

## History of the Oilfield – Oil 101

### **A Special Presentation for Petroleum Equipment & Services Association**



**28 September, 2016  
Steve Jacobs, Sinclair Group**

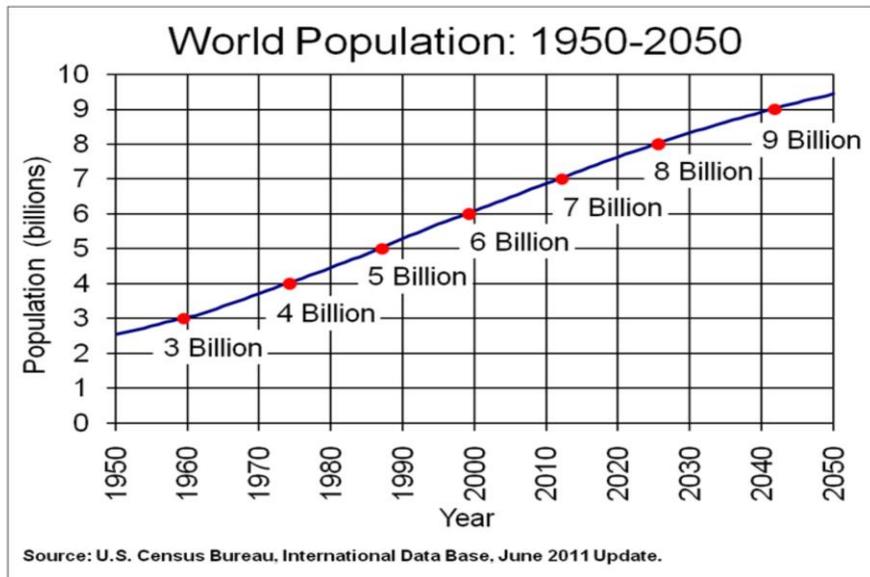


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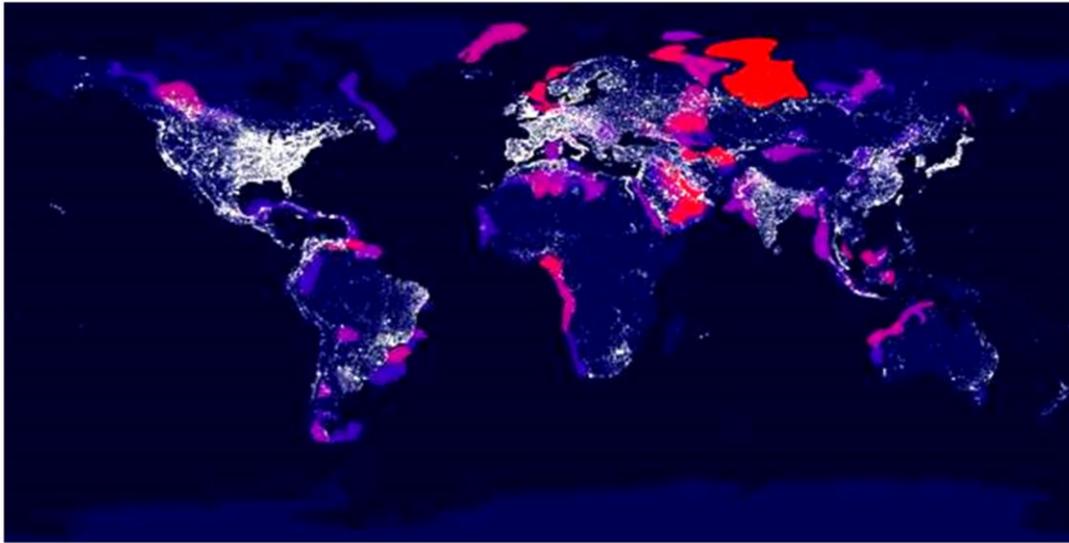
## World Population Growth (1950 – 2050)



In 1950 there were approximately 2.5 billion people on the planet. Today there is almost three times that number. By 2040 – 25 years from now – there will be over 9 billion people!!

This data confirms the importance of the oil and gas industry, to provide petroleum and products to a growing population that will depend on us to meet their energy needs.

