Introduction

And God said unto Noah. Make thee an ark of gopher wood; rooms shalt thou make in the ark, and shalt Coat it within and without with pitch. Genesis 6:13-14

HISTORICAL REVIEW OF PETROLEUM EXPLORATION

Petroleum from Noah to Organization of Petroleum Exporting Countries

Petroleum exploration is a very old pursuit, as the preceding quotation illustrates. The Bible contains many references to the use of pitch or asphalt collected from the natural seepages with which the Middle East abounds. Herodotus, writing in about 450 BC, described oil seeps in Carthage (Tunisia) and the Greek island Zakynthos (Herodotus, c. 450 BC). He gave details of oil extraction from wells near Ardericca in modern Iran, although the wells could not have been very deep because fluid was extracted in a wineskin on the end of a long pole mounted on a fulcrum. Oil, salt, and bitumen were produced simultaneously from these wells. Throughout the first millennium AD, oil and asphalt were gathered from natural seepages in many parts of the world. The early uses of oil were for medication, waterproofing, and warfare. Oil was applied externally for wounds and rheumatism and administered internally as a laxative. From the time of Noah, pitch has been used to make boats watertight. Pitch, asphalt, and oil have long been employed in warfare. When Alexander the Great invaded India in 326 BC, he scattered the Indian elephant corps by charging them with horsemen waving pots of burning pitch. Nadir Shah employed a similar device, impregnating the humps of camels with oil and sending them ablaze against the Indian elephant corps in1739 (Pratt and Good, 1950). Greek fire was invented by Callinicus of Heliopolis in AD 668. Its precise recipe is unknown, but it is believed to have included quicklime, sulfur, and naphtha and it ignited when wet. It was a potent weapon in Byzantine naval warfare.

Up until the mid-nineteenth century, asphalt, oil, and their by-products were produced only from seepages, shallow pits, and hand-dug shafts. In

1694, the British Crown issued a patent to Masters Eele, Hancock, and Portlock to “make great quantities of pitch, tarr, and oyle out of a kind of stone” (Eele, 1697). The stone in question was of Carboniferous age and occurred at the eponymous Pitchford in Shropshire (Torrens, 1994). The first well in the Western World that specifically sunk to search for oil (as opposed to water or brine) appears to have been at Pechelbronn, France, in 1745. Outcrops of oil sand were noted in this region, and Louis XV granted a license to M. de la Sorbonniere, who sank several borings and built a refinery in the same year (Redwood, 1913). The birth of the oil shale industry is credited to James Young, who began retorting oil from the Carboniferous shales at Torban, Scotland, in 1847. The resultant products of these early refineries included ammonia, solid paraffin wax, and liquid paraffin (kerosene or coal oil). The wax was used for candles and the kerosene for lamps. Kerosene became cheaper than whale oil, and therefore the market for liquid hydrocarbons expanded rapidly in the mid-nineteenth century. Initially, the demand was satisfied by oil shales and from oil in natural seeps, pits, hand-dug shafts, and galleries. Before exploration for oil began, cable-tool drilling was an established technique in many parts of the world in the quest for water and brine (Fig. 1.1). The first well to produce oil intentionally in the Western World was drilled at Oil Creek, Pennsylvania, by Colonel Drake in 1859 (Owen, 1975). Previously, water wells in the Appalachians and elsewhere produced oil as a contaminant. The technology for drilling Drake’s well was derived from Chinese artisans who had traveled to the United States to work on the railroads.

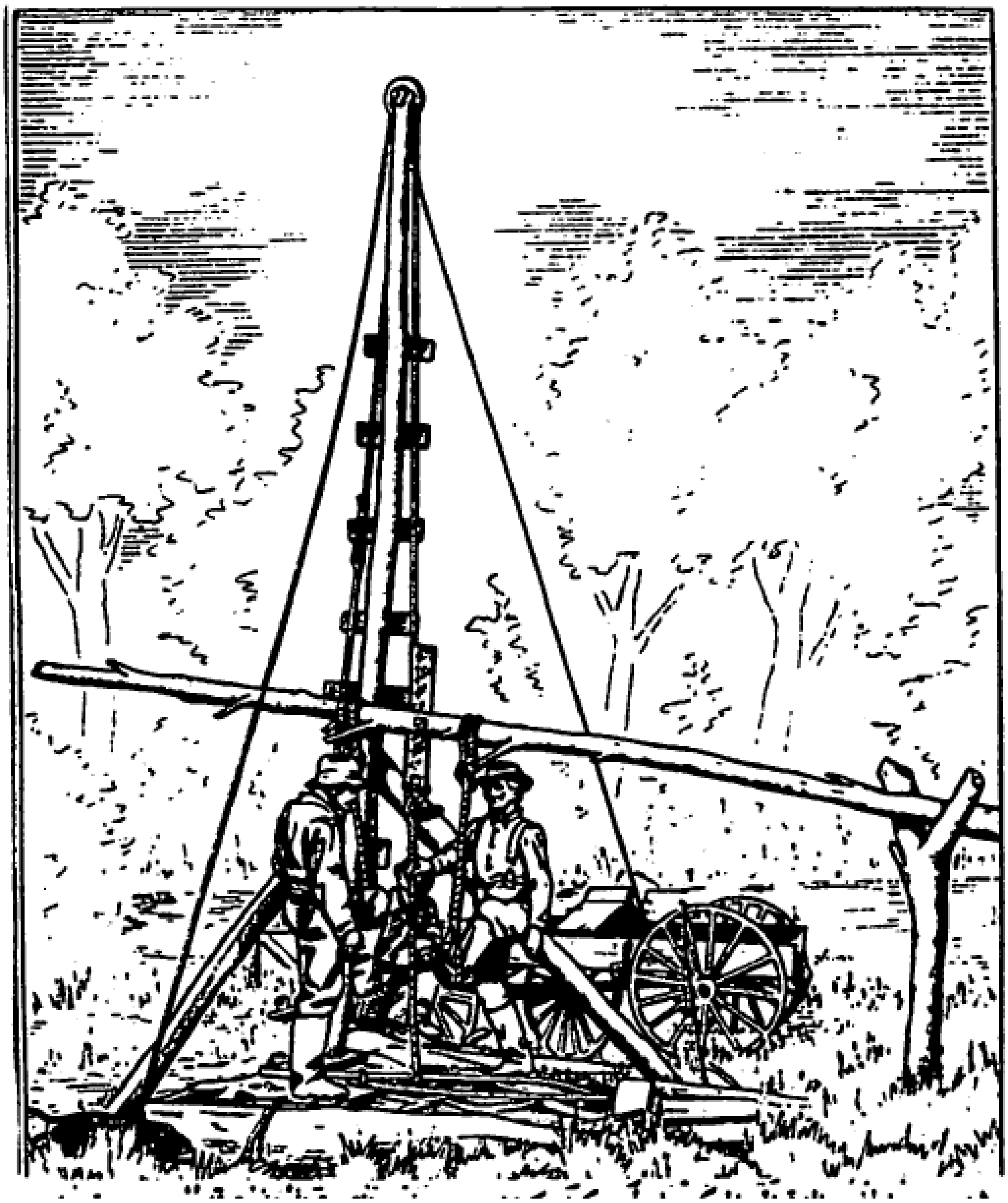

FIGURE 1.1 Early cable-tool rig used in America the motive power was provided by one man and a spring pole. Courtesy of British Petroleum.

