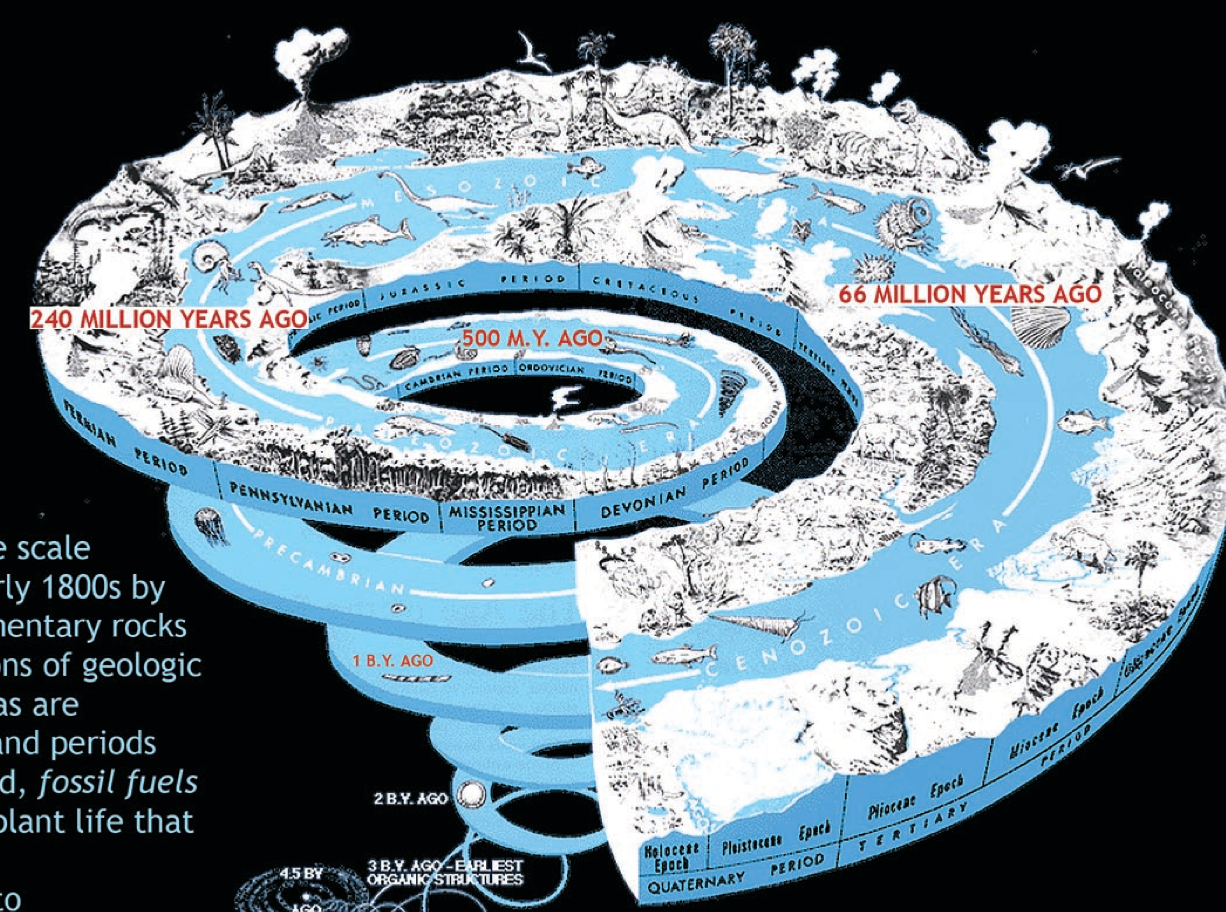
The Origin of Oil and Gas

The crude oil and natural gas in use today originated from the solar energy synthesized by organic life hundreds of millions of years ago.

"The fossil fuels...have all had their origin from plants and animals existing upon the earth during the last 500 million years. The energy content of these materials has been derived from that of the contemporary sunshine, a part of which has been synthesized by the plants and stored as chemical energy."

