الجمهورية الجزائرية الديمقراطية الشعبية
République Algérienne Démocratique et Populaire
وزارة التعليم العالي والبحث العلمي
Ministère de l'Enseignement Supérieur et de la Recherche Scientifique

Ecole Normale Supérieure d'Enseignement Technologique المدرسة العليا لأساتذة التعليم التكنولوجي بسكيكدة

Département des Sciences Naturelles قسم: العلوم الطبيعية

Mémoire de fin d'étude
مـذكـــرة التخرج

مـن إعــداد :

الطالبة :خلفة وردة

En vue de l'obtention du diplôme : Professeur d'Enseignement secondaire

لنيل شهادة : أستاذ التعليم الثانوي

Thème
الموضوع

An Overview of petroleum production and its economical importance

Sous la direction de :kahal Amina **تحت إشراف الأستاذ : *د.كحال امنة***

Promotion Juin 2024 ***دفعة جوان***

Dear Professor [Dr kahel amina and all the team of Enset skikda]

I would like to express my deep gratitude for everything you have provided us with during this University life. It has been a wonderful learning experience, thanks to your unmatched efforts and dedication.

Thank you very much for your valuable guidance and continuous support. We have greatly benefited from your knowledge and expertise in teaching, and we are grateful to you for your commitment to helping us grow academically and personally.

I wish you all the best and success in the future.

Student :khelfa ouarda.

Index:

Abstract:

Petroleum production, a cornerstone of modern industrialized societies, holds significant economic importance globally. This paper provides an overview of petroleum production processes and its profound impact on economies worldwide. Petroleum, comprising crude oil and natural gas, serves as a primary source of energy for transportation, heating, and electricity generation. Additionally, it is a crucial feedstock for the production of petrochemicals used in manufacturing various consumer and industrial goods.

The paper discusses the intricate processes involved in petroleum production, including exploration, drilling, extraction, refining, and distribution. It highlights the economic benefits derived from petroleum production . Moreover, it examines the geopolitical implications of petroleum production, as access to oil and gas resources often influences international relations and shapes global geopolitics.

And we take an overview of petroleum in Algeria.

- Petroleum production.

- crude oil and natural gas

- energy.

- petrochemicals

- economic.

ملخص :

يُعَدُّ إنتاج البترول، الذي يُعدُّ من أركان المجتمعات الصناعية الحديثة، ذا أهمية اقتصادية كبيرة على المستوى العالمي. يوفر هذا البحث نظرة عامة على عمليات إنتاج البترول وتأثيرها العميق على الاقتصادات في جميع أنحاء العالم. يتألف البترول من النفط الخام والغاز الطبيعي، ويعتبر مصدرًا رئيسيًا للطاقة في مجالات مثل النقل والتدفئة وتوليد الكهرباء. بالإضافة إلى ذلك، فهو مادة خام أساسية لإنتاج المواد البتروكيماوية المستخدمة في تصنيع السلع المستهلكة والصناعية المختلفة.

يناقش البحث العمليات المعقدة المتضمنة في إنتاج البترول، بما في ذلك الاستكشاف والحفر والاستخراج والتكرير والتوزيع. ويسلط الضوء على الفوائد الاقتصادية الناتجة عن إنتاج البترول، . وبالإضافة إلى ذلك، يفحص التأثيرات الجيوسياسية لإنتاج البترول، بالاضافة الى لمحة عن البترول في الجزائر

- إنتاج البترول
- . النفط الخام والغاز الطبيعي
- للطاقة
- البتروكيماوية

Introduction

Petroleum, often referred to as crude oil, is a complex mixture of hydrocarbons found beneath the Earth's surface. It has been a cornerstone of modern industrial society since the late 19th century, revolutionizing transportation, manufacturing, and energy production. This fossil fuel is not only integral to powering vehicles and machinery but also serves as a crucial raw material for the petrochemical industry, producing a vast array of products essential to daily life, from plastics to pharmaceuticals . Petroleum production, a cornerstone of the global energy sector, involves the extraction, refining, and distribution of crude oil—a vital resource that fuels economies worldwide. This process begins with exploration to locate reservoirs beneath the Earth's surface, followed by drilling wells to access these reserves. Once extracted, crude oil undergoes refining where it is processed into various products such as gasoline, diesel, jet fuel, and petrochemical feedstocks.

The economic significance of petroleum production is profound, driving industrial growth, transportation, and manufacturing sectors globally. Oil-producing countries often rely heavily on petroleum exports for revenue, shaping their economic policies and geopolitical strategies. The industry also fosters technological innovation in drilling techniques, refining processes, and environmental management practices.

The aim of this work is to give an overview of petroleum production and its economical importance.

1. Introduction:

Petroleum's importance to humankind took a giant leap in the late 1800's when it replaced coal as the primary fuel for the machines of the industrial revolution. In today's industrialized society, petroleum means power. It provides the mechanical power to run machines and industries and also the political power that comes from being able to shut down the machines and industries of those who depend on you for their oil supply. Today, petroleum remains our primary source of energy so what is it?what is its origin and properties? is it a new resource or old one ? and what is its history ? all of that we will know it in this chapter.

2. Basic Hydrocarbon Chemistry :

Petroleum is a general term for all naturally occurring hydrocarbons, whether gaseous, liquid, or solid. It is both simple and complex and is composed almost entirely of carbon and hydrogen. Impurities like nitrogen, sulfur, and oxygen play a somewhat important role in the formation of hydrocarbon molecules. The numerous varieties of petroleum are due to the way carbon and hydrogen can combine and form different sized molecules, thus creating different molecular weights. A thick black asphalt and yellow light crude are examples of two varieties of petroleum with different molecular weights. A hydrocarbon molecule is a chain of one or more carbon atoms with hydrogen atomschemically bonded to them . At room temperature and pressure, molecules with up to four carbon atoms occur as gases; molecules having five to fifteen carbon atoms are liquids; and the heavier molecules with more than fifteen carbon atoms occur as solids. Some petroleum contains hydrocarbon molecules with up to sixty or seventy carbon atoms. The molecular structure of hydrocarbons can vary from simple straight chains to more complex branched chains or closed-ring structures.[1]

[1] Halliburton, A.D. (2001)

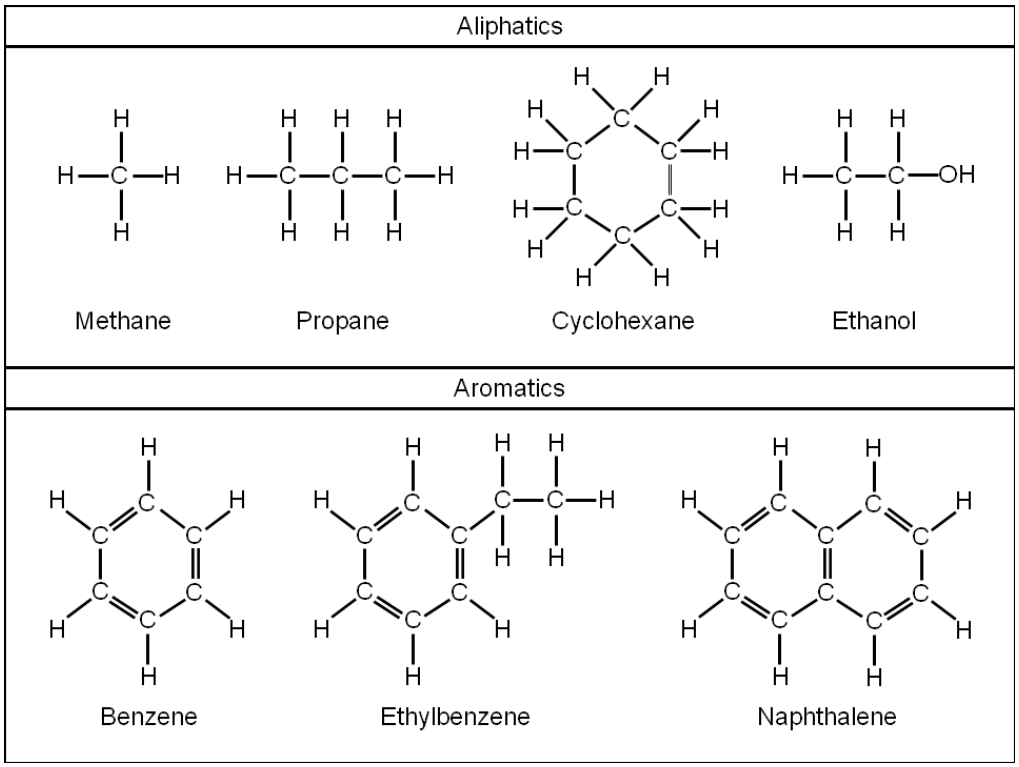


Image1: structures of common hydrocarbon compounds[2]

Defenetion of petroleum :

complex mixture of hydrocarbons that occur in Earth in liquid, gaseous, or solid form. A natural resource, petroleum is most often conceived of in its liquid form, commonly called crude oil, but, as a technical term, *petroleum* also refers to natural gas and the viscous or solid form known as bitumen, which is found in tar sands. The liquid and gaseous phases of petroleum constitute the most important of the primary fossil fuels.Liquid and gaseous hydrocarbons are so intimately associated in nature that it has become customary to shorten the expression "petroleum and natural gas" to "petroleum" when referring to both. The first use of the word *petroleum* (literally "rock oil" from the Latin *petra*, "rock" or "stone," and *oleum*, "oil") is often attributed to a treatise published in 1556 by the German mineralogist Georg Bauer, known as Georgius Agricola. However, there is evidence

[2] https://www.slideshare.net/slideshow/biochemistry2018/117449111

that it may have originated with Persian philosopher-scientist Avicenna some five centuries earlier. [3]

Image 2 crude: oil **Image 3:**Betumen

Image : Deferent types of petroleum .[4]

Crude oil History:

Petroleum is one of the most old substances that people where omplioed in there daily life for over than 4000years,in Babylon, they were using petroleum to construct walls and towers.They also use it to extract medicaments and to have lighting. Petroleum recovery, the earliest known wells were drilled in China in 347 BC to depths of 800 feet (240 m) and were drilled using bits attached to bamboo poles. The oil was burned to evaporate brine and produce salt. By the tenth century, extensive bamboo pipelines connected oil wells with salt springs. The first use of petroleum on the middle East was on the eight century when the streets of Baghdad was constructed, they used the nonvolatile residue derived from accessible petroleum and seepages (particularly Hit) in the region. The first distillation of petroleum was at Baku, Azerbaijan (image3)wherethey extruct naphtha which

[3]

[4] https://garystockbridge617.getarchive.net/amp/media/oil-refinery-baku-ad9beb

formed the basis of the incendiary Greek fire. The first mention of the American crude oil was in the Sir Walter Raleigh's documentation with the Trinidad Pitch Lake In 1861. The built of the first Russian refinery at the oil fields of Baku .The first commercial oil well drilled in North America was in Oil Springs, Ontario, Canada in 1858 by James Miller Williams.Between 1910to1950 so many big fileds were discovred and being developed at an industrial level. Even until the mid-1950s, coal was still the world's foremost fuel, but oil quickly took over, the energy crisis of 1973 and 1979 avow that petroleum is a limited resource .The value of petroleum as a transportable, high-energy source that can be used to power the vast majority of vehicles (gasoline and diesel) and as the base of many industrial chemicals makes it one of the world's most important commodities. The access of this petroleum fildes was available through world war 2 especialy in Middle East and the Persian Gulf . Approximately 80% of the world's readily accessible reserves are located in the Middle East with the majority coming from Saudi Arabia this is what the chiffres said but actually Canada and Vanzwilla have petroleum reserves more than what is located on the Middle East [5]

Image 4 : Baku refinery[6]

[5] JAMES G, 2016.