## Challenge: Developing Infrastructure In Volatile World Regions



Source: James Baker Institute For Public Policy



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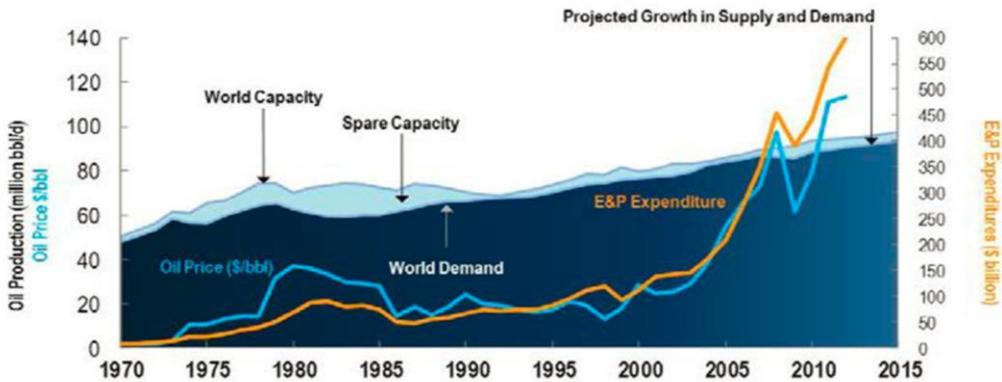
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Dr. Kenneth Medlock is with the James Baker Institute at Rice University in Houston. He analyzes various sectors of the petroleum industry. The chart above depicts a satellite photo composite of the various continents at night. Shown in the chart is: 1) areas where energy is being consumed on the planet (e.g. white lights) and 2) the presence of hydrocarbons around the globe (e.g. colored areas). It is evident from the chart that where hydrocarbons are produced on the planet are frequently not in the same locations as where they are consumed.

This situation raises a number of issues such as: 1) supply/demand imbalances and disruptions, 2) geopolitical stresses, 3) fluctuations in hydrocarbon prices, 4) significant transportation costs, 5) requirements for greater exploration and production technologies (e.g. LNG liquefaction and regasification, exploring in increasingly harsh environments like the Arctic, and having the flexibility to handle a range of sweet and sour hydrocarbons).

## Oil Supply and Demand – A Macro View



Source: BP Statistical Review, IEA World Energy Outlook, Monthly Oil Market Report, Medium-Term Oil Market Report, Lehman/Barclays, IIFP. Revised 0112

Schlumberger



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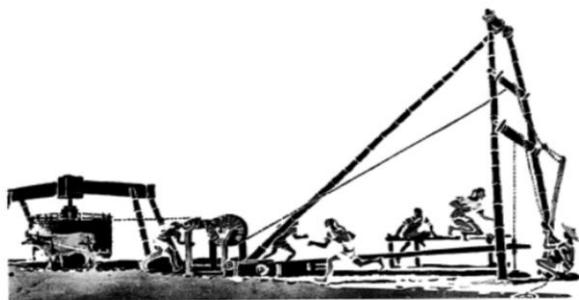
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Schlumberger has a wonderful composite chart using data from several sources (above) which is updated on a regular basis, and provides a visual summary of the important metrics from the petroleum industry, and their influence on exploration and production activity over time. It is important to look at world production capacity over the years versus global consumption. As shown in this chart the supply/demand relationship is the primary driver for oil prices around the world. Obviously, higher oil prices drive higher exploration and production expenditures around the world.

The recent oil price decline is not depicted in this slide as efforts to find a later version of this chart have been unsuccessful.

## 1,500 Years of Drilling Technology Progress?



**3<sup>rd</sup> Century AD**



**Early 1800's**

Early information on petroleum recovery and usage is scarce around the world, and not completely reliable. In the chart above the “rig” shown on the left side was supposedly developed in China around 300 A.D. and had a depth rating of approximately 800 feet. It is highly unlikely that such a depth capability existed at that time, but the design is interesting and features a “one water buffalo” power plant.

The drawing on the right is of the first well drilled (versus dug) in the United States. But it was not for oil; it was for brine, which was used for curing foodstuffs as the U.S. population moved westward. The well was drilled in 1806-1808 on the right bank of the Kanawha River near Charleston, West Virginia. Drilled by the Ruffner Brothers, the well was started in 1806 and completed in 1808 – taking 18 months to drill. Having a total depth of 53 feet, the average penetration rate for the well was three feet per month! (Using today’s drilling technology the entire Ruffner Brothers well could be drilled in seconds!)

## Chinese Bamboo Pipeline



**Gravity Driven Bamboo Pipeline (Late 1800's)**



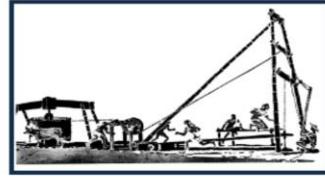
The concept of bamboo pipelines to carry brine and natural gas was an intriguing technology that was developed by the Chinese in the late 1800's. The pipelines were placed over producing wells, with the wellhead pressure utilized to pump the brine and gas through the line to the point of consumption. Reportedly, some of these pipelines were 70+ kilometers long!

By the 1700's wells near Sichuan, China were approximately 1,000 feet deep, and by 1835 a Shanghai well was (reportedly) the first in the world to reach a total depth of 3,000 feet. This is astounding in that the first oil well drilled in the United States was drilled in 1859 and was only 69.5 feet deep!

## 2,000 Years of Oilfield Technology Evolution



**Oil Seeps**



**3<sup>rd</sup> Century AD**



**Flexible Downhole  
Bamboo Cable**



**Late 1800's Rig**



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As shown in the chart, we have come a long way from using oil seeps that flow to the ground as a source for petroleum. One of the first drilling technologies according to early records was the Chinese bamboo drilling rig introduced around 300 AD which was described earlier.

