

Fossil Fuels, Chemistry of Fuels

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
- $\text{C}_3\text{H}_8 + 5 \text{O}_2 \rightarrow 3 \text{CO}_2 + 4 \text{H}_2\text{O} + 526 \text{ kcal}$

Reaction energy

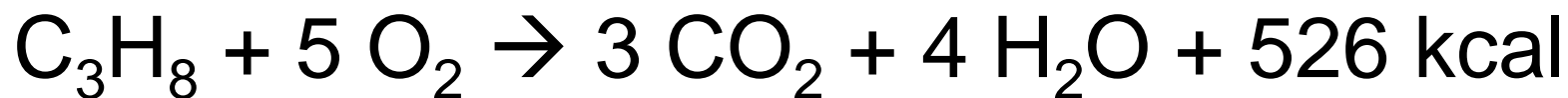
EXOTHERMIC

heats up environment

ENDOTHERMIC

absorbs heat from environment

Exothermic Reaction



- Burn 2 moles of propane
- $2 \times 526 \text{ kcal} = 1052 \text{ kcal}$
- Burn 308 g of propane
- $308 \text{ g} (1 \text{ mole}/44\text{g}) = 7 \text{ moles}$
- $7 \text{ moles} \times 526 \text{ kcal} = 3682 \text{ kcal}$

Endothermic reaction



- 5 moles of nitrogen, reacting with 5 moles of oxygen
- Consumes $5 \times 4.32 \text{ kcal} = 21.6 \text{ kcal}$

Energy and Chemical Reactions

- Temperature affects rate of reactions
 - More molecule collisions
 - More energy to break chemical bonds
- Concentration of reactants
- Presence of catalyst
 - Peroxide $2 \text{H}_2\text{O}_2 \rightarrow 2 \text{H}_2\text{O} + \text{O}_2$ proceeds slowly
 - Add platinum: takes seconds, not years

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

Entropy

- Lack of order of systems
- Nature tends toward disorder—greater entropy
- Takes energy to overcome entropy
 - Oil spill on Columbia River
 - CFC released into atmosphere

Energy sources

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

Fossil fuels

- Burn readily
- Reaction is oxidation
- Release heat energy

Fossil fuels

- Coal
- Petroleum
- Natural Gas

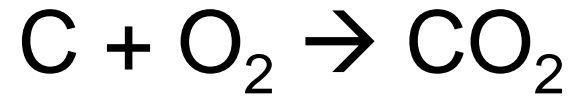
First law of thermodynamics

- 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

Coal



- Anthracite
- Bitumen
- Lignite

Coal

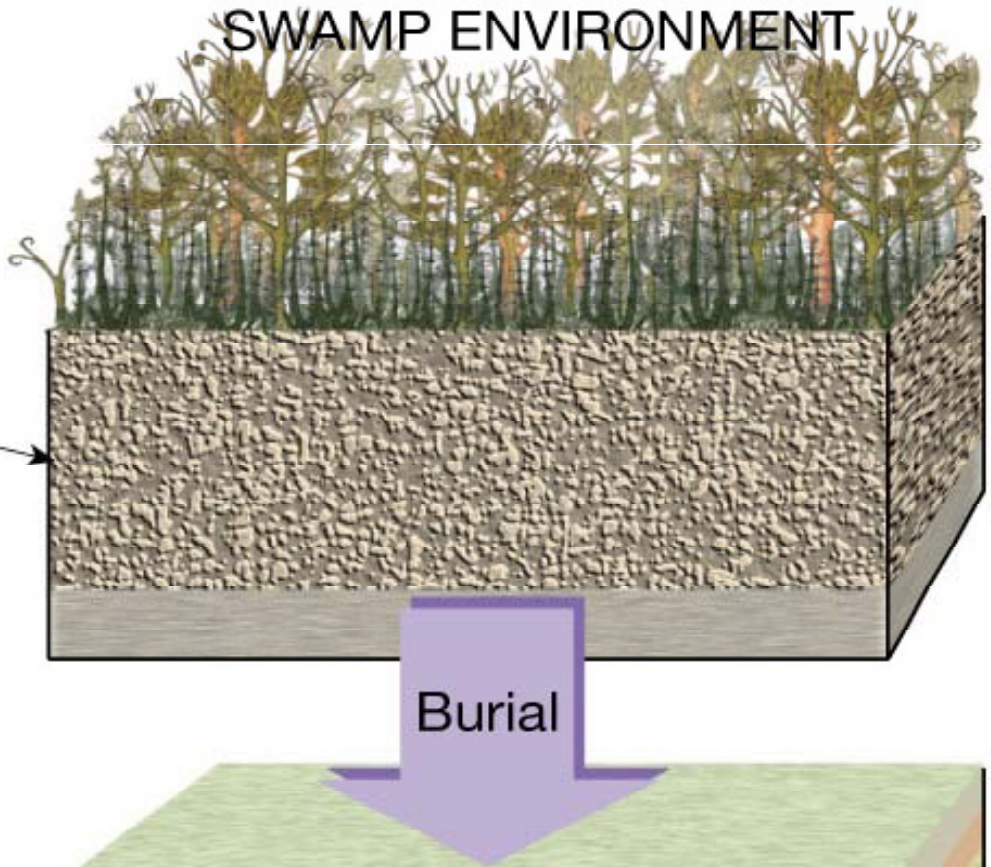
- Incompletely decayed plants
- Burial pressure releases O₂ and H₂
- Carbon remains
- Paleozoic—Pennsylvanian coal,
Carboniferous Period

Carboniferous Period Forest



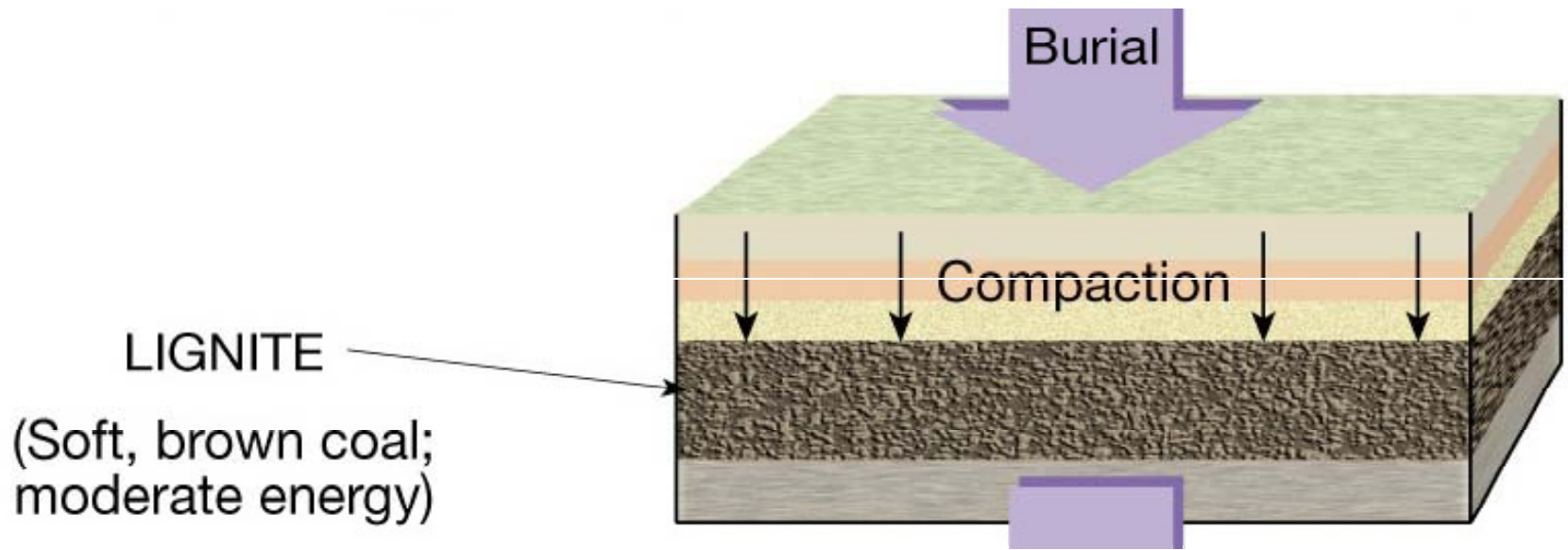
University of Michigan Exhibit Museum of Natural History Diorama

