पेट्रोलियम एवं
प्राकृतिक गैस मंत्रालय
MINISTRY OF
PETROLEUM AND
NATURAL GAS
सत्यमेव जयते

UrjaVarta 2025
Collaborate • Innovate • Synergize

DGH

SOUVENIR

17 July 2025 | Bharat Mandapam, New Delhi

Foreword

Dear Patron,

It is my distinct honor and pleasure to welcome you all to **UrjaVarta 2025**, a flagship initiative of the Directorate General of Hydrocarbons (DGH). As India continues its stride towards energy self-reliance and sustainability, this conclave stands as a testament to our collective resolve to unlock the full potential of our hydrocarbon resources through collaboration, innovation, and policy-driven growth.

India's position as the third-largest energy consumer in the world emphasizes the pivotal role of the Exploration and Production (E&P) sector in meeting our growing energy needs, fueling economic development, and ensuring energy security. This year has seen landmark developments including the passage of Oilfields Regulation & Development Amendment (ORDA) Act 2025 and the launch of Open Acreage Licensing Policy (OALP) Round X, Discovered Small Field (DSF) Bid Round IV, Special Coal Bed Methane Round 2025—each of which signifies our commitment to create a more investor-friendly, and progressive E&P landscape.

The theme of UrjaVarta 2025, **"Collaborate, Innovate, Synergize"**, encapsulates our vision to bring together stakeholders from across the energy ecosystem—industry leaders, policymakers, academia, and service providers—to deliberate on emerging opportunities, challenges, and the road ahead. With a thoughtfully curated agenda, engaging knowledge-sharing sessions, and exhibition zones, this year's conclave is designed to inspire transformative ideas and foster impactful partnerships.

On behalf of the DGH, I extend a warm welcome to all speakers, delegates, and participants. Your active engagement and insights are integral to shaping the future of India's upstream sector.

We are confident that UrjaVarta 2025 will catalyze new ideas, strategic alliances, and pioneer solutions that propel the sector toward a sustainable and resilient future. Let us come together to chart a course for progress and shared prosperity in India's energy journey.

Vinod Seshan

Director General, Directorate General of Hydrocarbons

UrjaVarta 2025

As India advances on its path toward energy transition, ensuring energy security for 1.4 billion citizens remains essential. Anchored through a five-pronged strategy—E&P reforms, global energy partnerships, startup and innovation promotion, investment facilitation, and a shift to green energy—India is navigating the evolving global energy landscape with strategic planning and resilience.

The Exploration & Production (E&P) sector plays a vital role in meeting growing energy demands and reducing import dependency. With a projected investment potential of **USD 100 billion by 2030**, the sector offers immense opportunities through innovation, collaboration, and advanced technologies.

India's upstream oil and gas sector has made significant progress in recent years, driven by a strong commitment to energy security. As the sector stands at a pivotal stage of innovation and transformation, high-level strategic dialogue is more critical than ever.

Recognising the vital role of upstream activities in securing India's energy future, the Directorate General of Hydrocarbons (DGH) successfully hosted the inaugural session of UrjaVarta in 2024. Building on this momentum and aligned with the various recent announcements by Govt. of India like passage of ORD Amendment Act, Launch of OALP X, DSF 4, SCBM 2025 Bid rounds etc., DGH is pleased to host the second edition of UrjaVarta 2025.

This year's conclave continues under the theme "Collaborate, Innovate, Synergize", bringing together stakeholders across the energy ecosystem. The event will feature high-impact sessions, workshops, and networking opportunities, with a focus on: Strategic Energy Resilience, Collaborations for a Better Tomorrow, Digital & AI in E&P and Pivoting Towards New Energy.

The objective of the conclave is to facilitate and foster collaboration among policymakers, industry leaders, and technology experts to accelerate upstream exploration and production activities, attract investments, and align regional energy strategies with national goals.

