Fossil Fuels, Chemistry of Fuels

Energy sources

- Wood—chemical energy stored by plants
- Kinetic energy—
  - Water power to grind grain
  - Wind to pump water
- Fossil fuels

http://www.adamandlyn.co.uk/country/greecewindmill.shtml

Sun's Energy

- Radiant energy
  - Released by fusion
  - Hydrogen fused into Helium
- 1.73×10^{17} watts received by Earth from Sun
- 99+% of Earth's energy
- Converted by plants into chemical energy

Photosynthesis

$6\ CO_2 + 6\ H_2O + \text{sun energy} \rightarrow C_6H_{12}O_6 + 3\ O_2$

- Converts CO_2 and H_2O to sugar and O_2
- Created the level of oxygen present in today's atmosphere
- Ancient algae in Archean and Proterozoic oceans released O_2 by photosynthesis

Energy and Chemical Reactions

- Heat released or consumed in chemical reactions
- Measured in calories
  - Food ‘calorie’ is a kilocalorie (kcal)
  - 1 Joule = 0.24 calories
- Energy shown in equation
- $C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O + 526$ kcal

Reaction energy

EXOTHERMIC

heats up environment

ENDOTHERMIC

absorbs heat from environment

Conservation of Energy

- Energy is not created or destroyed
- First Law of Thermodynamics

Heat Flow

- From objects with higher temperature to those with lower temperature
- Second law of thermodynamics

Implications of laws

- Change form from high quality to lower quality
  - Chemical energy to heat energy
  - Friction: mechanical to heat
- Energy wasted as frictional heat
- Need to put energy in to ‘make’ cold

Fossil fuels

- Burn readily
- Reaction is oxidation
- Release heat energy

Fossil fuels

- Coal
- Petroleum
- Natural Gas

First law of thermodynamics

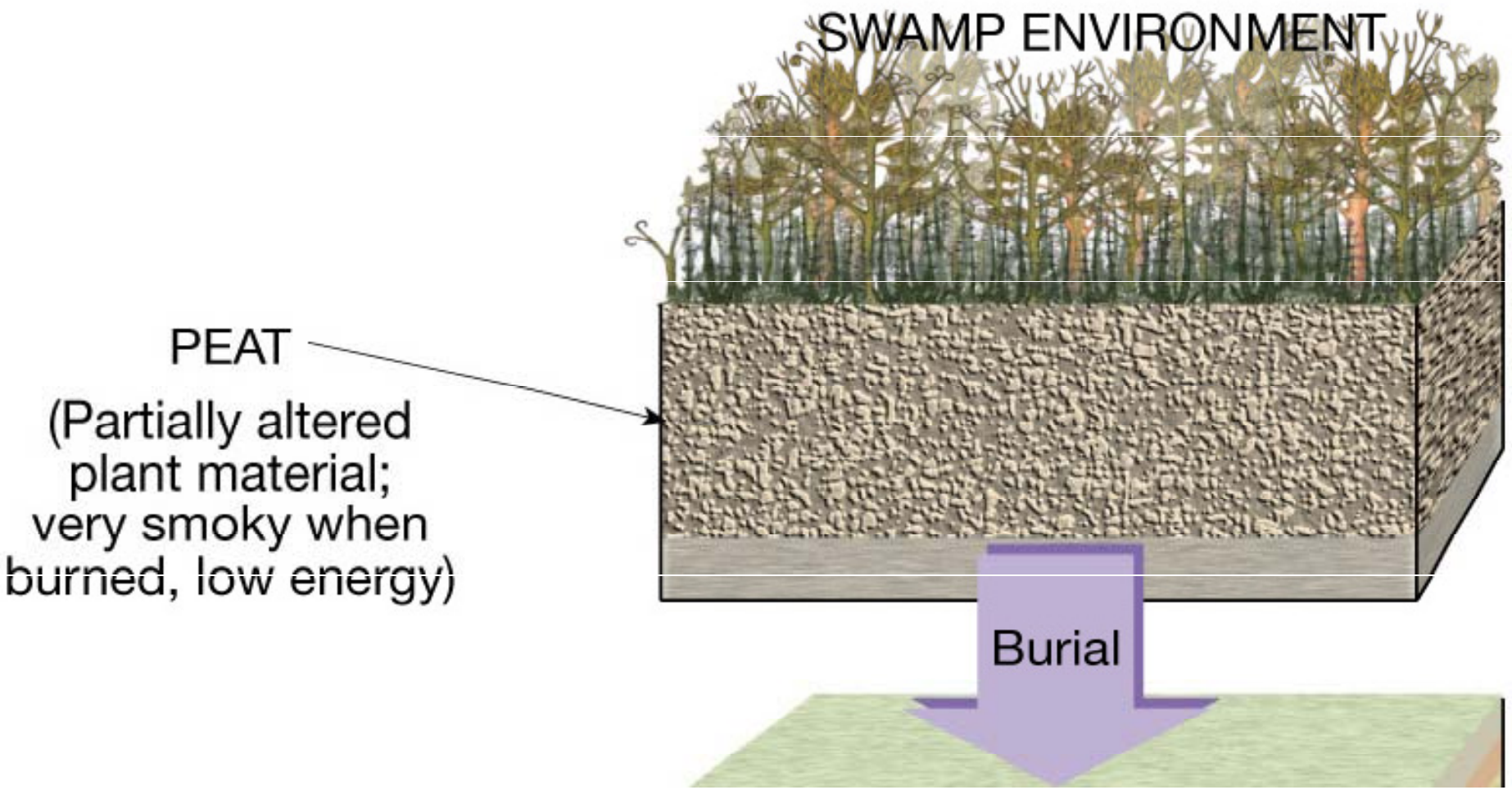
- Conservation of energy
- Cannot create or destroy energy
- (But we can convert to less-useful form)