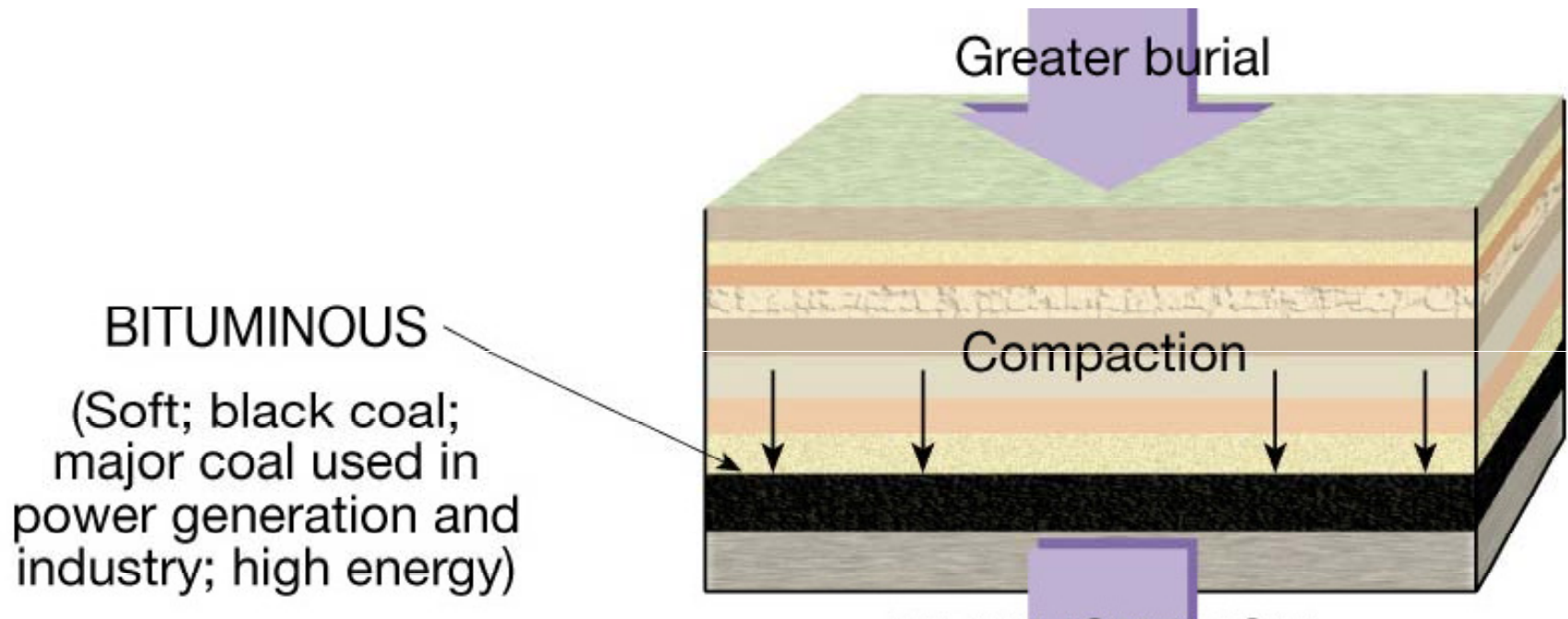
SWAMP ENVIRONMENT



PEAT

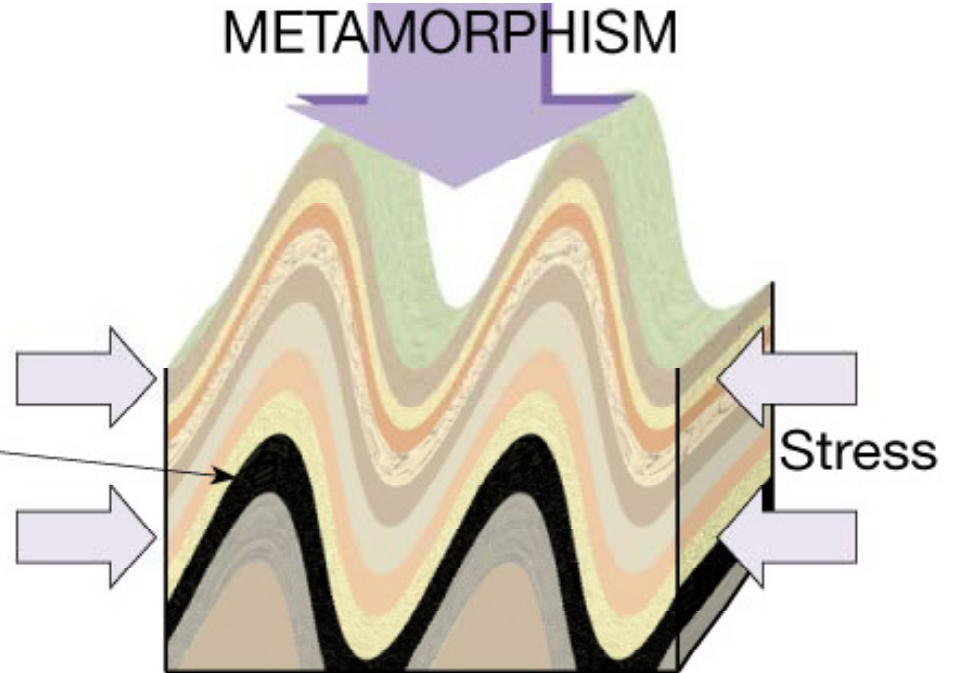
(Partially altered plant material; very smoky when burned, low energy)