Thematic areas of the conclave

THEME 1
Strategic Energy Resilience

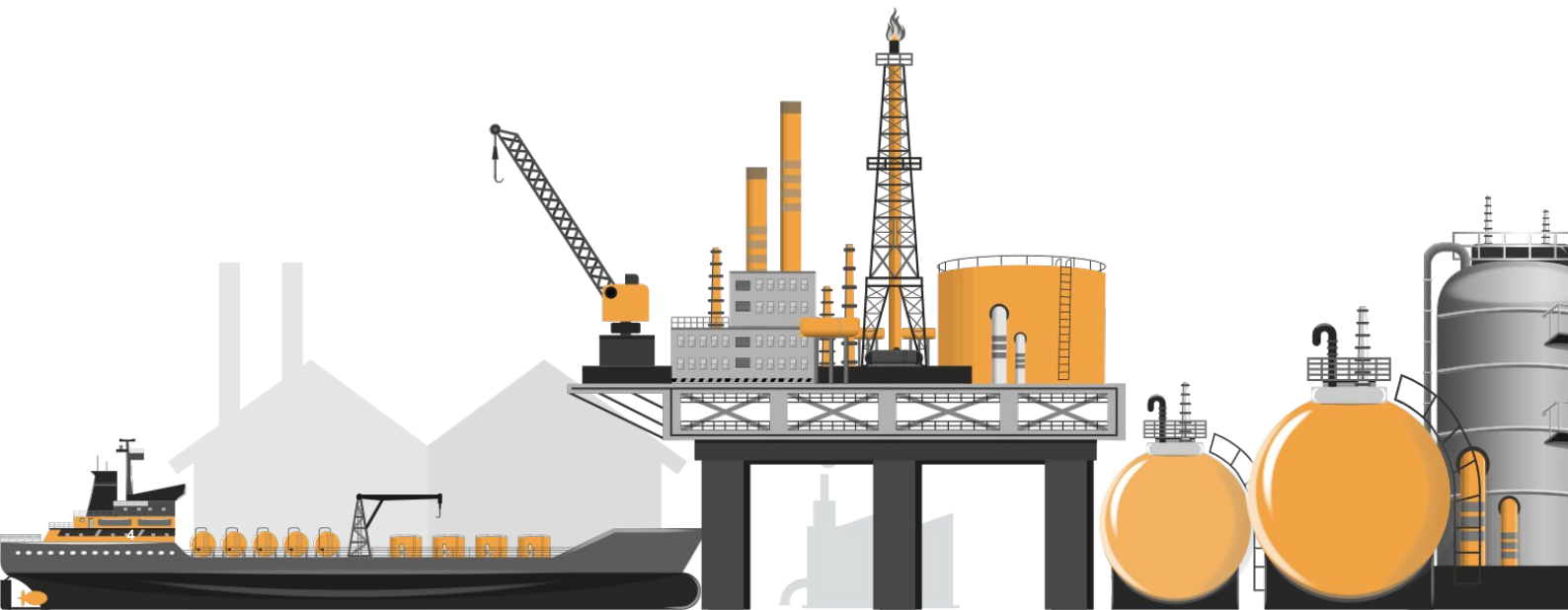
As global energy markets experience volatility and supply chain uncertainties, India must strengthen its upstream hydrocarbon to ensure long-term energy security. This theme focuses on:

- Strategies to accelerate exploration, fast-track monetization of discoveries, enhance domestic oil and gas production.
- Discussions will also cover risk mitigation, investment de-risking, and mechanisms to improve operational resilience in the face of geopolitical and market challenges.

THEME 2
Collaborations for a Better Tomorrow

Forging strategic alliances and driving investments to tap into the uncharted potential of our resources. This theme will explore strategies that can energize collaboration between industry, policy makers and other relevant stakeholders to drive implementable and scalable innovations. The sessions within the theme will delve into:

- Strategic alliances, joint ventures, technology partnerships, and the role of enabling policies such as the ORDA Act, DSF Round IV, and OALP Round X in fostering a conducive business environment
- Attract and direct investments into E&P and emerging sectors to drive long-term economic development.
- Foster inclusive alliances that prioritize equitable access to energy, technology, and opportunities for all communities.



THEME 3
Digital & AI in E&P

Harnessing cutting-edge digital technologies and artificial intelligence to optimize exploration and production processes. This theme will explore emerging digital technologies and their impact in E&P operations including the following:

- Opportunities in leveraging digital technologies to optimize exploration, drilling production.
- Case studies on the implementation of digital technologies such as AI, IoT, and big data analytics in E&P.
- Demonstrations of digital tools and platforms from startups, academia and industry experts for enhancing operational efficiency.

THEME 4
Pivoting Towards New Energy

Pioneering sustainable practices that reduce methane emissions and accelerate the transition towards new energy sources. This thematic area will explore:

- Emphasize the need to scale up investments in low-carbon technologies including geothermal, CCUS to meet the Net Zero goal by 2070
- Discuss the importance of policy support, financial incentives, and public-private partnerships to drive innovation, infrastructure development, and adoption of new energy solutions.
- Highlight the need for reskilling programs, job creation in green sectors, and ensuring that the energy transition is equitable and benefits all sections of society.

What to expect

Ministerial Session

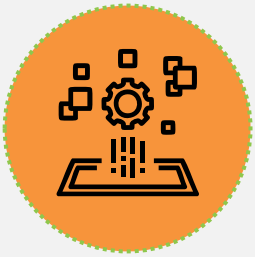
Featuring critical dialogues including Fireside Chats, Ministerial Roundtable with State Ministers and CXO Roundtable to explore and discuss the strategic priorities for upstream oil & gas sector in India.

Tech-Strat Forum

An exclusive platform for leaders in the E&P sector to explore how emerging technologies and strategic innovation are reshaping the industry. The forum will host high-level discussions that deliver actionable insights and foster meaningful connections in the sector.

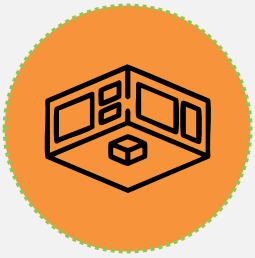
Technical Conference

Technical Paper Presentation based sessions, offering expertise across various technical themes on latest innovations, industry leading practices and technology advancements that accelerate Oil & Gas exploration, fast-track monetization and enhance production.



Innovation Centre

Dedicated platform for both domestic and international energy businesses, startups and academia to showcase their innovative products and services and explore new opportunities in the energy sector.



