Summer Internship Report

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On

Overview of Oil and Gas Exploration and Production Services

at

Oil India Limited, Jodhpur, Rajasthan, India.

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Sincerely,

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Abstract

There are different stages and methods used for the extraction of oil/gas from subsurface to surface in the oil and gas industry.

The production stage in oil extraction refers to the phase in which oil is actively produced from the reservoir and brought to the surface for further processing. Production stage includes various activities in the extraction & recovery of oil.

The exploration stage includes searching for underground/underwater oil deposits in various geological formations. It includes various surveys and identifications.

The chemical stage involves the use of various chemicals during drilling, production, and refining processes to enhance the extraction of oil. It involves the use of chemicals known as Drilling fluids in the oil/gas industry.

The drilling stage is a crucial step in the extraction of oil. It involves creating a wellbore for accessing oil from underground reservoirs. It involves creating a wellbore for accessing oil from underground reservoirs. It involves the use of drilling rigs and various other equipment.

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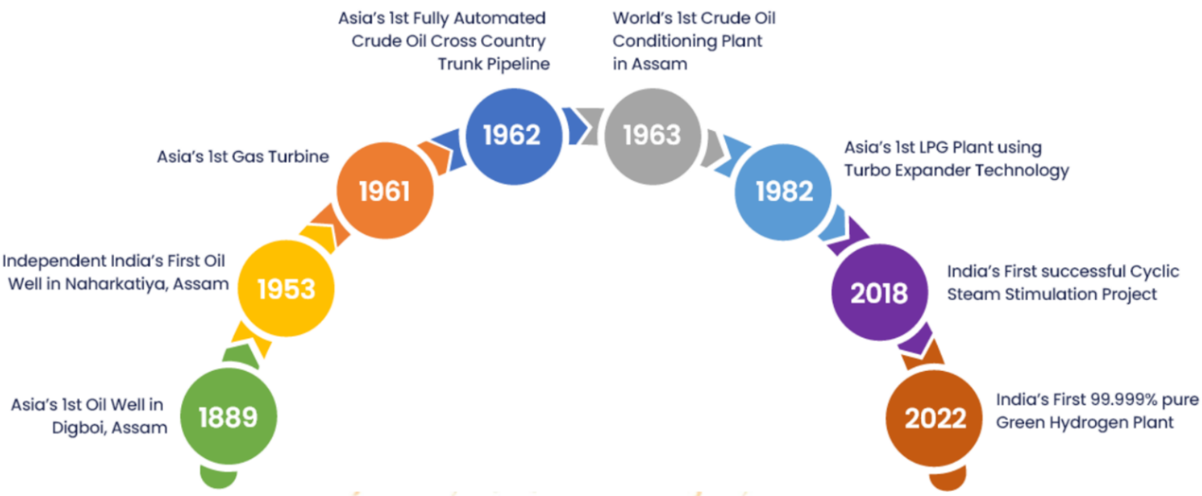
1. About the Company

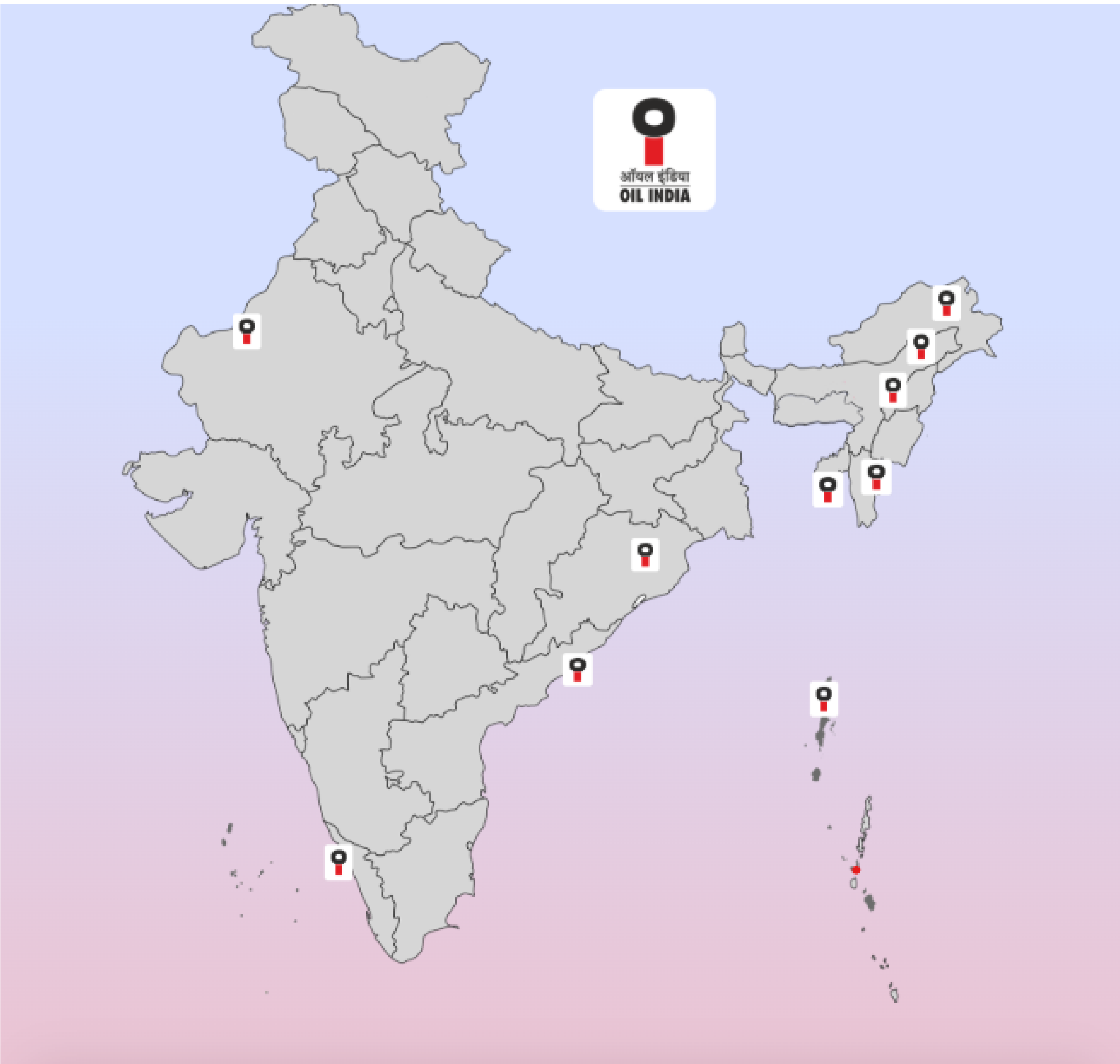
Oil India Limited (OIL) is a fully integrated Exploration & Production company in the upstream sector, with its origin dating back to the glorious year (1889) of oil discovery in India. A Navratna Company, OIL is a state-owned enterprise of the Government of India, under the administrative control of the Ministry of Petroleum and Natural Gas, and is the second largest national oil and gas company in India.

The story of OIL traces and symbolizes the growth and development of the Indian petroleum Industry. From the discovery of the crude oil in the far east of India at Digboi, Assam in 1889, to its present status as a fully integrated National Exploration and Production company with footprints across the entire E&P value chain. The company is India’s second-largest National E&P Company.

Oil India Private Limited was incorporated on 18th February 1959, to expand and develop the newly discovered oil fields of Naharkatiya and Moran in the North-Eastern region of India. In 1961, it became a joint venture company of the Government of India and Burmah Oil Company Limited, UK. In 1981, OIL became a wholly owned Government of India enterprise.



Today, OIL is a vertically integrated E&P company possessing rich expertise in the entire upstream E&P value chain, including Seismic API, Drilling, Wireline Logging, Field Development, Production, Reservoir Management, IOR/EOR & Pipeline Laying. OIL's current E&P infrastructural support resources include 2D/3D Seismic crews, 10 Logging Units, 28 Workover Rigs, and 19 Drilling Rigs.



Operating	No. of Blocks	Acreage (Sq Km)
PML (Nom)	25	4,821
PEL (Nom)	1	23
NELP	2	3,609
DSF	3	208
OALP	28	52,389
Total	**59**	**61,050**

1.1 Rajasthan Field

OIL has significantly expanded its operational footprint in the state of Rajasthan. OIL commenced exploration for hydrocarbons in the midst of the Thar Desert of Rajasthan in the early eighties. Rajasthan Project (RP) was set up in 1983, PEL was granted effective from January 1985, and the first Seismic Survey was commenced in the same year. This expansion is a testament to OIL's commitment to meeting the growing energy needs of India and contributing to the economic development of the region. The company has been actively involved in tapping Rajasthan's vast hydrocarbon potential. These areas have emerged as critical zones for oil extraction, with substantial reserves contributing to India's energy security.

HISTORY

The project was set up in 1983.