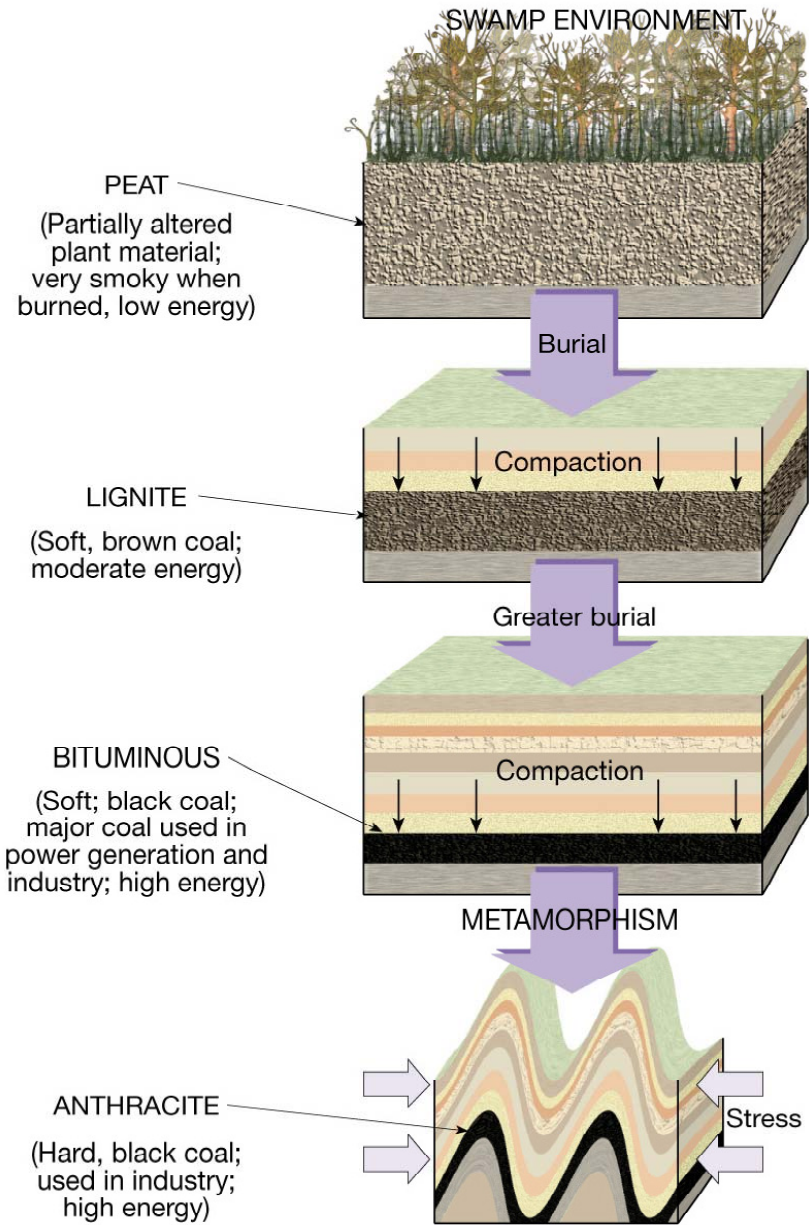




METAMORPHISM

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





Coal

- 'Coke' is made by heating coal
- Byproduct refined into organic chemicals

Coal

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

Natural Gas

- Mostly methane

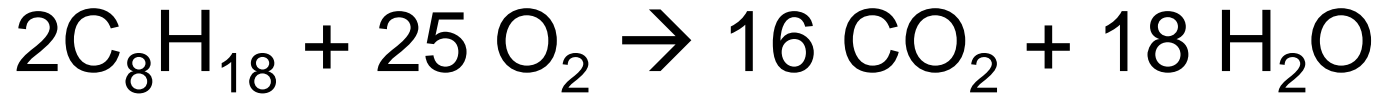


- Excellent, clean-burning fuel
- Raw material for plastics and other chemicals

Petroleum

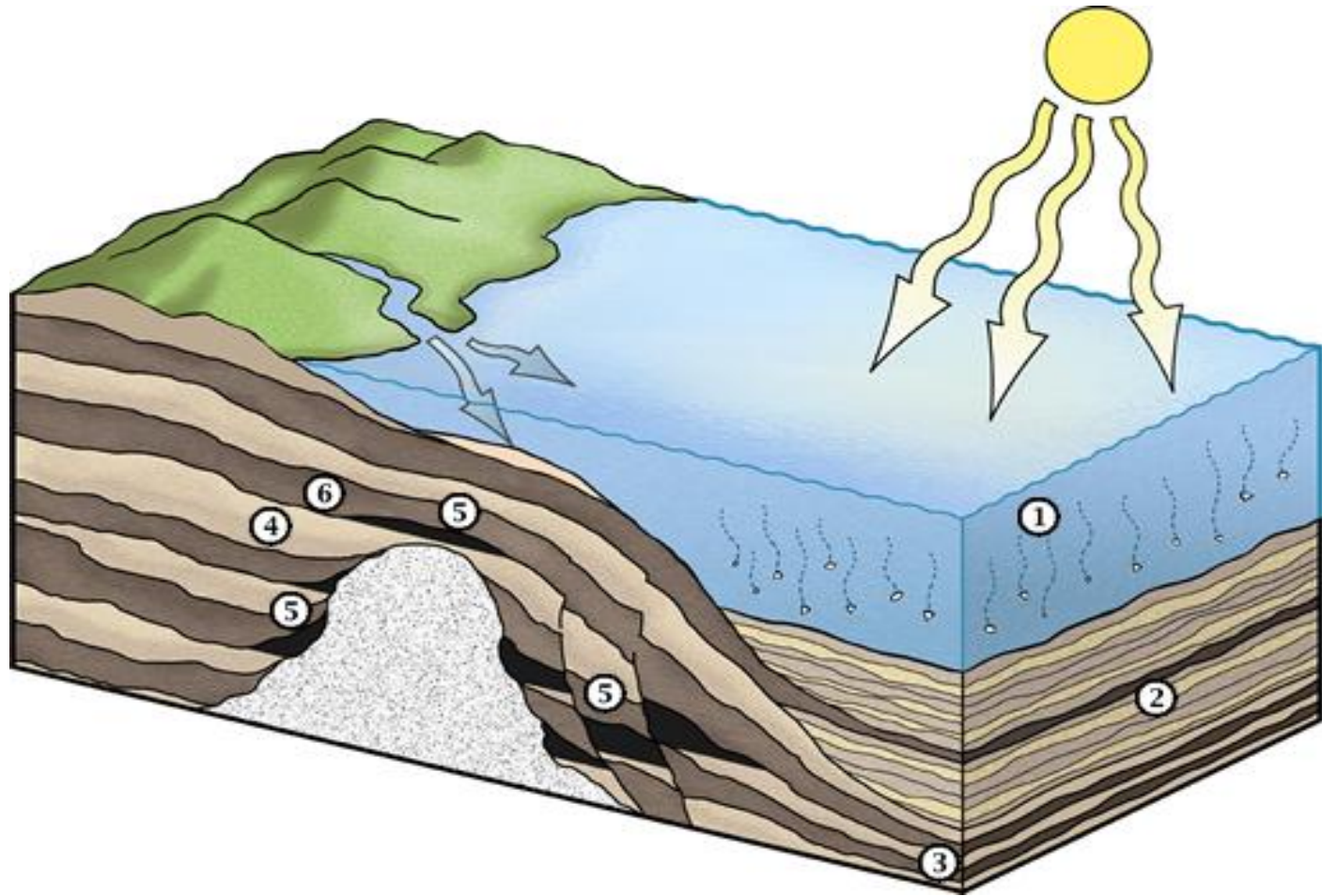
- Replaced coal by about 1950
- Complex hydrocarbon molecules
- Derived from fats
- Combustion products are carbon dioxide and water