[6] https://garystockbridge617.getarchive.net/amp/media/oil-refinery-baku-ad9beb

3. The origin of crude oil :

5.1 Early ideas about petroleum formation:

The ancient Greeks were familiar with the existence of petroleum and some of their natural philosophers discussed its origin. Aristotle and other Greek philosophers proposed a theory based on the idea that everything was made up from four different elements; Earth, air, water and fire. Since petroleum seeped out of the ground and was very flammable, it was thought to be connected to fire and Earth. Consequently, Aristotle thought that ores, minerals and hydrocarbons were the result of exhalations from the deep of the Earth . His followers suggested that the foul smell that was typical for many forms of petroleum indicated that it was related to sulphur in some way. The main force behind medieval development was Arabic science. Arabian and Persian intellectuals made significant contributions to alchemy and chemistry. A polymath from Arabia named Abu Musa Jabir Ibn Hayyan al Azdi laid the groundwork for chemistry and cleared the path for several scientists and alchemists who came after It was Abu Bakr Muhammad Ibn Zakariya Razi who first produced kerosene by distilling petroleum. Several European intellectuals and alchemists were later influenced by these attempts when manuscripts and publications made their way to medieval Europe. Many alchemists employed alembics, retorts, and crude chemical analysis to decipher nature's mysteries and advance knowledge of the universe. However, the literature from this era contains very little information on petroleum and its origins. In his dissertation Opus Tertium, Roger Bacon (1258) even mentioned how Aristotle and other Greek natural scientists were unable to sufficiently explain the origin of Petroleum

4.2 The theories of petroleum formation:

There are two theories on the origin of carbon fuels: (1) the abiogenic theory and the biogenic theory.The two theories have been intensely debated since the 1860s, shortly after the discovery of widespread occurrence of petroleum. It is not the intent of this section to sway the reader in his or her views of the origin of

petroleum and natural gas. The intent is to place before the reader both points of view from which the reader can do further research and decide. Generally, heavy oil was originally conventional oil that migrated from deep source rocks or deep reservoirs to the near surface, where the oil was biologically degraded and weathered by water. Bacteria feeding on the migrated conventional oil removed hydrogen and produced the denser, more viscous heavy oil. Lighter hydrocarbons may also have evaporated from the shallow, uncapped formations. Therefore the origins of heavy oil are the same as the origins of conventional oil and a brief discussion of the means by which oil is formed is warranted here as a point of reference for heavy oil properties and behavior.

- **AbiogenicOrigin:**

There have been several attempts at formulating theories that describe the detail of the origin of petroleum, of which the early postulates started with inorganic substances as a source material. For example, in 1866, Berthelot considered acetylene the basic material and crude oil constituents were produced from the acetylene.There are also several more recent theories related to the formation of petroleum from nonbiogenic sources in the Earth and references cited therein). Thus, the idea of abiogenic petroleum origin proposes that largeamounts of carbon exist naturally, some in the form of hydrocarbons. Hydrocarbons are less dense than aqueous pore fluids, and migrate upward through deep fracture networks. Thermophilic, rock-dwelling microbial life-forms are in part responsible for the biomarkers found in petroleum. However, their role in the formation, alteration, or contamination of the various hydrocarbon deposits is not yet understood. Thermodynamic calculations and experimental studies confirm that *n*-alkanes (common petroleum components) do not spontaneously evolve from methane at pressures typically found in sedimentary basins, and so the theory of an abiogenic origin of hydrocarbons suggests deep generation (below 120 miles). From the chemical point of view the inorganic theories are interesting because of their historical importance, but these theories have not received

much attention. Geological and chemical methods have demonstrated the optical activity of petroleum constituents, the presence of thermally labile organic compounds, and the almost exclusive occurrence of oil in sedimentary rocks.

- **Biogenic theory:**

The biogenic theory of petroleum formation posits that petroleum (crude oil) is formed from the remains of ancient plants and animals that were buried under layers of sedimentary rock and subjected to heat and pressure over millions of years. Here's a breakdown of the key points of this theory:

1. Organic Matter Source: Petroleum originates from organic matter, primarily marine plankton and algae, as well as some terrestrial plants and animals. When these organisms die, their remains settle on the seabed or lake beds along with sediments.
2. Deposition: Over time, sedimentary layers accumulate over the organic matter, burying it deep underground. The organic material is protected from decomposition by oxygen due to the sedimentary layers.
3. Heat and Pressure: As more sediment accumulates over time, the organic matter is subjected to increasing temperatures and pressures from the overlying sedimentary layers.
4. Chemical Changes: Through a process called diagenesis and catagenesis, the organic matter undergoes chemical changes. Initially, it transforms into kerogen, which is a solid, waxy substance. With more heat and pressure over millions of years, kerogen further matures into liquid and gaseous hydrocarbons, which form crude oil and natural gas.

5.Migration: Once formed, crude oil can migrate through porous rock layers until it is trapped beneath impermeable rocks, forming reservoirs that can be tapped for extraction.

The biogenic theory is supported by geological evidence and is widely accepted as the primary mechanism for the formation of conventional oil and gas deposits found in sedimentary basins around the world. It contrasts with the abiogenic

theory, which suggests that petroleum can also form from inorganic processes deep within the Earth's mantle, although this theory is less widely accepted in mainstream geology.[7]

5.Composition of petroleum :

Crude oil or petroleum contains many compounds not just hydrocarbons .there also some other chemical compositions like impurities, small quantities of sulfur, nitrogen and metals.

Table1: elemental composition of crude oils[8]

Element	Composition (wt%)
Carbon	83.0 – 87.0
Hydrogen	10.0 – 14.0
Sulphur	0.05 – 6.0
Nitrogen	0.1 – 0.2
Oxygen	0.05 – 2.0
Ni	<120 ppm
V	< 1200 ppm

Sulfur from these heavier sulfur compounds can only be eliminated by hydrotreating the sulfur under extreme pressure and temperature settings, over an appropriate catalyst, to produce H2S. The sulfur compounds that are lighter are often extracted using caustic soda or other appropriate proprietary solvents to often extracted using caustic soda or other appropriate proprietary solvents to eliminate as mercaptans.

[7] **Mikael H ,2010**

[8] https://www.britannica.com/science/crude-oil

-Organic chloride compounds are also present in crude oil. These are not removed assuch but metallic protection is applied against corrosion by HCl in the primary distillation processes. This protection is in the form of monel lining in the sections of the process most vulnerable to chloride attack. Injection of ammonia is alsoapplied to neutralize theHCl in these sections of the equipment. The most common metal impurities found in crude oils are nickel, vanadium, and sodium. These are not removed as metals from the crude and normally they are only a nuisance if they affect further processing of the oil or if they are a deterrent to the saleability of the fuel product.The metals can be removed with the glutinous portion of the fuel oil product called asphaltenes. The most common process used to accomplish this is the extraction of the asphaltenes from the residue oils using propan as solvent.

In fact, there are three main classes of hydrocarbons. These are based on the type of carbon–carbon bonds present. These classes are:

1. Saturated hydrocarbons contain only carbon–carbon single bonds. They are known as paraffins (or alkanes) if they are acyclic, or naphthenes (or cycloalkanes)if they are cyclic

2. Unsaturated hydrocarbons contain carbon–carbon multiple bonds (double, triple or both). These are unsaturated because they contain fewer hydrogens per carbon than paraffins. Unsaturated hydrocarbons are known as olefins. Those that contain a carbon–carbon double bond are called alkenes, while those with carbon–carbon triple bond are alkyenes.

3. Aromatic hydrocarbons are special class of cyclic compounds related in structure to benze

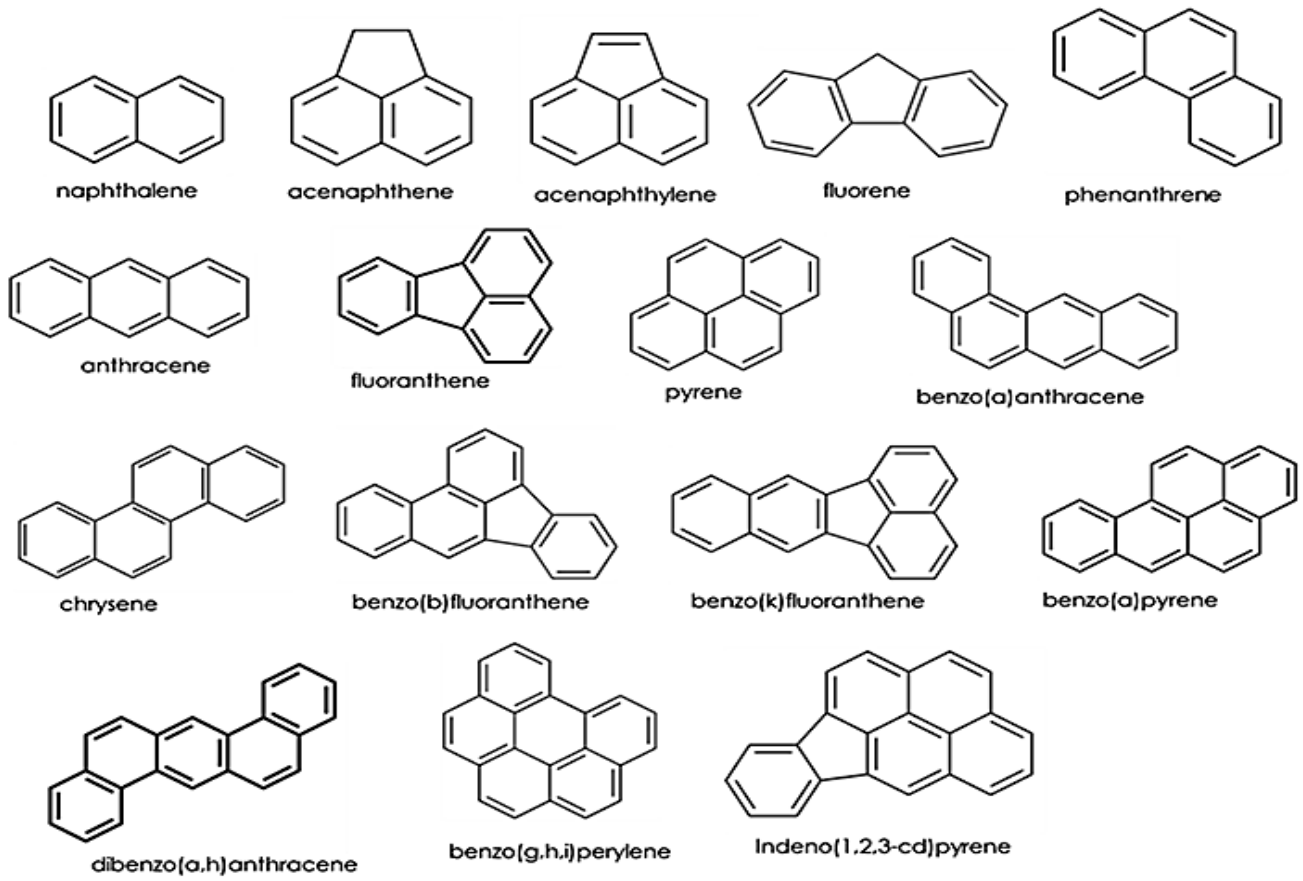


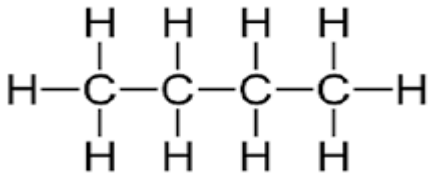
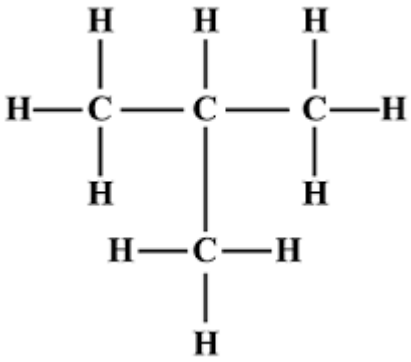
Image5 : Some examples of saturated and unsaturated hydrocarbons.

The process of refining changes the structure and compounds of hydrocarbons molecules so the most important is to know the its groups .We can find principal groups in crude oil:

a. **The paraffins**:

series of hydrocarbon compounds found in crude oil have the general formula CnH_2n+2 and can be either straight chains (normal) of carbon atoms in lighter fractions of crude oil (gasses and paraffin waxes) or branched chains (isomers) in heavier fractions.

