Chapter 21a

Energy Resources

Types of Resources

- *Geological Resources*
- Energy Resources
- Metals
- Nonmetallic Resources
- All are *nonrenewable resources*
  - Ground water an exception
- Resources vs. Reserves

Humans Require Abundant Energy

- **Fossil Fuels** are energy stored in chemical bonds of ancient organic life
  - Oil
  - **Natural gas**
  - Coal
  - Oil shale
  - Tar sand
- **When we burn them, we are using that stored energy**

Energy Resources

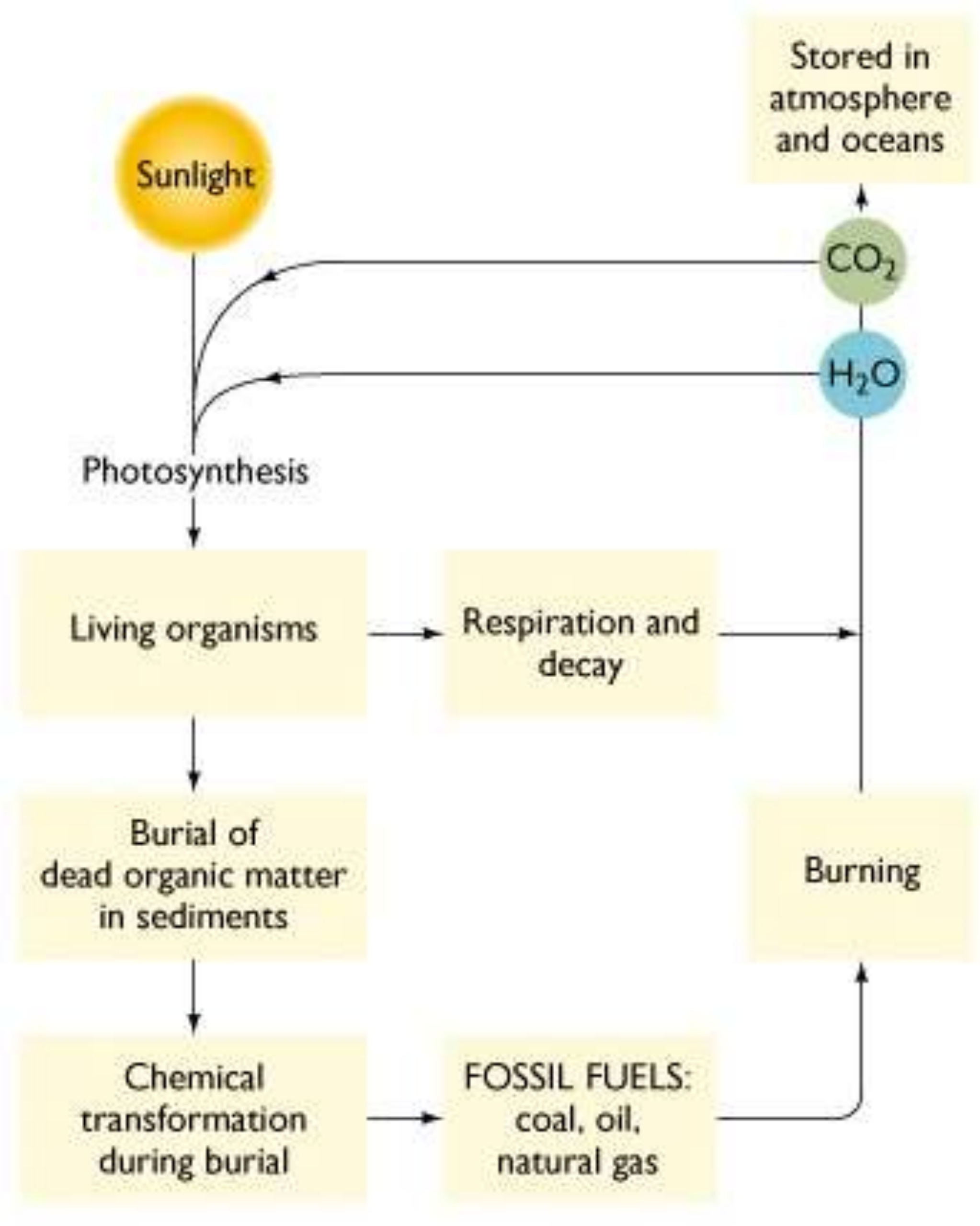
- Overview — Energy, population, and environment
- Fossil fuels (sedimentary origin and distribution)
  - Petroleum and natural gas (mainly marine)
  - Coal (terrestrial sources)
  - Distribution reflects geology, climate, preservation
- Other energy sources (origins and distribution)
  - Geothermal, nuclear (internal sources)
  - Solar, wind, hydropower (solar sources)
- Environmental and economic consequences
  - Of production, utilization, distribution

Energy Use

- Oil
- Natural gas
- Coal
- Nuclear
- Hydroelectric

Fossil fuels (hydrocarbons)

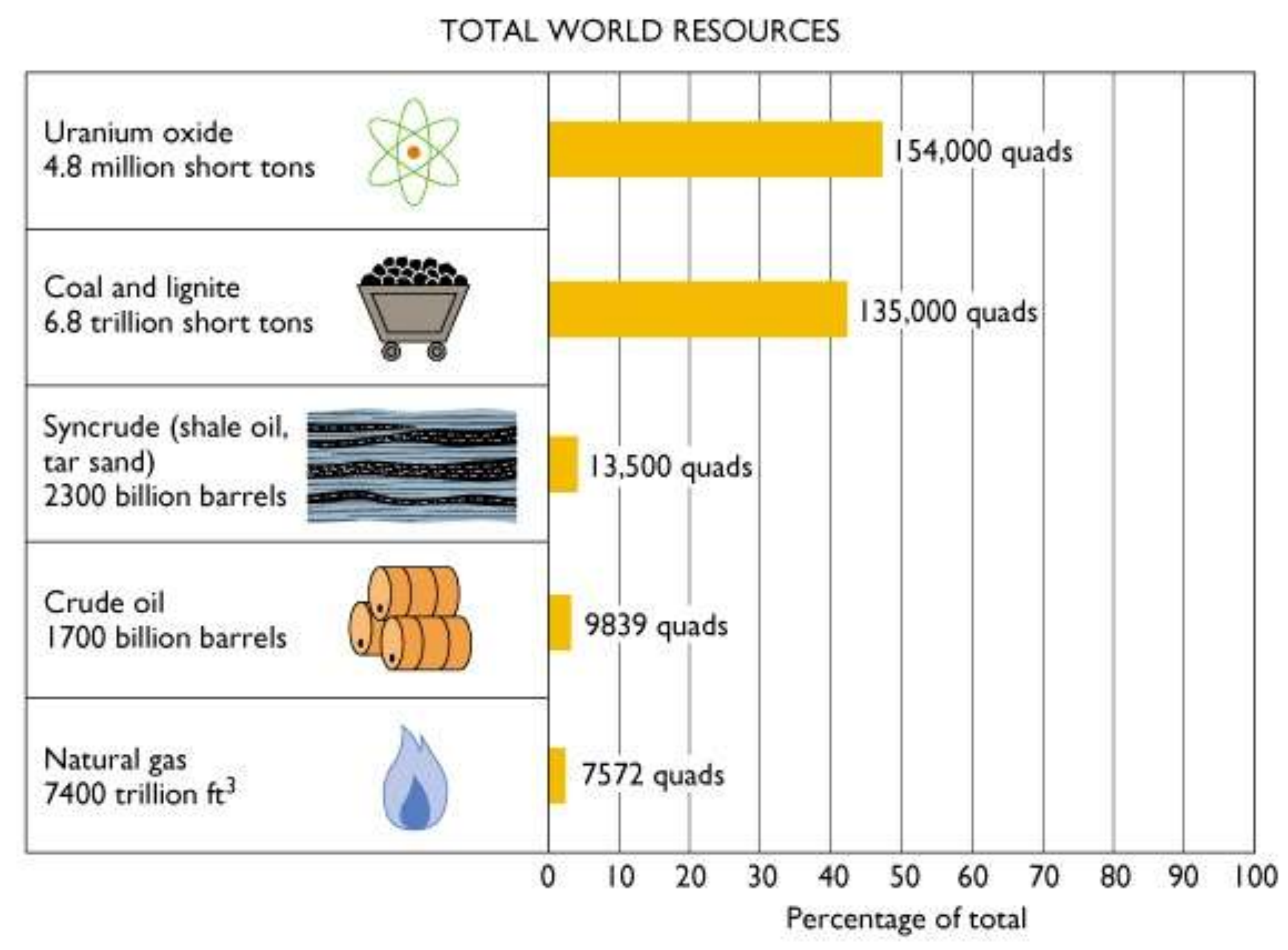
- Oil and coal
  - Complex organic molecules with C, H, N, and S
  - In general, combustion releases more CO_2 (greenhouse gas) and more pollutants, such as S (acid rain) and metal-bearing ash, than does the burning of natural gas per unit of energy
- Natural gas
  - Mostly methane (CH_4)
  - Cleaner burning than coal and oil
  - $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$



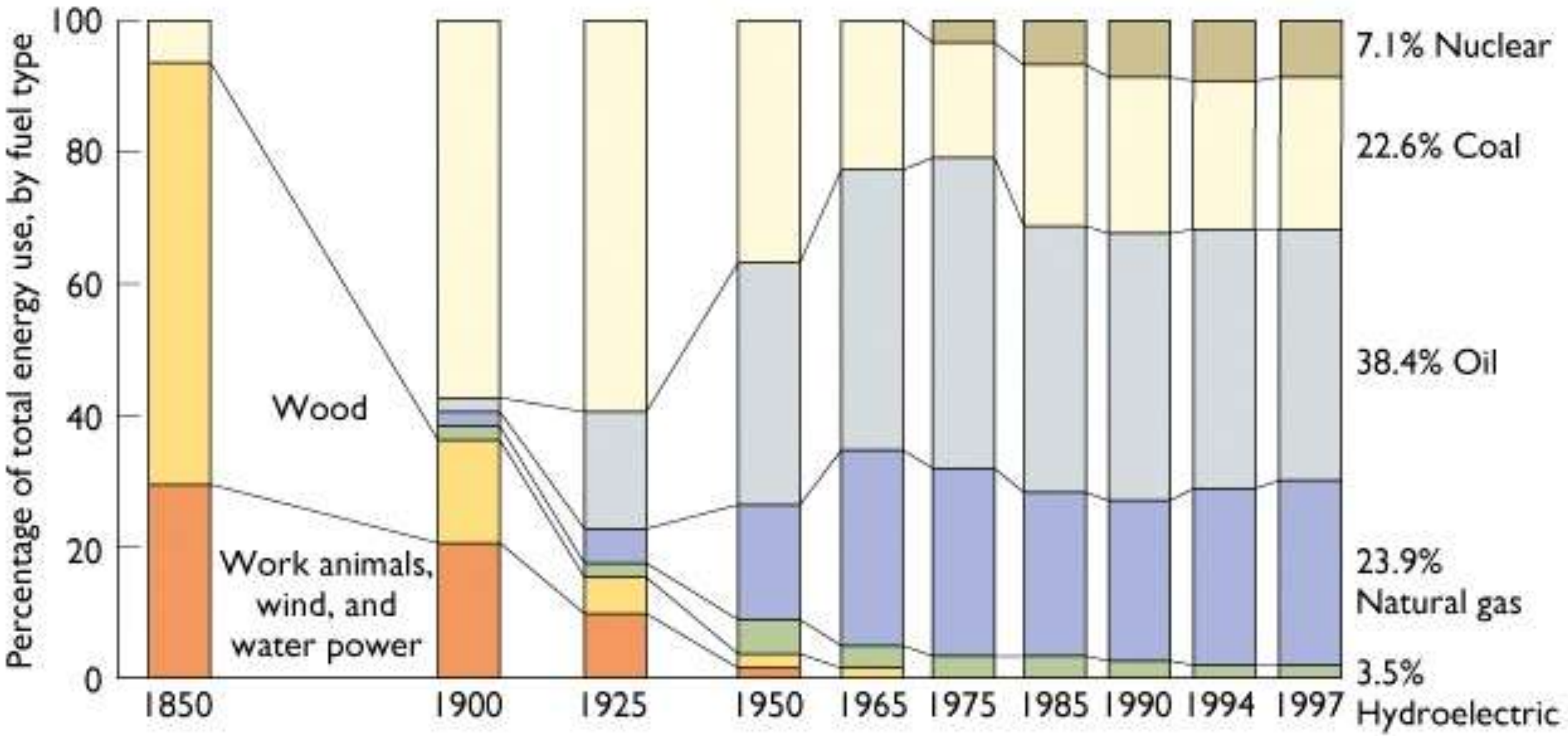
Fossil fuels

- Fossilized products of photosynthesis
- Burning releases carbon dioxide and water from which they were made

World energy resources



U. S. consumption history by type of energy



Coal

- Varieties of coal
- Occurrence of coal
  - Strip mine
  - Appalachian fields
  - Interior fields
  - Far western fields
- Environmental effects
- Reserves & resources

Peat Being Cut and Dried for Fuel

A

Bed of Subbituminous Coal

Coal

- Provides about 20% of U.S. energy supply
  - More than 50% of U.S. electric power generation
- Formation of Coal Deposits
  - **Coal** is formed from remains of land plants, not from marine organisms
  - Swamp settings ideal with abundant trees and leaves
  - Requires anaerobic conditions to convert the fallen trees and dead leaves into coal

Coal Forming Process

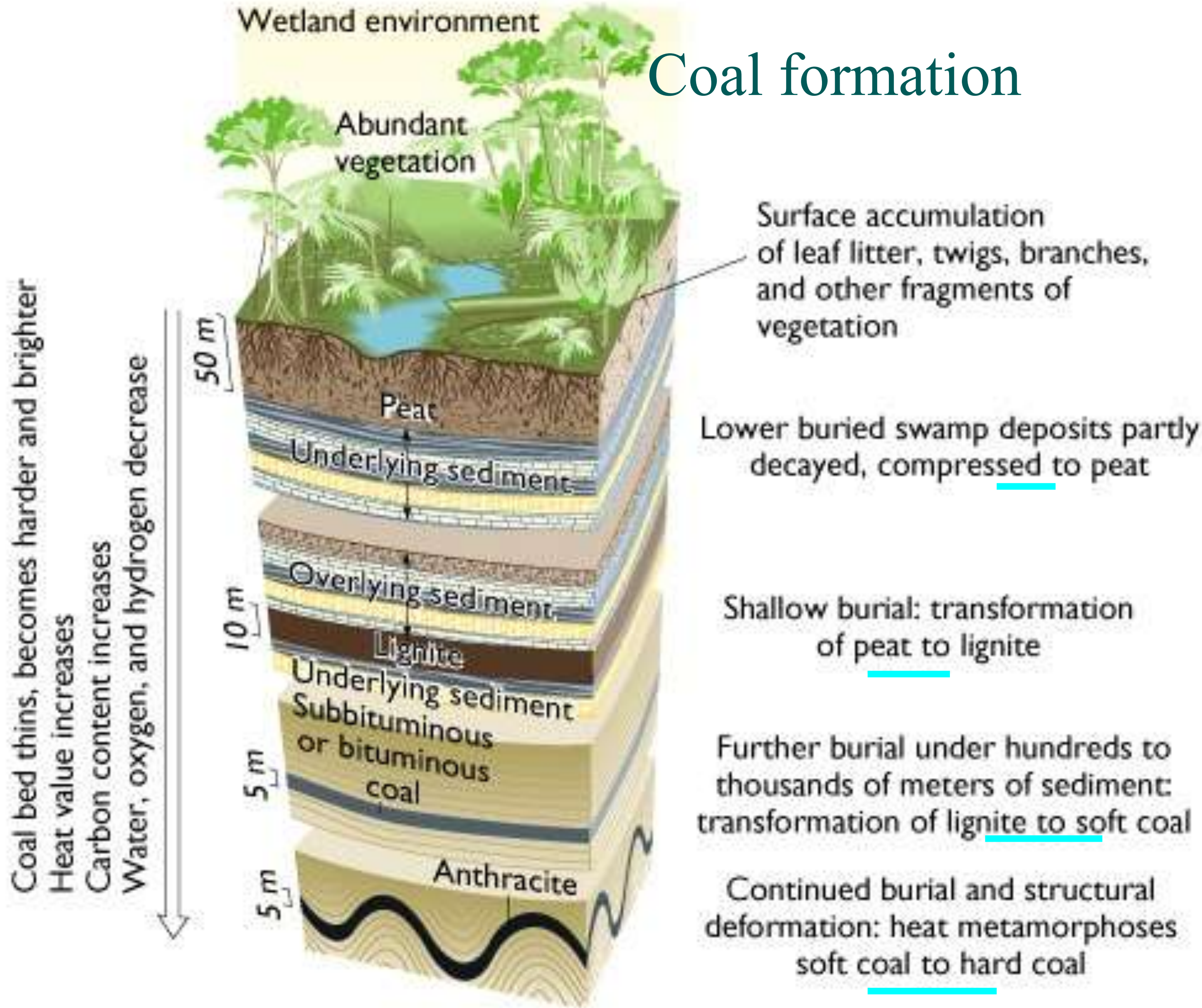
- Peat – first combustible product to form
  - Forms at surface given the suitable conditions
- Lignite – soft brown form of coal
- Bituminous – harder variety of coal
- Anthracite – hardest variety of coal
  - Harder coal gives off more heat for a given weight
- In general, the longer the time to form, the higher the grade of coal
  - Coal is a nonrenewable resource
- U.S. coal reserves represent about 50 times the energy in the remaining oil reserves and 40 times the energy of remaining natural gas reserves

How coal forms

18.03.a

Plant matter gets buried and heated into better coal

Coal formation

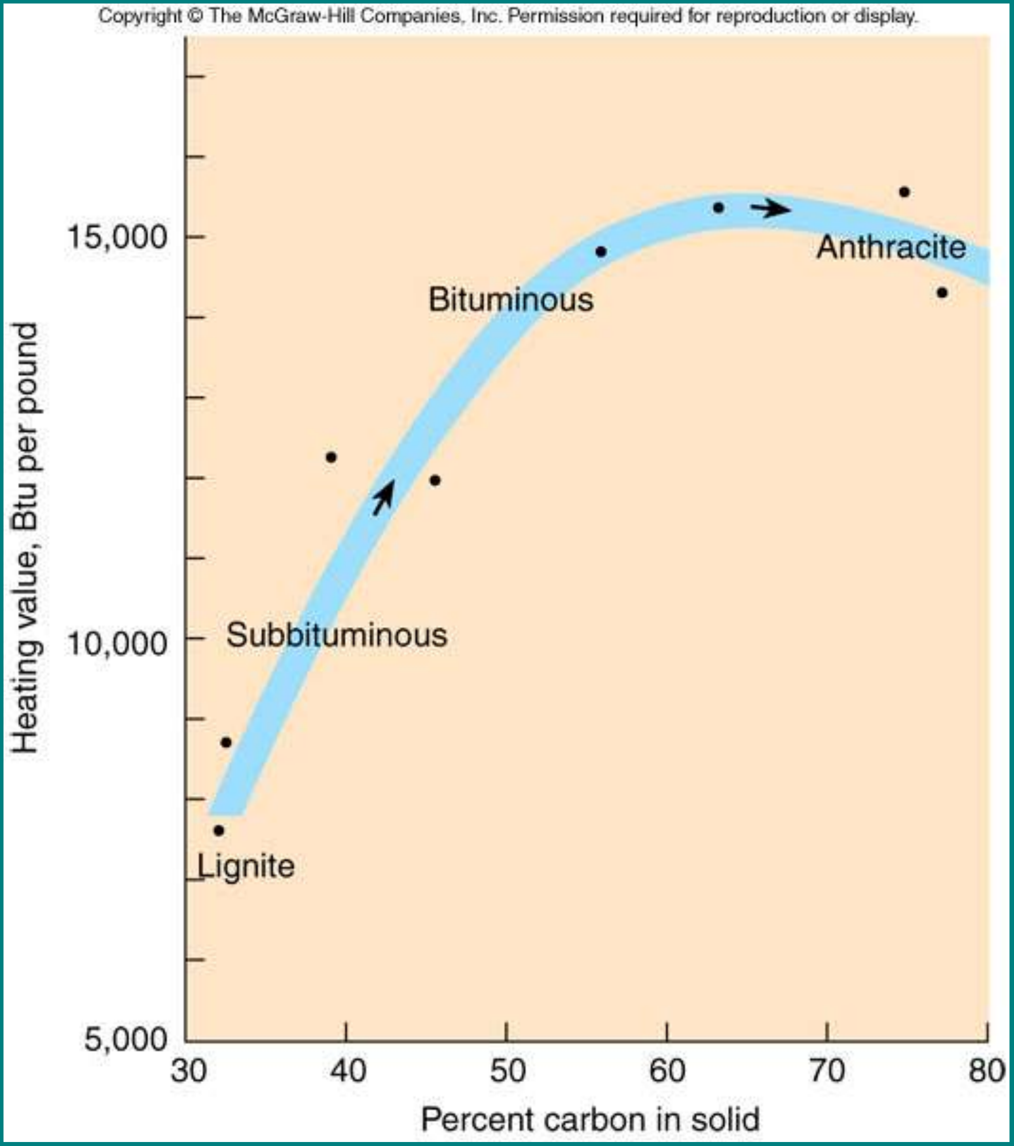


Quality of coal

Increasing burial/metamorphism, incr. carbon content, incr. heat value

- Plant materials
- Peat
- Lignite (v. soft coal)
- Subbituminous and bituminous (soft coal)
- Anthracite (hard coal)

Heat value of coal types



Coal Reserves and Resources

- Estimated world reserves of 1 trillion tons
  - Estimated 10 trillion tons in total resources
- Estimated U.S. reserves over 270 billion tons of recoverable coal
  - Estimated 2.7 trillion tons in total resources

How Coal is Mined, Transported, and Used

Strip mine

Underground mine

18.03.b

Where is my Dozer ?

This is what happens when things get lost and they turn up in the most unexpected places.

First of all .....

You have a big Tonka Toy called

The Ultimate Earth Mover

Ultimate Earth Mover

This is the largest earth mover
in the world.....
built by the German company, Krupp,
and seen here crossing a federal highway
in Germany
en route to its destination
(an open-pit coal mine).
It is cheaper to move the thing like this,
than to construct or reassemble onsite.


KRUPP

Specifications:

~ The mover stands 311 feet tall and 705 feet long.
~ It weighs over 45,500 tons
~ Cost $100 million to build
~ Took 5 years to design and manufacture
~ 5 years to assemble.
~ Requires 5 people to operate it.
~ The Bucket Wheel is over 70 feet in diameter with 20 buckets, each of which can hold over 530 cubic feet of material.
~ A 6-foot man can stand up inside one of the buckets.
~ It moves on 12 crawlers (each is 12 feet wide, 8' high and 46 feet long). There are 8 crawlers in front and 4 in back. It has a maximum speed of 1 mile in 3 hours (1/3 mile/hour).
~ It can remove over 76,455 cubic meters each day. (100,000 large dump trucks at 40yds. each)

Now where is that Dozer ?

Ahhh ... There it is

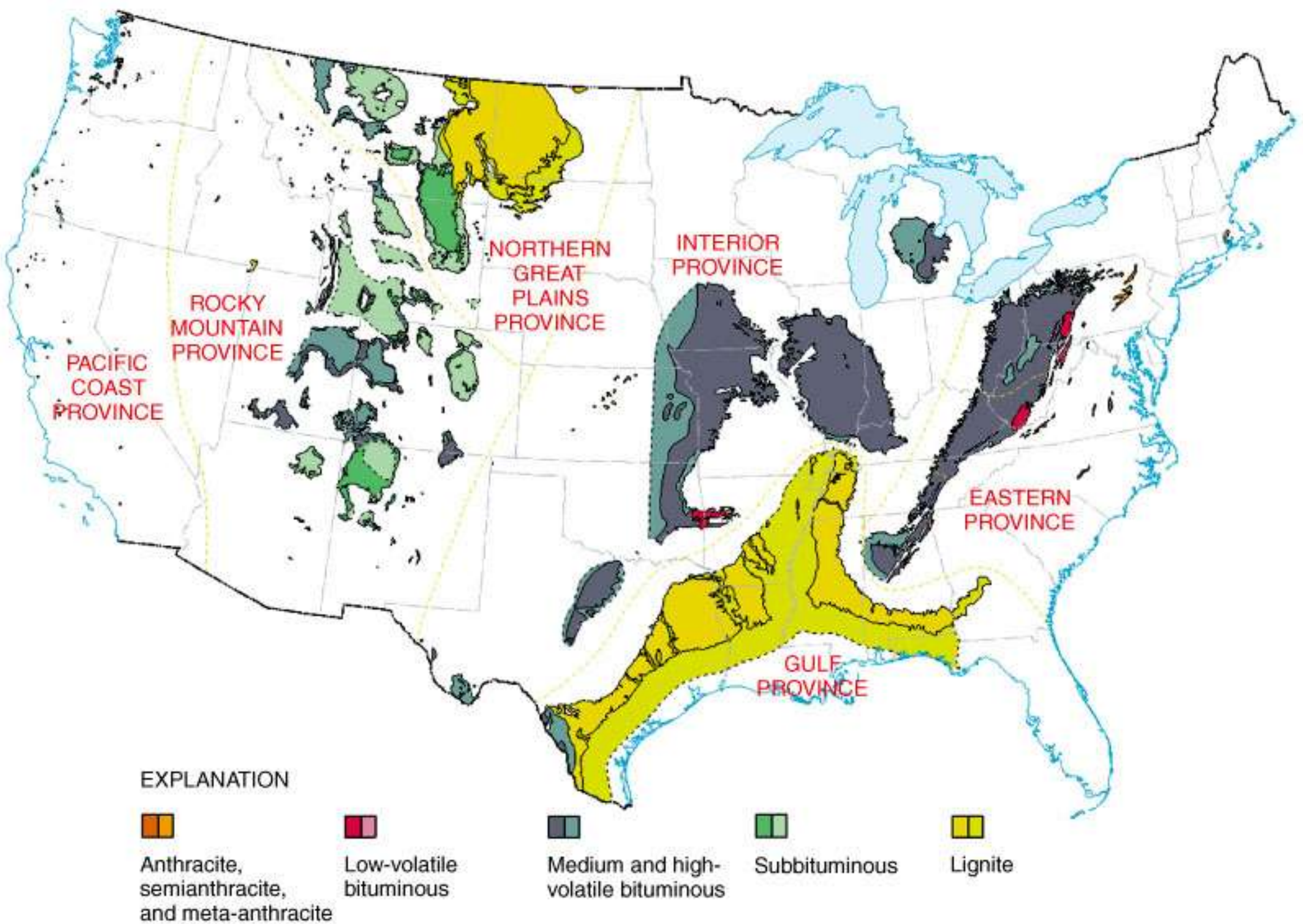
At the top of that big wheel !!