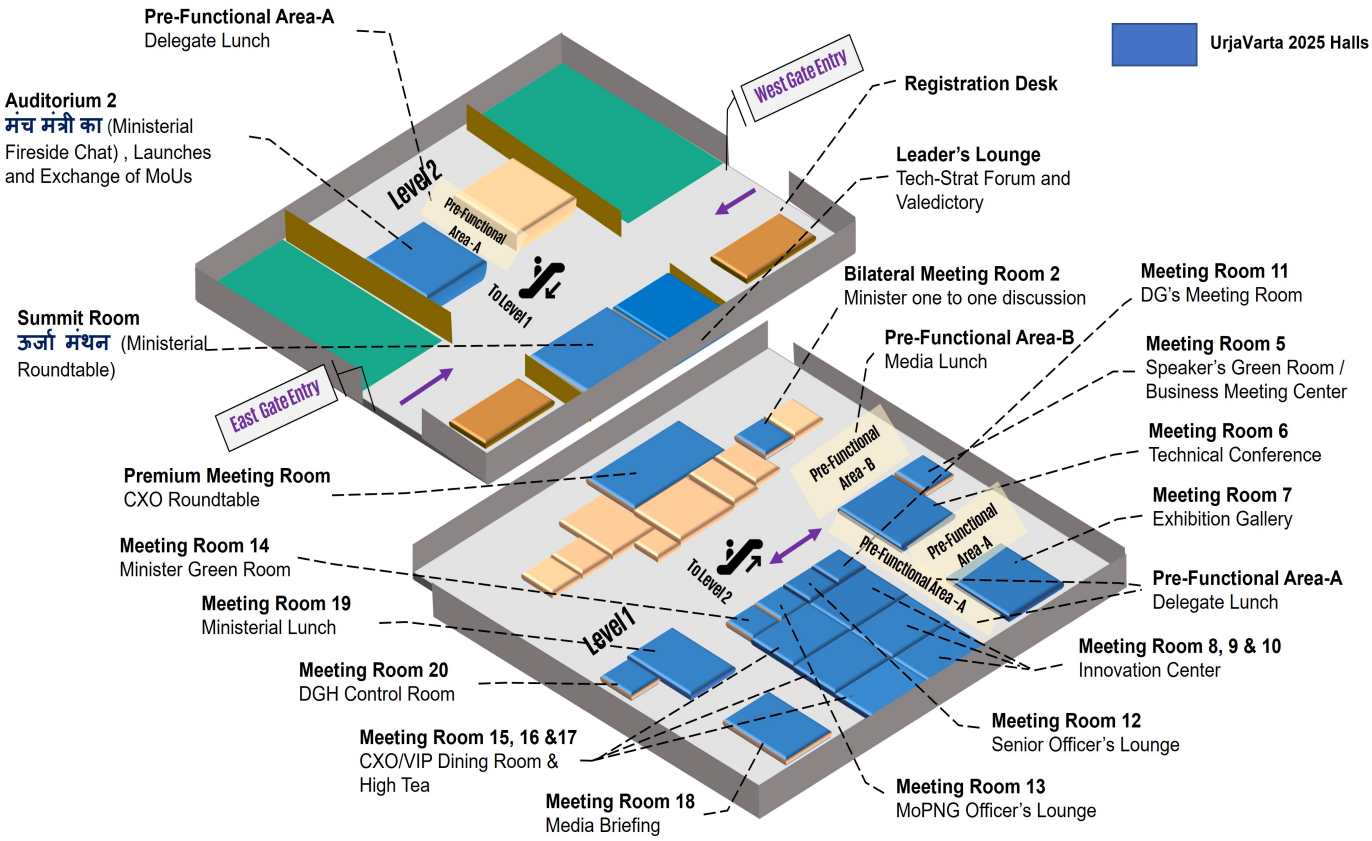
Exhibition Gallery

Demonstration of technical abstracts (poster presentation) representing new-age solutions in upstream sector by industry experts, academia and inventors.

Business Meeting Center

Dedicated pavilion and meeting rooms for networking and engaging stakeholders across energy sector.

Event Layout



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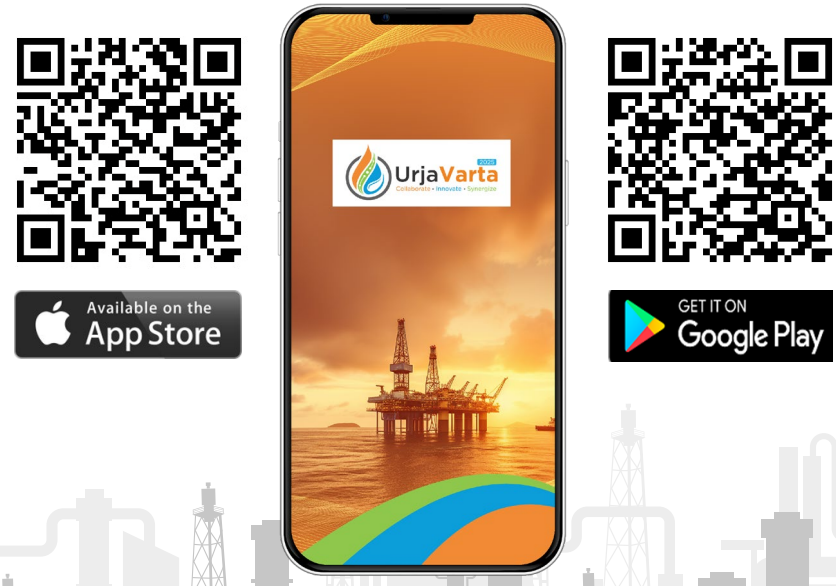