A significant advancement in drilling technology was the development of cable tools. Shown in the lower left picture above, this technology allowed the Chinese to develop a number of tools for drilling, cleaning out the wellbore, solving hole collapse issues, etc.

By the late 1800's rigs in the United States were typically powered by steam engines, and had an array of drill bits and other downhole tools. They were capable of drilling faster and deeper which was needed as many shallow fields throughout the country had already been exploited.

## End of One Era/Beginning of Another



**Hawaii: 1850's**



**Snake Oil Salesman**



**Early Refinery**

There are crossroads in any industry, and the petroleum sector was no different in the early years. In the 1850's the whaling industry was in full swing, with a particularly strong market in Hawaii due to the concentration of whales there. But the beginning of the end for the whaling industry started in 1859 with the drilling of the Edwin Drake well in Pennsylvania (which will be described later in this presentation).

One of the early obstacles for the petroleum industry was creating enough viable applications so that the increasing oil production would be matched with increasing demand. In the early days oil was used as a lubricant, and some enterprising individuals determined that by boiling the oil the "distillate" could be used for "medicinal purposes", although use as an alcoholic beverage was quite common. Obviously, many other applications for petroleum were developed over the decades to increase the demand for oil.

The bottom picture is of an early refinery in the United States. The main equipment was a fractional distillation tower for separating the various components of the oil by slowly raising the temperature and taking off the various

“fractions”. Additional applications which accelerated the development of the petroleum industry will be discussed next.

## Important Milestones in Petroleum



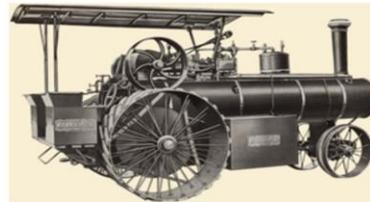
1853



Drake Well - 1859



1878



1880's



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The invention of a good kerosene lamp (developed by a Polish pharmacist in New York City) was a significant boost to petroleum demand in the late 1800's. Earlier lamps produced significant particulates which often blackened in the lampshade, rendering the lamps useless.

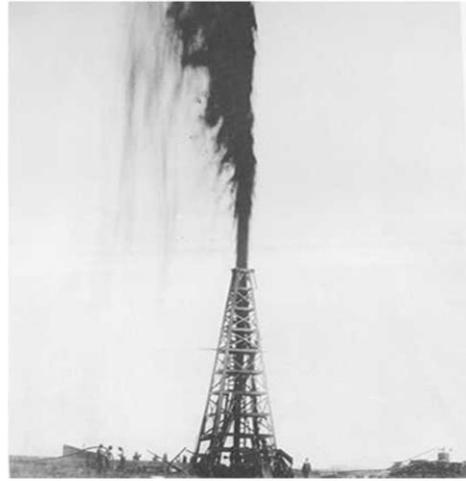
The first boom in the petroleum industry started in 1859 with the drilling of the Edwin Drake well. Hearing about the success of the Drake well a number of people in Pennsylvania decided to start their own exploration programs. Over the next few years as petroleum production grew there was a shortage of whiskey barrels to store the oil. The fundamentals of supply and demand played out and for a period of time the value of the whiskey barrels exceeded the value of the oil contained in them!!

The first downturn in the petroleum industry occurred in 1878 with the introduction of the electric light bulb by Thomas A. Edison. Cities went through a process of "electrification" whereby kerosene lamps on streets and in homes were replaced with electric lights. But this first downturn was short lived as the next big trend was the introduction of the automobile and steam engines.

## Modern Era of Petroleum Industry



1859 – Drake Well - PA



1901 – Spindletop TX



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Edwin Drake was a laid off railroad conductor who was hired by a small oil company to drill a well in Titusville, Pennsylvania -- where oil was known to seep to the surface. Shown in the left picture above is the first oil well drilled in the United States. (As stated previously, the first actual well drilled in the United States was in 1806 – for brine.) Many in the town of Titusville were skeptical of the drilling effort and called it “Drake’s Folly”. When the well reached a depth of 69.5 feet the crew went home for the day. The next morning when Drake returned he saw oil – 35 barrels in the bottom of the well! After that the well averaged 10 barrels per day, and is considered to be the start of the modern petroleum industry. Drake was a significant factor in the early days of the industry, and although he lost his fortunes several times over, the state of Pennsylvania provided him with special (retirement) compensation in recognition of the tremendous contribution he made.