Petroleum



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

Hydrocarbon System



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

SOURCES

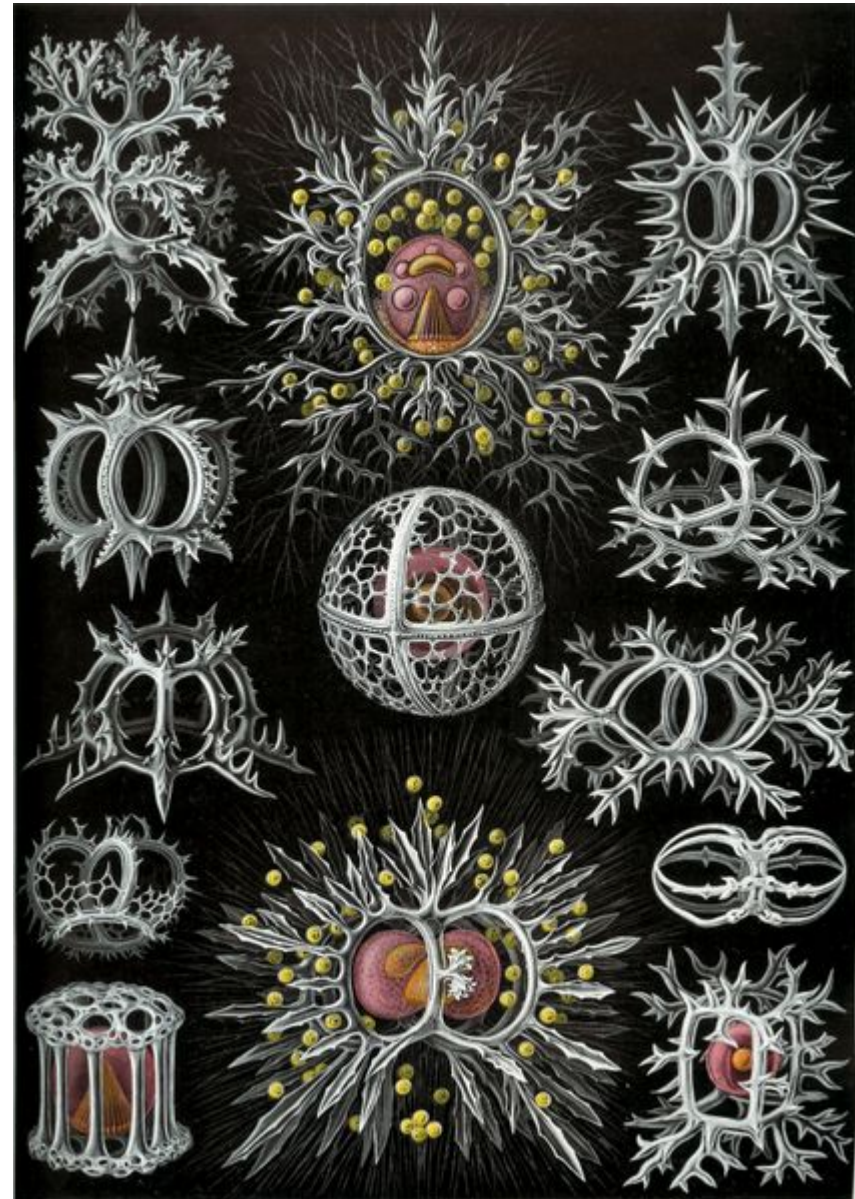
- Shale with organic material
- Gooney sludge on ocean floor

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

- Permeable
- Porous
- Usually a sedimentary rock

PERMEABLE

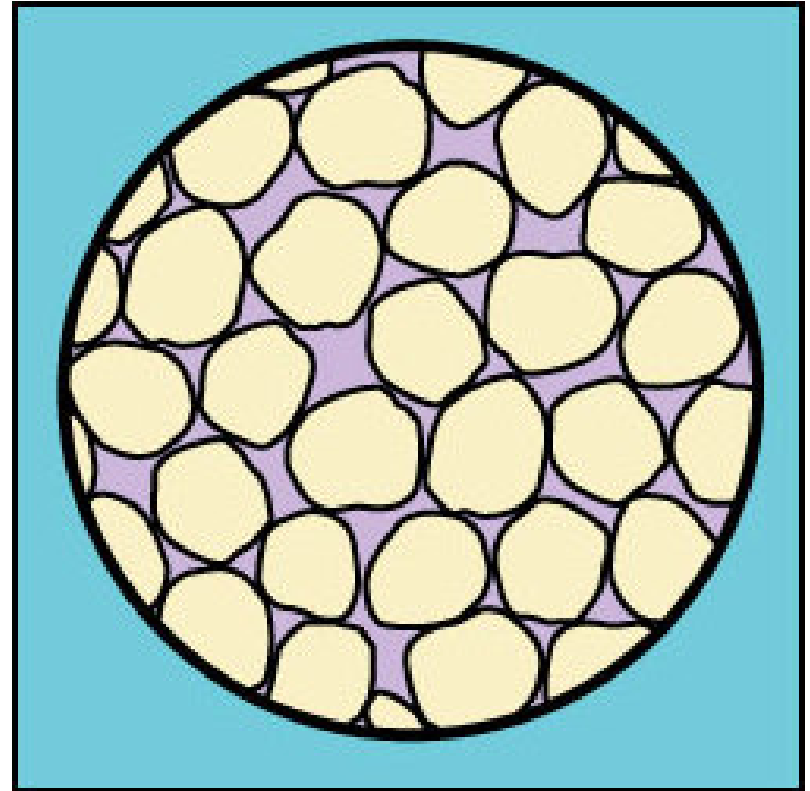
- Permits fluid throughflow
- Nylon scrubbie