Table2 : branched and straight paraffins[9]

	-straight chain paraffin molecule (Butane).
	-branched paraffin molecule (Isobutane).

b. The Aromatics:

Aromatics are unsaturated ring-type (cyclic) molecules with low hydrogen content in their carbon atoms, which makes them reactive. Every aromatic molecule has minimum of one benzene ring in its structure. The most prevalent type of chemicals are one-ring compounds, sometimes known as BTEX (benzene, toluene, ethylene, and xylene). Fused double-ring aromatic compounds are called naphthalenes. Heavier percentages of crude oil include the most complex aromatic compounds, known as polycyclic aromatic hydrocarbons (PAHs) or polynuclears (three or more fused aromatic rings).

[9] https://wou.edu/chemistry/courses/online-chemistry-textbooks/ch105-consumer-chemistry/ch105-chapter-7/

c. **Naphthenes**:

are saturated hydrocarbon groupings with the general formula C_nH_{2n}, arranged in the form of closed rings (cyclic) and found in all fractions crude oil except the very lightest. Single-ring naphthenes (monocycloparaffins)of with five and six carbon atoms predominate, with two-ring naphthenes(dicycloparaffins) found in the heavier ends of naphtha . .

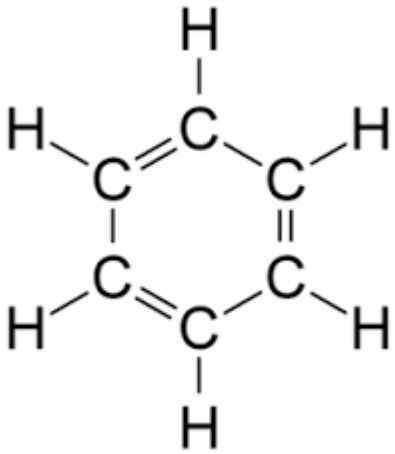


Image 5:example of aromatics; Benzene[10]

6-Types of Composition:

There are several methods to express a petroleum mixture's composition depending on its type. Below are some of the most significant categories of composition:

-PONA(paraffins,olefins,naphthenes,aromatics)
-PNA(paraffins,naphthenes,andaromatics)

[10] https://regenesis.com/en/glossary/benzene/

-PIONA(paraffins,isoparaffins,olefins,naphthenes,andaromatics) [11]

SARA(saturates,aromatics,resins,asphalthenes)

- Elemental analysis (C, H, S, N, O)

7-Types of Crude Oils:

- Light crude oil: Lighter crudes contain higher proportions of small molecules, which the refinery can process into gasoline, jet fuel, and diesel (for which demand is growing).
- Heavy crude oil:Larger molecules are more prevalent in heavier crudes, which the refinery may either convert into heavy industrial fuels, asphalt, and other heavy products.

Image 6: Defferente tyes of crude oil [12]

[11] https://www.researchgate.net/publication/340352059_CRUDE_OIL_PROPERTIES_Kolmetz_Handbook_Of_Process_Equipment_Design

[12] https://kimray.com/training/types-crude-oil-heavy-vs-light-sweet-vs-sour-and-tan-count

8-Properties of crude oil:

There is a big data base include information on the physical properties ,behavior, and potential environmental impacts of different types of oils .This resources can be invaluable for one –scene commanders and emergency reponse response teams dealing with oil spill incidence .By utilizing the oil properties database on scene commanders can quickly access information about spilled oil .This allow them to make informed decisions about response strateigies , such as determining the most effective for containment , cleanup, and minimizing environmental damage This database is created by The Emergencies Science Division (ESD), also known as the Environmental Emergencies Technology Division(EETD) prior to 1990, of Environment Canada, (the Canadian counterpart of the U.S. Environmental Protection Agency) wich make an analyse for more than 400 type of crude oils from many places to know their properties for the previous perposes . The oil catalogue has been so popular that interagency committees have requested that data collection and updating of the catalogue be an ongoing operation, and between 1986 and 1996, six updates were produced. This work has been continuously co-funded by the U.S. Minerals Management Service since 1989. can also be accessed via the internet at WWW.ETCENTRE.ORG/SPILLS Crude oils from the same region are often given the same name even though oils from different wells can have markedly different properties. Oils that are transported areoften blends of different crude oils, and the relative proportions of component oils frequently change. Therefore, the physical and chemical properties will vary. Similarly, the properties of oil taken from an individual well can vary with the depth of the well and the year of production.

9-Physical properties of crude oil :

The physical properties of crude oils are the quantitatively measurable characteristics of crude oils. They vary according to the composition of the oil, the relative abundance of the groups of hydrocarbons, and essentially depend on reservoir temperatures and pressures.

➢ Flammability:

Flammable or explosive mixtures can occur when crude oil is mixed with air and there is a source of ignition. The flammable range refers to the concentrations of flammable vapors or gases in air where a flash or flame can occur upon ignition at or above a certain temperature called the flash point. The Lower Flammable Limit (LFL) is the minimum concentration below which flame propagation does not occur, while the Upper Flammable Limit (UFL) is the maximum concentration above which flame propagation does not occur. These terms are also sometimes referred to as the Lower Explosive Limit (LEL) and Upper Explosive Limit (UEL). Crude oils can be categorized as either combustible or flammable based on theirflash point. Liquids with a flash point at or above 100ºF (37.8ºC) are considered combustible, while those with a flash point below 100ºF (37.8ºC) are considered flammable. The volatile components of crude oils influence their combustibility or flammability. To ensure safety, manufacturers and shippers of hazardous materials, including crude oil, are required to provide Material Safety Data Sheets (MSDS) by organizations such as the Occupational Safety and Health Administration (OSHA) and the Pipeline and Hazardous Materials Safety Administration (PHMSA). These MSDSs must include information about the material's fire and explosive properties, along with other relevant information.

➢ Volatility :

Volatility in petroleum refers to its evaporation characteristics. The ASTM D323-08 Standard Test Method, also known as the Reid Method, is utilized to determine the vapor pressure of petroleum products and crude oils with an initial boiling point above 0°C (32°F) at a temperature of 37.8°C (100°F). The measurement of vapor pressure is crucial for crude oil producers and refiners as it

aids in determining general handling and initial refinery treatment. Vapor pressure also serves as an indirect indicator of the evaporation rate of volatile petroleum solvents. Higher vapor pressures typically indicate greater losses from evaporation. It is worth noting that the New York Mercantile Exchange (NYMEX) has set restrictions on the Reid Vapor Pressure (RVP) for crude oil futures contracts.

- Density:

Density: A substance's mass per unit volume. Temperature affects density, which typically decreases as temperature rises. Whether an oil will float on water depends on its specific gravity, or density, with respect to water. The majority of fresh fuels and crude oils float on water. Asphalt and specific However, in specific temperature ranges, leftover fuel oils may have densities higher than water and may sink in water. When components of an oil spill are lost as a result of weathering, the density of the oil will also rise with time.

- Sulfur/Hydrogen Sulfide:

The amount of free sulfur in crude oil is a sign of possible corrosiveness due to the production of sulfur compounds with an acidic content. Another significant air pollution is sulfur oxides, which are emitted into the atmosphere when refined petroleum products are burned. In the process of biological matter breaking down It happens with hydrocarbons in some geologic formations. Sulfur and hydrogen may react chemically to produce hydrogen sulfide gas (H_2S), which is very poisonous, volatile, and corrosive. Producing oil and gas from sources containing high levels of H_2S might provide unique challenges. Oil well valves and conventional steel casing are susceptible to sulfide-stress-corrosion cracking due to H_2S, necessitating the replacement of these parts with more expensive stainless steel ones. Similar worries about sulfide stress corrosion in tank vehicles are shared by PHMSA. When digging, H_2S detection.

- Specific (or A.P.I) Gravity:

This is the mass of a specific amount of crude oil. Two gravity scales are used to measure it, as mentioned below:

$$\text{degrees Baumé} = \begin{cases} 145\left(1 - \dfrac{1}{\text{s.g.}}\right) & \text{for density greater than water} \\ \dfrac{140}{\text{s.g.}} - 130 & \text{for density lesser than water} \end{cases}$$

$$\text{s.g.} = \begin{cases} \dfrac{145}{145 - \text{degrees Baumé}} & \text{for density greater than water} \\ \dfrac{140}{130 + \text{degrees Baumé}} & \text{for density lesser than water} \end{cases}$$

Image8:API gravity low

The European Baume gravity scale is not as extensively used as the A.P.I. (American Petroleum Institute) gravity scale. However, they basically gauge a material'sdensity. crude petroleum. The composition of the oil has an impact on the A.P.I. gravity of the crude. Higher concentrations of dissolved gases in crude oils make them less dense, lighter, and hence have higher A.P.I. gravities; on the other hand, lower concentrations of dissolved gases in denser crude oils result in lower A.P.I. gravity values.The A.P.l. gravities of crude oils usually increase withdepth. This is because a combination of source and reservoir maturation processes, Associated with slow but continuously increasing geotemperatures,cause the generation of lighter(or High A.P.I gravity) oils at greater depths of burial.

- Viscosity:

This is the measure of resistance to flow in crude oils due to internal friction. It is expressed in 'poise' or ‘centipoise’.Crude oil is said to have a viscosity of 1 poise when a tangential force of 1 dyne causes a plane surface of 1 square centimetre area; spaced 1 cm from a stationary plane surface to move with a constant velocity of 1 cm per second, the space being filled with the viscous c. The viscosity of a crude oil is influenced by the amount of dissolved gases at the prevailing temperature. Crudes characterized by high amount of dissolved gases have high A.P.I gravities and low viscosity or moderately high fluidity; illustrated in figure 2. At high temperatures molecular agitation (or velocity) of the crude increases, making for a volumetric expansion and reduction in internal molecular friction, thus, reducing the oil. The greater the quantity of a high-molecular weight hydrocarbon group in a crude, the denser and more viscous.

- Volume:

The volume of a unrefined oil in its supplyshakecontrasts from the volume it possesseswithin the surface. Usually due to arrangement gas-oil proportion and supplyweights. The arrangement gas-oil proportioncommunicates Cthe volume of gas contained in one barrel of a unrefined oil because it comes from the storeshake. Beneathtallsupplyweight, the volume of oil within thesupplyincrementssince of the impact of broken upgasses. But on discharge of the storeweights the broken downgasseselude, driving to the shrinkage of the volume of the rough oil at the surface.

- Colour:

This is the light transmitted through crude oils. It is yellowish to red for light oils and dark or even opaque for heavy (or low A.P.I gravity) oils.

- Odour:

This is very different for crude oil. When crude oil contains large amounts of light hydrocarbons (paraffins and naphthenes), it produces a gasoline-like odor. When crude oil contains a large amount of aromatic hydrocarbons, it produces a pleasant aroma. However, oil contains large amounts of unsaturated hydrocarbon compounds, sulfur compounds, and nitrogen compounds, which create an unpleasant odour.

- Flourescence:

It might be blue, green, or yellow. For instance, gasoline-rich paraffin base crude oil exhibits a yellow color when exposed to ultraviolet fluorescence light, but the color of naphthenic oils is brownish. This characteristic is crucial for locating various oil horizons in well-logging interpretation as well as evaluating cutting, core, and drilling mud samples.

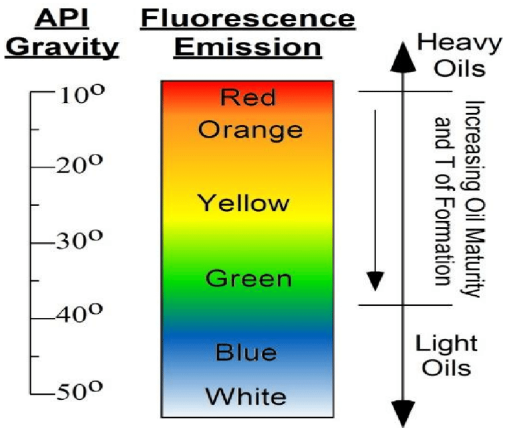


Image8:Relationshipe between flourecence and API gravity[13]

- Optical Activity:

Crude oil's ability to rotate a polarized light's plane of polarization is known as optical activity. The universal unit of measurement is degrees per millimeter. If the plane is affected by any crude oil When polarization rotates to the right, it is referred to as a "dextroratory," while when it rotates to the left, it is termed a "levorotary." At 250–300°C, high heat degrade this characteristic.

