2D Seismic Data Acquisition in North bank of River Brahmaputra using Cableless Equipment under OALP regime: A case study.

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Seismic data acquisition, OALP, Cableless equipment, Oil India Ltd. (OIL)

Summary

The Open Acreage Licensing Policy (OALP) introduced by the Government of India has opened up new opportunities for E&P companies to explore and produce oil and gas in designated blocks. Oil India Limited (OIL) has successfully secured a total of twenty-nine (29) blocks through bidding process in various OALP rounds. Among these blocks, five have been specifically located in the North Bank of the Brahmaputra River. From the perspective of seismic data acquisition, these areas presented several operational challenges related to field movement and layout of ground electronics. To overcome these challenges, OIL implemented cableless seismic data acquisition system, replacing the traditional cable-based systems.This innovative technology eliminates the need for extensive cables, providing flexibility in deployment and reducing logistical complexities. The successful deployment of cableless systems in the these areas by OIL demonstrates the transformative potential of this technology. It has led to improved operational efficiency, reduced project timelines, increased productivity, and a reduced acquisition footprint. The present case study highlights the successful deployment of cableless systems for conducting seismic surveys in these areas, OIL's achievements, and some of its advantages over the Cable systems.

Introduction

The aim of OALP was to attract both domestic and foreign investments, stimulate exploration activities, and enhance hydrocarbon reserves. Leveraging its extensive expertise and experience in hydrocarbon exploration and production, OIL actively participated in the OALP bidding rounds. As a result, OIL was awarded five blocks (figure.01) located on the north bank of the river Brahmaputra under this policy. The details of awarded blocks are tabulated below :-

Table.01: Details of the awarded block

Sr. No.	Block Name	OALP Regime	Committed Work Programme (CWP) (GLKM)
1.	AA-ONHP-2017/18 (North Bank – 1)	OALP-I	200
2.	AA-ONHP-2019/1 (Biswanath)	OALP-V	200
3.	AA-ONHP-2019/2 (North Lakhimpur)	OALP-V	250
4.	AS-ONHP-2021/2 (Pathsala)	OALP-VII	200
5.	AS-ONHP-2021/3 (Mangaldoi)	OALP-VII	150

The assigned blocks were characterized by rough terrains, multiple streams, and dense population areas which were giving rise to various operational challenges. Additionally, these blocks had fixed timelines for completing the committed exploration program. To meet these strict timelines and overcome the operational challenges associated with the OALP blocks, OIL utilized cableless seismic data acquisition equipment in above-mentioned five blocks. This advanced technology allowed OIL to efficiently acquire seismic data without the limitations of traditional cable-based systems. By employing cableless seismic data acquisition equipment, OIL was able to streamline operations and expedite the exploration process within the designated timeframe.

The effectiveness of cableless equipment acquisition technology in reducing acquisition footprints and its role in the exploration process has been extensively studied. Notable works by Cardama, Sanchez, and Mougenot in 2014, as well as Mougenot et al. in the same year, have elaborated on cableless technology and its benefits. Pellegrino et al. in 2012 compared wireless and wireline acquisition technologies in North Italy, while Lansley in 2012 discussed the workings of both systems in challenging operational environments. This article serves as a case study highlighting the utilization of cableless data

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acquisition systems and their advantages over cable-based systems in OIL's OALP blocks.

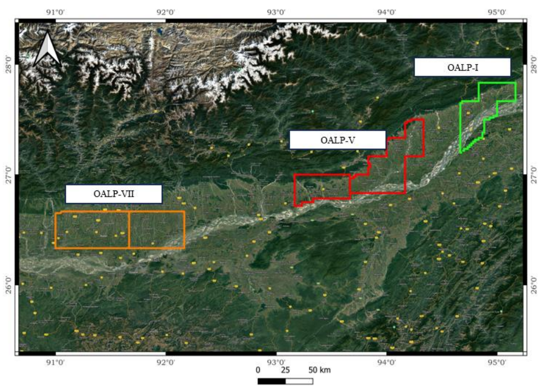

Figure 1: Areas of operation

Geology of study area

The geology of Assam-Arakan basin described as a shelf-slope-basinal system and can be divided into two major basins: the Assam-Shelf and the Assam-Arakan fold belt.