Cable-tool drilling had been used in China since at least the first century BC, the drilling tools being suspended from bamboo towers up to 60 m high. In China, however, this drilling technology had developed to produce artesian brines, not petroleum (Messadie, 1995). The first “oil mine” was opened in Bobrka, Poland, in early 1854 by Ignacy 2005; Wikipedia, 2014 “History of the Petroleum Industry”). Lukasiewicz was interested in Lukasiewicz (Frank, using seep oil as an alternative to the more expensive whale oil and was the first in the world to distill kerosene from seep oil.

A rapid growth in oil production from subsurface wells soon followed, both in North America and around the world. A major stimulus to oil production was the development of the internal combustion engine in the 1870s and 1880s. Gradually, the demand for lighter petroleum fractions overtook that for kerosene. Uses were found, however, for all the refined products, from the light gases, via petrol, paraffin, diesel oil, tar, and sulfur, to the heavy residue. Demand for oil products increased greatly because of the First World War(1914e1918). By the 1920s, the oil industry was dominated by seven major companies, termed the "seven sisters" by Enrico Mattei (Sampson, 1975). These companies included:

European:

British Petroleum

Shell

American:

Exxon (formerly Esso)

Gulf

Texaco

Mobil

Socal (or Chevron

British Petroleum and Shell found their oil reserves abroad from their parent countries, principally in the Middle and Far East, respectively. They were thus involved early in long-distance transport by sea, measuring their oil by the seagoing tonne. The American companies, by contrast, with shorter transportation distances, used the barrel as their unit of measurement. The American companies began overseas ventures, mainly in Central and South America, in the 1920s. In the 1930s, the ArabianeAmerican Oil Company (Aramco, now Saudi Aramco) evolved from a consortium of Socal, Texaco, Mobil, and Exxon Following the Second World War and the postwar economic boom, the idea of oil consortia became established over much of the free world. Oil companies risked the profits from one productive area to explore for oil in new areas. To take on all the risks in a new venture is unwise, so companies would invest in several joint ventures, or consortia. Table 1.1 shows some of the major consortia, demonstrating the stately dance of the seven sisters as they changed their partners around the world. In this process the major consortia shared a mutual loveehate relationship The object of any business is to maximize profit. Thus, it was to their mutual benefit to export oil from the producing countries as cheaply as possible and to sell it in the world market for the highest price possible. The advantage of a cartel is offset by the desire of every company to enhance its sales at the expense of its competitors by selling its products cheaper. In 1960, the Organization of Petroleum Exporting Countries (OPEC) was founded in Baghdad and consisted initially of Iraq, Iran, Kuwait, Saudi Arabia, and Venezuela (Martinez, 1969). It later expanded to include Algeria, Dubai, Ecuador, Gabon, and Indonesia.

TABLE 1.1 Partners of Some of the Major Overseas Oil Consortia[a]

Companies	The Consortium, Iran	I.P.C., Iraq	Aramco, Saudi Arabia	Kuwait Oil Co., Kuwait	Admar, Abu Dhabi	A.D. P.C., Abu Dhabi	Oasis, Libya
B.P.	X	X		X	X	X	
Shell	X	X				X	X
Exxon	X	X	X			X	
Mobil	X	X	X			X	
Gulf	X			X			
Texaco	X		X				
Socal	X		X				
C.F.P.	X					X	
Conoco							X
Amerada							X
Marathon							X

[a]*Note that partners and their percentage interest varied over the lifetime of the various consortia.*

Evolution of Petroleum Exploration Concepts and Techniques

From the days of Noah to OPEC the role of the petroleum geologist has become more and more skilled and demanding. In the early days, oil was found by wandering about the countryside with a naked flame, optimism, and a sense of adventure. One major U.S. company, which will remain nameless, once employed a chief geologist whose exploration philosophy was to drill on old Indian graves. Another oil finder used to put on an old hat, gallop about the prairie until his hat dropped off, and start drilling where it landed. History records that he was very successful (Cunningham-Craig, 1912). One of the earliest exploration tools was "creekology." It gradually dawned on the early drillers that oil was more often found by wells located on river bottoms than by those on the hills (Fig. 1.2). The anticlinal theory of oil entrapment, which explained this phenomenon, was expounded by Hunt (1861). Up to the present day, the quest for anticlines has been one of the most successful exploration concepts.

Experience soon proved, however, that oil could also occur off structure. Carll (1880) noted that the oil-bearing marine Venango sands of Pennsylvania occurred in trends that reflected not structure, but paleoshorelines. Thus was borne the concept that oil could be trapped stratigraphically as well as structurally. Stratigraphic traps are caused by variations in deposition, erosion, or diagenesis within the reservoir Through the latter part of the nineteenth and the early part of the twentieth century, oil exploration was based on the surface mapping of anticlines. Stratigraphic traps were found accidentally by serendipity or by subsurface mapping and extrapolation of data gathered.

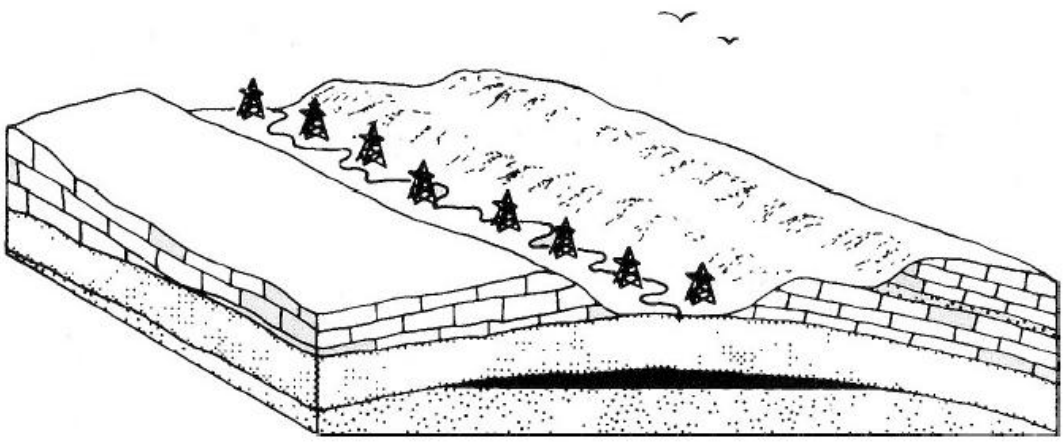

FIGURE 1.2 Creekology—the ease of finding oil in the old days.

from wells drilled to test structural anomalies. Unconformities and disharmonic folding limited the depth to which surface mapping could be used to predict subsurface structure. The solution to this problem began to emerge in the mid-1920s, when seismic (refraction), gravity, and magnetic methods were all applied to petroleum exploration. Magnetic surveys seldom proved to be effective oil finders, whereas gravity and seismic methods proved to be effective in finding salt dome traps in the Gulf of Mexico coastal province of the United States. In the same period geophysical methods were also applied to borehole logging, with the first electric log run at Pechelbronn, France, in 1927. Further electric, sonic, and radioactive logging techniques followed. Aerial surveying began in the 1920s, but photogeology, which employs stereophotos, only became widely used after the Second World War. At this time aerial surveys were cheap enough to allow the rapid reconnaissance of large concessions, and photogeology was notably effective in the deserts of North Africa and the Middle East, where vegetation does not cover surface geology.