M. King Hubbert
"Nuclear Energy and the Fossils Fuels"
API Paper, March 1956



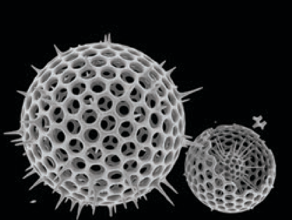
This spiral timeline depicts the geologic time scale developed during the early 1800s by relative age dating sedimentary rocks and fossils. Large divisions of geologic time are called *eras*. Eras are subdivided into *periods* and periods into *epochs*. Aptly named, *fossil fuels* are a product of earlier plant life that has been preserved and then transformed into hydrocarbons.

Step 1. Living Organic Life Synthesizes Sunshine

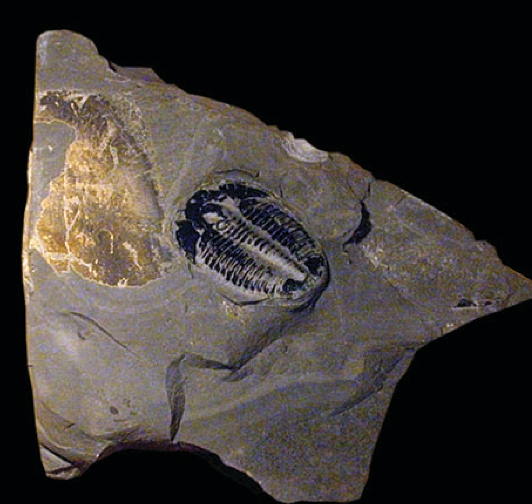
Burial in Sedimentary Source Rock

Organic matter living in surface waters of rivers, oceans, and lakes is the major constituent from which crude oil and natural gas form. Most of this organic matter are the remains of microscopic single-celled plants such as diatoms, and microscopic single-celled animals such as radiolaria. The remains are deposited as sediment along with inorganic particles such as sand and silt.

With continued deposition of sediment on top, organic remains become buried before they decay. These buried sediments with preserved organic remains can become source rocks for crude oil or natural gas.



Computer graphic image of radiolaria (Michael Spaw)



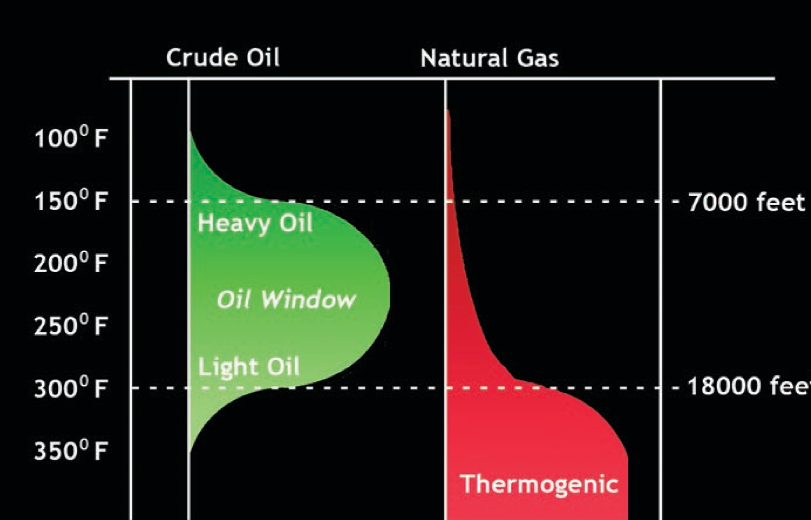
Black shale, a common source rock for oil and gas, has a high percentage of organic matter by weight, typically one to three percent, but up to 20 percent by weight.

Step 2. Transformation to Hydrocarbons

Temperature and Pressure Convert Organic Material to Oil and Gas

As sediment is overlain by more sediment, the temperature and pressure of the buried material increases.

As the temperature of the buried material reaches 150 degrees F, chemical reactions begin to transform the buried organic material into forms of hydrocarbon chemicals, one of which is crude oil. The depths of burial that control this reaction are generally between 7,000 and 18,000 feet (150 to 300 degrees F).