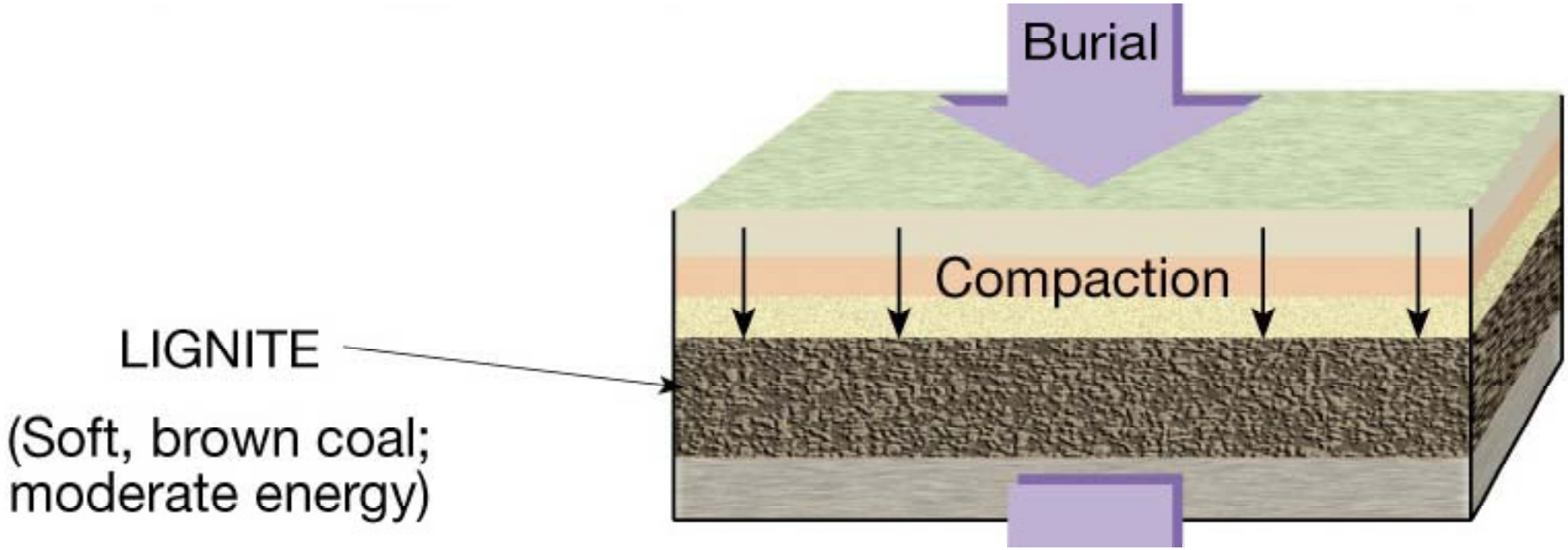
Fossil fuels

- Non renewable
- From ancient organisms
- Extracted from Earth

Carboniferous Period Forest

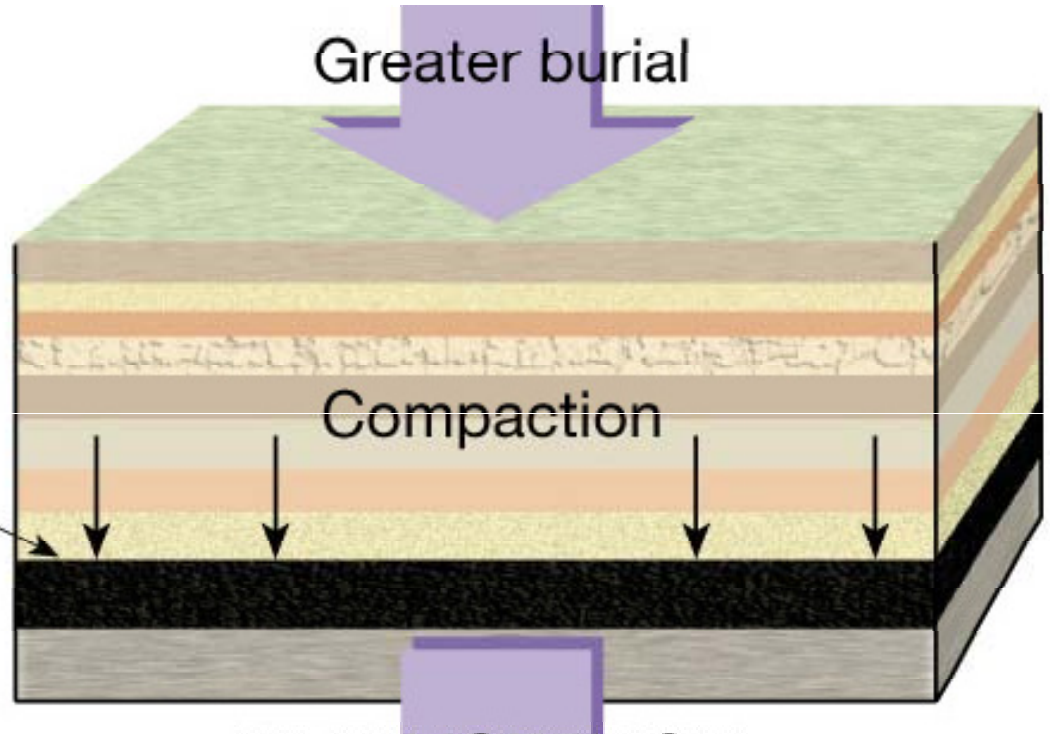
http://palaeos.com/Paleozoic/Carboniferous/Carboniferous.htm


SWAMP ENVIRONMENT
PEAT
(Partially altered plant material; very smoky when burned, low energy)
Burial


Burial
Compaction
LIGNITE
(Soft, brown coal;
moderate energy)

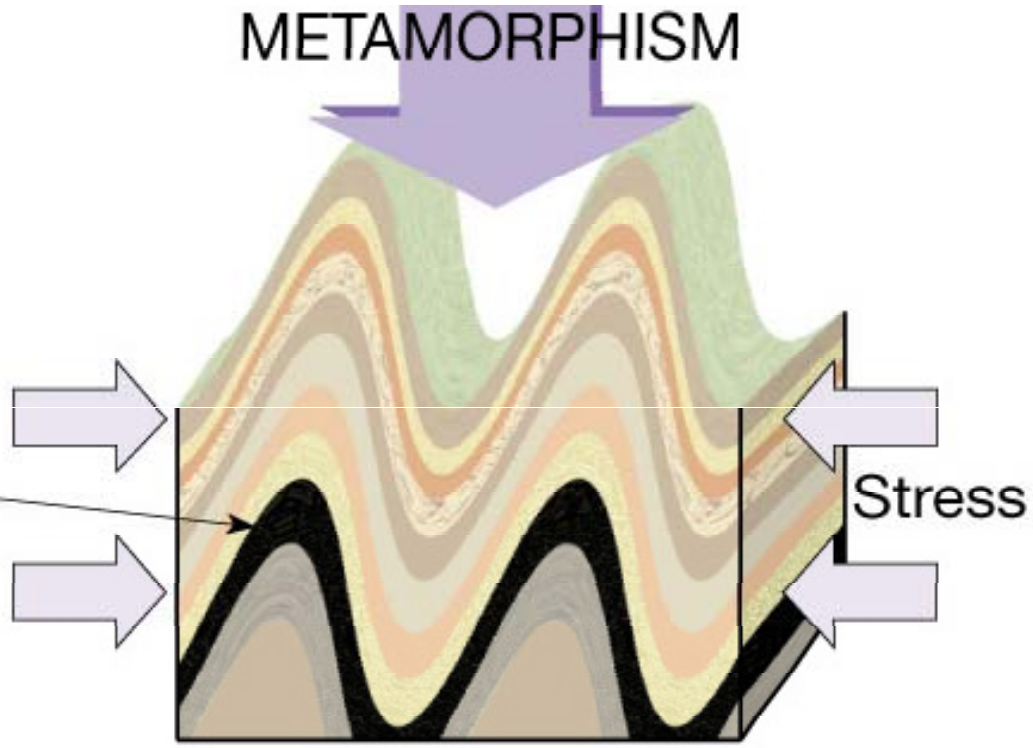
BITUMINOUS

(Soft; black coal; major coal used in power generation and industry; high energy)



ANTHRACITE

(Hard, black coal; used in industry; high energy)



Coal

$$C + O_2 \rightarrow CO_2$$

- Anthracite
- Bitumen
- Lignite

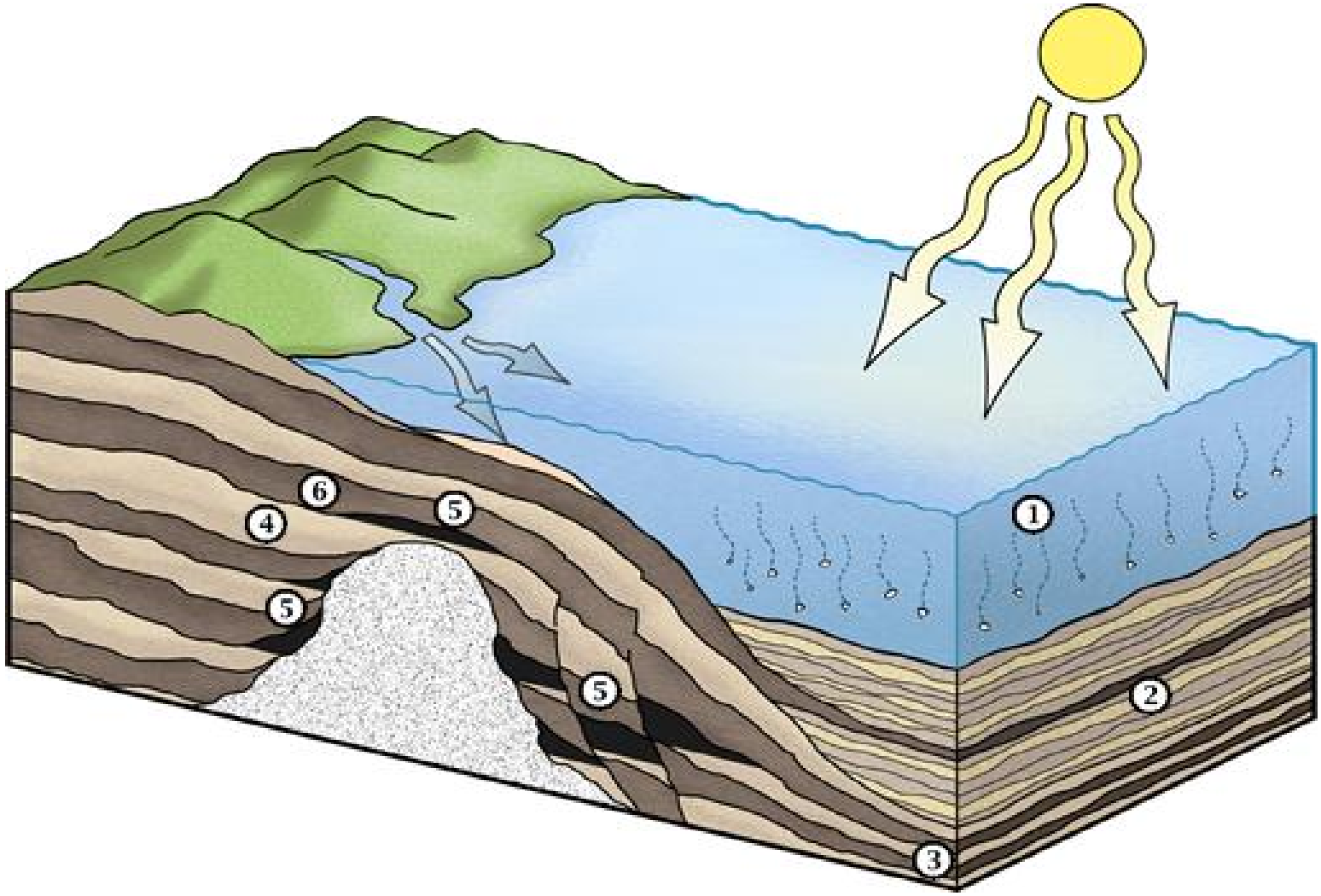
Coal

- Incompletely decayed plants
- Burial pressure releases O_2 and H_2
- Carbon remains
- Paleozoic—Pennsylvanian coal, Carboniferous Period

Coal

- Must be mined
- Pollutants in coal
  - Sulfur leads to acid rain
  - Also contains mercury, arsenic, nitrates