Pure geological exploration methods advanced slowly but steadily during the first half of the twentieth century. One of the main applications to oil exploration was the development of micropaleontology. The classic biostratigraphic zones, which are based on macrofossils such as ammonites, could not be identified in the subsurface because of the destructive effect of drilling. New zones had to be defined by microfossils, which were calibrated at the surface with macrofossil zones. The study of modern sedimentary environments in the late 1950s and early 1960s, notably on Galveston Island (Texas), the Mississippi delta, the Bahama Bank, the Dutch Wadden Sea, and the Arabian Gulf, gave new insights into ancient sedimentary facies and their interpretation. This insight provided improved prediction of the geometry and internal porosity and permeability variation of reservoirs. The 1970s saw major advances on two fronts: geophysics and geochemistry. The advent of the computer resulted in a major quantum jump in seismic processing. Instead of seismologists poring painfully over a few bunched galvanometer traces, vast amounts of data could be displayed on continuous seismic sections. Reflecting horizons could be picked out in bright colors, first by geophysicists and later even by geologists. As techniques improved, seismic lines became more and more like geological cross sections, until stratigraphic and environmental concepts were directly applicable.

In the 1980s, increasing computing power led to the development of 3D seismic surveys that enabled seismic sections of the earth's crust to be displayed in any orientation, including horizontal. Thus, it is now possible to image directly the geometry of many petroleum reservoirs. Similarly enhanced processing methods made it possible to detect directly the presence of oil and gas. These improvements went hand in hand with enhanced borehole logging. It is now possible to produce logs of the mineralogy, porosity, and pore fluids of boreholes, together with images of the geological strata that they penetrate As the millenium approaches, one can only speculate on what new advances in petroleum exploration technology will be discovered. All techniques may be expected to improve. Remote sensing from satellites may be one major new tool, as might direct sensing from surface geochemical or geophysical methods. These latter methods generally involve the identification of gas microseeps and fluctuations in electrical conductivity of rocks above petroleum accumulations. Such methods have been around for half a century, but have yet to be widely accepted.

From the earliest days of scientific investigation the formation of petroleum had been attributed to two origins: inorganic and organic. Chemists, such as Mendeleyev in the nineteenth century, and astronomers, such as Gold and Hoyle in the twentieth, argued for an inorganic origindsometimes igneous, sometimes extraterrestrial, or a mixture of both. Most petroleum geologists believe that petroleum forms from the diagenesis of buried organic matter and note that it is indigenous to sedimentary rocks rather than igneous ones. The advent of cheap and accurate chemical analytical techniques allowed petroleum source rocks to be studied. It is now possible to match petroleum with its parent shale and to identify potential source rocks, their tendency to generate oil or gas, and their level of thermal maturation. For a commercial oil accumulation to occur, five conditions must be fulfilled

1. There must be an organic-rich source rock to generate the oil and/or gas.

2. The source rock must have been heated sufficiently to yield its petroleum.

3. There must be a reservoir to contain the expelled hydrocarbons. This reservoir must have porosity, to contain the oil and/or gas, and permeability, to permit fluid flow.

4. The reservoir must be sealed by an impermeable cap rock to prevent the upward escape of petroleum to the earth's surface.

5. Source, reservoir, and seal must be arranged in such a way as to trap the petroleum.

6. The timing of trap formation, petroleum generation, and accumulation must be in a favorable sequence

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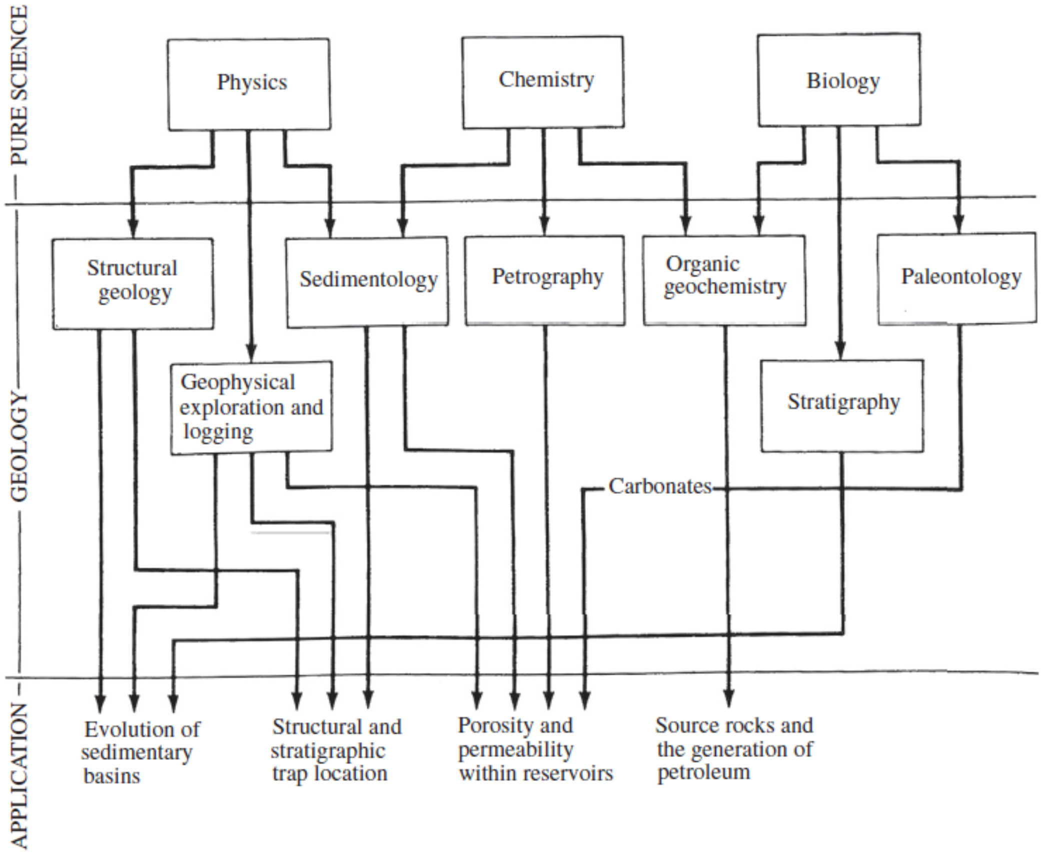
7. The accumulation must be preserved or protected from breaching, flushing, aerobic bacteria, thermal degradation, etc. until exploitation.