Compendium of Abstracts

Theme: Advanced Well Intervention Techniques in Upstream Oil and Gas

Abstract Title: Futuristic Biomass Derived Green Nano-Cellulosic-Bio-Products (NCBP): Decarbonizing Upstream Oil & Gas

Author: ***Ritesh Mittal, Anil Kumar and Saurabh Kumar***

Organization: Engineers India Limited

Abstract: Decarbonizing Upstream Oil & Gas by strategizing carbon neutral technologies, ratification of International-Climate-Change Paris & G-20 Delhi Charter to achieve Net Zero-2070 & impetus to promote Bio-products under National Biofuel Policy - 2018 are critical drivers to promulgate advanced Bio-Products like Green Nano-Cellulosic-Bio-Products (NCBP).

NCBP are derived from cellulosic nanofibers & nanocrystals extracted from ligno-cellulosic-biomass like rice husk, wheat straw, sugarcane bagasse, corn cob, etc. Three main nano-cellulosic materials: Cellulose Nano Crystals (CNC), Cellulose Nano Fibrils (CNF) & Bacterial Cellulose exhibits unique exceptional mechanical, thermal & optical properties making it versatile for E&P of Oil & gas futuristic domain.

This paper critically reviews applications of Nano-Cellulosic-Bio-Products in upstream gambit of Oil & Gas industry. In upstream domain, unique rheological properties of Nano-cellulose based fluid helps in Enhanced Oil Recovery (EOR) due to modification of viscosity & flow behavior of reservoir fluids, helping to displace trapped oil and improve oil recovery rates. It also improve filtration control, lubricity, enhance stability, reduce friction and mitigate issues like wellbore instability of drilling fluids by control of fluid loss in drilling. Nano-cellulose aids in Corrosion Protection as an additive in durable and cost effective corrosion-resistant coatings and materials designed to protect oil & gas infrastructure from corrosion. Nano-cellulose based additives are biodegradable and are eco-friendly alternative to synthetic additives for E&P applications making operations Environmentally Sustainable.

In downstream industry Nano cellulose based Bio-sensors due to high surface area & ability to be functionalized with specific biomolecules paves way for development of more efficient and sensitive futuristic Bio-ETPs. NCBP also holds innovative potential to supplement National Green Hydrogen Mission-2023 (NGHM) by aiding in novel Energy Storage products like Bio-dielectric materials, bio-supercapacitors and bio-nanogenerators with exhibited enhanced energy storage capacity & rapid charge-discharge rates, improved performance of lithium-ion batteries with structural stability & electrochemical properties enhancing battery efficiency & lifespan. This paper aims to establish that Nano-Cellulosic-Bio-Products (NCBP) can be promising substrate for Products used in E&P in oil & gas industry. Implementation with scaled development, cost-effectiveness, & compatibility with existing processes plays prudent role in integrating NCBP into oil & Gas operations. NCBP exhibits unique exceptional mechanical (tensile strength & modulus, flexural & impact strength, fatigue resistance), thermal (thermal conductivity & stability, heat resistance) & optical properties required in upstream and downstream industry.

EIL in its gambit of expanding its portfolio in sunrise technologies is expanding its wings to venture in this novel bio-products domain. This study will create interest amongst Oil & Gas Researcher & Practicing Engineers active in bio-derived products, Industrialist, Environmentalist towards meeting net zero goal in Upstream Oil and Gas Industry with Green Innovative Novel Biomass Derived Green Nano-Cellulosic-Bio-Products.

Abstract Title: Optimizing Brownfield Assets: Deploying Cutting-Edge DSL Technology for Rigless Intervention in Constrained Offshore Wells

Author: ***Amlan Das, Shlok Rai and Adrija Chakraborty***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: DSL technology operates as an advanced intelligent slickline system equipped with two-way digital telemetry, enabling real-time data transmission and operational command execution. The system integrates multiple functionalities, including executing TTP, Production Logging (PLT),CBL-VDL and Sigma logging with surface readout and controlled operation without the requirement of a logging mast. DSL works on the telegraph model of transmission with two-way digital communication i.e data-up and commands down. DSL has unique capability to log (Pressure, temp, GR, CCL, Spinner, Shock, Tension) with surface readout while the job along with all capabilities of conventional slick-line mechanical jobs. Making it logistically convenient (much smaller).

