World Journal of Pharmaceutical and Life Sciences

www.wjpls.org

Impact Factor: 8.21 Coden USA: WJPLA7

EMBRACING GEOPHYSICS WITH GEOCHEMISTRY RESULTS IN AN EXTRAVAGANZA LIFT TO GEOLOGICAL SCIENCE BY DIGGING

***[1]Dr. Dhrubo Jyoti Sen, [2]Dr. Pruthviraj K. Chaudhary, [3]Mukesh Sharma, [4]Amarish J. Patel**

*[1]School of Pharmacy, Techno India University, Salt Lake City, Sector-V, EM: 4/1, Kolkata-700091, West Bengal, India.
[2]Shri Sarvajanik Pharmacy College, Gujarat Technological University, Arvind Baug, Mehsana-384001, Gujarat, India.
[3]BDR Pharmaceuticals, At-Vanseti Village, PO. Tajpura, Dist. Panchmahal, Taluka-Halol, Gujarat-389350, India.
[4]Corbit India Pharmaceutical, B-406, Ganesh Glory 11, Nr. B.S.N.L. Office, S.G. Highway, Gota, Ahmedabad-382470, Gujarat, India.

***Corresponding Author: Dr. Dhrubo Jyoti Sen**

School of Pharmacy, Techno India University, Salt Lake City, Sector-V, EM: 4/1, Kolkata-700091, West Bengal, India.

DOI: https://doi.org/10.5281/zenodo.19367678

How to cite this Article: *[1]Dr. Dhrubo Jyoti Sen, [2]Dr. Pruthviraj K. Chaudhary, [3]Mukesh Sharma, [4]Amarish J. Patel (2026). Embracing Geophysics With Geochemistry Results In An Extravaganza Lift To Geological Science By Digging. World Journal of Pharmaceutical and Life Science, 12(4), 135-147.

Article Received on 05/03/2026 **Article Revised on 25/03/2026** **Article Published on 01/04/2026**

Petroleum from the sea is extracted via offshore drilling, providing roughly 30% of global oil production. It is formed over millions of years from organic matter (phytoplankton, algae) on the seafloor, which is covered by sediment and subjected to intense pressure. Specialized rigs (jackup, semi-submersible, drill ships) drill into the seabed to extract it. Petroleum is extracted from beneath the seabed through offshore drilling, where massive rigs and drill ships bore through rock layers to access, pump, and transport crude oil found in, for example, the Gulf of Mexico, North Sea, and Brazilian coast. It is a fossil fuel created over millions of years from marine algae, plants, and sediment buried under high pressure.

KEYWORDS: offshore, crude oil, seismic imaging, hydrocarbons, paraffin, cycloalkanes, naphthenes, aromatics, asphaltenes.

INTRODUCTION

Petroleum is extracted from beneath the seabed through offshore drilling, a process involving massive rigs and platforms that drill thousands of meters into the seafloor. Formed over millions of years from marine microalgae and organic sediment, these oil reservoirs are accessed by drilling through water layers to reach sedimentary rocks. Crude oil is then transported to land via pipelines or tankers.

Key Aspects of Offshore Petroleum Extraction

Formation: Petroleum originates from organic material—primarily dead microalgae and phytoplankton—that accumulated in sea floor sediments millions of years ago. Over time, these sediments, buried deep under high pressure and heat, underwent chemical transformations to become liquid and gaseous hydrocarbons.

Locating Reserves: Companies use seismic surveys to send sound waves into the ocean floor, analysing echoes to identify porous rock formations that likely hold oil.

Drilling Technology: Various offshore rigs are used based on depth:
Jackup Rigs: Used in shallow water, with legs resting on the seabed.

Semi-submersible Platforms: Floating structures for deeper waters, often anchored or held by dynamic positioning.

Drill Ships: Specially designed ships for drilling in very deep waters, as explained in this Facebook video.

Extraction Process: A drill bit is lowered through the rig and seabed, creating a hole strengthened by steel

casing and cement. A blowout preventer is crucial for controlling high-pressure oil and gas.

Transportation: Extracted oil is processed on the platform to remove initial contaminants and then transported to land via subsea pipelines or specialized tanker ships.

Environmental and Safety Considerations: Offshore drilling is challenging due to harsh environments, necessitating rigorous safety measures against oil spills and structural failures. The industry is moving towards advanced, remote-controlled technologies to manage extraction in deeper waters.

Figure 1: Petroleum extraction of fshore.

Key Facts about Offshore Petroleum

Formation: Organic residue settles in oxygen-free environments at the bottom of ancient seas, converting to hydrocarbons through chemical maturation.

Location: Reservoirs are located under the ocean floor, commonly accessed by companies in shallow to ultra-deep water.

Extraction Method: Massive offshore drilling platforms utilize drill bits to bore into the seafloor, using steel casings and blowout preventers to ensure stability.

Transport: Extracted oil is sent to land through underwater pipelines or via specialized ships called tankers.

Environmental Impact: Offshore extraction poses risks, including oil spills and pollution from produced water and seismic surveys. Technological advancements have enabled drilling in **deepwater (up to 1,500 meters) and ultra-deepwater (greater than 1,500 meters)**, allowing access to previously unreachable deposits.

Petrol (crude oil) is extracted from beneath the ocean floor through a sophisticated, multi-stage engineering process, primarily involving offshore drilling rigs. The mechanism uses seismic imaging to locate reserves and various types of floating or fixed platforms to drill into the seabed, with wells often reaching thousands of feet deep.