Hydrocarbon System



- http://www.priweb.org/ed/pgws/systems/systems_home.html

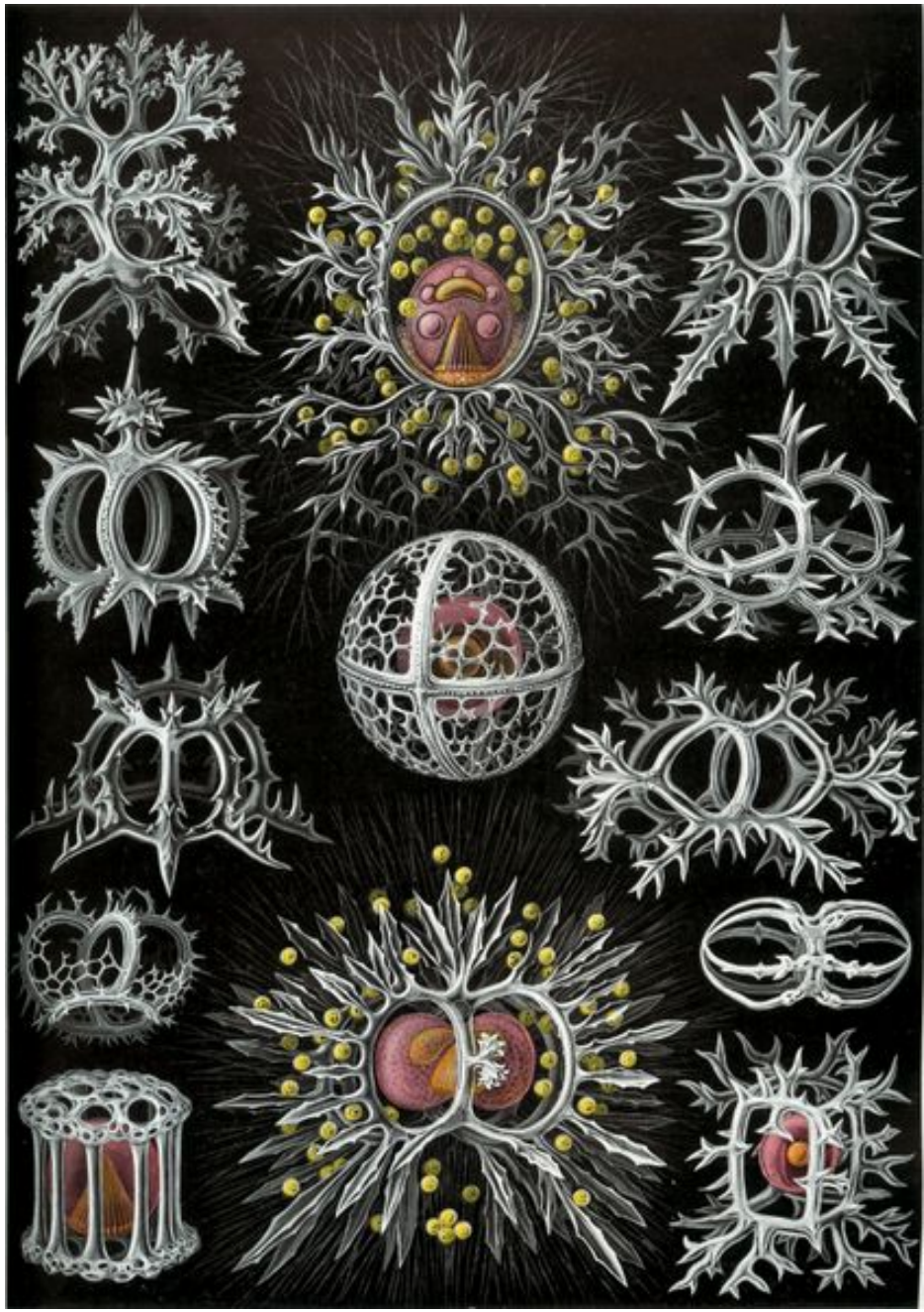
SOURCES

- Shale with organic material
- Gooey sludge on ocean floor

Zooplankton

- Planktonic organisms
- Probable source of petroleum

http://www.priweb.org/ed/pgws/systems/source/source.html



- http://en.wikipedia.org/wiki/Image:Haeckel_Stephoidea.jpg

COOKING

- Just right temperature
- Just right pressure
- Just right time

RESERVOIR

- Porous
- Permeable
- Usually a sedimentary rock

POROUS

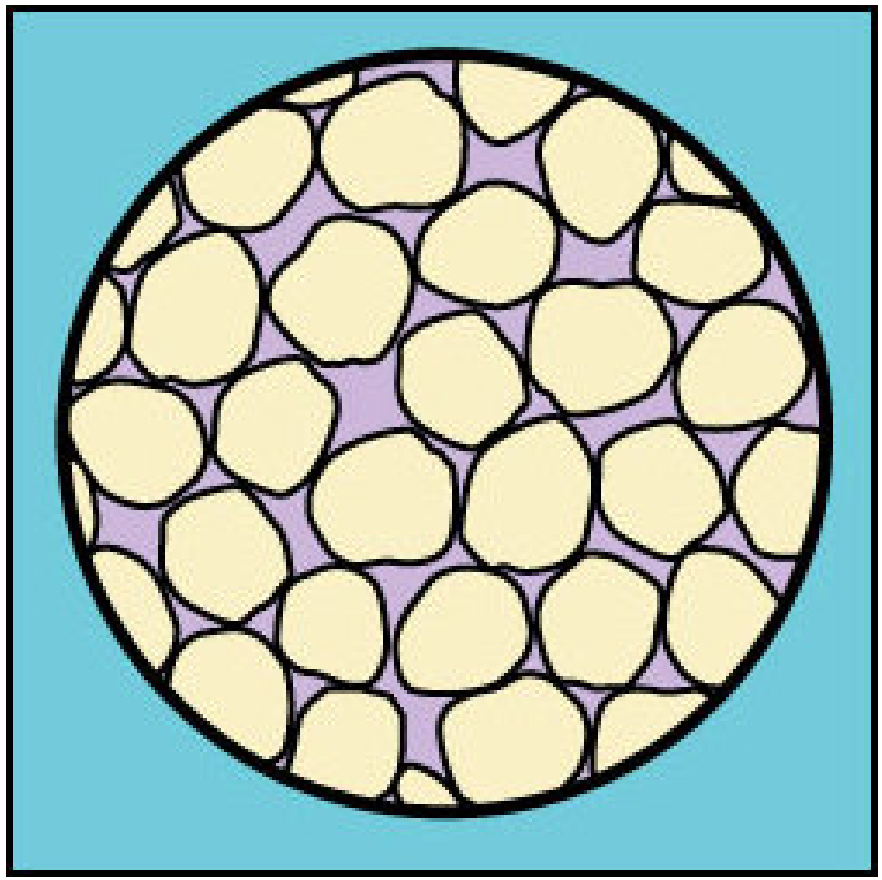
- Has open space
- Sponge

PERMEABLE

- Permits fluid throughflow
- Nylon scrubbie

RESERVOIR

- Permeable
- and Porous

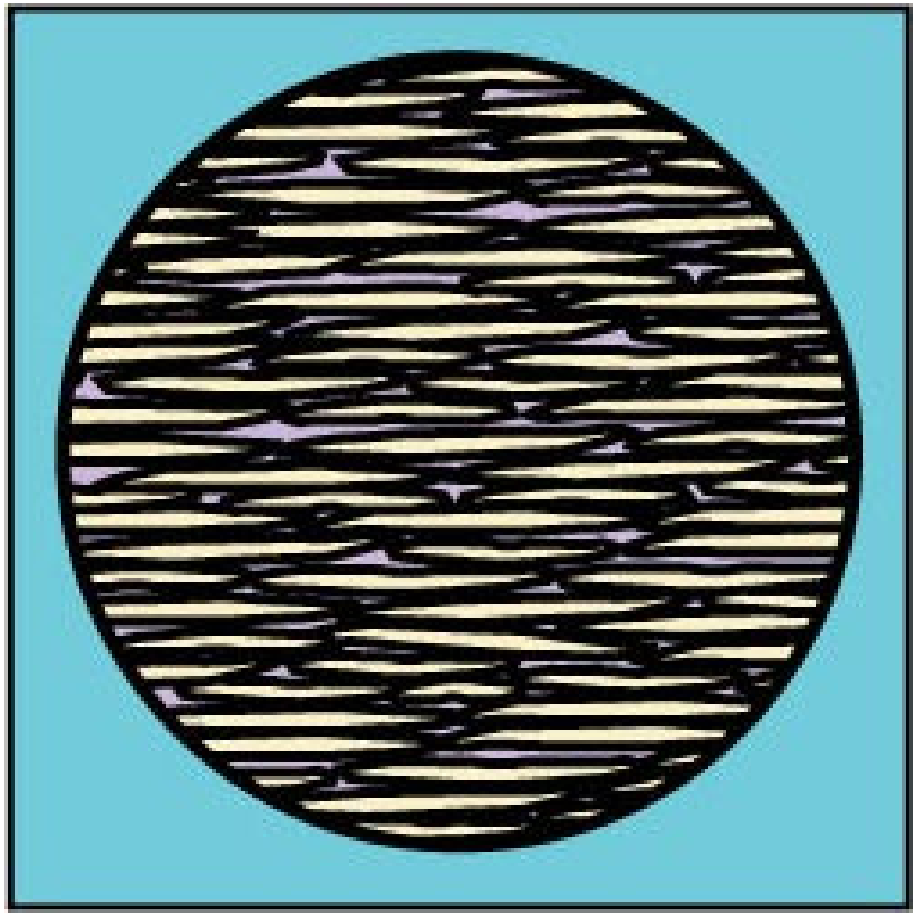


http://www.priweb.org/ed/pgws/systems/reservoir/reservoir.html

TRAP

Almost no permeability or pore space

- Shale (Usually not source shale)