THE CONTEXT OF PETROLEUM GEOLOGY



Methods of Exploration

WELL DRILLING AND COMPLETION

In the earliest days of oil exploration, oil was collected from surface seepages. Herodotus, writing in about 450 BC, described oil seeps in Carthage (Tunisia) and the Greek island Zachynthus. He gave details of oil extraction from wells near Ardericca in modern Iran, although, as mentioned in Chapter 1, the wells could not have been very deep, because fluid was extracted in a wineskin on the end of a long pole mounted on a fulcrum. Oil, salt, and bitumen were produced simultaneously from these wells. In China, Burma, and Romania, mine shafts were dug to produce shallow oil. Access was gained by ladders or a hoist, and air was pumped down to the mines through pipes. Oil seeped into the shaft and was lifted to the surface in buckets. This type of technology was not conducive to a healthy life and long retirement for the miners.

Oil has also been mined successfully in several parts of the world by driving horizontal adits into reservoirs. Oil dribbles down the walls onto the floor and flows down to the mine entrance. This technique has been used in the North Tisdale field of Wyoming (Dobson and Seelye, 1981). Conventionally, however, oil and gas are located and produced by drilling boreholes. Before exploration for oil began, cable-tool drilling was an established technique in many parts of the world in the quest for water and brine (Fig. 3.1). The first well to produce oil intentionally in the Western World was drilled at Oil Creek, Pennsylvania, by Colonel Drake in 1859 (Owen, 1975). Previously, water wells in the Appalachians and elsewhere produced oil as a contaminant. The technology for drilling Drake's well was derived from Chinese artisans who had traveled to the United States to work on the railroads. Cable-tool drilling had been used in China since at least the first century b.c., the drilling tools being suspended from bamboo towers up to 60 m high. In China, however, this drilling technology

Cable-Tool Drilling

Cable-tool drilling seems to have developed spontaneously in several parts of the world. In the early nineteenth century, the Chinese were sinking shafts to depths of some 700 m using an 1800-kg bit suspended from a rattan cord. Hole diameters were of the order of 10e15 cm, and the rate of penetration was about 60e70 cm/day. The wells were cased with bamboo orhollow cypress trunks (Imbert, 1828; Coldre, 1891). These wells were sunk in the search for freshwater and for brines from which salt could be extracted. In modern cable-tool drilling, a heavy piece of metal, termed the bit, is banged up and down at the end of a cable on the bottom of the hole. The bit is generally chisel shaped. This repeated percussion gradually chips away the rock on the bottom of the hole. Every now and then, the bit is withdrawn to the surface, and a bailer is fitted to the end of the cable. This bailer is a steel cylinder with a one-way flap at the bottom. As the bailer is dropped on the floor of the hole, chips of rock are forced into it through the trap flap.

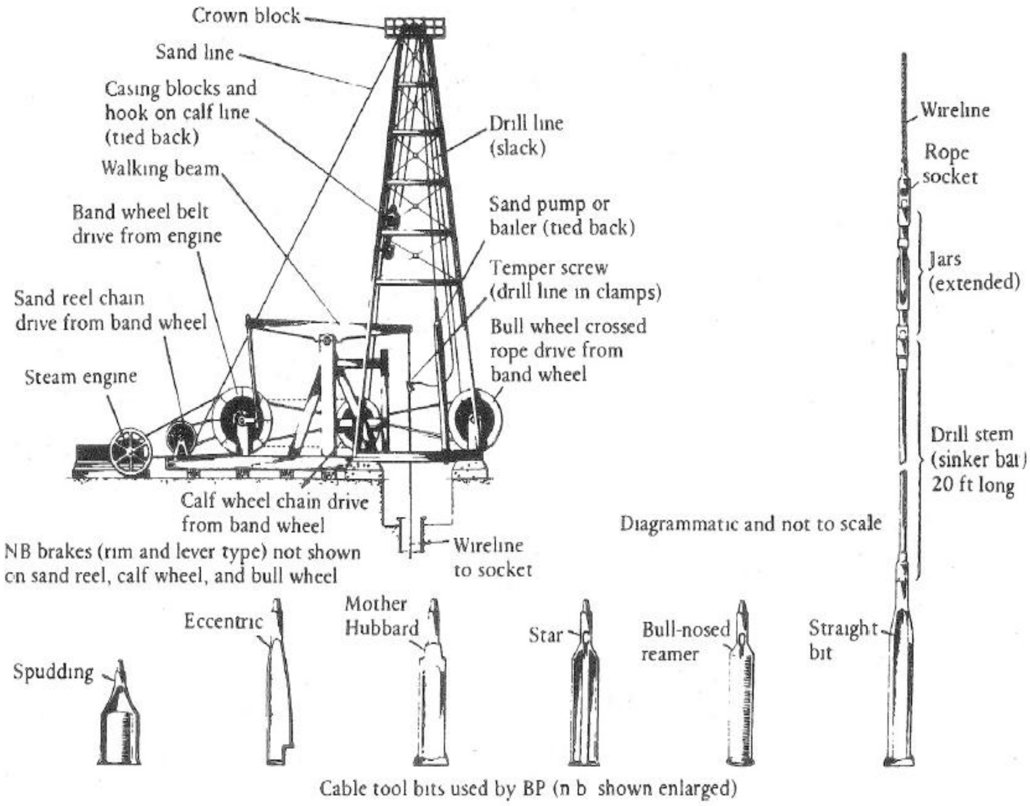


FIGURE 3.1 A steam-driven cable-tool rig and equipment. *Courtesy of British Petroleum.*

When the bailer is lifted prior to the next drop, the rock cuttings are retained in the trap (Fig. 3.1). When the cuttings have been removed from the borehole, the bailer is drawn out and emptied. The bit is then put back on the end of the cable, and percussion recommences. As the hole is gradually deepened, the sides have a natural tendency to cave in. This tendency is counteracted by lining the hole with steel casing. In the early days of oil exploration, the percussive power of the cable tool was provided by a man or men pulling on the rope or, later, aided by a spring-pole. In more recent times, however, motive power was provided by a steam or internal combustion engine. The mechanical cable-tool drilling method evolved toward the end of the eighteenth century. It was then used primarily for the sinking of water wells. Occasionally, such wells would find water contaminated with oil, to the displeasure of the driller.

When the economic uses of oil were discovered in the mid-nineteenth century, however, the cable-tool rig became the prime method of sinking oil wells, and it remained so for some 80 years. Cable-tool drilling has several major mechanical constraints. First, the depth to which one may drill is severely limited. The deeper the hole, the heavier the cable. There comes a point, therefore, when the cable at the well head is not strong enough to take the combined weight of the bit and the downhole cable. Although cable-tool rigs have drilled to>3000 m, the average capability is about 1000 m. This capability is adequate for most water wells, but too shallow for the increased depths required for oil exploration. A further limitation of the cable-tool method is that it can only work in an open hole. The cable must be free to move, so it is not possible to keep the hole full of fluid. The bailer removes water that oozes into the hole. Thus, when the bit breaks through into a high-pressure formation, the oil or gas shoots up to the surface as a gusher. Because of these limitations of penetration depth and safety, cable-tool drilling is of limited use in petroleum exploration.