Chemistry: Petroleum (crude oil) is a complex, naturally occurring liquid mixture composed primarily of hydrocarbons (compounds containing carbon and hydrogen) and organic compounds containing nitrogen, sulphur, and oxygen. It typically consists of 83–87% carbon, 10–14% hydrogen, with minor amounts of sulphur, nitrogen, oxygen, and trace metals. Petroleum (crude oil) is a complex liquid mixture composed primarily of hydrocarbons (hydrogen and carbon) with smaller amounts of nitrogen, oxygen, sulphur, and trace metals. It consists mainly of alkanes (paraffins), cycloalkanes (naphthenes), and aromatics, with elemental compositions ranging from 83–87% carbon and 10–14% hydrogen.

Key Chemical Constituents

Hydrocarbons (90–97%): Alkanes (Paraffins): Straight or branched chain molecules (C_nH_{2n+2})

Cycloalkanes (Naphthenes): Saturated ring molecules (C_nH_{2n}) common in heavier fractions.

Aromatics: Unsaturated ring structures (e.g., benzene).

Non-Hydrocarbons (SNO Compounds)

Sulphur: The most significant impurity (0.05–6.0%).

Nitrogen (0.1–2%): Includes basic (pyridines) and non-basic (pyrroles) compounds.

Oxygen (0.05–1.5%): Occurs as carboxylic acids, ketones, and phenols.

Trace Metals (<0.1%): Nickel, vanadium, iron, and copper.

Elemental Composition by Weight

Carbon: 83–87%, **Hydrogen:** 10–14%, **Sulphur:** 0.05–6.0%, **Nitrogen:** 0.1–2%, **Oxygen:** 0.05–1.5%, **Metals:** iron, copper, chromium, molybdenum, sodium, and zinc.

Physical Structure: The mixture contains molecules ranging from light gases to heavy solids, mainly

categorized into saturates, aromatics, resins, and asphaltenes. The exact molecular composition varies significantly depending on the source rock. Asphaltenes are the heaviest, most polar, and highest molecular weight component of crude oil, existing as solid, amorphous particles. Known as a solubility class, they are insoluble in light n-alkanes (like pentane or heptane) but soluble in aromatic solvents (like toluene). They cause significant flow assurance issues, including pipeline blockages and emulsion stabilization, due to their tendency to precipitate when pressure, temperature, or oil composition changes.

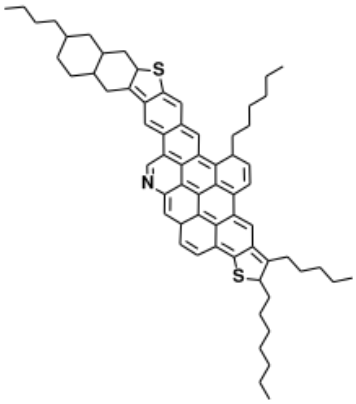

Figure 2: Asphaltenes.

Key Characteristics and Properties
Structure: Complex, highly aromatic, and polydisperse, often containing sulphur, nitrogen, oxygen, and trace metals like vanadium and nickel.

Appearance: Brittle, shiny, and dark brown to black solid powder.

Solubility: Insoluble in n-alkanes (e.g., n-pentane, n-heptane); soluble in aromatics (e.g., benzene, toluene).

Surface Activity: They are polar molecules that migrate to oil-water interfaces, stabilizing water-in-oil emulsions and often acting as natural emulsifiers.

Production and Refining Challenges
Precipitation/Deposition: Changes in pressure (pressure drop) or composition (e.g., gas injection) during oil extraction can cause asphaltenes to precipitate, causing blockages in reservoirs, wellbores, and pipelines.

Viscosity Impact: High asphaltene content significantly increases the viscosity of crude oil, reducing mobility.

Processing Difficulties: In refineries, high asphaltene content leads to heavy deposits in equipment, catalyst deactivation, and reduced, lower-quality fuel output.

Management and Remediation
Chemical Treatment: Dispersants and inhibitors are used to prevent aggregation, and solvents (like xylene) are used to remove deposits.

Monitoring: Analysing the stability and prediction of potential precipitation using tools like the **Asphaltene Dispersancy Test (ADT)** is crucial.

Structure and Composition: Recent research suggests an "island" architecture with one polycyclic aromatic core per molecule. They are highly stable, with thermal degradation generally starting above. They are closely associated with resins, which act as a stabilizer to prevent precipitation, but which are separated based on solubility.

Key Chemical Composition
Hydrocarbons: The primary constituents, categorized into three main types:
Paraffins (Alkanes): Saturated hydrocarbons (straight or branched chains).

Naphthenes (Cycloalkanes): Saturated rings, commonly 40-60% of crude oil.

Aromatics: Unsaturated ring compounds, such as benzene.

Non-Hydrocarbons (SNO Compounds): Nitrogen, Sulphur, and Oxygen compounds usually make up a small percentage but heavily impact refining.

Sulphur: The most abundant heteroatom, ranging from 0.05% to 6.0%.

Nitrogen: Ranges from 0.1% to 2%.
Oxygen: Ranges from 0.05% to 1.5%.
Trace Metals: Include nickel, vanadium, iron, and copper, often totalling<0.1%.

Physical and Elemental Structure
Main Elements: Carbon (83–87%), Hydrogen (10–14%).

Structure: Varies widely by source, resulting in different properties like density and viscosity (light vs. heavy oil).

Compound Classes: Contains saturates, aromatics, resins, and asphaltenes.

The exact molecular composition of crude oil varies by geological formation but is fundamentally a mixture of compounds that are separated into usable fractions during refining.

1. Exploration and Site Identification: Before drilling, companies identify potential oil reserves trapped beneath the seafloor.

Seismic Surveys: Sound waves (acoustic waves) are sent through the ocean floor, and sensors (hydrophones) detect reflections from different rock layers to create a map of underwater geology.

Drilling Site Pinpointing: Specialized ships detect small oil seepages, and GPS coordinates are established to mark the best location for drilling.

2. Offshore Drilling Types: Depending on the water depth and ocean conditions, different rigs are used:
Jack-up Rigs: Used in shallower waters, these platforms lower legs to the seafloor, lifting the main platform above the water surface.