Petroleum Exploratory License (PEL) awarded in 1985 for two basins.

Jaisalmer Basin

- 1985: Started Seismic Survey.
- 1988: First Exploratory Drilling & Discovery of Tanot Field.
- 1990: Discovery of Dandewala Field.
- 1994: Discovery of Bagitibba Field.
- 1996: Set up of DND-GPC.

Bikaner Nagaur Basin

- 1985: Started Seismic Survey.
- 1991: Discovery of Heavy Crude Oil.
- 2006: First Pilot CSS.
- 2017: Commercial Production Started.
- 2017: 1st Successful CSS.

Baghewala Heavy Crude

The Rajasthan field has been producing heavy crude oil from its Baghewala field since 2017. At present, in the Baghewala field, 35 wells have already been drilled, out of which 23 wells are in production.

The wells are produced with the help of sucker rod pumps (SRPs) and the produced crude is stored in tanks at individual well locations. The utilization of SRP as an artificial lift technique along with CSS (Cyclic Steam Stimulation) as a thermal EOR technique has been found to be the most effective way to produce heavy oil in Baghewala Field. Accordingly, most of the wells in Baghewala are thermally completed using thermal wellheads, VIT(Vacuum Insulated Tubings), and are produced using conventional as well as hydraulic SRP units.

The crude oil stored in the tanks is heated with the help of steam and hot water generated by the Mobile Steam Generator for flowability enhancement and is then pumped onto Bowsers. The crude oil is then transported to ONGCL's North Santhal CTF at Mehsana, Gujarat, for processing and further transportation to IOCL's Koyali refinery through their pipeline. OIL has a COTA (Crude Oil Transport Agreement) with M/s ONGCL for crude oil handling, processing, and transportation. OIL has a COSA (Crude Oil Sales Agreement) with M/s IOCL for the sale of crude oil.

Dandewala Natural Gas

OIL had discovered commercially viable gas fields at Tanot, Dandewala, and Bagitibba in the Jaisalmer District of Rajasthan. These fields are located at a distance of approximately. 120 kms. Northwest of Jaisalmer town.

The Dandewala-Gas Processing complex is located about 35 km from Tanot. Gas produced from the wells at Dandewala and Bagitibba Fields are collected at the central location Dandewala Gas Processing Complex (DND-GPC).

The processed gas is then metered using the custody transfer meter and then dispatched to GAIL India Limited for further distribution to the final customer, RRVUNL. Pipeline Distance from DND – GPC to RRVUNL 65 KM.

The existing Natural Gas process plant of DND-GPC is capable of treating the raw Natural Gas to remove formation water, heavy hydrocarbons, and moisture. OIL has a Gas Sale Agreement with M/s GAIL INDIA LIMITED for the sale and purchase of natural gas in Rajasthan.

Current Acreage

- OIL has 03 Mining Leases.
- For Heavy Oil - Bhagewala.
- For Gas – Jaisalmer & Bakhritibba Till date, OIL has acquired around 18200 LKM of 2D Seismic Data & 5000 sq. km of 3D Seismic Data. OIL has a current acreage of 6868 sq. km in Rajasthan.
- The Dandewala field has been developed significantly, where 37 wells have been drilled so far. Average gas potential is around 0.85 MMSCMD.
- Baghewala field operating under Baghewala PML with an area of 200 sq. km is in the development phase. Currently, 35 wells have been drilled, and the total oil production is above 600 barrels/day.

Future Prospects

- The Bakhritibba Area has been acquired in the DSF-III Round, where drilling is scheduled to start from July 2024. It is expected to come into production in 2024-25.
- Exploitation of Upper Carbonate.
- OALP blocks of Jamba and Nagrasar.

2. Department (Production)

2.1 Petroleum Policies in India

Ministry of Petroleum and Natural Gas (MoPNG)

The Ministry of Petroleum and Natural Gas (MoPNG) is a ministry of the Government of India responsible for the exploration, production, refining, distribution, marketing, import, export, and conservation of petroleum, natural gas, and petroleum products. MoPNG formulates and implements policies, laws, and strategic frameworks to ensure the country's energy security while encouraging private and foreign participation.

It oversees key PSUs such as ONGC, OIL, IOCL, BPCL, HPCL and regulates the upstream sector through bodies like the Directorate General of Hydrocarbons (DGH).

Directorate General of Hydrocarbons (DGH) -

The Directorate General of Hydrocarbons (DGH) is a key technical body under the Ministry of Petroleum and Natural Gas (MoPNG), Government of India. It was established in 1993 to oversee and regulate the exploration and production of India's oil and gas resources in an efficient, safe, and transparent manner.

Headquarters – Noida , Uttar Pradesh

DGH acts as the regulatory and advisory agency for the upstream petroleum sector (exploration and production). Its primary responsibilities include:

- Managing exploration and production (E&P) activities in India
- Assisting MoPNG in policy formulation
  Monitoring the implementation of production sharing contracts (PSCs)
- Promoting private and foreign investment in the oil and gas sector
- Conducting technical evaluations of oil and gas blocks
- Supervising data acquisition, interpretation, and reservoir management
- Maintaining and operating the National Data Repository (NDR)

Policy	Year Launched	Issued By	Key Features	Current Status	Remarks / Linked Policies
PEL (Petroleum Exploration License)	1948	MoPNG / State Govts	License to explore hydrocarbons in a defined block; typically valid for 7 years (extendable).	Active	First stage of upstream operations, before PML
PML (Petroleum Mining Lease)	1948	MoPNG / State Govts	License to produce hydrocarbons commercially from a discovered field; valid for 20–30 years.	Active	Issued after successful exploration under PEL
NELP (New Exploration Licensing Policy)	1999	MoPNG	Opened India's E&P to private and foreign firms; bidding system; profit-sharing model with cost recovery.	Discontinued (2015)	Replaced by HELP
HELP (Hydrocarbon Exploration and Licensing Policy)	2016	MoPNG	Revenue-sharing model; single license for oil, gas, CBM, shale; open acreage; market pricing freedom.	Active	Replaced NELP; umbrella policy now
OALP (Open Acreage Licensing Policy)	2017	DGH / MoPNG	Part of HELP; allows companies to bid for blocks anytime via Expression of Interest (EOI); auction cycles are bi-annual or annual.	Active	Operational via HELP and supported by NDR
DSF (Discovered Small Fields)	2015	MoPNG / DGH	Monetization of small/marginal oil and gas fields; simplified contractual terms to encourage small players.	Active	Fields mostly relinquished by ONGC/OIL
NDR (National Data Repository)	2017	DGH / MoPNG	Digital archive of India's geological, seismic, and well data; helps companies evaluate blocks before bidding.	Active	Supports OALP and enhances transparency

2.2 Enhanced Oil Recovery (EOR)

Crude oil recovery takes place in three production stages: primary, secondary, and tertiary oil recovery processes. On average, oil recovery from the primary and secondary production stages is approximately one-third of the original oil-in-place (OOIP), while the remaining two-thirds of the oil, can be partially recovered through the application of tertiary processes also known as enhanced oil recovery (EOR) processes, which are key drivers for incremental oil recovery. EOR processes include thermal (TEOR), chemical (CEOR), gas flooding, miscible and immiscible (GEOR), and microbial or MEOR processes.

Stage	Description	Recovery Factor
Primary Recovery	Utilizes the natural energy of the reservoir, such as: – Solution gas drive – Gas cap drive – Water drive – Gravity drainage	10-20%
Secondary Recovery	Involves external injection of water or gas to maintain reservoir pressure and push oil toward production wells	20-40%
Tertiary Recovery (EOR)	Applies advanced techniques like injecting steam, gas (CO_2), or chemicals to extract remaining trapped oil	40-60% or Higher

Cyclic Steam Stimulation (CSS) : A Thermal EOR Technique

Cyclic Steam Stimulation (CSS), often referred to as the 'huff-and-puff' method, is a thermal Enhanced Oil Recovery (EOR) technique widely used for the extraction of heavy and highly viscous crude oil. Cyclic steam stimulation was discovered by accident in the MeneGrande field in Venezuela in 1959 when steam broke out behind casing in a steam-injection well.