where coal and coal-bed methane occur

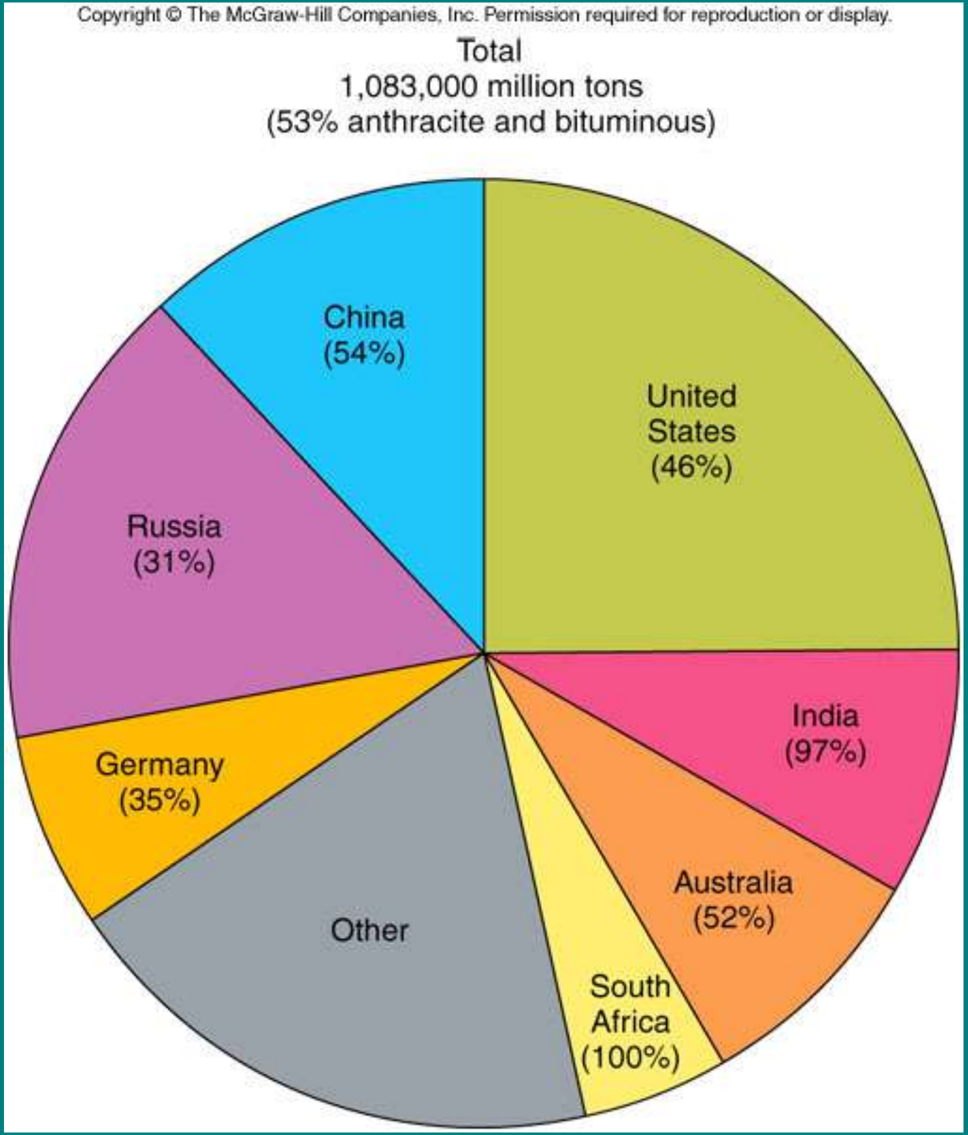
18.04.a

Methane collection tanks

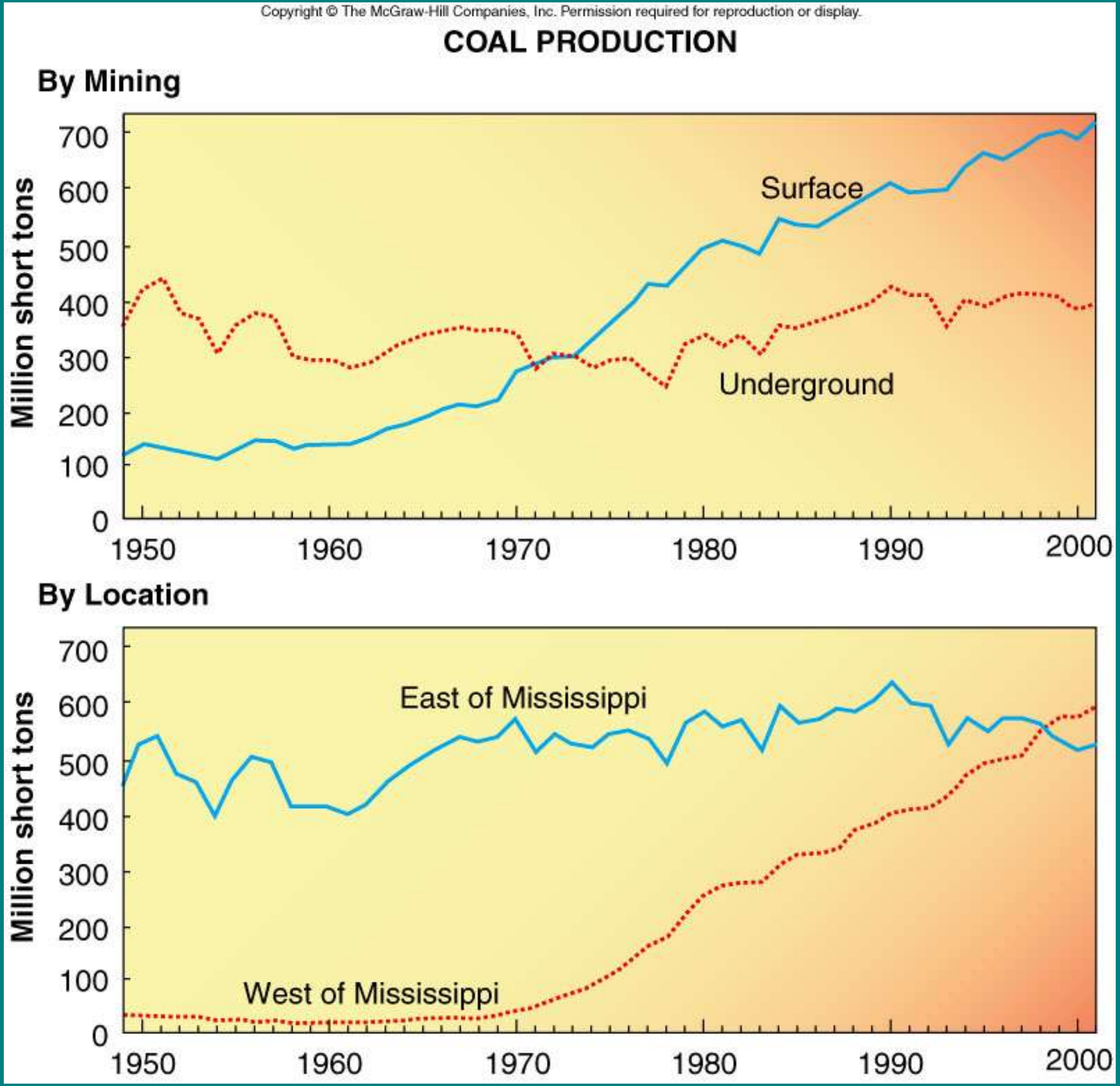
Coal occurrences in US



Distribution of coal resources



Coal production



Environmental issues--coal

- Reclamation of coalfields
- *Other issues?*

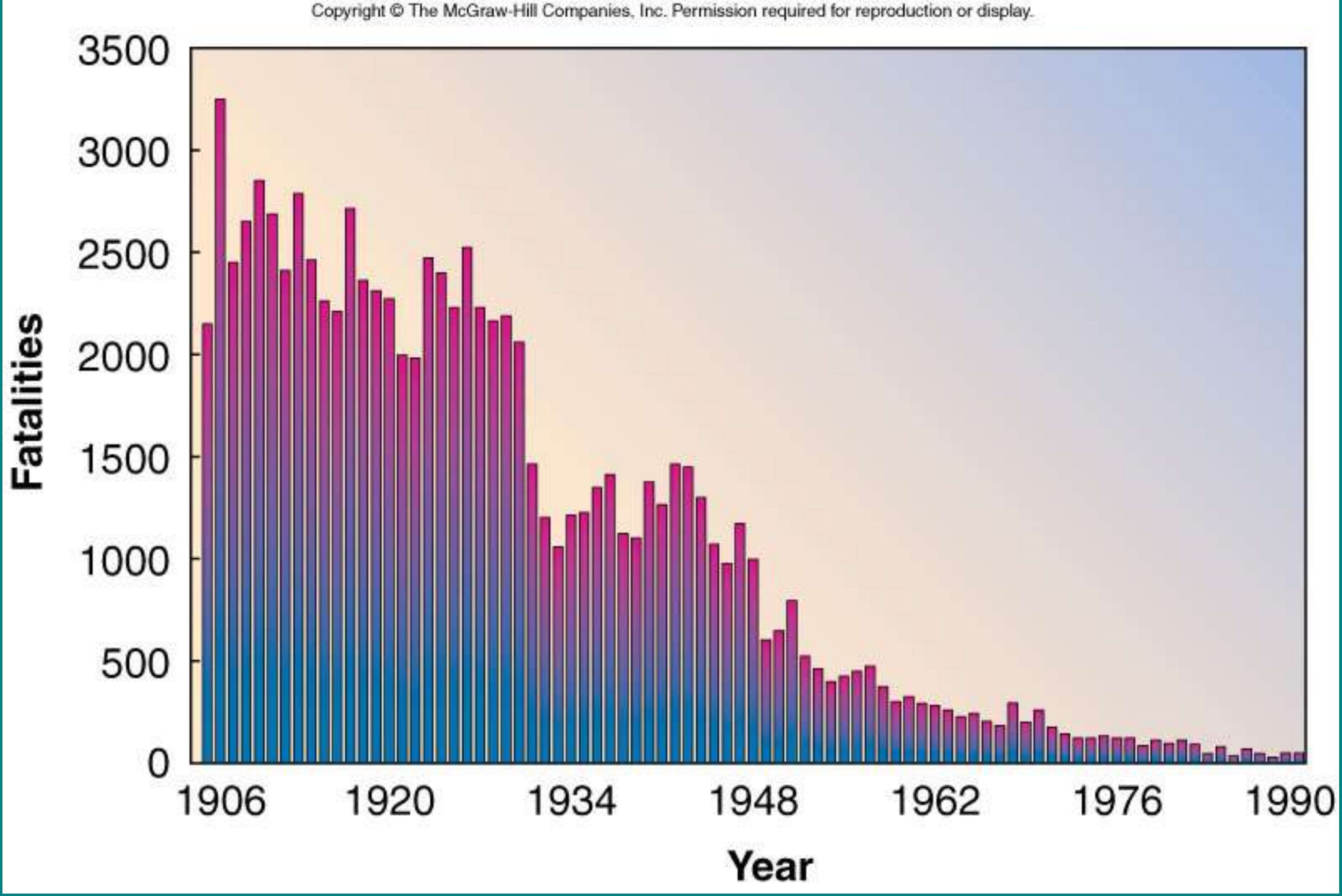
Environmental Impacts of Coal Use

- Produces abundant carbon dioxide when burned
  - Carbon dioxide is a greenhouse gas
- Liberates sulfur as sulfur dioxide into atmosphere upon burning
  - Acid Rain: sulfur dioxide is toxic and complexes with atmospheric water to produce sulfuric acid
- Ash is liberated from coal upon burning
  - Ash is as much as 20% of the volume of coal
  - Often contains toxic metal such as selenium and uranium
- Coal mining poses further problems: safety and environmental issues

Coal-Mining Hazards and Environmental Impacts

- Underground mining of coal is dangerous and expensive
  - Mines can collapse
  - Miners contract black lung disease from coal dust or cancer from radon gas
  - Explosion occur from pockets of natural gas
- Strip mining exposes the coal to the weather
  - Rain water and air comes in contact with sulfur in the coal beds or waste rock – produces sulfuric acid
- Coal mine reclamation is expensive and time consuming

Safety in coal mines



Strip mining coal

Underground coal fires

Limitations on Coal Use

- Coal is not clean
  - To mine
  - To burn
  - To handle
- Coal is not produced in a usable form for transportation purposes
- Coal can be converted to a liquid fuel by **liquefaction**
- Coal can be converted to a gas by **gasification**

Gasification

- Low heat gas mix of carbon monoxide, methane, and hydrogen
- Produces about 15 to 30% of the heat as methane
- Various technologies are being developed to increase the quality and production of this gas
- *In situ* production projects ongoing also

Liquefaction

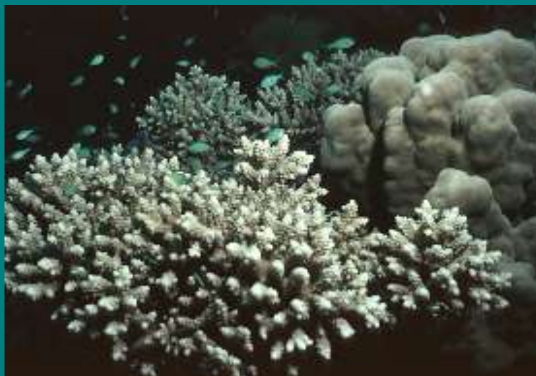
- Liquid fuel has been generated from coal in the past successfully
- U.S. not poised technologically or economically to generate this alternative fuel
- May be possible and practical in the future

Oil & Natural Gas

- *Petroleum*
  - Crude oil
  - Natural gas
- Occurrence of Oil & Gas
  - Oil pool
    - Source rock
    - Reservoir rock
    - Trap- structural trap; stratigraphic trap
    - Deep enough burial
  - Oil field

Where Petroleum Comes From

18.01.a-b

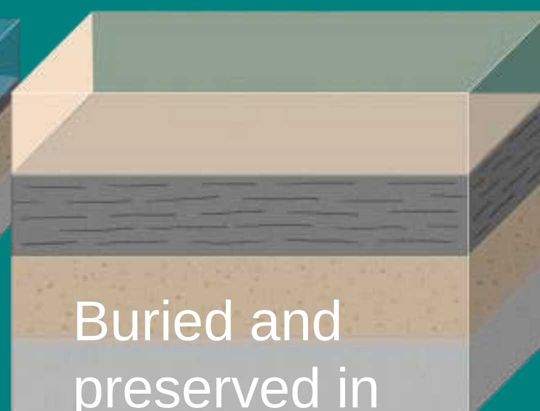


Reefs

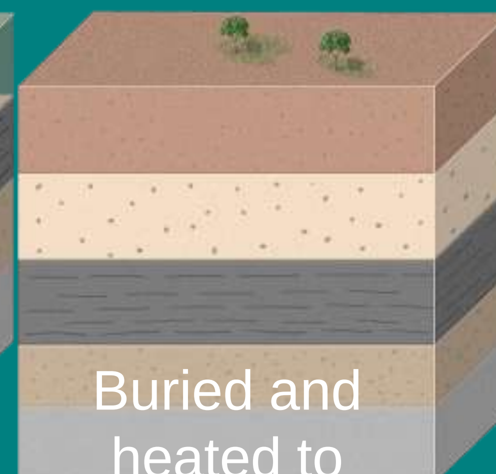
Plants

Microorganisms

Accumulation of organic material



Buried and preserved in oxygen-poor conditions



Buried and heated to right temp.

Serpentinite Reaction and Photograph of Serpentinite Hand Specimen

Source: Stanley B. Keith, MagmaChem.com

SIMPLIFIED SERPENTINIZATION REACTION

$6(Mg_{1.5}Fe_{0.5})SiO_4 + 7(H_2O) \rightarrow 3Mg_3Si_2O_5(OH)_4 + Fe_3O_4 + H_2 + H_2O +$ HEAT

Olivine - peridotite

Serpentine

Evidence for Hydrothermal/Abiogenic Hydrocarbons

Non-Terrestrial

- Non-terrestrial Hydrocarbons

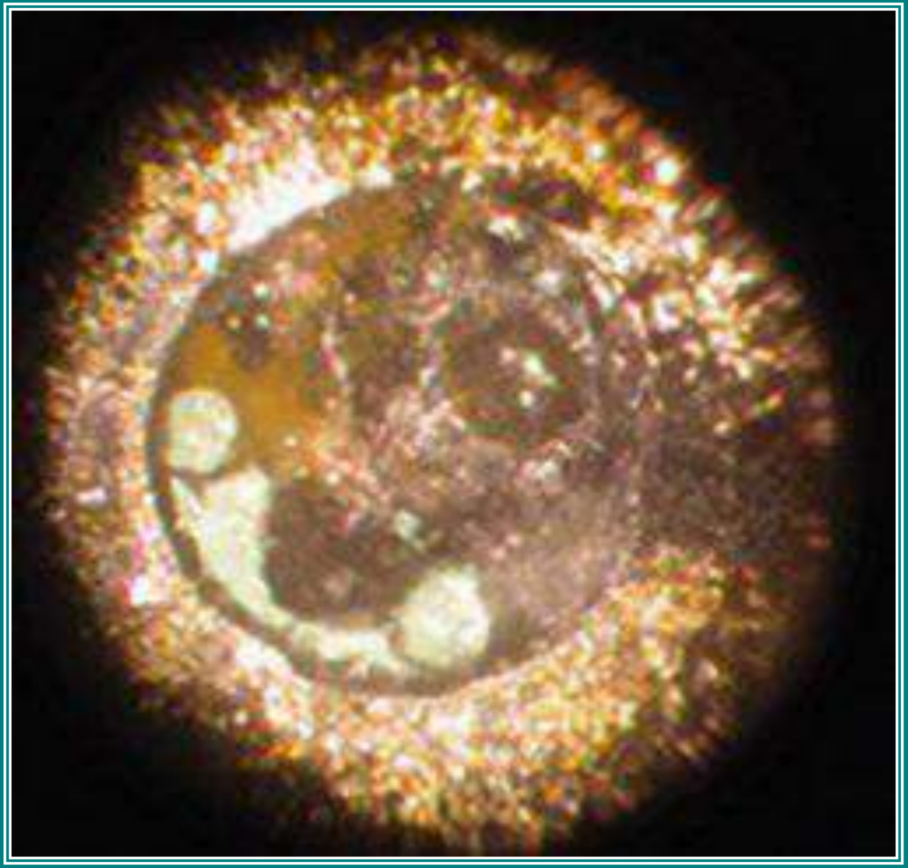
Terrestrial

- Hydrocarbons in Hydrothermal Metal Deposits
- Hydrocarbons in Olivine
- Diamondoids
- Native Metal Nanoparticles
- Hydrothermal Dolomite
- Experimental Hydrothermal Oil
- Hydrothermal Hydrocarbon Seeps

Source: Stanley B. Keith, MagmaChem.com

Hydrocarbons in Olivine

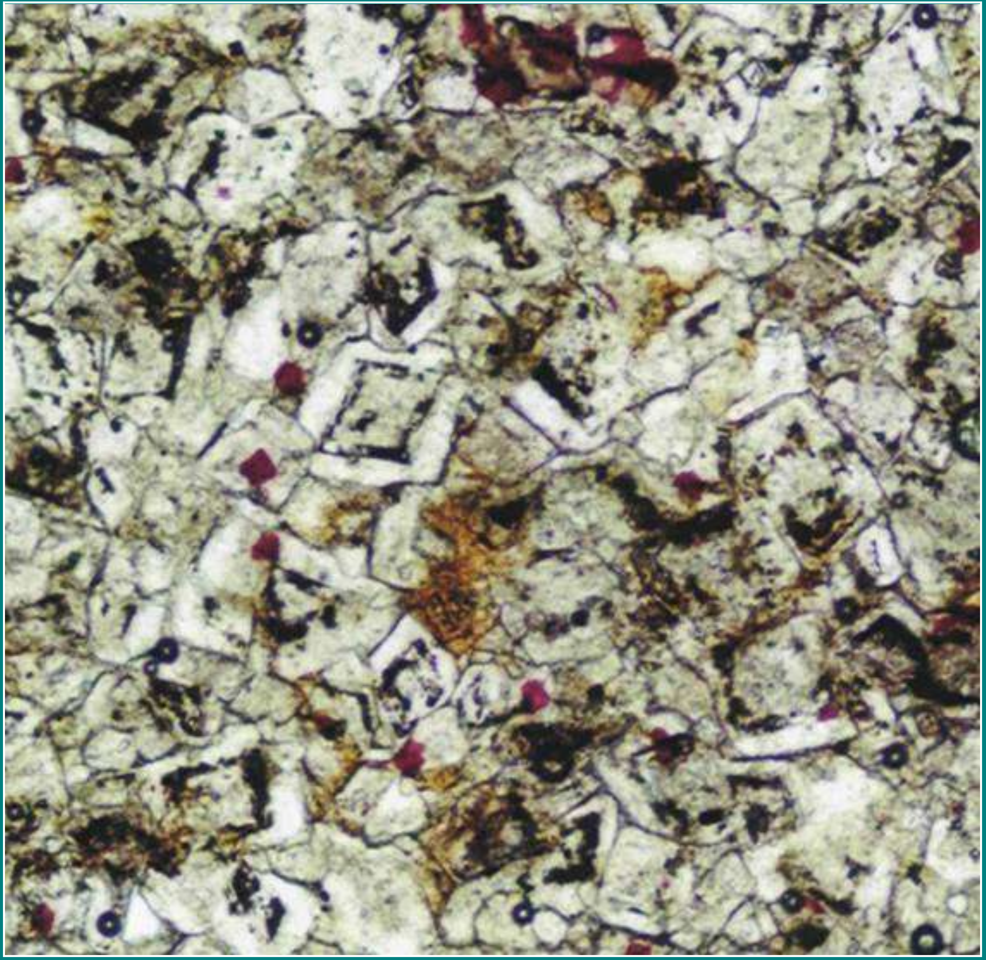
METHANE IN THE MANTLE?



EXTREME CHEMISTRY.
During a simulation of the conditions in Earth's mantle, this bubble of methane formed when researchers mixed iron oxide, calcite, and water at high temperature and pressure.
A logical repository for mantle methane would be in olivine.

Source: Stanley B. Keith, MagmaChem.com

Hydrothermal Dolomite



Zoned sucrosic dolomite with pyrobitumen formed during hydrothermal dolomite formation

-from Amsterdam, NY HTD; photo courtesy of Taury Smith

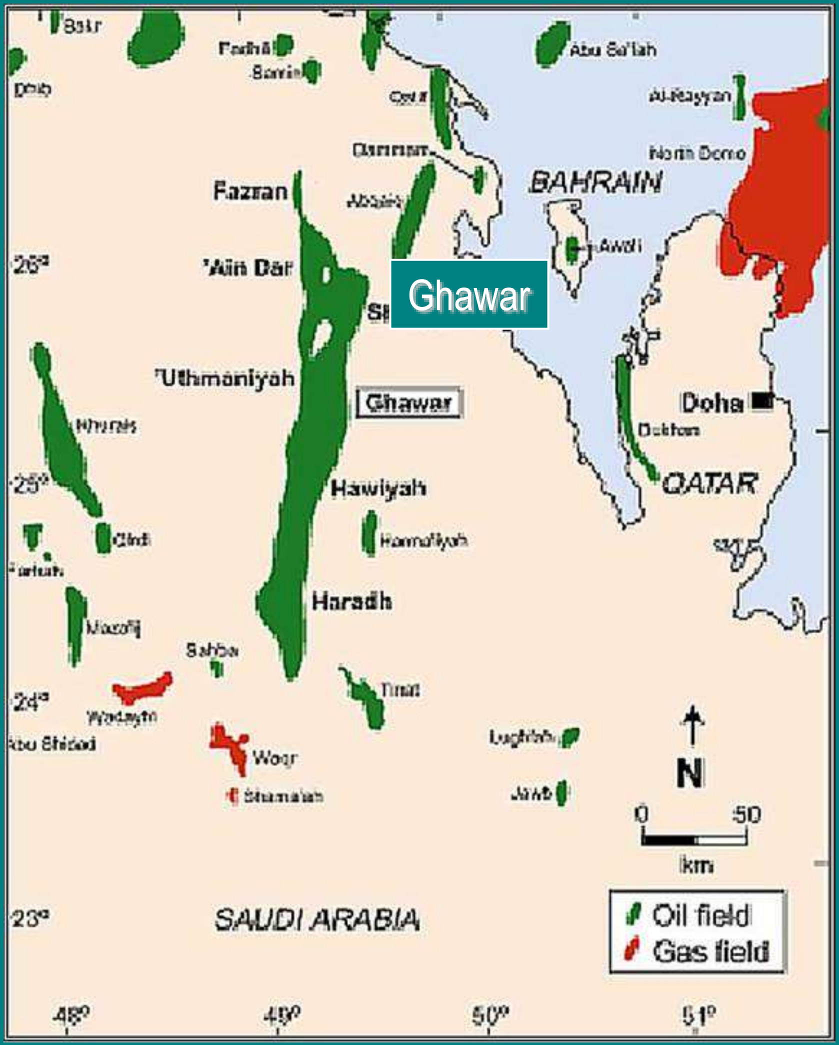
Hydrocarbon-bearing Hydrothermal Dolomite (HTD's)

-In cratonic basin geotectonic settings hydrocarbon bearing hydrothermal dolomite reservoirs exist beneath virtually every petroleum accumulations

-Formation of hydrothermal dolomite implies carbon and magnesium addition from magnesium and hydrocarbon-charged brines sourced in serpentinized peridotite beneath the cratonic basin.

Source: Stanley B. Keith, MagmaChem.com

Hydrothermal Dolomite



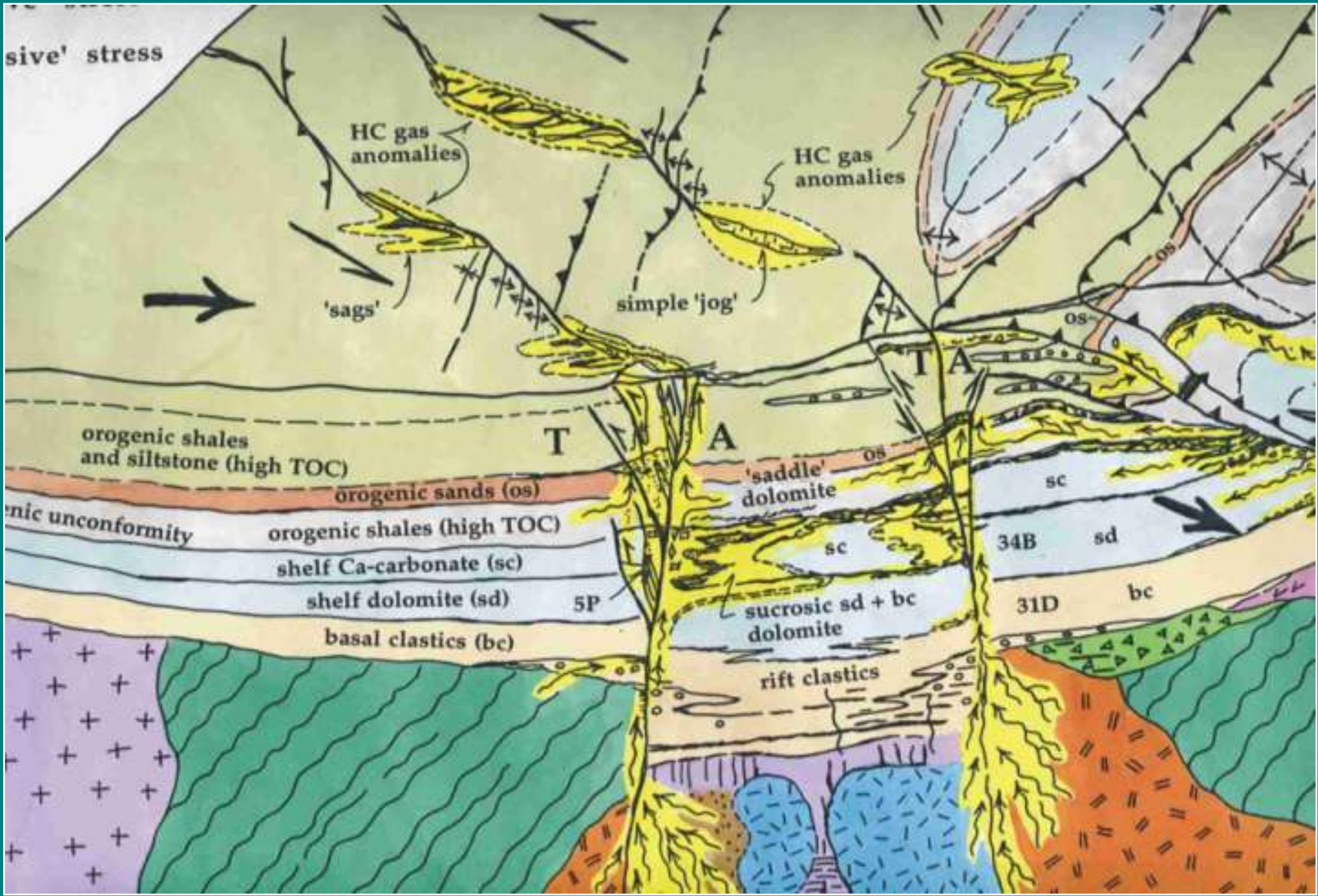
HTD deposits may be the largest hydrothermal systems in the world

Location of the supergiant Ghawar oil field, Saudi Arabia

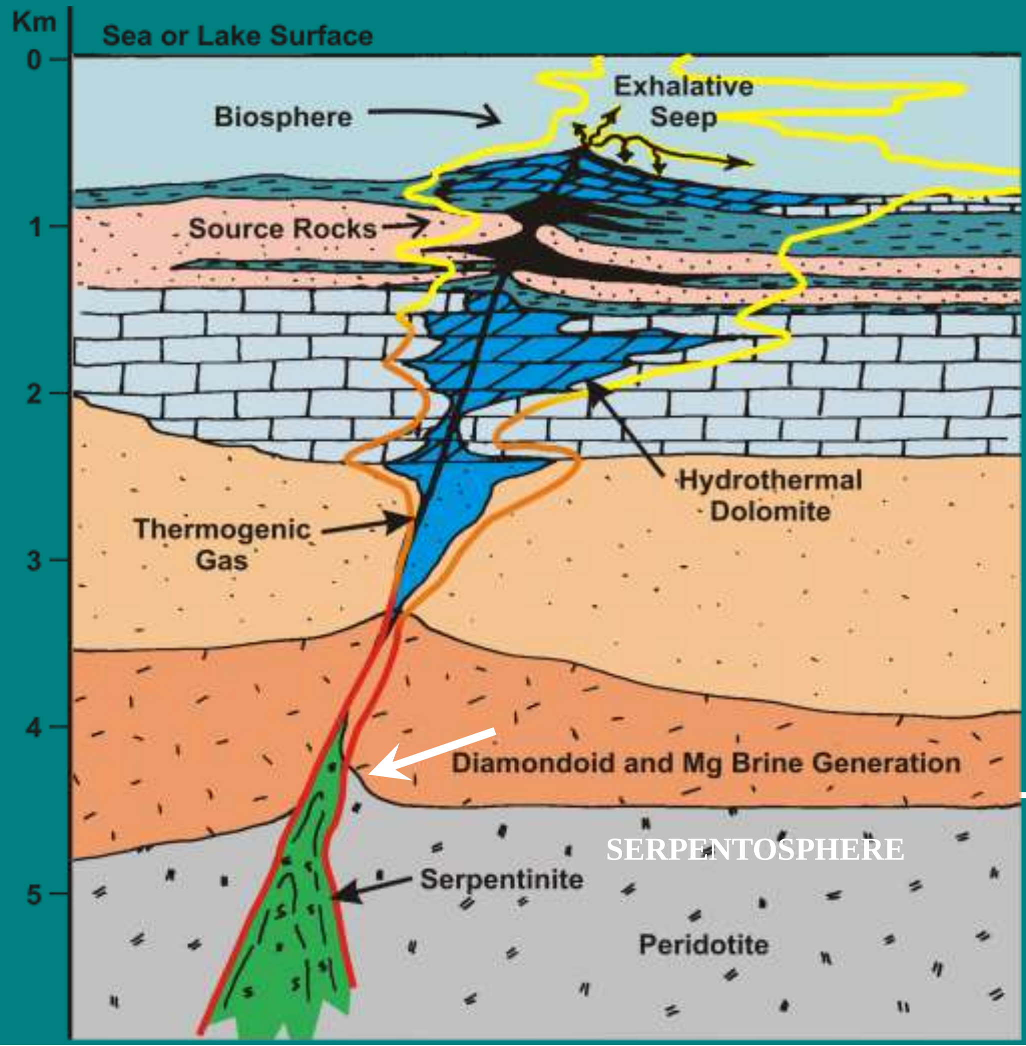
Source: Stanley B. Keith, MagmaChem.com

Hydrothermal Dolomite

Model for Formation of HTD Hydrocarbon Deposits in the Northern Appalachian Basin