Semi-submersible Rigs: These float above the site and are held in place by massive anchors, suitable for deeper, rougher waters.

Drill Ships: Self-propelled ships with a drilling rig in the centre, used for extremely deep water.

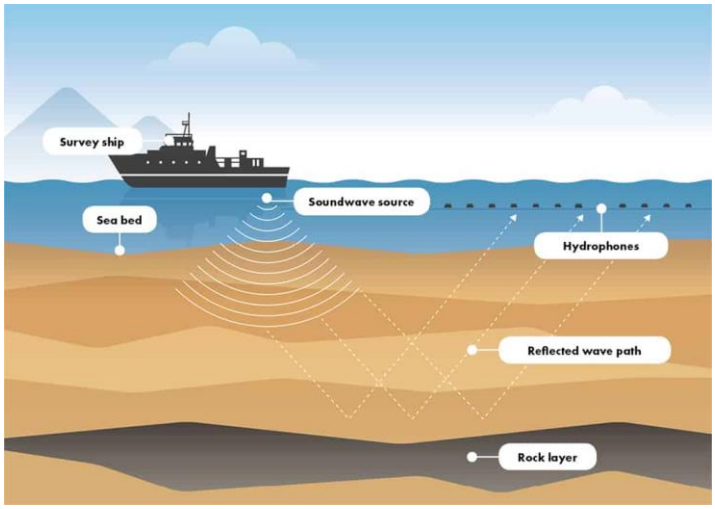

Figure 3: Seismic Surveys in petroleum extraction.

3. Drilling and Extraction Mechanism: The actual process involves several key technological components:
Drill String and Bit: A "drill string" of pipes is lowered through a riser tube to the seafloor. A drill bit grinds through rock layers, with mud constantly pumped down to cool the bit and carry rock cuttings back up.

Blowout Preventer (BOP): To manage high-pressure oil and gas pockets, a massive, remote-controlled blowout preventer is installed on the seafloor as a primary safety mechanism.

Casing and Cementing: Steel pipes (casing) are inserted and cemented into the well to provide stability and create a sealed channel, preventing oil from leaking into the ocean.

"Christmas Tree" Valve: Once drilling reaches the reservoir, a specialized wellhead, known as a "Christmas tree," is installed on the ocean floor to regulate the flow of oil.

4. Transportation and Processing: The extracted mixture of crude oil, gas, and water is brought up to the platform.

Initial Processing: The platform separates the crude oil from water, natural gas, and impurities.

Transport: The purified crude oil is transported to land via pipelines or loaded onto specialized tanker ships for transport to refineries.

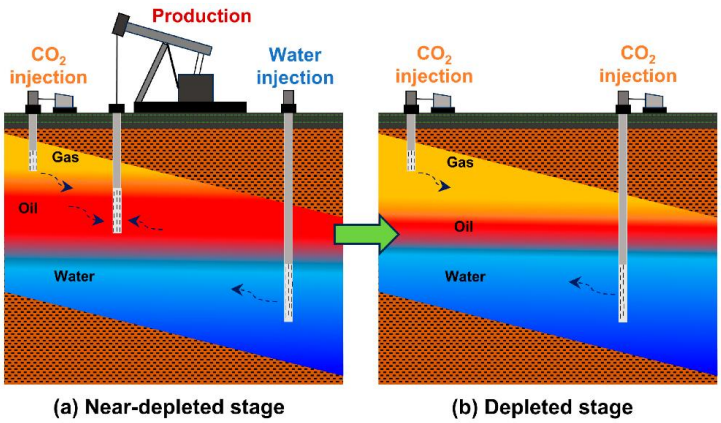

Figure 4: Drilling process.

5. Advanced Recovery Techniques: If natural pressure is insufficient, secondary recovery methods are used, such as injecting water or gas into the reservoir to force the oil out. Enhanced Oil Recovery (EOR) techniques, such as injecting steam or chemicals, can also be employed to maximize output.

Saudi Aramco is the world's largest and most famous petroleum extraction company, producing over 10 million barrels of oil per day and holding the top spot in market capitalization. Other dominant global leaders include ExxonMobil, Chevron, Shell, PetroChina, and Total Energies, which dominate exploration, extraction, and refining.

Top World-Famous Petroleum Extraction Companies

- **Saudi Aramco (Saudi Arabia):** The undisputed leader in oil production, accounting for approximately 10% of global supply. Saudi Aramco, officially the Saudi Arabian Oil Company, is the world's largest oil-producing company and a top-four company by revenue, headquartered in Dhahran, Saudi Arabia. Majority state-owned, it controls over 270 billion barrels of crude oil reserves and operates globally in chemicals, refining, and natural gas.

Figure 5: Process of petroleum extraction from sea bed.

Key Facts & Operations

Production & Reserves: Holds the world's largest proven crude oil reserves and top daily oil production.

Revenue: Generated over $480 billion in revenue in 2024, with net income exceeding $106 billion.

Structure: Primarily state-owned (roughly 82% by the government, 16% by PIF) with a small percentage publicly traded on the Tadawul exchange.

Key Figures: Amin H. Nasser serves as President and CEO; Yasir Al-Rumayyan is Chairman.

Global Presence: Operates in Asia, Europe, and North America, with major refining assets like Motiva in the United States.

Recent Developments

Infrastructure Investment: Recently signed contracts worth over $64 million with Arabian Pipes Company for infrastructure in 2026.

Digital Transformation: Partnered with solutions by stc for a SAR 1.4 billion AI and high-performance computing project.

Safety & Security: While operating a massive pipeline network, the company has managed, and quickly recovered from, previous attacks on its infrastructure.

Saudi Aramco is transitioning towards being an integrated energy and chemicals enterprise, diversifying its portfolio to include significant petrochemical production.