A breakthrough in this technology is the integration of Production Logging pressure-temperature, density, flowmeter sensors along with the tool string containing perforating gun (TTP). Enabling real-time downhole flow regime analysis. This groundbreaking implementation provides never- seen-before insights into reservoir behavior pre and post-perforation. The data collected provided better-informed production decisions and optimize well performance. Making it logistically convenient (much smaller footprint), navigate through restrictions and acquire data simultaneously to improve overall intervention efficiency and take informed decisions during the operations. This helps to reduce the substantial cost, as rig deployment expenses are typically 20-25 times higher. Moreover, DSL is particularly suited for platforms with limited space, limited crane

capacity, old wells with restriction and can be effectively deployed in wells with inclinations up to 60. The Platform X containing wells Well A and Well B were identified for Through Tubing Perforation but it was not possible to carry out Rigless operations in this platform due to limited space, which were insufficient to deploy Rigless Logging MAST, the platform had prevented any rigless intervention since the wells were drilled (1986-87). . In this plat form as a solution to the space limitation challenge Digital Slickline (DSL) technology deployment was strategically aligned with the objective of enhancing brownfield recovery in mature assets. The wells were chosen based on their history of production decline, existing mechanical restrictions, and space constraints that previously prevented conventional rigless intervention. This technical paper presents DSL as a comprehensive tool and technology induction in brownfield recovery, emphasizing its capabilities beyond Through-Tubing Perforation (TTP)

Well A: Total 18m TTP carried out in 6 runs with real-time depth control and confirmation through downhole shock and temp measurements. Post TTP last run acquired data while flowing and confirmed the active TTP intervals leading to significant production gain in terms of gas (50,000m3). Well B: twelve meters of TTP was executed over four runs, with similar real-time data acquisition and depth control. The intervention transformed the well from non-flowing to producing status, evidenced by a rise in Tubing Head Pressure (THP) to approximately 16 KG leading to significant production gain in terms of gas (30,000m).C

Abstract Title: A Case Study on Rigless Multi Well Acid Stimulation

Author: ***Chandan Gupta***

Organization: Oceaneering International Services

Abstract: To detail a feasible and cost-effective solution that was used to restore the production of five wells that had reduced significantly over time due to fines mobilization, calcium carbonate and scale accumulation.

The project used a dual-vessel stimulation approach. A multipurpose service vessel (MPSV) deployed the coiled tubing, dual work class ROVs, and well stimulation tool while executing crane operations, and a well stimulation vessel provided the fluids and pumping for the stimulation. Four open water coiled tubing units were used to achieve flow rate as high as 16bpm to the well stimulation tool. Using a two-vessel solution enabled the campaign to save time by equipping the vessel with all chemicals needed for the entire campaign at once, saving a trip back to shore to refill tanks after each well.

For the five well campaign, the average well experienced a 350% increase in Productivity Index (BPD/PSI) and a production rate (BOE/day) increase of >70%. The major risk for this project was maintaining effective communication during simultaneous operations. To mitigate this risk, transponder frequencies for the entire field were managed by one individual, the Field Mooring Master. This ensured constant and reliable positioning information for all dynamically positioned (DP) rigs and vessels in the proximity of the operation. As the vessels were required to remain near each other for extended periods of time, both vessels operated in dynamic positioning mode during pumping operations. A major concern for all jobs requiring hazardous chemicals is the prevention of any leaks, thus protecting personnel and the environment. Therefore, the connections from the coiled tubing to the well stimulation tool were made using no-leak hot stabs. By employing the use of no-leak hot stabs, the tooling cost was reduced, and ROV operations were simplified.

On average, there was a 350% increase in the productivity index, accompanied by a more than 70% rise in the production rate. By employing the multi-vessel approach, we reduced both time and costs, saving 8 days by eliminating the need for trips back to shore to refill tanks. We ensured no hazardous chemical leaks into the environment by using leak-proof hotstabs and simplifying ROV operations.

Abstract Title: Delivering success through Integrated Abandonment Planning & Value Generation in the Central North Sea

Author: ***Pranati Pritinanda Mohanty, Sankarshan Mohanta, Randhir Kumar***

Organization: Shell India Markets Pvt. Ltd.

Abstract: Shell, as a part of its sustainability commitment of efficiently carrying out the decommissioning and restoration plans, aims to abandon its wells in a safe, secure, efficient, cost-effective and environmentally responsible manner while meeting the regulatory requirements. For this, a subsurface isolation strategy (SIS) needs to be developed. This paper talks about the Subsurface Isolation Strategy (SIS) work done for three fields in the Central North Sea.

The aim of the study was to propose a robust and integrated abandonment strategy to identify formations which are zones of flow potential and need to be permanently isolated along with the depth range for isolation. This was achieved through a detailed understanding of the fields and wells, reservoir and overburden characterization, cross flow analysis, assessment of the seal integrity, plug optimization and definition of minimum abandonment depths.

In one of the fields, the SIS study not only aided in significant cost savings due to plug optimization but also provided a foundation for the detailed well-by-well abandonment designs which are currently being documented in the individual Well Abandonment Functional Specifications (WAFS). In addition to this, the SIS also incorporated further use of the field, to ensure opportunities for e.g., CCS. The SIS is a live document; it is reviewed and updated if there is a change to the well status and any configuration that might impact the abandonment.

In one of the fields, the SIS study aided in significant cost savings due to plug optimization. It also helped in designing a well-by-well abandonment plan in the next stage of WAFS (Well Abandonment Functional Specifications).

Abstract Title: Advanced well Intervention

Author: ***Mayank Ranjan***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: Advanced well intervention techniques encompass a wide range of operations aimed at maintaining, enhancing, and restoring well performance in upstream oil and gas operations. This includes both remedial and proactive measures to optimize production, improve recovery rates, and ensure well integrity. The scope covers emerging technologies such as coiled tubing interventions, robotic well intervention systems, real-time data analytics, and AI-driven diagnostics. The primary objectives of advanced well intervention techniques in upstream oil and gas include: Enhancing Well Productivity, Extending Well Life, Ensuring Well Integrity, Reducing Operational Costs, Optimizing Reservoir Management, Integrating Digital Innovations and Minimizing Environmental Impact.