Certain organisms that include cholesterine compounds (such as cholesterol C26 H45 OH) also display optical activity. Amosov (1951) asserts that a crude oil's optical rotation is mostly determined by the quantity of triterpane and steranepentacyclic compounds it contains. Furthermore, they are hydrocarbon compounds that are produced when organic cholesterine molecules are decarboxylated by microorganisms.

- Refractive Index:

The refractive index n, of a crude oil is measured from

$$n = \frac{\sin i}{\sin r}$$

[13] https://www.researchgate.net/figure/Relationship-between-API-gravity-fluorescence-colour-and-oil-maturity_fig2_318212748

where; i = incidence angle

r = angle of refraction

It depends on the density of the oil. Heavy crudes (of lowA.P.I) have high refractive indices. This is because a dense crude would create a dense medium for a passing ray of light, which is refracted towards the normal at a low angle (r). On the other hand, light oils have low refractive indices.

- Coefficient of Expansion:

This is the measure of volumetric increase of a crude under thermal influence. It increases with increase in A.P.I gravity. Oils containing high amount of (dissolved) gasesand possibly of high A.P.I gravities possess high values of coefficient of expansion. Heavy crude oils (low A.P.I gravity) have lower coefficients of expansion.

- Aqueous Solubility

The aqueous solubility of crude oil and its fractions increases linearly with temperature. The rate of solubility becomes significant at temperatures of about 100°C. Attemperatures above 180°C, crudes occur as molecular solutions in mixed phase with water. According to Cartmill and Dickey (1970), at such high temperatures, the nature of the phase enhances primary migration of oil by molecular solution mechanism. And salinity of about 1 50,000ppm of sodium chloride results in the seperation of liquid hydrocarbons from the aqueous phase.

- Surface tension Effect:

Crude oils possess some intermolecular forces of cohesion,expressed as force per unit peripheral outline. Because ofthis force, oil in dispersed state cannot move through waterwet sand, much less, fine-grained shales. The small forces created by natural hydrodynamic gradients do not overcomethose created by surface tension. Consequent the oil isdispersed in the form of globules.

- Flash Point:

This is the temperature at which the volatiles rising off the surface of heated oil will ignite with a flash, on passing a flame over the surface. This provides some clew about the gaseous content of the crude oil. [14]

[14] Spraggins - Review of Business Research - 2016

Introduction :

The process of extracting oil is extremely expensive and time-consuming. It requires a number of measurements, tests, sampling and finally boring wells to confirm the presence of the raw material. Of course, there are a number of difficulties, such as porosity of the rock or the viscosity of the substrate itself. In the past, only 10% of the raw material was mined from the discovered deposit, leaving the rest underground. Thanks to modern mining technologies, the degree of recovery of crude oil and natural gas has increased to over 60%.In various regions all over the world, oil is found in the geological structures that form oil reservoirs. According to the depth of the oil reservoir, they are classified as follows: shallow, 30–800 m; medium, 800–2000 m; deep, 2000–5000 m and over deep, more than 5000 m. This classification is constantly changing as advances in drilling equipment with opportunity to achieve greater depth. However, irrespective of the depth of the oil reservoir, the main principle of oil extraction stays the same and is based on the life cycle of the oil field . There are five stages of oil and gas fields' life cycle: exploration, appraisal, development, production and abandonment.

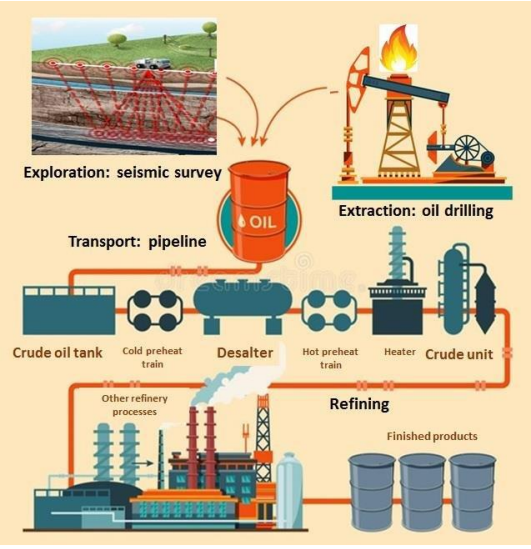


Image 7:petroleum production processes[15]

15 https://www.researchgate.net/figure/Figure-A3-Oil-production-process-Modified-from-wwwdreamstimecom_fig22_321993233

1. Exploration:

Oil and gas exploration encompasses the processes and methods involved in locating potential sites for oil and gas drilling and extraction. Early oil and gas explorers relied upon surface signs like natural oil seeps, but developments in science and technology have made oil and gas exploration more efficient. Geological surveys are conducted using various means from testing subsoil for onshore exploration to using seismic imaging for offshore exploration. Energy companies compete for access to mineral rights granted by governments by either entering a concession agreement, meaning any discovered oil and gas are the property of the producers, or a production-sharing agreement, where the government retains ownership and participation rights.[4] Exploration is high risk and expensive, involving primarily corporate funds.[5] The cost of an unsuccessful exploration, such as one that consisted of seismic studies and drilling a dry well, can cost $5 million to $20 million per exploration site, and in some cases, much more. However, when an exploration site is successful and oil and gas extraction is productive, exploration costs are recovered and are significantly less in comparison to other production costs.

1.1-Exploration and Mapping Techniques:

Exploration for oil and gas has long been considered an art as well as a science. It encompasses a number of older methods in addition to new techniques. The exploration is must combine scientific analysis and an imagination to successfully solve the problem of finding and recovering hydrocarbons.

1.1.1 Subsurface Mapping:

Geologic maps are a representation of the distribution of rocks and other geologic materials of different lithologies and ages over the Earth's surface or below it. The geologist measures and describes the rock sections and plots the different formations on a map, which shows their distribution. Just as a surface relief map shows the presence of mountains and valleys, subsurface mapping is a

valuable tool for locating underground features that may form traps or outline the boundaries of a possible reservoir. Once a reservoir has been discovered, it is also the job of the geologist to present enough evidence to support the development and production of that reservoir. Subsurface mapping is used to work out the geology of petroleum deposits. Three dimensional subsurface mapping is made possible by the use of well data and helps to decipher the underground geology of a large area where there are no outcrops at the surface. Some of the commonly prepared subsurface geological maps used for exploration and production include; (1) geophysical surveys, (2) structural maps and sections, (3) isopach maps, and (4) lithofacies maps.

1.1.2 Geophysical Surveys :

Geophysics is the study of the earth by quantitative physical methods. Geophysical techniques such as seismic surveys, gravity surveys, and magnetic surveys provide a way of measuring the physical properties of a subsurface formation. These measurements are translated into geologic data such as structure, stratigraphy, depth, and position. The practical value in geophysical surveys is in their ability to measure the physical properties of rocks that are related to potential traps in reservoir rocks as well as documenting regional structural trends and overall basin geometry.

1.1.3 Seismic Surveys:

The geophysical method that provides the most detailed picture of subsurface geology is the seismic survey. This involves the natural or artificial generation and propagation of seismic (elastic) waves down into Earth until they encounter a discontinuity (any interruption in sedimentation) and are reflected back to the surface. On-land, seismic“shooting” produces acoustic waves at or near the surface by energy sources such asdynamite, a “Thumper” (a weight dropped on ground surface), a “Dinoseis” (a gas gun), or a “Vibroseis” (which literally vibrates the earth’s surface). Electronic detectors called geophones then pick up the reflected acoustic waves. Thesignal from the detector is then amplified, filtered to remove

excess “noise”, digitized, and then transmitted to a nearby truck to be recorded on magnetic tape or disk In the early days of offshore exploration, explosive charges suspended from floats were used to generate the necessary sound waves. This method is now banned in many parts. of the world because of environmental considerations. One of the most common ways to generate acoustic waves today is an air gun. Air guns contain chambers of compressed gas. When the gas is released under water, it makes a loud “pop” and the seismic waves travel through the rock layers until they are reflected back to the surface where they are picked up by hydrophones, the marine version of geophones, which trail behind the boat. The data recorded on magnetic tape or disk can be displayed in a number of forms for interpretation and research purposes; including visual display forms (photographic and dry-paper), a display of the amplitude of arriving seismic waves versus their arrival time, and a common type of display called variable-density. The variable-density display is generated by a technique in which light intensity is varied to enhance the different wave amplitudes. For example, low amplitude waves are unshaded and higher amplitude waves are shaded black, thus strong reflections will show up as a black line on the display. Seismic waves travel at known but varying velocities depending upon the kinds of rocks through which they pass and their depth below Earth’s surface. The speed of sound waves through the earth’s crust varies directly with density and inversely with porosity. Through soil, the pulses travel as slowly as 1,000 feet per second, which is comparable to the speed of sound through air at sea level. On the other hand, some metamorphic rocks transmit seismic waves at 20,000 feet (approximately 6 km) per second, or slightly less than 4 miles per second. Some typical average velocities are: shale = 3.6 km/s; sandstone = 4.2 km/s; limestone = 5.0 km/s. If the subsurface lithology is relatively well known from drilling information, it is possible to calculate the amount of time it takes a wave to travel down through the earth to a discontinuity and back to the surface. This information is used to compute the depth of the discontinuity or unconformity. However, the only way of accurately determining depth is by correlating seismic sections to wireline logs. Reflections are generated at unconformities because unconformities

separate rocks having different structural attitudes or physical properties, particularly different lithologies. These principles form the basis for application of seismic methods to geologic study.

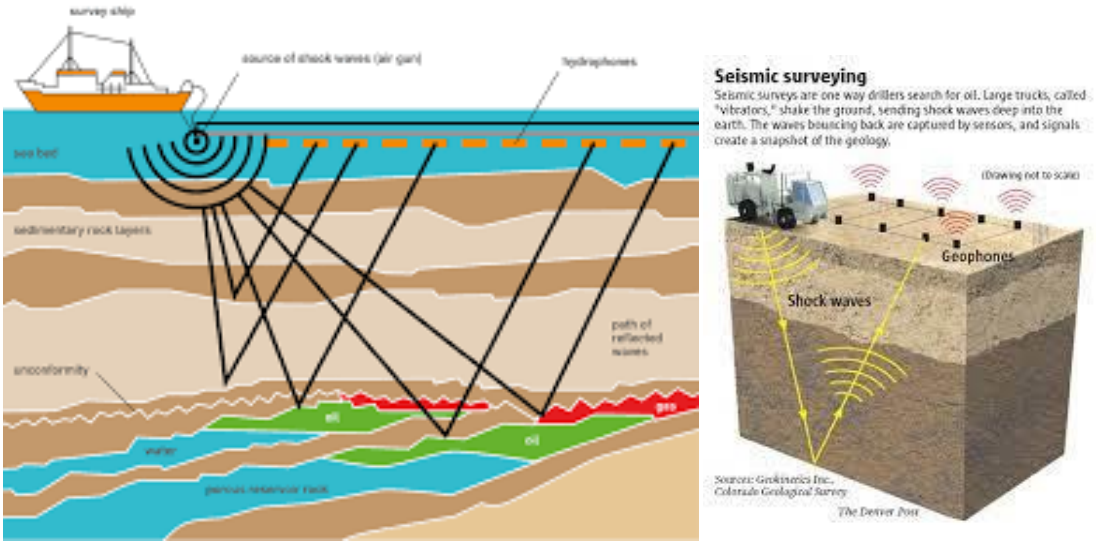


Image9: **Seismic Surveys**[16]

1.1.4 Magnetic Surveys:

Magnetic surveys are methods that provide the quickest and least expensive way to study gross subsurface geology over a broad area. A magnetometer is used to measure local variations in the strength of the earth's magnetic field and, indirectly, the thickness of sedimentary rock layers where oil and gas might be found. Igneous and metamorphic rocks usually contain some amount of magnetically susceptible iron-bearing minerals and are frequently found as basement rock that lies beneath sedimentary rock layers. Basement rock seldom contains hydrocarbons, but it sometimes intrudes into the overlying sedimentary rock, creating structures such as folds and arches or anticlines that could serve as hydrocarbon traps. Geophysicists can get a fairly good picture of the configuration of the geological formations by studying the anomalies, or irregularities, in the structures

[16] https://www.denverpost.com/2013/03/15/seismic-surveying-rattles-colorado-homeowners-2/

The earth's magnetic field, although more complex, can be thought of as a bar magnet, around which the lines of magnetic force form smooth, evenly spaced curves. If a small piece of iron or titanium is placed within the bar magnet's field it becomes weakly magnetized, creating an anomaly or distortion of the field. The degree to which igneous rocks concentrate this field is not only dependent upon the amount of iron or titanium present but also upon the depth of the rock. An igneous rock formation 1,000 feet below the surface will affect a magnetometer more strongly than a similar mass 10,000 feet down. Thus, a relatively low magnetic field strength would indicate an area with the thickest sequence of nonmagnetic sedimentary rock. Once the magnetic readings have been plotted on a map, points of equal field strength are connected by contour lines, thus creating a map that is the rough equivalent to a topographic map of the basement rock This can be useful in locating basic geologic structures, although it will not reveal details of the structures or stratigraphy.