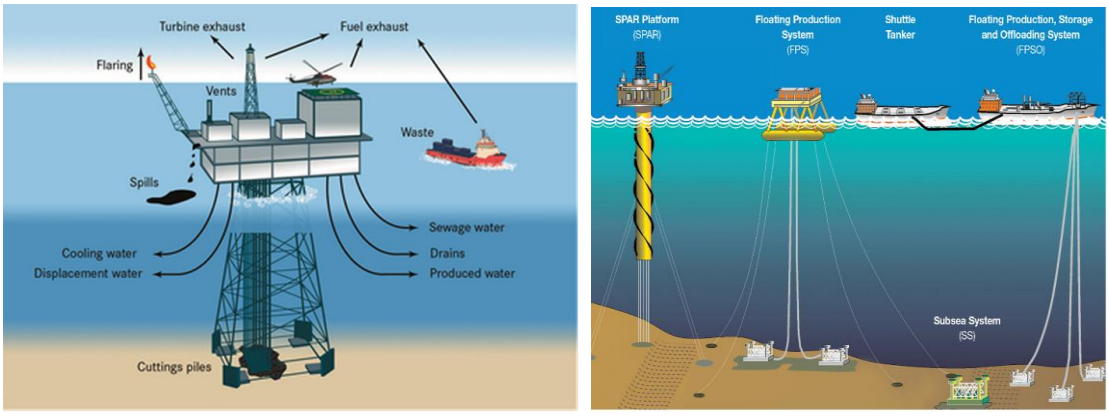

Figure 6: SPAR platform project.

- **ExxonMobil (USA):** A major international "supermajor" known for massive global upstream exploration and production, particularly in the US, Exxon Mobil Corporation is a direct successor to Standard Oil. ExxonMobil is a leading American multinational oil and gas corporation headquartered in Spring, Texas, formed by the 1999 merger of Exxon and Mobil. As the largest investor-owned oil company by revenue and market cap, it focuses on high-return upstream oil/gas (Permian/Bakken) and downstream refining, with deep roots in Rockefeller's Standard Oil. Esso is a major international trade name for ExxonMobil, originating as a phonetic spelling of the initials "S" and "O" from the predecessor company Standard Oil of New Jersey. It operates as a brand for petrol, gasoline, and diesel fuels worldwide, with a significant presence in Europe and Canada.

Origin: Following the 1911 breakup of Standard Oil, "Jersey Standard" retained rights to the name, marketing products as Esso from 1926.

Corporate Parent: It is a trading name for ExxonMobil Corporation.

Products & Services: In addition to fuel, Esso stations offer lubricants, convenience products, and loyalty programs, such as with Nectar points in the UK.

Other Potential Meanings: The term can also refer to the European Society of Surgical Oncology (ESSO), or the Earth System Science Organisation (ESSO) in India.

Key Aspects of ExxonMobil
Company Structure: It is a major player in upstream (exploration), downstream (refining and marketing), and chemical manufacturing.

Key Assets: Known for substantial, low-cost-of-supply operations, including major holdings in the Permian Basin, Bakken shale, and global assets in Guyana and Brazil.

History: Traces its roots back to 1870, with Wikipedia listing it as a primary successor to Standard Oil.

Strategy: The Company is currently focused on maximizing shareholder value, enhancing production through low-cost assets, and investing in lower-carbon technologies like carbon capture.

Corporate Identity: Often ranked in the top positions of the Fortune 500 and Global 500.

It is one of the world's largest publicly traded international oil and gas companies.

- **Chevron (USA):** A massive integrated energy company with extensive global upstream projects, Chevron operating in over 180 countries, notes Energy Digital Magazine. Chevron U.S.A. Inc., headquartered in Houston, Texas, is a major subsidiary of Chevron Corporation, acting asone of the largest integrated energy companies in the United States. It produces, refines, and markets fuels, lubricants, chemicals, and natural gas, having recently increased U.S. production by nearly 20%.

Key Aspects of Chevron USA
Operations: Vertically integrated, involving exploration, production, refining, and transport of oil and natural gas.

Refineries: Operates five major U.S. refineries located in Richmond and El Segundo, California; Pasadena, Texas; Pascagoula, Mississippi; and Salt Lake City, Utah.

Brands: Markets products under the Chevron®, Texaco®, and Caltex® brands.

Growth & Strategy: Focuses on strengthening its portfolio through acquisitions (e.g., PDC Energy, Hess Energy) and advancing lower-carbon energy solutions, including hydrogen and renewable fuels.

History: The entity was incorporated in 1922 and has roots in the early California oil industry.

Recent Developments
Production Increase: Chevron increased U.S. production by roughly 20% in the previous year.

Acquisitions: The Company has acquired PDC Energy and Noble Energy to expand its supply and strengthen assets.

Energy Transition: Chevron is actively building hydrogen fuelling stations and targeting 100,000 barrels per day of renewable fuel production by 2030.

- **Shell PLC (UK/Netherlands):** A top Anglo-Dutch multinational specializing in extraction, refining, and liquefied natural gas (LNG). Shell PLC is a global energy company operating in upstream (oil/gas extraction), integrated gas, and downstream (refining, chemicals) sectors. It offers products like Shell Helix Ultra oils, fuels, and EV charging, along with rewards programs, notes Shell. Key synonyms include Petroleum Company, energy group, oil firm, or fuel provider.

Figure 7: Logo of petroleum companies.

Key Aspects of Shell (SHEL)

Business Structure: Operates in Integrated Gas, Upstream, Downstream (refining/marketing), and Renewables/Energy Solutions.

Retail/Service: Offers fuels like Shell V-Power and lubricants through branded retail outlets.

Sustainability & Technology: Focuses on decarbonisation, digital technology, and R&D for energy transition.

Market Position: A major publicly traded energy company with a diverse, international presence, listed on London, Amsterdam, and New York exchanges.