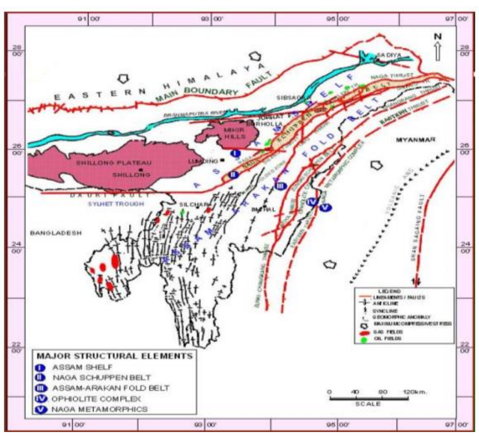

Figure 2: Map of Assam-Arakan basin with major structural and tectonic elements (courtesy DGH)

The Assam shelf portion of the basin extends across the Brahmaputra valley and the Dhansiri valley. The latter lies between the Mikir hills and the Naga foothills. Moving westward from Digboi, the shelf runs towards the southern slope of the Shillong plateau. The transition from the shelf to the basinal slope, known as the hinge zone, is located beneath the Naga Schuppen belt. The basinal (geosynclinal) part of the basin is occupied by the Cachar, Tripura, Mizoram, and Manipur fold belts. Figure 2 shows the structural-tectonic map of Assam-Arakan basin**.** The objective of the proposed 2D seismic survey in the OALP blocks was:

• To identify Strati- Structural prospect in the area.
• To map all formations up to the Eocene.

Description of Cableless Equipment

Most of the cableless systems utilize autonomous sensors that operate in standalone mode, independently recording data without the need for continuous transfer to a central recording system. These systems offer two types of sensor deployment options. The first type involves separate components, including an external battery, GPS-enabled storage box, and geophone, connected by cables. In contrast, the second type integrates all these components into a single unit, eliminating the need for external connections.

The cableless system deployed by OIL is based on the first type of sensor deployment option , consisting of two types of field setups. The first setup comprises field equipment, which includes the GSX box, battery, geophone strings, blasting unit (decoder), line viewer (QC), (Figure. 3) and recording truck. The recording truck is equipped with an encoder and workstations. The whole shooting operation is controlled using the two software programs, EScontrol and Seismic SourceLink installed in the workstations.

The second setup is the harvesting unit, which includes harvesting racks (data harvested from the GSX box), charging racks (battery charging), and two workstations. The workstations are equipped with two software programs, Georeaper and Geomerge (Figure 4). The whole setup is responsible for harvesting the recorded data and then merging them to generate raw SEGD shot gathers.

The cableless seismic data acquisition system is deployed by interconnecting GSX box, battery and Geophone string as illustrated in Figure 5. This setup enables the channels to be powered up, initiates the data acquisition process. As data is acquired, it is stored directly in the internal memory of the GSX unit.

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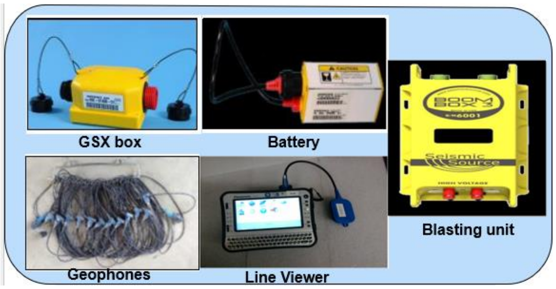

Figure 3: Field Equipment

Figure 4: Harvesting Unit

Figure 5: Ground electronics

These lightweight batteries have the capacity to work for up to 30 days once fully charged. GSX boxes are GPS enabled in addition to their inbuilt memory .

Figure 6: Recording Unit

GPS-enabled blasting unit ensures safe and controlled blasting process and facilitates precise position quality control of the shot points during the seismic survey. The encoder ensures precise timing of the shots.

The recorded data is reaped from the GSX boxes in harvesting unit. Georeaper is a software tool for efficient retrieval of recorded data, ensuring its integrity and accuracy. Geomerge, on the other hand, is a software program that aids in generating SEGD/SEGY data. It combines and merges the extracted data from multiple GSX boxes and time stamps from trigger logs creating comprehensive and coherent seismic data sets.

Advantages of Cableless Acquisition System:

- Autonomous operation with data storage in local flash drive at each picket.
- Easy layout across river, terrain & urban region.
- Lighter components compared to cable system, hence reduces carrying & transportation costs.
- On the field, line QC.

Field deployment of Cableless system and acquisition parameter

The field deployment of a cableless system involves several key steps to ensure its successful implementation. The process typically includes:

System Configuration: The cableless system is configured according to the specific requirements of the project. This includes setting up the necessary project parameters related to the geodetic and seismic survey in the system.