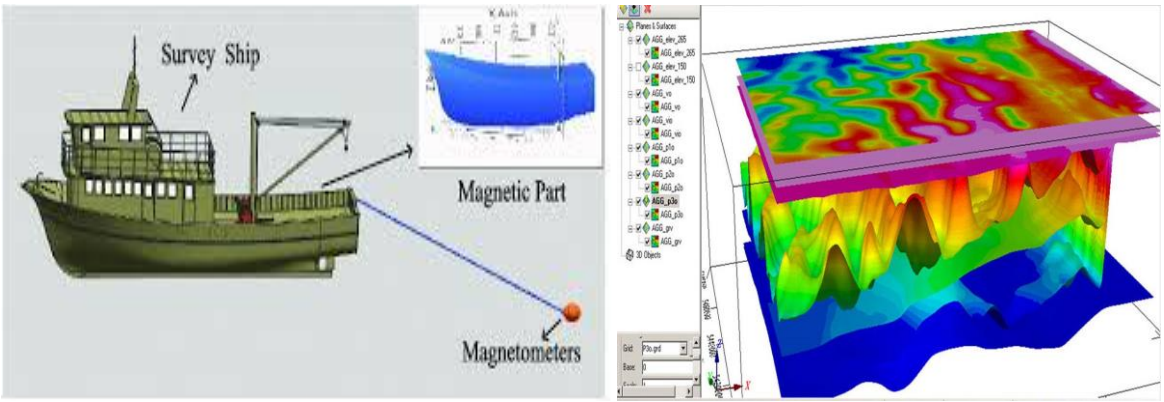


Image10: Magnetic Surveys[17]

1.1.5 Gravity Surveys:

The gravity survey method makes use of the earth's gravitational field to determine the presence of gravity anomalies (abnormally high or low gravity values) which can be related to the presence of dense igneous or metamorphic rock

[17] https://geoken.com/en/portfolio/en-magnetic-surveys/

or light sedimentary rock in the subsurface. Dense igneous or metamorphic basement rocks close to the surface will read much higher on a gravimeter because the gravitational force they exert is more powerful than the lighter sedimentary rocks. The difference in mass for equal volumes of rock is due to variations in specific gravity.

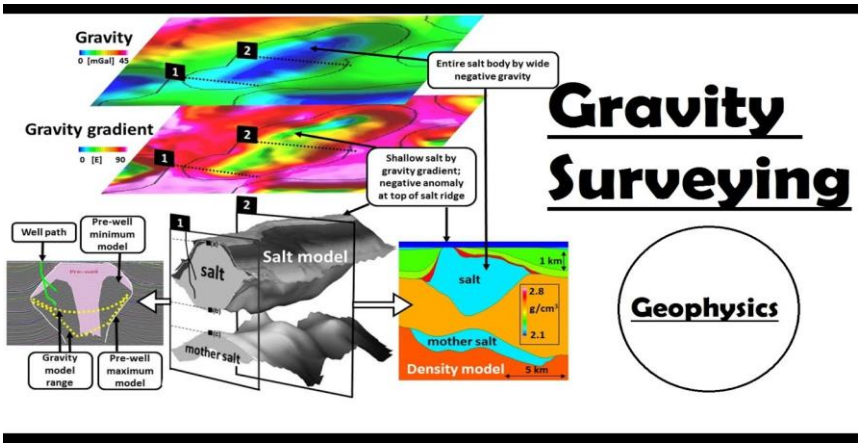


Image11: **Gravity Surveys**[18]

1.1.6 Structural Contour Maps:

Contour maps show a series of lines drawn at regular intervals. The points on each line represent equal values, such as depth or thickness. One type of contour map is the structural map, which depicts the depth of a specific formation from the surface. The principle is the same as that used in a topographic map, but instead shows the highs and lows of the buried layers. Contour maps for exploration may depict geologic structure as well as thickness of formations. They can show the angle of a fault and where it intersects with and other faults, as well as where formations taper off or stop abruptly. The subsurface formations structural contour map is almost or fully dependent on well data for basic control Although mechanically simple, a gravimeter can measure gravity anomalies as small as one

[18] https://youtu.be/lH-tqmFRylQ?si=YGYCjKfxM3dgxSE3

billionth of the earth's surface gravity. Data collected from gravity surveys can beused to construct contour maps showing large-scale structures and, like magnetic surveycontour maps, smaller details will not be revealed. Geophysicists applied this knowledge, particularly in the early days of prospecting off the Gulf of Mexico. Often, they could locate salt domes using data from a gravity survey because ordinary domal and anticlinal structures are associated with maximum gravity, whereas salt domes are usually associated with minimum gravity.

Cross-Sections:

Structural, stratigraphic, and topographic information can be portrayed on cross-sectionsthat reproduce horizontally represented map information in vertical section. Maps represent information in the plan view and provide a graphic view of distribution. Crosssections present the same information in the vertical view and illustrate vertical relationships such as depth, thickness, superpostion, and lateral and vertical changes of geologic features. Raw data for cross-sections come from stratigraphic sections, structural data, well sample logs, cores, wireline logs, and structural, stratigraphic, and topographic maps.

1.1.7Isopach Maps:

Isopach maps are similar in appearance to contour maps but show variations in the thickness of the bed. These maps may be either surface or subsurface depending on data used during construction. Isopach maps are frequently color coded to assist visualization. and are very useful in following pinchouts or the courses of ancient stream beds. Porosity or permeability variations may also be followed by such means. Geologists use isopach maps to aid in exploration work, to calculate how much petroleum remains in a formation, and to plan ways to recover it.

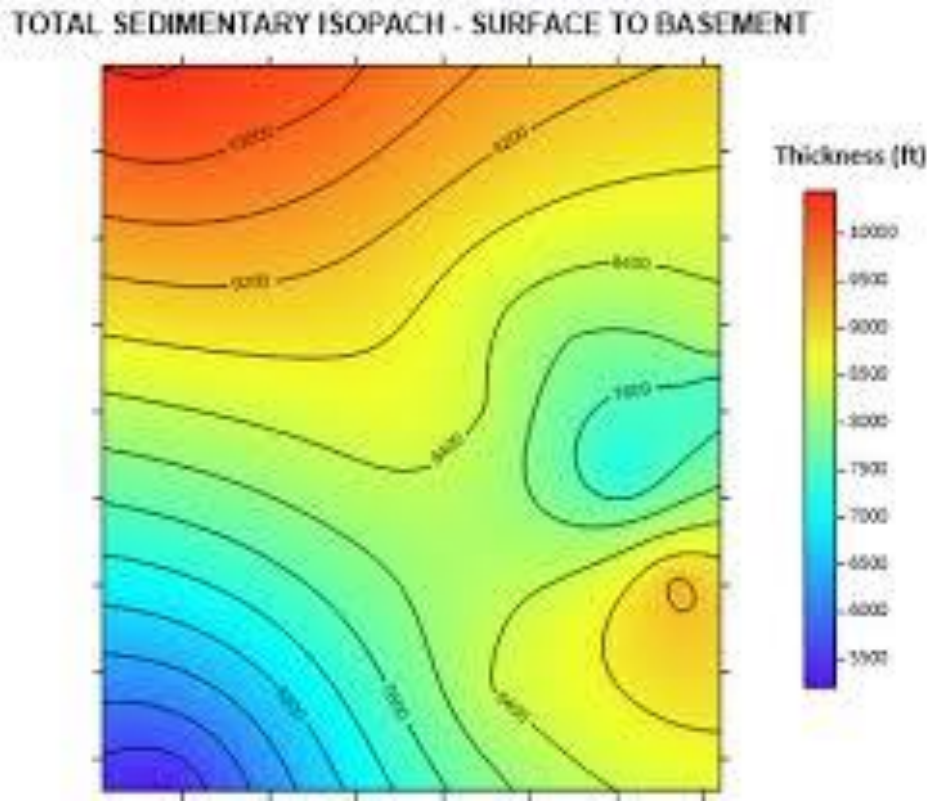


image12: Isopach Maps[19]

1.1.8Lithofacies Maps:

Lithofacies maps show, by one means or another, changes in lithologic character and how it varies horizontally within the formation. This type of map has contours representing the variations in the proportion of sandstone, shale, and other kinds of rocks in the formation. Identification of source and reservoir rocks, their distribution, and their thickness' are essential in an exploration program, therefore, exploration, particularly over large areas, requires correlation of geologic sections. Correlations produce cross-sections that give visual information about structure, stratigraphy, porosity, lithology and thickness important formations. This is one of the fundamental uses of well logs for geologists of Wells that have information collected by driller's logs, sample logs, and wireline logs enable the geologists to predict more precisely where similar rock formations will

[19] https://support.goldensoftware.com/hc/en-us/articles/360006142654-Create-an-Isopach-or-Isochore-map-in-Surfer

occurin other subsurface locations. Subsurface correlation is based primarily on stratigraphic continuity, or the premise that formations maintain the same thickness from one well to another. A major change in thickness, rock type, or faunal content can be a geologic indicator that conditions forming the strata changed, or it may be a signal of an event that could have caused hydrocarbons to accumulate.[20]

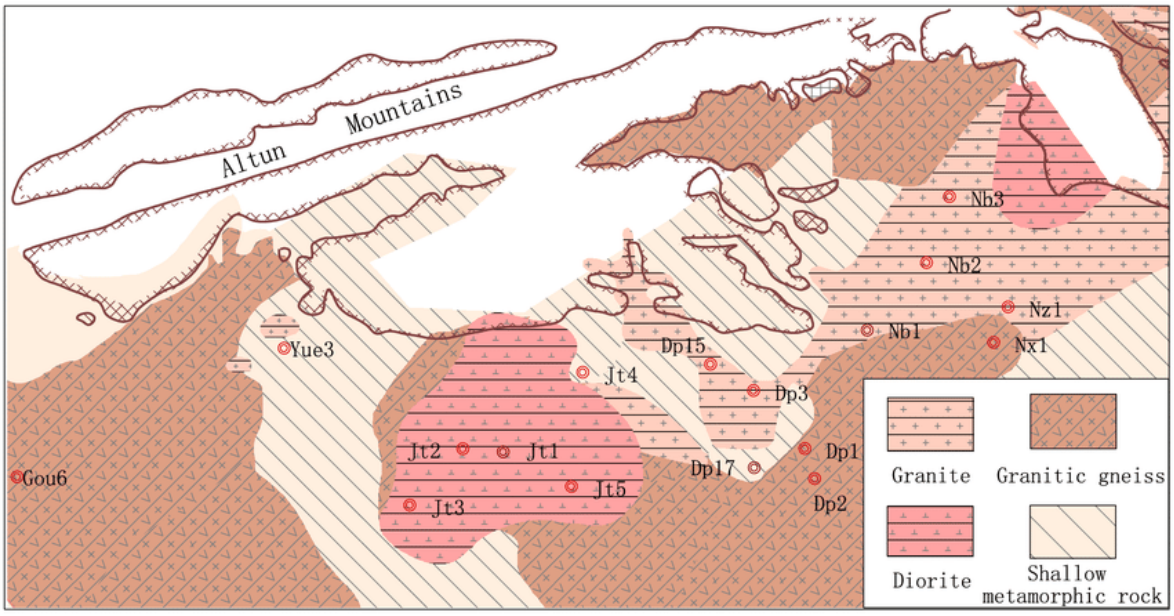


Image13: Lithofacies Maps[21]

2 .Production :

Oil and gas production is one of the most capital intensive industries: It requires expensive equipment and highly skilled labors. Once a company identifies where oil or gas is located, plans begin for drilling. Many oil and gas companies contract with specialized drilling firms and pay for the labor crew and rig dayrates. Drilling depths, rock hardness, weather conditions and distance of the site can all affect the drilling duration. Tracking data using smart technologies can help with drilling

[20] Halliburton, A.D. (2001) Basic Petroleum Geology and Log Analysis. Halliburton Company

[21] https://www.researchgate.net/figure/Lithofacies-distribution-in-the-front-of-the-Altun-Mountains-This-map-was-drafted-by_fig2_345341322

efficiency and well performance by providing real-time information and trends. While every drilling rig has the same essential components, the drilling methods vary depending on the type of oil or gas and the geology of the location.

