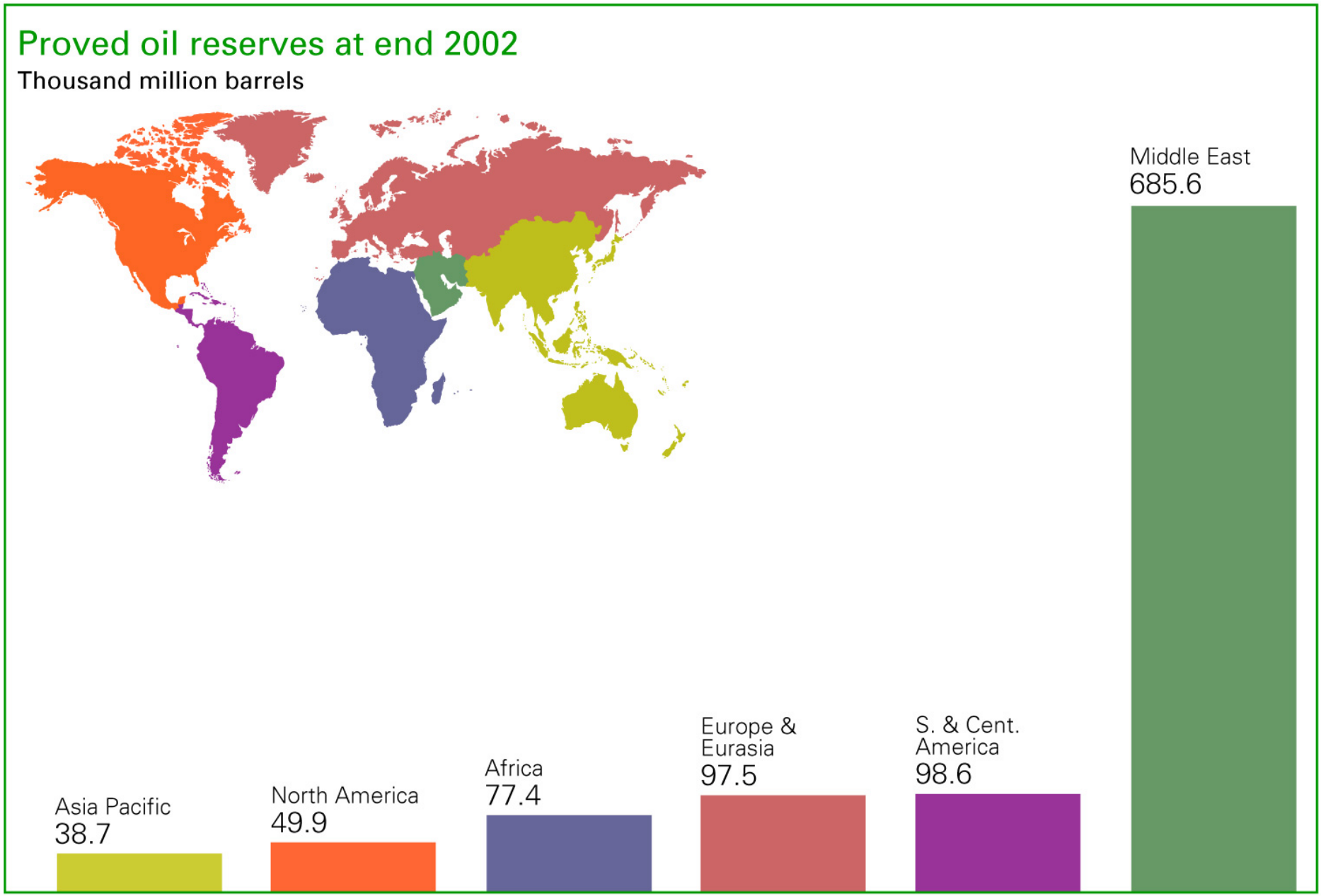
World Oil Supply Tomorrow



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