The next important event was in 1901 when drilling around Beaumont, Texas paid off in a big way when the Lucas 1 well hit, and overnight tripled oil reserves in the United States. Called “Spindletop” the production from

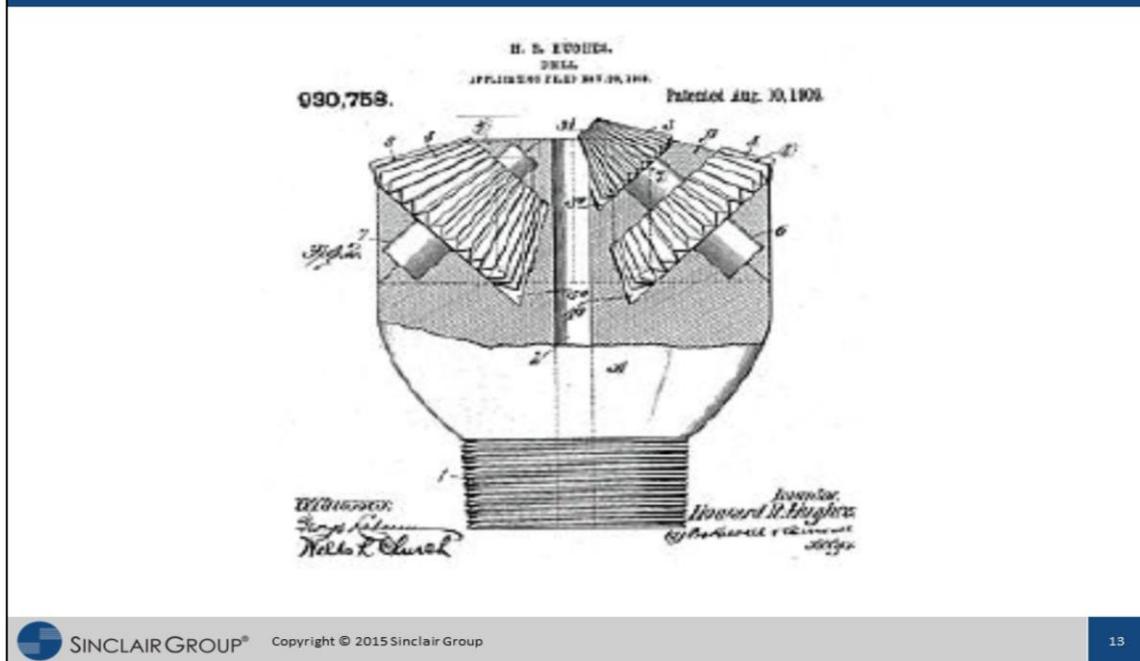
this area totaled millions of barrels over the last 100+ years.

**“NECESSITY IS THE  
MOTHER OF INVENTION.”**  
**– PLATO**

Nowhere is the above saying more true than in the petroleum industry. Through the last couple of centuries our industry has had to come up with an amazing array of drilling and production technologies that still must constantly evolve and become more robust in order to exploit deeper and more difficult reserves. Here is just one example:

**Drilling Motor** – A Russian engineer by the name of Alexander Grigoryan gets the credit for developing the positive displacement mud motor (i.e. drilling motor) in 1953. This technology was created out of necessity – the metallurgy of drill pipe at that time was quite inadequate, and resulted in “twist offs” where the pipe would break and fall to the bottom of the hole. This enterprising Russian engineer decided the way to solve the problem was to eliminate the need to rotate the drill pipe. He developed a downhole motor powered by the flow of the drilling fluid, which turned a “rotor” which in turn rotated the drill bit. The only portion of the drill string that rotates is the motor section and below. Today, this technology is frequently used around the world as a preferred method of efficiently drilling wells.

## Howard Hughes Bit – 1908

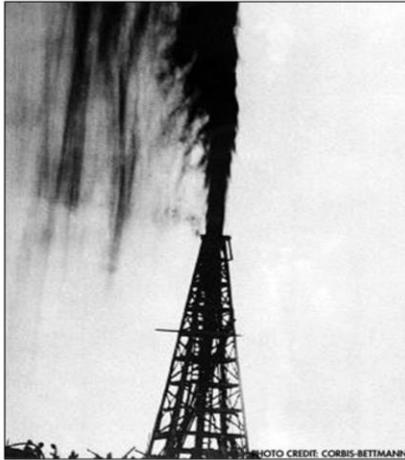


During the late 1800's drill bit technology was only adequate for drilling shallow wells with soft formations. However, even some bit designs that were good at "making hole" quickly often lacked durability, thus requiring numerous "trips" in the same well to change out the dull bits. This practice greatly slows down the drilling process and increases the time and expense to complete the well.

As the need to find oil in deeper and harder formations increased, the necessity for a more robust bit design was required by the industry. In 1908 a novel design received a patent from the United States government. Employing two rotating cones, this "rotary bit" became the dominant design until the late 1900's. "Fixed cutter bits" were introduced around that time and are now the dominant design.

Howard Hughes was significantly involved in the development of rotary bits, and bought the patent above from a bit designer in Shreveport, Louisiana in 1908.

## Invention of Blow Out Preventor (BOP) – 1922



1910



1922

Many people know what a blowout preventor (BOP) is. But this technology did not exist until the early 1920's. Prior to that time when pressurized formations were penetrated during drilling an ecological disaster often ensued which resulted in a significant amount of oil spilled around the drill site. Called "gushers", these blowouts would sometimes last months until the bottomhole pressure subsided. One of the most famous ones was in the San Joaquin Valley in California. Called the "Lakeview 1" well, when the bit reached 2,225 feet the ground started to rumble and oil streamed out of the well at a rate of 125,000 barrels the first day. Production gradually dropped off to a healthy 18,000 barrels per day and produced for 544 days. The total production was 9.4 million barrels! The oil was literally scooped up in buckets, and only half of it was recovered.

