Usually drilling rigs are located in remote areas with severe environments: desert, jungles, mountains, marshes, arctic and others.

To reach the drilling site we will need a kind of transport.
The history of modern oil drilling:

- **1854 - Oil Creek**

- **August, 1859 - Drake well in Titusville, Pennsylvania:**
  - Cable-tool Drilling
  - Depth = 69\(\frac{1}{2}\) feet (21.2 m)
  - Production = around 800 to 1,200 gallons (about 3,000 to 4,800 litres) per day.

- Depth = about 1,000 feet (300 m)
- Production = at least 2 million gallons (nearly 8,000 cubic meters) of oil per day - 50,000 barrels of oil per day.
1. CABLE-TOOL DRILLING

• This drilling technology was first used in... China to drill for water.
• In oil well drilling this system was used in the 19th century and predominantly in the first two decades of the 20th.

• The cable-tool system was essentially a method of pounding out a hole by repeated blows with a bit attached to a “drill stem”, a heavy length of steel suspended from a wire rope. The drill stem provided the weight to force the bit into the ground, and the hole was kept empty for a little water at the bottom.
After drilling a few feet, the bit was pulled out and the cuttings removed with a “bailer”, an open tube with a valve at the bottom.
Steel pipes known as casing, of progressively smaller diameter, were run from time to time to prevent the hole from caving in and to keep back any water flow.
CABLE-TOOL DRILLING
Description of Equipment and Process:

1. The walking beam was a wooden bar that rocked up and down on a central pivot.

2. The derrick provided a space to raise the cable and pull the long drilling tools out of the hole.

3. As the beam rocked up it raised the cable and attached chisel, or bit.

4. Then, when the walking beam rocked down, heavy weights, *sinker bars*, above the bit provided weight to ram it into the ground.

5. The bit punched its way into the rock.

6. Repeated lifting and dropping made the bit drill.

7. Special equipment played out the cable as the hole deepened.
• **Main Advantage**: Cable-tool drilling worked very well in the hard-rock formations.

• **Main Disadvantage (Limitation)**: The cable-tool technique didn't work in soft formations like clay or loose sand.
  
  • Clay and sand closed around the bit and wedged it in the hole.
  
  • This limitation led to the increased use of rotary rigs because more wells were being drilled in places where cable-tool bits got stuck.

Nowadays Cable-tool Drilling is almost not in use.
2. ROTARY DRILLING

Rotary bit has rows of teeth or other types of cutting devices that penetrate the formation and then scrape or gouge out pieces of it as the rig system rotates the bit _____ in cable-tool drilling – chisel.

By screwing together several joints of pipe, drilling crew put the bit on the bottom of the hole. As the hole deepens, they add joints of pipe _____ in cable-tool drilling – cable.
Above the bit, long sections of pipe, the *drill pipe*, screw together in a *drill string* to connect the equipment in the hole to the equipment on the surface.
Two main processes characterize the rotary drilling: Rotation & Circulation.

1- **Bit Rotation:** Three types of equipment are used today to rotate the bit, together with the drill string:

2- Top Drive

3- Downhole Motor

1- Rotary Table
2- **Fluid Circulation:** The main purpose of the fluid circulation is to bring the cuttings, that were made by the bit downhole, up to the surface.

- In the fluid circulation:
  1. a powerful pump on surface moves the drilling fluid downhole through the hollow drill string,
  2. the fluid then comes out through the bit,
  3. the fluid picks up the cuttings as the bit makes them and carries them through the annulus to the surface,
  4. on the surface the cuttings are disposed of the fluid,
  5. Finally, the clean mud is send back down the hole by the pump to repeat the same cycle.

**Two Drilling-Fluid Pumps**
Drilling Fluid Circulation
Drilling Fluid - Mud

• Drilling fluid—*mud*— is usually a mixture of base fluid, clay, weighting material, and a few chemicals.
• The base fluid can be a liquid (basically water and oil), a gas (gas or air), or a combination.
• For example: some formations swell in the presence of water and impede drilling, so the operating company requires that the contractor use oil instead of water, as a base for the mud.
• Gas and air are less used as a base fluid in drilling mud.

• Functions of drilling fluid - mud:

1. keeping boreholes from caving in
2. moves the cuttings away from the bit
3. cools and lubricates the bit
4. keeps formation fluids from entering the hole and blowing out to the surface
5. gives information about the reservoir formations.
Basically, all rotary drilling rigs are divided into two principle categories:

I- rigs that work on land (onshore), and

II- rigs that work offshore

Some define a third category of drilling rigs that work in inland waters (in lakes, marshes, and estuaries).