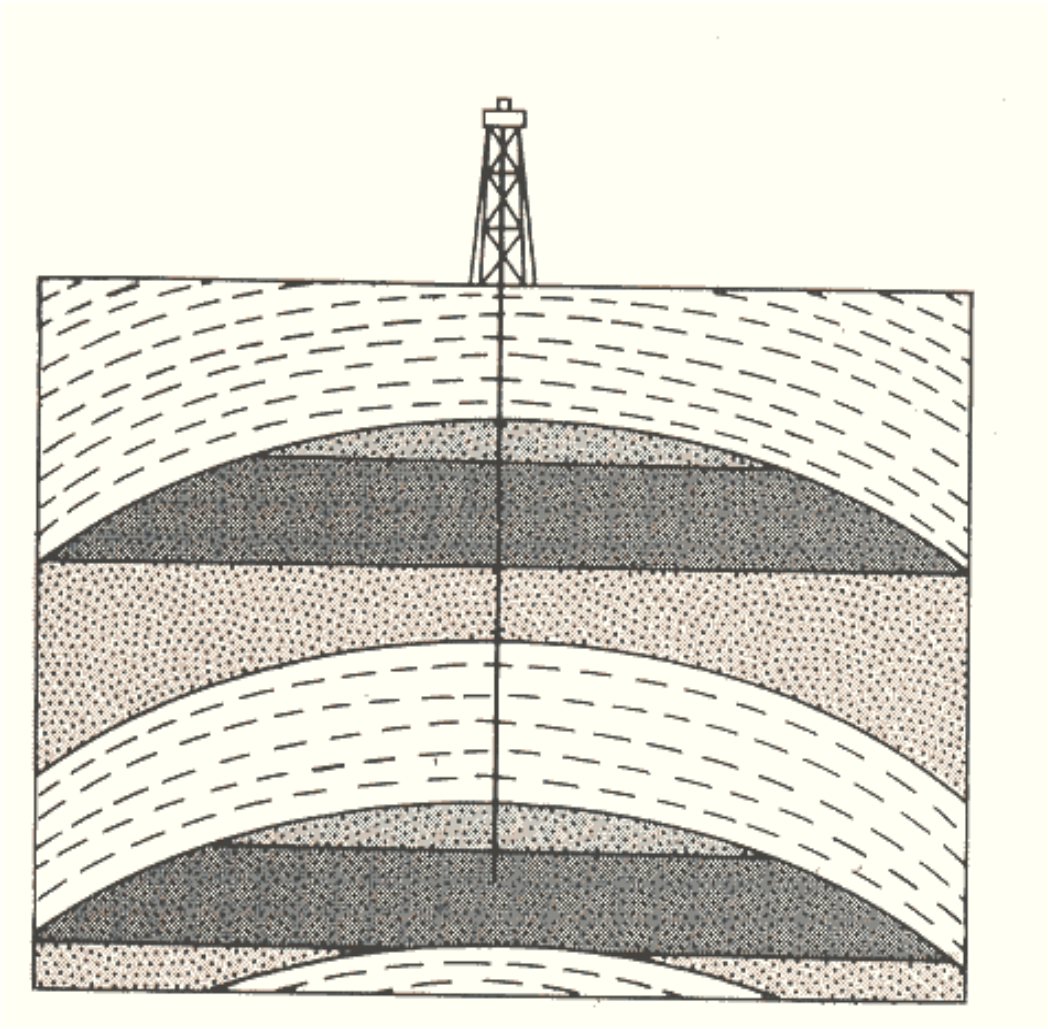
http://www.priweb.org/ed/pgws/systems/seal/seal.html

STYLES OF TRAPS

- Structural
- Stratigraphic

STRUCTURAL TRAP

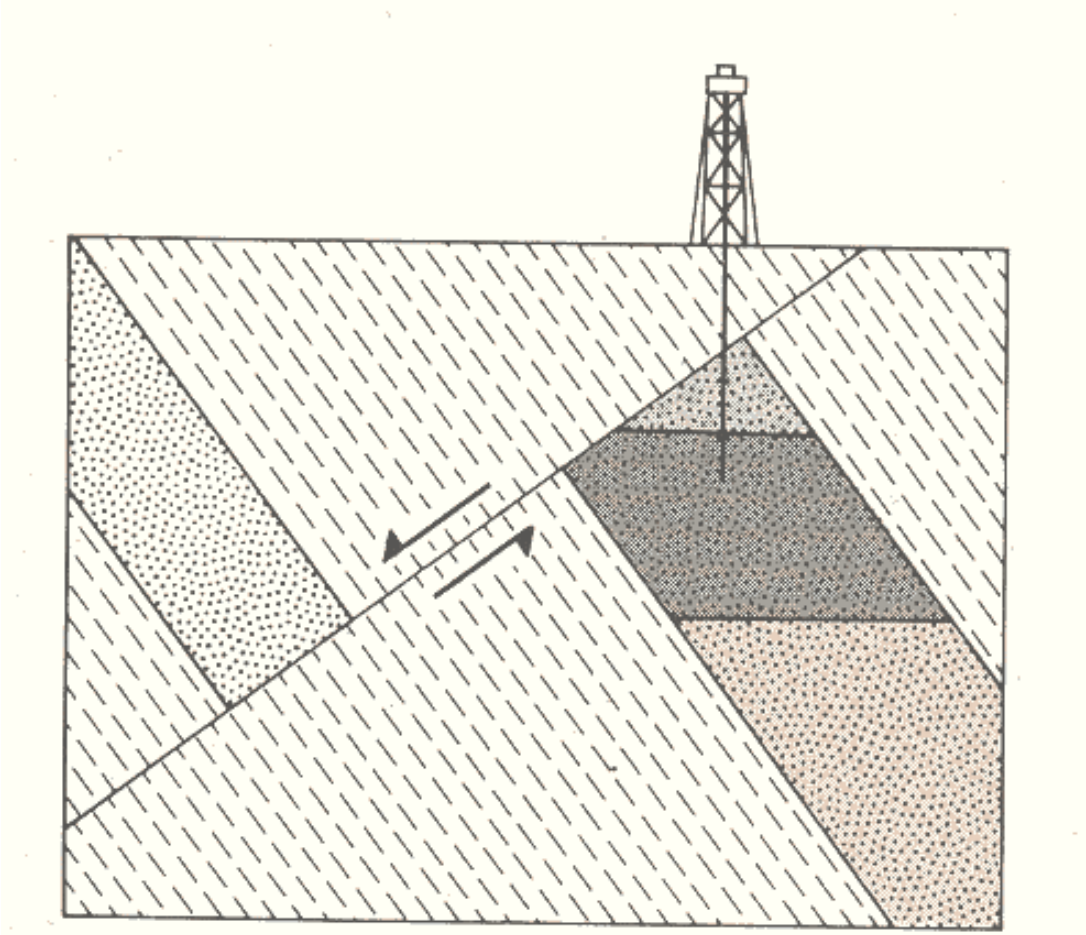
- Reservoir sand
- Capping shale
- Arched fold