James Abercrombie was a driller in Texas and grew tired of running for his life every time they struck oil. He teamed up with Harry Cameron (e.g. the founder of Cameron) who had a machine shop in Humble (near Houston) to create the first BOP in 1922. This was an extremely important technology that is still vital today. Versus the small BOP Abercrombie and Cameron

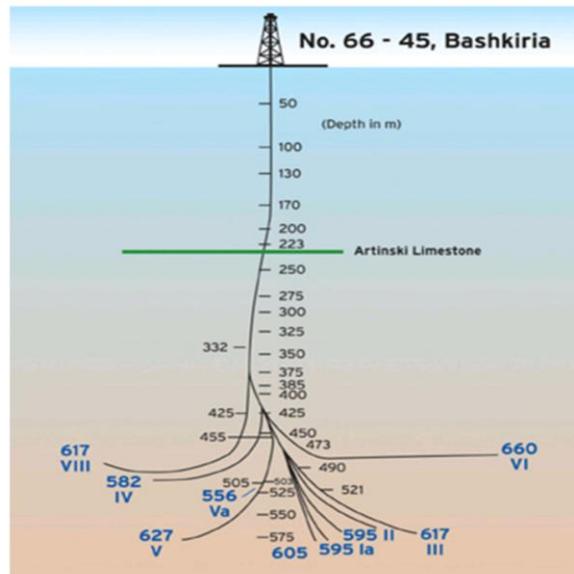
designed, current offshore BOP's can weigh upwards of 300 tons.

## National Petroleum, Coffeerville, Kansas - 1911



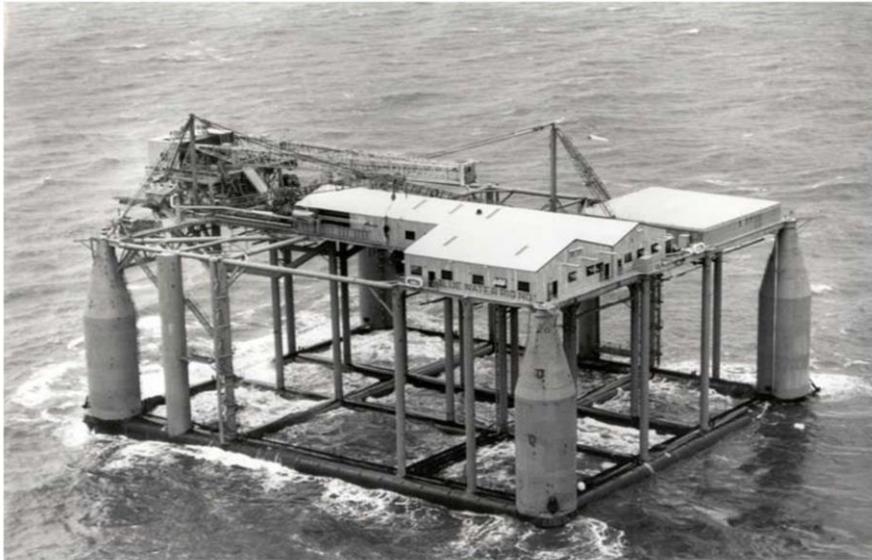
This is an early refinery in Coffeerville, Kansas in 1911. The three tanks in the back left of the picture were used for fractional distillation. And yes, in the early days they used whisky barrels for transporting the crude and other products. Each barrels was, and still is 42 gallons.

## Alexander Grigoryan – 1<sup>st</sup> Mud Motor & Multilateral – 1953



Many people think that directional and horizontal drilling is a relatively new technology. Actually this capability was first invented in the mid-1950's by the same Russian engineer who developed the mud motor, as shown in the chart above. This technology is the forerunner of horizontal and extended reach drilling technologies used around the world today.

## First Semi-submersible in Gulf of Mexico - 1961



**Blue Water Rig No. 1**



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This picture is of the first semi-submersible drilling rig in the Gulf of Mexico developed by Shell Oil in 1961. Before this design most rigs were varieties of bottom-supported platforms on the ocean floor. However, as the industry moved into deep waters it was necessary to develop new rig designs. The Blue Water Rig No.1 was redesigned from a submersible rig used in the Gulf of Mexico in the late 1950's.

The technology was quite secretive at the time. In the mid-1960's Shell made this technology available to other oil companies in a workshop that cost \$100,000 per participant. The Blue Water Rig No. 1 was lost in 1964.

## How Major Service Companies Started

**Schlumberger**



**Weatherford®**

  
**BAKER  
HUGHES**

**HALLIBURTON**



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Many honored companies have made important contributions to the petroleum industry – and a number of these same companies are still a part of the industry today:

**Schlumberger** – In 1911 Conrad and Marcel Schlumberger determined that various fluids had different properties with regard to electrical resistivity. They invented the “electric log” which is still an important method of formation evaluation in the industry today.