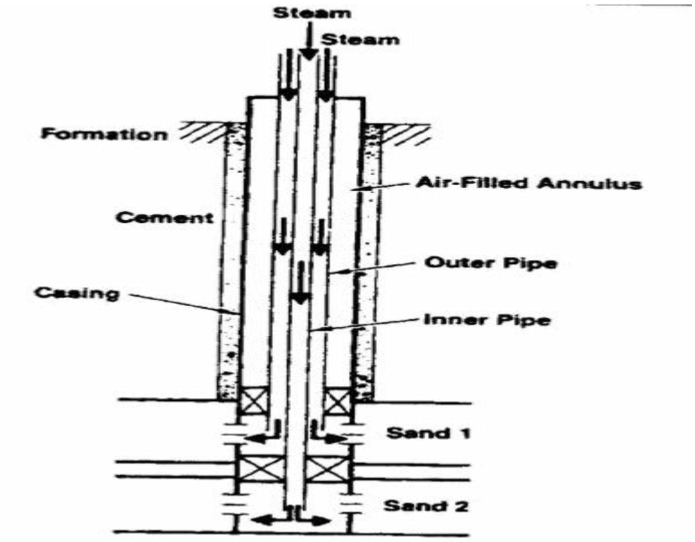
CSS consists of three primary phases:

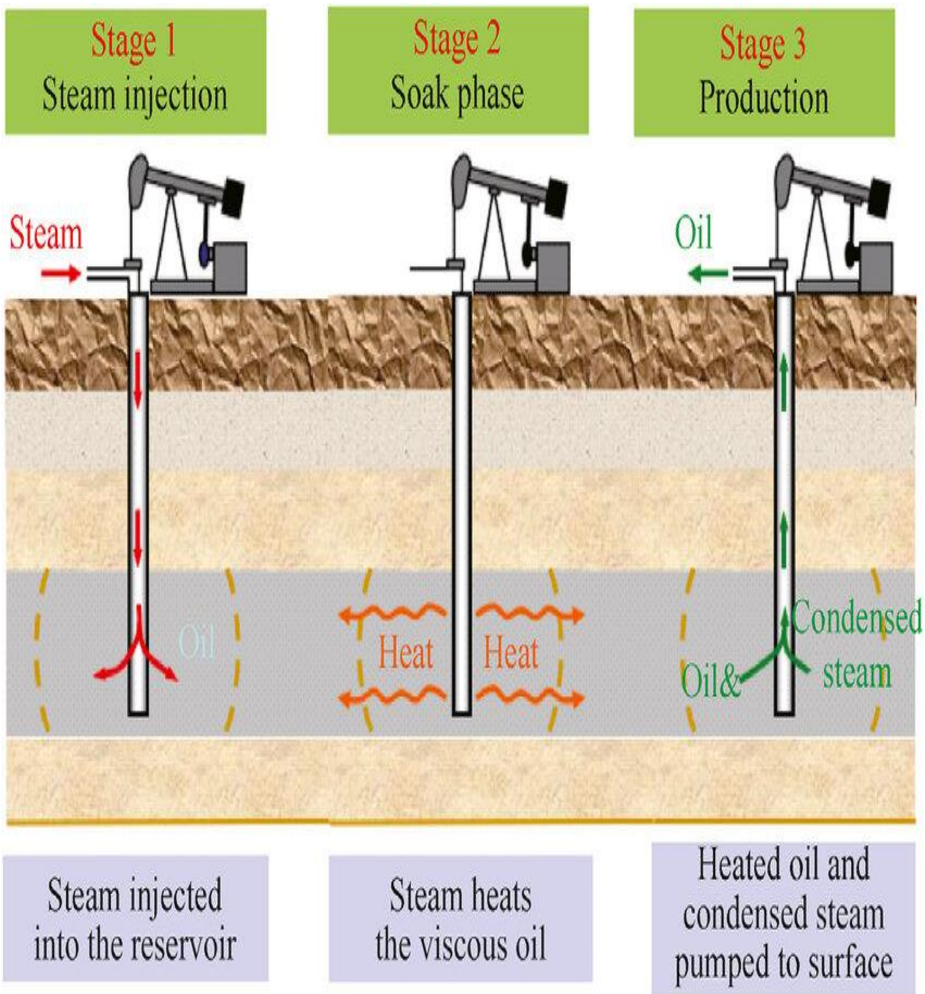
• **Steam Injection**: High-temperature steam (300–350°C) is injected into the well for 5 to 15 days.

• **Soaking**: The well is shut in for several days to allow heat to reduce oil viscosity.

• **Production:** Heated and mobilized oil is produced from the same well over weeks or months.

Concentric steam injection well



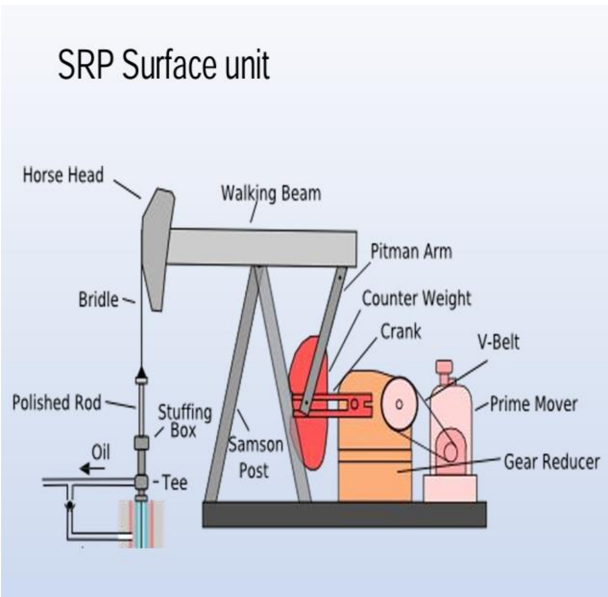


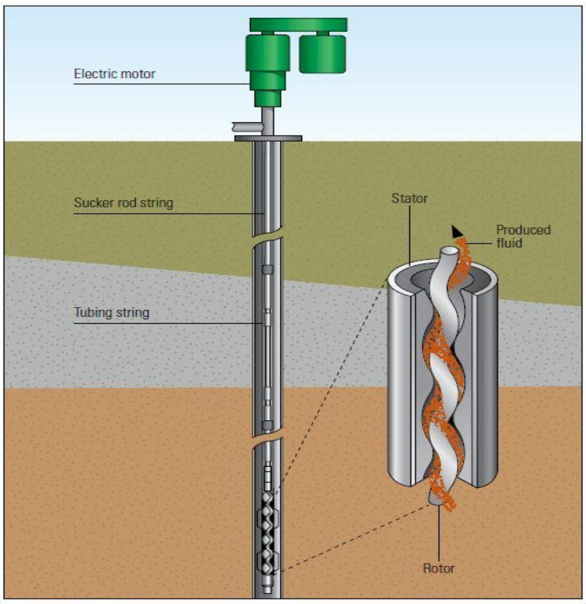
2.3 Artificial Lift

Artificial Lift is a method used in the oil and gas industry to increase the flow of hydrocarbons from a well when the natural reservoir pressure is insufficient to lift the fluids to the surface. It is essential for maintaining or boosting production in mature fields or in wells with low pressure.

Artificial lift is crucial in the oil industry, with over **90% of wells** worldwide relying on it at some point in their lifecycle. Advances in automation (e.g., IoT sensors, AI-driven optimization) are improving efficiency and reducing downtime.

Lifting Methods	Working	Field usage & Usability
SRP (Sucker rod pump)	Surface motor drives a downhole plunger via a rod string, lifting oil to surface.	Low-to-medium depth wells with low gas content. Widely used in Assam fields.
ESP (Electric submersible pump)	Multi-stage centrifugal pump placed downhole; lifts large fluid volumes.	Deep wells and high-volume producers like some in Rajasthan.
PCP (Progressing cavity pump)	Helical rotor and stator pump used for viscous fluids and sand-laden oil.	Suitable for heavy oil fields like Baghewala.
Gas Lift	High-pressure gas is injected into the tubing to reduce fluid density and help lift oil.	Flexible and used in deviated wells; suitable for Assam where gas is available.

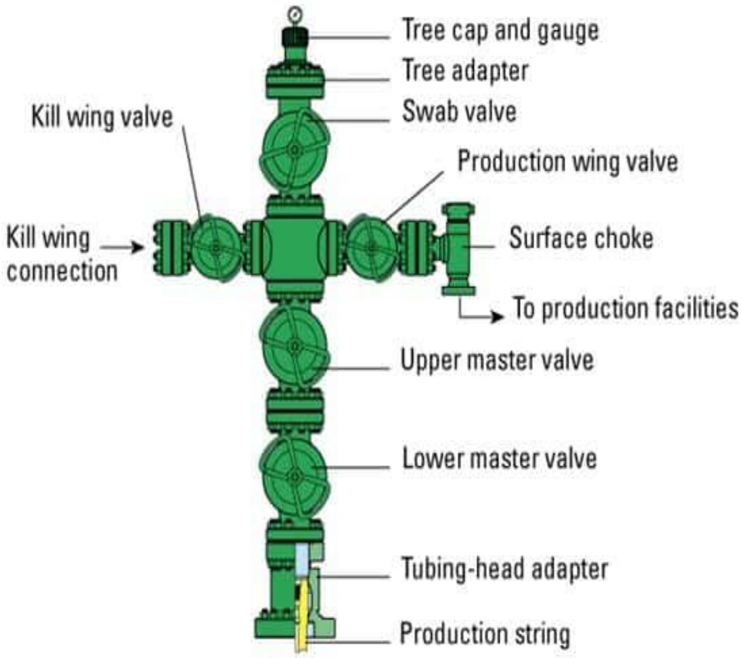




2.4 Christmas Tree

The X-Mas tree is a valve assembly installed immediately above the tubing head spool to control the flow from the well. The X-Mas tree usually consists of one top valve, a Cross piece, and a bean body. The bean body accommodates the bean housing and the housing.