Planning and Site Assessment: This step involves thoroughly assessing the site where the cableless system will be deployed.

Receiver station unit Placement: The receiver station unit which has three components viz. GSX box , battery and geophone was strategically placed at pre-marked survey points across the survey area.

Wireless Network Setup: A wireless network is established to facilitate uninterrupted communication with field personnel and to effectively manage operational control.

Quality Control during field operation: Before data acquisition begins, a comprehensive quality control process is performed to ensure location and health of various components of receiver station unit with the help of field Qc equipment Line viewer.

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Data Acquisition: Once the system is set up and validated, the data acquisition process begins.

Data harvesting and deliverables generation: Upon completing the seismic data acquisition phase, the GSX box and batteries are carefully transported back to the base camp. With the help of the harvesting unit, we harvest the data and generate deliverables.

Acquisition parameters:

To ensure effective imaging of the target geology, a set of specific parameters were employed in various blocks for seismic acquisition, which were tabulated below: -

Table .02: Acquisition Parameters

Acquisition Parameter/ Blocks	OALP-I (North Bank - 01)	OALP-V (Bishwanath and North Lakhimpur)	OALP-VII (Pathsala & Mangaldoi)
Recording System	Geospace Cableless	Geospace Cableless	Geospace Cableless
Geophone	GS-20 DX	GS-20 DX	GS-20 DX
Geometry	Symmetric Spilt Spread	Symmetric Spilt Spread	Symmetric Spilt Spread
Active Channels per shot	600 channels	540 channels	500 channels
Shot Interval	60 meters	60 meters	40 meters
Receiver Interval	20 meters	20 meters	20 meters
Min offset	10 meters	10 meters	10 meters
Maximum offset	5990 meters	5390 meters	4990 meters
Nominal fold	100	90	125
Recording length	7 sec	7 sec	7 sec
Sampling Interval	2 ms	2 ms	2 ms

Challenges Faced during Deployment the Cableless System

Transitioning from cable-based systems to cableless technology posed logistical and operational challenges. Overcoming these challenges required careful planning, collaboration, and innovative problem-solving. The following section outlines the key challenges encountered during the implementation process.

Transition from Cable-Based Systems:

In the past, a cable-based seismic data acquisition system was used in seismic operations at OIL. The crew was well-versed in deploying the system, including cable layout and real-time QC of connected channels. Line supervisors were skilled at placing channels accurately, even for few missing pickets, by observing the line's orientation. However, when transitioning to the cableless system, the crew initially had reservations due to resistance to change. To overcome this, effective training programs were implemented, emphasizing equipment handling, troubleshooting, and safety protocols. Clear communication played a vital role in facilitating a smooth transition, equipping the team with the necessary skills and knowledge for the cableless system.

Operational Challenges:

Cableless equipment offers several advantages due to its freedom from cable constraints and lightweight in design such as improved flexibility and ease of movement through rough terrains, swamps, densely populated areas, and dense vegetation when deploying ground electronics. The quality control features in this equipment greatly assist in accurately placing receiver stations on the ground, ensuring proper line orientation, monitoring the health of receiver station components, and precisely identifying shot hole locations. Additionally, the Covid-19 pandemic imposed additional constraints, but through effective management, these challenges were successfully addressed during operations. Figures 7-9 show problems faced during operations.

Figure 7: Layout in swampy areas and vegetations

Figure 8: Crew movement during Covid-19 pandemic

Figure 9: Seismic lines passing through densely. populated areas.

Outcomes and Impact

Data quality & continuity in Surface coverage :In a cable-based system, real-time QC allows for prompt identification and resolution of faults in bad channels. Conversely, a cableless system lacks real-time QC, requiring supervisors to physically approach each channel to check its status three times daily. After five years of successful seismic data acquisition using the cableless system, it can be concluded that the presence of faulty traces caused by bad channels in the raw shot gathers obtained from the cableless system was negligible. The cableless technology also eliminates leakage problems caused by cable cuts, which are common in cable-based systems Furthermore, in field scenarios where obstacles like houses, private farms, marshy areas, rivers, etc., necessitate channel offsets or omissions which leads to detours in the cable-based system, increasing operational downtime and the need for additional cables. In contrast, the cableless system streamlines operations as channels are not interconnected. Fig 10-11 showing brute stack belonging to data acquired by cable-based system and cableless in similar area respectively.