Advanced well intervention techniques are designed to optimize hydrocarbon recovery, enhance well integrity, and reduce operational risks. The approach involves integrating cutting-edge technologies, data analytics, and automation to minimize downtime and improve efficiency. The methodology for implementing advanced well intervention techniques includes a structured process involving planning, execution, and evaluation. 1. Well Diagnostics & Assessment :Conduct comprehensive well integrity evaluations using smart sensors, fiber optics, and real-time downhole monitoring. 2. Intervention Planning & Design : Select appropriate intervention techniques based on well conditions (e.g., coiled tubing, slickline, hydraulic fracturing, robotic intervention). 3. Execution of Well Intervention : Deploy advanced tools such as intelligent wireline systems, pressure-controlled drilling, and downhole video logging. 4. Data Acquisition & Post-Intervention Analysis.

The implementation of advanced well intervention techniques has led to significant improvements in well productivity, integrity, and operational efficiency. Some key results observed include: Enhanced Hydrocarbon Recovery, Reduced Downtime, Improved Well Integrity, Cost Optimization, Environmental Sustainability Observations Through practical applications, the following trends and observations have been noted:

- Technological Integration: AI, machine learning, and robotics are playing a growing role in intervention techniques.
- Shift Toward Non-Invasive Methods: Operators prefer minimally intrusive interventions that maximize efficiency while reducing risks.
- Data-Driven Decision-Making: Real-time analytics have enabled more precise interventions, reducing trial-and-error approaches.
- Challenges in Complex Reservoirs: While advanced techniques improve outcomes, HPHT wells, deepwater operations, and unconventional reservoirs still pose technical hurdles.

Advanced well intervention techniques have revolutionized upstream oil and gas operations, offering a blend of efficiency, safety, and sustainability. By integrating cutting-edge technologies and data-driven strategies, operators can enhance well performance while optimizing costs and environmental impact. However, continuous innovation is necessary to address emerging challenges, particularly in complex reservoir environments. The future of well intervention will likely rely on further advancements in automation, AI, and digital twin technologies to ensure precision and effectiveness in operations.

Advanced well intervention techniques hold significant value for the upstream oil and gas industry, driving efficiency, cost savings, and sustainability while maximizing reservoir performance. Key areas of impact include. Enhanced Production & Recovery, Cost Optimization & Operational Efficiency, Increased Safety & Well Integrity, Integration of Digital Technologies, Sustainability & Environmental Benefits By leveraging advanced intervention techniques, operators can significantly improve well productivity while minimizing costs and risks.

Abstract Title: Wireline key-seating during logging: A case study on causes & mitigation

Author: ***Anup Gourav Sahu, Birupakshya Panda***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: The study aims to understand the causes and mitigation strategies for wireline key-seating during logging operations in oil and gas wells, with a focus on advanced well intervention techniques. By analyzing a case study of well XX#11, the research identifies key factors contributing to wireline key-seating, such as tool weight, wellbore design, and geological settings. The objective is to evaluate the operational challenges and risks associated with wireline key-seating, propose effective mitigation strategies, and enhance the overall efficiency and safety of logging operations by minimizing the occurrence of key-seating and its associated delays.

The study involved a detailed analysis of well XX#11, an inclined "S" profile well. The methodology included collecting data on well construction, logging operations, and instances of wireline key-seating. Key factors such as tool weight, number of runs, and wellbore design were examined. The study utilized various advanced well intervention techniques, including multiple fishing attempts with tools like overshot assemblies and cable catchers, to recover the stuck wireline. The analysis focused on understanding the formation of slots in the wellbore wall and the impact of geological settings on wireline key-seating. Preventive measures, such as using wireline stand-offs and visualizing cable thrust, were also evaluated to mitigate the issue.

The analysis of well XX#11 revealed that wireline key-seating occurred due to the formation of slots in the wellbore wall, exacerbated by the weight of the tool and the number of runs. The well's "S" profile and the presence of soft, pliable formations contributed to the problem. Multiple advanced well intervention techniques were employed to recover the stuck wireline, with varying degrees of success. The study concluded that key-seating could be mitigated by implementing preventive measures

such as straighter wellbore sections, avoiding angle build and hold sections in permeable formations, and using wireline stand-offs. Regular visualization of cable thrust during logging operations was also recommended. The successful recovery of the logging tool and cable demonstrated the effectiveness of the proposed mitigation strategies. The study emphasized the importance of understanding the geological and operational factors contributing to wireline key-seating to enhance the efficiency and safety of logging operations.

The study provides valuable insights into the causes and mitigation of wireline key-seating, offering practical solutions to enhance logging operations through advanced well intervention techniques. By implementing the recommended preventive measures, operators can reduce the risk of cable entrapment, minimize operational delays, and avoid costly interventions. The findings can be applied to similar wells, improving the overall efficiency and safety of logging operations. Additionally, the study highlights the importance of continuous monitoring and adaptation of logging practices based on geological and operational conditions, promoting a proactive approach to managing wireline key-seating in the oil and gas industry.