The X-Mas tree used by OIL INDIA LIMITED is rated at 3000psi, 5000psi, and 10,000psi. The X-Mas tree also provides means for wireline operations.



3. Department (Rajasthan Basin)

OIL's systematic and scientific approach to exploration has been rewarded with a high success ratio of 65% of exploratory wells drilled. OIL also possesses 2D and 3D seismic data acquisition capabilities, with excellent support services ranging from satellite navigation systems to remote blasting units.

OIL owns a vast array of advanced computing systems and experienced personnel to process and interpret geo-scientific data through integrated exploration applications such as Remote Sensing, Structural and Stratigraphic Interpretation, Seismic Attribute Analysis, Source Rock Evaluation, Biostratigraphy, Petrophysics, Sequence Stratigraphy, Basin Analysis, Techno-economic Evaluation, etc. Formation evaluation through an integrated approach of geological, geophysical, geochemical, and reservoir engineering studies has allowed OIL to develop and exploit deep (3500-4700m) thin sand prospects. Today, these reservoirs contribute over 50% of OIL's production. It is envisaged that the current introduction of extensive 3D seismic will assist in reservoir management in both new as well as ageing fields, heralding a new chapter in reservoir engineering studies. OIL has so far acquired, processed, and interpreted over 70,000 line km of 2D and 5,000 sq. km of 3D seismic data in a variety of terrains, including hills, deserts, rivers, marshes, etc.

3.1 Exploration and Production Cycle

INTRODUCTION

The oil and gas sector comprises three main activities:

- Upstream (exploration and production)
- Midstream (transportation and processing)
- Downstream (distribution and sale to end users/consumers)

EXPLORATION AND PRODUCTION CYCLE IN THE UPSTREAM SECTOR

In the Upstream sector, the Exploration and Production (E&P) life cycle has four phases:

1. **Exploration Phase-**

In this phase, exploration is done for potentially viable oil/gas resources through geological surveys. Land surveys are performed to identify the areas that are the most promising. The government grants access to firms to explore potential oil fields. In India, prior to the implementation of the New Exploration Licensing Policy (NELP), Petroleum Exploration License (PEL) has been granted to National Oil Companies, Viz. Oil and Natural Gas Corporation Ltd. (ONGC) and Oil India Ltd. (OIL) on a nomination basis. For the Pre–NELP Discovered Fields, a Petroleum Mining License (PML) has been granted under a small/medium-sized discovered field Production Sharing Contract (PSC). Pre-NELP Exploration Blocks have been awarded to private companies as well. Since 1999, the New Exploration Licensing Policy (NELP) has been in place, under which exploration blocks have been awarded through an international competitive bidding process. Under the Discovered

Small Field (DSF), discoveries have been awarded under the Revenue Sharing Model. The Government has adopted the Hydrocarbon Exploration and Licensing Policy (HELP) since 2017, using the Open Acreage Licensing Policy (OALP). On exploration, often no potentially viable oil/gas sources are discovered, and operations are terminated. On the instances where potentially viable oil/gas are identified, investment is made in the technical and commercial component of exploration, and in social and environmental impact assessments.

2. **Appraisal Phase-**

The sites identified as potentially viable oil/gas sources are examined in further detail. Infrastructure may be developed to access the sites. Site drilling is planned, and exploratory wells are drilled to seek to map oil/gas reserves. The companies may engage with communities, depending on the location of the field, as their operations impact the local environment and economy. If no commercially viable oil/gas is identified, operations will be terminated. Where oil/gas reserves are deemed commercially viable, exploration companies will prepare to develop the site.

3. **Development Phase-**

The field is prepared for production in this phase. Government contracts and permits may be revised/renewed. Limited infrastructure and site development will already be in place as part of 5 the exploratory and initial drilling phase, but during the field development phase, the activity will increase and the first oil/gas will be produced towards the end of this phase.

4. **Production Phase-**

Oil/gas reserves are being extracted and transported for processing and distribution. There is uncertainty in any field about the amount of oil/gas, so it can be difficult to predict the volume of production which will fluctuate across this phase, with the rate of extraction typically rising to a peak and tapering off towards the end of the field's commercial lifetime

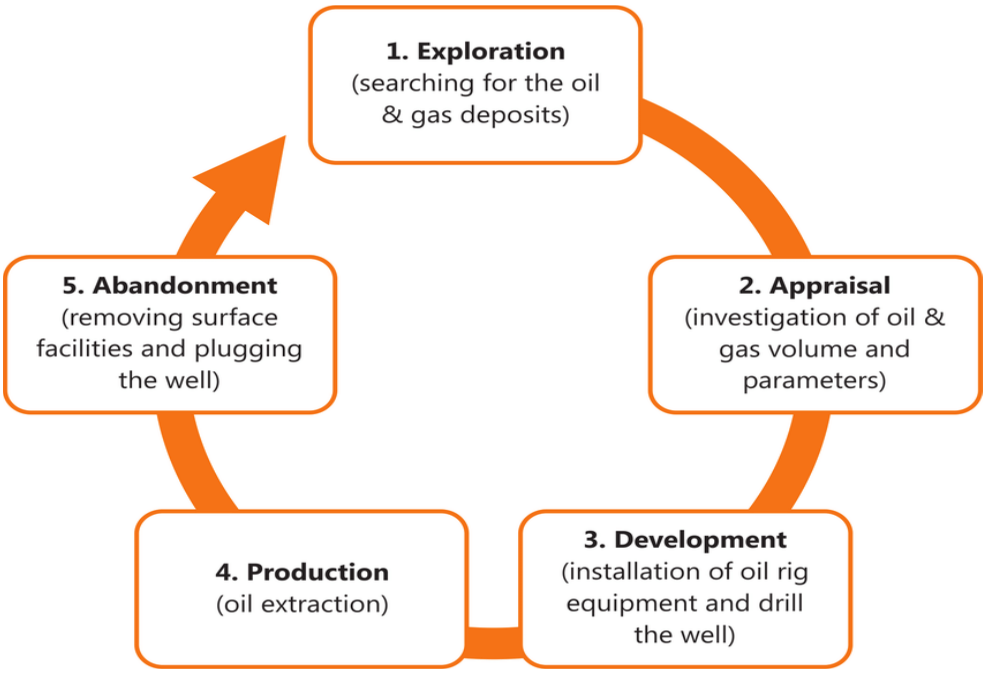


Figure 1: Exploration and Production cycle.

3.2 Seismic Data Acquisition

INTRODUCTION

The initial stage in seismic prospecting is seismic data acquisition. It entails gathering raw data from the field with the use of field devices and procedures. Seismic acquisition necessitates the use of a seismic source at predetermined locations for a seismic survey, and the energy that travels within the subsurface as seismic waves generated by the source is recorded at predetermined locations on the surface by receivers (geophones or hydrophones).