**Cameron** – Harry Cameron introduced the BOP to the industry in 1922.

**Baker Hughes** -- In 1907 Ruben Baker introduced the Casing Shoe which revolutionized the cable tool drilling business.

**Halliburton** – Erle Halliburton created the Cement Jet Mixer in 1921 – a significant technology advance.



This is a picture of the entire Weatherford organization in the early 1940's. They were celebrating a \$1 million order received from the Gulf Oil Corporation. There are about 35 people in the picture.

## California Pier Drilling



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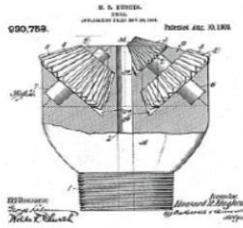
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Recognize Marina-Del Ray in sunny southern California? In the early years of California drilling the industry lacked the ability to drill directionally. The only alternative was to perform “pier drilling” whereby reserves in shallow bays and harbors were exploited by drilling on wooden piers and platforms.

As pier drilling grew it became increasingly less acceptable to maritime interests and the public in general. The state of California eventually outlawed pier drilling, and directional drilling became the accepted technique.

California is one of the birthplaces of directional drilling. Operators sometimes used “slant drilling” where they literally placed a rig on the beach and slanted it so the wellbore would be drilling out under the water. Years later Arthur Lubinski (a mathematician) and John Eastman developed more sophisticated methods for directional drilling.

## Drill Bits – 1908 and Present



**Hughes Bit**



These are examples of three modern “fixed cutter bits” used in drilling today, along with the patent illustration for the first rotary bit (upper left). Drill bits are extremely important in the drilling process. More than any other downhole technology the bit determines the rate at which the well can be drilled. Modern drill bits employ synthetic diamonds that are capable of handling hard and abrasive formations encountered in many wells around the world.

## Wireline – 1912



Conrad & Marcel  
Schlumberger



An early look at Conrad and Marcel Schlumberger (upper left), and pictures of some of their most important legacy – wireline logging. This is one of the most important technologies ever developed in the petroleum industry.

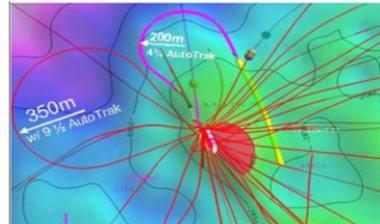
## Subsea Equipment – 1967



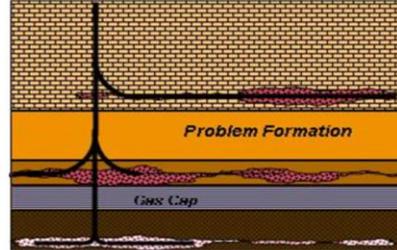
As the industry expanded into deeper waters it became necessary to place the drilling and production control equipment on the ocean floor. Various components of “subsea” equipment are pictured above, which are responsible for controlling high pressures, separating out the various fluids/gases and sand produced in a well, and pumping the hydrocarbons to shore for the refining operation.

The lower right picture is a remotely operated vehicle (ROV). ROV’s are an efficient way to install, maintain and repair equipment on the ocean floor. It is safer than using divers, who are limited by the depth at which they can operate. ROV’s are also used for monitoring pipelines and subsea equipment to determine their integrity.

## Logging While Drilling – 1978



The AutoTrak rotary closed-loop system delivers higher penetration rates, more precise well placement and high-quality holes in directional and horizontal applications.



Logging While Drilling is a very important technology for directional drilling and evaluating formations, and optimizing the placement of the wellbore within the producing interval. Introduced in 1978, this technology is one of the most important ones ever developed in the petroleum industry.

## Geophysical Surveys

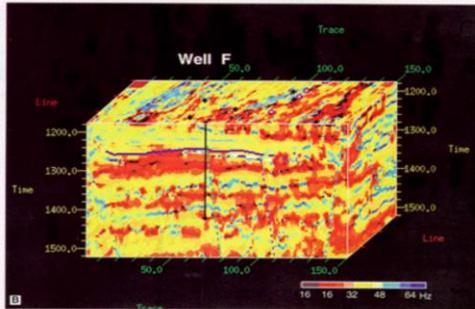


Figure 15. View of the seismic data cube volume display instantaneous frequency variation in the 3-D volume.



A seismic survey shows where oil and gas may be located, and can be “shot” in 3D or 4D (where one for example can view the changes in a producing interval over time).