Compendium of Abstracts

Theme: AI-Driven Predictive Maintenance and Asset Integrity Management for Oil & Gas

Abstract Title: Upgradation of the Power ecosystem with Cloud based solutions for Predictive Maintenance and Asset Integrity Management

Author: ***Deepti Maurya***

Organization: Oil and Natural Gas Corporation Limited

Abstract: Ensuring equipment reliability at ONGC's Uran Plant, which processes 42% of crude oil and 15% of gas from Bombay High, is critical for operational efficiency. Frequent maintenance and repairs undermine asset integrity, leading to increased downtime and occasional blackouts. To address this, there is a need for implementing modern, technologically advanced systems that reduce the frequency of maintenance, enhance reliability, minimize system downtime, and create a safer, accident-proof environment for continuous operations.

A comprehensive study was conducted with both in-house experts and external specialists to assess the situation, analyze available market options, evaluate system integrity, and recommend improvements for long-term reliability. The assessment concluded that the enhancement of asset integrity could be achieved by upgrading the medium voltage 6.6kV and 11kV switchgear systems. The proposed upgrades included safer interlocks, cloud-based predictive maintenance, continuous monitoring systems, and remote breaker rack-in/rack-out facilities. These new panels are designed to integrate cutting-edge technologies, such as advanced interlocking mechanisms for safety, remote-controlled earth switches, and cloud solutions that facilitate predictive and preventive maintenance. This modern approach will not only improve operational reliability but also ensure that the plant's systems are more resilient, safe, and capable of minimizing downtime through advanced, data-driven insights.

- Upgradation of 6.6kV and 11kV Switchgear: Enhances system reliability with advanced Cloud-based Predictive Maintenance and remote operation capabilities.
- Cloud-based Predictive Maintenance: Replicates power flow diagrams, providing real-time data on switchgear status, fault logs, events, and trend displays for better risk management and scheduled maintenance.
- Remote Rack-in/Rack-out Mechanism: Reduces human intervention in critical operations, increasing operational efficiency and safety by minimizing exposure to high-voltage components.

Observations and conclusion :

These technological advancements reflect Uran Plant's commitment to adopting modern solutions, ensuring a safer, more reliable, and future-ready electrical infrastructure. The upgrades will contribute to operational excellence, reduce downtime through predictive maintenance measures, and help maintain the integrity of the plant's electrical systems.

The adoption of cloud-based solutions for predictive and preventive maintenance will also extend the life of equipment, as potential issues can be identified early and addressed proactively. Additionally, the implementation of remote rack-in/rack-out breaker mechanisms will significantly enhance safety, reducing the need for direct human intervention during critical operations and minimizing exposure to high-voltage components.

Abstract Title: Predictive Maintenance in Upstream Oil & Gas: AI/ML Applications for Equipment Health Monitoring and Failure Forecasting

Author: ***Dr. Pranava Chaudhari, Dr. Ashish Kapoor, Dr. G. L. Devnani***

Organization: Harcourt Butler Technical University

Abstract: The presentation explores the role of AI/ML in predictive maintenance of critical upstream equipment like pumps and compressors. The objective is to demonstrate how sensor-based analytics and ML models help in early fault detection and maintenance planning, thereby reducing downtime and improving reliability in exploration and production operations.

The study adopts a technical case-based approach, analyzing how AI and ML algorithms are applied to predictive maintenance in upstream oil and gas. It begins with the acquisition of high-frequency sensor data from critical equipment such as pumps, compressors, and drilling rigs. This data is preprocessed and analyzed using anomaly detection, supervised learning, and deep learning models to identify patterns indicative of failure. Industry case studies are used to illustrate implementation workflows, model validation, and the impact on operational performance and maintenance scheduling.

Implementation of AI/ML-based predictive maintenance in upstream oil and gas operations has shown substantial improvements in equipment reliability and cost efficiency. Case studies from industry leaders like Shell, BP, and Saudi Aramco reveal that deploying machine learning models for real-time fault detection and failure prediction has reduced unplanned

downtime by 30–40% and maintenance costs by up to 25%. Observations indicate that anomaly detection and deep learning algorithms, when trained on historical and real-time sensor data, can accurately forecast degradation in rotating equipment like pumps and compressors days in advance. Integration with digital twins enhances model accuracy and allows simulation of failure scenarios, supporting proactive decision-making. Edge computing further enables real-time alerts even in remote field operations. However, challenges remain in data quality, model scalability, and legacy system integration. The study concludes that AI-driven predictive maintenance is not only technically feasible but also economically beneficial, offering a path toward more resilient, safe, and efficient upstream operations. As digital maturity improves across the sector, predictive maintenance will become a cornerstone of asset integrity management, enabling condition-based interventions and data-driven operational strategies.

This abstract provides a focused synthesis of AI/ML applications in predictive maintenance specific to upstream oil and gas operations, highlighting underexplored integration of digital twins, edge analytics, and domain-specific ML models. It adds novel insight by linking real-world industrial deployments with methodological advancements, offering a practical framework for scalable, data-driven maintenance strategies beyond traditional condition monitoring techniques documented in existing literature.