POROUS

- Has open space
- Sponge

RESERVOIR

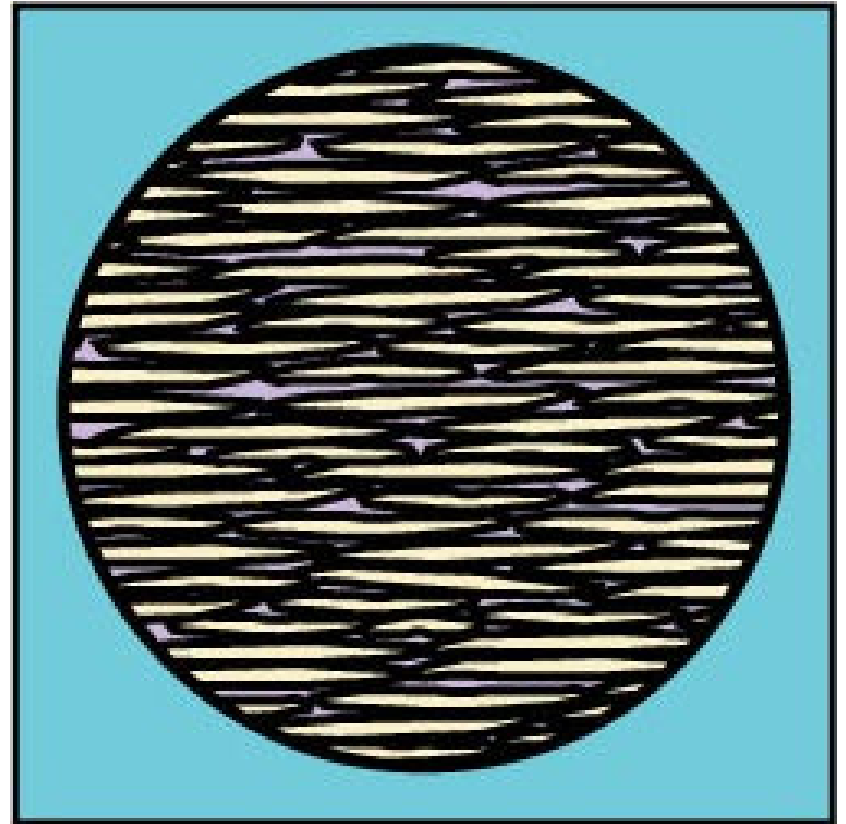
- Permeable
- and Porous



Trap

Almost no permeability or pore space

- Shale (Usually not source shale)