Many accept the inland rigs as offshore rigs, because they also drill in water.
I - LAND RIGS:

Land rigs differ in details depending on their size (dimensions) and portability. According to their size land rigs are classified into the following groups:
1. Light duty
2. Medium duty
3. Heavy duty
4. Very heavy duty.

The size of the rig defines the maximum depth of wellbore it can drill.

<table>
<thead>
<tr>
<th>Rig Size</th>
<th>Maximum Drilling Depth, Feet (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Duty</td>
<td>3,500 – 5,000 (1,000 – 1,500)</td>
</tr>
<tr>
<td>Medium Duty</td>
<td>4,000 – 10,000 (1,200 – 3,000)</td>
</tr>
<tr>
<td>Heavy Duty</td>
<td>12,000 – 16,000 (3,500 – 5,000)</td>
</tr>
<tr>
<td>Very Heavy Duty</td>
<td>18,000 – 25,000 (5,500 – 7,500)</td>
</tr>
</tbody>
</table>
According to their portability, basically, all land rigs are very mobile.

Usually after drilling a hole in one site, the rig will be disassembled into huge pieces transported to another site, where it will be assembled to drill another hole.
II - OFFSHORE RIGS:

The most common types of rigs used in offshore drilling are mobile rigs, or *Mobile Offshore Drilling Units* (MODU).

Depending on the kind of drilling MODU are divided into two main groups:

1- **Bottom – Supported Units**: Used basically for Exploration Drilling.
   
   Include: *Submersibles* (posted barges, Bottle types, Arctic types, Inland barges) and *Jackups*.

2- **Floating Units**: Used mainly for development drilling.
   
   Include: *Semisubmersibles and Drill Ships*.
According to their size land rigs are classified into the following groups:
1. Light duty
2. Medium duty
3. Heavy duty
4. Very heavy duty.

- The size of the rig defines the maximum depth of wellbore it can drill.
- The choice of the offshore unit type also depends on the depth of the water, the weather environment and other factors.
# Types of Mobile Offshore Drilling Units (MODU)

<table>
<thead>
<tr>
<th>Bottom-Supported Units</th>
<th>Floating Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1- Submersibles:</strong></td>
<td><strong>1- Semisubmersibles</strong></td>
</tr>
<tr>
<td>1. Posted Barges</td>
<td></td>
</tr>
<tr>
<td>2. Bottle Types</td>
<td></td>
</tr>
<tr>
<td>3. Arctic Types</td>
<td></td>
</tr>
<tr>
<td>4. Inland Barges</td>
<td></td>
</tr>
<tr>
<td><strong>2- Jackups</strong></td>
<td><strong>2- Drill Ships</strong></td>
</tr>
</tbody>
</table>
Bottom-Supported Units

1- Submersibles:

- The lower part of a submersible's structure rests on the sea-floor.

- A submersible MODU floats on the water's surface when moved from one drilling site to another.

- Wind, waves, and currents have little effect on submersibles, because the base of the rig is in contact with the ocean/sea bottom.
Bottom-Supported Units

1. Posted Barges:

- The first use of MODU for offshore drilling was in 1949

- A well in the Gulf Coast of Louisiana - 18 feet (5.5 meters) of water.

- It was a posted-barge submersible—a barge hull and steel posts (columns) supported a deck and drilling equipment.

- It proved that mobile rigs could drill offshore.
Posted Barge - Submersible

1. TOWING
2. HULL FLOODING
3. PONTOONS FLOODING
4. DRILLING
2. Bottle Types:

- First use in 1954.
- For drilling in water depths 30 feet (9 meters) and more.
- A bottle-type rig has four tall steel cylinders (bottles) at each corner of the structure.
- The main deck lies across several steel supports and the bottles.
- The rig and other equipment are placed on the main deck.
- When flooded, the bottles cause the rig to submerge to the seafloor.
- In the early 1960s, the biggest bottle-type submersibles drilled in 150-foot (45-meter) water depths.
- Today, jackups have largely replaced them; jackups are less expensive to build than bottle-types and can drill in deeper water.
- Some rig owners modified some of bottle-type submersibles to drill as semisubmersibles.
3. Arctic Types:

- In the arctic petroleum deposits lie under shallow oceans such as the Beaufort Sea.

- Arctic submersibles have a reinforced hull, a *caisson*.

- One type of caisson has a reinforced concrete base on which the drilling rig is installed.

- When the sea is ice-free in the brief arctic summer, boats tow the submersible to the drilling site.