Financials: Generally, a company with high market capitalization but subject to volatility due to global oil prices and energy demands, according to Traders Union.

Usage Examples & Services

Fuels & Lubricants: Using Shell V-Power for engine performance and purchasing Shell Helix Ultra oil.

Retail Loyalty: Earning rewards through the Shell Asia App and Shell GO+ Rewards program.

Energy Transition: Accessing Shell Recharge for electric vehicle charging services.

Figure 8: Crude petroleum storage from deep sea bed.

Business Opportunities: Retailers operating Shell-branded service stations.

- **Petro China/CNPC (China):** A top producer with vast exploration operations, listed in Wikipedia. PetroChina Company Limited is China's largest oil and gas producer and distributor, acting as the listed arm of the state-owned China National Petroleum Corporation (CNPC). Headquartered in Beijing, it is a dominant integrated energy company involved in exploration, production, refining, chemicals, and marketing.

Key Aspects of PetroChina

Core Business: Explores, develops, and produces crude oil and natural gas; operates pipelines; and manufactures petrochemical products.

Market Position: As of 2020, it was ranked as the 32nd-largest public company in the world and contributes roughly 50% of China's domestic oil production and 60% of its natural gas production.

Structure: Listed on the Hong Kong (0857.HK) and Shanghai stock exchanges.

International Operations: Operates in multiple countries, including Kazakhstan, Oman, Peru, Thailand, and Azerbaijan.

Growth Focus: Actively investing in natural gas expansion, digital intelligence at sites like Daqing Oilfield, and high-end chemical production.

- **TotalEnergies (France):** An international oil company involved in upstream projects across

several continents. TotalEnergies is a major French-based, international integrated energy company founded in 1924, ranking among the world's seven "supermajor" oil companies. It produces and markets oil, biofuels, natural gas, and green gases, while actively transitioning towards renewables. The company operates significant refining and petrochemical activities, along with extensive service station networks in France.

Thixotropy in petroleum, particularly in waxy crude oils and emulsions, is the time-dependent, reversible decrease in viscosity under shear, where the fluid thins when pumped and gels when resting. This property is crucial for flow assurance, as it causes viscosity recovery in pipelines, making restarts difficult.

Key aspects of petroleum thixotropy
Mechanism: Waxy crude oils form a network of paraffin crystals, while emulsions form water-in-oil structures. Shear breaks down these networks, decreasing viscosity, which recovers over time when shear is removed.

Waxy Crude Oil Behavior: These oils show a hysteresis loop in shear stress/rate experiments. As temperature drops, the thixotropic behavior becomes more pronounced as paraffin gels form.

Petroleum Emulsions: Water-in-oil emulsions exhibit both positive (shear-thinning) and negative (shear-thickening) thixotropy, with higher water content generally increasing the complexity of the flow behavior.

Engineering Impact: Thixotropy is critical for analyzing pressure drops in pipelines, especially in subsea or cold climates. It is also essential for maintaining drilling mud stability to hold suspended cuttings while the pump is off.

Key measurements to characterize this behavior include shear stress decay at constant shear rate and the analysis of hysteresis loops.

Key aspects of TotalEnergies' oil and energy operations include
Energy Transition & Oil: Despite its oil roots, the company is diversifying into renewables and transforming sites, such as converting the Grandpuits refinery into a "zero-crude" platform focused on recycling.

Fuel Supply & Retail: TotalEnergies operates a widespread network of service stations in France, offering a comprehensive range of fuels and services.

Global Oil Operations: The Company continues to maintain a significant presence in global oil and gas exploration, production, and trading.

Sustainable Aviation Fuel (SAF): TotalEnergies is actively developing and supplying SAF to support the aviation sector's decarbonisation.

Performance & Pricing: In 2023, the company generated high profits from oil and, in coordination with the French government, took measures to reduce fuel prices.

The company, formerly known as Compagnie française des pétroles, was initially established to ensure France's energy independence.

- **Rosneft (Russia):** A major state-controlled producer, noted for being a top publicly traded producer globally, states Offshore Technology. Rosneft is a major Russian state-controlled integrated energy company and a global leader in hydrocarbon production. Headquartered in Moscow, it specializes in exploration, production, refining, and marketing of oil and gas. Key projects include Vostok Oil, and the company is heavily involved in supplying markets in Europe and Asia.

Key Details about Rosneft
Ownership: Controlled by the Russian government through parent company Rosneftegaz (approx. 70%) and a significant investment by Qatar Investment Authority (18.46%).

Key Personnel: Igor Sechin serves as the Chief Executive Officer and Chairman of the Management Board.

Operations: Operates numerous refineries and petrochemical plants, with a strong focus on exploration in Siberian and Arctic regions.

Key Strategic Focus: The Company is advancing the Vostok Oil flagship project, which consists of 60 license areas in the Krasnoyarsk territory.

Financials: The Company was ranked as the top Russian taxpayer in 2024, holding major energy partnerships in Asia, particularly with India.

Crude petroleum extraction on a ship, or from a floating vessel, primarily involves specialized vessels like drillships for exploration and Floating Production, Storage, and Offloading (FPSO) units for active production. These vessels are used for deep-water extraction where fixed rigs are impractical, allowing for drilling, separation, and storage before transferring oil to shuttle tankers.