Plummer, McGeary Physical Geology, 2nd, Wm. C. Brown Co., 1979

STRUCTURAL TRAP

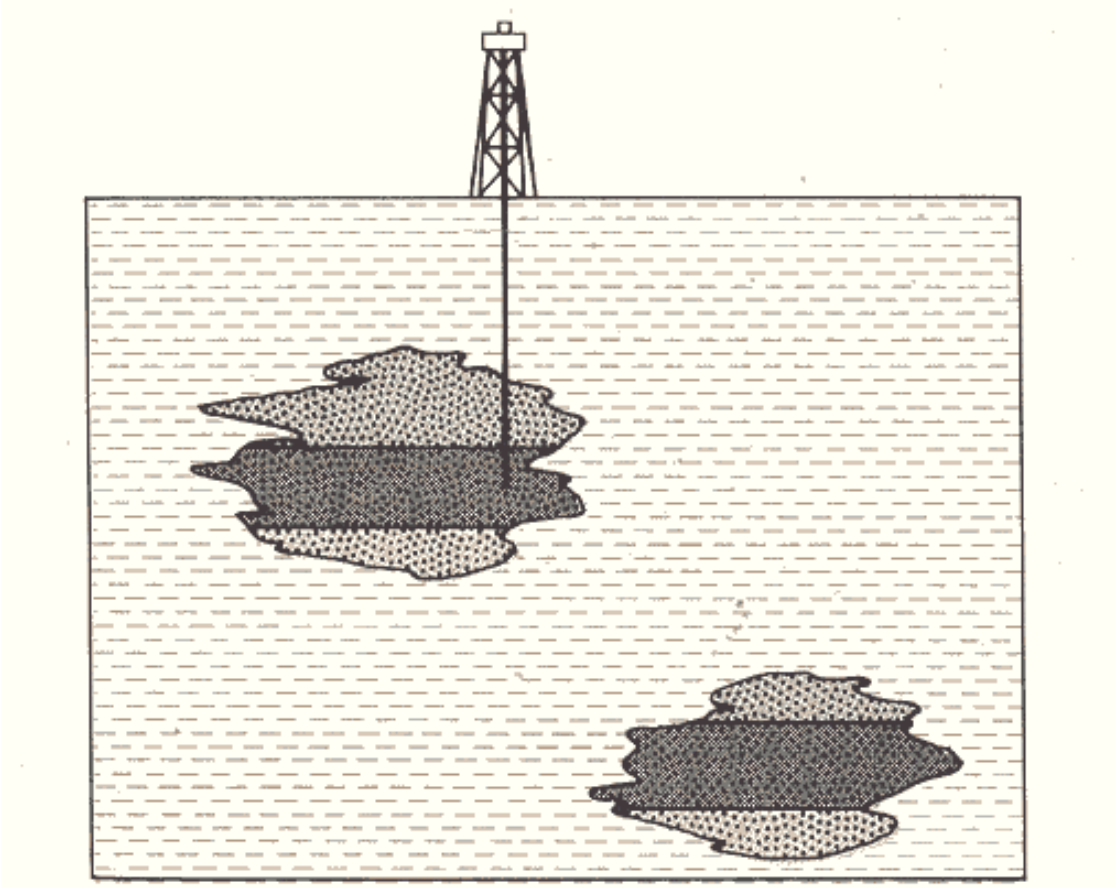
- Reservoir exists
- Fault creates trap



Plummer, McGeary Physical Geology, 2nd, Wm. C. Brown Co., 1979

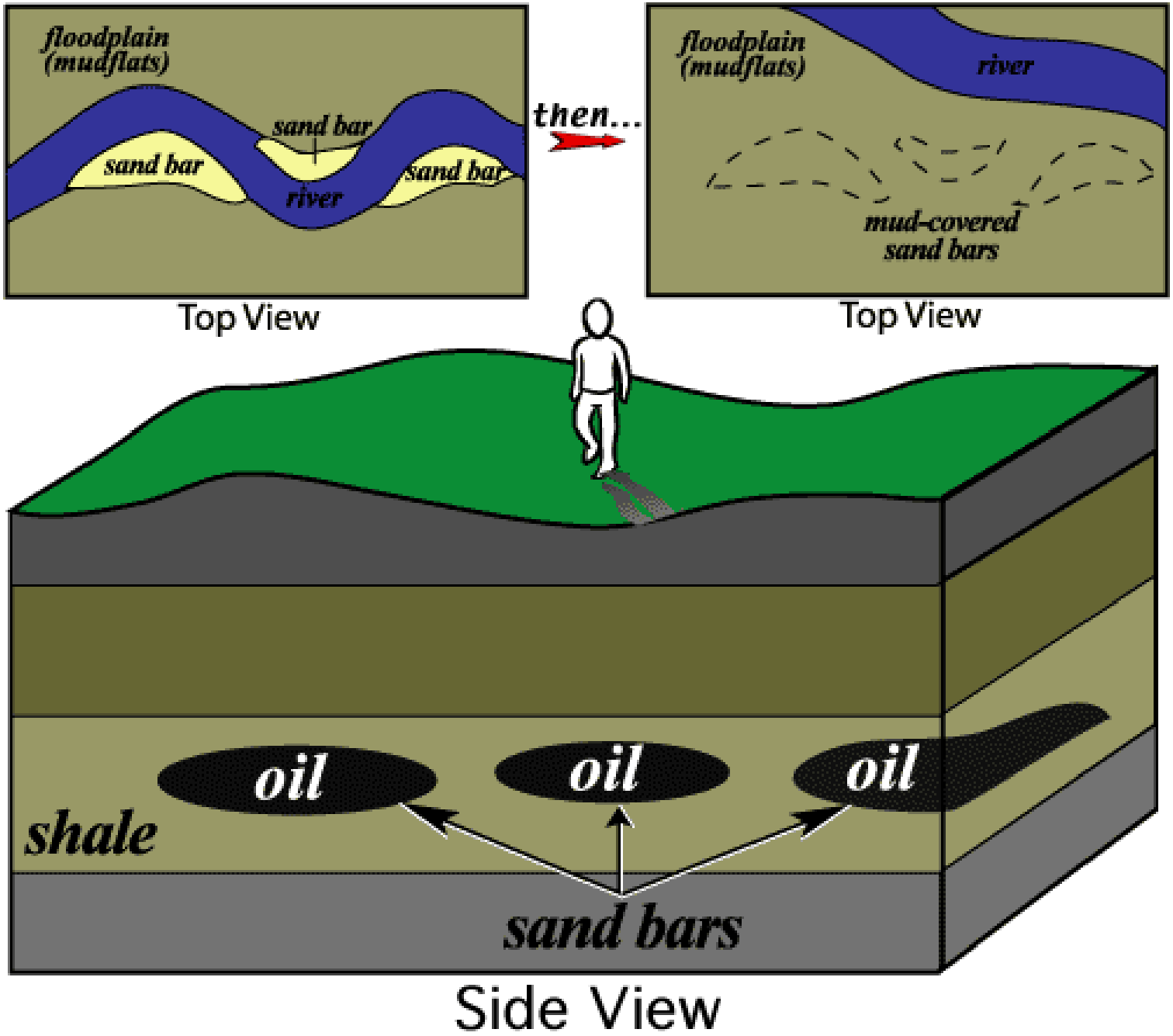
STRATIGRAPHIC TRAP

- Channel sand
- Shifting channel of river
- Shale above caps reservoir



Plummer, McGeary Physical Geology, 2nd, Wm. C. Brown Co., 1979

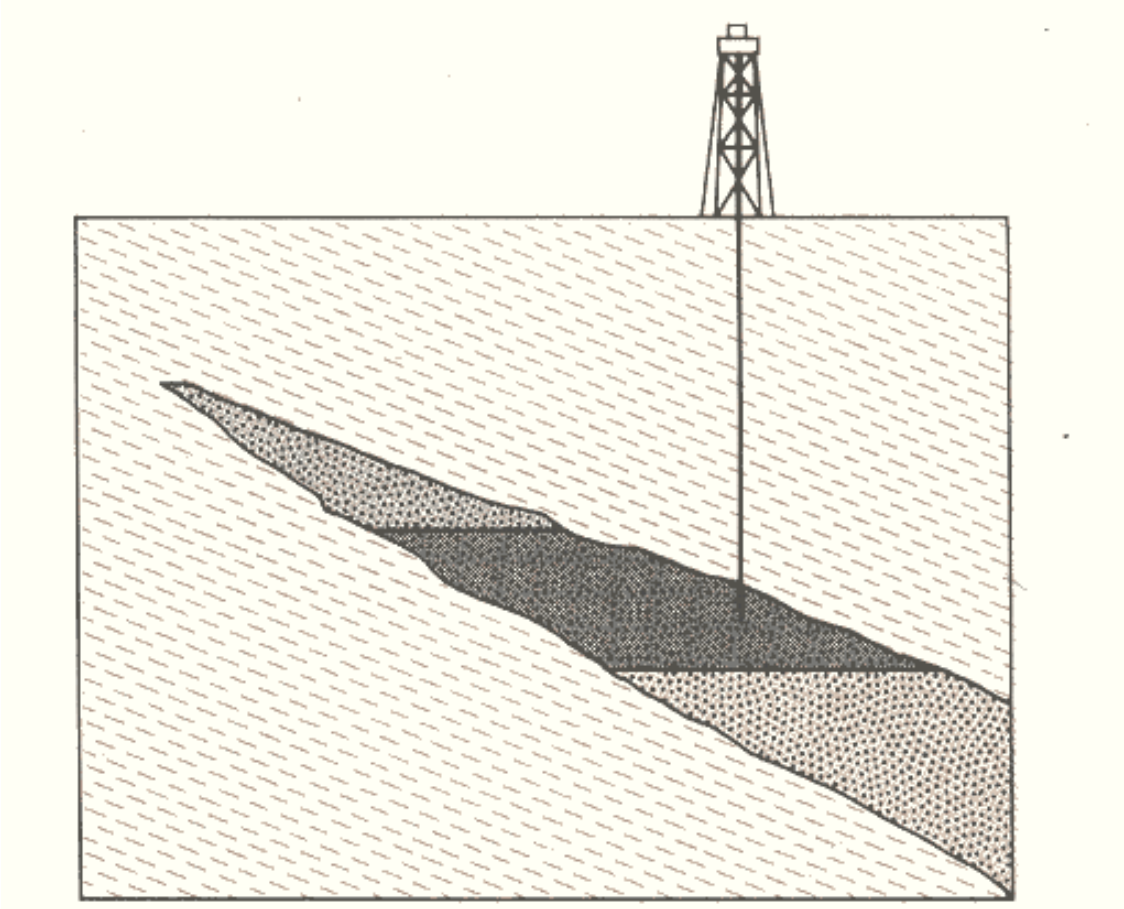
Sand lens Traps from meandering streams



http://www.priweb.org/ed/pgws/systems/traps/strat/strat_traps.html

STRATIGRAPHIC TRAP

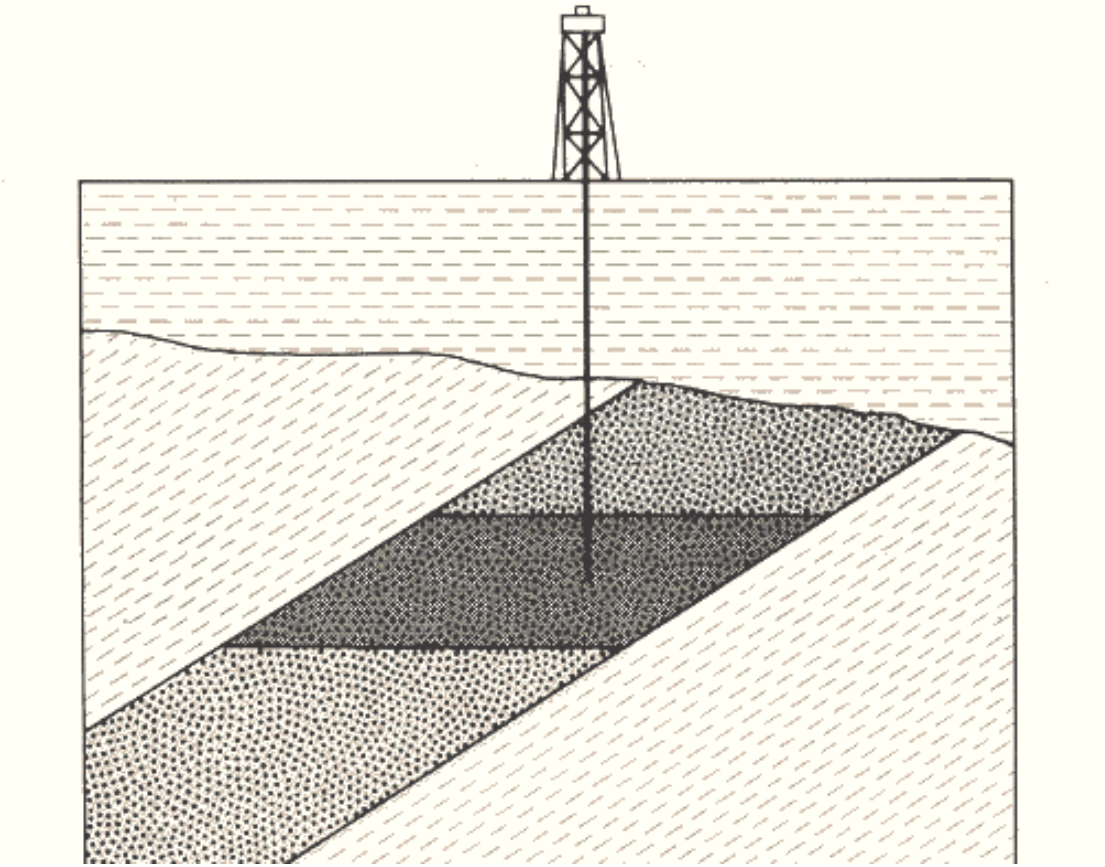
- Deposition of sand
- Shale deposited above sand
  - Deltas
  - Invading seas



Plummer, McGeary Physical Geology, 2nd, Wm. C. Brown Co., 1979

UNCONFORMITY TRAP

- Reservoir rock tilted and eroded
- Impermeable rock deposited above erosion surface