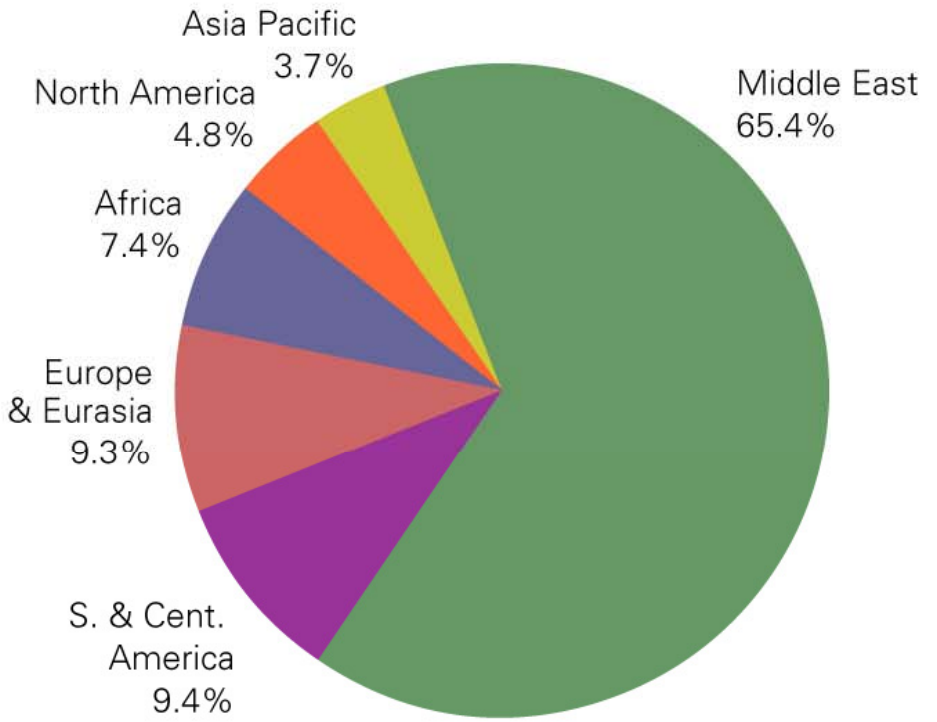
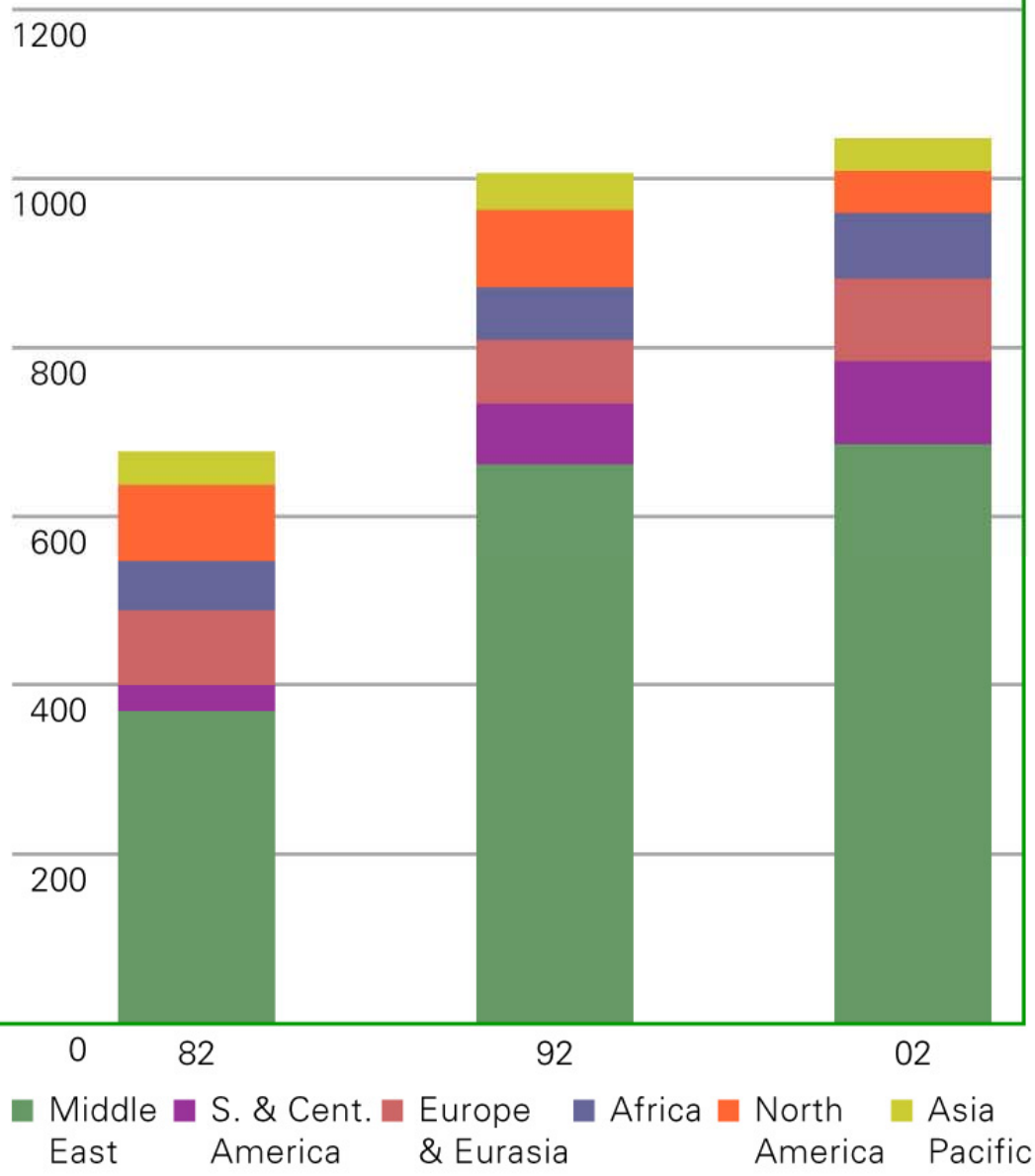
Distribution of proved oil reserves 2002