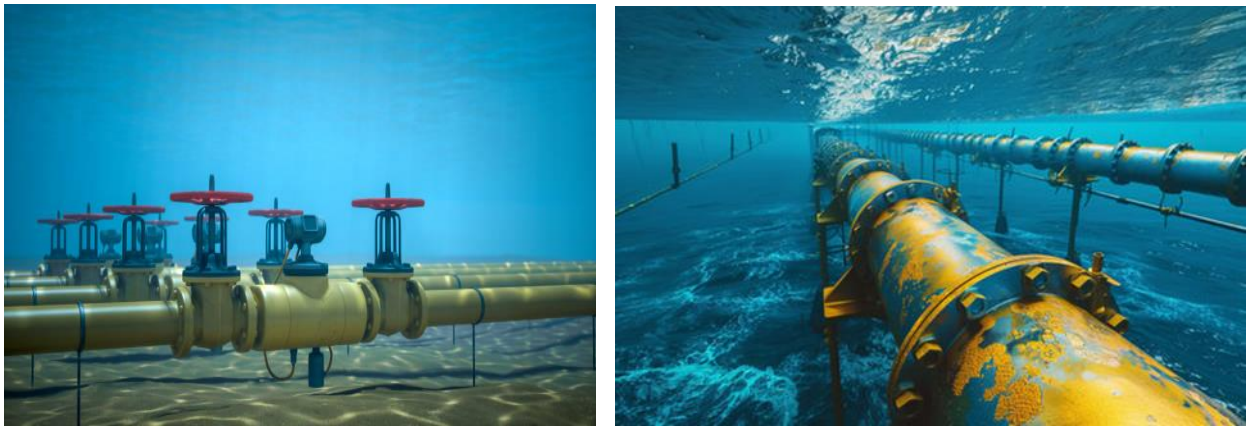

Figure 9: Drillships extraction.

Key Vessels in Ship-Based Extraction

Drillships: Maritime vessels equipped with drilling apparatus, utilized in deep waters (up to 10,000 feet). They use dynamic positioning systems to remain perfectly positioned over a well without anchors.

FPSO (Floating Production, Storage, and Offloading): A large vessel that receives crude from subsea wells, separates it from water and gas, and stores it in hull tanks until it is offloaded to tankers.

Semi-submersibles: Floating drilling rigs that can be submerged to a specific depth for increased stability in harsh environments.

Mechanism of Extraction and Processing

The process of bringing oil from the seabed to the ship is a complex, multi-stage mechanism:

Drilling & Well Construction: A drill ship lowers a drill string through a moonpool (opening in the center of the ship) to bore through the ocean floor.

Subsea Wellhead and BOP: After drilling, a subsea "Christmas tree" (valve system) is installed on the seabed to control flow. A Blowout Preventer (BOP) is connected to prevent uncontrolled release of oil/gas.

Riser System: Flexible riser pipes connect the subsea wellhead to the floating vessel, carrying the crude oil, gas, and water mixture up to the surface.

Onboard Processing (Topside): Once on board the FPSO, the raw mixture passes through separator units that utilize gravity or centrifugal force to separate crude oil from water, gas, and impurities.

Storage & Transport: The processed crude is stored in the vessel's hull cargo tanks. Shuttle tankers come alongside to receive this cargo for transport to refineries.

A pump jack (nodding donkey) is a surface reciprocating piston pump used to artificially lift oil from wells that lack enough natural pressure. It uses a prime mover (motor) to drive a rotating crank, which a walking beam converts into a vertical, nodding motion, pushing a string of sucker rods up and down to operate a down hole pump. A pump jack is a surface unit for a reciprocating piston pump, using a motor-driven gearbox to convert rotational motion into a vertical, oscillating "nodding" motion via a walking beam. It lifts oil from artificial lift wells by driving a sucker rod string up and down, creating a suction and plunger effect that brings fluid to the surface.

Key Technologies

Dynamic Positioning (DP): Computer-controlled systems that use propellers and thrusters to maintain the vessel's position, crucial for drillships.

Turret Mooring System: Allows an FPSO to rotate freely 360 degrees, helping it withstand harsh winds and sea conditions, while keeping the riser connections stable.

Subsea Injection: Water or gas is sometimes separated from the oil and reinjected into the well to maintain pressure and maximize recovery.

Recent Developments (2024–2025)

Global Impact: Controls over 6% of global oil supply.

Strategic Partnerships: In December 2024, Rosneft agreed to a 10-year deal to supply roughly 500,000 barrels of crude per day to Indian refiner Reliance, valued at $\sim$$13 billion annually.

Challenges: The Company has faced sanctions by the US, resulting in disruptions to international operations.

Strategy 2030: Prioritizes operational efficiency, increasing gas production, and implementing environmentally responsible technologies. These firms are generally referred to as "Supermajors" or national oil giants, dominating the upstream (exploration and extraction) sector of the energy industry.

Offshore drilling is the process of locating and extracting petroleum from beneath the ocean floor using specialized, floating or fixed platforms. It involves

seismic surveys to find deposits, drilling a well with a drill bit on a long string of pipes, and installing casing and a blowout preventer (BOP) to prevent collapses and accidents.

Drilling Rigs: Types include jackup rigs for shallow water (fixed to seabed) and semi-submersibles or drillships for deepwater, which may use dynamic positioning to stay in place.