Generation of Hydrothermal Hydrocarbons via Serpentinization of Peridotite Source



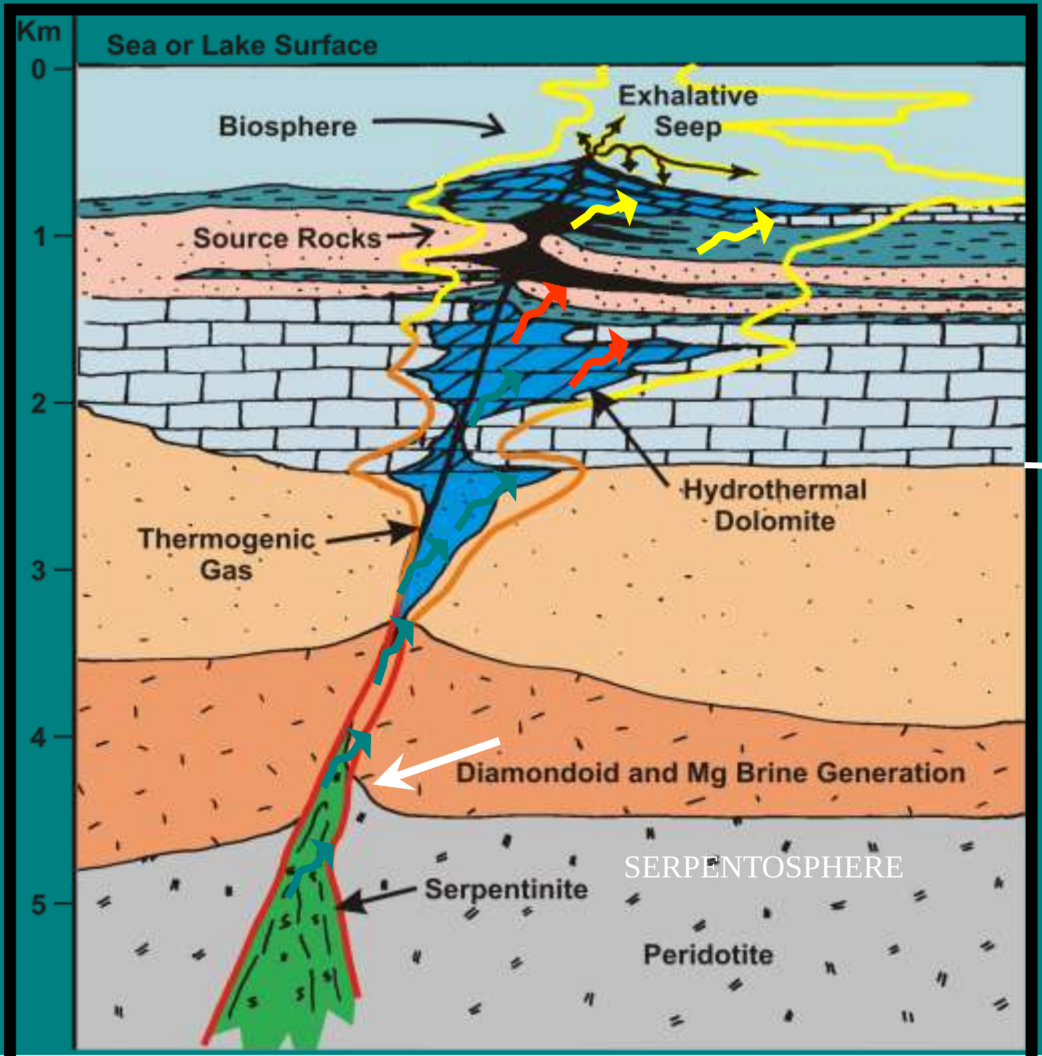
- Nature of Peridotite Source

- Generation of Hydrothermal Hydrocarbon Fluids from the Peridotite Source

- Supercritical Nature of the Hydrothermal Hydrocarbon Fluids

I
Fluid Generation in Serpentinized Source Region

Migration of Hydrothermal Hydrocarbons from Serpentinite Source to Trap Environments in the Upper Crust



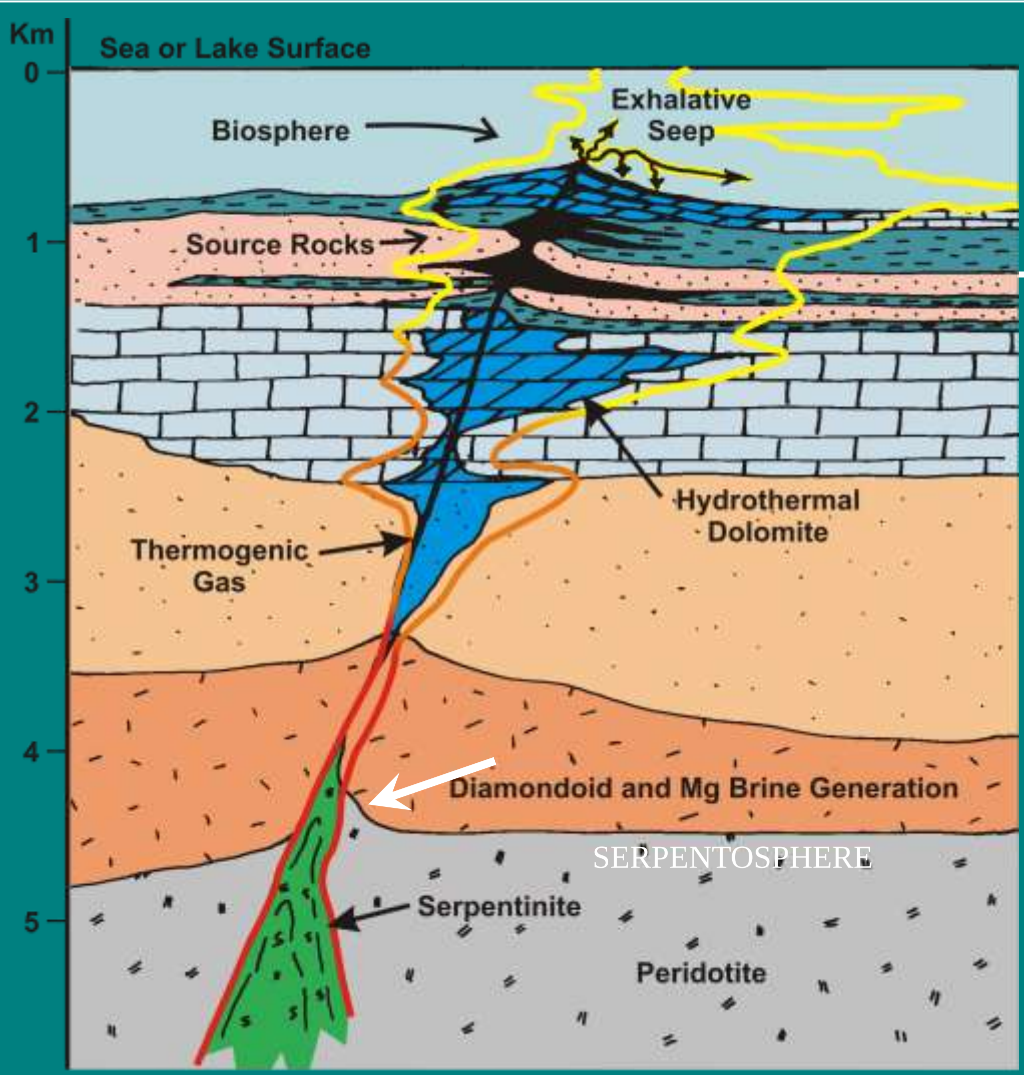
- Fluids travel through the basement in a supercritical state

- Fluids may deposit thermogenic gas in high pressure, footwall tensile structural trap environments within the basement

- Expanded volume of serpentinite relative to peridotite induces a highly-geopressured catapulsion of fluid product out of serpentinized basement source

II
Hydrothermal Supercritical Hydrocarbon Fluid Migration through the Crust Utilizing Crustal Scale Fractures (Cracks of the World)

Formation of Hydrothermal Dolomite-Hosted Hydrocarbon Reservoirs



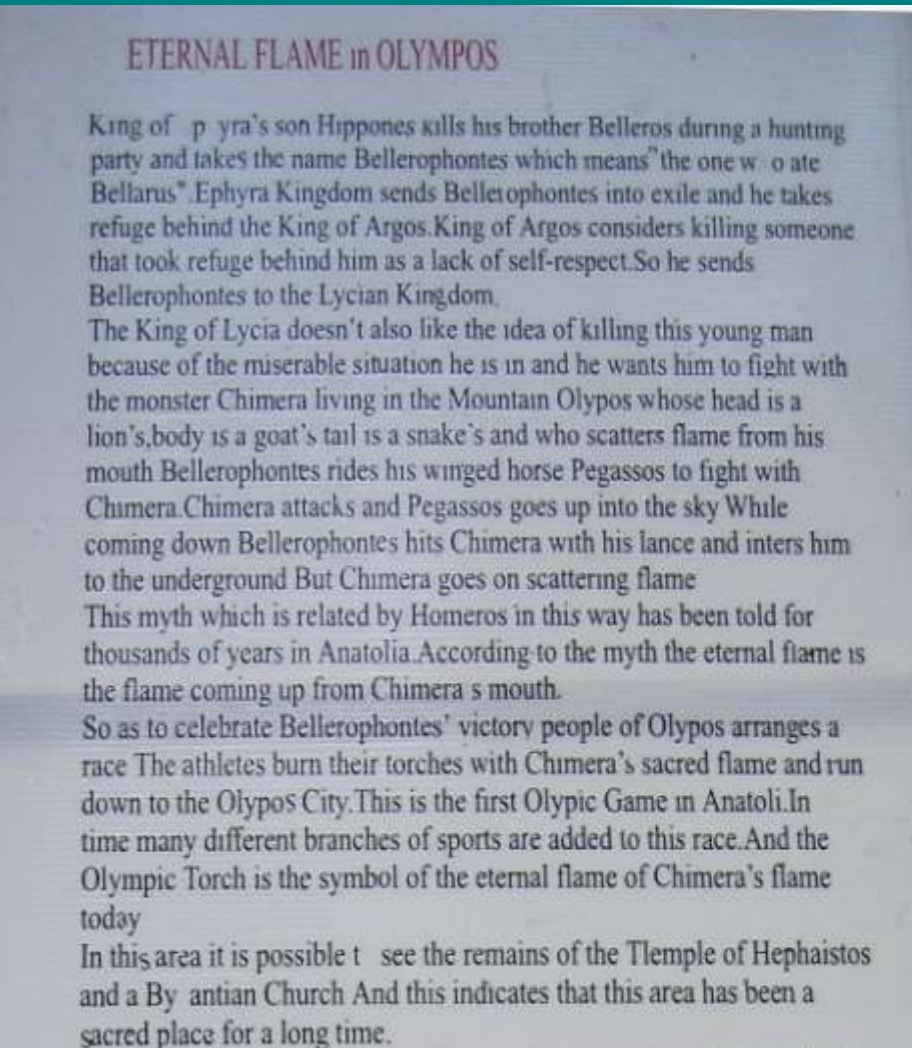
III
Epigenetic Deposition of Hydrothermal Hydrocarbon in Structural and Stratigraphic Traps Within Sedimentary Basins of the Upper Crust

SERPENTINITE-RELATED METHANE SEEP AT CIRALI, TURKEY AND THE ORIGIN OF THE OLYMPIC FLAME

Source: Stanley B. Keith, MagmaChem.com

Serpentinization and the Olympic Flame

The Legend



ETERNAL FLAME in OLYMPOS

King of p yra's son Hippones kills his brother Belleros during a hunting party and takes the name Bellerophontes which means"the one w o ate Bellarus".Ephyra Kingdom sends Bellerophontes into exile and he takes refuge behind the King of Argos.King of Argos considers killing someone that took refuge behind him as a lack of self-respect.So he sends Bellerophontes to the Lycian Kingdom.

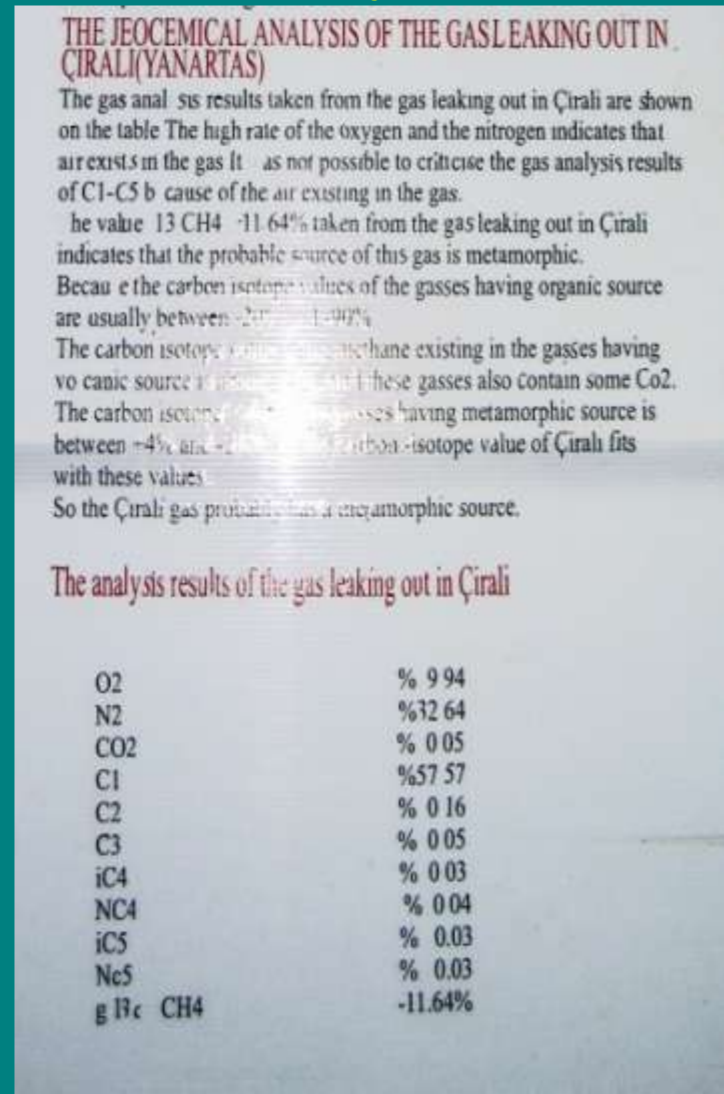
The King of Lycia doesn't also like the idea of killing this young man because of the miserable situation he is in and he wants him to fight with the monster Chimera living in the Mountain Olypos whose head is a lion's,body is a goat's tail is a snake's and who scatters flame from his mouth Bellerophontes rides his winged horse Pegassos to fight with Chimera.Chimera attacks and Pegassos goes up into the sky While coming down Bellerophontes hits Chimera with his lance and inters him to the underground But Chimera goes on scattering flame

This myth which is related by Homeros in this way has been told for thousands of years in Anatolia.According to the myth the eternal flame is the flame coming up from Chimera s mouth.

So as to celebrate Bellerophontes' victory people of Olypos arranges a race The athletes burn their torches with Chimera's sacred flame and run down to the Olypos City.This is the first Olypic Game in Anatoli.In time many different branches of sports are added to this race.And the Olympic Torch is the symbol of the eternal flame of Chimera's flame today

In this area it is possible t see the remains of the Tlemple of Hephaistos and a By antian Church And this indicates that this area has been a sacred place for a long time.

The Reality



THE JEOCEMICAL ANALYSIS OF THE GAS LEAKING OUT IN ÇIRALI(YANARTAS)

The gas anal sis results taken from the gas leaking out in Çirali are shown on the table The high rate of the oxygen and the nitrogen indicates that air exists in the gas It as not possible to criticise the gas analysis results of C1-C5 b cause of the air existing in the gas.

he value 13 CH4 -11 64% taken from the gas leaking out in Çirali indicates that the probable source of this gas is metamorphic.

Becau e the carbon isotope [illegible] of the gasses having organic source are usually between [illegible]

The carbon isotope [illegible] methane existing in the gasses having vo canic source [illegible] hese gasses also contain some Co2.

The carbon isoto [illegible] sses having metamorphic source is between -4% an [illegible] rbon -isotope value of Çiralı fits with these values

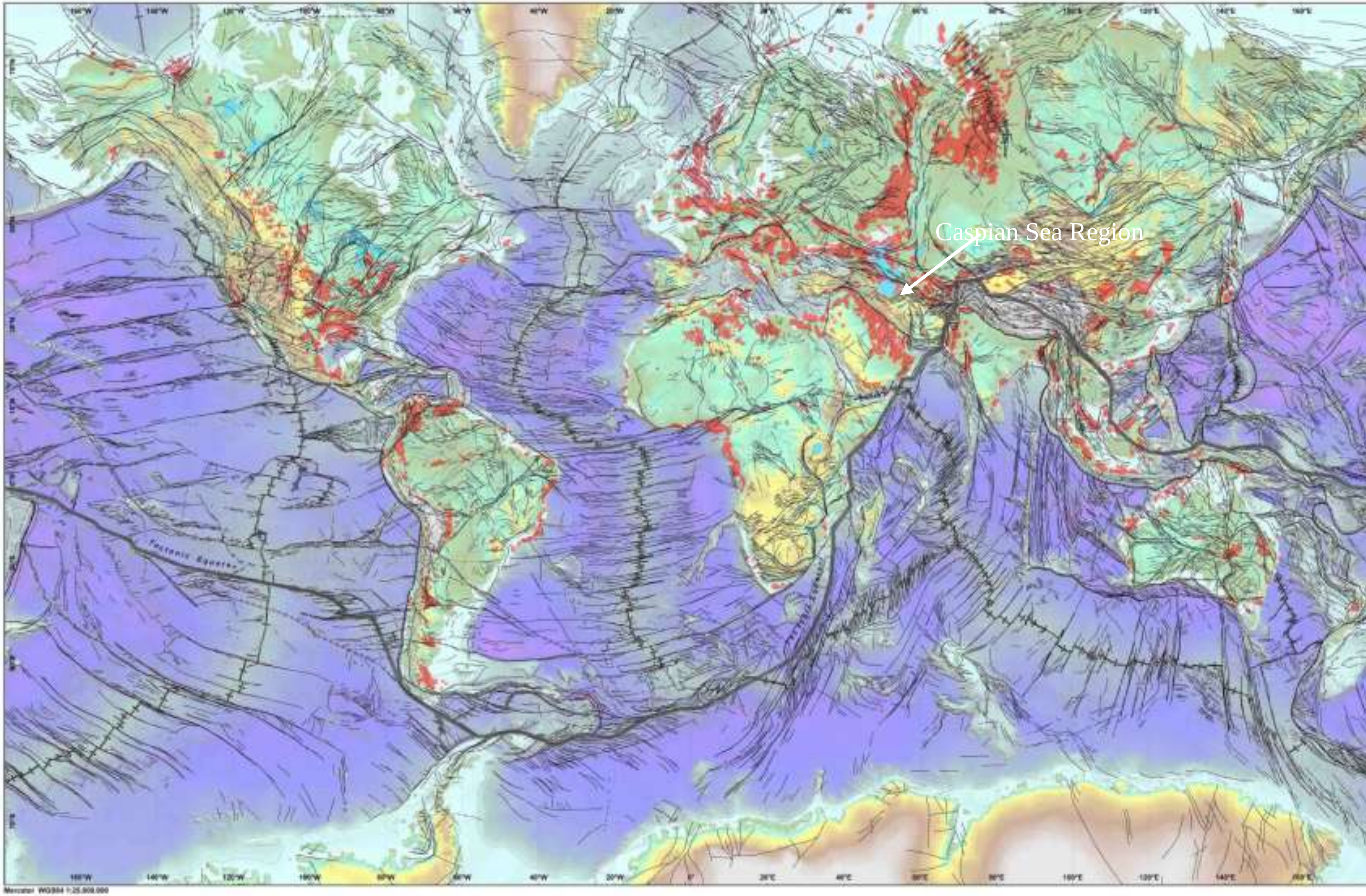
So the Çiralı gas prob [illegible] a metamorphic source.

The analysis results of the gas leaking out in Çirali

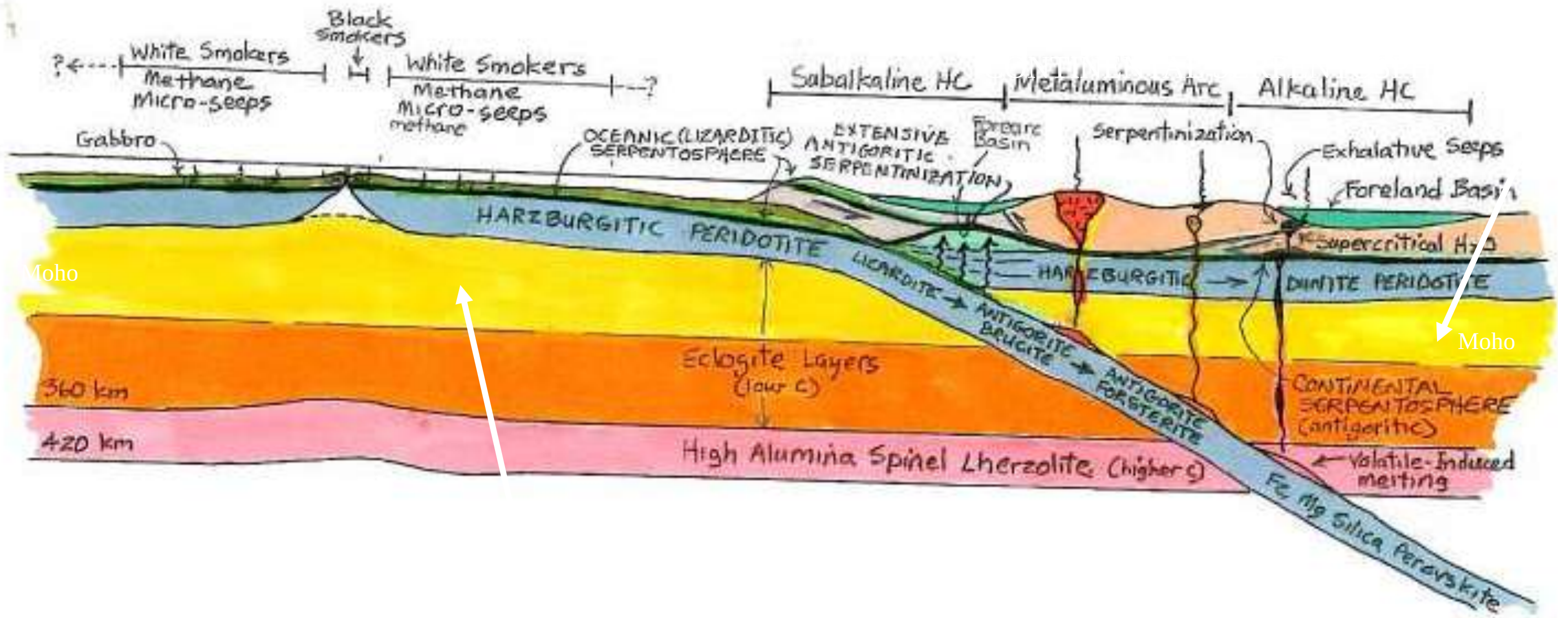
O2	% 9 94
N2	%32 64
CO2	% 0 05
C1	%57 57
C2	% 0 16
C3	% 0 05
iC4	% 0 03
NC4	% 0 04
iC5	% 0.03
Nc5	% 0.03
g 13c CH4	-11.64%

Source: Stanley B. Keith, MagmaChem.com

CRACKS OF THE WORLD – MARCH 2007

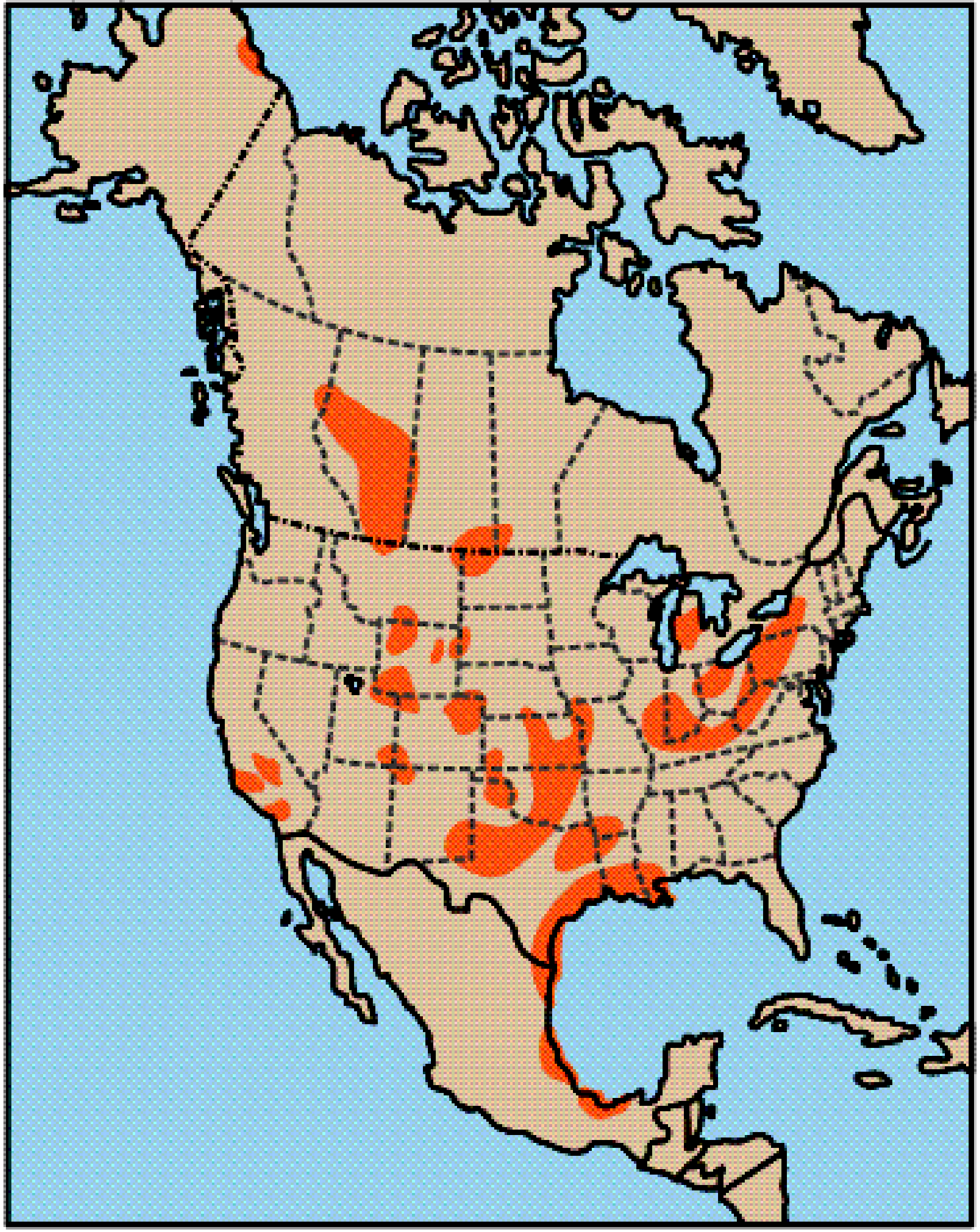


POSITION OF SERPENTOSPHERE IN OCEANIC AND CONTINENTAL SUBDUCTION SETTINGS



Source: Stanley B. Keith, MagmaChem.com

Major Oil Fields in North America



Petroleum basins in the U.S.