Thousand million barrels %



Thousand million barrels



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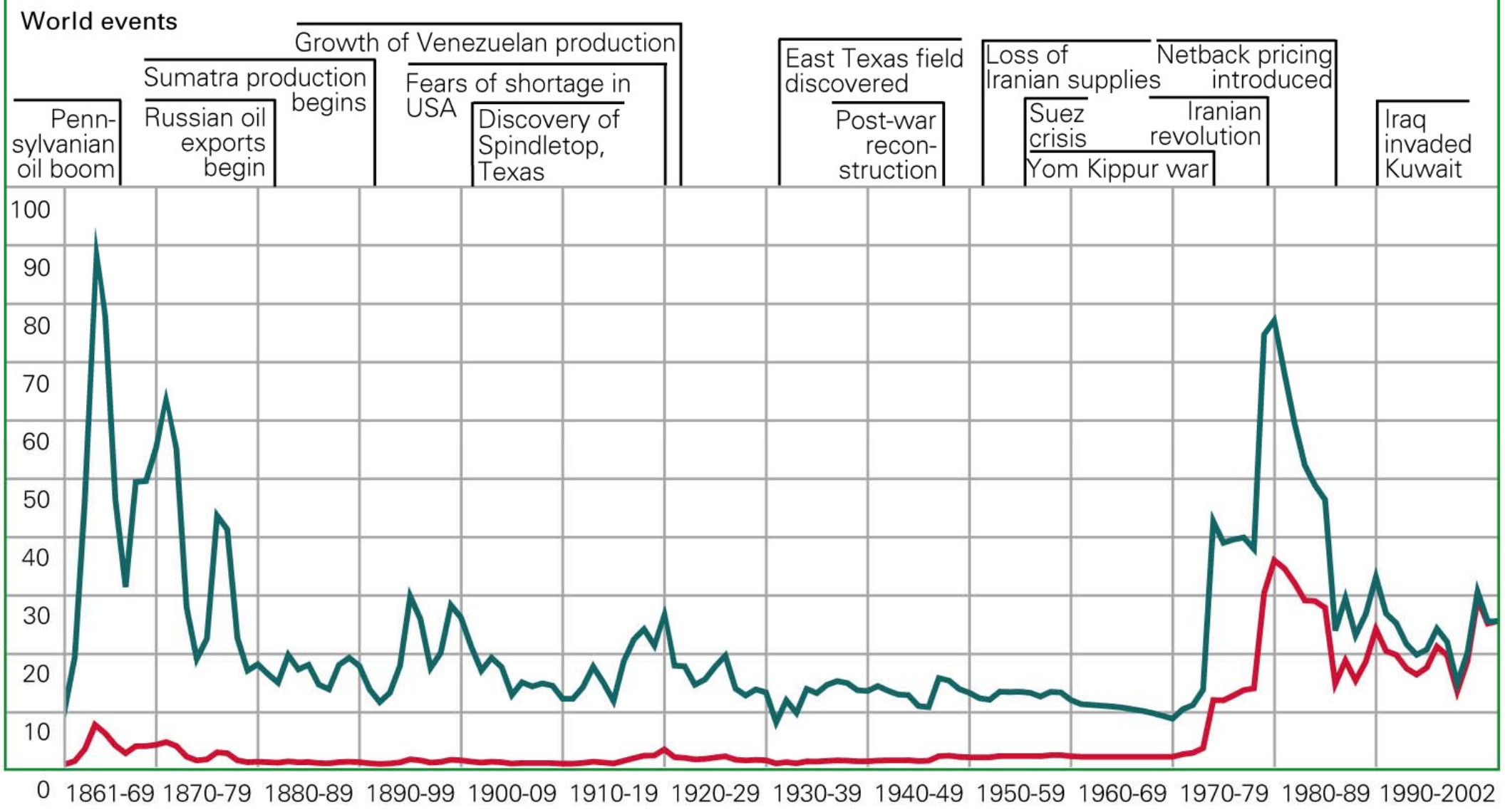
Crude oil prices since 1861