Rotary Drilling

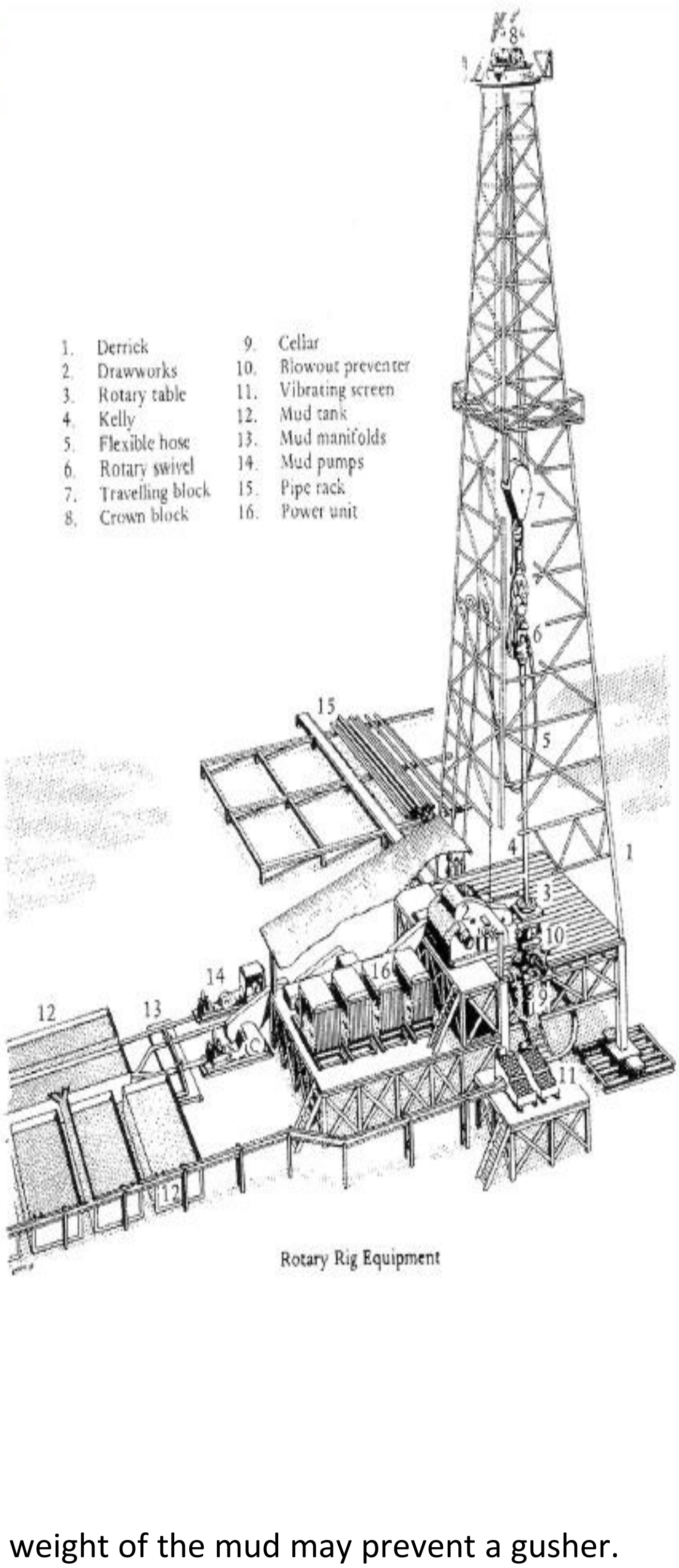
Because of the greater safety and depth penetration of rotary drilling, it has largely superseded the cable-tool method for deep drilling in the oil industry (Fig. 3.2). In this technique the bit is rotated at the end of a hollow steel tube called the drill string. Many types of bit are used, but the most common consists of three rotating cones set with teeth(Fig. 3.3). The bit is rotated, and the teeth gouge or chip away the rock at the bottom of the borehole. Simultaneously, mud or water is pumped down the drill string, squirting out through nozzles in the bit and flowing up to the surface between the drill string and the wall of the hole. This circulation of the drilling mud has many functions: It removes the rock cuttings from the bit;

it removes cavings from the borehole wall; it keeps the bit cool; and, most importantly, it keeps the hole safe. The hydrostatic pressure of the mud generally prevents fluid from moving into the hole, and if the bit penetrates a formation.

As the bit deepens the hole, new joints of drill pipe are screwed on to the drill string at the surface. The last length of drill pipe is screwed to a square-section steel member called the kelly, which is suspended vertically in the kelly bushing, a square hole in the center of the rotary table. Thus, rotation of the table by the rig motors imparts a rotary movement down the drill string to the bit at the bottom of the hole. As the hole deepens, the kelly slides down through the rotary table until it is time to attach another length of drill pipe (Fig. 3.4). When the bit is worn out, which depends on the type of bit and the hardness of the rock, the drill pipe is drawn out of the hole and stacked in the derrick. When the bit is brought to the surface, it is removed and a new one is fitted.

After drilling for some depth, the borehole is lined with steel casing, and cement is set between the casing and the borehole wall. Drilling may then recommence with a narrower gauge of bit. The diameters of bits and casing are internationally standardized. Depending on the final depth of the hole, several diameters of bit will be used with the appropriate casing (Fig. 3.5). The average depth of an oil well is between 1 and 3 km, but depths of up to11.5 km can be penetrated.

FIGURE 3.2 Simplified sketch of an onshore derrick for rotary drilling. *Courtesy of British Petroleum.*



With a high-pore pressure, the weight of the mud may prevent a gusher. A gusher can also be prevented by sealing the well head with a series of valves termed the blowout preventers had developed to produce artesian brines, not petroleum (Messadie, 1995). The two methods, cable-tool and rotary-tool drilling, are briefly described in the following sections.

Types of Wells

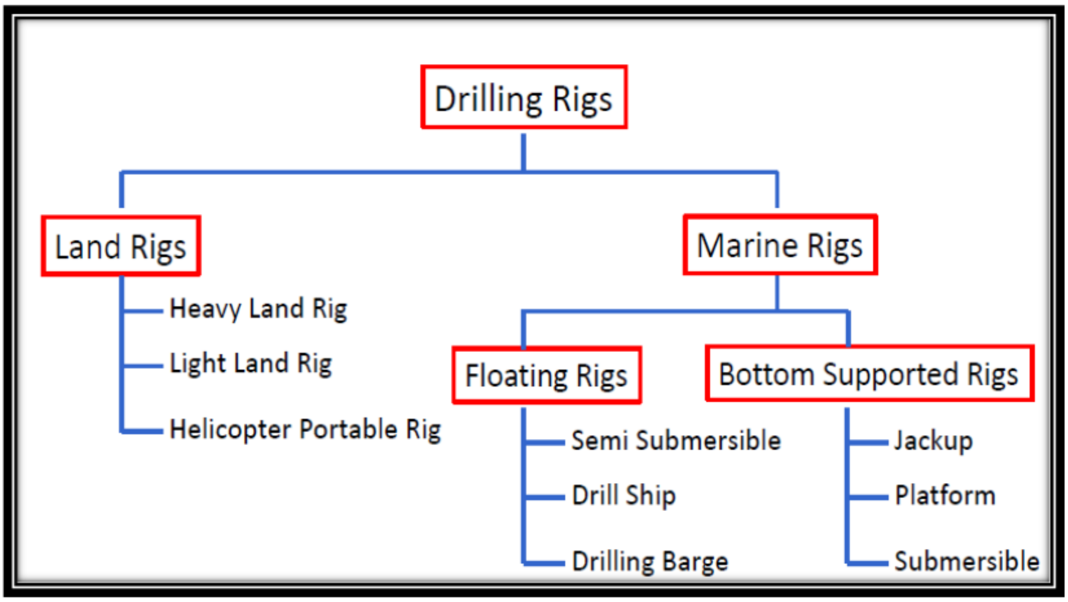
1) **Wildcat or Exploration Well:** to discover new petroleum reservoir**.**
2) **Development Well:** exploit a known reservoir.

