

Crude Oil 101: A Primer for Oil and Gas Investors

It's a remarkable fact of life that the one substance all of modern living depends upon is so little understood. When you have finished this article, you will understand more than most anyone you know about how oil is produced, refined and consumed.

The Basics

Crude oil, or petroleum, is a fossil fuel; a descendant of decayed plants and animals that had been living in ancient seas millions of years ago. If you've found crude oil, you've found what was once an ancient sea bed. Crude oils are usually black, but not always. Sometimes they are nearly clear, and their thickness, or viscosity, can range from goopy to water-thin.

Crude oils are valuable because they contain hydrocarbons. Hydrocarbons derive their name from the fact that they contain both hydrogen and carbon; it is the hydrogen in hydrocarbons which we use for energy, and the carbon is generally emitted as waste.

Crude oil contains hundreds of different types of hydrocarbon "chains," and the refining process is what separates those chemical chains out to make the many different petroleum products we use every day. Each different chemical chain length creates a different petroleum by-product. The different hydrocarbon chemical chains are separated out by distillation, wherein crude is heated, and the various chains are derived by their vaporization temperatures.

Some of the best-known petroleum products are:

- Petroleum gas -- heating and cooking fuels like methane, butane and propane
- Kerosene -- fuel for jet engines, tractors and some heaters
- Naphtha or Ligroin -- intermediate compounds used to produce gasoline
- Gas oil or diesel distillate -- diesel fuel and heating oil
- Lubricating oil - used for motor oil, grease, other lubricants
- Residuals - coke, asphalt, tar, waxes

So how did this magical liquid, to which we owe so many useful and necessary products, materialize?

How oil was formed

When tiny plants and animals (especially plankton) died in ancient waters between 10 million and 600 million years ago, they naturally sank to the bottom of the sea.

These organisms decayed in the sedimentary layers, where little or no oxygen was present. After microorganisms broke the plant and animal remains into carbon-rich compounds, organic layers formed, which mixed with the available sediments, forming shale, or source rock. Now the hydrocarbons in shale are very difficult to extract. But fortunately, in many spots new sedimentary layers were deposited which exerted intense pressure and heat on the source rock, distilling the hydrocarbon-rich material in the shale into liquid crude oil and natural gas. Finally, oil migrated from the source rock and accumulated, typically in the voids of limestone or sandstone. Limestone and sandstone are porous, which allowed the oil to migrate further, except when trapped by a harder, impenetrable rock, such as granite or marble. In these cases, underground pools of oil accumulate, and it is these pockets of constantly seeping oil which geologists and oil explorers search for today.

How oil is discovered

Geologists bear the burden finding the right conditions for all three oil producing factors: source rock, reservoir rock and oil entrapment. Today, oil geologists can examine surface rocks and terrain with the help of satellite images. They can also use gravity meters and hypersensitive magnetometers to measure tiny changes in the Earth's gravitational field that could indicate flowing oil. They can even detect the smell of hydrocarbons using sensitive electronic noses called sniffers.

But the most common method is the use of seismology, which is the science of sending shock waves through hidden rock layers and interpreting the waves that are reflected back to the surface. The reflected shock waves travel at different speeds depending upon the type or density of rock layers underground. Variations of wave patterns offer possible clues to the existence of oil and gas traps.

However, although modern oil-exploration methods are more advanced than ever, geologists still expect to achieve only a 10 per cent success rate in finding new oil fields. Oil exploration is still a highly speculative enterprise.

How oil is drilled

Finding a likely oil location is merely the beginning of a sometimes arduous process. Sites must be surveyed and lease agreements, titles and right-of way easements for the land must be obtained.

Once the legal issues have been settled, the crew goes about preparing the land:

1. If necessary, the land is cleared and leveled, and access roads may be built.

2. Because water is used in drilling, there must be a source of water nearby. If there is no natural source, a water well is drilled.
3. They dig a reserve pit, which is used to dispose of rock cuttings and drilling mud during the drilling process, and line it with plastic to protect the environment.

Now it's time to drill. These are the major components of a land oil rig:

- Power system

Electric line hookup from the grid must be established. If grid electricity is unavailable, large diesel engines drive generators to provide electrical power. Power is necessary to drive the mechanical system.