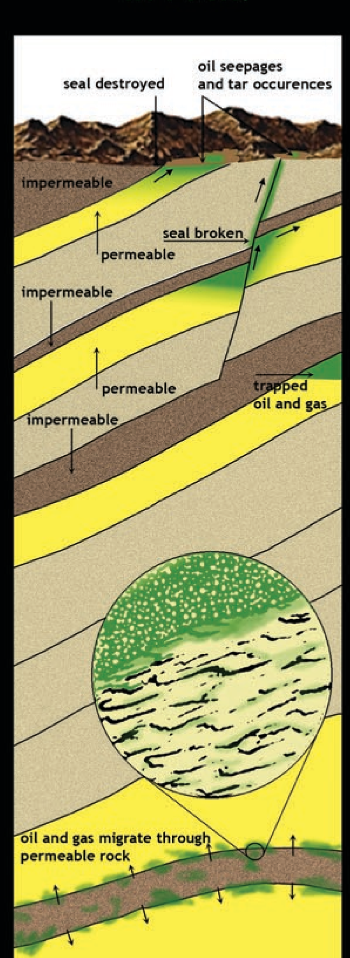
Oil forms throughout a temperature range from about 150 to 300 degrees F (the *oil window*.) Thermogenic natural gas is formed at temperatures above 300 degrees F.

At burial temperatures greater than 300 degrees F, the chemical reactions convert the organic material, including crude oil, to natural gas.

Step 3. Migration from Source Rock Beds

Density and Volume

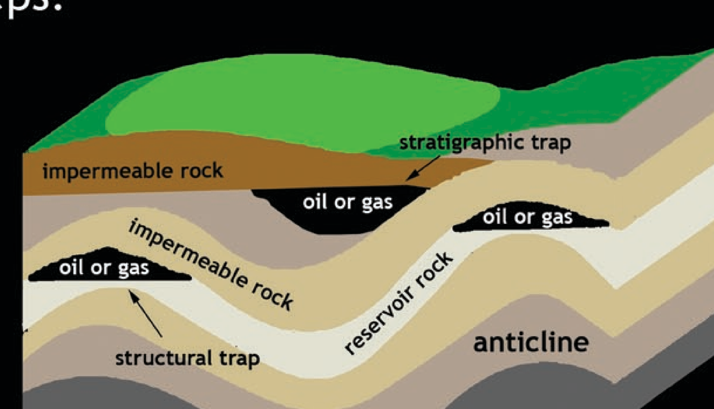
Oil and gas can migrate through pore spaces within rock, or through fractures in rock.



Crude oil and natural gas are less dense than the solid organic material from which they originate. Also, oil and especially gas occupy more volume than the solid organic material. The space in the source rock is insufficient to hold the oil and gas in place, so the oil and gas migrate out of the source rock and into the surrounding porous and permeable rock beds. The lighter densities of oil and gas cause them to move upward through the water and other substances in the pore space of the surrounding rock beds. This upward movement of oil and gas through porous and permeable rocks continues over time until it is stopped by a subsurface barrier. If a barrier is not encountered, then the oil and gas will escape to the surface and appear as surface seeps.

Step 4. Accumulation of Oil and Gas

Reservoir Traps Hold Oil and Gas in Place



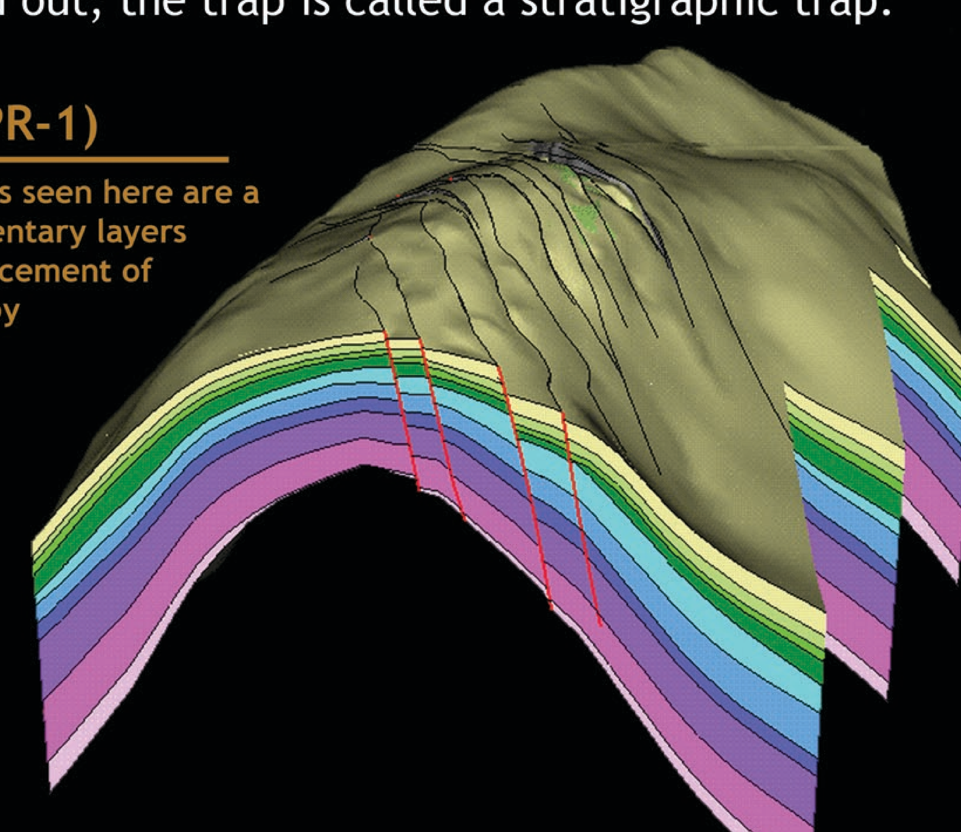
Impermeable rock (brown) overlying reservoir rock containing oil and gas creates a stratigraphic trap. Impermeable rock (tan) overlying domed reservoir rock containing oil and gas creates a structural trap.