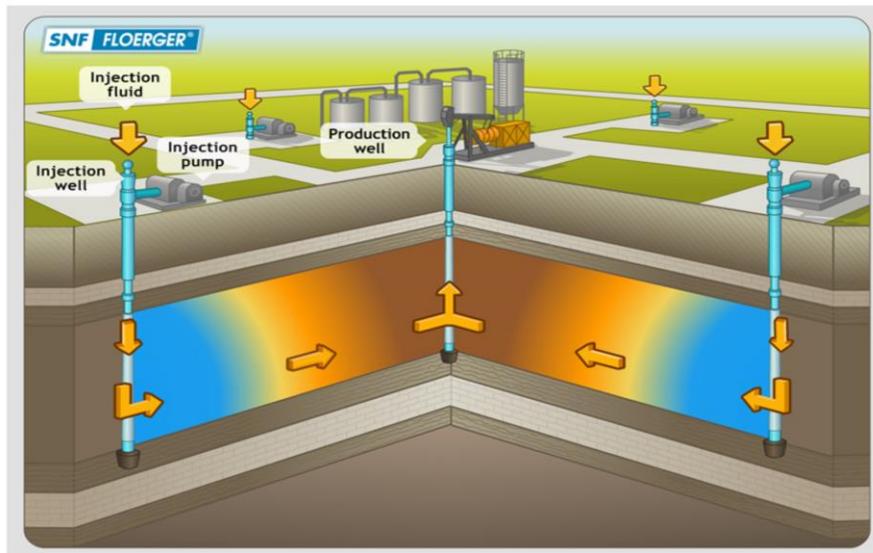
The picture on the right shows a specialized vessel used for collecting seismic information offshore. Seismic surveys are also one of the most important technologies developed in the petroleum sector.

## Drilling Rigs



An array of land and offshore rigs have been developed for specific drilling environments around the world.

## Enhanced Oil Recovery - Waterflood



The most prevalent method of enhanced oil recovery, waterflooding is where massive amounts of water are injected into the producing interval to increase the downhole pressure (or minimize the amount of pressure loss) and thereby enhance the amount of hydrocarbons produced over the years. One of the largest waterflooding programs is on Ghawar, the largest oilfield in the world, which produces 5 million barrels of oil per day.

## Hydraulic Fracturing History



**Father of Shale Plays**



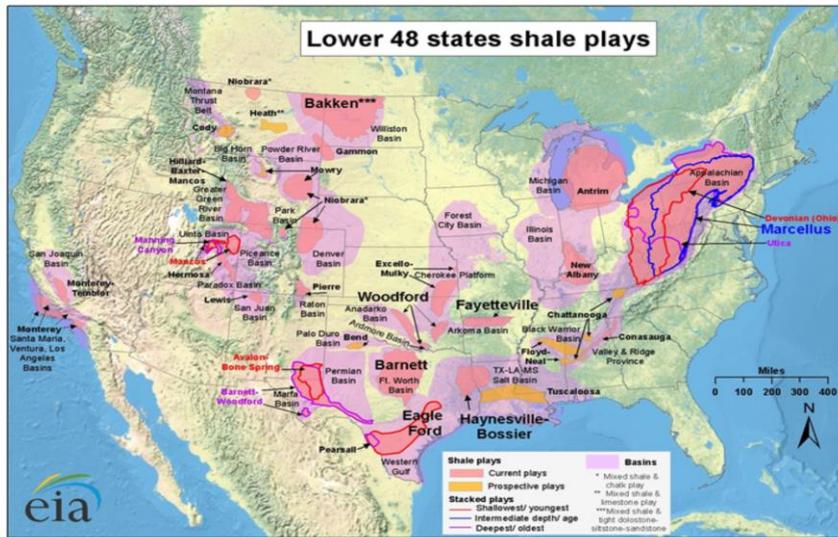
**1866: Roberts Petroleum  
Torpedo Company**

George Mitchell was the founder and CEO of Mitchell Energy, and is generally considered the “Father of Shale Plays”, by combining hydraulic fracturing and extended reach drilling techniques to produce unconventional oil and gas. There is certainly more to the history of enhanced oil recovery technologies. After the drilling of the Drake well in 1859 a range of technologies were developed for enhancing the amount of oil recovered.

Unlike “Colonel” Edwin Drake, there was a real Colonel in the Civil War during the 1860’s that is partially credited with inventing the concept of fracturing. During the battle of Vicksburg Colonel Edwin Roberts noticed a strange occurrence when Confederate shells would hit near the Union lines. Roberts noticed that when the shells exploded in a small pond, the water caused the force of the downward explosion to be somewhat diminished, which re-directed most of the energy to the sides of the pond where numerous holes were created from the shrapnel. This gave Roberts the idea to use a downhole explosive device to open up more of the formation and increase the oil production. After several trials the technology was proven effective and the Roberts Petroleum Torpedo Company was created based upon a U.S. patent awarded in 1866. This early enhanced oil recovery technique proved so effective that Roberts charged \$100 to \$200 per torpedo, AND 1/15 of the increased oil production. This price was high enough that some drillers ignored the patent and used their own explosives to open up their formations. In a effort to avoid

being caught violating Roberts' patent (which he aggressively defended) these illegal stimulation jobs were performed at night. Working these jobs at night was the genesis of the term "moonlighting" as Roberts hired the Pinkerton Agency to find those in violation of his patent.

# The Shale Play Revolution Has Changed the World



This slide shows the various oil and gas shale plays in North America. The Barnett in north central Texas was the first successful shale play of consequence, and is viewed as the birthplace of the Shale Play Revolution. It was in the Barnett that Mitchell Energy proved that hydraulic fracturing and extended reach drilling could result in productive “unconventional” wells, which changed the course of history in the petroleum industry.