- Mechanical system

The hoisting system is used for lifting heavy loads, and consists of a mechanical winch with a large steel cable spool.

- Rotating equipment

The various components include:

- Kelly -- four- or six-sided pipe that turns the turntable and drill string
- Swivel -- bears the weight of the drill string, and forms a pressure-tight seal on the hole
- Turntable or rotary table -- drives the drill rotation
- Drill string -- consists of drill pipe in 30 foot-long sections and drill collars
- Drill bit(s) -- tip of the drill that chews up the rock
- Casing -- large-diameter concrete pipe which lines the drill hole, providing support to the hole, preventing collapse

- Circulation system

This system pumps drilling mud (rock cuttings from the drill bit to the surface) under pressure through the rotating equipment

- Other important components include the derrick, or support structure that holds the drilling apparatus, and blowout preventer that seals the high-pressure drill lines and relieves pressure when necessary to prevent an uncontrolled gush of gas or oil to the surface.

Drilling

There are five basic steps to drilling the surface hole:

1. Place the drill bit, collar and drill pipe in the hole.
2. Attach the kelly and turntable and begin drilling.
3. As drilling progresses, circulate mud through the pipe and out of the bit to float the rock cuttings out of the hole.
4. Add new sections of drill pipes as the hole gets deeper.
5. Remove the drill pipe, collar and bit when the pre-set depth is reached.

Once they reach the pre-set depth, they must cement casing-pipe sections into the hole to prevent it from collapsing in on itself.

Drilling continues in stages: Drill, run and cement new casings, then drill again. When the rock cuttings from the mud reveal the oil sand from the reservoir rock, they may have reached the final depth. At this point, they remove the drilling apparatus from the hole and perform several tests to confirm this finding:

- Well logging -- lowering electrical and gas sensors into the hole to take measurements of the rock formations there
- Drill-stem testing -- lowering a device into the hole to measure the pressures, which will reveal whether reservoir rock has been reached
- Core samples -- taking samples of rock to look for characteristics of reservoir rock

Once they have reached the final depth, the crew completes the well to allow oil to flow into the casing in a controlled manner. First, they lower a perforating gun into the well to the production depth. The gun has explosive charges to create holes in the casing through which oil can flow. After the casing has been perforated, they run a small-diameter pipe (tubing) into the hole as a conduit for oil and gas to flow up the well. A device called a packer is run down the outside of the tubing. When the packer is set at the production level, it is expanded to form a seal around the outside of the tubing. Finally, they connect a multi-valved structure called a Christmas tree to the top of the tubing and cement it to the top of the casing. The Christmas tree allows them to control the flow of oil from the well.

Once the well is completed, they must start the flow of oil into the well. For limestone reservoir rock, acid is pumped down the well and out the perforations. The acid dissolves channels in the limestone that push oil into the well. For sandstone reservoir rock, a specially blended fluid containing proppants (sand, walnut shells, aluminum pellets) is pumped down the well and out the perforations. The pressure from this fluid makes small fractures in the sandstone that allow oil to flow into the well, while the proppants hold these fractures open. Once the oil is flowing, the oil rig is removed from the site and production equipment is set up to extract the oil from the well.

Extracting the Oil

After the rig is removed, a pump is placed on the well head.

In the pump system, an electric motor drives a gear box that moves a lever. The lever pushes and pulls a polishing rod up and down. The polishing rod is attached to a sucker rod, which is attached to a pump. This system forces the pump up and down, creating a suction that draws oil up through the well.

In some cases, the oil may be too heavy to flow. A second hole is then drilled into the reservoir and steam is injected under pressure. The heat from the steam thins the oil in the reservoir, and the pressure helps push it up the well. This process is called enhanced oil recovery.

Congratulations

You probably now know more about oil and how it is discovered and extracted than anyone in your acquaintance outside the oil industry. For our part, our mission for sharing this information with you is simple: to help you make the most informed decision possible when considering an oil and gas investment.

We hope you won't hesitate to call us with any questions or concerns you may have about oil and gas partnerships and their investment potential.