- There, workers submerge the caisson to the sea bottom and start drilling.
Arctic - Type Submersible
4. Inland Barges

- Inland Bares usually drill in marshes, bays, swamps, or other shallow inland waters.
- Since they often drill in swampy shallow waters they are often called “Swamp Barges.“
- Inland Barge has a barge hull—a flat-bottomed, flat-sided, rectangular steel box.
- The drilling rig and other equipment are placed on the barge deck.
- These barges are not self-propelled; they have no built-in power to move them from one site to another.
- Boats tow them to the drilling location.
- When being moved, the barge floats on the water's surface.
- When positioned at the drilling site, the barge is flooded so that it rests on the bottom ooze.
Inland Barges  Submersible
2- Jackups:

- Widely used mobile offshore drilling unit

- Floats on a barge hull when towed to the drilling location

- Most modern jackups have three legs with a triangular-shaped barge hull

- Others have four or more legs with rectangular hulls

- Jackup's legs can be cylindrical columns

- They also can be open-truss structures (like a mast or a derrick).
2- Jackups:

- When a jackup's barge hull is positioned on the drilling site,
  - The crew jacks down the legs until they contact the seafloor.

- Then they raise, or jack up, the hull above the height of the highest anticipated waves.

- The drilling equipment is on top of the hull.

- The largest jackups can drill in water depths up to about 400 feet (about 120 meters).

- They are also capable of drilling holes up to 30,000 feet (10,000 meters) or close to 5 1/2 miles, deep.

- Jackups are suitable for a severe weather environment.
Floating Units

1- Semisubmersibles:

Semisubmersibles (Semis) are among the largest floating structures ever made.

They can be over 100 feet (30 meters) tall

Their main decks can be almost as big as a football field _3,000 square yards (2,500 square meters).

Most semis have two or more pontoons on which the rig floats.

A pontoon is a long, narrow, and hollow steel float with a rectangular or round cross section.
Floating Units

1- Semisubmersibles:

✧ They are called semisubmersibles, because in drilling mode the rig’s pontoons are submerged only a few feet (meters) below the water's surface and do not contact the sea bottom.

✧ The main deck rests on top of the large cylindrical or square columns that extend upward from the pontoons columns.
Semisubmersible Rig
When Semis are moved from one site to another their pontoons contain mostly air.

After that usually tow-boats are tied onto the rig to move it.

Some Semis are self-propelled—they have built-in power units.

With its pontoons submerged below the waterline, waves do not affect the rig as much as they do when it floats on the surface.

So, Semis are more stable for drilling than drill ships.

Usually, Semis are kept on the drilling station by anchors.

Most semis work in water depths from 1,000 to 3,500 feet (300 to 1,000 m).

The Max. water-depth in which Semis can work is 8,000 feet (2,500 m).

Semis can drill holes up to 30,000 feet (10,000 meters) deep.
Semisubmersibles
2- Drill Ships

- Drill Ships are self-propelled and have a streamlined hull that allows them to move at good speed;

- Their ship-shaped hull can carry a large amount of the equipment and materials required for drilling;

- They are suitable for drilling remote locations.

- Usually, while drilling, drill ships are kept on station by anchors.

- In deep waters Drill Ships require Dynamic Positioning System with computer-controlled thrusters and sophisticated electronic sensors.
2- Drill Ships

- Most drill ships operate in water depths ranging from 1,000 to 3,000 feet (300 to 1,000 m), or nearly 2 miles (3.2 km).

- They can drill holes over 30,000 feet (10,000 meters) deep.

- Big drill ships can be more than 800 feet (350 m) long, 100 feet (30 m) wide, and with hulls tower more than 60 feet (18 m) high.

- They are more susceptible than semisubmersibles to bad weather.
Drill Ship
## World Deepwater Drilling Records

<table>
<thead>
<tr>
<th>Depth (Ft.)</th>
<th>Drilling Rig</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,969</td>
<td>Sedco 445</td>
<td>1974</td>
</tr>
<tr>
<td>3,937</td>
<td>Sedco 472</td>
<td>1977</td>
</tr>
<tr>
<td>7,467</td>
<td>Discoverer Seven Seas</td>
<td>1988</td>
</tr>
<tr>
<td>7,612</td>
<td>Discoverer 534</td>
<td>1996</td>
</tr>
<tr>
<td>9,111</td>
<td>Deepwater Expedition</td>
<td>1999</td>
</tr>
<tr>
<td>9,687</td>
<td>Discoverer Spirit</td>
<td>2001</td>
</tr>
<tr>
<td>9,727</td>
<td>Discoverer Spirit</td>
<td>2001</td>
</tr>
<tr>
<td>10,011</td>
<td>Discoverer Deep Seas</td>
<td>2003</td>
</tr>
</tbody>
</table>