People working at the drilling rig site

1- Company crew (company man, geologist, HSE health suavity and environment , logging supervisor, cement engineer, mud engineer,
2- Drilling rig crew (roustabout, floor man, derrick man, assistant driller, driller, toll pusher, rig manager, rig welder, rig mechanic, rig electric.)
3- Service crew by job(mud logger, fluid engineer,
4- Catering crew(chef, waiter, room boy, laundry).

Types of drilling rig:

1) **Land rigs:** jackknife or cantilever rigs and portable-masts.
   - Main design features are portability and maximum operating depth. Derricks are built on locations.
2) **Marine (or offshore) rigs:** bottom-supported offshore rigs, semi-submersible floating rig, drill- ship floating rig.
   - Main design features are portability and maximum water depth (WD) of operation.



Terms "Rig move," "Rig down," and "Rig up

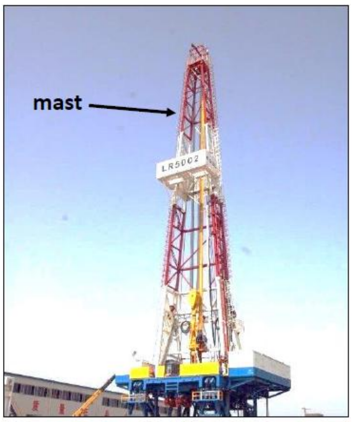
The terms "Rig move," "Rig down," and "Rig up" are commonly used in the oil and gas industry, especially in drilling operations. Here's what each term typically means:

- Rig move: This refers to the process of transporting a drilling rig from one location to another. It involves dismantling necessary components, transporting them (often using trucks or trailers), and then reassembling at a new site.
- Rig down: his means taking apart or dismantling the drilling rig at the end of operations on a site. It's the process that precedes a rig move. Equipment is disassembled, cleaned, and prepared for transport.
- Rig up: This is the opposite of rig down. It refers to assembling and setting up the rig at a new drilling location. This includes erecting the derrick, connecting power systems, setting up safety equipment, and preparing the site for drilling.

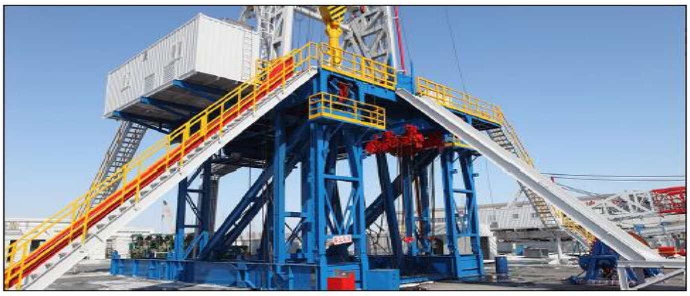
Drilling rig component

Hosting and Rotation system

1. Mast: A tall steel structure on the rig that supports the drill string and other equipment. It provides the height needed to raise and lower drill pipe into the wellbore.

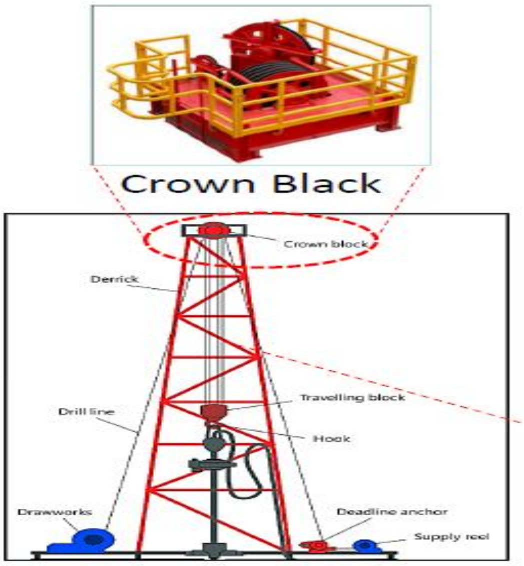


2. Substructure : The base support structure of the rig that holds up the mast and provides space underneath for blowout preventers (BOPs), casing, and well control equipment.



Substructure

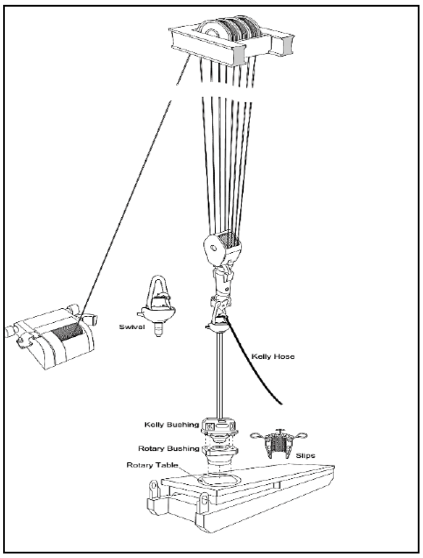
3. Crown clock: A fixed set of pulleys at the top of the mast through which the drill line runs. It works with the traveling block to raise/lower the drill string.



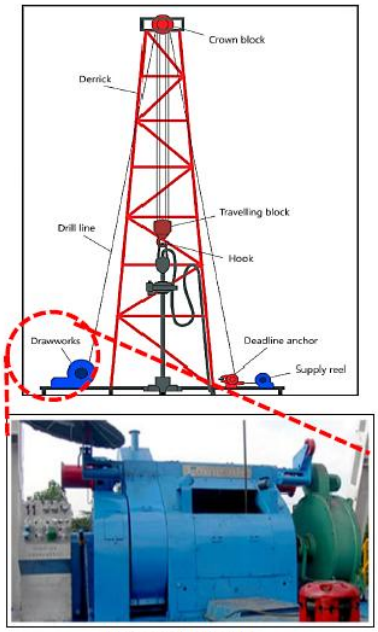
4. Top drive : A motorized device that rotates the drill string from the top, replacing the traditional rotary table. It allows for more efficient and safer drilling operations.