US dollars per barrel



1861-1944 US average.
1945-1985 Arabian Light posted at Ras Tanura.
1986-2002 Brent spot.

BP statistical review of world energy 2003

The End of Cheap Oil

Campbell and Laherrere

Scientific American, 1998

What oil companies would have you believe

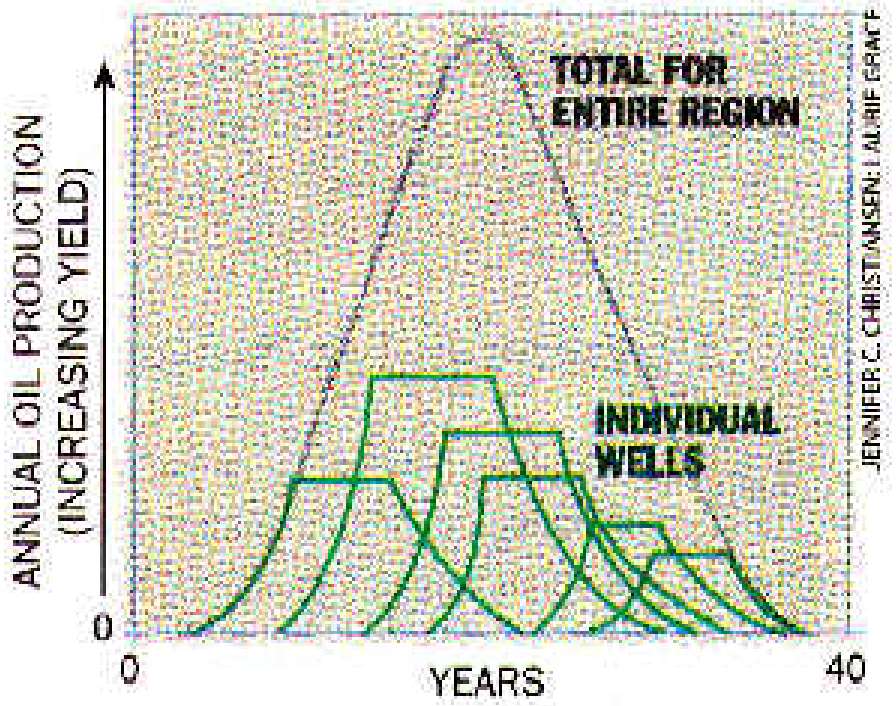
- 1,020 billion barrels of oil in reserve that will be just as cheap as it is today
- Production can continue at today's levels for many decades to come