Plummer, McGeary Physical Geology, 2nd, Wm. C. Brown Co., 1979

Natural Gas

- Mostly methane

  $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O + \text{heat}$

- Excellent, clean-burning fuel
- Raw material for plastics and other chemicals

Petroleum

- Replaced coal by about 1950
- Complex hydrocarbon molecules
- Derived from fats
- Combustion products are carbon dioxide and water

Petroleum

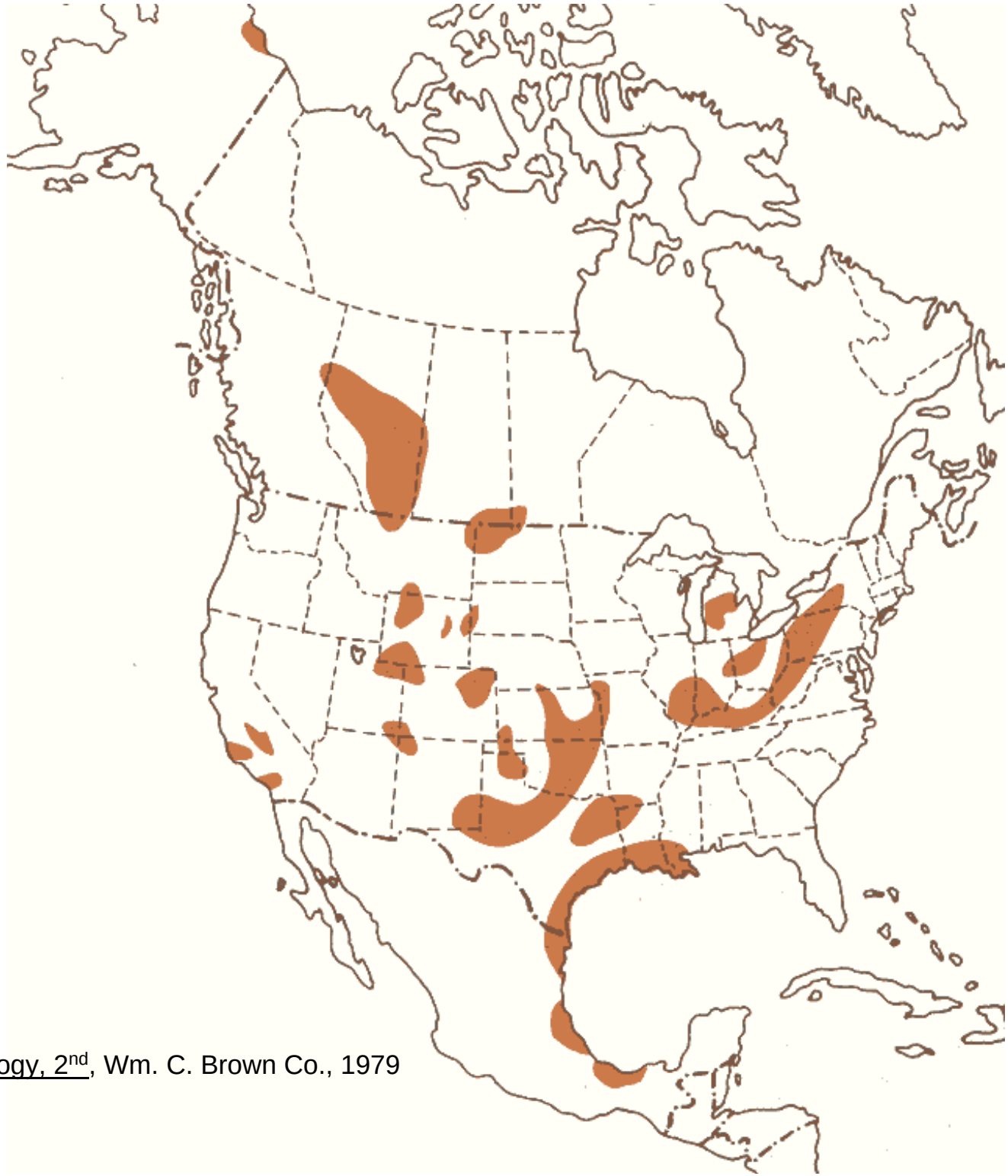
$$2C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O$$

- Also contains some sulfur compounds
- Fuel oil is fairly clean
- Burning gasoline results in smog
  - Internal combustion engines inefficient

Petroleum Requirements

- Source
- Cooking
- Reservoir
- Trap

MAJOR OIL FIELDS IN NORTH AMERICA



Plummer, McGeary Physical Geology, 2nd, Wm. C. Brown Co., 1979

TITUSVILLE, PA

- Oil Creek Valley in the 1860s
- Phillips well (rt) 4000 bbl/day
- Woodford well (lt) 1500 bbl/day

