The Lease Pumper's Handbook

CHAPTER 4

UNDERSTANDING THE OIL WELL

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Section A

LOOKING DOWNHOLE

The part of the well operation that is underground is generally referred to as *downhole*. There are several reasons why the lease pumper must understand what it is like downhole. This need for understanding begins at a basic level in knowing the procedure for drilling a well, responsibilities of the rig personnel, how decisions are made when drilling, and how the bore hole is finished when casing strings are run and cemented into position. During the production phase, the lease pumper must know what is happening in the formation, the production interval or perforated area, the tubing string, the flow lines, and the processing vessels—from the bottom of the hole all the way to the stock tank.

The lease pumper must also have some knowledge of what causes oil and gas production to slow down or stop and what options may be available to identify or even remedy the problem. With experience, the lease pumper will recognize the symptoms for a wide range of downhole problems as they begin to affect production and will have some knowledge of what can be done to restore production.

Many small operators do their own well servicing, and the lease pumper may work as part of the service crew. This could lead to the lease pumper becoming the well service crew operator when pulling and running rods and tubing.

Even if the company contracts all of the well services to others, quite often the lease pumper acts as a representative of the oil company and supervises the well service operation to ensure that everything is performed to the company's satisfaction. Further, the lease pumper must understand what records must be kept, how to accurately record any changes made downhole, and how to submit change records to the office. This chapter presents information on how a well is drilled and completed. This first section discusses the structure of oil-bearing formations and provides an overview of oil well design.

A-1. Oil-bearing Reservoirs.

The purpose of a well is to bring oil and gas up from underground deposits. Petroleum researchers generally agree that oil and gas consist of the chemical remains of ancient plants and animals. These remains were laid down as deposits on the beds of ancient seas. As layers of sand and other sediments covered these chemical remains, the pressures built up to compress the minerals into rock. The hydrogen and carbon portions of the plant and animal remains combined to form chemical chains referred to as *hydrocarbons*, or natural gas and crude oil.

Over time, more layers of rock will form. Some types of rock, such as sandstone, are *porous*—that is, there are openings between the grains of the rock, and water, oil, and/or gas can sometimes occupy this space. These fluids may remain in the porous rock or, if acted upon by other pressures, they may move from one place in the formation to another. Other types of rocks, like granite, are nonporous.

These layers of porous and nonporous rock are called *strata* (singular, *stratum*). Hydrocarbons remain trapped in the strata of porous rock when the porous rock is enclosed with layers of nonporous rock or when certain types of rock formations keep the oil contained in an area. This area may be referred to as a *reservoir* and the formation as *oil-bearing rock* or sometimes as the *pay section*.

Oil is found in stratified rock that was loose sand at one time before being compressed under pressure into *sedimentary* rock. Igneous rock—that which was formed by heat as from a volcano—is nonporous and never contains oil. Metamorphic formations of sedimentary rock—such as limestone that has metamorphosed to marble—will not usually contain oil. The most common oil-bearing formations consist of:

Stratified rock	**Abbreviation**
Sandstone	S
Limestone	LS
Dolomite	Dolo
Conglomerate	Congl
Unconsolidated sand	US

A-2. Formation Shapes.

An analysis of rock samples and land formations can tell geologists whether a given area is likely to have oil deposits. Through various types of tests that measure the underground formations, petroleum exploration crews can determine the locations of probable petroleum reservoirs. By using special instruments, oil exploration crews can measure the speed of sound associated with the density of underground formations to determine whether those formations are likely to contain oil reservoirs. Great strides have been made in understanding the many shapes of reservoirs since the discovery of overthrust belts in the 1970's. The use of computers and software programs continues to improve the ability of geophysicists and geologists in determining whether hydrocarbons are likely to be found.

After considering numerous factors, the oil company may make the decision that a deposit of petroleum is great enough to justify drilling a well.

There are many formation shapes that can result in underground reservoirs. The characteristics of these formations are sometimes visible along roadcuts, canyons, and other areas where the layering of the earth can be observed. Some of the more important oil-trapping formations include:

Dome formations. Dome formations develop when underground pressures push up against the layers above, causing a fold in the strata to rise dramatically. Underground hydrocarbons may be trapped within the dome or trapped in the donut-shaped formations surrounding the dome. As the reservoir is produced, the oil may be driven toward the center of the dome or, in other situations, it may migrate outward. Another term used for dome reservoirs is *plug traps*. Often the dome formation will consist of salt.

Anticline formations. An anticline is an upward fold of the formation. Instead of creating a dome shape, the upward fold spreads across a wide area, often many miles though it may be quite narrow in many areas. An anticline can develop finger-like projections that trap petroleum and that can be very productive if discovered. Some anticlines disappear for many miles then crop up unexpectedly, only to disappear and then reappear perhaps several times. The depths of the reservoirs may vary from shallow to deep over the length of the anticline.

Fault trap formations. Fault traps are formed by the shearing or breaking of the earth at great depths. This break is called a *fault*, and fault lines are frequently the sites of earthquakes as the two split sections of earth shift relative to each other. Faults may be visible on the surface of the ground.