Top Drive

5. Kelley: A long, square or hexagonal pipe that fits into the rotary table to transfer rotary motion to the drill string (used mostly in older rigs; largely replaced by top drives).

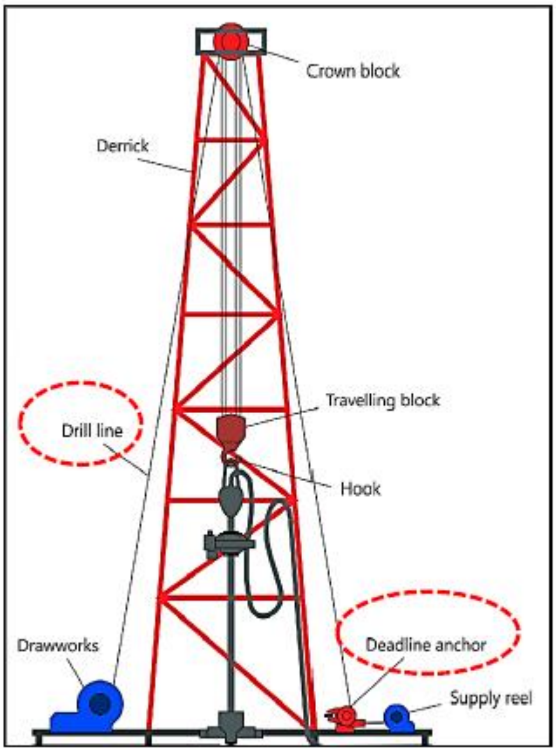


6. Draw works: The main hoisting mechanism on the rig. It contains the drum and braking system used to spool the drill line in and out, controlling the movement of the traveling block.

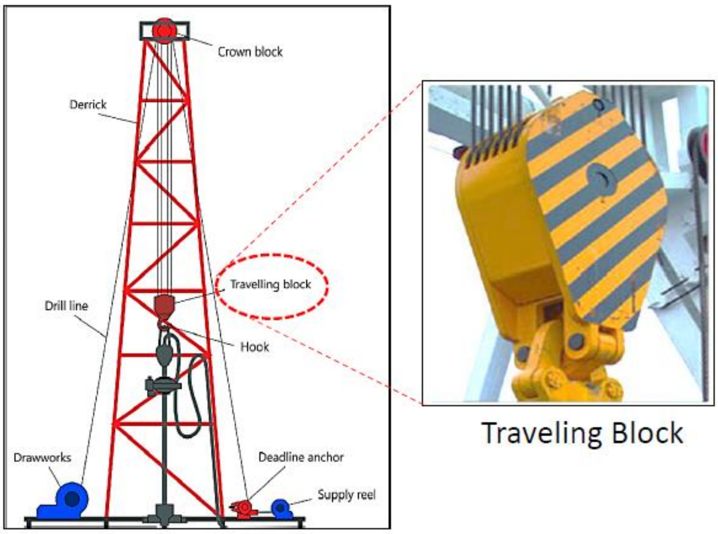


Draw Work

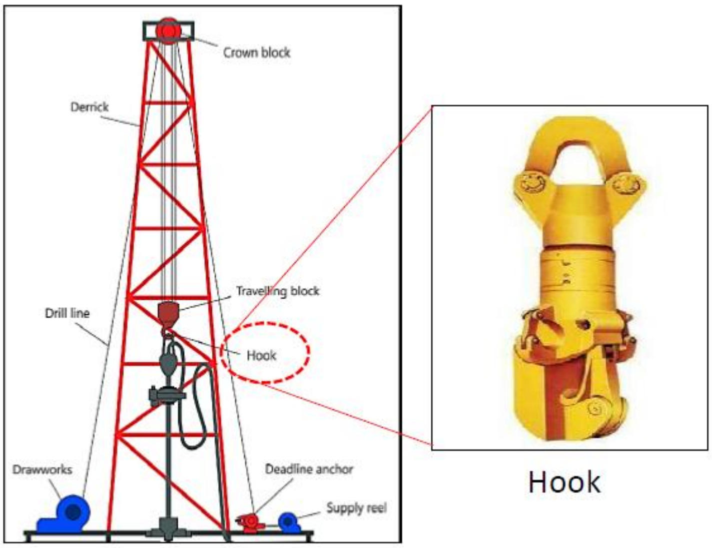
7. Drill line: A strong, thick wire rope that runs through the crown block and traveling block, connecting to the drawworks. It’s used to hoist and lower heavy loads.



8. Travelling block: The Travelling Block is a set of pulleys (sheaves) mounted in a steel frame that moves up and down along the mast or derrick of the drilling rig. It is suspended by the drill line, which passes over the Crown Block and wraps around the Draw Works.

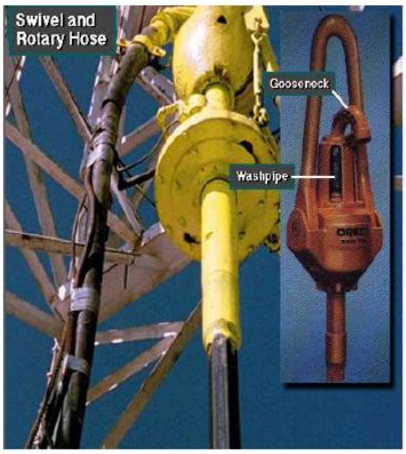


9. Hock: The Hook is a large, heavy-duty hook-shaped device that hangs from the Travelling Block on a drilling rig. It is used to connect the hoisting system to the Top Drive, Kelly, swivel, or elevator—essentially linking the hoisting equipment to the drill string or casing.



Hook

10. Swivel: The Swivel is a large, rotating connection device suspended from the Hook, located above the Kelly. It allows the drill string to rotate while also providing a passage for drilling fluid (mud) to flow down into the wellbore.