2.1 Oil Recovery (Drilling):

After geologists of an oil company have located the general area in which petroleum is thought to occur, a well is drilled. Selecting the site for drilling requires detailed knowledge of the geologic features under the earth's surface. We can see from Figure 8-7 that of the three wells shown, all of which are reasonably close to the oil pool, only well B would actually produce oil. Drilling is also done to determine the extent of the reserves. Once the oil has been located, additional drilling might be done over an area around the first producing well to assess the geographic extent of the oil pool and its depth. This information allows geologists to estimate the amount of oil in the pool. When a drilling site has been selected, the first job is to rig up, or to assemble the drilling rig derrick. This is routinely taken as a sign of activity of the entire oil exploration industry, and is periodically reported among the economic indicators. [22]

2.1.1 Petroleum drilling platforms :

Onshore:*

Onshore production is economically viable from a few tens of barrels a day upwards. Oil and gas is produced from several million wells world-wide. In particular, a gas gathering network can become very large, with production from hundreds of wells, several hundred kilometers/miles apart, feeding through a gathering network into a processing plant The picture shows a well equipped with a. sucker rod pump (donkey pump) often associated with onshore oil production. However, as we shall see later, there are many other ways of extracting oil from a

[22] College of Earth and Mineral Sciences personal pages

https://personal.ems.psu.edu/~radovic/Chapter8.pdf

non-free flowing well For the smallest reservoirs, oil is simply collected in a holding tank and collected at regular intervals by tanker truck or railcar to be processed at a refinery. But onshore wells in oil rich areas are also high capacity wells with thousands of barrels per day, connected to a 1.000.000 barrel a day gas oil separation plant(GOSP). Product is sent from the plant by pipeline or tankers. The production may come from many different license owners. Metering and logging of individual wellstreams into the gathering network are important tasks... Recently, very heavy crude, tar sands and oil shales have become economicallyextractible with higher prices and new technology. Heavy crude may need heating and diluent to be extracted, tar sands have lost their volatile compounds and are strip mined or could be extracted with steam. It must be further processed to separate bitumen from the sand. These unconventional of reserves may contain more9 than double the hydrocarbons found in conventional reservoirs.

Image14:ex of Onshore[23]

[23] https://blog.fenstermaker.com/onshore-vs-offshore-oil-and-gas-drilling/

***Offshore:**

Offshore, depending on size and water depth, a whole range of different structures are used. In the last few years, we have seen pure sea bottom installations with multiphase piping to shore and no offshore topside structure at all. Replacing outlying wellhead towers, deviation drilling is used to reach different parts of the reservoir from a few wellhead cluster locations. Some of the common offshore structures are:

- **Gravity Base**: Enormous concrete fixed structures placed on the bottom, typically with oil storage cells in the "skirt" that rests on the sea bottom. The large deck receives all parts of the process and utilities in large modules. Typical for 80s and90s large fields in 100 to 500 water depth. The concrete was poured at an at shore location, with enough air in the storage cells to keep the structure floating until tow out and lowering onto the seabed. The picture shows the world's largest GBS platform, the Troll A during construction.

Image15:ex of offshore[24]

- **Compliant towers** are much like fixed platforms. They consist of a narrow tower,attached to a foundation on the seafloor and extending up to the platform. This tower is flexible, as opposed to the relatively rigid legs of a fixed platform. This flexibility allows it to operate in much deeper water, as it can 'absorb' much

[24] https://images.app.goo.gl/mn6LKPapFgjugoB79

of the pressure exerted on it by the wind and sea. Compliant towers are used between 500 and 1000 meters water depth.

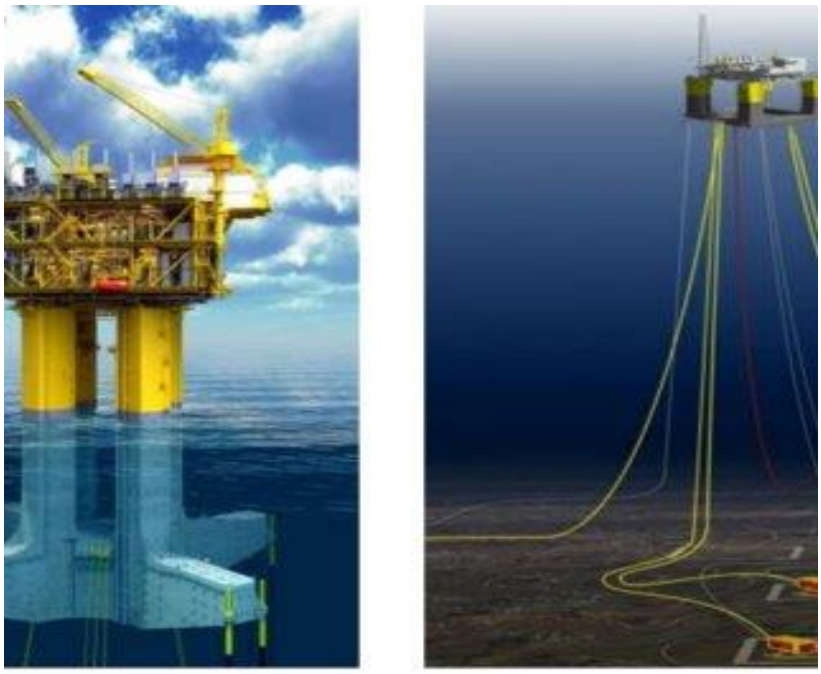


Image16: Compliant towers[25]

- **Floating production**: where all topside systems are located on a floating structure with dry or subsea wells. Some floaters are:

FPSO and FSO systems are the primary method for many offshore oil and gas producing regions around the world.

Most FPSOs/FSOs are ship-shaped and can be secured to the seabed via a variety of mooring systems, the choice of which is determined by the specific environment. They are suitable for a wide range of water depth, environmental conditions and can be designed with the capability of staying on location for continuous operations for 20 years or longer.

An FPSO is a floating production system that receives fluids (crude oil, water and a host of other things) from a subsea reservoir through risers, which then separate fluids into crude oil, natural gas, water and impurities within the topsides

[25] https://images.app.goo.gl/ttsx5zc7zNER4tq59

production facilities onboard. Crude oil stored in the storage tanks of the FPSO is offloaded onto shuttle tankers to go to market or for further refining onshore.[26]

Image17:floating production system [27]

***Types of drilling:**

1- Vertical drilling

Vertical drilling is considered the traditional drilling method for accessing reservoirs directly beneath the surface. Once the only method of extracting oil and gas, vertical drilling has become a less common method of drilling due to the advancement of horizontal and directional drilling technologies. Vertical wells are considered simple and offer some initial cost savings at startup by requiring less equipment and labour. In larger formation zones, multiple vertical wells are required to effectively produce oil & gas, which can negate some of the initial cost savings. Today, vertical wells are mostly used during the exploratory phase in evaluating the potential of new oil and gas zones.

2- Horizontal drilling

As the 20th century came to an end, technology was quickly evolving, paving the way for more precise drilling capabilities through the use of directional or steerable drilling equipment. Wells are considered horizontal when they approach a drilling angle 85-90˚ from vertical. Horizontal drilling, also called directional drilling, facilitates an increase of production volumes from a single wellbore by accessing a larger surface area of an oil and gas zone.[28]

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[26] Havard D,2006,oil and gas production handboock

[27] https://images.app.goo.gl/RZUbraUMDgbsdo1x8

[28] College of Earth and Mineral Sciences personal pages

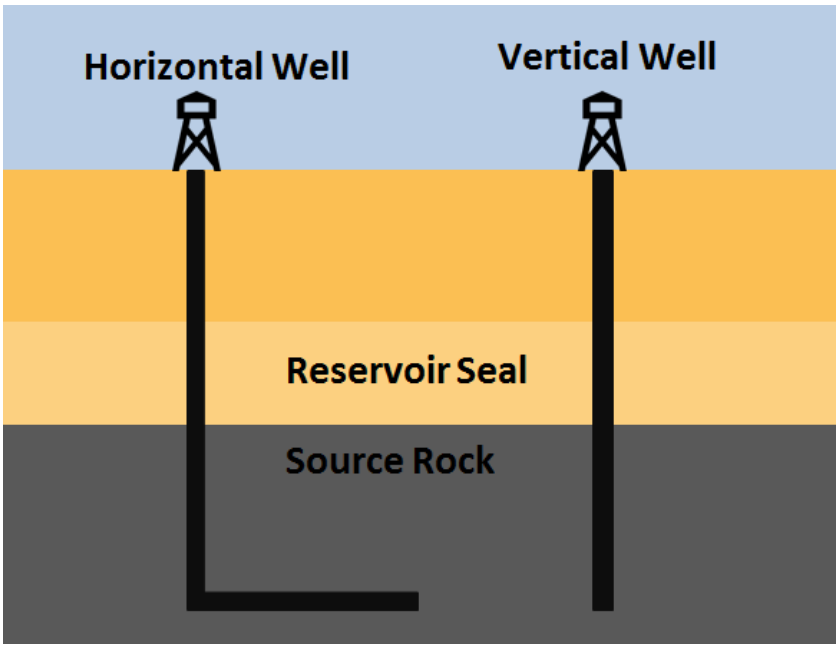

Image18:**vertical and** horizontal drilling [29]

Petroleum transportation :

Before the refining process can take place, first the crude oil must be transported to a refinery. It is generally the case that all crude oils, natural gas, liquefied natural gas, liquefied petroleum gas (LPG) and petroleum products flow through pipelines at some time in their migration from the well to a refinery or gas plant, then to a terminal and eventually to the consumer.

6 Modes of Transportation :

The U.S. Coast Guard defines a tank vessel as one that is constructed or adapted to carry oil or hazardous material in bulk as cargo or cargo residue. There are various types of tankers: oil tanker, parcel tanker (chemical vessels), combination carrier (designed to carry oil or solid cargoes in bulk), and barges. International bulk chemical codes govern the safe transport of chemical cargoes and provide various levels of protection against the uncontrolled release of substances. Tank vessels are classified by the trade in which they routinely operate over a period of time. The three most common categories are crude oil carriers, product carriers: which can carry clean (e.g., gasoline, jet fuel) and dirty (e.g. black oils): and parcel carriers (chemicals). Tankers tend to remain in one trade but market conditions can dictate a change, even though the process to change a vessel's trade involves extensive work.

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https://personal.ems.psu.edu/~radovic/Chapter8.pdf

[29] https://images.app.goo.gl/uMttwzUro4MZsgsd8

Crude carriers are classed as either VLCCs (Very Large Crude Carriers) or ULCCs (Ultra Large Crude Carriers) and are designed to transport vast quantities of crude oil over many long and heavily traveled sea routes. In addition, "lightering," offloading or transferring oil from large tankers to smaller ones, is used so that the smaller vessels can enter smaller ports that the larger vessels cannot.

One of the major concerns in the safe transport of bulk liquid cargos by tank vessel is the stress on the hull. Bending in the form of sagging (concentration of weight in the mid-section of the vessel causing the deck to be subjected to compression forces while at the same time the keel is under tension), hogging (concentration of weight at both ends of the vessel causing the deck to experience tensile forces while the keel is under compression), and shear force, which occurs when two forces act in opposite directions parallel to each other, such as at a bulkhead between an empty ballast tank and a full cargo tank. The weight or gravitational and buoyant action experienced on either side of the bulkhead causes the shear force phenomenon. Tankers that transport oil domestically from one U.S. port to another must comply with the Jones act, which requires a vessel to be U.S. built, with a majority U.S. crew and majority U.S. ownership. These requirements greatly reduce the number of vessels available for domestic oil transportation, although waivers have been granted for emergencies.