3D SEISMIC

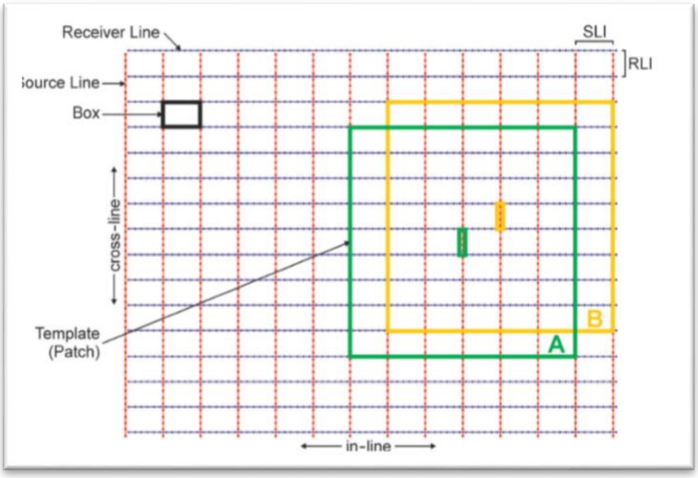


Figure 2: 3-D survey layout

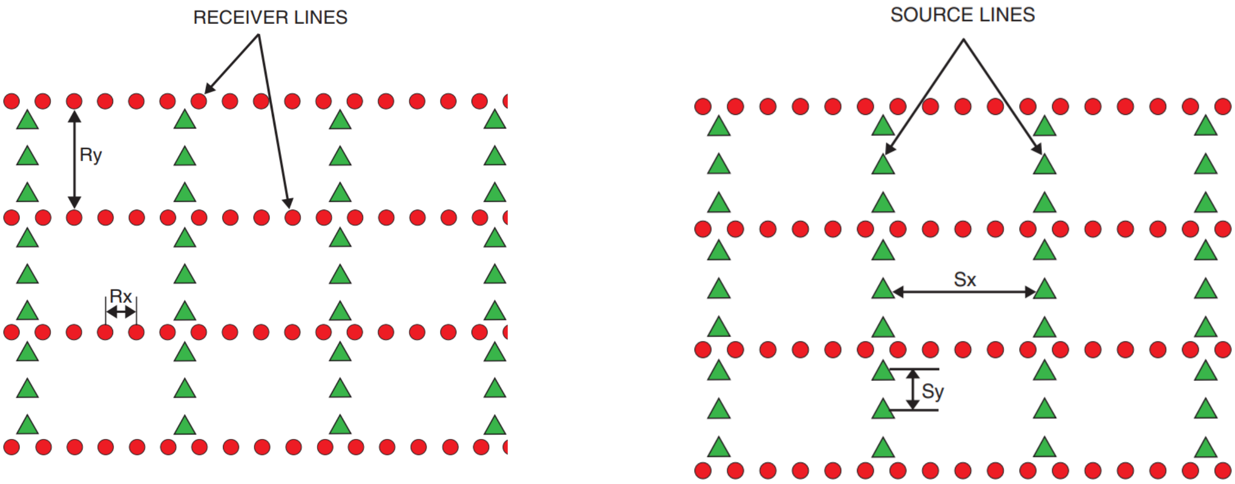


Figure 4: Source and receiver lines spacing, and source and receiver intervals.

3D SURVEY PLANNING

Seismic data collecting projects necessitate the formalisation of a systematic work plan. In essence, we are discussing the Physical and Technical planning done by the team and its implementation here. The planning components of the seismic survey operation begin as soon as the plan for the region to be covered with seismic surveys is obtained from the geological department, which is usually three to four months before the actual recording activities.

1. **Logistic Constraints**:

Logistic constraints are the first to be discussed in the planning. Here accessibility and topography of the area to be covered and cultural sensitivity in and around the area are discussed. Also means to overcome these constraints are discussed here.

2. **Selection of 2D or 3D Seismic Reflection Survey:**

Selection of 2D or 3D depends on the logistic constraints and the geological objective of the survey as provided by the geological department. In a virgin area with poor accessibility and difficult topography we generally will go for 2-D seismic reflection survey. In an area where 2-D seismic reflection survey have been carried out earlier and in case if we need precise structural or stratigraphic information, we will opt 3D seismic reflection survey.

3. **Selection of Equipment**:

Equipment to be used for the seismic survey is selected considering the accessibility and topographic condition of the prospective area. In case of rough topography, water or forest covered area and poor accessible area where laying the cables is challenging, radio telemetry is used. Otherwise, we generally opt for line telemetry.

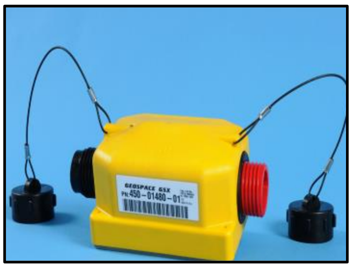
4. **Selection of Acquisition Geometry and Parameters:**

Standard procedures were followed to decide on the various acquisition parameters. We approached to selection of acquisition parameters for seismic surveys as a two-step.

- Pre-survey Design (Preliminary Inputs)
- Detailed Design (finalizing the acquisition geometry and parameters)

Pre-survey design primarily involves gathering of various available information viz. exploration objectives, review of existing geo-scientific data, socio-cultural data from the operational area including logistics and so on. The pre-survey design sets the constraints in terms of fold, offset & azimuth distribution, bin size (in 3D) etc. i.e., sets the preliminary inputs to the survey designing. A large number of geometries are simulated based on the technical requirement as observed in the pre-survey design which serves as the input to the second step i.e., detailed design. The detailed design process incorporates the choice of critical acquisition parameters such as shooting pattern, spacing of shots, shot lines and receiver-lines as well as the inline and cross-line spread length that are consistent with the broad technical requirement as observed during the pre-survey design process.

INSTRUMENTS FOR SURVEYING

NAME OF THE INSTRUEMENT	INFORMATION	FIGURE
GSX Box **Battery**	The GSX is made for wireless seismic data gathering on land without the use of cables or radios. One to four channels of 24-bit digitisation, a built-in high-sensitivity GPS receiver, a built-in test signal generator, up to 32 GB of non-volatile solid-state data storage per channel, and a high-speed data interface are all features of the standalone GSX Land Based Recorder unit. The device has a data port connector, an input connector, an extended life **battery,** and a sealed enclosure.	 
GEOPHONE	**Geophone**, trade name for an acoustic detector that responds to ground vibrations generated by seismic waves. Geophones—also called jugs, pickups, and tortugas—are placed on the ground surface in various patterns, or arrays, to record the vibrations generated by explosives in seismic reflection and refraction work.	

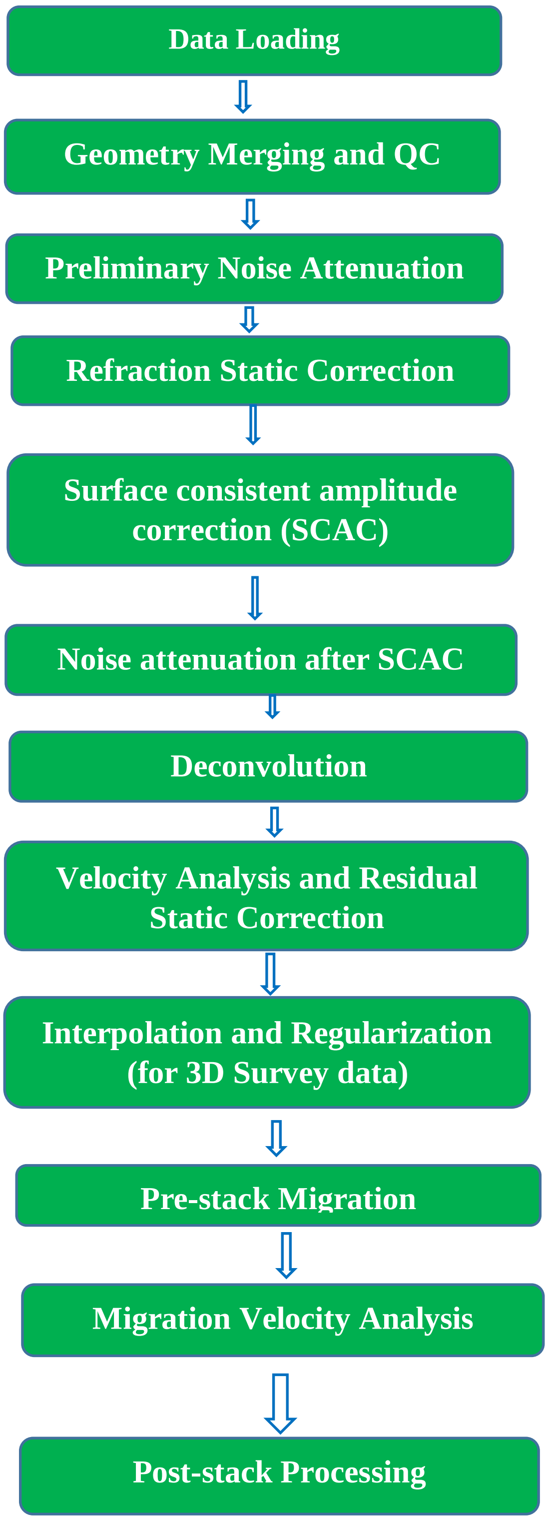
BLASTING UNIT	The blaster box can also be used in Legacy Mode with conventional VHF radios. In this mode, the blaster box is compatible with the previous generation of blasters like the blasting Unit. The central recording system controls all the shooters via VHF radio link. Start Messages, Ready Messages, and Shot Quality Control (PFS) messages are all sent via the VHF radio link. The up hole data, GPS position, and accurate GPS shot times are acquired "real time" on the central computer.	 
HARVESTING UNIT		 

3.3 Seismic Data Processing

INTRODUCTION

Raw seismic data from 2D or 3D multichannel seismic datasets is processed using several complex data-processing steps consisting of a number of sequential mathematical processes. The output of the seismic data processing is a Seismic Section which is an image of the layers of the subsurface and velocity structure of the subsurface.

Seismic Processing Workflow



3.4 Reservoir Geophysics

INTRODUCTION

Reservoir characterization is a tool to estimate fluid and rock properties in the reservoir. It involves the utilization of data from different resources of Geosciences viz. Well Logging, Geology & Geophysics and Reservoir Engineering. This study mainly deals with Reservoir Characterization using AVO Analysis and Pre-Stack Seismic Inversion methods.