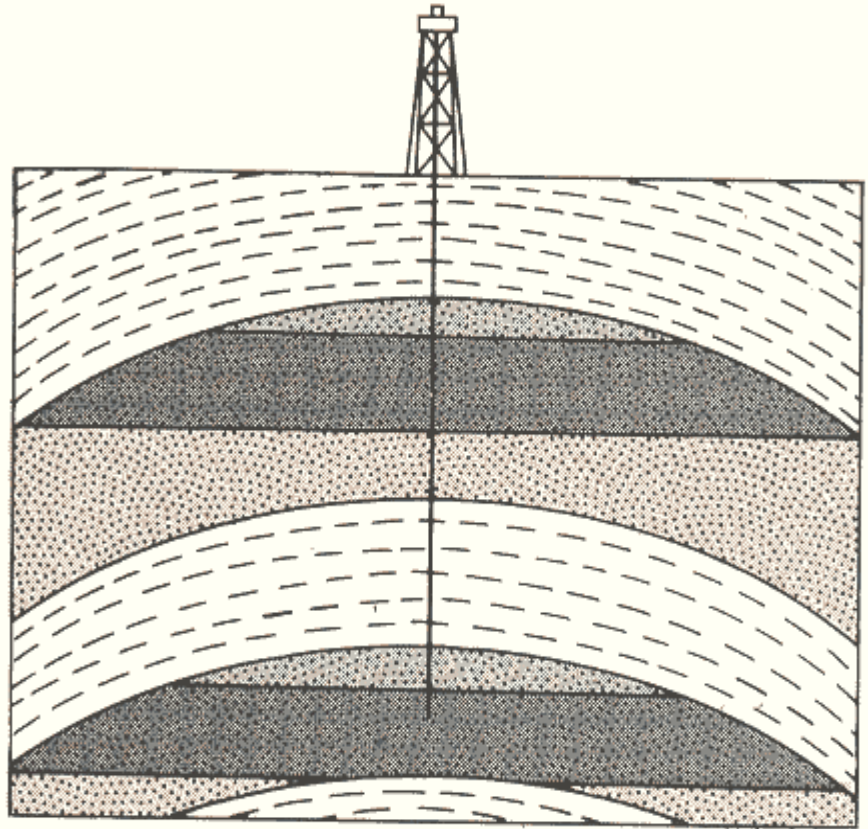


STYLES OF TRAPS

- Structural
- Stratigraphic

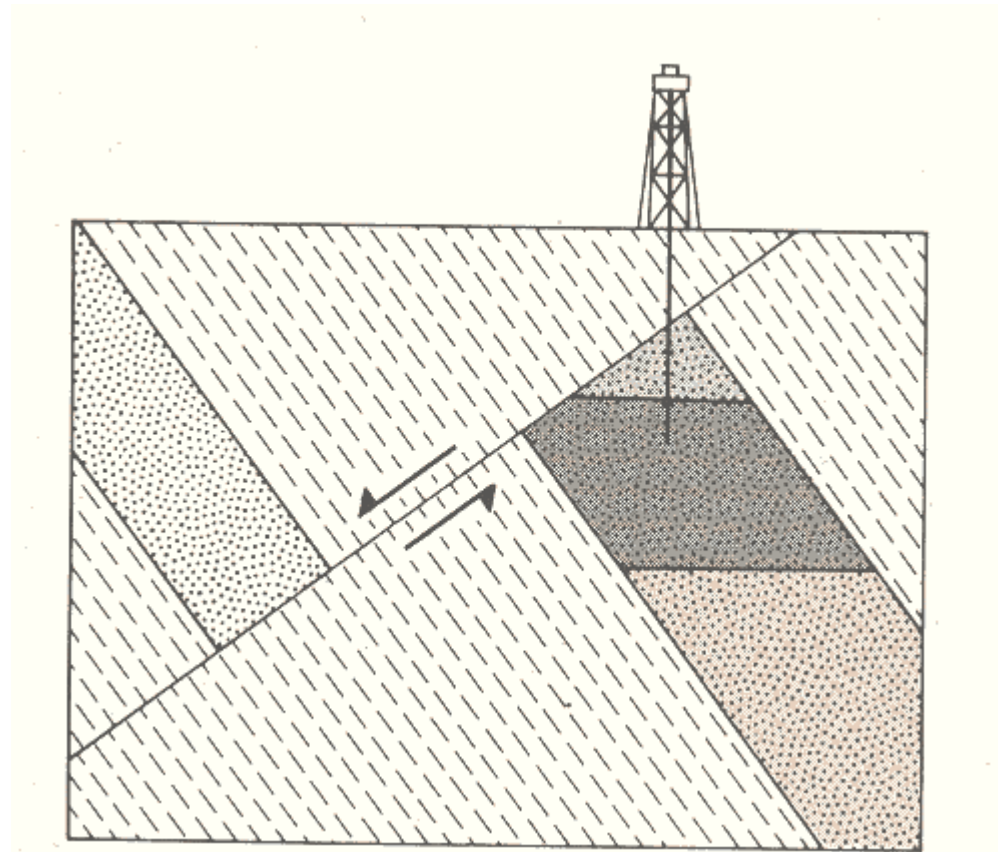
STRUCTURAL TRAP

- Reservoir sand
- Capping shale
- Arched fold



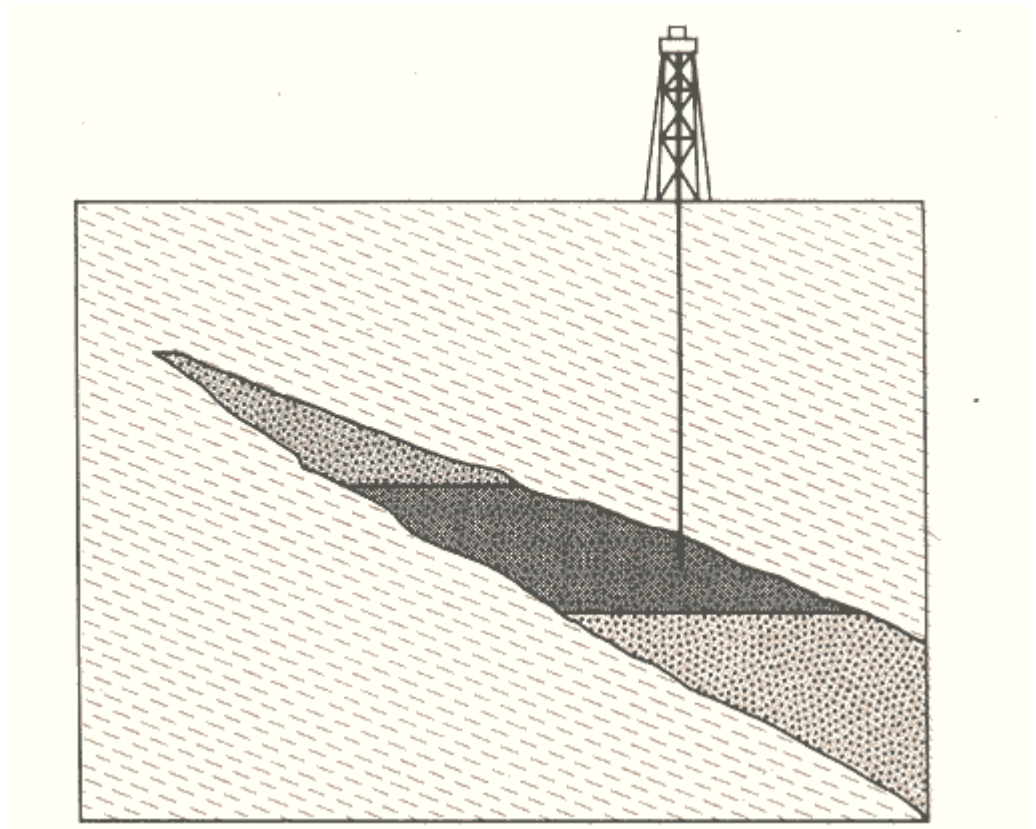
STRUCTURAL TRAP

- Reservoir exists
- Fault creates trap



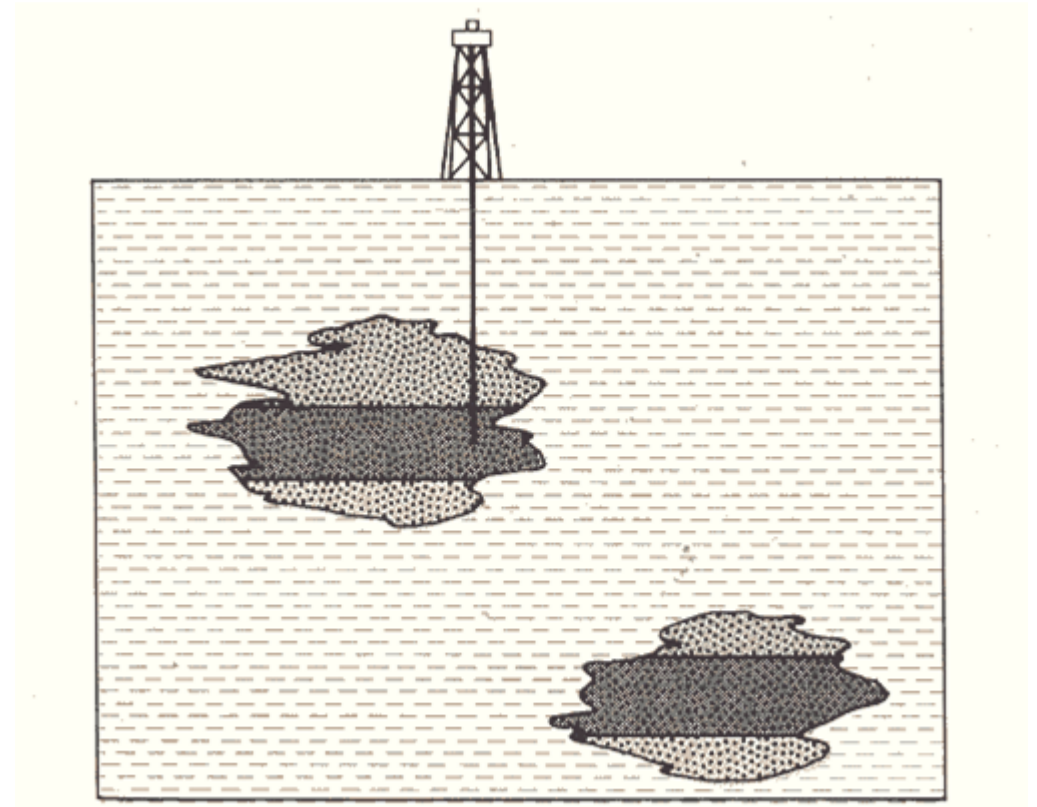