What Campbell and Laherrere would have you believe

- Amount of oil in reserve has been distorted
- Production will not remain constant for very long
- The last bucket of oil is not as easy to remove as the first

Hubbert Curve

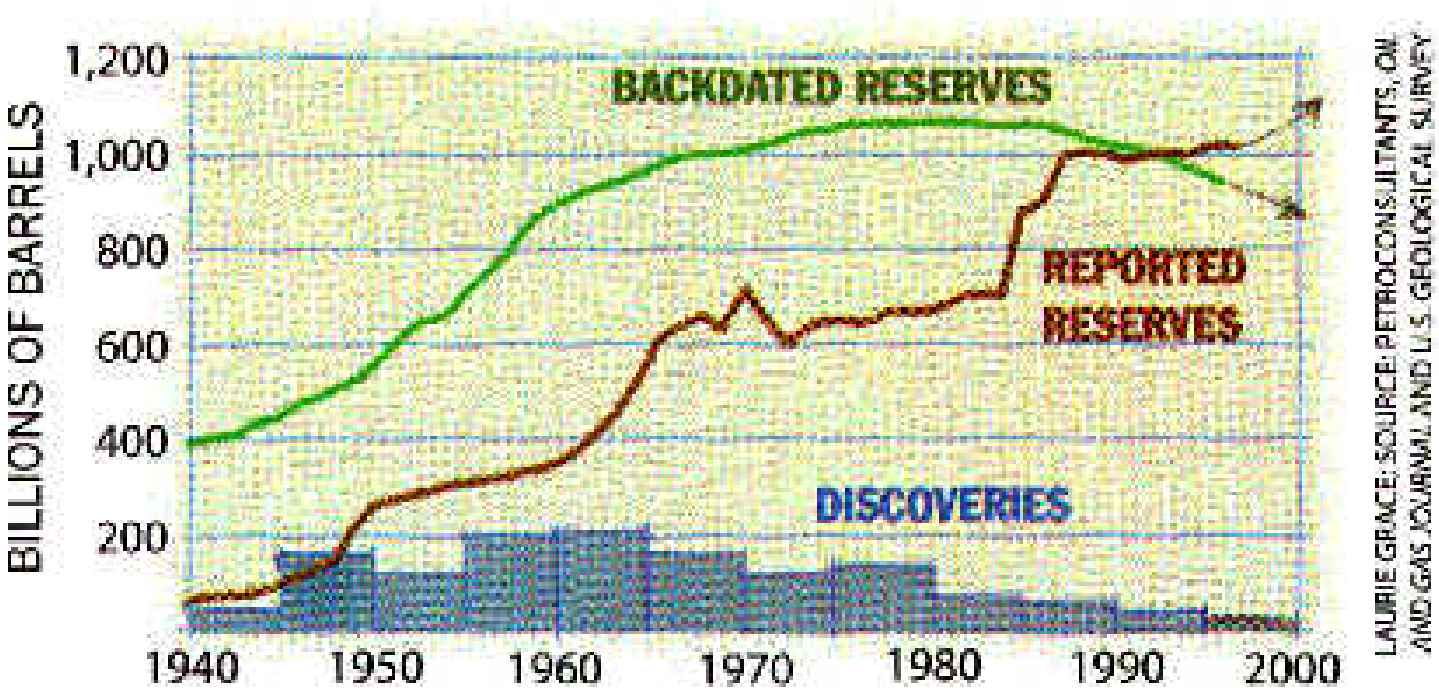
- Flow of oil starts to fall when ~1/2 of crude oil is gone
- In 1956, M. King Hubbert of Shell Oil used this curve to successfully predict US peak in production in 1970