Image19 :Petroleum transportation[30]

*6.1.1.1 *LNG Tankers:*

High pressures and explosions make it difficult to transport compressed natural gas on tankers. Due to scientific advancements in the mid-20th century, natural gas can be turned to liquid at extremely low temperatures and transported as liquefied natural gas (LNG). LNG tankers are specially designed with double hulls, to allow extra ballast water because LNG is lighter than gasoline, and additional safety features. Due to the restrictions of the Jones Act, there are currently no approved vessels to transport LNG domestically by tanker.

[30] https://images.app.goo.gl/7kNXqmfSae4KRGUE6

*6.1.1.2 *Pipelines:*

Pipelines can refer to gathering systems (wellhead to processing facilities), transmission lines (supply areas to markets), or distribution pipelines (most commonly to transport natural gas to medium or small consumer units). Pipelines play a very critical role in the transportation process because most of the oil moves through pipelines for at least part of the route. After the crude oil is separated from natural gas, pipelines transport the oil to another carrier or directly to a refinery. Petroleum products then travel from the refinery to market by tanker, truck, railroad tank car, or pipeline. As natural gas production grows in the United States, demand for new pipeline construction has been increasing. The United States has about 300,000 miles of natural gas transmission pipelines.

Strategic planning involves determining the shortest and most economical routes where pipelines are built, the number of pumping stations and natural gas compression stations along the line, and terminal storage facilities so that oil from almost any field can be shipped to any refinery on demand. Offshore pipelines carry more risk for leaks and environmental impact than onshore pipelines, but technological advancements in pipeline material and monitoring systems have improved pipeline safety and efficiency. Standards exist for safety in the design and construction of pipelines, and are published by organizations such as the International Organization for Standardization (ISO) and the American Petroleum Institute (API). The Federal Energy Regulatory Commission (FERC) regulates the interstate transportation of natural gas and oil, and approves LNG terminals and natural gas pipelines. Before FERC was created in 1977, Interstate Commerce Commission was responsible for regulating oil and gas transportation.

*6.1.1.3 *Barges:*

Barges are primarily used on rivers and canals. They require less infrastructure than pipelines, but are more costly, transport much less volume, and take more time to load.

*6.1.1.4 *Railroad / Tank Trucks:*

Historically, railroads were the primary means of petroleum transportation. Today, railroads compete with pipelines: While usually more expensive than pipelines, the already existing railroad infrastructure creates a more flexible, alternative route when pipelines are at capacity. Many petroleum products travel from refineries to markets by tank truck or railroad tank car. Tank trucks deliver gasoline to service stations and heating oil to houses.

6.1.1.5 Tugboats:

The increasing demand for oil has led to deeper drilling, with larger drilling rigs located further offshore, which has justified building of larger and more powerful tugs and larger barges.[31]

6 Petroleum Refining:

Crude oil in its natural state has no value to consumers and must be transformed into products that can be used in the marketplace. Various physical and chemical methods are used in refining processes. Heat, pressure, catalysts, and chemicals are applied under widely varying process designs, operating conditions, and chemical reactions to convert crude oil and other hydrocarbons into petroleum products. Refining begins with distillation by boiling crude into separate fractions or cuts. All crude oils undergo separation processes through distillation, and so it is common to express the capacity of a refinery in terms of its distillation capacity. Two measures are commonly used: barrels per stream day (BPSD) and barrels per calendar day (BPCD). A barrel per stream day is the maximum number of barrels of input that a distillation facility can process when running at full capacity under optimal crude and product slate conditions with no allowance for downtime. A barrel per calendar day is the amount of input that a distillation facility can process under usual operating conditions, making allowances for the types and grades of products to be manufactured, environmental constraints, and unscheduled and scheduled downtime due to maintenance, repairs, and shutdown. Capacity expressed in BPSD is a few percentage points higher than BPCD capacity. After crude oil is separated into its fractions, each stream is further converted by changing the size and structure of the molecules through cracking, reforming, and other conversion processes. The

1 [31] Rahil O,2021 , Transportation and storage of crude oil and natural gas

converted products are then subjected to various treatment and separation processes to remove undesirable constituents and improve product quality.

Petroleum refining processes and operations are classified into five basic types

1. Distillation is the separation of crude oil in atmospheric and vacuum distillation columns into groups of hydrocarbon compounds based on molecular size and boiling-point ranges.

2. Conversion processes change the size or structure of hydrocarbon molecules by Decomposition: Breaking down large molecules into smaller molecules with lower boiling points through cracking and related processes. Unification: Building small molecules into larger molecules through alkylation, polymerization, and related processes. Reforming: Rearranging molecules into different geometric structures in isomerization, catalytic reforming, and related processes.

3. Treatment processes prepare hydrocarbon streams for additional processing and to prepare finished products using chemical or physical separation. Processes include desalting, hydrodesulfurization, solvent refining, sweetening, solvent extraction, and dewaxing.

4. Blending is the process of mixing and combining hydrocarbon fractions, additives, and other components to produce finished products with specific performance properties.

5. Other refining operations include light-ends recovery, sour-water stripping, solid waste and wastewater treatment, process-water treatment and cooling, storage and handling, product movement, hydrogen production, acid and tail gas treatment, and sulfur recovery. In general terms, refineries operate under the physical laws and engineering specifications of the system, the economic principles that guide investment and operating requirements, and the human-made rules governing production activities and product specifications. Complex interrelationships exist

among the physical laws by which a system operates, the product demands required by the market, and the commercial rules and regulations established for the system.

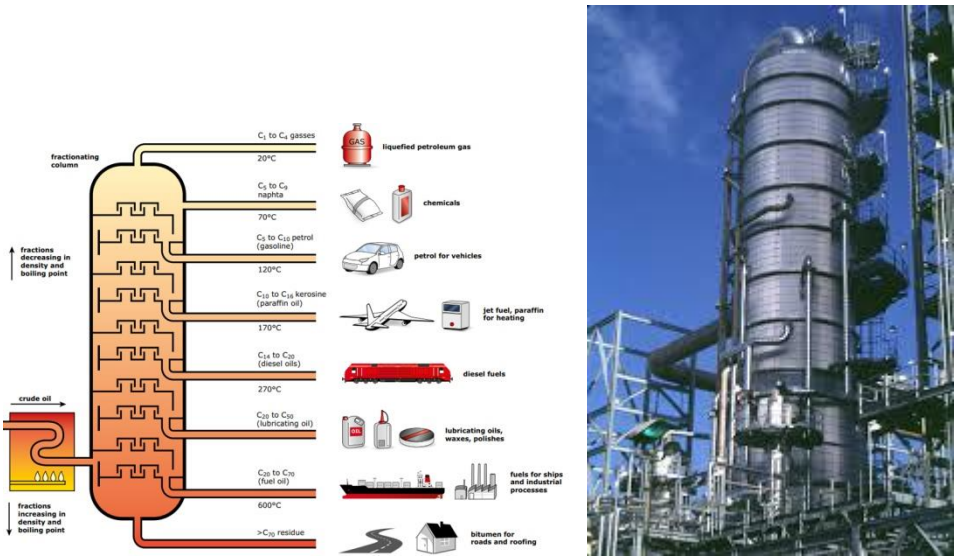

figure: Petroleum Refining[32]

6.1 Petroleum products :

When crude oil is subjected to refining processes, which are heating and distilling or a combination of cracking and distilling,in a fractionating column,it is separated into many different types of products by their various boiling temperature and is taken out at different heights of the column .By varying designs of the process and operating conditions, different types of products are produced.

Starting from the top of the fractionating column ,different fractions, or different oils ,derived from crude oil and the approximate ranges of boiling temperatures are:

Petroleum ether(largely pentanes and hexanes)	90°F to	170°F
Naptha(largely hexanes and heptanes)	90° F to	300°F
Gasoline	100 ° F to	400°F
Kerosene	300°F to	480° F
No.2Distillate	325°F to	750° F
No.5or6Fuel oil(also called residual Or reduced crude)	600°F to	1000 F

[32] https://images.app.goo.gl/YYBUdpJFzWpg8PFVA

Many of these products receive additional treatment to remove impurities and unwanted properties ,but fuel oils do not.

Introduction:

Oil is a very critical and essential product to the international community to such an extent that it benefits the globe especially in terms of reserves and production at totally different levels. While the reserves are beneficial to the Southern developing nations of the world, the Northern developed countries are appreciably put at a serious disadvantage in areas that relate to reserves and production of oil. It is however important to note that oil is such a very important product to both the North that is disadvantaged in reserves and production and equally to developing nations that have great reserves and are at advantage in production. It can in fact be asserted that oil is by far much more needed in the developed countries than in developing ones. This is clearly reflected and represented in the consumption levels of developed nations which are by far higher and greater than those in developing nations. In fact to an appreciable extent, the civilization of the western, Northern, developed, technologically advanced countries are strongly attached to adequate and regular supply of oil. Invariably therefore, it has become imperative that those nations strategise at employing new sources of oil supply that will be internal and which will considerably reduce dependence on the outside.

1.History of industry :

As techniques for extracting and refining fossil fuels improved, and as technology-driven demands increased, petroleum and natural gas became sought-after resources. The United States and Russia become leading countries in the oil industry, joined at times by Canada, Mexico, Iran, Trinidad, Saudi Arabia, and Venezuela throughout the 19th and 20th centuries.

In 1855, looking for a more efficient replacement for asphalt-based kerosene, George Henry Bissell and a group of investors formed the Pennsylvania Rock Oil Company. They hired Edwin Drake who completed the first drilled oil well—often seen as the beginning of the modern oil era—at Oil Creek near Titusville, Pennsylvania on August 27, 1859 Their renamed Seneca Oil Company was soon overshadowed by the Standard Oil Company, which was founded by John D.

Rockefeller in 1870 and went on to control close to 80 percent of the oil products market With the introduction of electricity in 1882, natural gas and oil were no longer needed to fuel light. The natural gas industry shifted to heating and cooking applications, and the oil industry found demand in the newly invented automobile. In 1909, anti-trust laws forced Standard Oil into 34 different companies, but by the 1940s three of them, along with four other international companies, grew to dominate the market and were nicknamed the "Seven Sisters."

Table3 :Development of oil companies

Founding Oil Companies - Date founded	**Seven Sisters**
Standard Oil Company - 1870	Standard Oil of New Jersey (later Esso, then Exxon)
Gulf Oil - 1901	Standard Oil of New York (Mobil)
Texaco - 1901	Standard oil of California (Socal, then Chevron)
Royal Dutch Shell - 1907	Royal Dutch Shell
Anglo-Persian Oil Company - 1909	Texaco
Turkish Petroleum Company - 1910	Gulf
Seneca Oil Company - 1858	Anglo-Persian (British Petroleum (BP))

As oil exporting countries became more protective of their resources and interested in benefiting from the wealth of the oil industry, the major companies had to negotiate deals to continue to extract oil. A fifty-fifty profit sharing arrangement was put in place after World War II, but soon oil exporting countries began nationalizing companies in order to have more control over revenue. Oil supply and

prices were in a tenuous balance for both the oil exporting and oil importing counties, often upset by politics and wars which resulted in a number of oil crises and panics in the latter half of the 20th century. The following are select resources for researching the history of the oil and gas industry.

2.The Importance of Oil in the Global Economy:

-Natural resources including energy are unevenly distributed in the world and very few countries have been endowed with an abundant commercial energy base. Invariably, therefore, commercial sources of useful energy and their distribution among nations vary considerably over time. This makes energy a commodity of paramount importance to individuals, enterprises and nations .

- oil is a raw material of immense value to the economies of the world has been given adequate attention in changing the asymmetrical nature of international economic relations.