Key Components and Process

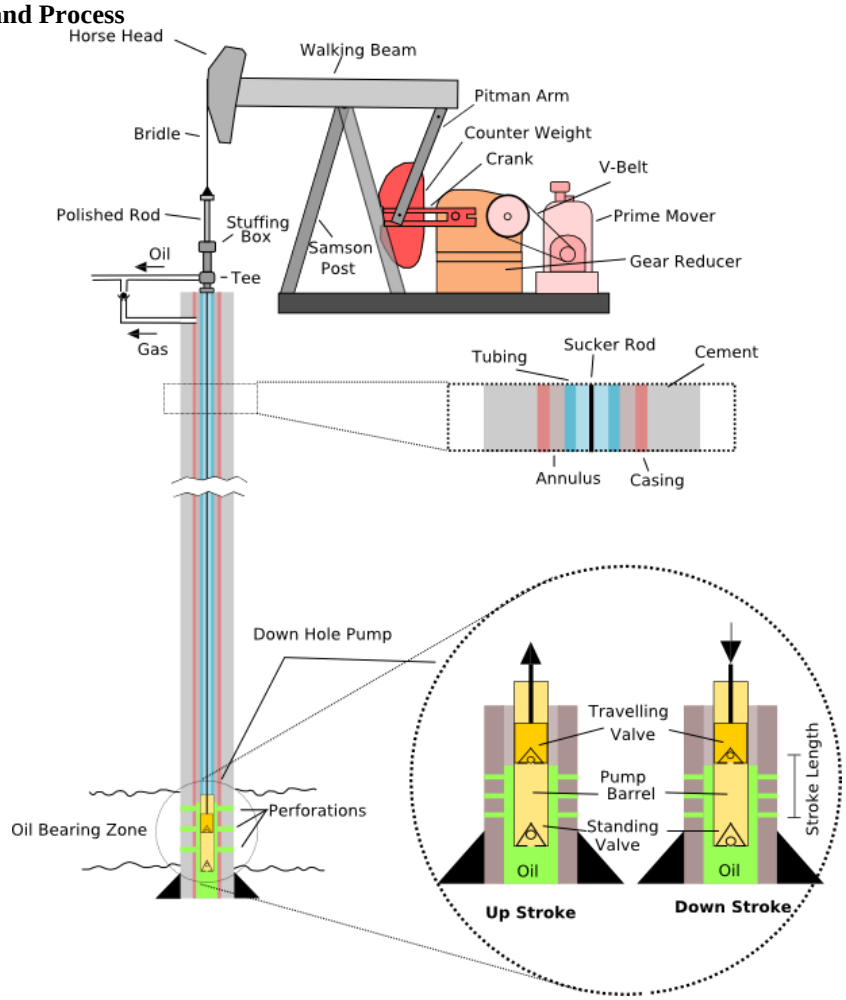

Figure 10: Pumpjack.

Drilling Process: A drill bit cuts through the seabed, and a marine riser connects the platform to the well. Drilling mud is used to cool the bit, stabilize the hole, and bring rock cuttings to the surface.

Securing the Well: As the hole deepens, steel pipes (casing) are inserted and cemented into place to ensure stability.

Blowout Prevention: A Blowout Preventer (BOP) is installed on the seafloor to seal the well in case of high-pressure emergencies, acting as a critical safety mechanism.

Extraction and Transport: Once oil is found, it is pumped up through a riser and stored on the platform before being transported to land via tankers or undersea pipelines.

Mud (drilling mud/drilling fluid and associated cuttings) is separated from petroleum oil primarilythrough a combination of mechanical, physical, and chemical processes designed to remove solid particles, water, and contaminants from the produced hydrocarbons. This separation is essential both during drilling to reuse the drilling fluid and at the surface to process the extracted crude oil.

1. Mechanical Separation (Solids Control): The first phase of separation occurs on the drilling rig using solids control equipment to remove cuttings from the drilling mud.

Shale Shakers: These use vibrating screens to remove large rock cuttings from the liquid mud.

Hydrocyclones (Desanders/Desilters): Centrifugal force is used to separate smaller sand and silt particles from the mud.

Centrifuges: High-speed decanter centrifuges remove fine particles that pass through the shakers and hydrocyclones.

Vertical Cuttings Dryer: Specifically used for oil-based mud (OBM) to reduce the oil content on cuttings to less than 5% by centrifugal force.

2. Separation of Oil-Based Mud (OBM): When oil-based mud is used, the cuttings are coated in expensive oil that needs to be recovered and separated.

Thermal Desorption (TDU): The most efficient method, which involves heating the mud-coated cuttings to evaporate the oil and water, which are then condensed and separated.

Liquid-Liquid Extraction: A solvent (such as hexane) is used to extract the oil from the solid cuttings, followed by distillation to separate the solvent from the oil.

Reversible Phase Inversion: Amine-based surfactants are used to temporarily change the emulsion, allowing solids to be separated by gravity or mechanical means.

3. Separation of Crude Oil from Water/Solids (Surface Separation): Once the mixture of oil, gas, water, and solid mud solids is brought to the surface, it is treated using:
Heater Treaters/Heating: Heating the emulsion reduces its viscosity, allowing water and solids to settle out more easily.

Gravity Settling/Sedimentation: Allowing the mixture to settle in large tanks over time, where heavier water and solids sink to the bottom (BS&W - Bottom Sediment and Water).

Chemical Demulsifiers: Specific chemicals are added to break the stable emulsions of water and mud in the oil.

4. Purification of Recovered Oil: After primary separation, the recovered oil may still contain trace mud solids.

Centrifuging/Polishing: The oil is passed through high-speed centrifuges to remove remaining fine particles, producing high-quality, and clean oil.

These techniques ensure the oil is free from sediments for transport and that the drilling mud can be reused.

Crude petroleum (or crude oil) is a naturally occurring, yellowish-black liquid fossil fuel found in geological formations beneath the Earth's surface. Composed primarily of hydrocarbons, it formed over millions of years from ancient organic matter. It is refined into essential products like gasoline, diesel, and plastics.

Key Characteristics and Components
Composition: A mixture of hydrocarbons (paraffins, naphthenes, aromatics, asphaltenes) with small amounts of nitrogen, sulphur, and oxygen.

Types: Classified by density (API gravity) and sulphur content. "Light" crude flows easily, while "heavy" crude is more viscous.

Formation:
Extraction: Extracted by drilling wells, often thousands of feet below the surface, both on land and offshore.

Refining: Processed in refineries through distillation, which separates the crude into fractions (e.g., gasoline, kerosene, and diesel) based on boiling points.

Uses and Economic Significance
Energy: It is the world's most-used energy resource, providing over 90% of global transportation energy.

Petrochemicals: Used to manufacture fertilizers, plastics, medicines, and synthetic materials.

Market: It is a critical, non-renewable global commodity heavily traded in futures and spot markets.

Environmental and Political Impact
Pollution: Burning petroleum products releases large amounts of carbon dioxide and toxic gases, causing air pollution and climate change.