The source rock beds generate the oil and gas hydrocarbons that migrate into the adjacent permeable rock layers. Eventually, the migrating oil and gas encounter an impermeable barrier (e.g., cap rock, fault plane, salt dome) and form an accumulation described as an oil and gas pool or field.

Reservoir traps are generally characterized as structural traps, stratigraphic traps or a combination of the two. The tectonic folding of the earth's layers into an anticline (see figure below) is an example of a structural trap. When the earth's layers are lenticulated, or pinched out, the trap is called a stratigraphic trap.

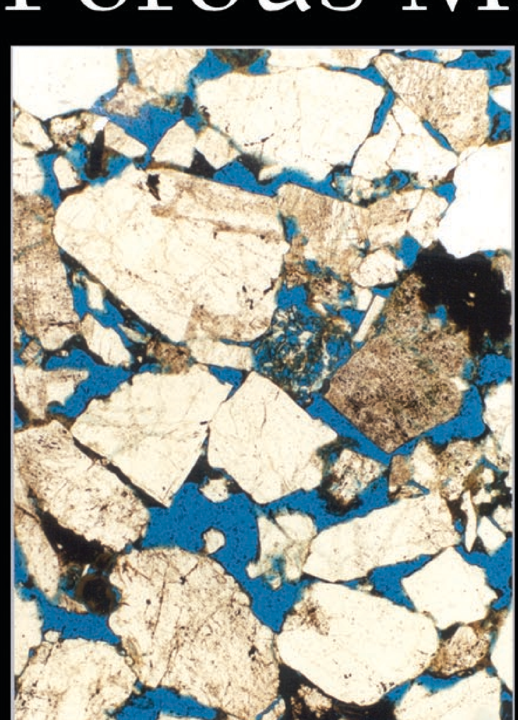
Elk Hills Oil Field (NPR-1)

The major trapping mechanisms seen here are a structural folding of the sedimentary layers into an anticline and the displacement of the layers, one from another, by faulting.



Step 5. Flow of Oil and Gas through Porous Media

Sedimentary Reservoir Rocks



Microscopic photograph of sandstone from the Elk Hills Oil Field (formerly the Naval Petroleum Reserve No.1) near Bakersfield, California. The blue areas are the interconnected pore spaces.

Most oil and gas fields are found in sedimentary rocks like sandstone and limestone. A few smaller fields have been found in igneous and metamorphic rocks. But sedimentary rocks are better suited because they have the interconnected pore spaces needed for oil and gas to move through and accumulate in, thereby forming a pool or field. The two factors required for this process to work are the pore space, called rock porosity, and the interconnectivity of the pore space, called rock permeability. The pore space determines the capacity of the pool (its total volume) and the permeability determines the productivity of the pool (its production rate). Taken together, porosity and permeability are two of the factors that control the volumes of recoverable oil and gas from the pool or field.