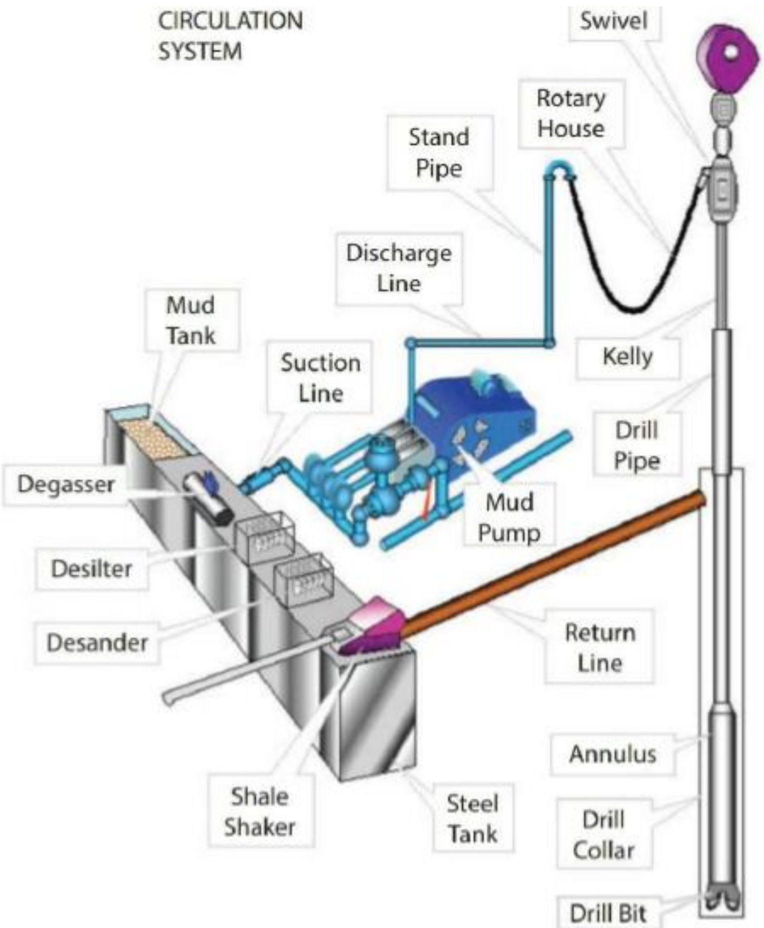


Swivel

11. Rotary table: The Rotary Table is a mechanical device mounted on the rig floor that rotates the Kelly and drill string, allowing the drill bit at the bottom of the well to cut through rock and soil.

Rotary Table

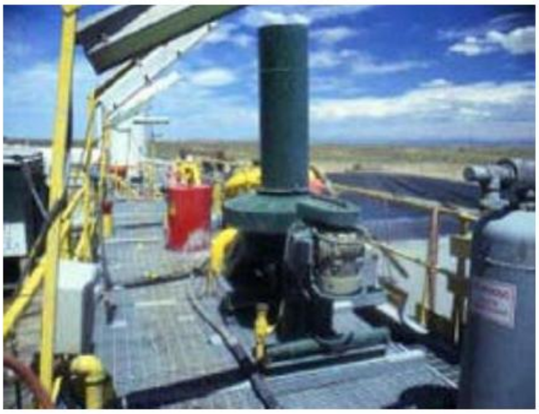
Mud circulation system



1. Shale shakers : A Shale Shaker is a vibrating screen system used on drilling rigs to separate large solids (cuttings) from the drilling fluid (mud) as it returns from the wellbore. It ensures that drilling mud is cleaned and recycled for reuse.

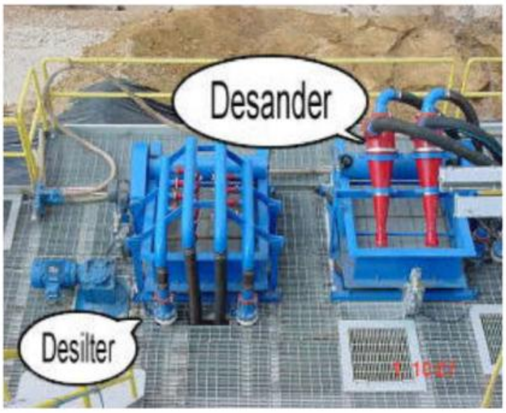
Shale Shakers

2. Degasser: A Degasser is a critical solids control device used in drilling operations to remove gas from the drilling mud.



degasser

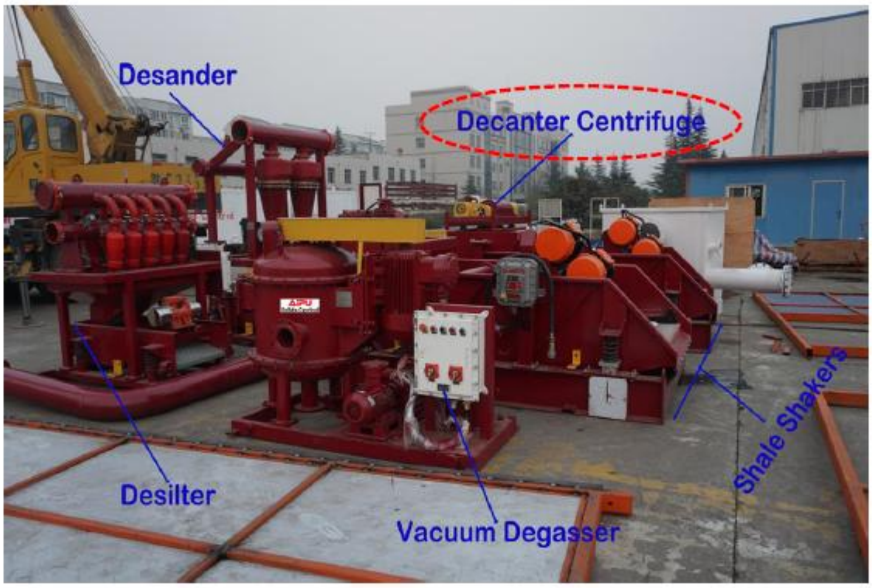
3. De sander : A Desander is a key part of the solids control system used in drilling operations. It removes medium-sized solid particles, particularly sand, from the drilling fluid (mud) after the shale shaker and degasser stages.



Desander & desilter

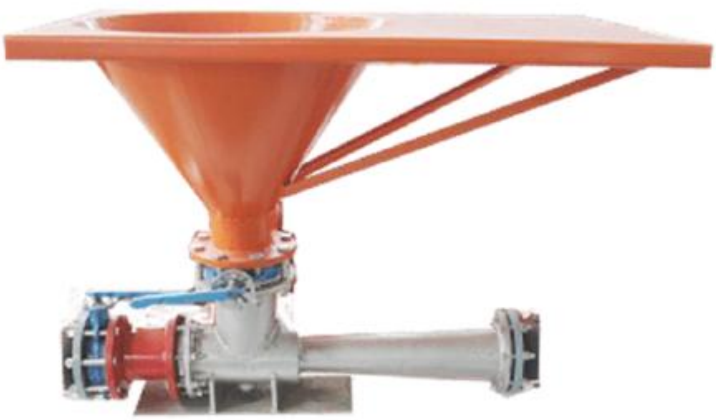
4. De silter : A Desilter is an essential part of the solids control system on a drilling rig. It is used to remove very fine particles, smaller than what the Desander can handle, from the drilling mud.

5. Centrifuges: A Centrifuge in drilling operations is a high-speed solids control device used to remove ultra-fine solids and recover valuable drilling fluid (mud).



6. Mud pit : Mud Pit is a large, open tank used in drilling operations to store and circulate drilling fluid (mud). It plays a crucial role in the mud system by receiving used mud from the well, holding the drilling fluid for reconditioning, and maintaining a supply of fresh mud for circulation.

7. Mud mixing hopper: A Mud Mixing Hopper is an essential piece of equipment used to mix drilling fluid (mud) components efficiently and quickly on a drilling rig. It is part of the mud system, allowing for the continuous preparation of fresh mud or the addition of necessary additives to the existing fluid.



8. Mud pumps: Mud pumps are crucial equipment in the drilling fluid circulation system. They are responsible for pumping the drilling mud from the mud pits through the entire system and back down to the wellbore, maintaining the flow of the fluid during the drilling process.