Geopolitics: Major reserves are held in regions like West Asia, making supply security a key factor in global politics.

Crude petroleum (or crude oil) is a naturally occurring, yellowish-black liquid found in geological formations beneath the Earth's surface. It is a complex fossil fuel mixture consisting mainly of hydrocarbons (83-87% carbon, 11-14% hydrogen), formed over millions of years. It is refined into products like gasoline, diesel, and plastics.

Key Characteristics and Components
Composition: Primarily hydrocarbons, with small amounts of sulphur, nitrogen, oxygen, and trace metals like nickel and copper.

Physical State: A thick, viscous liquid that varies in colour and density depending on its composition.

Types: Classified by density (API gravity) as light, medium, or heavy, and by sulphur content as "sweet" (low sulphur) or "sour" (high sulphur).

Formation: Derived from the remains of ancient marine organisms subjected to high heat and pressure over millions of years.

Refining and Usage
Crude oil is not used in its raw form. It is sent to refineries, where it undergoes distillation to separate it into useful fractions, including:
Fuels: Gasoline, diesel, jet fuel, and heating oil.
Petrochemicals: Used to make plastics, synthetic fabrics (polyester, nylon), rubber, and lubricants.
By-products: Asphalt for road construction.

Global Significance
Energy Source: It is the world's most-used energy resource, providing over 90% of global transportation energy.

Trading: Traded globally, with benchmarks like Brent and West Texas Intermediate (WTI) influencing prices.

Impact: While vital for the economy, its extraction and combustion are primary contributors to greenhouse gas emissions and air pollution.

Crude petroleum is extracted from beneath the seabed using advanced offshore drilling rigs, such as semi-submersibles or drillships, which operate in shallow to ultra-deep waters. These rigs bore through the seafloor, utilizing steel pipes and cement to create secure, pressurized paths for extracting oil, which is then transported by pipelines or tankers.

Figure 11: Petroleum by mining.

Key Aspects of Subsea Oil Extraction
Exploration: Seismic surveys, which use sound waves to map underwater geological structures, are conducted to identify potential reservoirs.

Drilling Technology: Drill bits, often equipped with specialized mud to maintain pressure and remove debris, penetrate thousands of meters below the sea floor to reach oil trapped in porous rock layers.

Offshore Rigs: Specialized structures are used depending on depth: jackup rigs (shallow water), semi-submersible platforms, and drill ships (deep water).

Production & Transport: A wellhead is installed on the seabed to control the flow, with oil transported via seabed pipelines or tanker ships to coastal refineries.

Environmental Considerations: The process faces risks regarding potential oil spills in sensitive ecosystems and requires the decommissioning of rigs once production endsthe oil itself is formed over millions of years from the decay of prehistoric microscopic marine life and plants that settled on the seabed.

Asphalt from the sea, or marine asphalt, forms when petroleum seeps from the seabed, losing lighter components and solidifying into deposits. These natural, often toxic, asphalt "volcanoes" and "tar lilies" occur deep in the ocean (e.g., Gulf of Mexico, California coast), creating unique, chemosynthetic ecosystems. It is also found in the Dead Sea.

Key Aspects of Marine Asphalt
Formation: Deep petroleum reservoirs leak, and the resulting, denser hydrocarbons solidify in cold seawater, creating asphaltic structures or "tar volcanoes".

"Tar Lilies" and Volcanoes: Scientists discovered flower-like, solid asphalt extrusions at depths of ~1,900–2,200 meters in the Gulf of Mexico, which form massive, hard structures on the seabed.

Unique Ecosystems: Despite being a natural oil seep, these asphalt structures support thriving communities of mussels, tube worms, and bacteria that live on or around the hardened material.

Figure 12: Underwater petroleum deep sea exploration.

Historical Use: Asphalt from the Dead Sea has been collected for thousands of years, as it frequently rises to the surface and is carried ashore.

Dead Sea Significance
Known as the "Hemar Sea" due to its abundance of asphalt (hemar in Hebrew).

The asphalt is often found as floating lumps in the Dead Sea, which are washed onto the shore.

It has been used for various purposes throughout history, including as a sealant.

Deep Sea Exploration Discoveries
2003-2004: Researchers identified asphalt volcanoes in the Gulf of Mexico (Chapopote).

2014: Scientists found "tar lily" structures at 1,900 meters in the Gulf.

2015: Further exploration of these sites confirmed they act as a carbon source for specialized bacteria.

CONCLUSION

Petroleum from the sea is extracted via offshore drilling, providing roughly 30% of global oil production. It is formed over millions of years from organic matter (phytoplankton, algae) on the seafloor, which is covered by sediment and subjected to intense pressure. Specialized rigs (jackup, semi-submersible, drill ships) drill into the seabed to extract it. Petroleum extraction in the ocean relies on offshore rigs (fixed or floating) to drill into the seabed, utilizing subsea pipelines to transport oil and gas hundreds of miles to coastal refineries. These underwater pipelines are crucial infrastructure, often laying directly on the seabed or buried in trenches, ensuring efficient transport. Offshore drilling is a mechanical process where a wellbore is drilled below the seabed. It is typically carried out in order to explore for and subsequently extract petroleum that lies in rock formations beneath the seabed. Most commonly, the term is used to describe drilling activities on the continental shelf, though the term can also be applied to drilling in lakes, inshore waters and inland seas.

ACKNOWLEDGEMENT

The authors **Amarish J. Patel** and **Mukesh Sharma** were the 1st batch of BPharm of Shri Sarvajanik Pharmacy College, Mehsana [1998-2002] and both of them did their 4th year BPharm project [Amarish J. Patel: *Quinolone antibiotics* and Mukesh Sharma: *Investigation on newer FDA approved anti–HIV agents*] under Dr. Dhrubo Jyoti Sen.

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