It is the energy source that dominated the 20th Century and willcontinue to be pivotal for the foreseeable partof the 21st Century. It is the most versatile energysource available today. It is the most political of energy sources, the resource that makes countries go to war, the resource that countries must have to wage war. It is the single largest commodity in international trade and has been one of the most volatile

-Oil was the major global energy fuel and is likely to remain so for the next 30 years, at least. Fossil fuels dominated the energy supply in the second half of the last century and will almost certainly continue to do so in the second half of this century. The promise of new and renewable energy sources and its great expectations were not realized and are unlikely to do so in the foreseeable future. New energy fuels, like biofuels proved to be uneconomical, and new energy carriers hydrogen energy and fuel cells are still in the research laboratories rather than in markets and are unlikely to have a dent on the energy scene for years to come .
In the near future, as the stress on the world's scarce mineral resources grows stronger and supply of strategic minerals becomes more uncertain, new mineral problems of a social and political nature are bound to take shape, with even more important bearings on world affairs This situation has made the

Third World, especially net producers of mineral resources, critical and important in today's world. Oil as a Southern weapon of bargaining is fundamentally represented in Zindani's description of the commodity as the element of blue tactics in the Third World's economic and political.

- . Crude oil is the most important single commodity in world commerce and it has accounted for over 50 percent by weight of all sea-borne international trade. What is more, in many applications, the mostnotable of which is transport, there was as at 1996 and even at present, no substitute for oil products. 59 Oil isperhaps the most important source of energy in theworld today. Apart from the common energy derivedfrom oil, more than 600,000 chemical products are said to be obtainable from the commodity. Some common by products of oil are lubricating oil, paraffin oil(kerosene), Gasoline (Petrol) etc. These do not have immediate effective substitutes

- Oil is also easier and cheaper for industrial use than coal and solar energy. Coal is difficult to extract and heavy to transport. It has been difficult discovering solar energy for industrial use due to scientific problems and the heavy cost involved. Oil there fore provides nearly half of the world's energy requirements and since1973, energy demand has risen by an average of 2% per year. 60 It is estimated that by 1 970, the world required an equivalence of 173 million barrels of oil per day and by 1979 the world outside the communist areas consumed 80% of the world's oil supplies. 61 The Organisation for Economic Cooperation and development (OECD) member countries remained heavily dependent on oil, most of which came from OPEC. In 1981, the world outside communist areas was dependent on OPEC for three fifths of its oil supplies

3.Factors affecting the demand for oil in the world:

-Economic boom:

increase/decrease of complementary goods to oil According to the Secretary General of the Organization of Petroleum Exporting Countries, Haitham Al Ghais, global demand for oil will increase to 110 million barrels per day by 2045 . This is mainly due to the rising standard caused by the economic boom in the world's two most populous countries: China and India, which enable the citizens of these two

countries to earn higher incomes. As the income of the population of China and India increases, the demand for private motor vehicles will also increase to reduce travel time and to eliminate the need to wait for public transportation, which in turn will increase global oil demand as oil and motor vehicles complement each other. transportation, which in turn will increase global oil demand as oil and motor vehicles complement each other

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- Population size:

As the global population size is expected to increase about 5 percent annually, the demand for oil would undoubtedly increase. This is because growing populations consume more energy, and oil is one ofthe resources needed to produce electricity

3.Organizations and Cartels:

A cartel, as defined by the Organisation for Economic Co-operation and Development (OECD), is when firms create a formal agreement to "raise or fix prices and to reduce output in order to increase profits." This agreement harms consumers because it makes products unavailable or overly-expensive. Industries that are made up of a few large companies, have high start-up costs, and produce less complex goods are more likely to collude on price and production. Historically, cartels have existed in the steel, railroad transportation, and vitamin industries. In the oil and gas industry, the Organization of the Petroleum Exporting Countries (OPEC) is often used as an example of a cartel. Although there is debate around whether the economic evidence demonstrates it is a true cartel, OPEC's member countries do exert market influence.The focus of OPEC is to control oil output in order to influence prices .

4 Organization of the Petroleum Exporting Countries (OPEC):

OPEC is a permanent, intergovernmental organization (IGO) created at the Baghdad Conference on September 10-14, 1960. It was an outgrowth of the 1st Arab Petroleum Congress in 1959 when the Oil Consultation Commission, created by a few of the oil

producing countries, signed what was known as the Maadi Pact. Its current mission is to coordinate petroleum policies between its member countries with the goal of stabilizing the oil market for consumers, producers, and investors. A number of countries have sought various agreements and acts to limit the impact of OPEC on the global oil market. In 2016, OPEC entered an agreement (Declaration of Cooperation) with a number of non-OPEC oil producing countries, creating OPEC+ or OPEC Plus

5. International Oil and Gas Organizations:

- World Petroleum Council (WPC) External

  Started in 1933, World Petroleum Council includes 70 members from both OPEC and non-OPEC countries. It is a United Nations-accredited, non-advocacy, non-political organization based in the United Kingdom.

- World Energy Council (WEC) External

  "Formed in 1923, the Council is the UN-accredited global energy body, representing the entire energy spectrum, with more than 3000 member organisations located in over 90 countries and drawn from governments, private and state corporations, academia, NGOs and energy-related stakeholders." Congresses, speeches, current online and free publications, and archives are available on their website.

- International Gas Union (IGU) External

  The International Gas Union (IGU) is a global non-profit organization that was founded in 1931. Its mission is to advocate for natural gas to be an integral part of a sustainable energy system. It is also to promote the political, technical, and economic progress of the natural gas industry. It has more than 160 members.

- Gas Technology Institute (GTI) External

  The Gas Technology Institute (GTI) is a leading research, development, and training organization that addresses global energy and environmental challenges GTI is a non-profit institution that has been around since 1941.

- International Group of Liquefied Natural Gas Importers (GIIGNL) External

  GIIGNL is a non-profit organization whose objective is to promote the development of activities related to LNG, including purchasing, importing, processing,

transportation, handling, regasification, among other things

National Oil and Gas Associations

Natural Gas Council is made up of five associations that cover the entire United States oil and gas industry, "from the wellhead to the burner tip." Leadership rotates each year between the associations.

- Natural Gas Council External

  The Council addresses industry issues and concerns, and issues joint statements, reports, letters and filings representing the unified views of the industry.

- American Petroleum Institute (API) External

  API's website provides access to their industry standards and API Weekly Statistical Bulletin. They also publish research and statistics on a variety of oil industry topics.

- American Gas Association External

  AGA's website includes natural gas policy profiles by state, American Gas magazine, a glossary, and education overview of natural gas.

- Independent Petroleum Association of America External

  IPAA provides resources for independent oil and gas producers, such as talking points, press kits, and links to resources. They also publish the Energy In Depth website, which advocates for the development of onshore energy resources.

- Interstate Natural Gas Association of America External

  INGAA and its accompanying groups, INGAA Foundation and Energy Link, "advocates regulatory and legislative positions of importance to the natural gas pipeline industry in North America." The website has overviews of pipelines, a glossary, and INGAA reports.

- Natural Gas Supply Association External

  NGSA publishes short guides to natural gas topics and studies and research reports, with the purpose of supporting a competitive marketplace for specifically downstream activities of the industry.

Many countries have their own industry associations. For example:

- Oil and Gas UK External

  The oil and gas trade association for the United Kingdom.

- L'Union Française des Industries Pétrolières External

  The petroleum industry association for France.

Introduction :

Algeria is the largest producer of natural gas in Africa. The North African country has the tenth-largest proven natural gas reserve in the world at approximately 159 trillion cubic feet (TCF). Algeria holds also a proven crude oil reserve of approximately 12.2 billion barrels. In addition to the conventional resources, Algeria is believed to have the world's third-largest reserve of shale gas.

1.Overview:

In terms of market size, Algeria has the tenth-largest proven natural gas reserves globally, is the world's fourth-largest gas exporter, and has the world's third-largest untapped shale gas resources. It also ranks sixteenth in proven oil reserves and exports roughly sixty percent of its total production. All the country's proven oil reserves are onshore. According to Algeria's national oil company, Sonatrach, about two-thirds of the Algerian territory remains underdeveloped or unexplored, with an estimated 100 undeveloped discoveries.

Given pressure from European Union customers to increase its supply of gas, Sonatrach and its international partners are intensifying oil and gas exploration. Simultaneously, Algerian authorities are calling for locally manufactured products and services for small and medium-sized oil and gas service projects. As a part of this push to further develop the local oil service industry, Sonatrach encourages Algerian oil and gas services companies to conclude subcontracts and licensing agreements with international oil and gas equipment manufacturers. For large projects, however, Sonatrach continues to rely on world-class Engineering, Procurement, and Construction (EPC) contractors, who routinely work with American equipment and service providers. U.S. equipment and service suppliers should work proactively with Sonatrach to be included in its approved vendor list and become familiar with the technical specifications for upcoming EPC projects.

Sonatrach and its subsidiaries are the leading players in Algeria's oil and gas sector. They control roughly 80 percent of hydrocarbon production in Algeria, while IOCs account for the remaining 20 percent. Sonatrach's five main divisions include E&P, midstream, downstream liquefaction and separation, downstream refineries and petrochemicals, and sales. A special unit within Sonatrach, the Division Associations' office, develops projects with IOCs. In addition, Sonatrach has multiple specialized subsidiaries, including ENAFOR (drilling and extraction), ENTP (drilling, work-over activities, and rig transfer), ENGTP (civil engineering earthworks, welding, piping, and test control), ENSP (oil well services), ENAGEO (seismic and reservoir management), and GCB (oil services and civil engineering).

Regarding competition, Algeria's oil and gas sector includes a mix of more than two dozen IOCs working on more than 30 significant projects. These IOCs partner with various local and international oil field services companies, and the **Algeria Oil and Gas Energy Resource Guide** provides a comprehensive list of these companies.

Table4: Algerian oil production (thousand barrels/day)

	2020	2021	2022 estimated	2023 projected
Total Local Production	899	911	1,057	1,165
Total Exports	438.7	446.0	421.1	400.07
Total Imports	6	4	5	2
Imports from U.S.	0	0	0	0
Total Market Size	460.3	465.0	635.9	716.1
Exchange Rates (DA/USD)	126.8	135.1	142.6	145.5

2.The importance of petroleum in the Algerian economy:

The strategic importance of the hydrocarbon sector in the Algerian economy: The hydrocarbons sector occupies great importance in the Algerian economic system, given that oil and gas achieve important financial resources for the public treasury from hard currency, and the hydrocarbons sector is the main reliable source of economic and financial activity, as it constitutes about 40% of the public budget that is financed by petroleum taxation. This sector alone contributes more than 97% of Algerian exports. Algeria is the first producer and exporter of oil, especially natural gas in the Mediterranean basin, and it is the third supplier to the European Union after Russia and Norway . Modern life is increasingly linked to the use of energy in general and to oil in particular. Therefore, changes in oil prices affect directly and even indirectly the levels of development, and energy prices affect the costs of economic activities to a degree that leads to a change in the level of competition of these activities with their counterparts in other countries. Oil is an important strategic material for the economy of any country in the world, whether it is a producer or a consumer.

Conclusion:

Petroleum production stands as a cornerstone of the global economy, playing a pivotal role in fueling industries, transportation, and everyday life. Its significance extends beyond mere energy provision, influencing geopolitical dynamics, economic stability, and technological advancements worldwide. As a finite resource, the sustainability of petroleum production hinges on technological innovation, environmental responsibility, and strategic resource management. Therefore, understanding its economic importance underscores the need for balanced policies that address energy security, environmental impact, and socio-economic development in a rapidly evolving global landscape However, the economic importance of petroleum production comes with challenges:

- **Environmental Impact**: Extraction, transportation, and combustion of petroleum contribute to environmental degradation, air pollution, and greenhouse gas emissions, necessitating stringent regulations and investments in cleaner technologies.
- **Resource Depletion**: Petroleum is a finite resource, and the extraction of remaining reserves becomes increasingly complex and costly as easily accessible reserves diminish.
- **Energy Transition**: Global efforts towards decarbonization and diversification of energy sources pose long-term challenges to the petroleum industry's economic sustainability.

In conclusion, while petroleum production remains pivotal to global economic stability and development, its sustainable management and eventual transition to alternative energy sources are crucial for mitigating environmental impacts and ensuring long-term economic resilience. Balancing economic benefits with environmental responsibility is essential in shaping future energy policies and strategies.

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