18.02.c5

Oil & Natural Gas

- Recovering oil
  - Environmental effects
- How much oil do we have left?
  - World situation
  - Outlook in United States

Oil and Natural Gas

- **Petroleum:** complex suite of chemical compounds including oil and natural gas associated with it
- **Oil:** a variety of heavy liquid hydrocarbon compounds
- **Natural Gas:** gaseous hydrocarbon compound most commonly methane (CH_4)

Formation of Oil and Gas Deposits

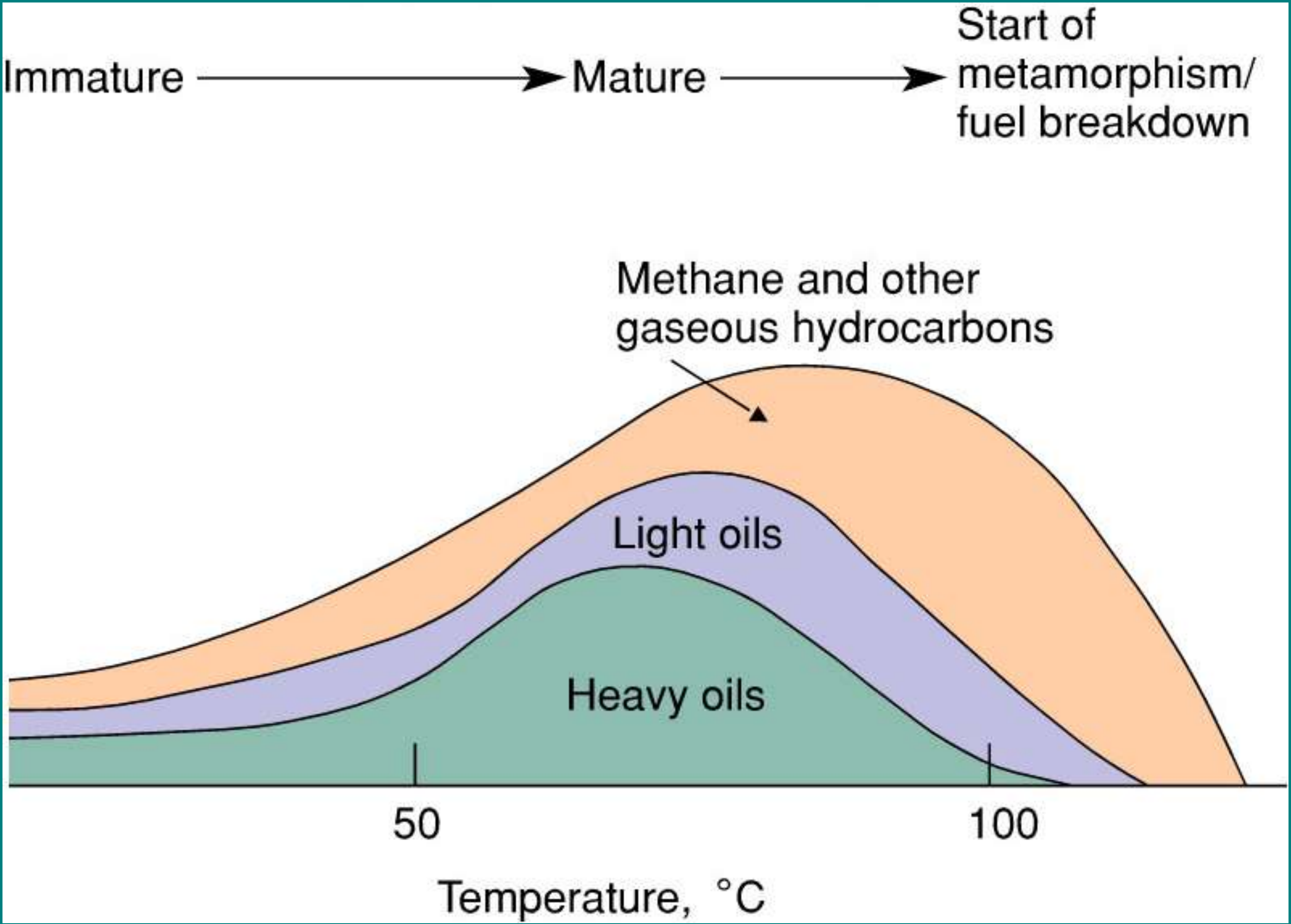
- A mixture of hydrocarbon products are derived from most oil fields
- The time and history of the formation of the energy deposit are factors
  - Heat and pressure act to modify the organic molecules
  - Large organic molecules (‘heavy’ hydrocarbons) will be broken down into smaller molecules (‘lighter’ hydrocarbons)

Formation of Oil and Gas Deposits

- Organic matter, rich in carbon and hydrogen, accumulate and are rapidly buried
- Rapid burial aids in the decay of the organic material protecting it from oxygen and biological reactions that would destroy the formation of the hydrocarbons
- Source of the organic material is microscopic life abundant in the seas of the earth
  - These organisms die and their remains settle to the sea floor
  - Some natural gases are derived by burial of massive amount of plant material

Formation of oil and natural gas

- Organic matter
  - More produced than destroyed by scavengers and decay (high productivity areas with low oxygen)
  - Source beds; maturation; migration during diagenesis
- Source → Migration → Trap
- Types of traps
  - Structural (anticlines, faults)
  - Stratigraphic
  - Salt domes
- Reservoir — *What are the major ones (rock types)?*
  - Porosity
  - Seals

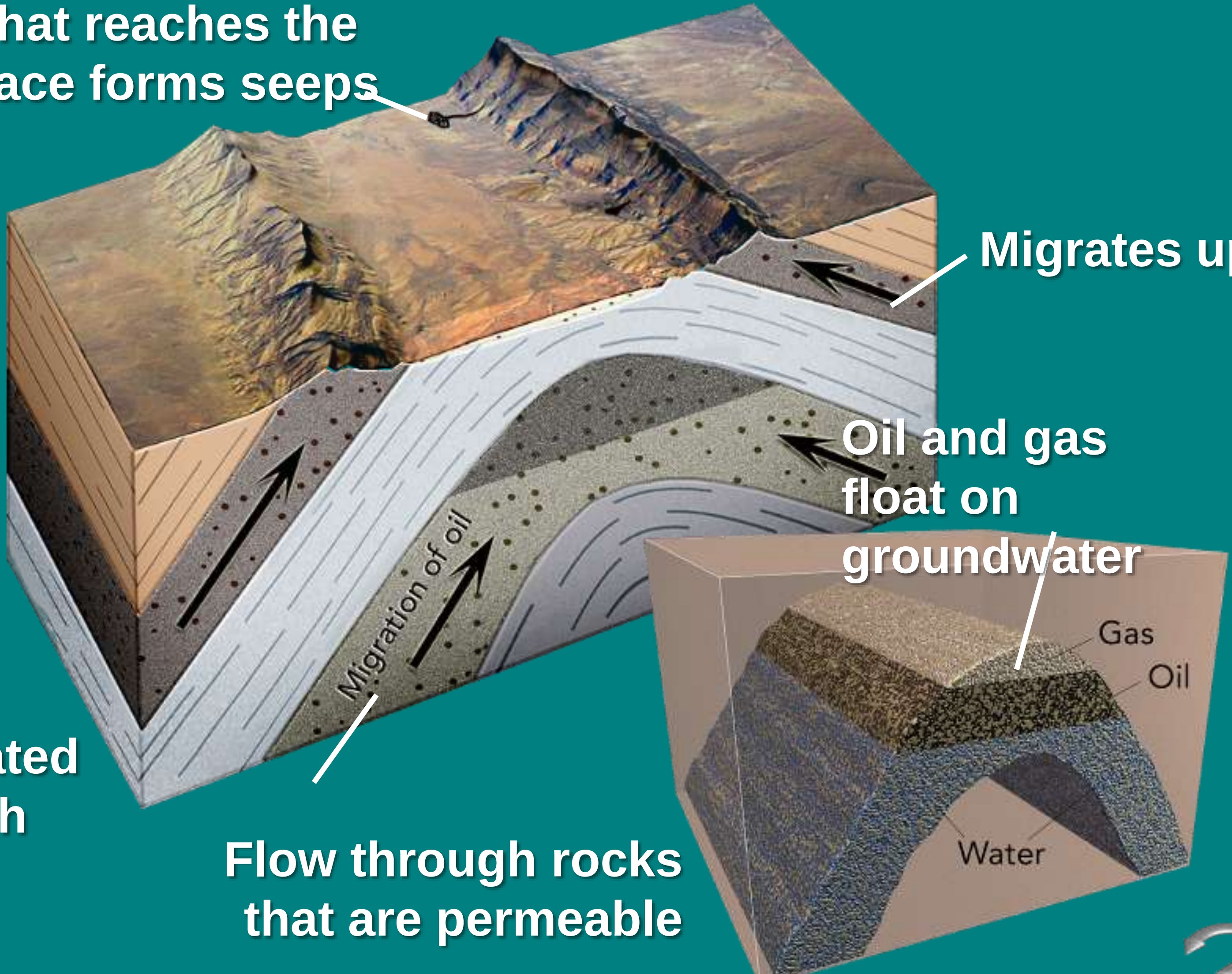


process of petroleum maturation

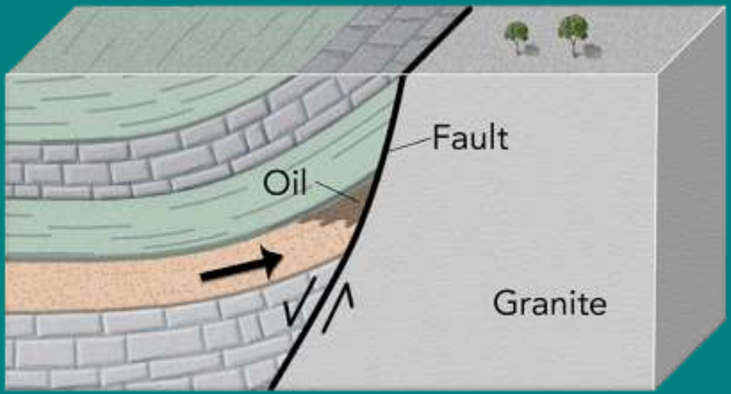
Oil and Gas Migration

- The solid organic matter will be converted to liquids and/or gases (hydrocarbons)
- Liquid and gaseous hydrocarbon will migrate out of the rocks in which they formed
- The migration is required so the hydrocarbon will pool in economically usable deposits
- Reservoir rocks for hydrocarbon are overlain by impermeable caps that trap the migration of the hydrocarbons, otherwise, oil and gas may keep rising to the earth's surface

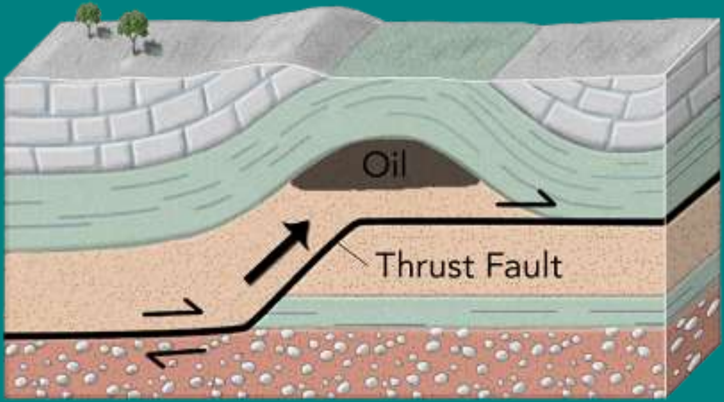
How oil and gas migrate



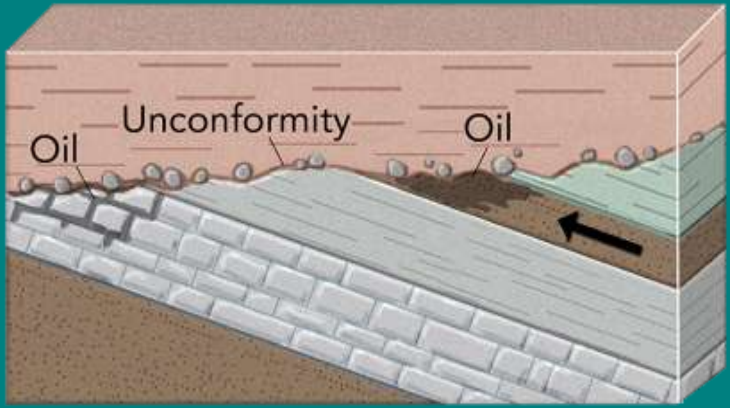
Other Ways Petroleum Is Trapped



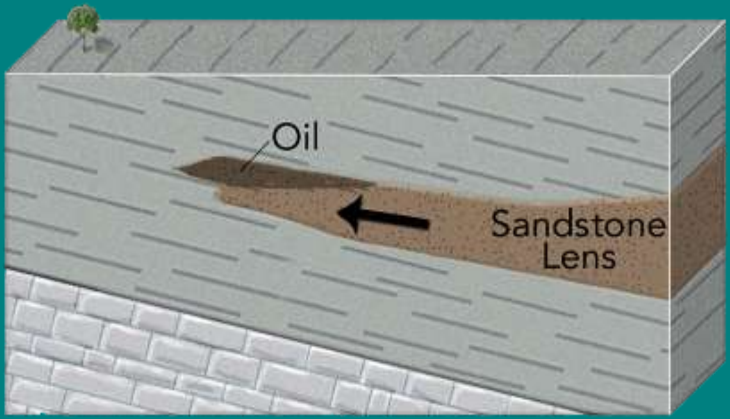
Normal faults



Thrust faults



Unconformities



Lenses

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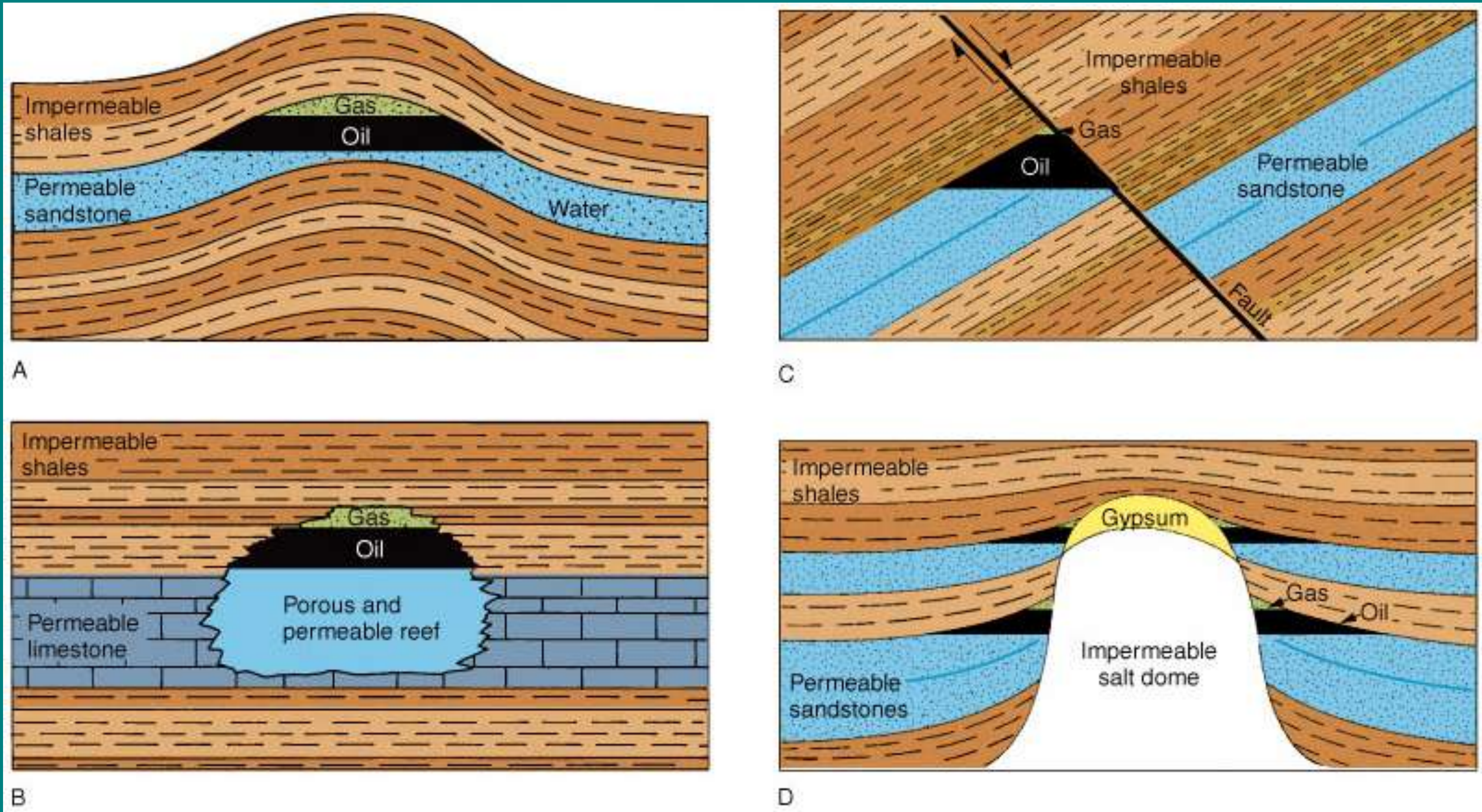
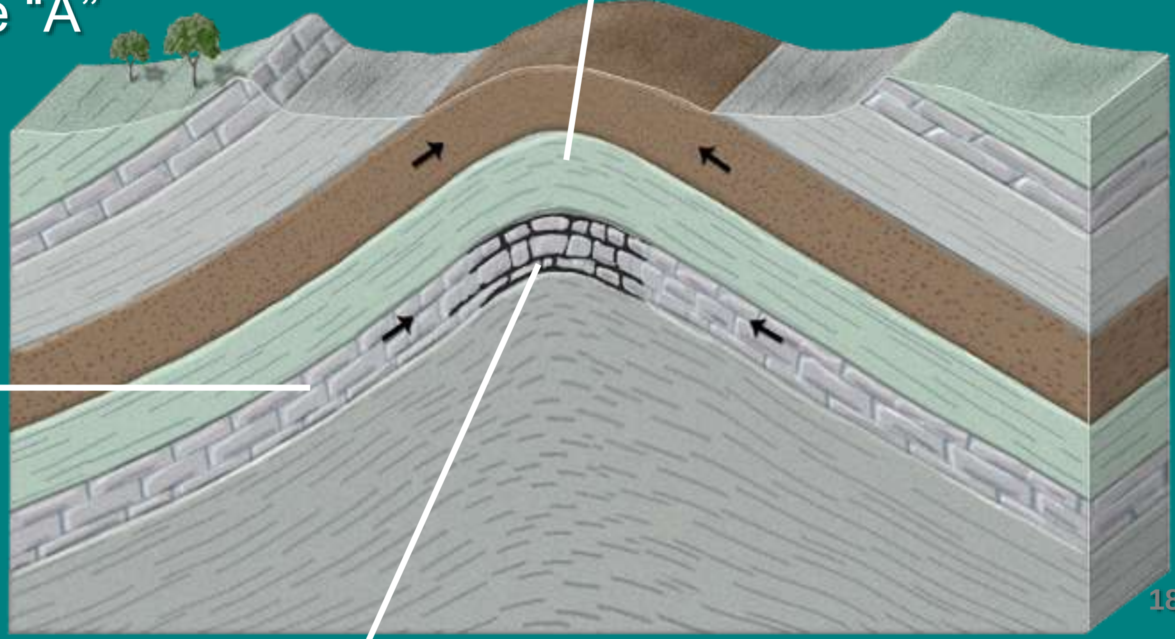


Types of petroleum traps

How Folded Layers Trap Oil and Gas

Most anticlines shaped like “A”

Trapped in anticline below impermeable layer (*cap rock*)



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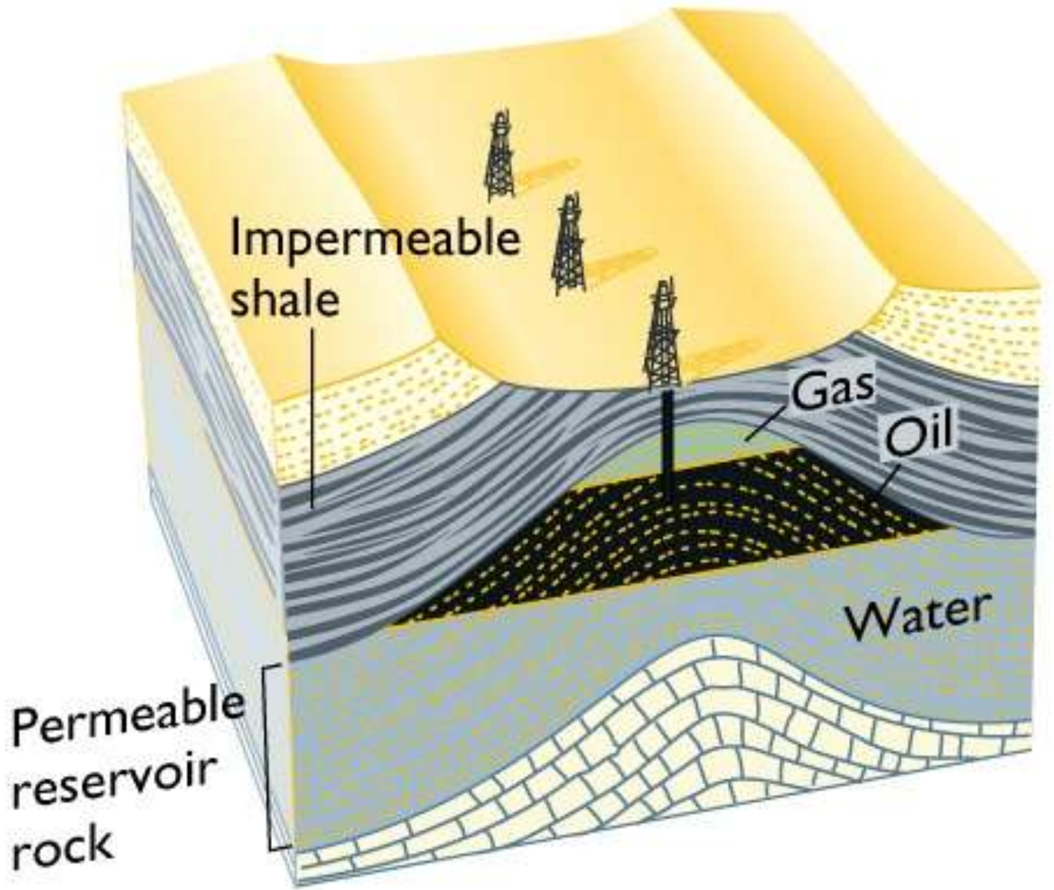
Oil and gas migrate up flanks of anticline

In pore spaces between grains and along bedding planes and fractures in *reservoir rock*