## Hydraulic Fracturing Spread



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The above picture is fairly representative of a frac spread on a shale play well. This massive amount of equipment and materials (e.g. water, chemicals and proppant) is the first issue that neighbors sometimes complain about during these operations. In large frac jobs there can be in excess of 1,000 trucks required, which results in heavy traffic, noise, deteriorated roads, safety issues, emission and water resource issues, etc. The size of reservoir and specific formation characteristics of the well determine how much water, chemicals and proppants are needed. There are also issues with induced seismicity (industry-caused earthquakes) – but this is typically caused by disposal wells – not hydraulic fracturing.

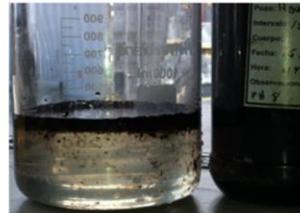
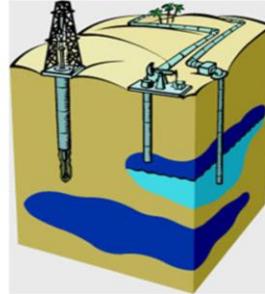
Even though hydraulic fracturing is controversial, it is important to weigh the benefits of increased domestic oil, and lower dependence of on foreign sources for meeting domestic petroleum requirements. After decades of being dependent on other countries for over half our oil production, in the coming years it is expected that foreign oil as a percent of total domestic consumption will decline to approximately 25 to 30%.



## Water Management Issues in Petroleum Industry



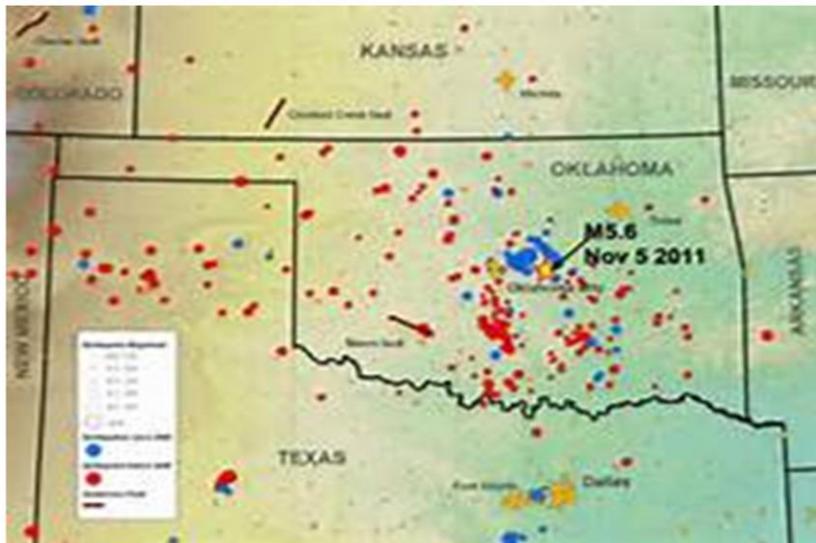
**Disposal Wells**



**Produced Water**

Pictures of disposal wells, required primarily to inject produced water (e.g. water co-produced with oil that must be separated and disposed of properly) from production wells. Frac water that flows back after the stimulation job is also injected into disposal wells, but is a small percent of the total injected fluids.

## Induced Seismicity -- Oklahoma Earthquake Situation

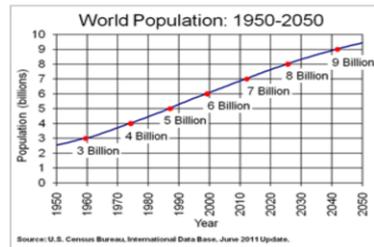


A recent map showing the significant earthquake activity in Oklahoma as a result of injecting produced water into disposal wells at high pressures. Prior to shale play drilling activity, and the need to inject significant produced water into disposal wells, there were few earthquakes in the state of Oklahoma.

## Petroleum Industry Challenges

- Minimizing uncertainty in an increasingly complex world
- Continuous incorporation of AI, robotics, analytics, etc. into oilfield
- Increasingly competitive: 1) alternative power sources, 2) new techs

**But – Your jobs are still very important to a world with an insatiable appetite for oil and gas.**



While the “Shale Play Revolution” was been of significant benefit to the United States, the global crude oil market has been impacted significantly by bringing on excess production at a time when it was not needed around the world. This situation has resulted in a significant decline in global oil prices starting in mid-2014. This price decline has also resulted in a considerable reduction in the infrastructure to drill and produce petroleum, with many rigs stacked, and thousands of workers laid off. High levels of uncertainty exist for our industry.

There is also growing resistance to our industry -- from communities and governments alike. Clearly, there are challenges ahead for the industry to prove it can exploit reserves in an environmentally responsible manner to the benefit of the billions on the planet.

However, there are emerging energy sources that will likely impact the oil and gas industry in the coming years. But here again, much uncertainty exists as to when these technologies will have an impact in the coming years.

**Questions?**