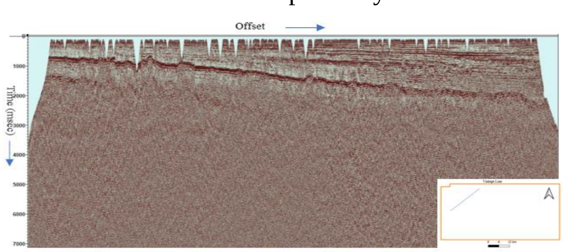

Figure 10: Brute Stack (Cable-based system)

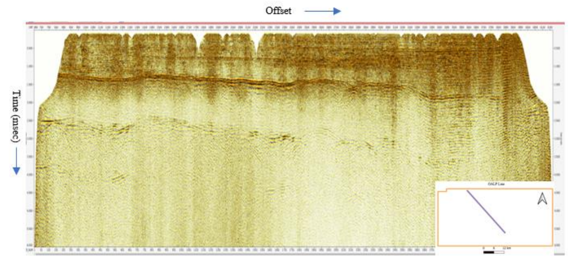

Figure 11: Brute Stack (Cableless system)

Reduction in Ground Electronics weight: It has been observed that the per station weight of the ground electronic of the cableless system is approximately 42.4% less than that of the cable system. As a result, transporting the ground electronics of cableless system in the field was easier compared to the cable system. This improved ease of transportation in the field contributed to an increase in the quantum of data recorded using the cableless system.

Reduction in downtime and standby time: In case of cableless system the disturbances caused by animals or local people in the layout of a few receiver stations have no impact on the shooting operation. Consequently, we can proceed with the shooting without interruption since the receiver stations function independently. In contrast, if such a problem arises in a cable-based system where the receivers are interconnected, we would be compelled to halt the shooting operation until the issue is resolved. This led to reduced downtime in the cableless system. Additionally, the cableless system required no cable usage to connect two consecutive receivers, making the layout of ground electronics much simpler in agricultural fields which leads to less damage to vegetations. This resulted in less opposition from local farmers and a decrease in standby time. These two factors combined contributed to an increase in operational time by 10-12%.

Cost saving and Enhanced Productivity: The cableless system eliminates the long cables and reduced ground electronics weight which leads to reduction in manpower. Further reduction in time required for ground electronics layout ,downtime, and standby time increased the shooting operations window . This streamlined data acquisition workflow has significantly increased productivity and lowered the cost compared to the cable system in the same operational area. Figure 12 provides a comparison of the per-day shot production in two regions, highlighting the higher production rate achieved with the cableless system. However, the difference in production rates is less pronounced in Region-I, as external factors such as assembly elections and the Covid-19 pandemic affected operations in this region.

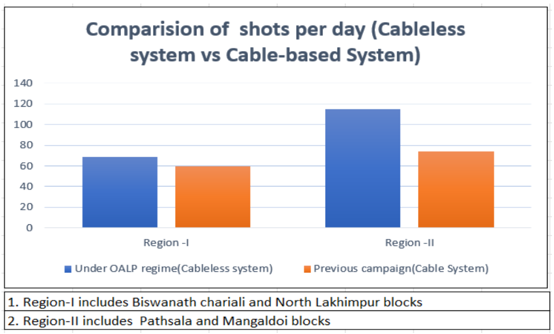

Figure 12: Production statistics

Expanded Accessibility: Cableless equipment enhanced the accessibility of seismic data acquisition in challenging terrains and environments.

Improved Safety: The adoption of cableless equipment had a positive impact on safety during seismic data acquisition operations.

Reduced Acquisition footprints: The removal of extensive cables reduced the environmental footprint associated equipment.

Technological Advancement and Innovation: The implementation of cableless equipment showcased OIL's commitment towards technological advancement and innovation.

Conclusions

The adoption of cableless seismic data acquisition systems has revolutionized exploration and production activities, overcoming the limitations of traditional cable systems. OIL has successfully embraced this transformative journey by implementing cableless equipment for seismic data acquisition. The remarkable achievements of OIL in deploying cableless equipment are evident in this case study. It is noteworthy that OIL, with the introduction of this innovative technology, accomplished the 2D-seismic data acquisition targets within record timeframes across all OALP blocks. The use of cableless systems has been a game-changer, empowering OIL to achieve unprecedented milestones in their operations.

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*Views expressed in this paper are that of the authors(s) only and may not necessarily be that of OIL.

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