Trap--Structural

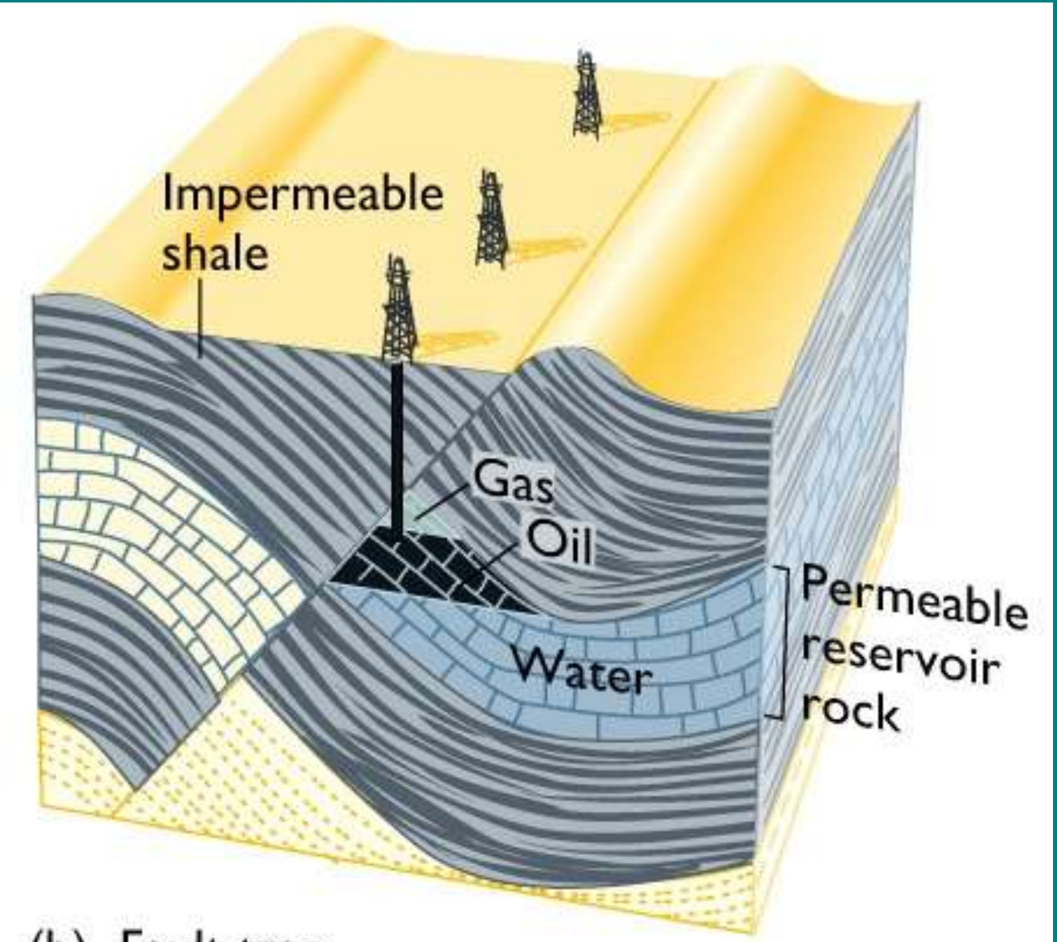
- Anticline

- *Why the sequence gas / oil / water?*



(a) Anticlinal trap

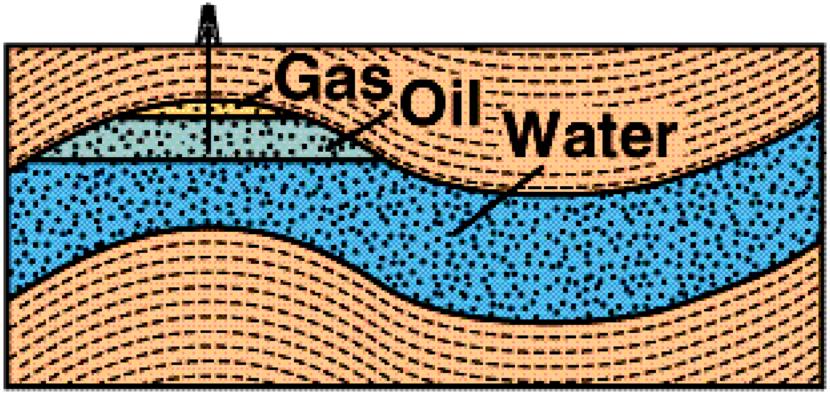
Trap -- Structural



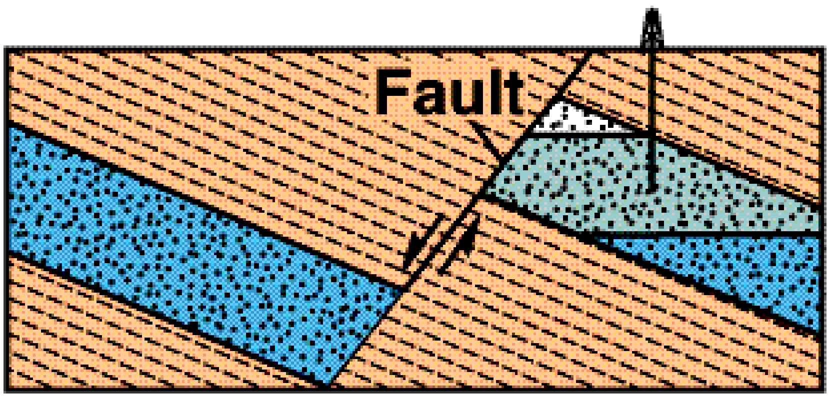
(b) Fault trap

- Thrust faults
- Normal faults

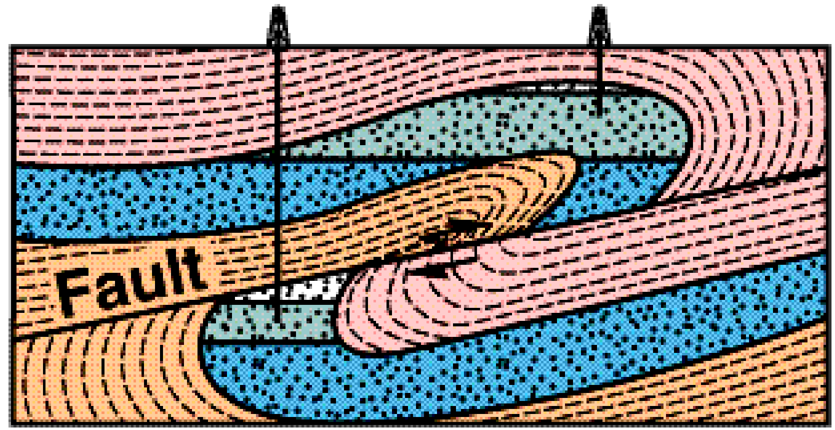
Structural Oil Traps



A Anticline



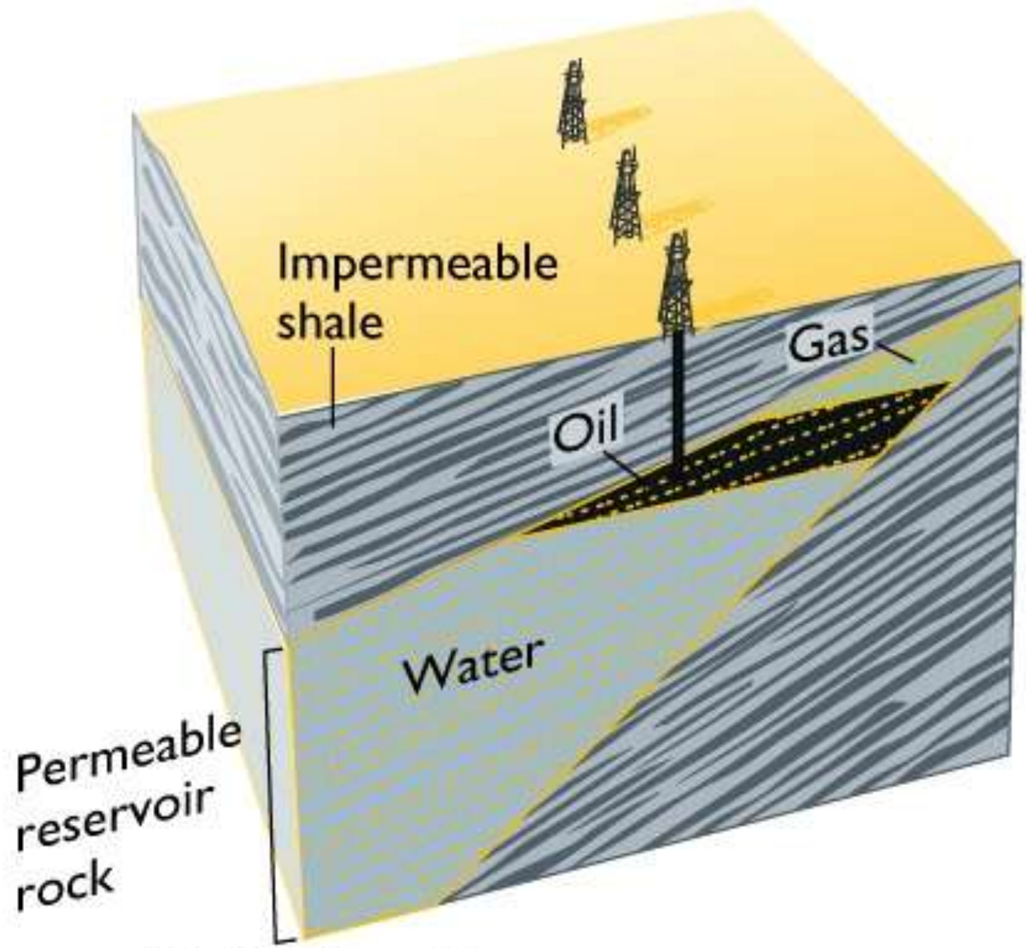
B Normal fault



C Thrust fault

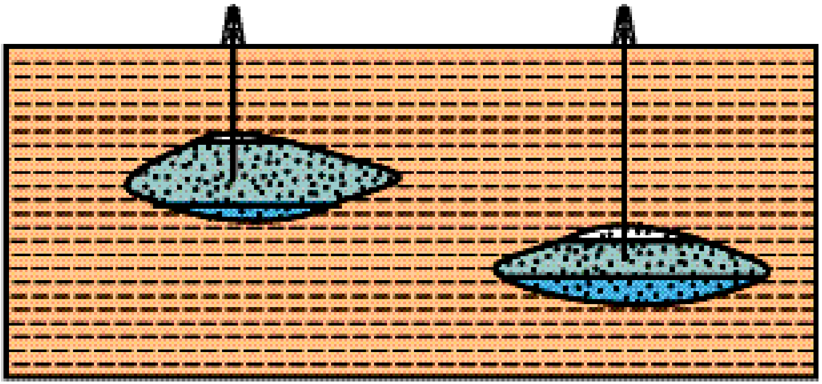
Trap -- Stratigraphic

- Stratigraphic pinch outs in transgressive sequences
- Fluvial channel deposits

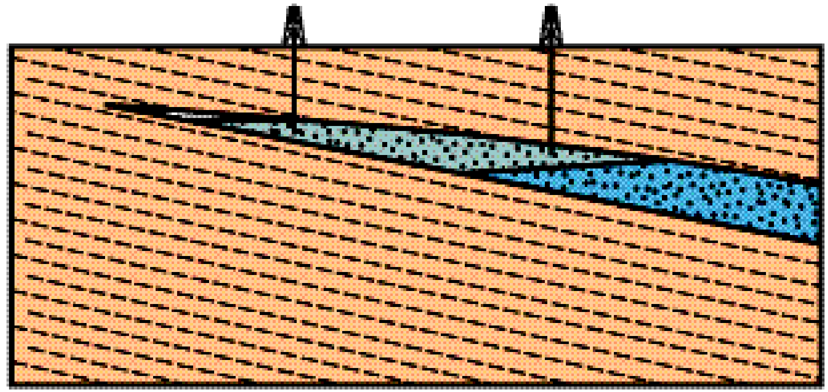


(c) Stratigraphic trap

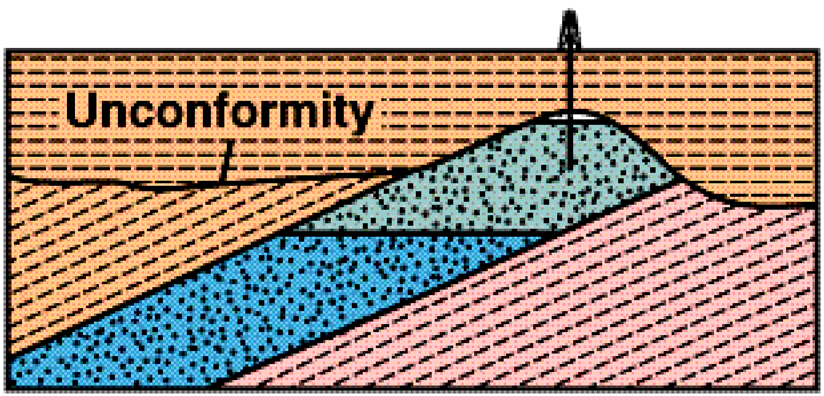
Stratigraphic Oil Traps



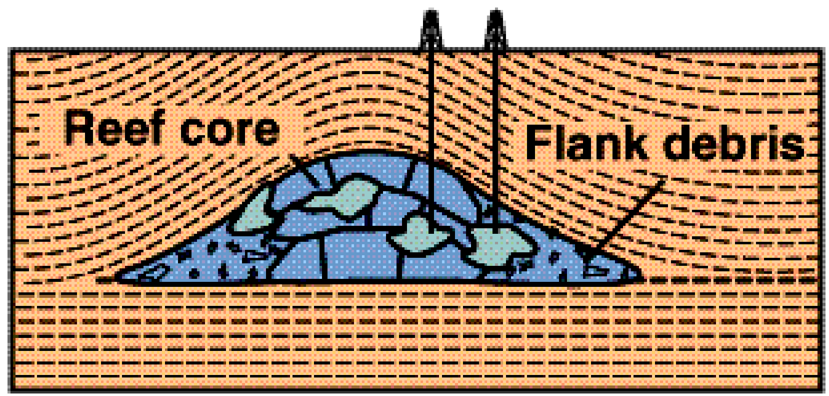
D Sandstone lenses



E Sandstone pinchout



F Unconformity



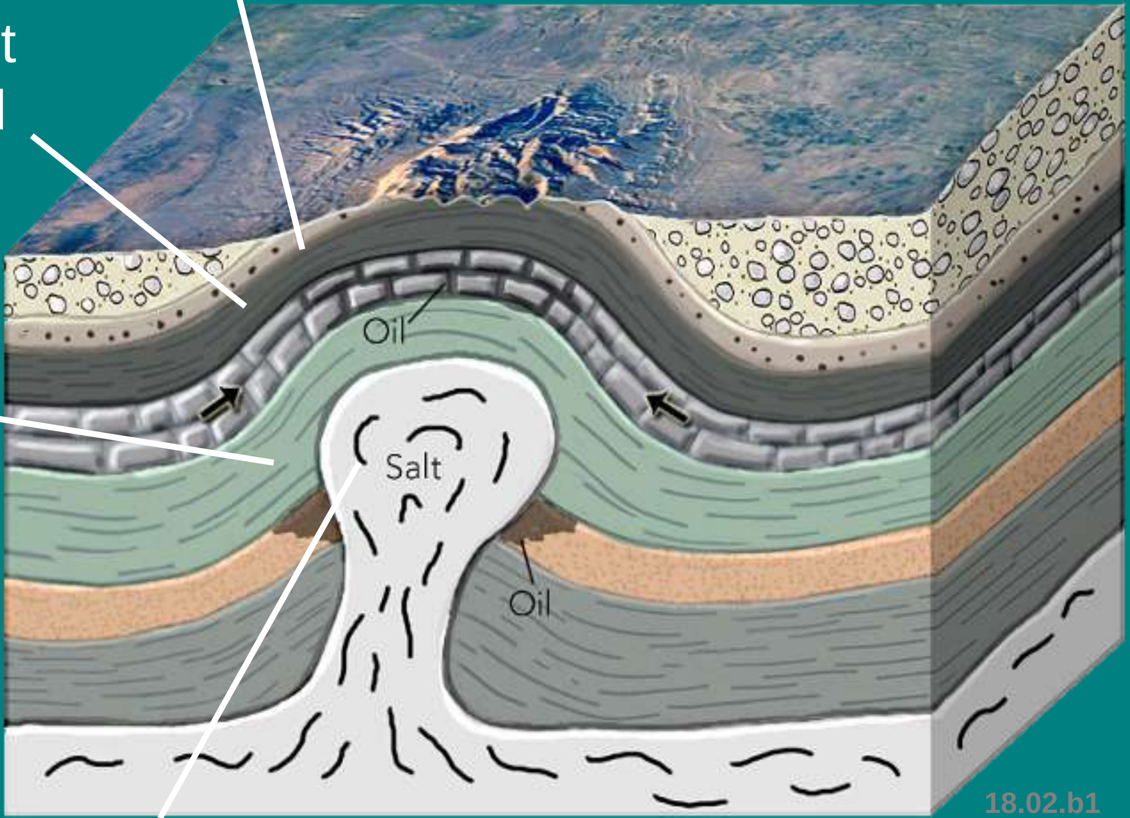
G Reef (a small "patch" reef)

How Salt Domes Trap Oil and Gas

Petroleum trapped in top of dome

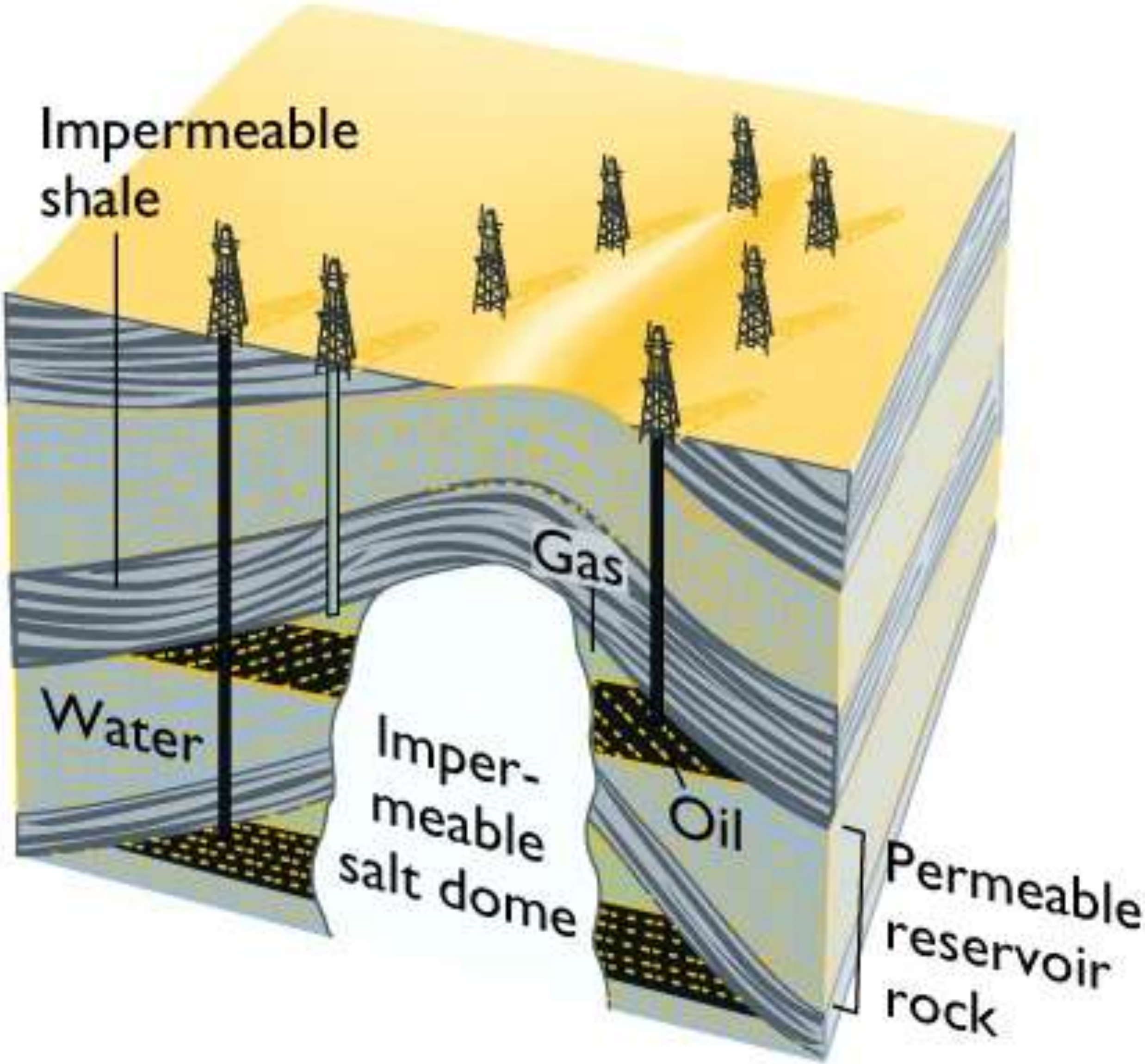
Rocks above salt dome are bowed up

Oil and gas trapped on sides of impermeable dome



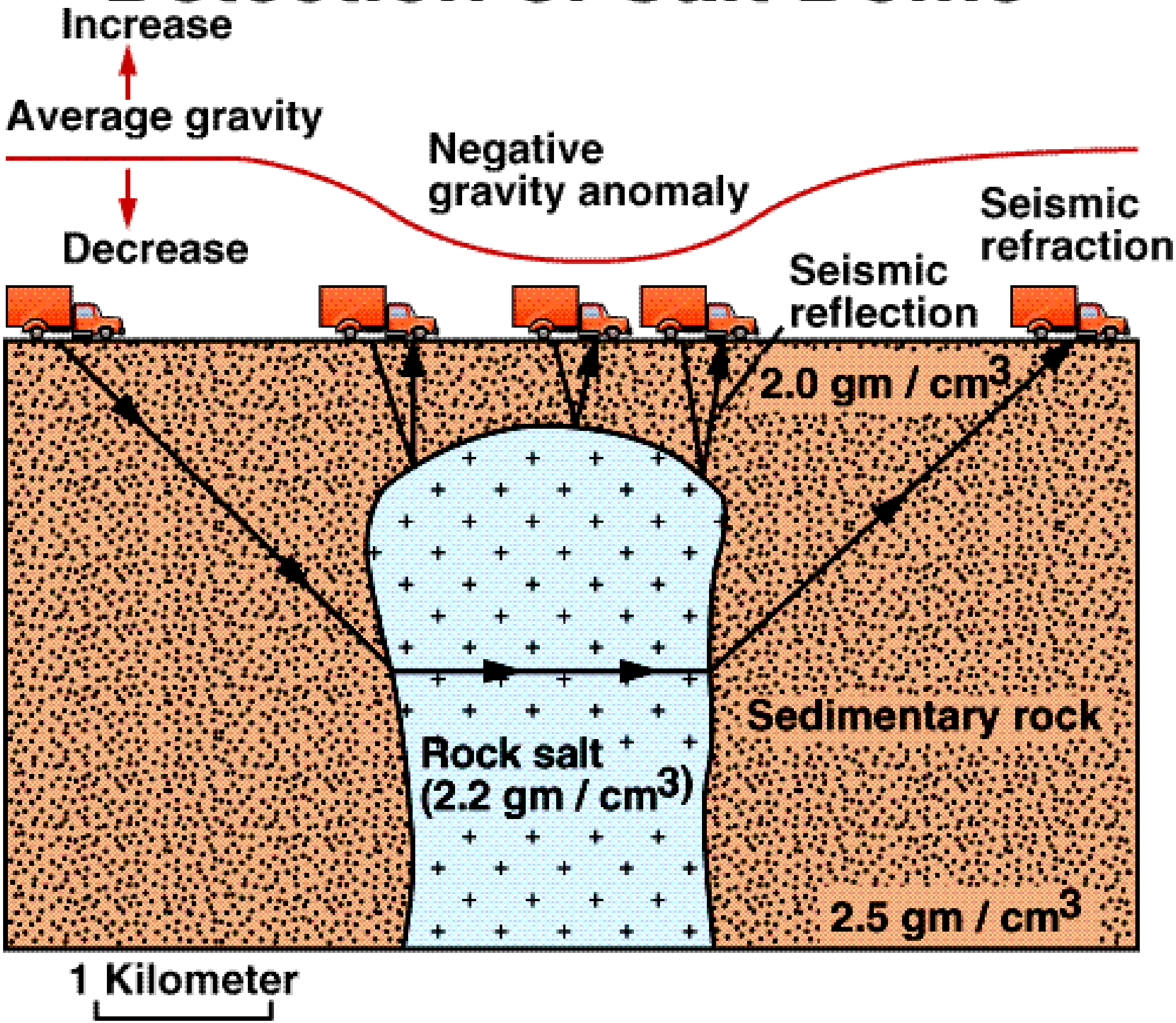
Salt flows up as a weak mass

Salt Domes

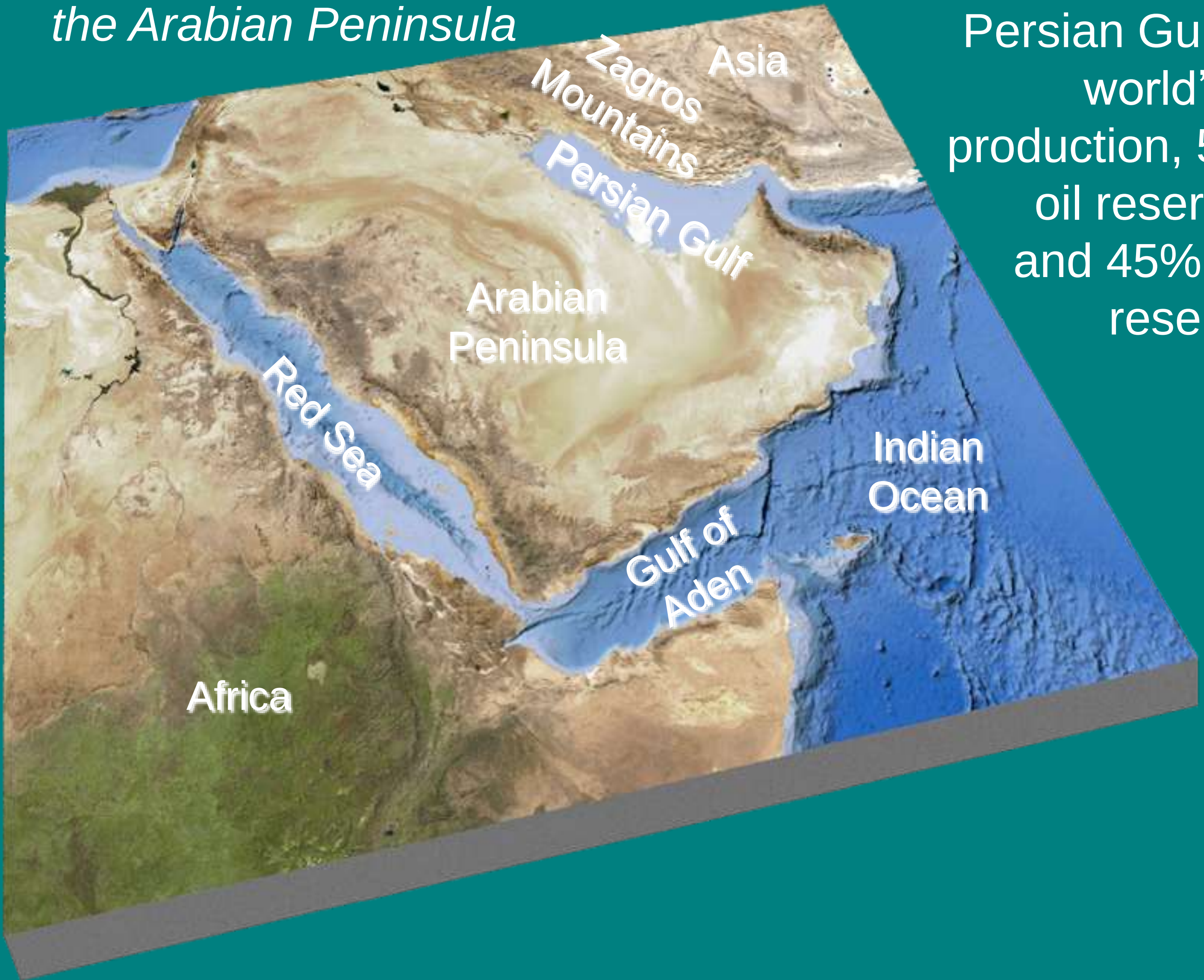


(d) Salt dome trap

Detection of Salt Dome



the region around
the Arabian Peninsula



Persian Gulf: ¼ world's oil production, 57% oil reserves, and 45% gas reserves

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3D

Geologic Setting of Arabian Peninsula

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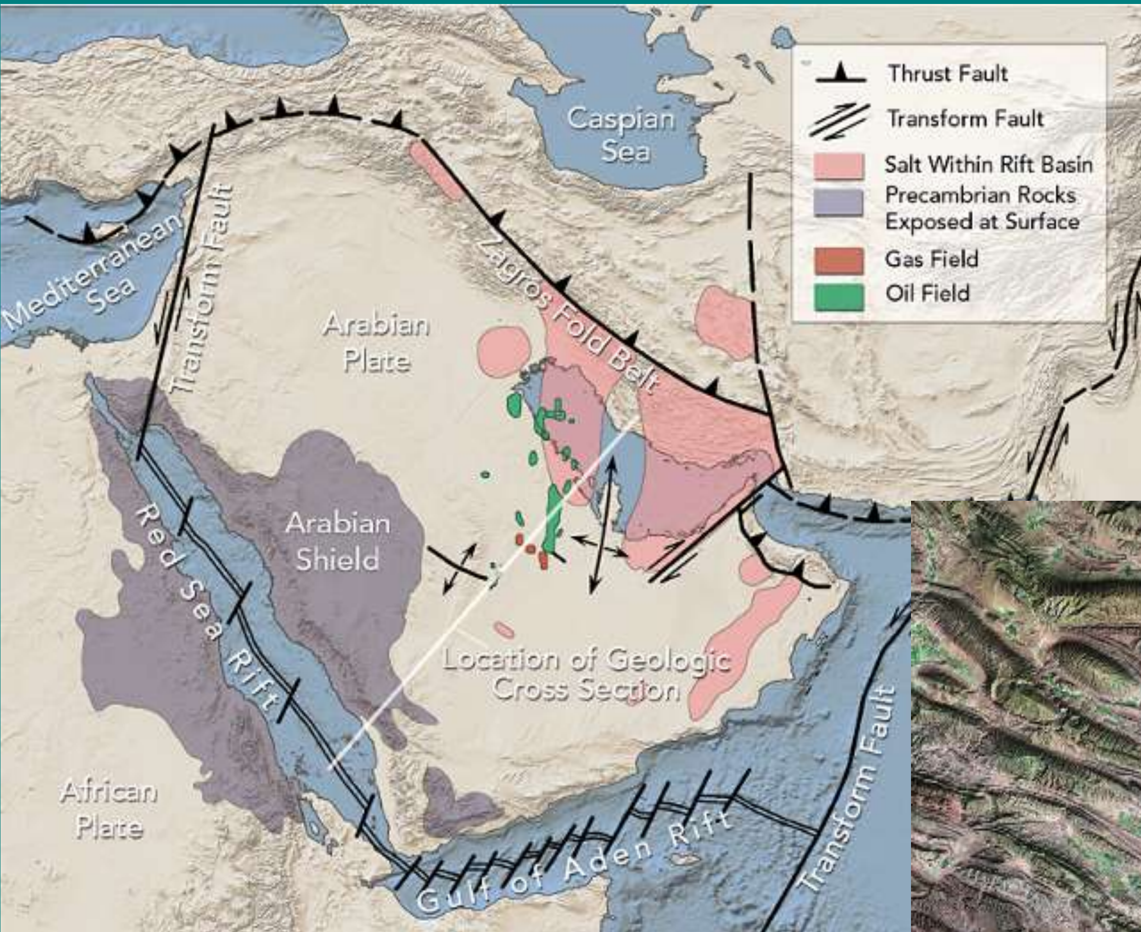
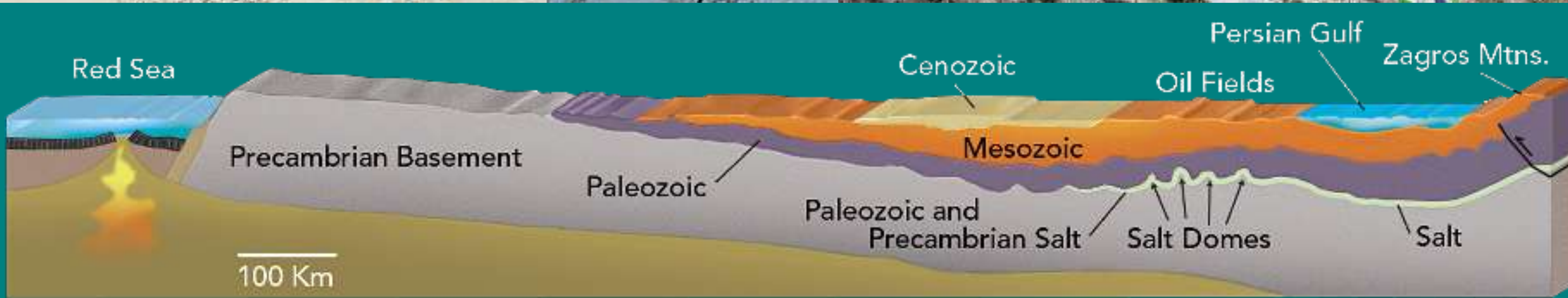
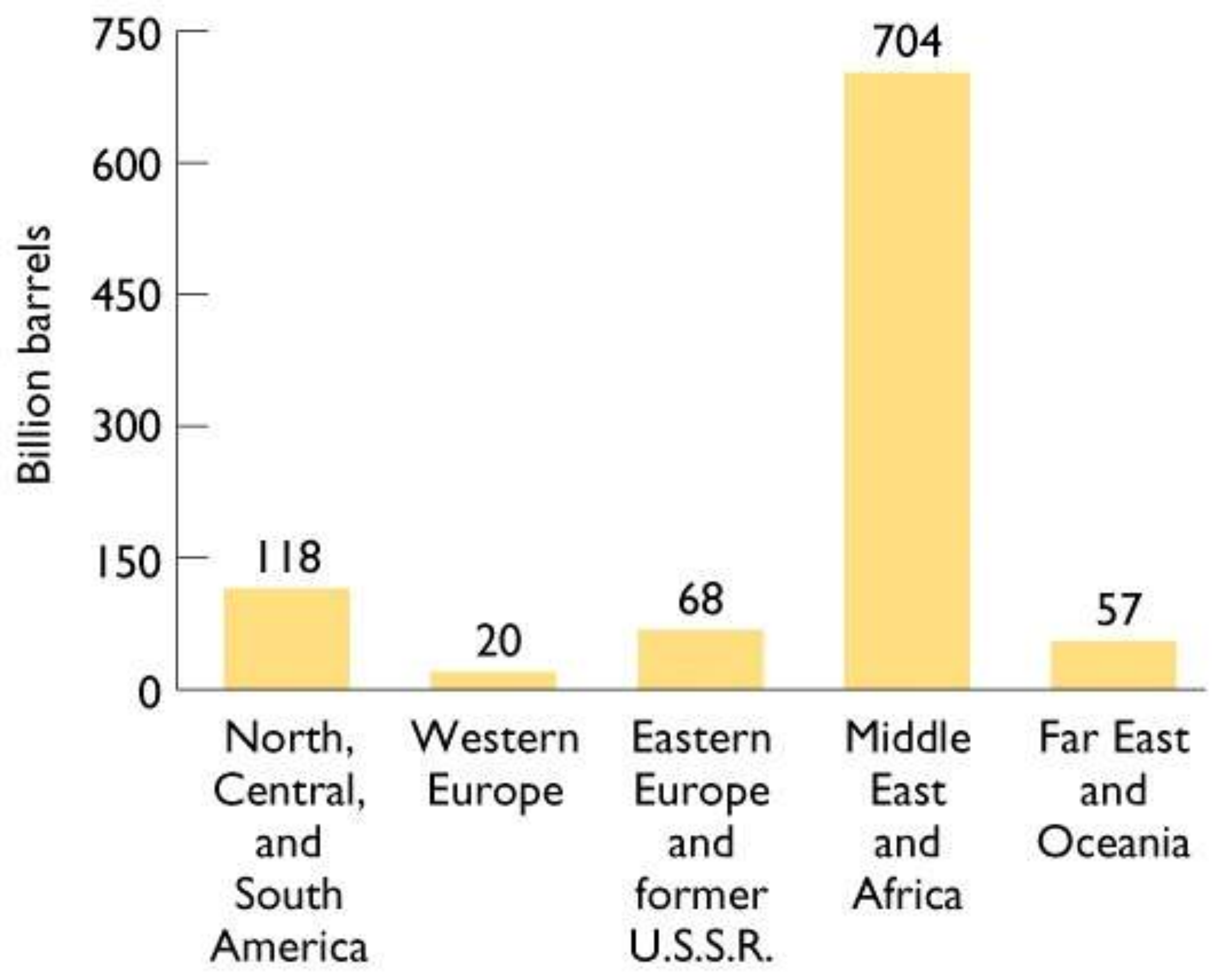
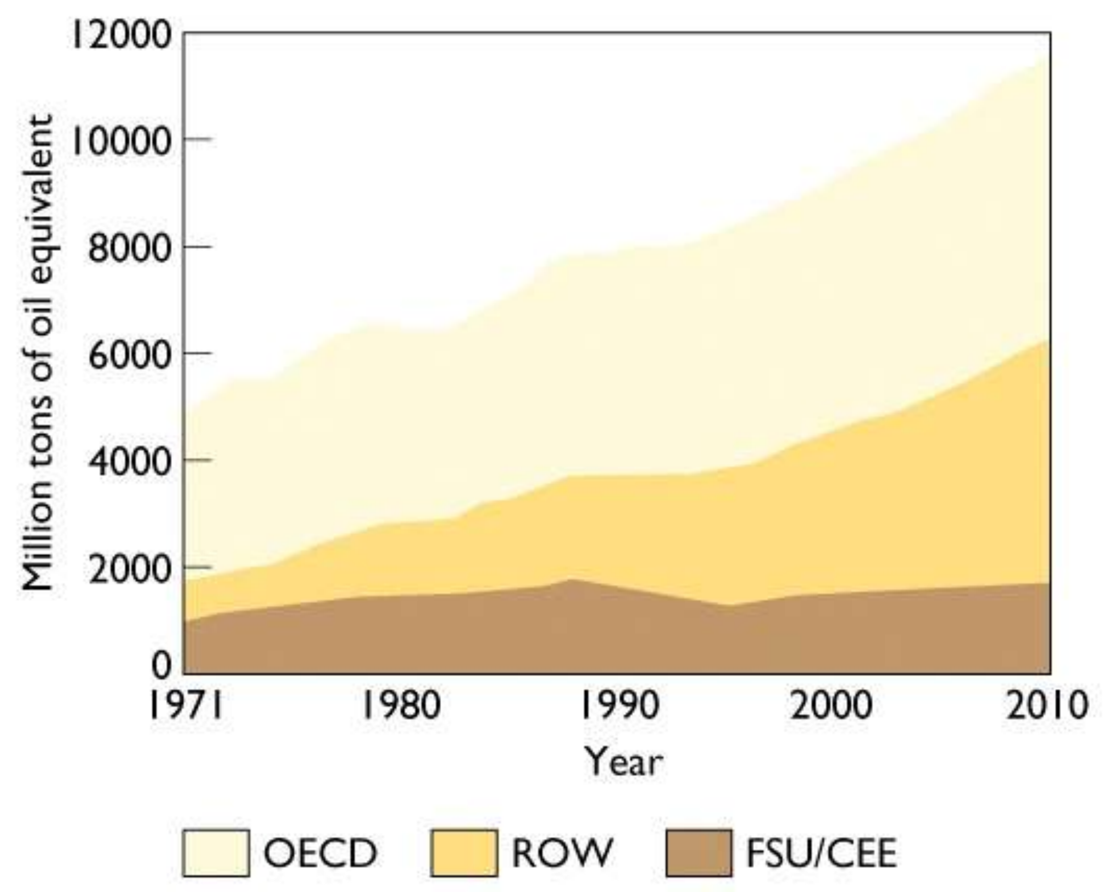