These methods are used to simulate the behaviour of the fluids within the reservoir under different sets of circumstances. It is one of the most important components of seismic data interpretation. It has been demonstrated that the seismic reflections vary with offset, due to changes in the angle of incidence and are evident in pre-stack CMP gathers.

A reservoir geophysics study generally focuses on a specific target, makes use of legacy seismic data calibrated to wells, and employs models of the seismic petrophysical responses of various scenarios anticipated in the reservoir. As a result, a reservoir geophysics study could collect that data, and only that data, which will be required to observe the features of interest. For example, one could acquire only far-offset seismic data if one were convinced that the far offsets contained all the information that was essential to the study. It is not clear that such highly focused approaches are being used, which is true probably because the cost savings do not warrant the added risk of missing an important piece of data. There may also be a natural aversion to purposefully collecting data that are not as “good” or “complete” as conventionally-acquired seismic data.
Characteristics of reservoirs-

1. Porosity: - Porosity is the percentage of void space in a rock. It is defined as the ratio of the volume of the voids or pore space divided by the total volume. It is written as either a decimal fraction between 0 and 1 or as a percentage. For most rocks, porosity varies from less than 1% to 40%.
2. Permeability: - It describes how the pore spaces are interconnected.
3. Hydrocarbon saturation: - It describes the nature of the fluids filling the pore spaces and saturation state.
4. Drive: - It is the pore pressure that causes the fluid to flow.

Apart from these characteristics, there are also other characteristics, for example, sealing faults and stratigraphy, etc.

PORE PRESSURE

Pore pressure is defined by the pressure exerted by the fluid present in the reservoir. When this pore pressure is very high with comparison to hydrostatic pressure, then it is termed as overpressure, and if it is less than hydrostatic pressure, then it is termed as underpressure.
Hydrostatic pressure is defined as the pressure predicted at a depth that is exerted by a column of freshwater from sea level.

$$p=\rho gh$$

Here, p= hydrostatic pressure, ρ=density of fluid, g=acceleration due to gravity, h=height from the surface.

Presence or withdrawal of water and hydrocarbon can produce overpressure and under pressure. Fracture pressure and its gradient are important in planning well-drilling programme. The estimation of pore pressure is important for well planning.

We can get an idea about the fluid content in the subsurface by looking at the pressure gradient of the particular fluid. With the increase of depth, the pore pressure increases due to compaction and other factors. Though the pore pressure will increase the pressure gradient of the fluid will be the same. If we drill two wells say well 1 and well 2. We can look at the diagram that the water and gas are following a particular trend of the gradient by which we can predict the fluid present. By looking at the trend we can also recognize the contact present in the subsurface. In the portion where the gradient is changing, we can say there is a contact.

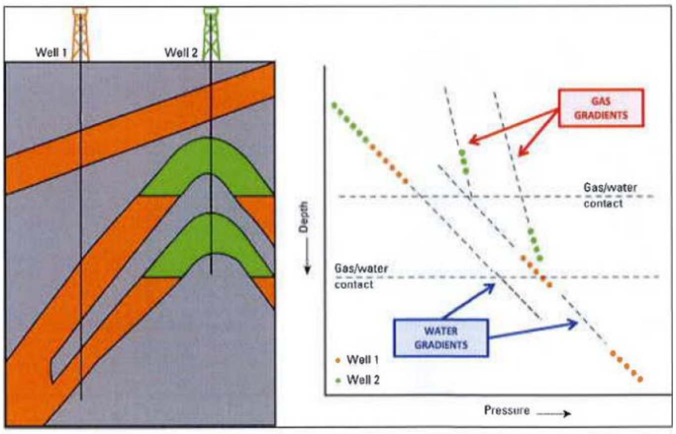


Figure 24: Recognizing the contacts

GENERATION OF OVERPRESSURE

Different factors contribute to the pore pressure scenario. An increase in stress, water release, temperature increase is some of the factors.

1. **Increase in Stress**

The situation when sediments are unable to expel their pore fluid in response to compaction is known as disequilibrium compaction. Mostly found in low permeable rocks like clay, shale. When there is high horizontal stress which results in partial dewatering and thus creates overpressure.

2. **Aquathermal expansion**

It also plays a crucial role in creating overpressure. Due to the heat produced by radioactive decay with increasing depth temperature increases.

3. **Tectonic Compression**

When there is an incomplete dewatering due to high horizontal stress then there is a creation of over pressure. Horizontal compression is significant in collision boundaries. The increase in horizontal stress is therefore the result from tectonic forces.

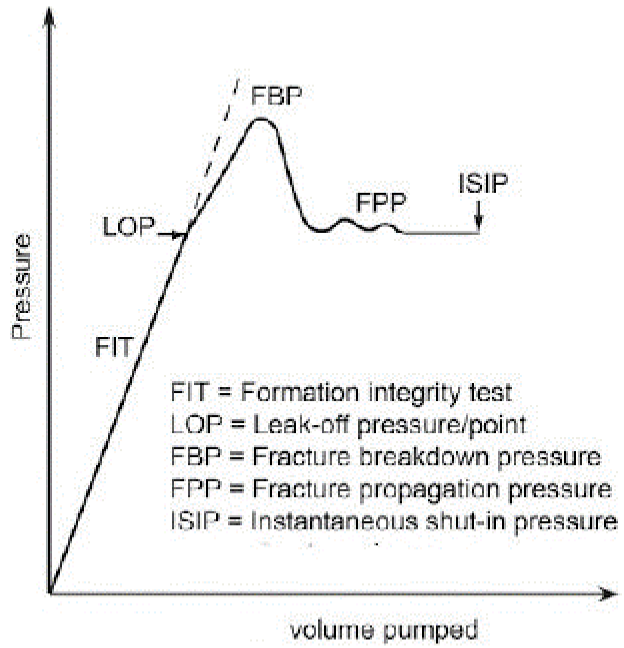
4. **Chemical Processes**

Temp-controlled reaction of gypsum at around 40-60o C, transforming to anhydrite results in loss of bound water, thereby, thought to be an important mechanism to generate overpressure in evaporate section during shallow in excess of overburden pressure at around 1 km.

Importance of pore pressure information- This information is very critical for well planning and drilling. Fracture pressure is the pore pressure above which there will be fractures in the formation. While drilling a well we have to take care that the mud weight should be in between fracture pressure and pore pressure of the formation. The effective stress is conventionally defined to be the subtraction of pore pressure from overburden stress. The increase in overpressure causes reduction in the effective stress. The mud weight should be appropriately selected based on pore pressure gradient. As discussed earlier overpressure develops by many processes such as sediment compaction, tectonic compression, faulting etc.

Leak Off Test- Leak Off Test is conducted in order to find the fracture gradient of certain formation at casing shoe depth. The results of the leak off test also dictate the maximum equivalent mud weight that should be applied to the well during drilling operations.

Formation Integrity Test- Formation Integrity Test is a method to test strength of formation and shoe by increasing Bottom Hole Pressure (BHP) to designed pressure. FIT is normally conducted to ensure that formation below a casing shoe will not be broken while drilling the next section with higher BHP or circulating gas influx in a well control situation. Normally, drilling engineers will design how much formation integrity test pressure required for each hole section.



3.5 Well Logging Operations

Well logging is a vital component of formation evaluation, providing essential data for reservoir characterization and development decisions. This technique involves lowering specialized instruments into the wellbore to measure the physical and chemical properties of rock formations and their fluids, offering critical insights into subsurface conditions.

Fundamentals of Well Logging

Well logging, also known as borehole logging, serves multiple purposes in oil and gas operations. Its primary objectives include identifying hydrocarbon-bearing formations, determining reservoir properties such as porosity, permeability, and saturation, assessing formation lithology and structure, evaluating completion zones, monitoring production performance, and supporting reservoir management decisions. The process entails lowering logging tools on a wireline to record continuous measurements against depth, providing indirect information about formation properties that cannot be directly observed. Key logging parameters include natural gamma radiation, electrical resistivity, bulk density, photoelectric factor, neutron porosity, acoustic properties via sonic logs, formation 12 imaging, nuclear magnetic resonance, and pressure and sampling data. These measurements collectively enable a comprehensive understanding of subsurface conditions.

Types of Logging Operations

Well logging operations are classified into four main types based on industry practices and ONGC procedures. Open hole logging, conducted before casing installation, provides comprehensive formation evaluation through basic log suites and specialized measurements, critical for completion design decisions. Cased hole logging, performed after casing installation, focuses on production monitoring, including production logging and cement evaluation, and supports workover planning. Logging While Drilling (LWD) offers real-time measurements during drilling, enabling geosteering in horizontal wells, immediate formation evaluation, and reduced non-productive time. Measurement While Drilling (MWD) provides drilling parameters and directional data, facilitating real-time drilling optimization and safe operations through formation pressure measurements. Common log types include Spontaneous Potential (SP), Gamma Ray (GR), various resistivity logs, density-neutron combinations, Photoelectric Factor (PEF), sonic logs for compressional and shear waves, Formation Micro Imager (FMI), and Nuclear Magnetic Resonance (NMR).