C & L, p. 80

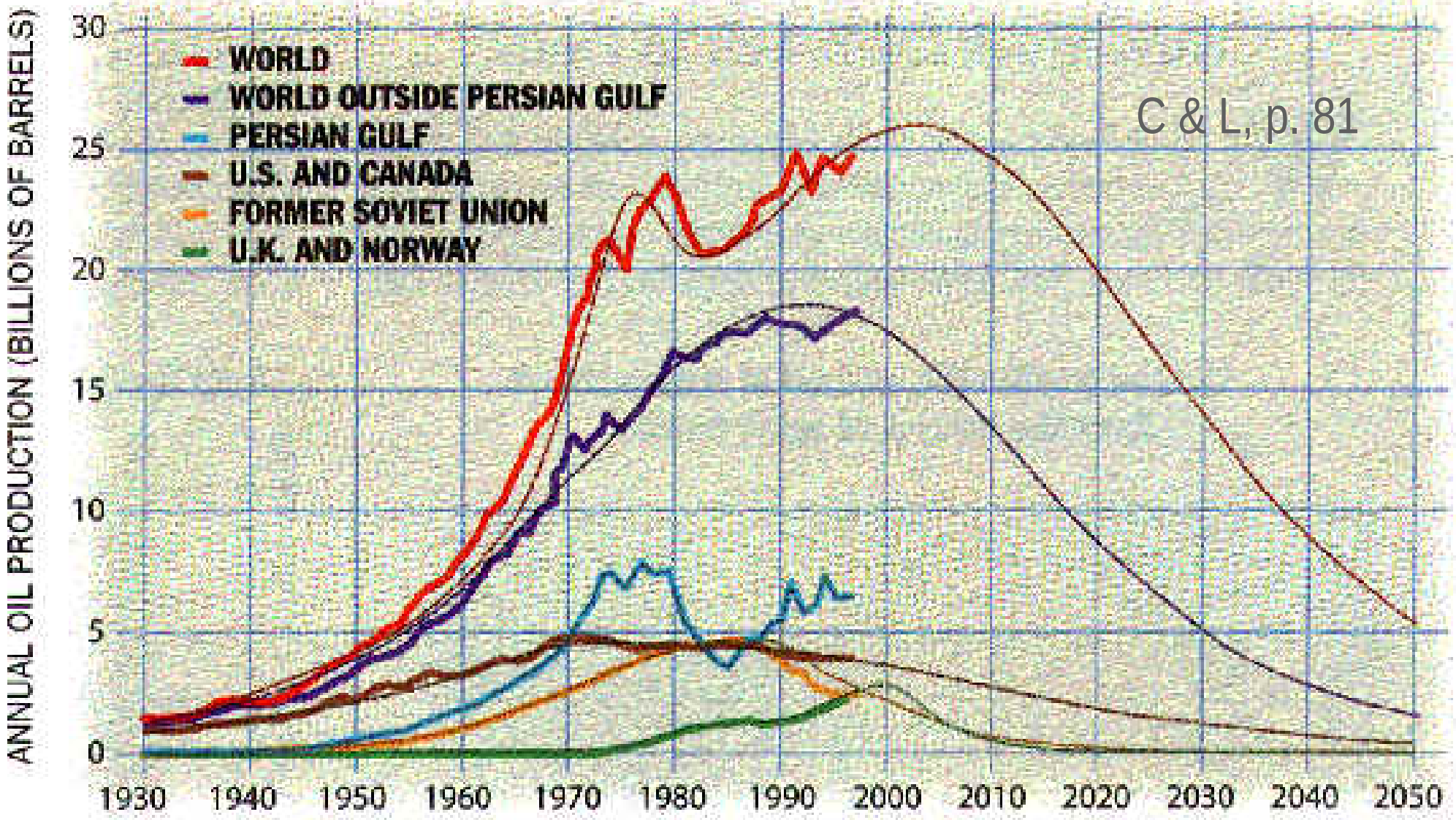
Global discovery peaked in 1960

C & L, p. 82



Industry has found 90% of oil that exists

How long will it last?



Perhaps more importantly, when will it become expensive?

Major conclusions of Campbell and Laherrere

- US oil production peaked in 1970
- World production will peak this decade!
- By 2002, Mid-East will have control over major part of supply
- What about Latin America?

Oil will get expensive!

- 1,000 billion barrels left
- At 20 billion barrels/year, will last about 50 years
- Will start to decline in production within 15 years
- Oil shale and tar sands may help ease pain, but will have environmental consequences
- Check this http://www.oilcrisis.com/