World oil reserves

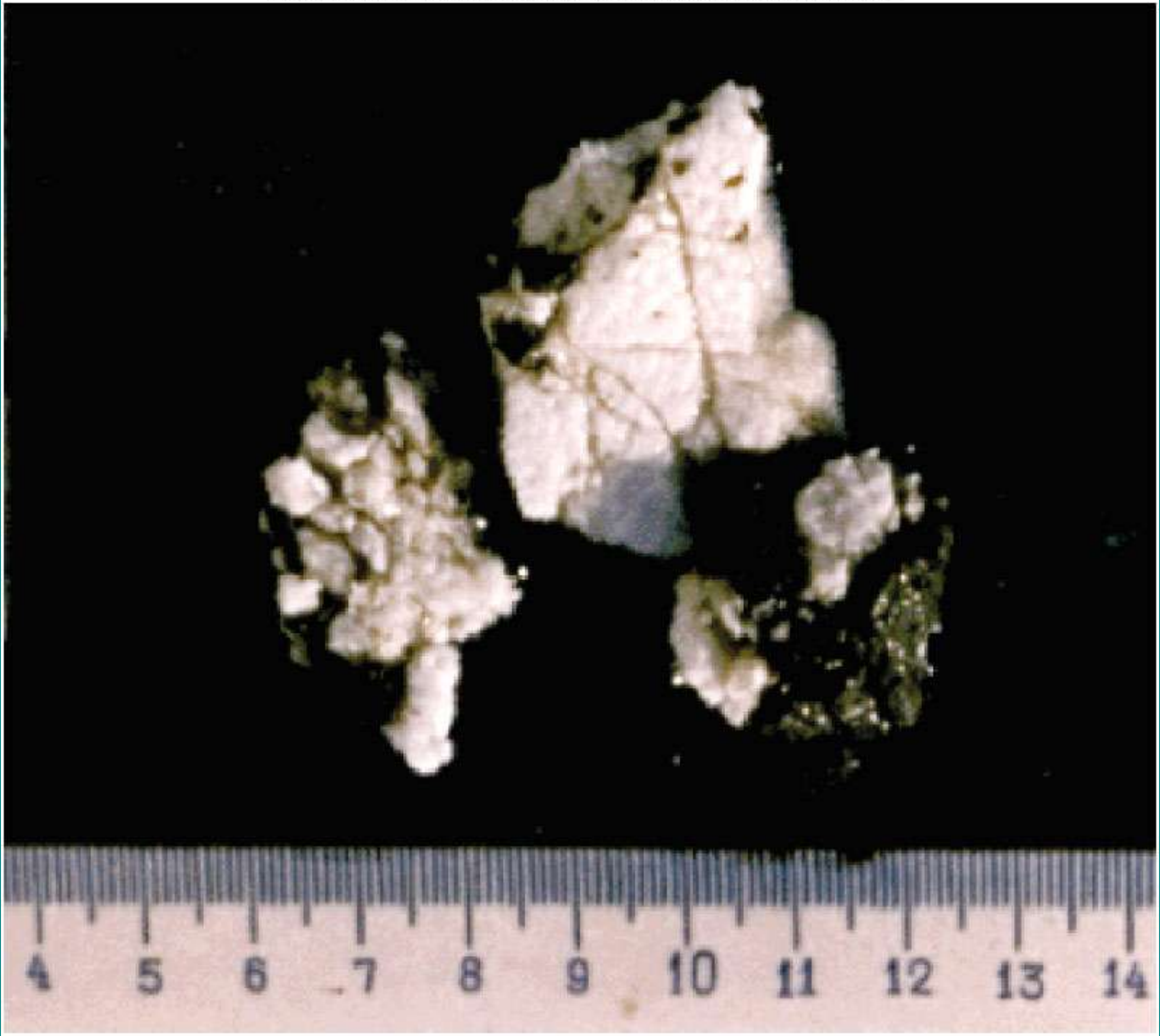


World energy demand



OECD = Advanced, industrialized
FSU/CEE = Former Soviet Union, central and eastern Europe
ROW = Rest of the world

Methane hydrate

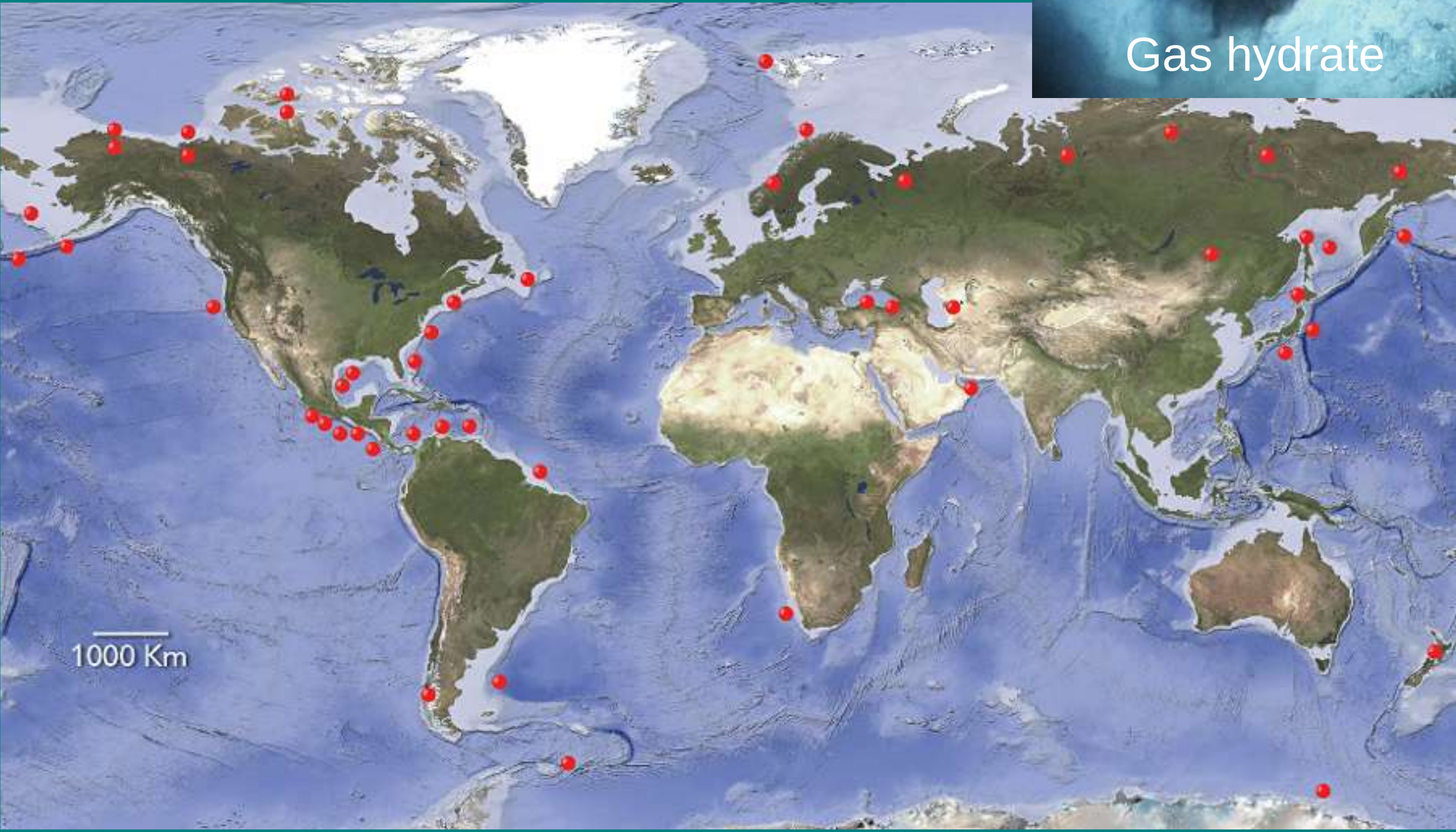


Alternate Natural Gas Sources

- Methane in **methane hydrate** exists as crystalline solids of gas and water molecules
- Found to be abundant in the arctic regions and in marine sediments
- Estimates of over 1300 trillion cubic feet of methane in methane hydrate have been studied off the Carolina coast
- It is not clear how we can tap into this potential reservoir

Where does gas hydrate occur?

Icy mixture of water and gas (below surface)



Environmental issues--oil

- *Why is the pipeline above ground?*

TABLE 13.1

Relative Energy Contents of Selected Fossil Fuels

U.S. and world energy consumption are commonly reported in quadrillions of Btu (British Thermal Units). One quadrillion Btu equals, 1,000,000,000,000,000 Btu (10^{15} Btu). For comparison, the energy contents of the following fossil fuels, in Btu, are:

	Btu
1 barrel crude oil	5,800,000
1 gallon gasoline	124,070
1 ton coal	20,753,000
1 million cubic feet of natural gas	1,026,000,000

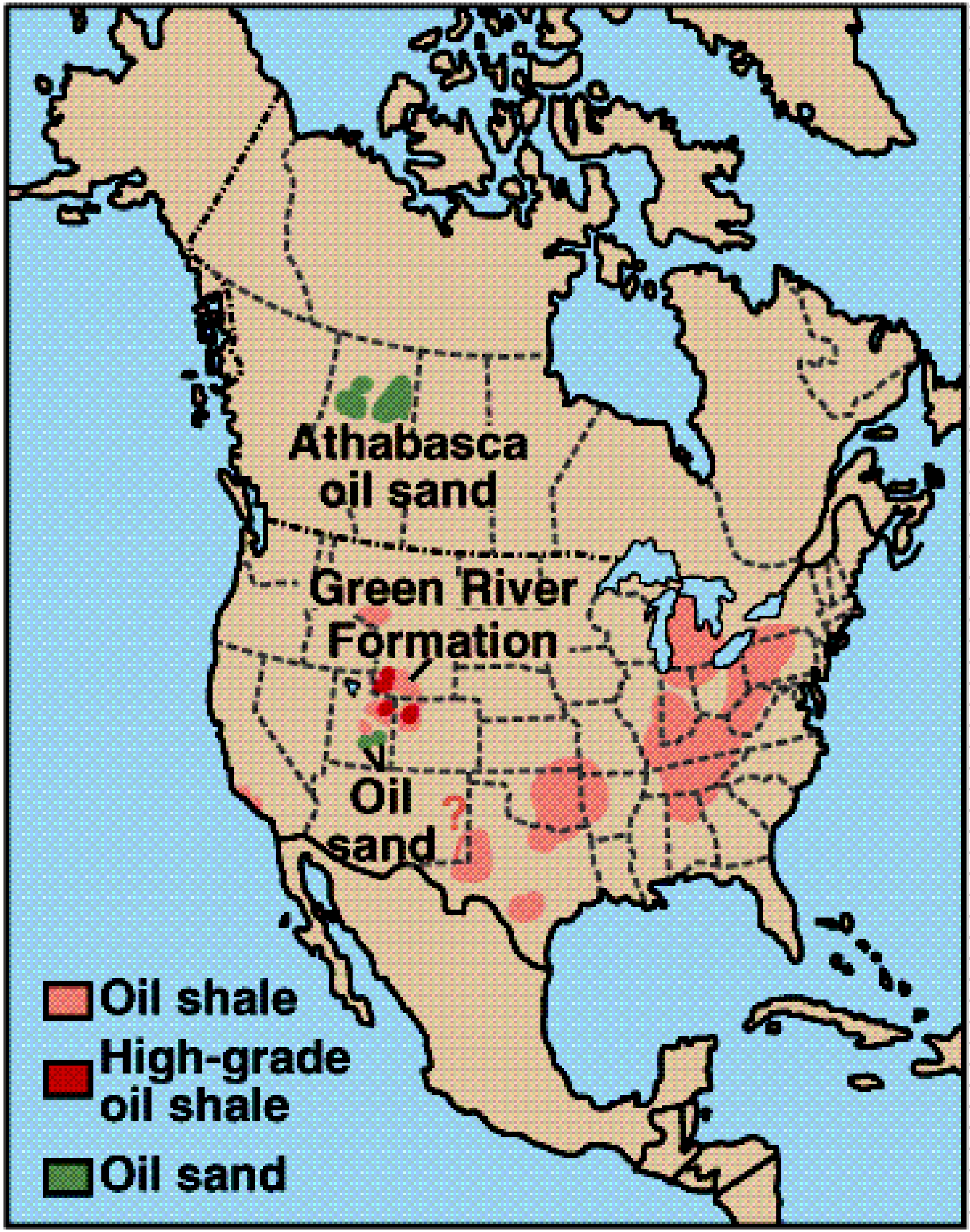
Heavy Crude & Oil Sands

- Heavy crude
- Oil sands (or tar sands)

Oil Shale

- Oil shale
- Problems with mining oil shale

Distribution of Major Deposits



Alternative Sources of Energy

- Hydroelectric power
- Geothermal power
- Solar power;
- wind power
- tidal power; wave power; ocean current power
- Vertical temperature differences in the sea
- Hydrogen from dissociation of water

Alternative energy sources

Source

- Hydroelectric
- Nuclear energy

- Solar
- Wind
- Geothermal

Issues

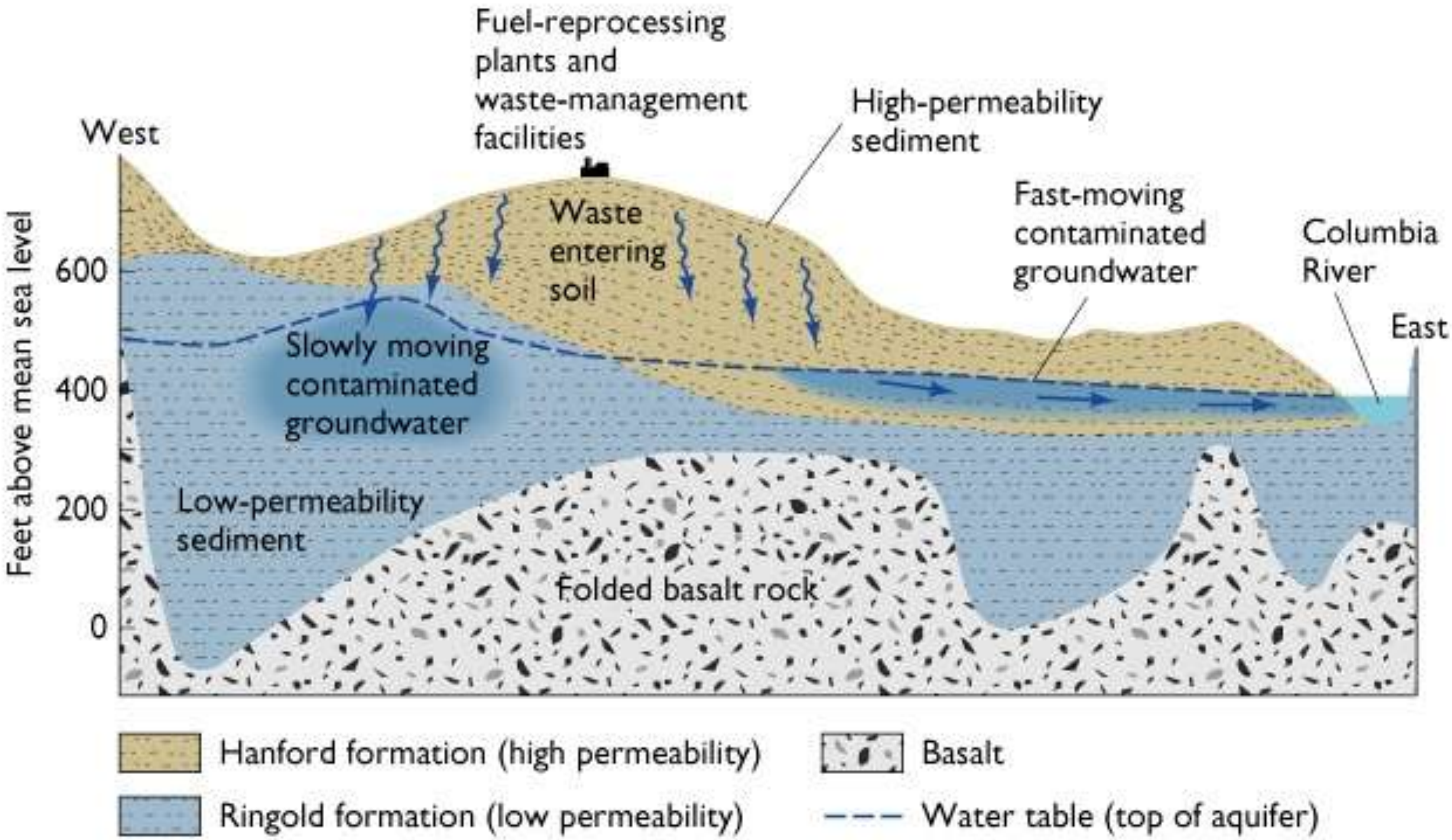
- Dams
- Waste disposal, safety, cost
- Land area, cost
- Land, birds, cost
- Sludge

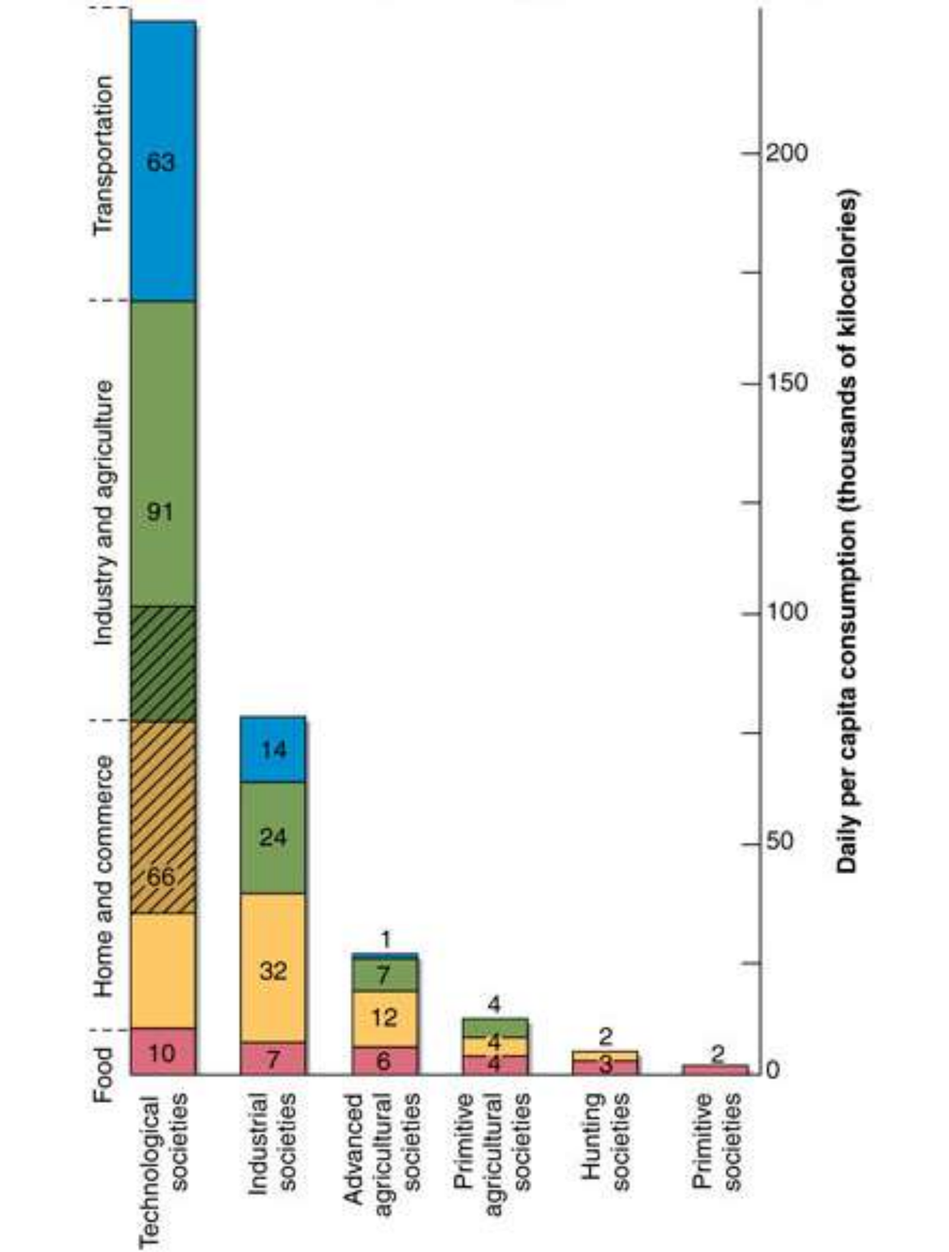
The Geysers, northern California


CONTACT

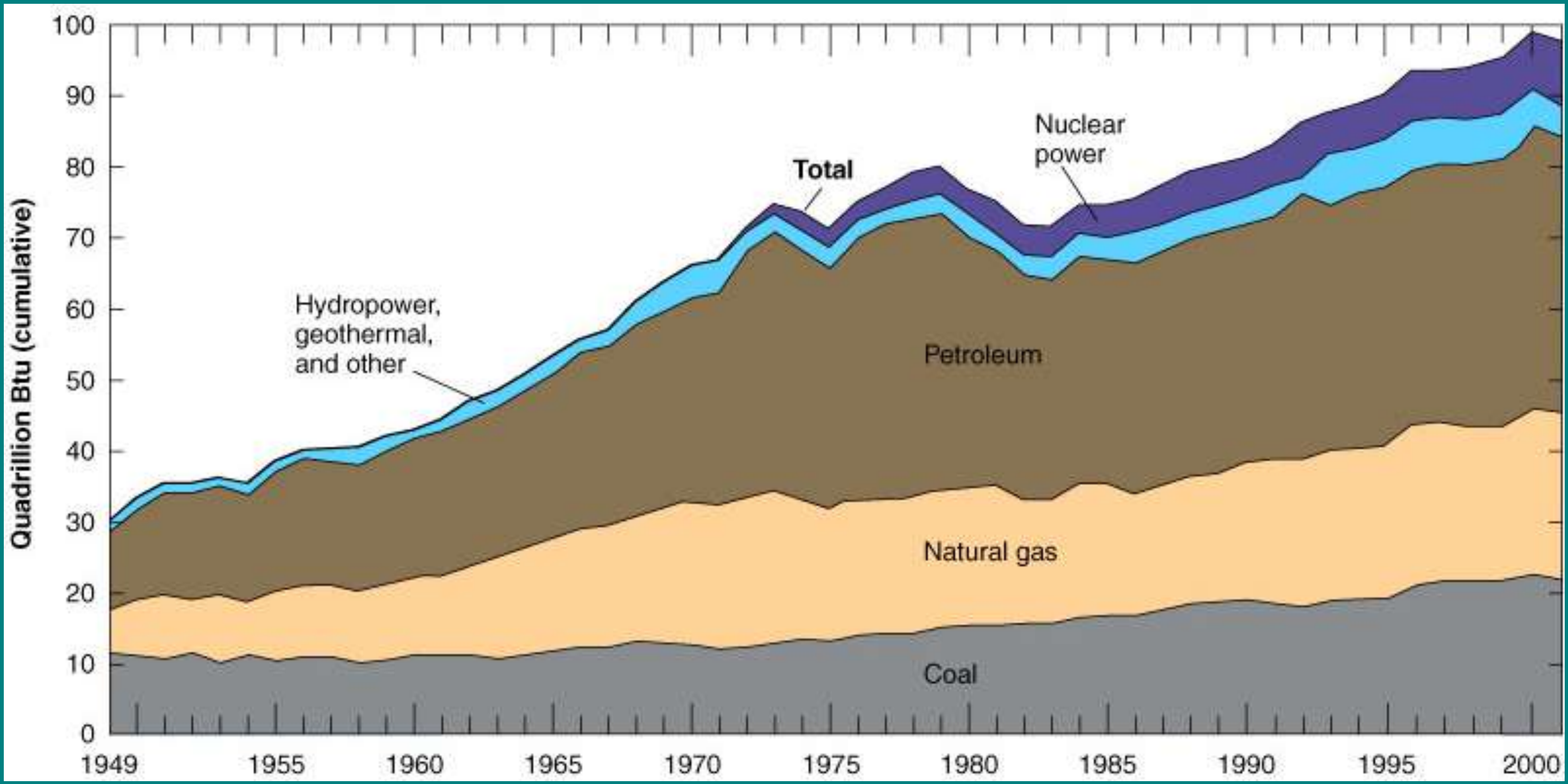
Solar Power

Environmental issues--nuclear

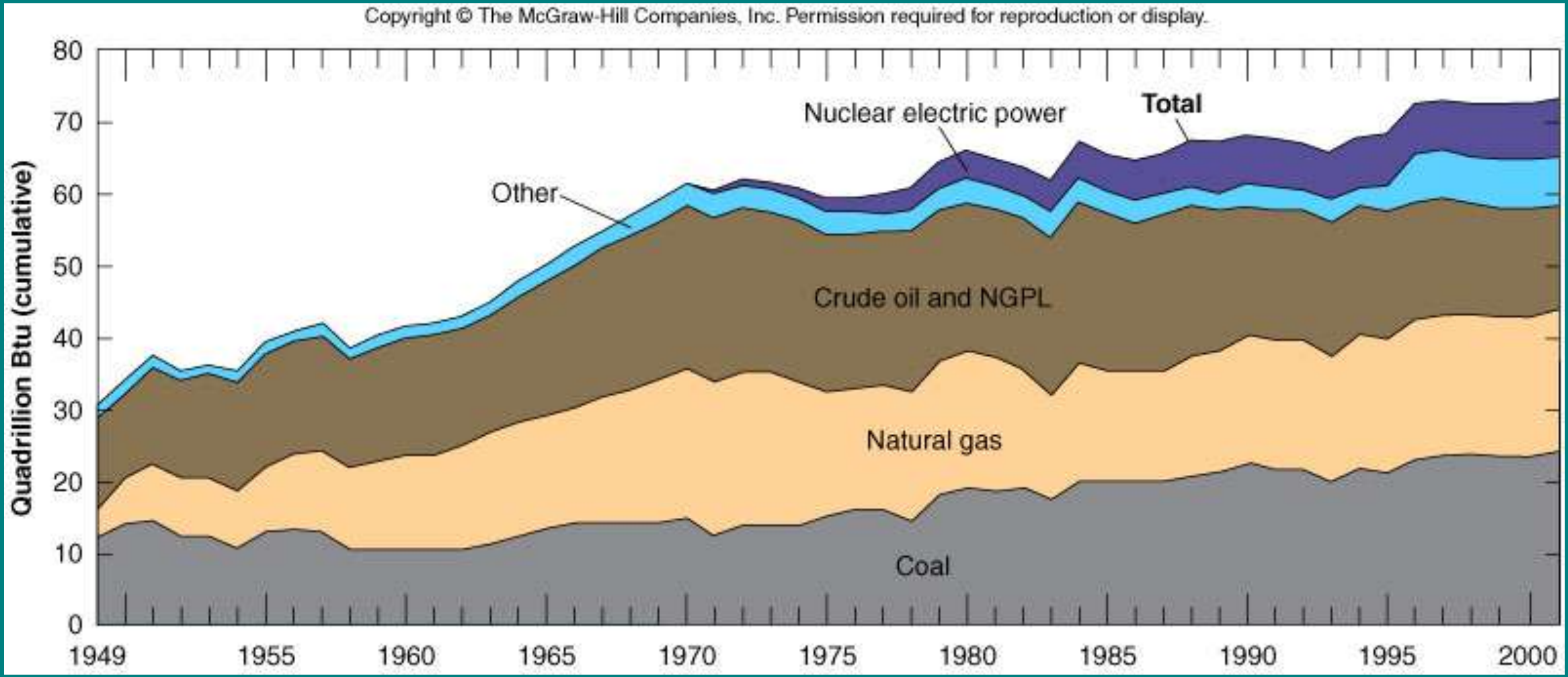




Society and Energy



U.S. energy consumption, 1949-2001



U.S. energy production by energy source

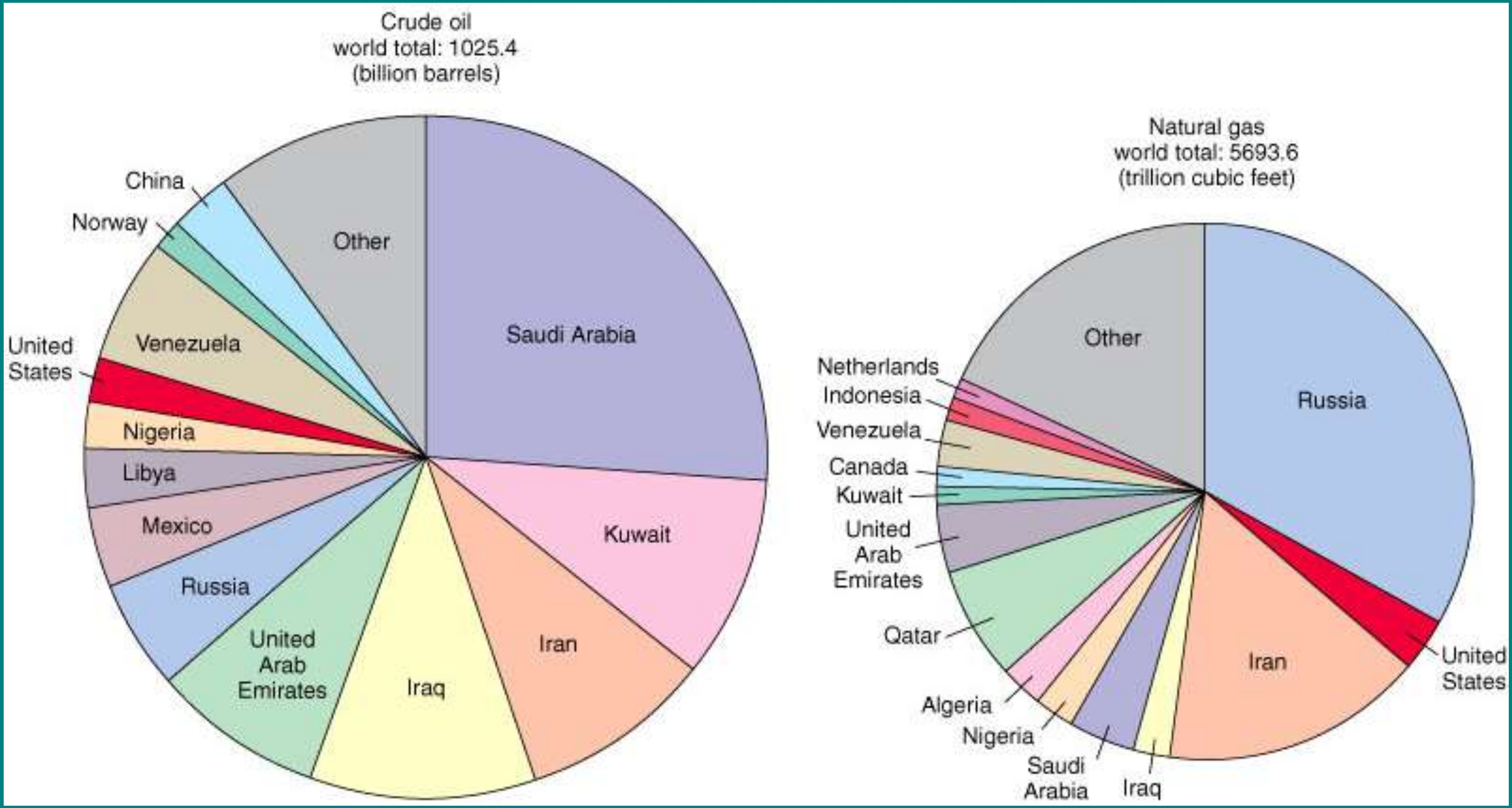
Supply and Demand for Oil

- 500 billion barrels of oil have been consumed

  1 barrel = 42 gallons
- Recent consumption rates have rapidly increased
- Proven remaining reserves are estimated at 1 trillion barrels
  - Unevenly distributed around the world
  - Most oil is consumed by the highly industrialized countries
- The United States alone consumes over 25% of the oil used worldwide
- Kuwait has 10% share of world oil reserves