Log Interpretation and Analysis

Log interpretation is a complex process requiring expertise in geology, petrophysics, and reservoir engineering. Basic interpretation involves quality control and environmental corrections, lithology identification using gamma ray and photoelectric factor data, porosity calculation from density neutron logs, water saturation determination using resistivity data, permeability estimation from porosity and lithology, net-to-gross ratio calculation, and reserve estimation with completion recommendations. Advanced techniques include multi-well correlation for structural interpretation, rock typing and flow unit identification, fracture detection and characterization, stress analysis for completion design, and time-lapse logging for production optimization. These results inform reservoir characterization, modeling, completion design, production forecasting, development planning, enhanced recovery implementation, and environmental impact assessments. 13 Modern interpretation leverages sophisticated software and integrated workflows, combining logging, seismic, and production data for a comprehensive reservoir understanding.

4. Department (Chemical)

4.1 Drilling Fluids

It is a medium suitable for carrying out efficient and effective drilling operations and to impart borehole stability for performing various operations necessary for the exploration and exploitation of hydrocarbons.

TYPES OF DRILLING FLUIDS:

The most common classification of drilling fluid is:

- **Water base (WBM):** In this system, water is the continuous medium.
- **Oil base (OBM):** In this system, oil is the continuous medium.
- **Pneumatic system:** Air or Foam is used as a fluid for the circulating medium.

FUNCTIONS AND CHARACTERISTICS OF A DRILLING FLUID:

- Suspend and carry cuttings
- Effective cleaning of the hole
- Control formation pressure by balancing it with the hydrostatic pressure of the mud
- Cool and lubricate the drill string and bit
- Transmit hydraulic energy to tools and the bit
- Prevent ball-balling
- Seal permeable formations by forming a thin filter cake
- Support the drill string and casing weight by the effect of buoyancy.
- Maintain pH
- Facilitate logging
- Facilitate cementing

WATER BASE MUD:

Fresh water is the main medium. It is further classified as:-

- **Nondispersed - noninhibited systems:** Do not contain inhibiting ions such as chloride (Cl^-), calcium (Ca^{2+}), or potassium (K^+) in the continuous phase and do not utilize chemical thinners or dispersants to effect flow control. E.g.: Bentonite muds.
- **Nondispersed-inhibited systems:** Do contain inhibiting ions, but do not utilize chemical thinners or dispersants. KCl-polymer muds.
- **Dispersed-inhibited systems:** Contain both chemical dispersants and inhibiting ions. Lime muds.
- **Dispersed-noninhibited systems:** Utilize chemical thinners or dispersants, but do not contain inhibiting ions. Lignite-lignosulfonate muds.

Testing of drilling fluids:

API has presented a recommended practice for testing liquid drilling fluids. These tests were devised for the CHEMIST / MUD ENGINEER to determine whether the drilling fluid is performing its functions properly.

The following parameters are required to be determined:

- Mud weight
- Marsh funnel viscosity
- Rheology (Apparent viscosity, Plastic viscosity, Yield point.)
- Gel strength (0 min gel,15 min gel)
- Fluid loss (API fluid loss & HP-HT fluid loss)
- Sand content
- Oil/water/solid content
- Methylene blue test
- Salinity
- Hydrogen ion determination (pH).

Drilling fluid additives for WBM:

1. CMC (CARBOXY METHYL CELLULOSE): It is a long-chain molecule that can be polymerized to produce different molecular weights and different viscosity grades. It is cheap, water-dispersible, colourless, odourless, non-toxic powder & does not ferment under normal conditions of use. CMC is available as CMC (LVG) and CMC (HVG) according to their molecular weight. Either grades provide effective fluid loss control, CMC(HVG) also acts as a viscosifier for fresh water mud. Its thermal degradation starts as temp. approaches 300°F(150oC).

2. POLYANIONIC CELLULOSE (PAC): Available in two grades- PAC (R) and PAC(SL).

PAC(R) is widely used as:

- fluid loss controller
- viscosifier
- shale stabilizer
- It increases cutting carrying capacity of mud PAC(SL) is used as
- fluid loss reducer
- shale stabilizer.

3. BARYTES: It has a specific gravity of 4.2.

- Increase mud density.
- Extensively used as a weighting material

4. SULPHONATED ASPHALT:

- Shale stabilizer

- Adsorbed on shale, plugs microfractures in the shale.
- Readily dispersible in water, & stabilizes emulsions of oil in water.
- Reduces torque & drill pipe drag.
- Temperature stable, having a softening point of over 500°F (260 °C).

5. FLC – 2000:

- It is a high-temperature, stable, dynamic fluid loss control and borehole stabilizing agent.
- It is designed for ease of mixing in all systems with minimal increase in viscosity.
- It reduces formation damage,
- reduces differential sticking,
- imparts wellbore stability to micro-fractured shale and brittle coal seams.

6. BENTONITES (SODIUM MONTMORILLONITE): It is the basic chemical for preparing drilling fluid. It swells when it comes in contact with water, and the resultant mud has unique rheological and thixotropic properties, which make it an excellent drilling fluid. Its main functions are:

- Viscosifier,
- Fluid loss reducer,
- Lubricating agent,
- Gel strength enhancer.
- Form a thin filter cake of low permeability.

7. SODIUM HYDROXIDE(NaOH) / POTASSIUM HYDROXIDE (KOH):

- Used for pH control in water-based mud in the range 9-10. The high pH of water-based mud acts as
- a Corrosion control agent,
- an Active organic thinner,
- and a Contamination reducer.
- It also acts as a bactericide.

8. PARTIALLY HYDROLYZED POLY ACRYL Amide (PHPA):

- Used as a highly efficient fluid loss reducer
- Viscosifier
- Forms protective colloid for shales and cutting
- It is resistant to bacterial fermentation.

9. XC-POLYMER: Produced by the bacterial action of the genus Xanthomonas campestris on carbohydrates.

- It is used as a viscosifier,
- fluid loss reducer,
- shale stabilizer
- It has the shear-thinning property

10. LINSEED OIL: It is a vegetable oil & used as a lubricant. It creates a film between two surfaces (i.e., between formation & string).

11. POLYOL (POLY GLYCOL):

- Used for shale stabilization & lubrication.
- Plugs formation pores & thus imparts borehole stability.
- Thickens the filtrate & acts as a lubricant at all temperatures.

12. PIPELAX: Used for freeing differentially stuck pipe in high-pressure wells.

4.2 Drilling Fluid Solid Control

DRILLING FLUID

SOILD PART

(Chemicals, Clays, Weight material

Drill Soils)

LIQUID PART

(Water, Oil, etc.)

WHY SOLID CONTROL OR REMOVAL?

Several bad things happen if too many drilled solids are allowed to remain in the drilling fluid. The detrimental effects of drilled solids frequently do not appear immediately, but in the course of time, a series of problems like stuck pipe, loss circulation, well kick situation, poor cement job, etc., may arise due to high concentration of drilled solids in the mud system. These happen because high concentrations of drill solids adversely affect the mud properties.

DETRIMENTAL EFFECTS OF DRILL SOLIDS

EFFECT OF PARTICLE SIZE DEGRADATION

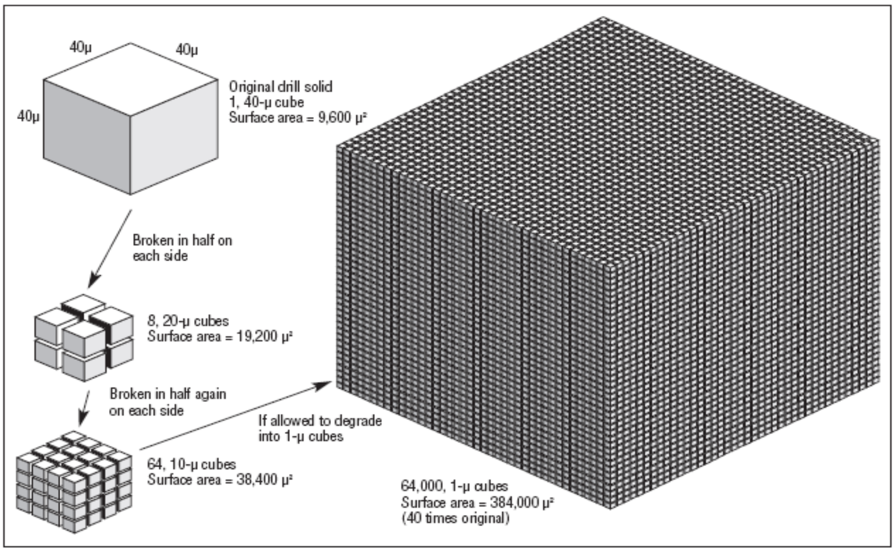


Figure 4: Effect of particle size on surface area.