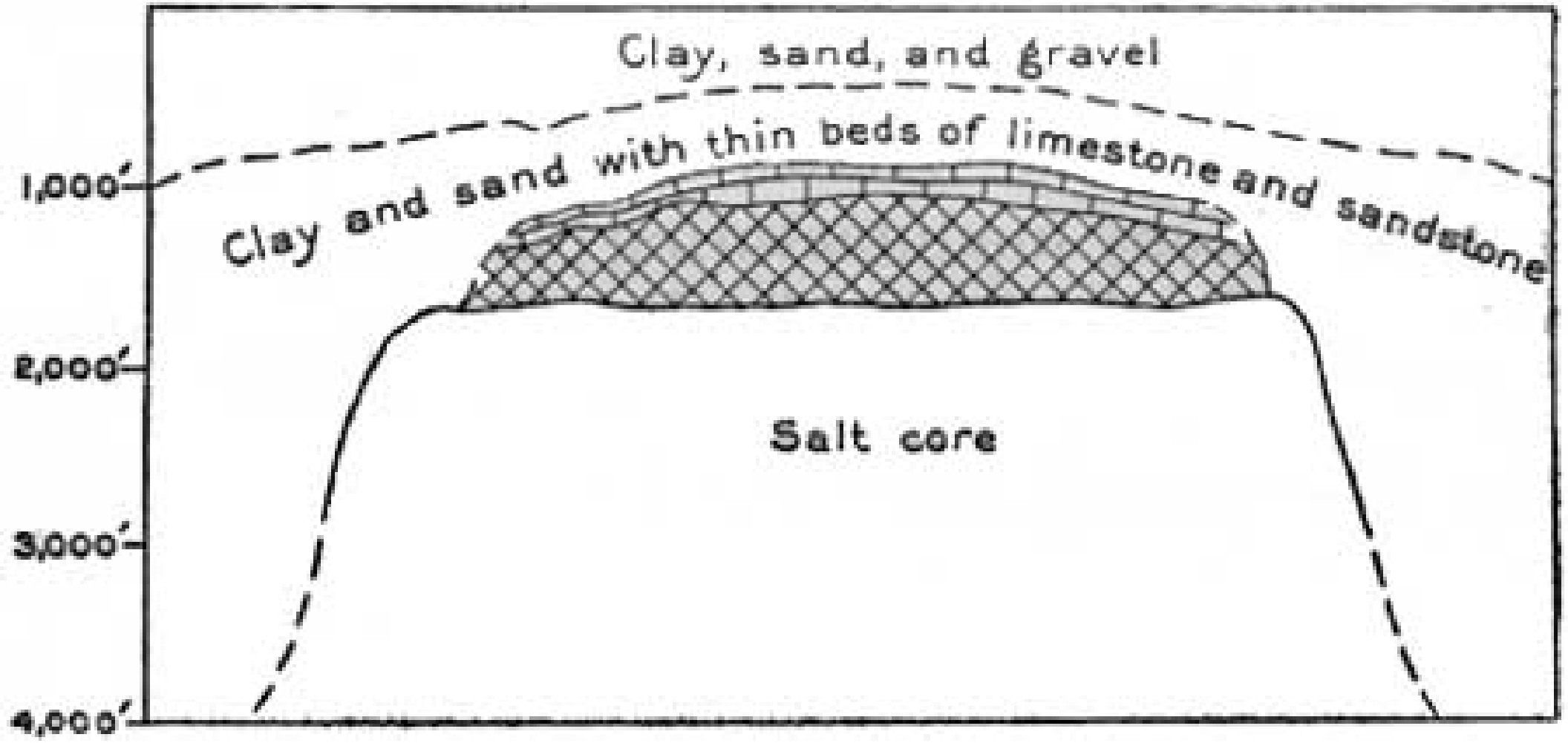
http://www.priweb.org/ed/pgws/history/pennsylvania/tarr_farm.html

Texas Oil

- Lucas Gusher, 1901
- Initial production 100,000 bbl/day
- Salt dome traps

http://www.priweb.org/ed/pgws/history/spindletop/spindletop.html

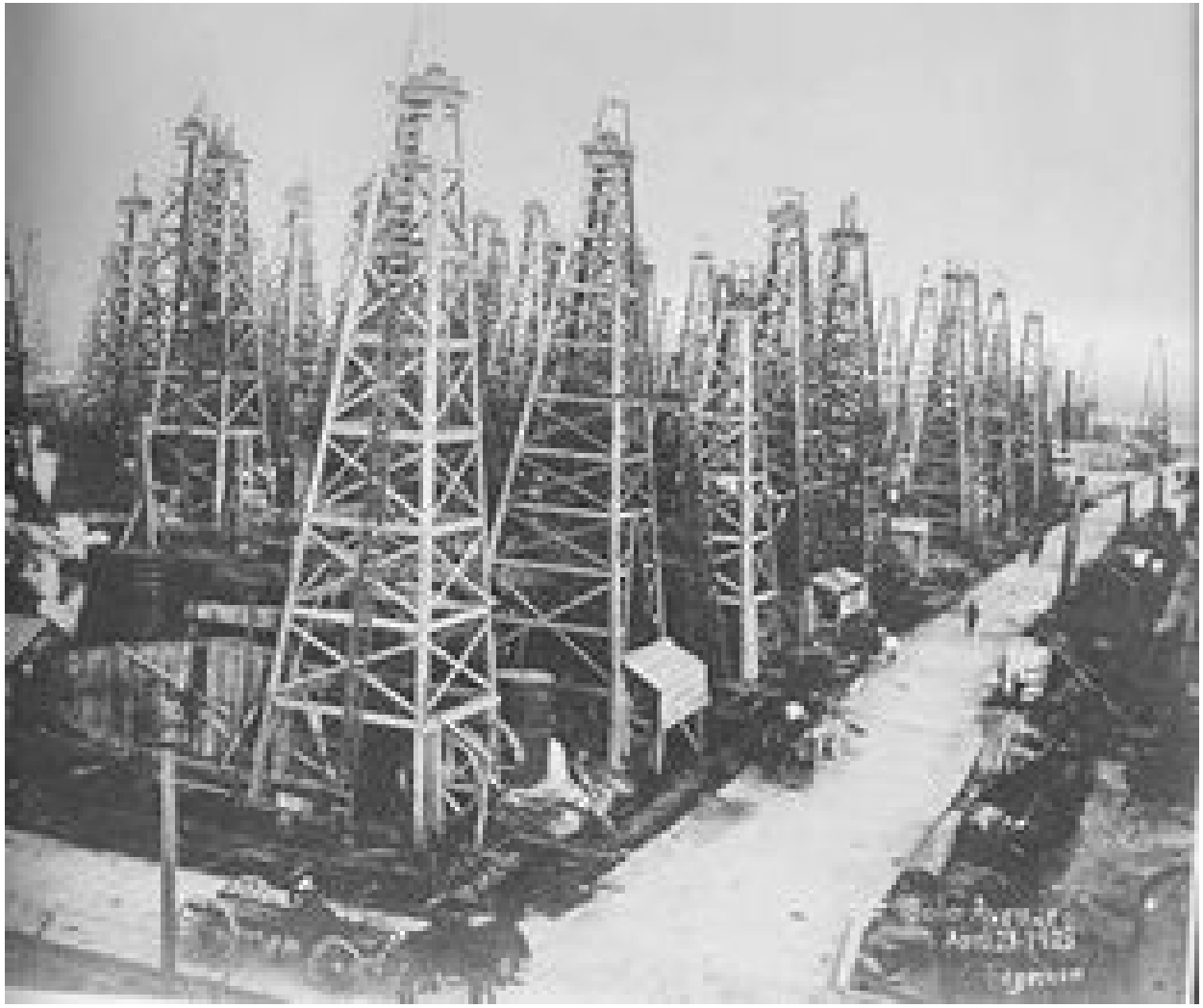
Spindletop Salt Dome



http://www.nps.gov/history/history/online_books/geology/publications/bul/845/contents.htm

Boiler Avenue

On Spindletop salt dome at Beaumont, Texas



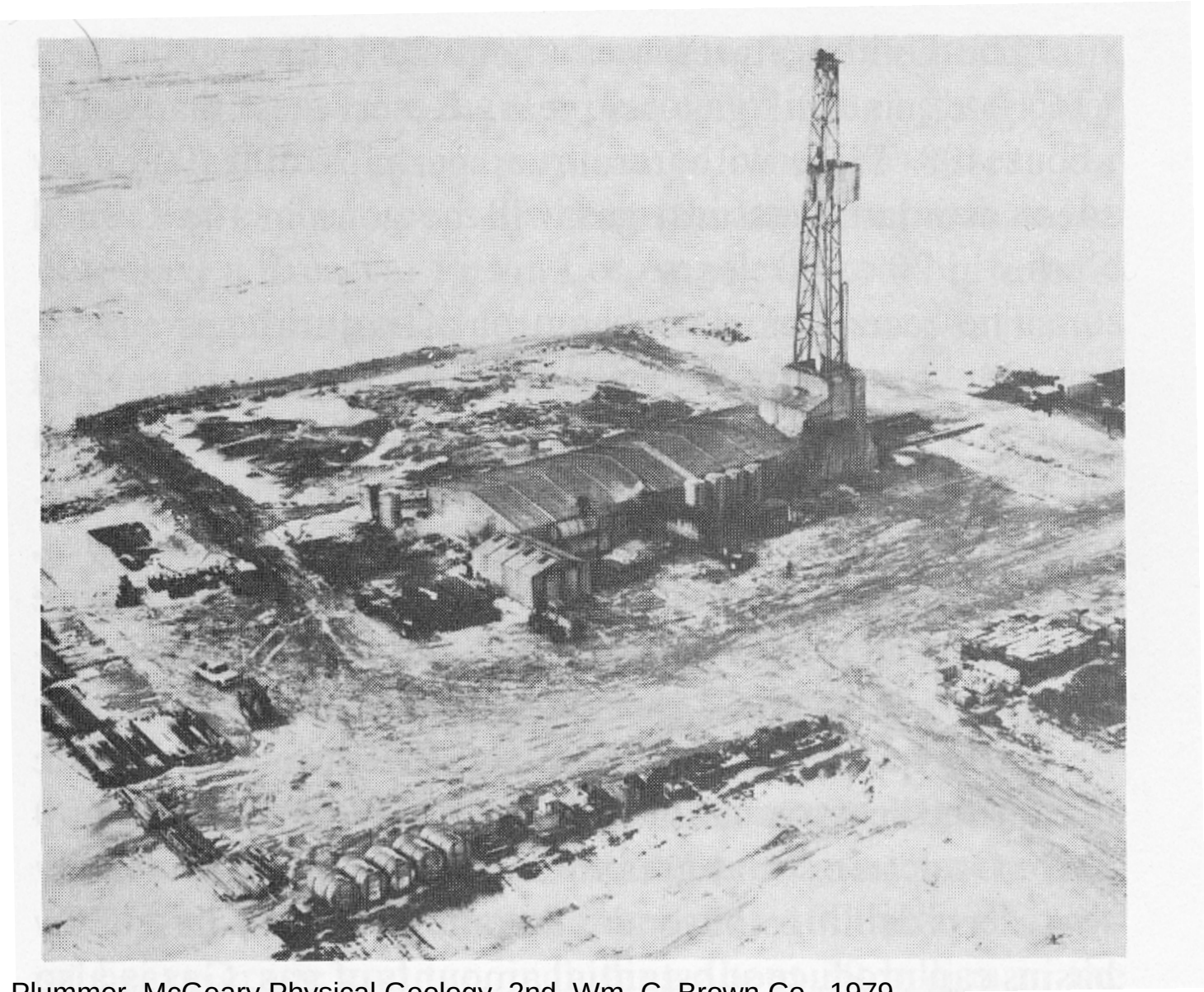
http://www.priweb.org/ed/pgws/history/spindletop/spindletop.html