U.S. Oil Supplies

- 200 billion barrels of oil have been produced and consumed in the U.S.
  - Using about 7 billion barrels of oil per year
  - 7 billion barrels stand for 40% of all the energy used per year
- U.S. has less than 23 billion barrels of proven reserves
  - U.S. production has recently been declining
  - New fields are being considered
- U.S. is heavily dependent on oil imports
  - More than half the oil consumed has been imported from other countries
  - The amount of oil in the Strategic Petroleum Reserve is about 550 million barrels



Proven world reserves of crude oil and natural gas, 2002

TABLE 13.2

Fuels Derived from Liquid Petroleum and Gas

	Material	Principal Uses
Heavier hydrocarbons	waxes (for example, paraffin)	candles
↑	heavy (residual) oils	heavy fuel oils for ships, power plants, and industrial boilers
	medium oils	kerosene, diesel fuels, aviation (jet) fuels, power plants, and domestic and industrial boilers
	light oils	gasoline, benzene, and aviation fuels for propeller-driven aircraft
↓	"bottled gas" (mainly butane, C_4H_{10})	primarily domestic use
Lighter hydrocarbons	natural gas (mostly methane, CH_4)	domestic/industrial use and power plants

Source: Data from J. Watson, *Geology and Man,* copyright © 1983 Allen and Unwin, Inc.

Time Factor

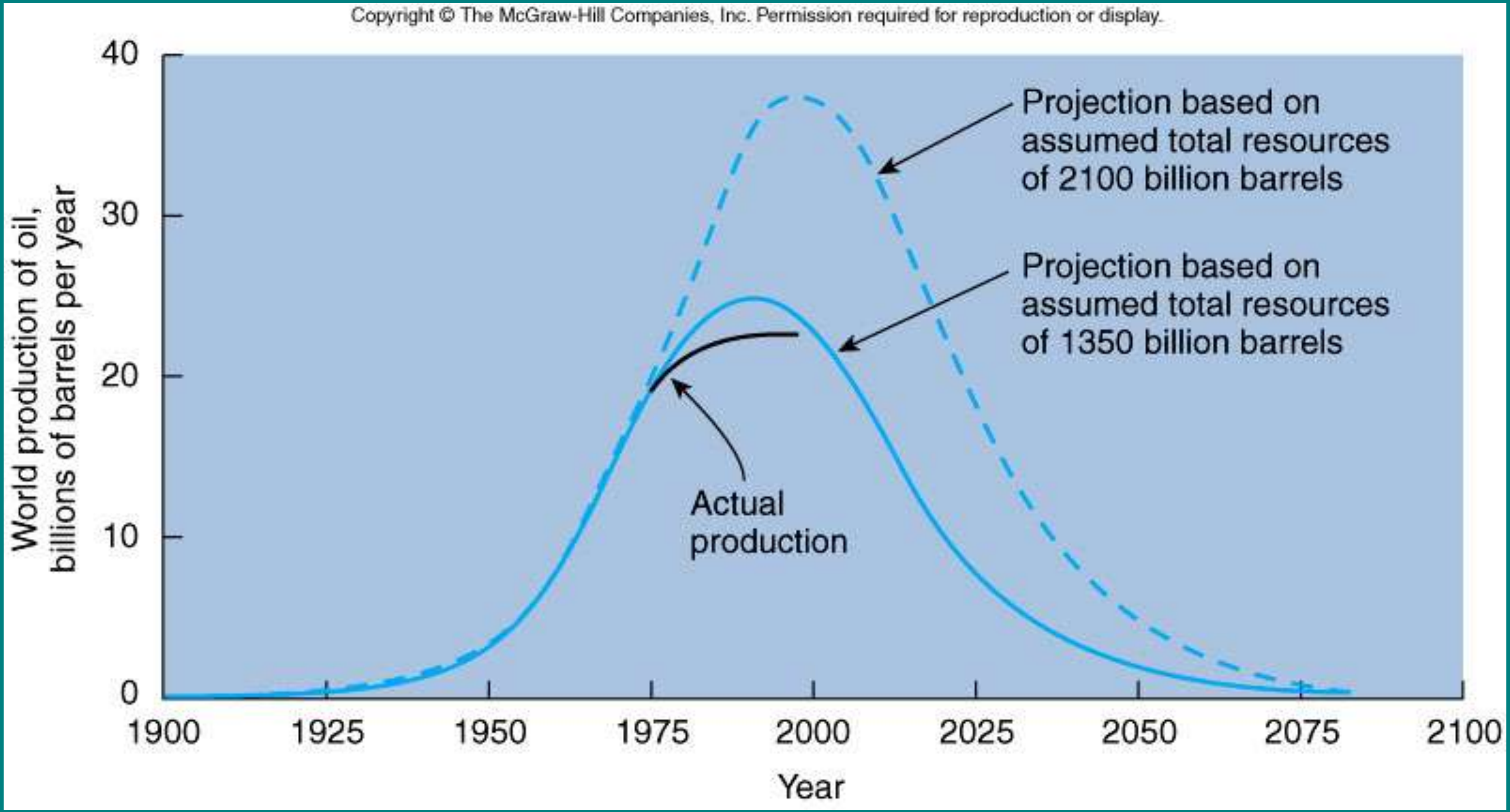
- Very few hydrocarbon deposits are found in rocks less than 1 to 2 million years old
- Geologist suspect the process is slow and takes longer than a few tens of thousands of years
- Oil and Natural gas are **nonrenewable** energy resources
- The organic material falling to the sea floors today will not be useful as petroleum products in our lifetime

TABLE 13.3

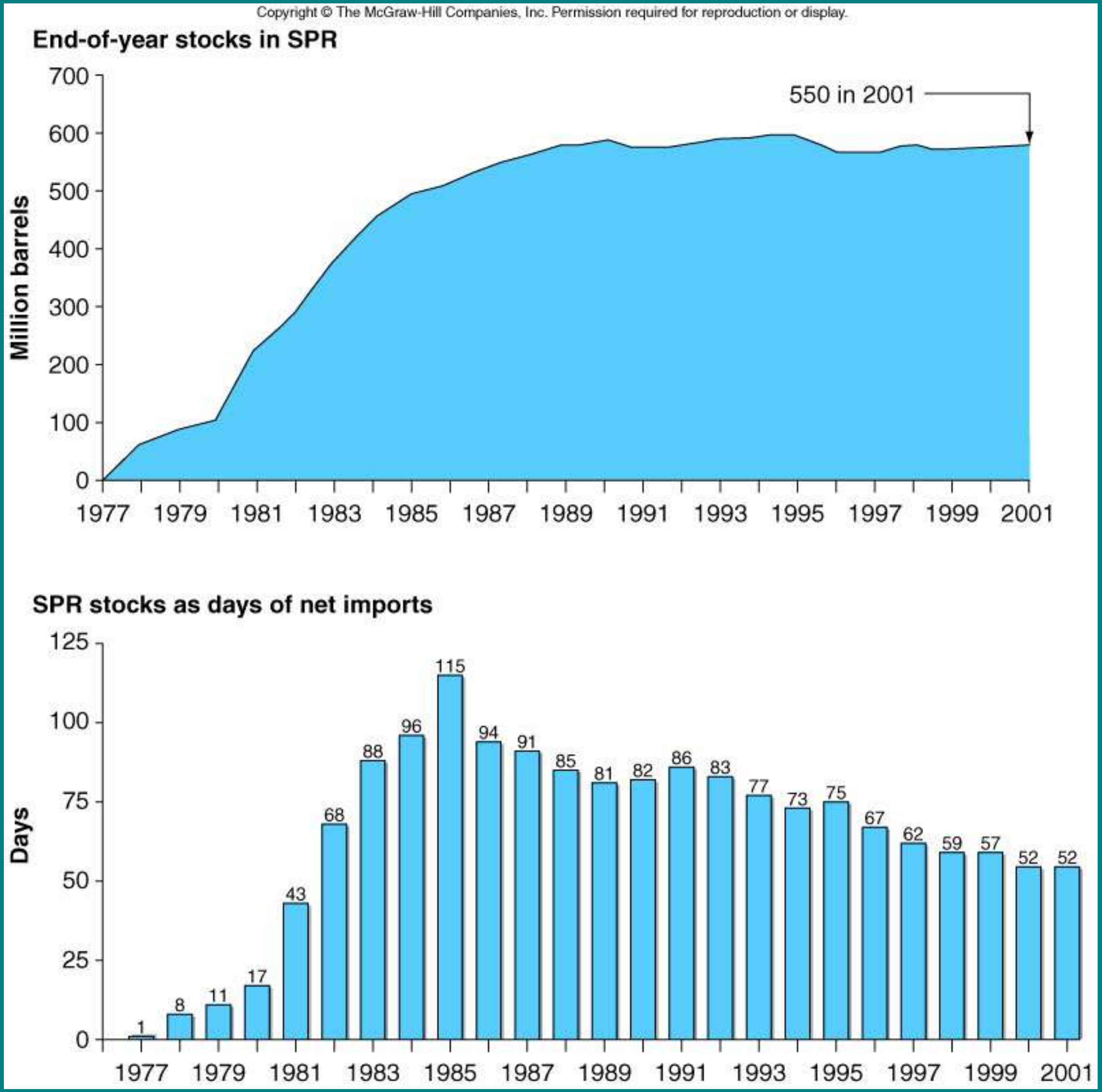
Proven U.S. Reserves Crude Oil and Natural Gas, 1982–2002

Year	Crude Oil (billions of barrels)	Natural Gas (trillions of cu ft)
1982	29.5	209.3
1986	28.3	201.1
1990	27.6	177.6
1994	23.6	171.9
1998	22.7	141.8
2002	22.4	183.5

Source: Data from *Annual Energy Review 1999,* and *International Energy Annual 2001,* U.S. Energy Information Administration, Department of Energy.



Projection of Oil Production



Strategic Petroleum Reserve (SPR)

Supply and Demand for Natural Gas

- About 25 % of energy used in U.S. is natural gas
  - About 20 trillion cubic feet consumed most years
  - 200 trillion cubic feet of proven reserves with limited new reserves found each year
- U.S. is a major natural gas importer
  - Imports account for 15% of consumption

Future Prospects

- With dwindling supply of oil and natural gas, increased exploration is expected
  - Most promising areas have been explored
  - A few protected or environmentally sensitive fields do exist
- The costs of exploration have gone up, and yield from producing wells is declining
  - Drilling for oil costs an average of over $125 per foot and the average oil well drilled is over 6000 feet deep
  - From 18.6 barrels of oil per well per day in 1972 to 10.9 barrels in 2000
- U.S. energy future must shift away from petroleum and will continue to be an import based situation

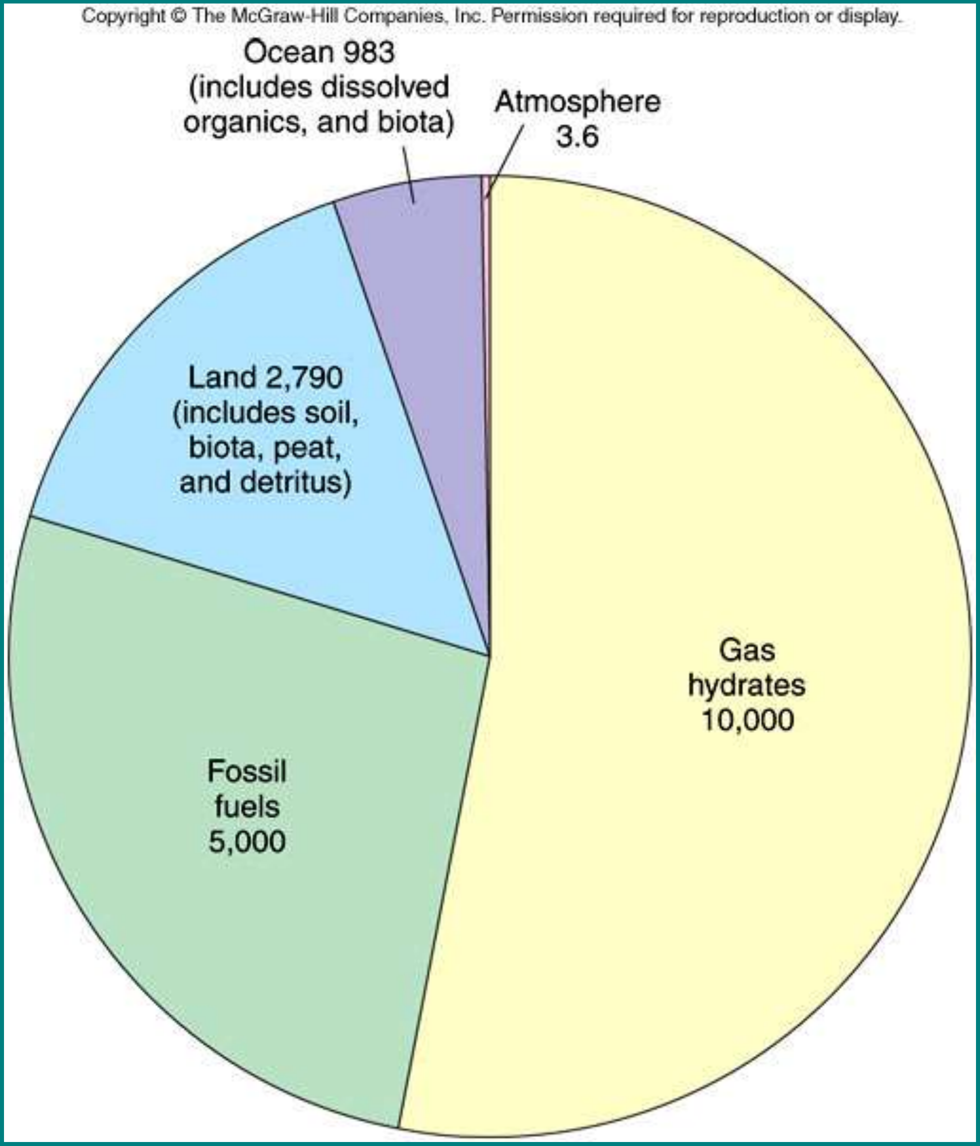
Enhanced Oil Recovery

- New technologies have increased production from marginally producing fields
- Primary recovery – limited to original pumping
- Secondary recovery – pump water into reservoir to fill in empty pores and buoy up more oil to be pumped from the well
- Enhanced recovery – used after primary and secondary recovery techniques have depleted the recoverable oil. As much as 75% of the oil remains in the reservoir. A variety of technologies can be used to obtain more oil from such reservoirs

Alternate Natural Gas Sources

- Geologists must look deeper into the hot interior of the earth for more natural gas
- Natural gas may be dissolved into the water found in the rocks at depth
- This gas may be recoverable from these **geopressurized zones**
  - Estimates range from 150 to 2000 trillion cubic feet
  - These deposits will be expensive to drill
  - The gas is dissolved into very saline brines that will present an environmental risk

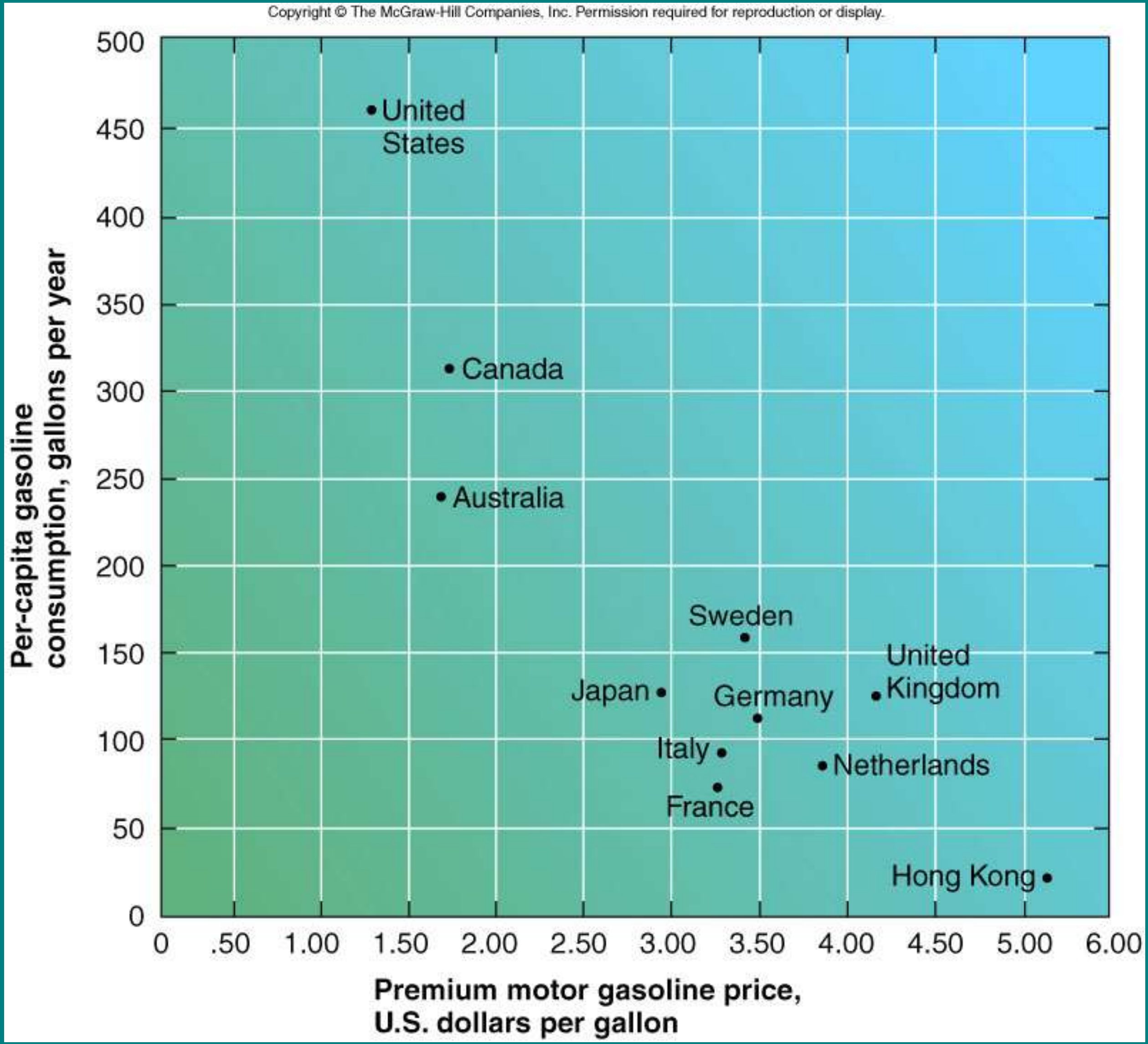
Hydrocarbon distribution by type



Conservation

- Very important method to stretch our remaining energy supplies
- Conservation ideas:
  - Increase car pool activities
  - Build energy efficient mass transit systems
  - Increase fuel efficiency in automobiles
  - Better insulation to buildings, homes, and schools
  - Increase use of alternative energy methods

Price vs. consumption



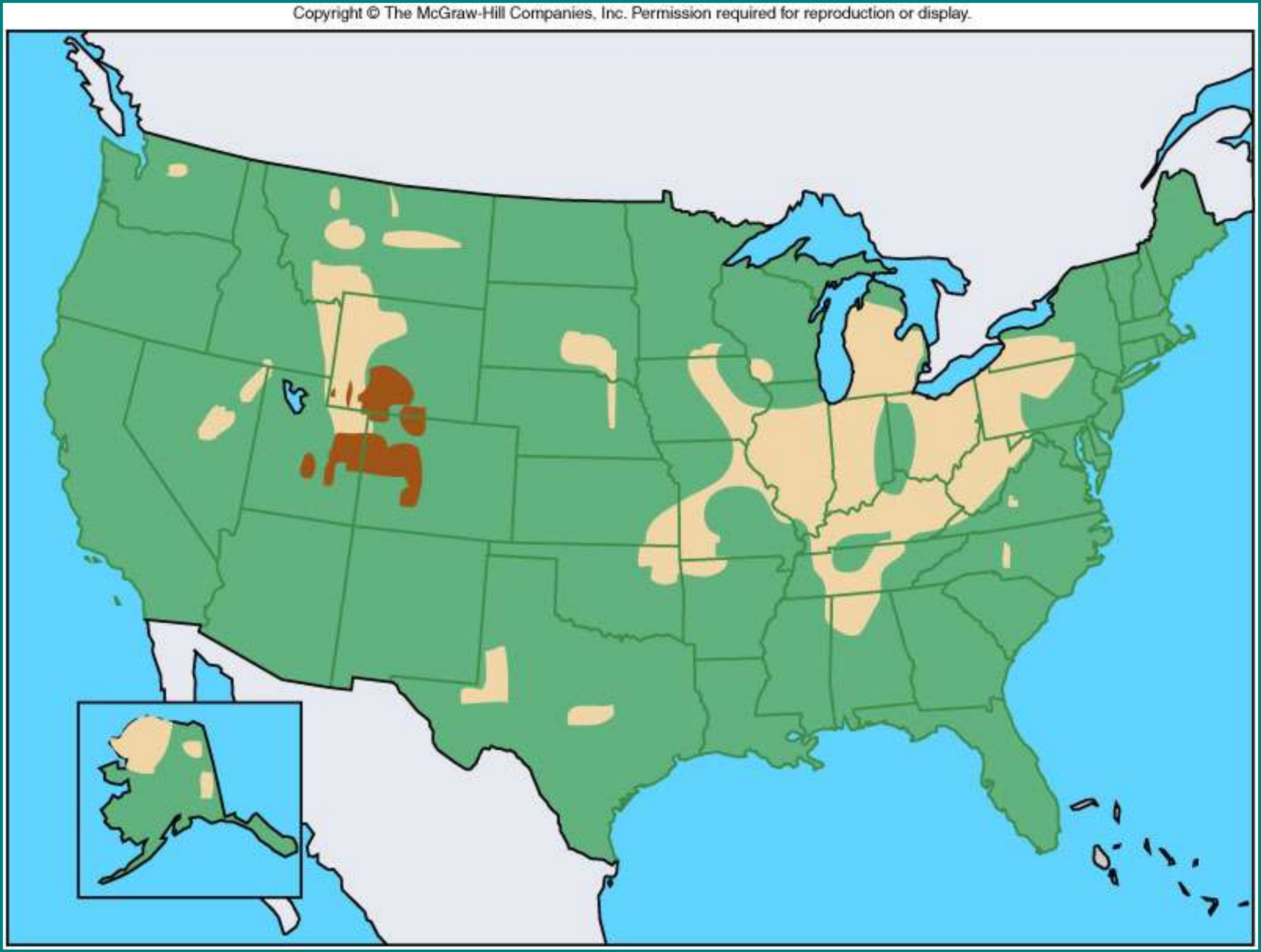
Alaska port

Oil shale

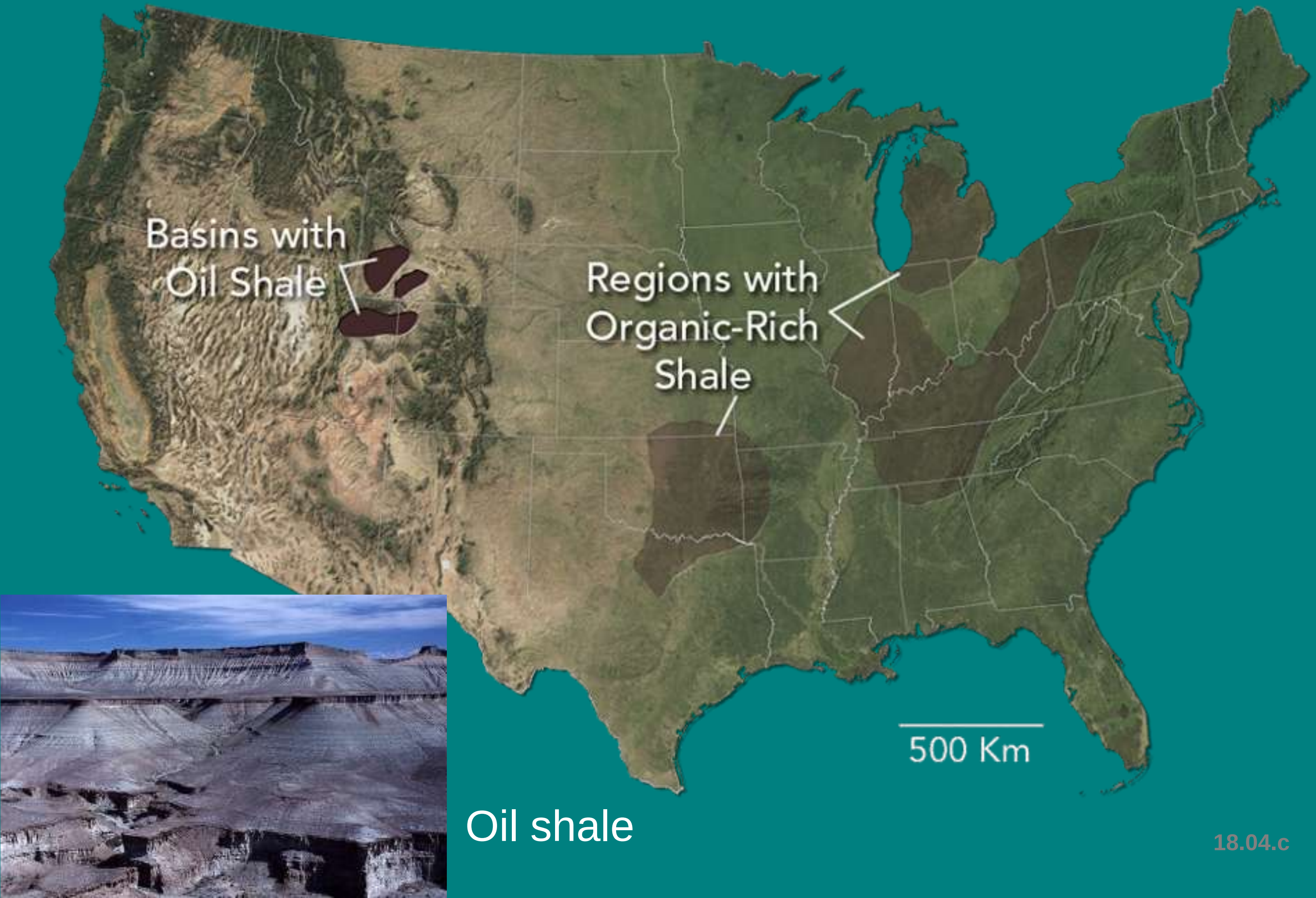
Oil Shale

- **Oil Shale** refers to a waxy solid hydrocarbon called **kerogen** contained in a sedimentary rock
- Oil Shale is an abundant resource in U.S.
  - About 2 to 5 trillion barrels of shale oil
  - Not yet cost effective to exploit
  - Problems remain to be solved:
    - Technology requirements
    - Limited water supplies in mining areas
    - Actual amount of oil to be produced from shale is not clearly defined
    - Environmental concerns

Oil shale in US



Where oil shale is found in the U.S.