STRATIGRAPHIC TRAP

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



STRATIGRAPHIC TRAP

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

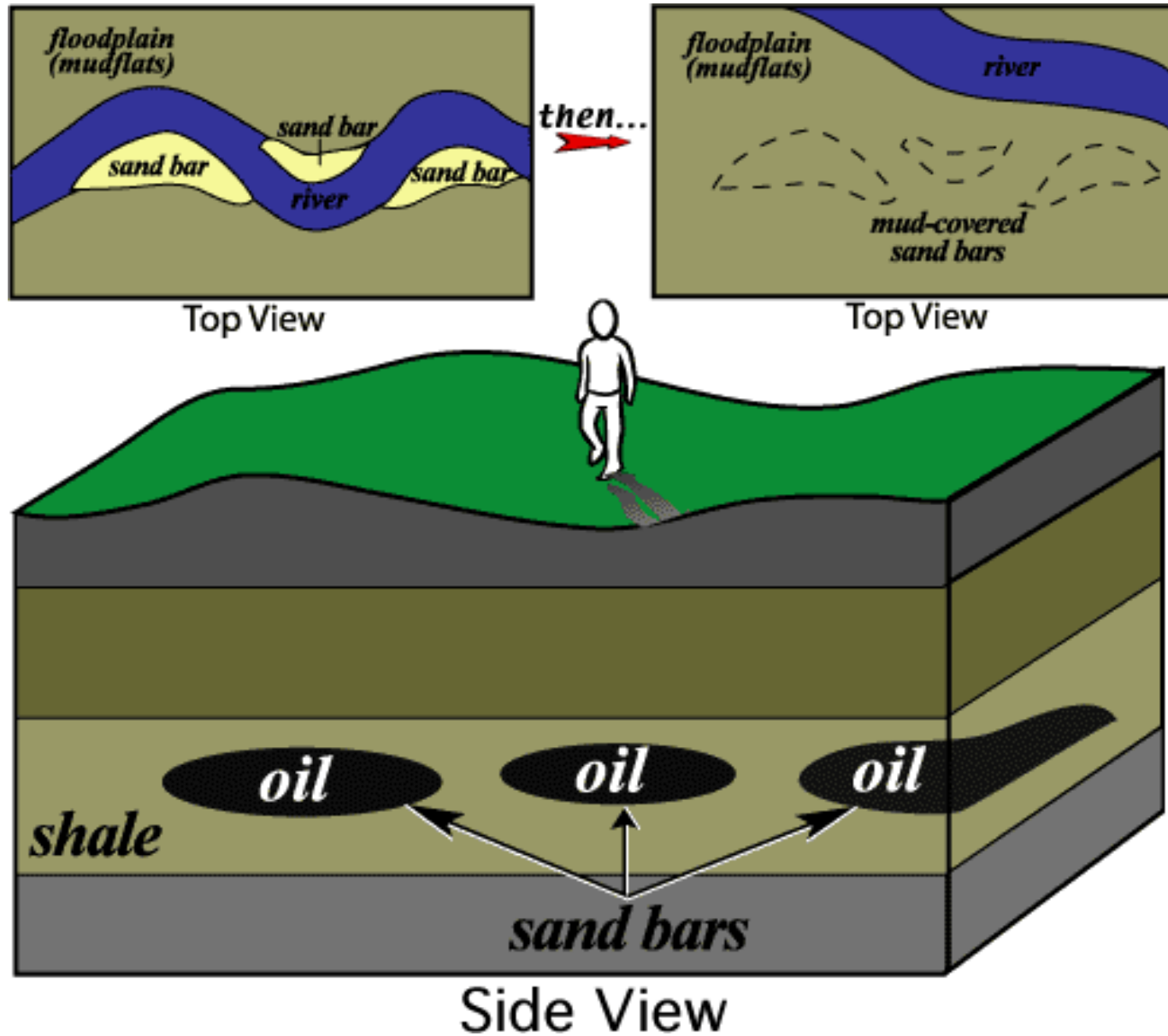




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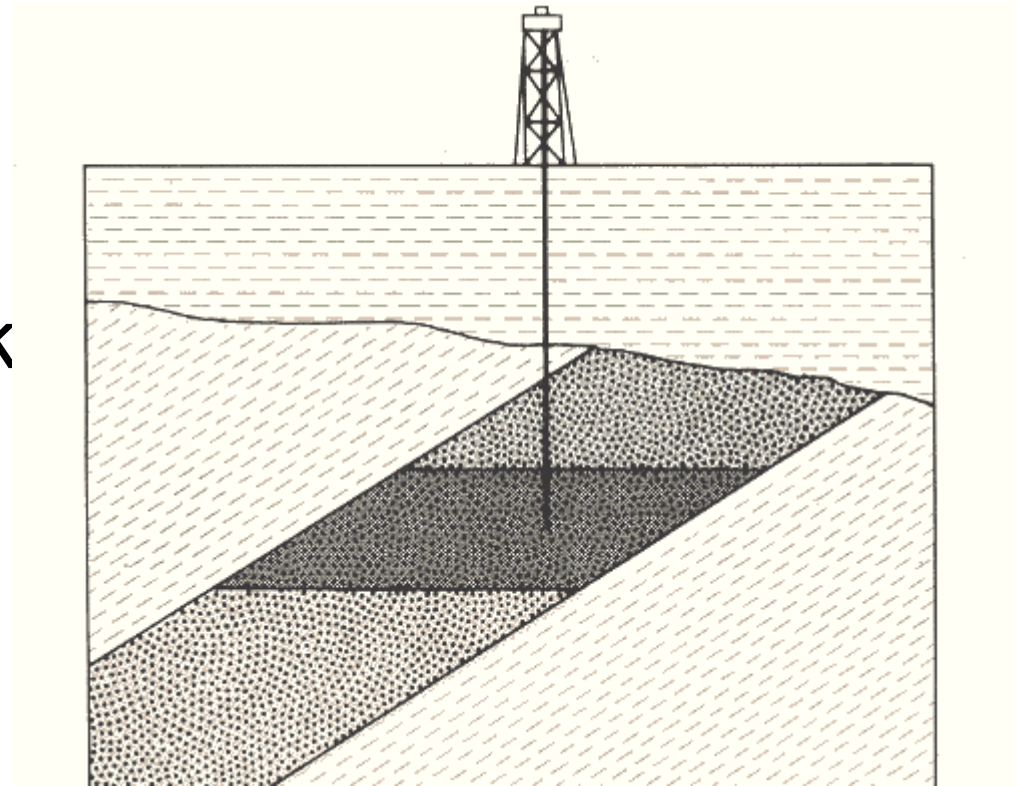
Loading