Signal Hill, Long Beach, CA

1932

http://www.priweb.org/ed/pgws/history/signal_hill/signal_hill2.html

Drilling on the North Slope



Plummer, McGeary Physical Geology, 2nd, Wm. C. Brown Co., 1979

Drilling in the North Sea

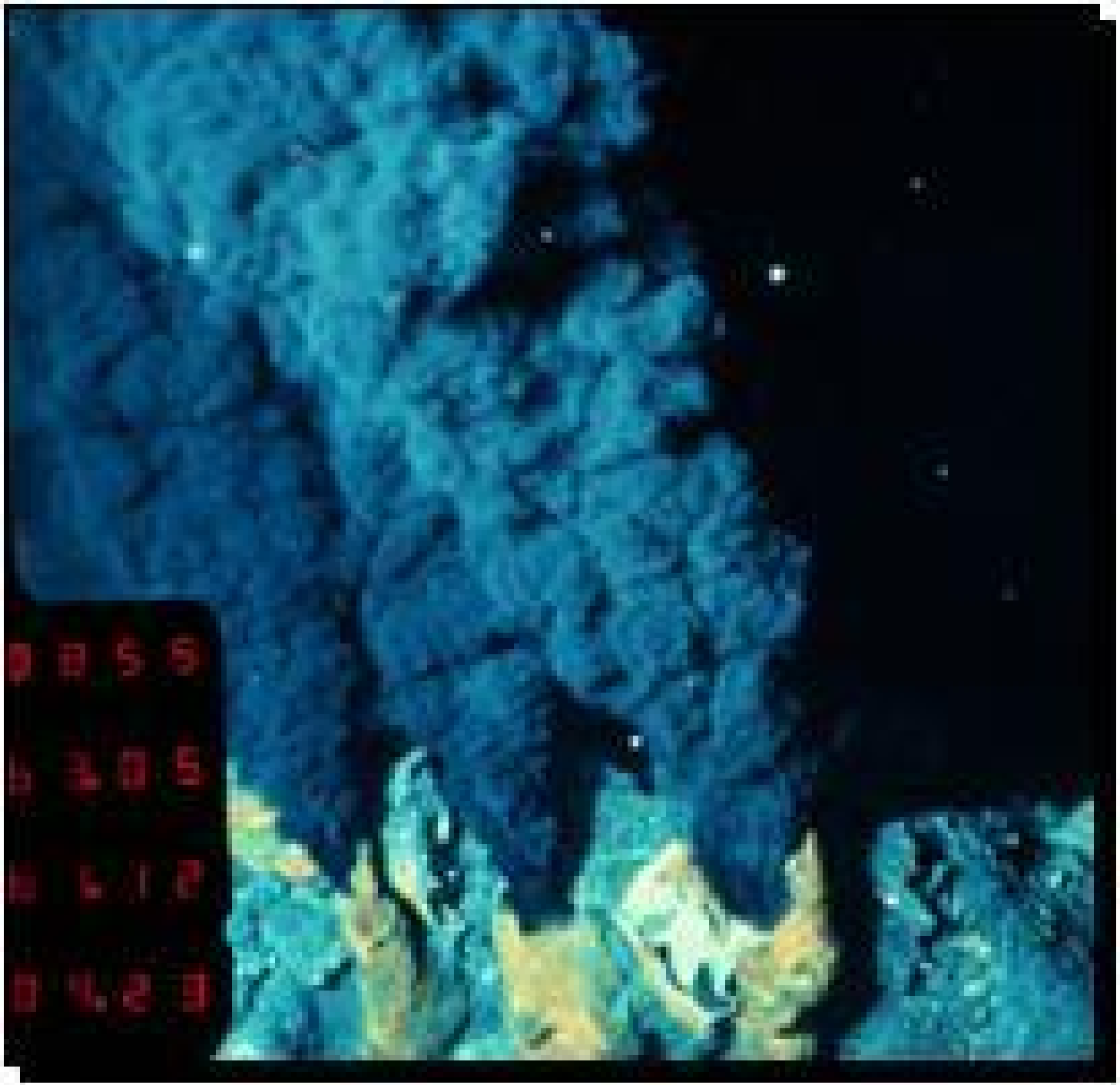
Rocks and Fossils, Busbey, Doenraads, Willis and Roots, Fog City Press, 1997

Top 10 Countries—Oil Statistics

- Reserves
- http://www.nationmaster.com/graph-T/ene_oil_res&int=10
- Comsumption
- http://www.nationmaster.com/graph-T/ene_oil_con&int=10

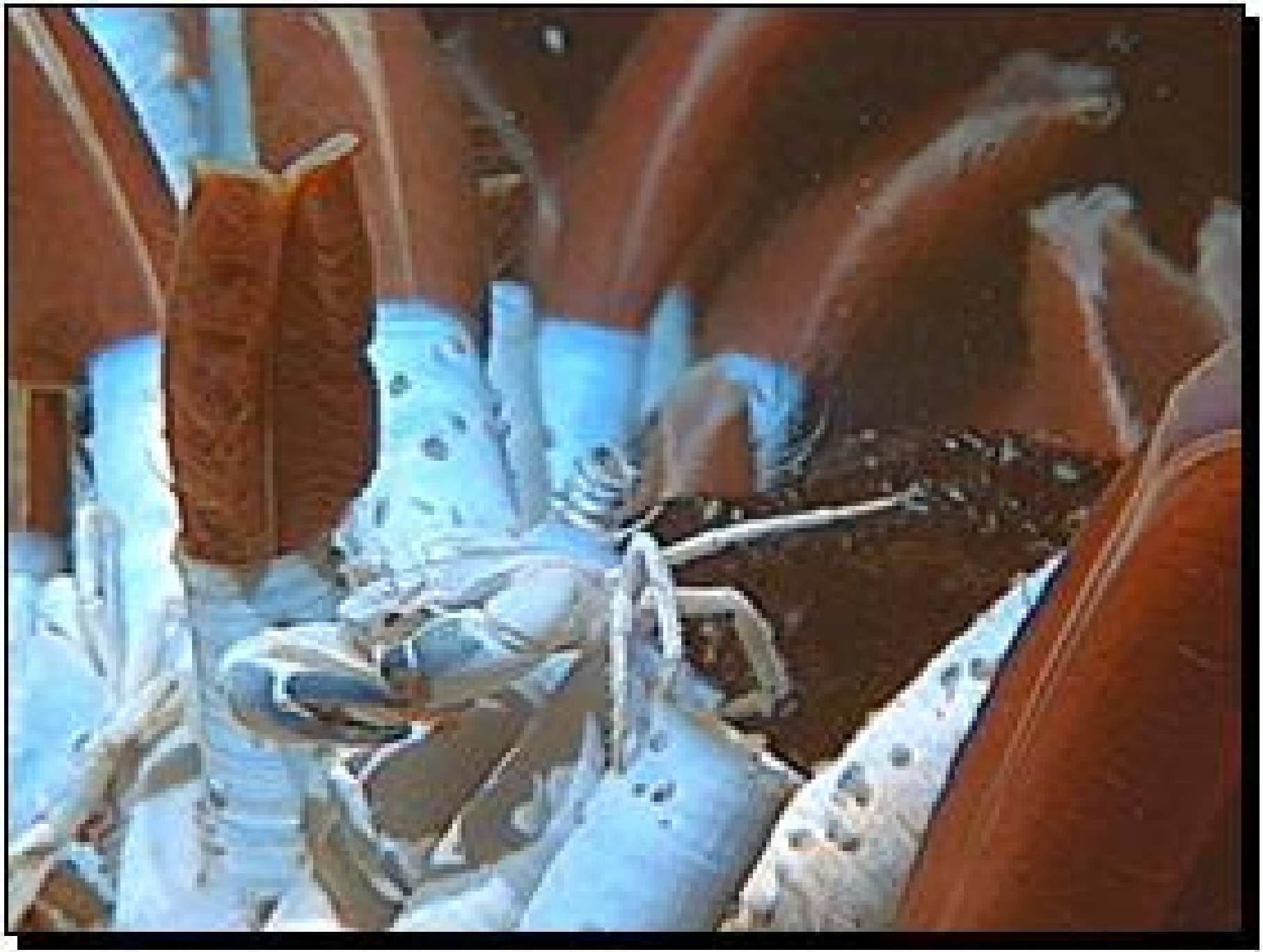
Source of energy not from Sun

- Rare deep sea vent communities
- Sulfurous hotsprings supports bacteria
- Other organisms subsist on bacteria
- Larger creatures can survive on the bacteria-eating organisms



http://www.punaridge.org/doc/factoids/Biology/

http://www.punaridge.org/doc/factoids/Biology/



http://www.punaridge.org/doc/factoids/Biology/