Oil shale

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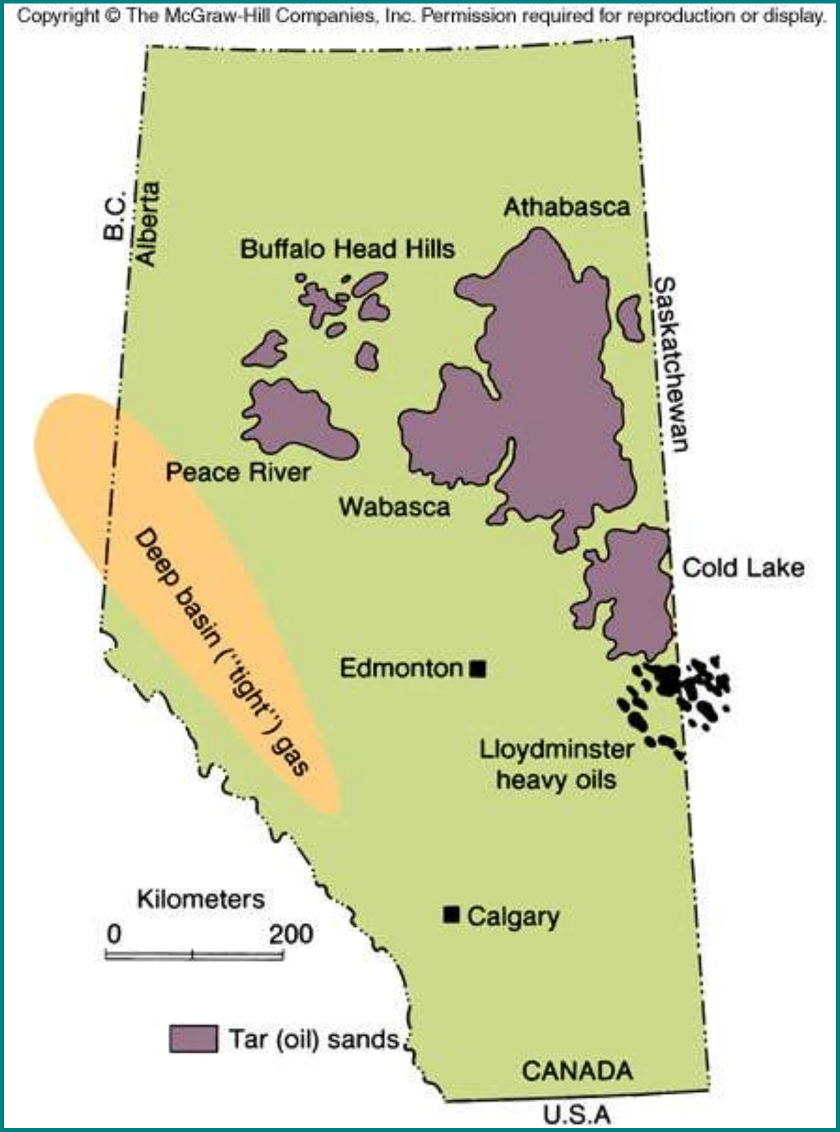
Oil shale deposits

Tar Sand

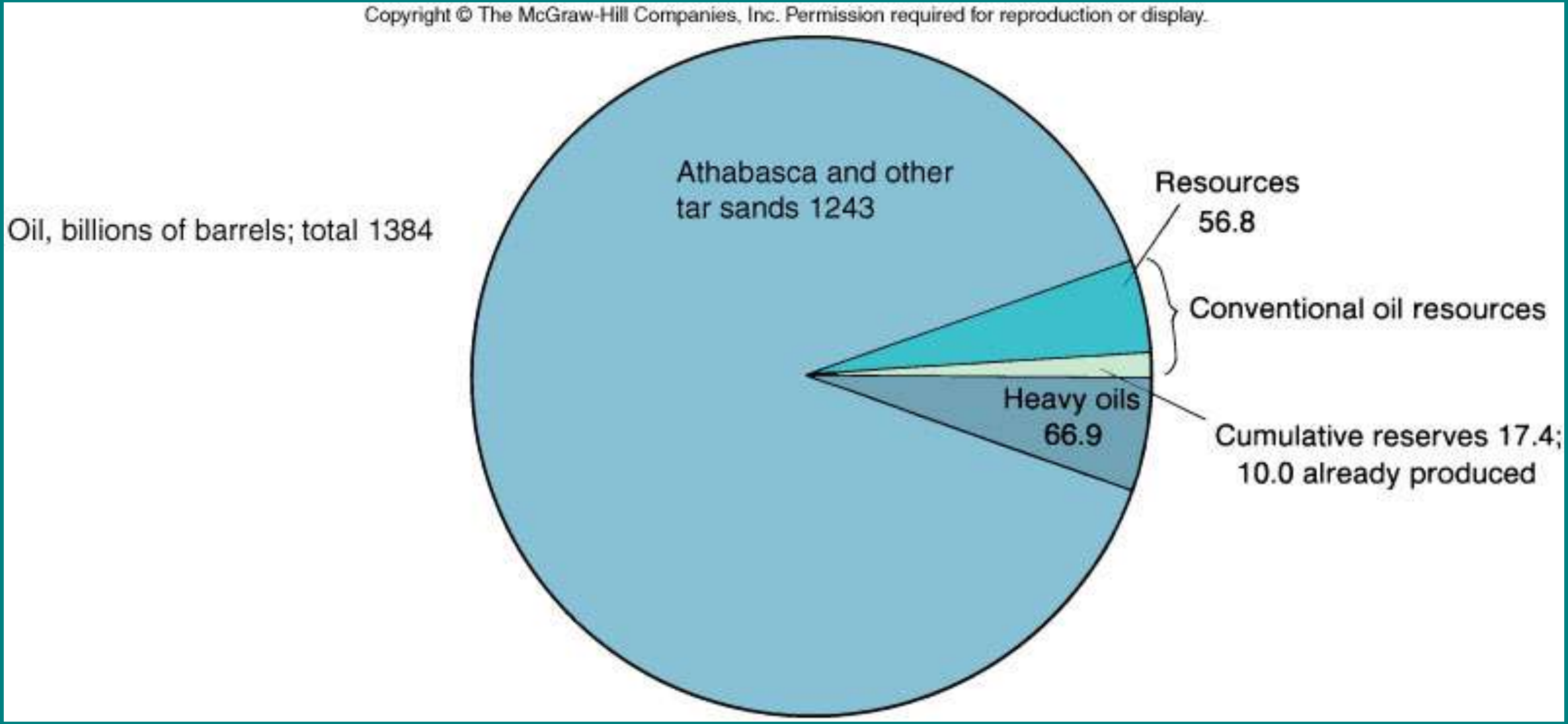
- **Tar Sands** are sedimentary rocks containing a very thick, semi-solid, tarlike petroleum. Tar sand deposits may represent very immature petroleum deposits.

- Oil shale and tar sand must be mined, crushed, and heated to extract the petroleum, which can then be refined into various fuels

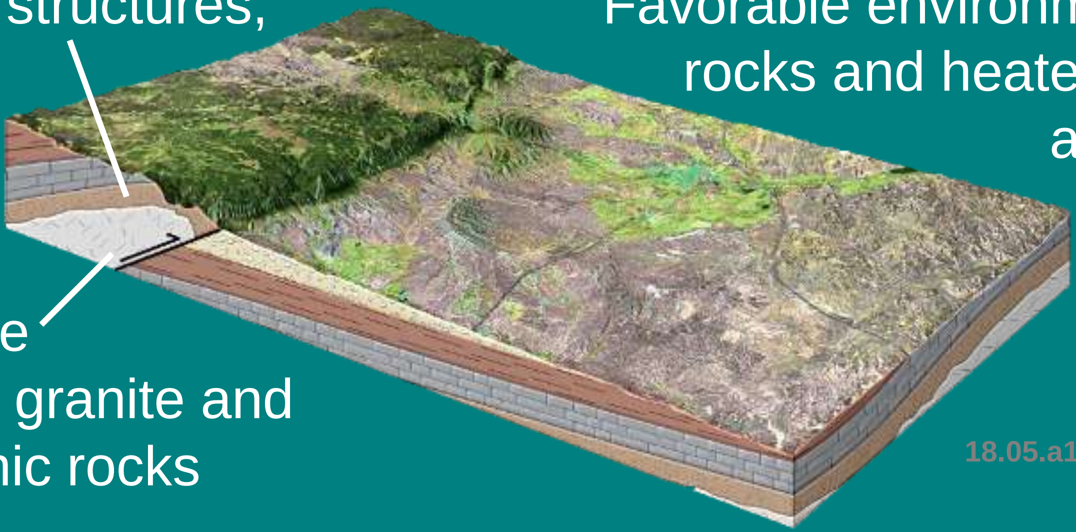
Tar sands in Alberta, Canada

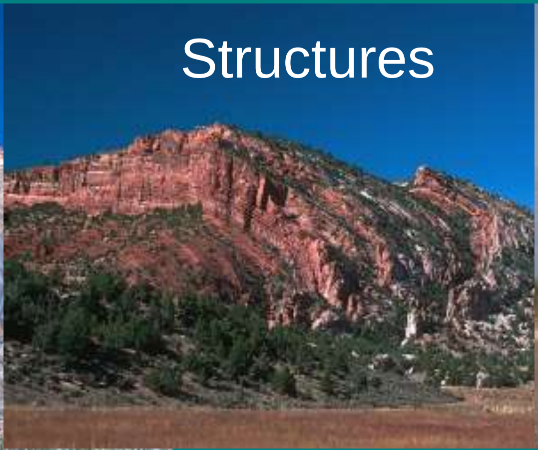


Tar sands and heavy oil



How Do We Explore for Fossil Fuels?



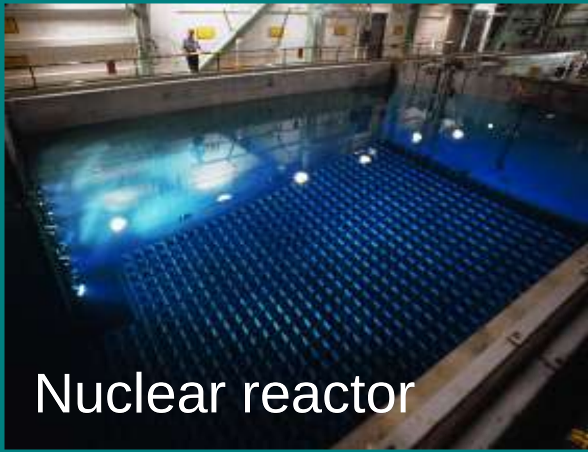


Summary

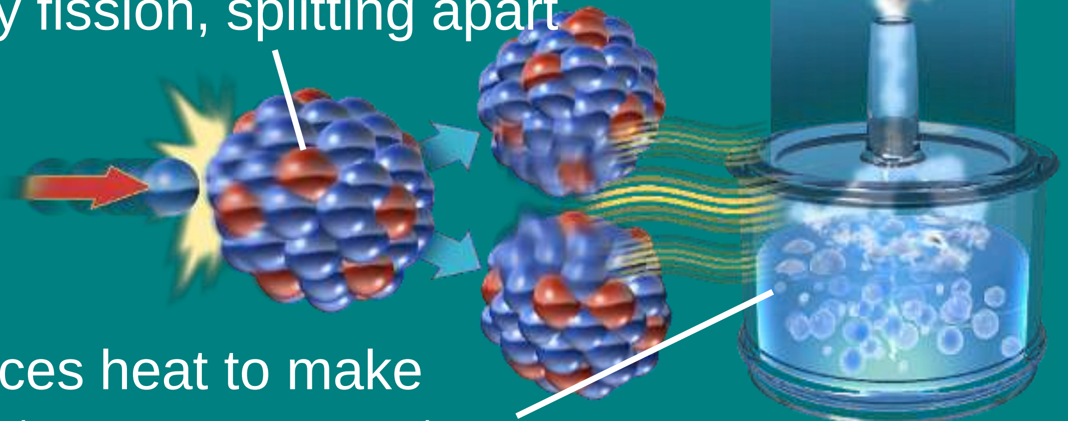
- Fossil fuels
  - Sedimentary origin for coal
  - Petroleum and natural gas (hydrothermal, or marine, organic-rich source rocks; sandstone and limestone reservoir rocks)
  - Coal (terrestrial sources)
  - Distribution reflects geology, climate, preservation
- Other energy sources (origins and distribution)
  - Geothermal, nuclear (internal sources)
  - Solar, wind, hydropower (solar sources)
- Environmental and economic consequences
  - Of production, utilization, distribution
- Next time—Mineral resources

How Uranium Generates Electricity

Uranium mined and processed at mill



^{235}U radioactive decay by fission, splitting apart



Produces heat to make steam to power generator

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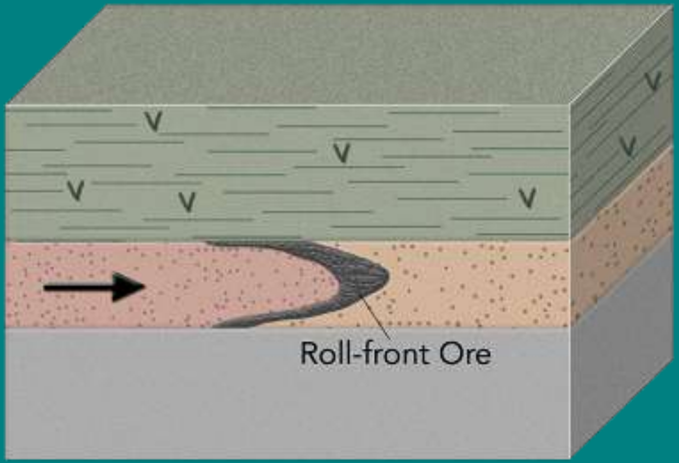
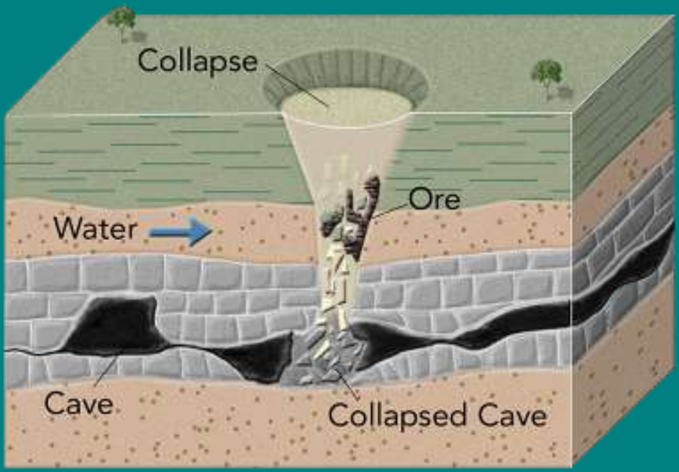
Geologic Setting of Uranium Deposits

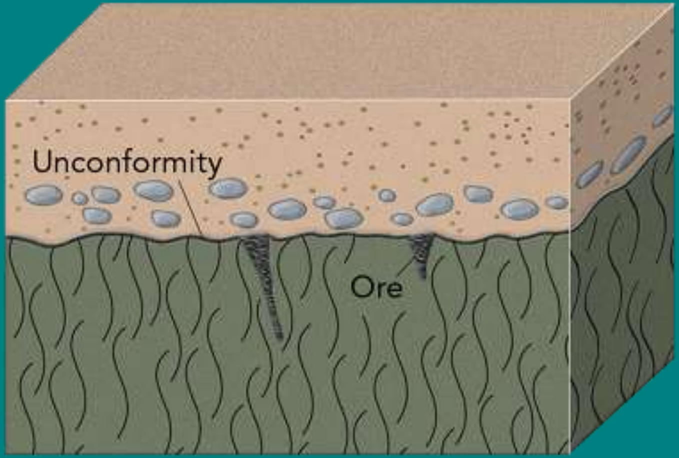


Roll-front

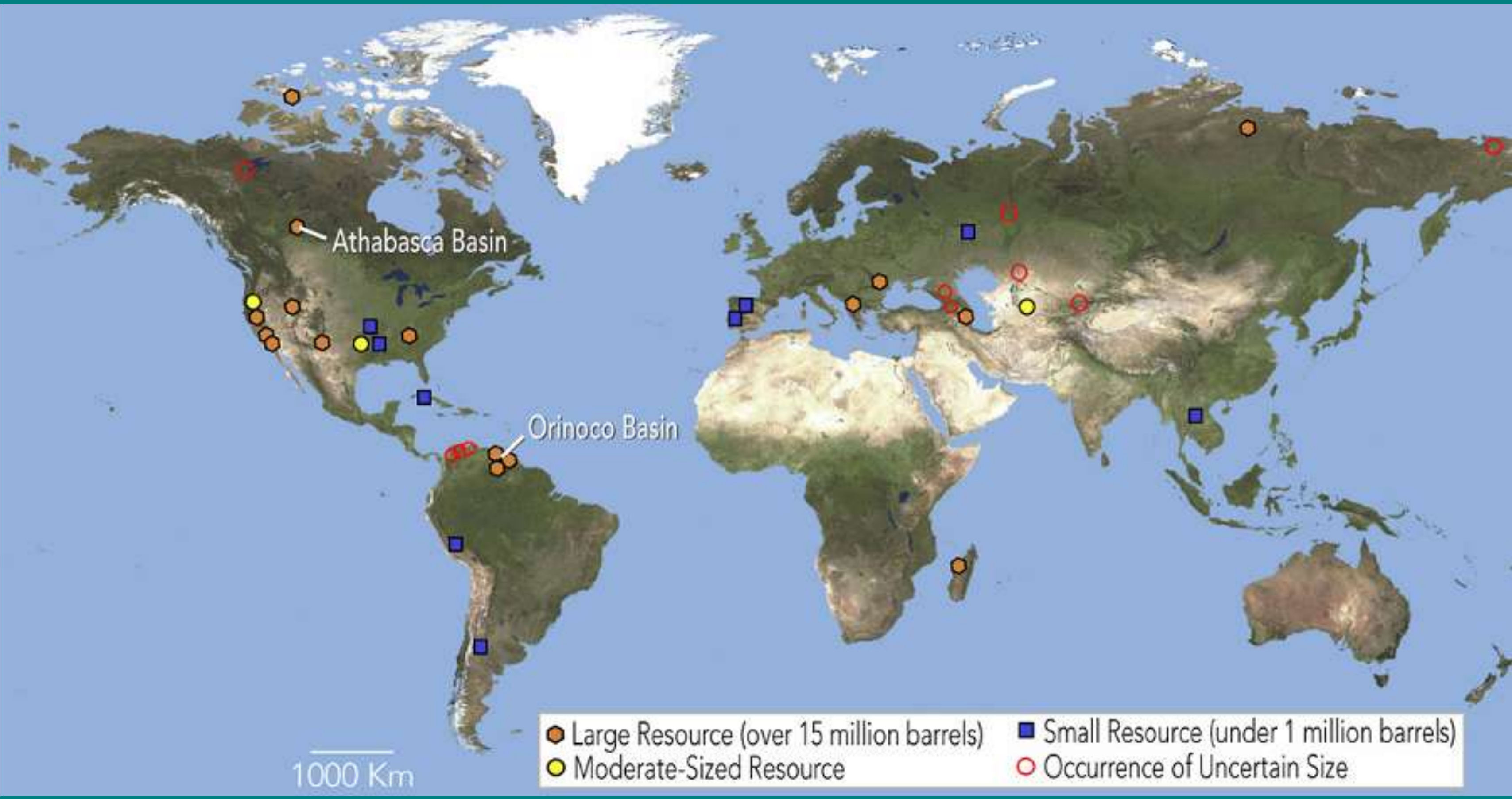


Breccia pipes

Unconformities



Location of the world's largest deposits of tar sands



Hydroelectric Dams

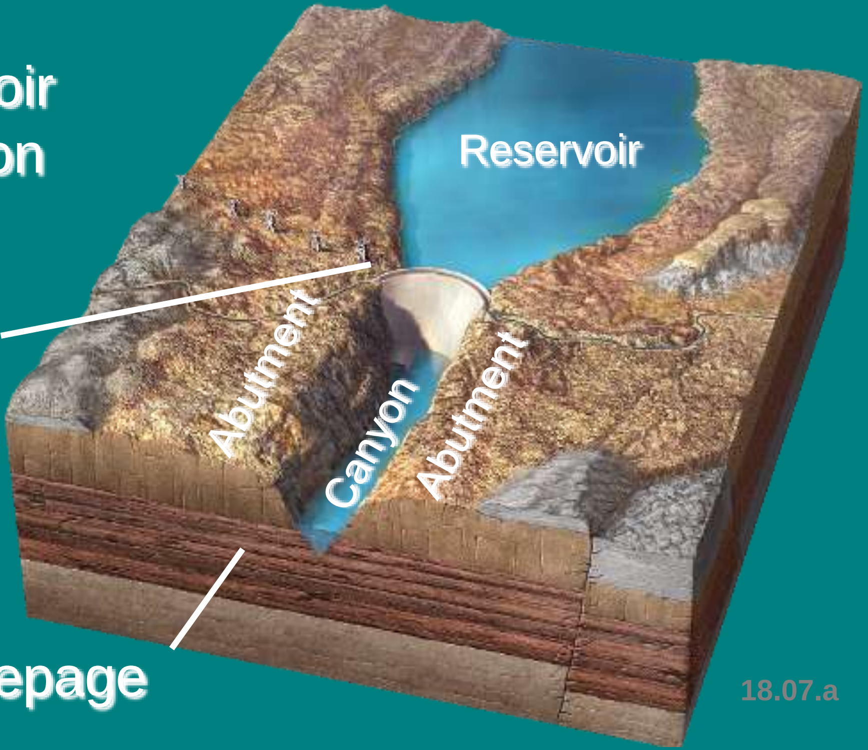
Store water behind dam

Falling water spins turbines, generating electricity

Narrow, deep reservoir minimizes evaporation and provides drop

Strong, unfractured rock in abutment

Impermeable, nonreactive rock near dam to limit seepage



Generating Electricity from Ocean Tides and Currents

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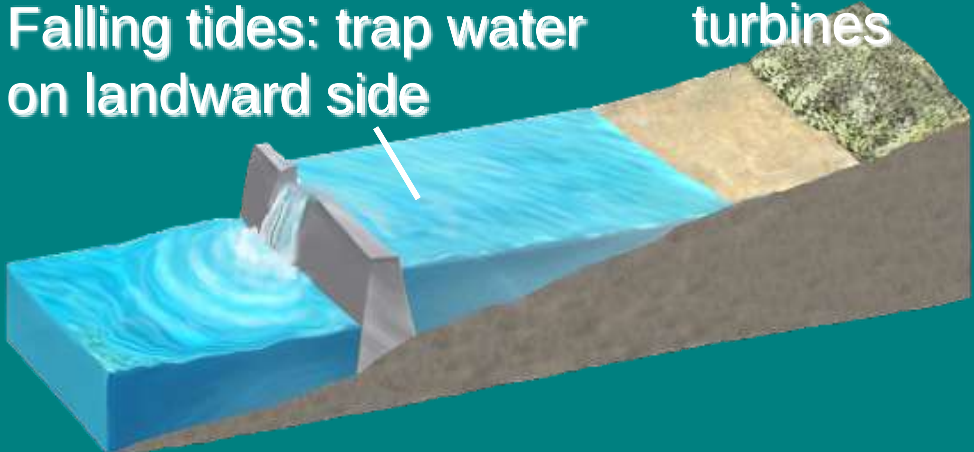
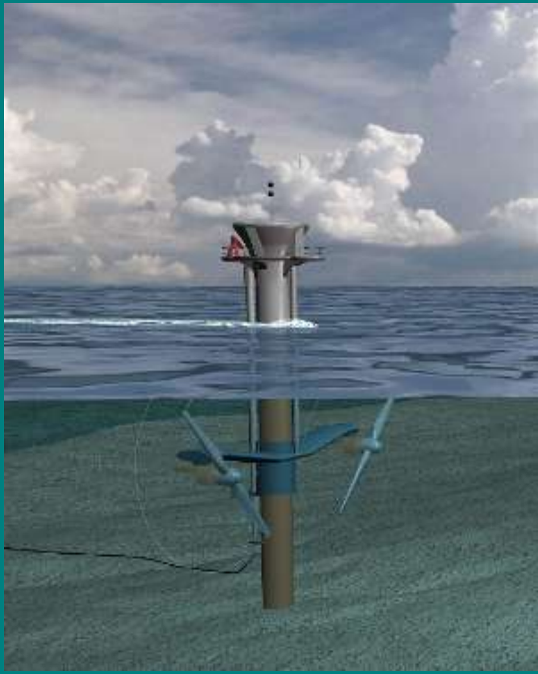
Rising tide: water piles up on seaward side of barrier

Either case, flowing water turns turbines

Falling tides: trap water on landward side

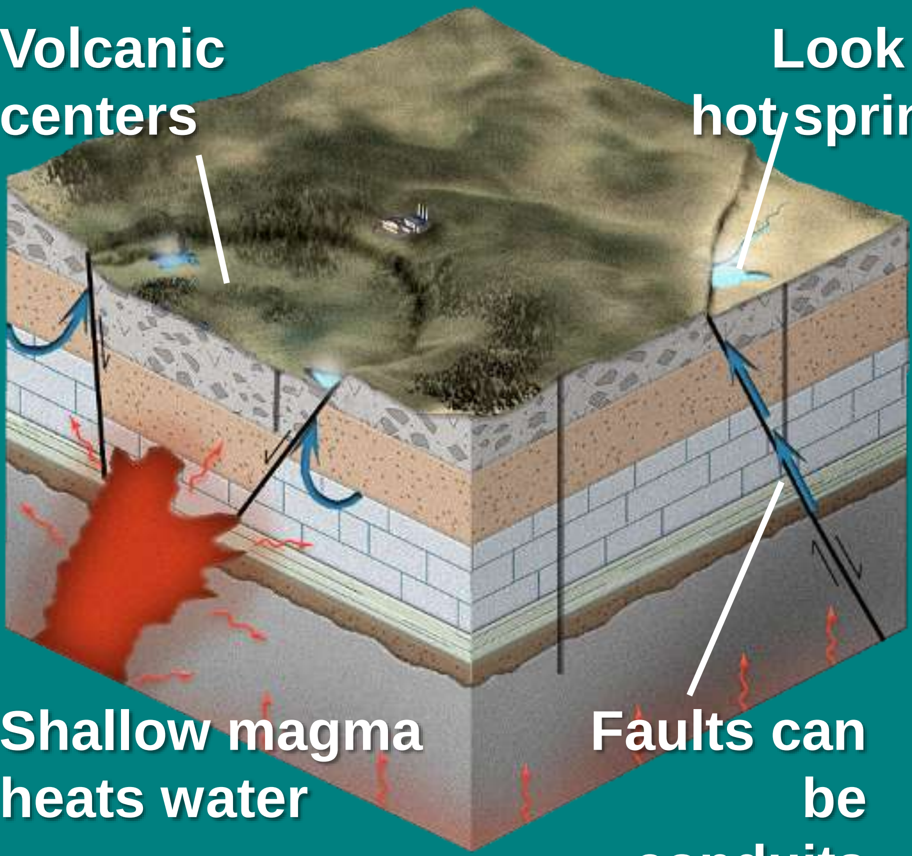




Ocean currents turn turbines or propellers

What sites would be favorable for geothermal energy?

Temp. increases down, so deep water is hot



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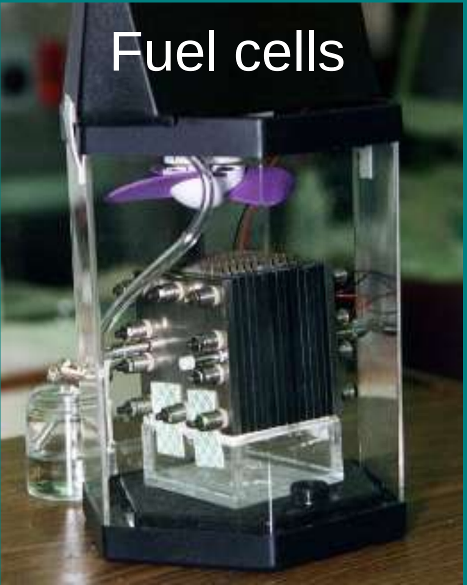
Alternative Energy Sources



Oil Spills

- Damage Control techniques:
  - Floating barriers and skimmers
  - Mop up with absorbent material (wood chips, peat moss, chicken feathers, …)
  - Burn it off

Oil Spills

- About 10,000 spills each year in U.S. waters
  - 15 to 25 million gallons of oil annually
- Sources of spills
  - Oil tankers
  - Drilling accidents
  - Careless disposal of used oil
  - Intentional destruction of pipelines
  - A few natural seeps do occur

Oil spill