If the formations on each side of the fault move so that the strata on one side of the break no longer line up with the same strata on the other side of the fault, it is possible that a porous layer will become aligned with a nonporous stratum on the other side of the fault. When this occurs, oil and gas can be trapped on the porous side. Oil may be discovered only on one side of the fault or on both sides. Many dry holes have been drilled trying to follow a productive fault line.

Reef trap formations. Reef trap formations were usually developed by great limestone and dolomite deposits. These deposits generally contain the minerals from dead marine plants and animals. Often these minerals are dissolved as water passes through the formation. This can create cavities in which hydrocarbons may become trapped and held.

Lens formations. The term *lens formation* generally refers to any strata in which the oil-bearing rock is penetrated by bands of nonporous rock. This causes the pay section to be broken into small reservoirs. For this reason, lens formations can make it difficult to properly complete and produce a well.

One type of lens formation occurs when an underlying nonporous stratum undergoes extensive folding. The folds may penetrate the oil-bearing layer at intervals like a rumpled blanket. Pockets of oil, water, or gas may become isolated in small sections of the porous layer between the folds of the lens formation. Depending on whether or not the nonporous rock completely separates the oil-bearing layer, hydrocarbons may or may not be able to flow between the pockets. This means that hydrocarbon production may vary slightly or even dramatically from well to well along the oil-bearing stratum. In some cases, each isolated section may have to be drilled separately. Sections will deplete at different rates. It may be difficult to determine how to enhance.

Unconformities. Unconformities were formed by the rock formations being thrust upward and worn off by actions of the elements. After this wearing away occurred, an impervious stratum was laid down to form a cap over the end of the porous layer. These formations trap and preserve oil reservoirs. Some of the most significant oil fields in the world reflect partial unconformities.

A-3. The Anatomy of an Oil Well.

Perhaps the best way to learn about the process of drilling an oil well is to first consider a completed oil well and then review how everything came together to create the finished well.

Figure 1 on the next page shows the well as it is being drilled. With the derrick in place, drill pipe is run into the hole with the bit cutting through the rock formations at the end of the drill pipe. Mud is pumped into the top of the drill pipe and forced out the lower end. This serves several purposes. The mud cools the drill bit and forces the cuttings up the side of the hole and to the top where they are emptied into the mud pit. The mud also reduces the chances of the hole walls crumbling and helps to prevent the uncontrolled release of oil and gas.

As the well is drilled, casing is installed. The drill pipe is removed from the hole and heavy steel pipe is installed in the hole. This pipe is filled with cement and topped with a plug. Mud is then pumped into the casing while the cement is still wet. The pressure of the mud forces the plug and cement down the inside of the casing so that the cement is forced into the space between the casing and walls of the bore hole from the bottom of the casing. The cement will fill this space to the surface of the well. Once the cement hardens, the drilling continues if necessary. The crew switches to a smaller drill bit that will fit inside the casing and drills through the plug at the bottom of the hole and into the next formation.

When the well has been drilled into the oil-bearing rock, the drill pipe is removed and the last string of casing installed and cemented in place. A section of the casing that passes through the reservoir will then be perforated—that is, holes will be created to allow oil and gas to pass into the casing. After the casing has been perforated, tubing is installed. The tubing is smaller diameter pipe that goes down inside the casing. Tubing is used to bring oil and gas to the surface. Once the well goes into production, the derrick is removed and the tubing is topped with a set of control valves known as a *Christmas tree* or wellhead.

This overview should help clarify the more detailed information in the following section.

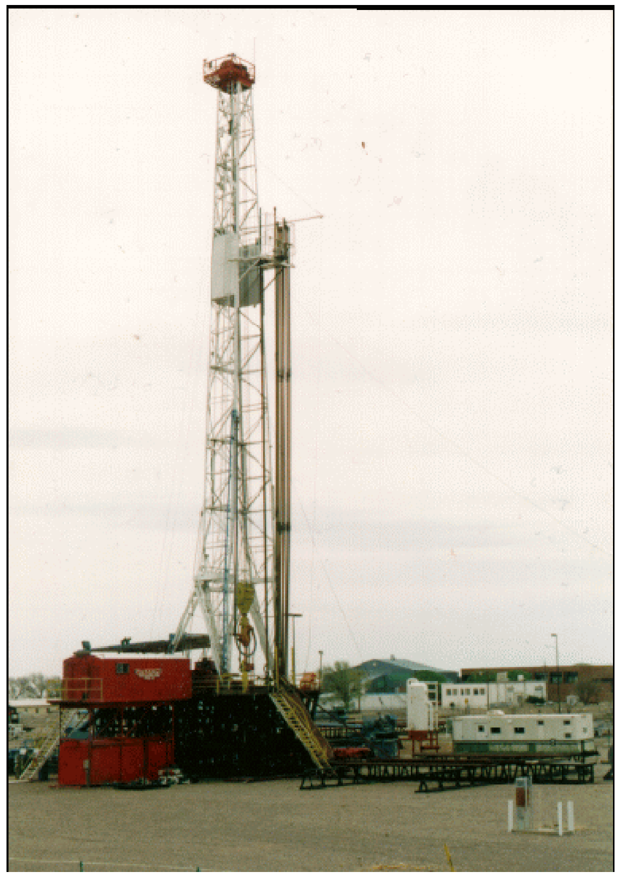

Figure 1. A drilling rig in erected to bore a well. Note the pipe in the rack alongside the derrick.