5. Department (Drilling)

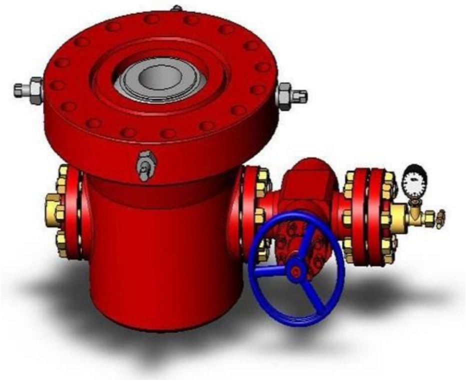
5.1 Drilling Rig

DRILLING RIG COMPONENTS:

- **CROWN BLOCK:** An assembly of sheaves or pulleys mounted on beams at the top derrick. The drilling line is run over the sheaves down to the hoisting drum.

- **CASING:** A casing is a series of steel pipes that are run into a drilled oil well to stabilize the well.

- **CASING HEAD:** A heavy flanged steel fitting connected to the first string of the casing. It provides housing for slips & packing assemblies, a string of casing & supplies, and the means for the annulus to be sealed off. It is also called a Spool.



- **CHOKE MANIFOLD:** The arrangements of piping & special valves called Chokes. Through which drilling mud is circulated when the BOPs are closed to the pressures & encountered during a kick.

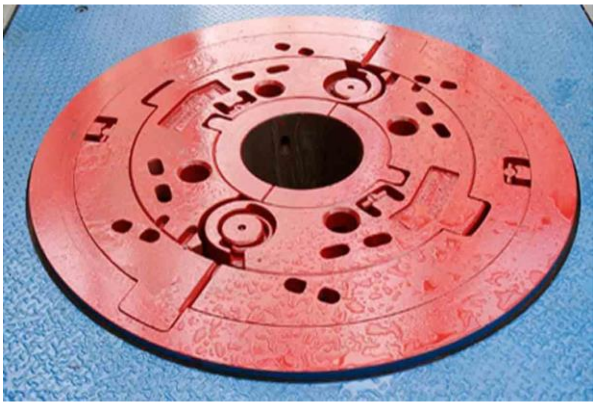
- **SWIVEL:** It is a device that creates the connection between Hook & Kelly. It carries the weight of the drill string & allows the rotation of the string.

- **TRAVELLING BLOCK:** An arrangement of pulleys or sheaves through which drilling cable is reeved, which moves up & down in the derrick & mast.

- **DRILLING BIT:** A drill bit is a tool used to cut or crush rocks, with rotary drill & drilling operations. A hole (well) is drilled by the continuous turning of a drill bit.

- **KELLY:** It is a square or hexagonal cross section. It is made up of high-quality steel. It provides the cock in a case of kick to stop the mud flow.

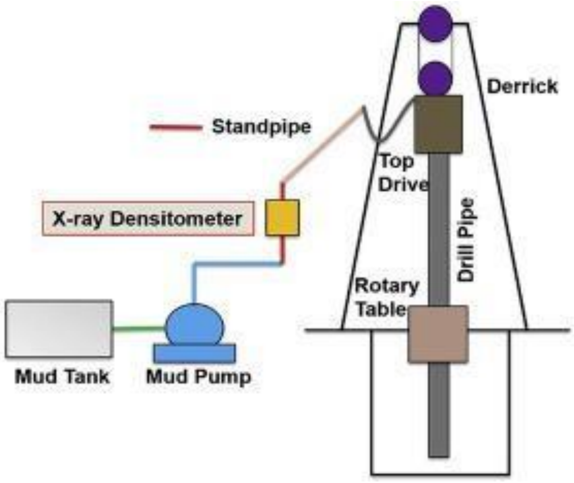
- **ROTARY TABLE:** A rotary table is a device on a drilling rig that provides clockwise rotational force to the drill string to facilitate the process of drilling a borehole.



- **MONKEY BOARD:** The derrick man's working platform. Double board, Treble board, Fourable board; a monkey board located at a height equal to two, three, four lengths of pipe, respectively, in the derrick or mast.

- **MUD PUMPS:** A Large reciprocating pump is used to circulate the mud (Drilling fluid) on a drilling rig.

- **STANDPIPE**: A vertical pipe rising along the side of the derrick or mast. It's joints through which mud is pumped into the hole.



- **DRILL PIPE:** The heavy seamless tubing used to rotate the bit & circulate the drilling fluid, joints of pipe 30ft. Long is coupled together with a tool joint.

- **DOGHOUSE:** A small enclosure on the rig floor used as an office for the driller or as a storehouse for small objects. Also, any small building used as an office or for storage.

- **HOOK:** It is a high-capacity J-shaped equipment used to hang various other equipment, particularly the swivel & Kelly.

5.2 Hoisting System

Function: lowering or raising the drill string, casing string, into or out of the hole.

Components:

- The Draw works
- Block and Tackle system

Operations:

- Making a connection - periodic addition of a new joint of drill pipe as the hole deepens.
- Making a trip - removing the drill string to change a portion of the downhole assembly and lowering the drill string back to the hole bottom.

5.3 Mud Circulation System

Function:

- To have a pressure balance in the well.
- To maintain the drillability of the rock.
- To remove the rock cuttings from the hole.

Mud Cycle:

- From steel tanks (mud pits) to the mud pump
- From the pump through the Standpipe and Rotary Hose to the drill string
- Through the drill string to the bit
- Through the nozzles of the bit and up the annular space between the drill string and the hole to the surface
- Through the contaminant removal equipment, back to the suction tank

The principal components of the rig's circulating system include:

- Mud pumps
- Mud pits

MUD PUMPS:

- Their function is to circulate the drilling fluid at the desired pressure and volume
- The pump normally used for this service is a reciprocating piston, double-acting, and duplex type

STANDPIPE:

- A rigid metal conduit that provides the high-pressure pathway for drilling mud to travel approximately one-third of the way up the derrick, where it connects to a flexible high-pressure hose (Kelly hose)
- Many large rigs are fitted with dual standpipes so that downtime is kept to a minimum if one standpipe requires repair.

5.4 Power System

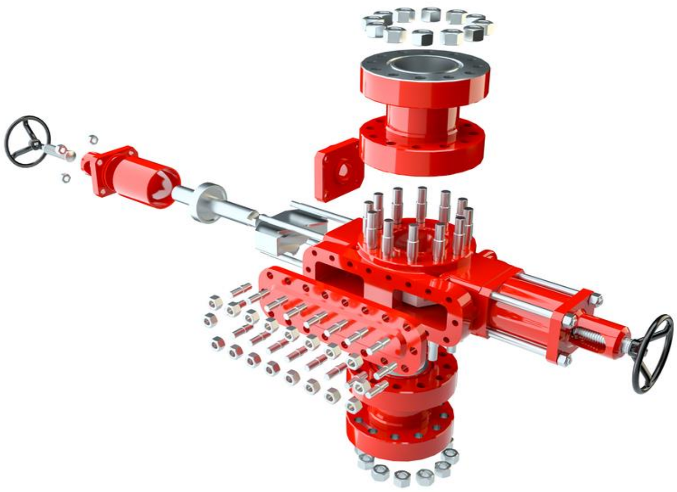
PRIME MOVERS:

- These are used to supply power to drilling operations. These can be steam engines, electric motors, or internal combustion engines
- The bulk of rig power is consumed in two operations, namely the circulation of fluid and hoisting

5.5 Blow-Out Preventor (BOP)

If the formation pressure is more than the pressure imposed by the drilling fluid, in this case, formation fluids flow into the borehole and eventually to the surface. This effect is called blow-out.

The main function of blow-out preventers is to close the annular space between the drill pipe and the casing.



Conclusion

The summer internship at Oil India Limited (OIL), Jodhpur, provided an invaluable opportunity to gain hands-on experience and deep insights into the upstream oil and gas sector. Over the course of the training, I was exposed to various critical aspects of exploration and production, including reservoir engineering, drilling operations, seismic data acquisition, and enhanced oil recovery techniques. The internship also highlighted the importance of advanced technologies like Cyclic Steam Stimulation (CSS) and artificial lift methods in optimizing production, particularly in challenging environments such as the Baghewala heavy oil field.

The training underscored OIL's commitment to innovation, safety, and sustainability in hydrocarbon exploration and production. The exposure to real-world operations, coupled with guidance from experienced professionals, enhanced my understanding of the technical and operational challenges in the industry. Additionally, the internship emphasized the significance of interdisciplinary collaboration in achieving efficient and sustainable energy solutions.

This experience has not only strengthened my technical knowledge but also reinforced my passion for contributing to the energy sector. I am grateful to OIL for this enriching opportunity and to my mentors and professors for their unwavering support. The insights gained during this internship will undoubtedly serve as a strong foundation for my future career in petroleum engineering.

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