Sand lens Traps from meandering streams



UNCONFORMITY TRAP

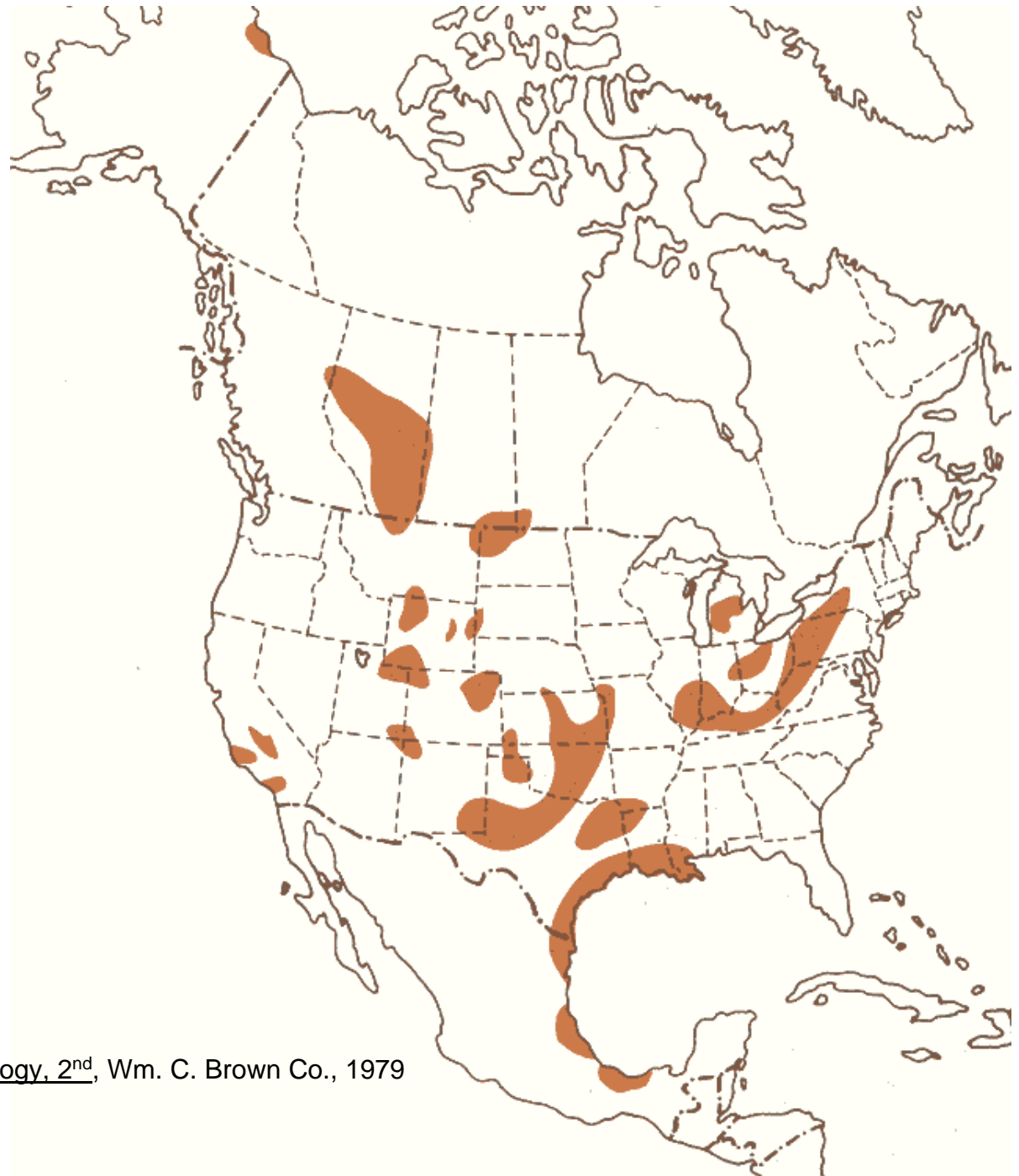
- Reservoir rock tilted and eroded
- Impermeable rock deposited above erosion surface



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



Texas Oil

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



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

Boiler Avenue

On Spindletop
salt dome at
Beaumont,
Texas



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

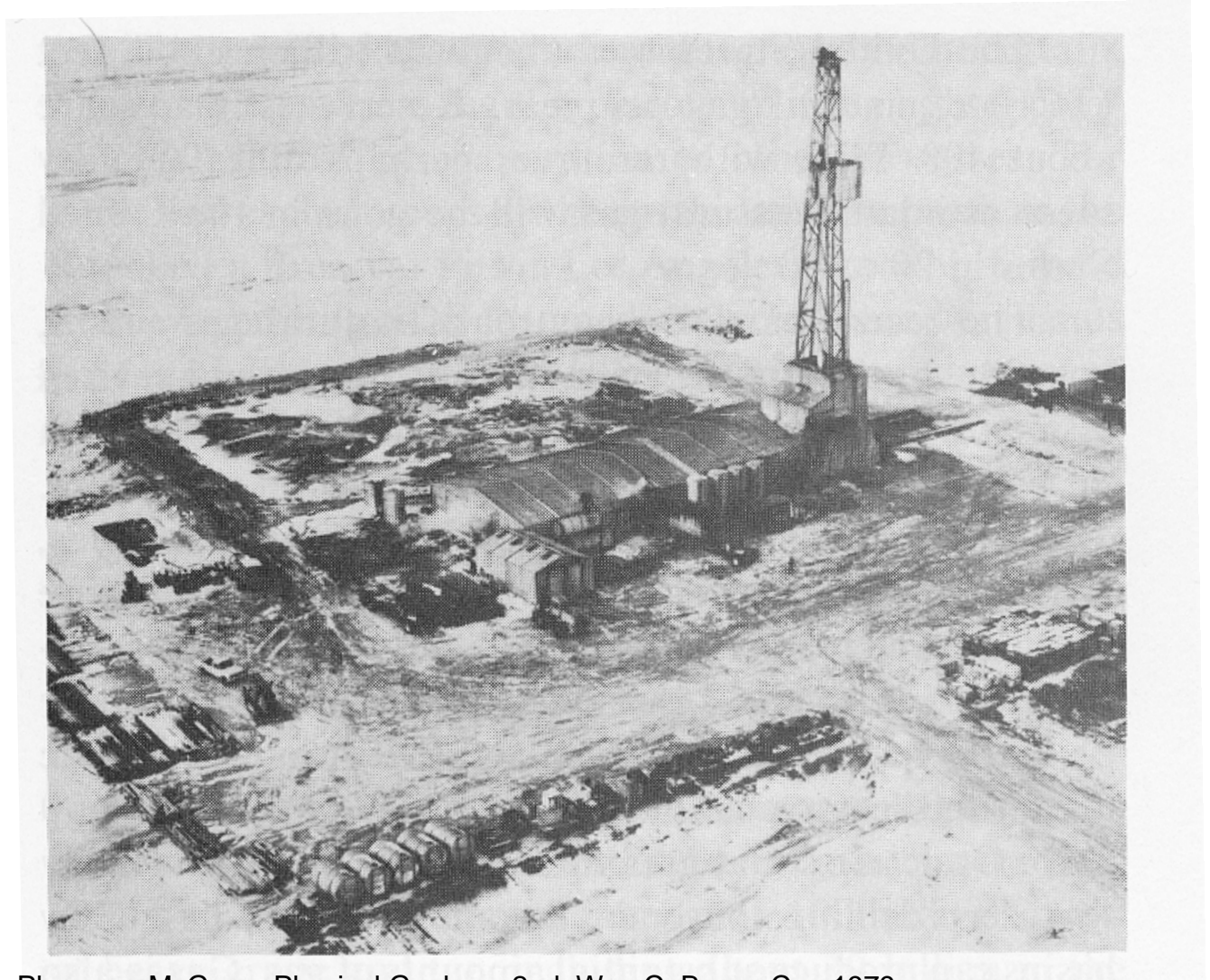
Signal Hill, Long Beach, CA

1932



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

Drilling on the North Slope



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

Drilling in the North Sea



Top 10 Countries— Oil Statistics

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

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



- 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

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

