

## Fossil Fuels and other Energy Resources



- coal, petroleum and natural gas are called fossil fuels because they represent stored solar energy. Energy from the sun is converted by biologic processes into combustible, carbon rich substances (i.e. plants and animals). This organic material may then be buried and preserved. Only a small portion of the organic matter buried has a chance to become a natural resource.

## Coal

- Coal deposits originate from plant material that flourished in ancient temperate swamps. ex. low-lying floodplains, deltas and barrier islands.



Modern Examples include the Great Dismal Swamp along the coast of Virginia and North Carolina (see left) and the coastal swamps of Sumatra



- Lush vegetation growth produces a layer of peat more than 2 meters thick



- As sea level changes the peat becomes covered with sand and mud



- The pressure of the overlying layers turns the sand/mud into rock and starts converting the peat into coal



- The water and organic gasses are cooked out of the peat increasing the percentage of carbon

- Depending on the degree of heat and pressure, different grades of coal are formed.

The four types (or grades) of coal are:

- Lignite: The largest portion of the world's coal reserves is made up of lignite, a soft, brownish-black coal that forms the lowest level of the coal family. You can even see the texture of the original wood in some pieces of lignite that is found west of the Mississippi River in the United States.

- Subbituminous: Next up the scale is subbituminous coal, a dull black coal. It gives off a little more energy (heat) than lignite when it burns. It is mined mostly in Montana, Wyoming and a few other western states.

- Bituminous: Still more energy is packed into bituminous coal, sometimes called "soft coal." In the United States, it is found primarily east of the Mississippi River in midwestern states like Ohio and Illinois and in the Appalachian mountain range from Kentucky to Pennsylvania.

- Anthracite: Anthracite is the hardest coal and gives off a great amount of heat when it burns. Unfortunately, in the United States, as elsewhere in the world, there is little anthracite coal to be mined. The U.S. reserves of anthracite are/were located primarily in Pennsylvania.

- Coal is a complex mixture of graphitic carbon and more complex carbon rings and chains.
- Coal is the dirtiest of all fossil fuels, considerable sulfur and other impurities are trapped during the formation of coal



- As much as 30% of the coal can be ash - materials such as clay and quartz which do not combust.

•show animation CO2but

## Petroleum and Natural Gas

- are hydrocarbons which originate from microscopic algae called zooplankton and phytoplankton (and other larger animals and plants that lived in lakes and oceans), which floated on the surface of lakes and seas millions of years ago. As the plankton died and drifted downward, they mixed with sediments of mud and silt.

- Hundreds of centuries passed and layers of sediment covered the decaying animals and plants, burying them deeper and deeper. The pressure and temperature rose, transforming the plankton into the compounds of hydrogen and carbon that make up crude oil and natural gas - petroleum. (The word "petroleum" comes from the Latin *petra*, meaning "rock," and *oleum*, meaning "oil.")

## Natural Gas and Petroleum Formation



Show Animation petsys

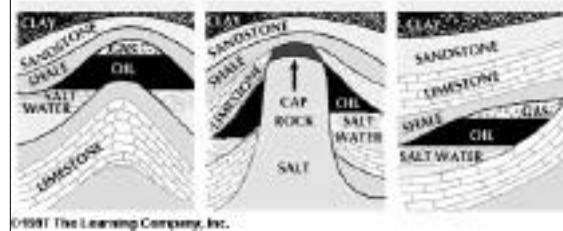
1. The source beds must have sufficient organic material in fine grained sediments and it must be in an anoxic environment.
2. The beds must be buried deep enough (at least 500m) for the heat and pressure to compress the rock and cause chemical transformation of the organic matter. - if it gets too hot the hydrocarbons break down even more into methane ( $\text{CH}_4$ ) i.e natural gas

3. The hydrocarbons must be able to migrate from their scattered locations through the source rock to become concentrated.
4. The low density fluids must migrate upwards through porous rock (hydrocarbon reservoir) until it reaches a low permeability layer (cap rock), called a hydrocarbon trap where the oil/gas accumulate.

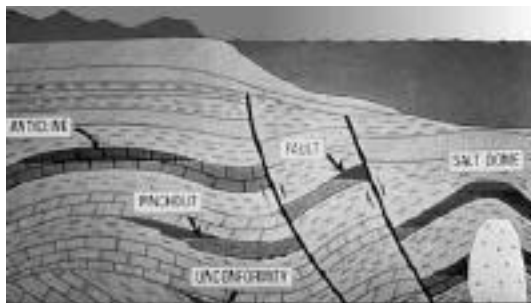
## Hydrocarbon Traps



## Hydrocarbon Traps



## More Traps

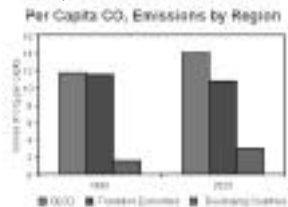


## Oil Shale

- When the oil is not allowed to escape and migrate from its original source rock, oil shale can be formed instead.
- There are huge reserves of oil in oil shale but it currently can not be economically extracted.

## Problems with all these sources

1. These sources are all *finite* and will run out
2. These sources are all “dirty” resulting in air pollution, increase greenhouse gas emissions, acid rain...



3. Acquiring these resources damages the environment





4. The cost (monetary and energy) of recovery and processing is getting higher and higher as the easily accessed sources are used up

## Methane Hydrates

- Gas hydrates occur abundantly in nature, both in Arctic regions and in marine sediments. Gas hydrate is a crystalline solid consisting of gas molecules, usually methane, each surrounded by a cage of frozen water molecules. It looks very much like water ice.



- Methane hydrate is stable in ocean floor sediments at water depths greater than 300 meters, and where it occurs, it is known to cement loose sediments in a surface layer several hundred meters thick.



- The worldwide amounts of carbon bound in gas hydrates is conservatively estimated to total twice the amount of carbon to be found in all known fossil fuels on Earth.
- Extraction of methane from hydrates could provide an enormous energy resource.
- Additionally, conventional gas resources appear to be trapped beneath methane hydrate layers in ocean sediments.



### Problems with methane hydrate

- Methane, a "greenhouse" gas, is 10 times more effective than carbon dioxide in causing climate warming.
- Hydrates are highly volatile - they cannot be drilled into or pumped to the surface - currently there is no know way of safely and economically recovering hydrates.
- Huge explosions of oceanic hydrates have caused massive landslides in the geologic past

## Uranium

- The average content of uranium in the Earth's crust is 2ppm
  - Igneous - late stage segregation
  - Metamorphic - skarn
  - Sedimentary - Placer deposits
    - Uranium roll deposits