Abstract Title: From Shutdowns to Sustainability:AI-Driven Root Cause Modeling for Offshore Shutdown Prevention and ESG Optimization

Author: ***Meena Mourya, Tarun Tyagi***

Organization: Oil and Natural Gas Corporation Limited & Xaigi

Abstract: This white paper proposes a cross-asset, AI-powered root cause analysis (RCA) framework aimed at reducing unplanned offshore shutdowns and supporting Environmental, Social, and Governance (ESG) goals. The objective is to integrate heterogeneous datasets from SCADA, DCS, ETAP, process simulators, and maintenance records into a hybrid AI system using Graph Neural Networks (GNNs), LSTM models, Dynamic Bayesian Networks (DBNs), Structural Equation Modeling (SEM), Autoencoders, and Granger Causality. Structured around the 6Ms framework, the system aims to provide early fault prediction, causal explainability, and prescriptive mitigation. The scope includes quantifying its impact on flaring, downtime, energy efficiency, and decision-making agility.

This methodology outlines a five-stage process for developing a cross-asset, AI-based Root Cause Analysis (RCA) system for offshore operations. Data from SCADA, DCS, ETAP, process simulators, and maintenance logs is integrated and structured using the 6Ms framework: Man, Machine, Method, Material, Measurement, and Mother Nature. Graph Neural Networks (GNNs) and Structural Equation Modeling (SEM) are used to capture system interdependencies, while Dynamic Bayesian Networks (DBNs) model cross-domain causal relationships. Long Short-Term Memory (LSTM) networks and Granger Causality identify temporal patterns and validate cause-effect sequences. Autoencoders detect subtle anomalies in multivariate datasets. The model is validated through historical shutdown cases and simulated failures to assess accuracy, intervention lead time, and operational impact. The output includes real-time causal graphs and prescriptive recommendations for ESG-aligned, proactive decision-making.

The proposed AI-driven Root Cause Analysis (RCA) framework will be validated using historical shutdown records and simulated failure chains to assess its predictive accuracy, robustness, and practical applicability in offshore environments. The model can achieve over 90% accuracy in forecasting cascading failure events and will provide a lead time of 6 to 12 hours, enabling operators to implement preventive actions such as controlled ramp-downs instead of resorting to emergency shutdowns. This predictive capability will help field teams act smartly—not in panic—by proactively addressing failure sequences, thereby reducing equipment stress, production disruptions, and safety risks. When deployed across multiple offshore platforms, the framework can prevent four to six major unplanned shutdowns annually, potentially saving over 96 hours of production and avoiding up to 1,600 tons of CO_2e emissions resulting from emergency flaring. The model will reduce operating expenditure (OPEX) by minimizing reactive maintenance, logistics delays, and fuel inefficiencies. It can also support better capital expenditure (CAPEX) planning by identifying degradation trends early and enabling risk-based investment prioritization. Explainable AI outputs will improve collaboration across engineering, operations, and management by providing transparent, traceable insights and prescriptive recommendations. In conclusion, the RCA framework will act as a strategic enabler for building intelligent, low-carbon, and financially optimized offshore operations—delivering measurable value and advancing long-term Environmental, Social, and Governance (ESG) commitments.

The AI-driven RCA framework can significantly enhance offshore asset performance by enabling early fault prediction and proactive intervention. It reduces unplanned downtime, lowers OPEX through optimized maintenance, and minimizes flaring-related emissions—supporting ESG targets. The model supports smarter CAPEX planning by identifying degradation trends and aligning investment with risk. Explainable AI outputs improve cross-functional collaboration and accelerate decision-making. It also helps reduce alarm fatigue and enhances vendor accountability through performance-linked insights. As a scalable solution, the framework can serve as a digital transformation catalyst—modernizing asset management and delivering measurable operational, financial, and environmental value across oil and gas operations.

Abstract Title: Improving ESP Uptime hrough Digital Ranking and Automated Event Detection system

Author: ***Anuj Bhatia, Prasoon Srivastava***

Organization: Sensia Global

Abstract: The scope focuses on a smart digital system employing AI/ML for automated event detection and ranking in ESP operations. The system addresses prioritizing wells needing attention to improve operational efficiency. It achieves this through frequent ESP data collection, creation of problem fingerprints, and AI/ML-driven detection of undesired conditions. The main objective is to demonstrate the system's ability to provide timely alerts and enable proactive interventions, ultimately maximizing productivity and reducing ESP failure events.

The methodology employs an AI/ML-driven digital system for proactive ESP management. Initially, ESP data undergoes rigorous preprocessing via a data quality engine to identify and flag anomalies. Subsequently, a reference engine establishes baseline operating conditions, utilizing domain-based models and signal processing to generate reference levels and extract features like noise and slugging presence. Event detection is achieved through ML models that analyze data streams for characteristic ESP event patterns. An event identification layer then prioritizes detected events, incorporating a TRIAGE module to rank wells by criticality. The system is designed for continuous adaptation, with dynamic threshold adjustments and integration of domain knowledge to accommodate evolving operational parameters. Validation includes both historical data analysis and real-world deployment testing, ensuring ongoing performance optimization.

The implementation of the AI/ML-driven digital system yielded significant operational improvements. Alert resolution times demonstrated a notable reduction, decreasing from over 5 days to less than 2 days, showcasing enhanced responsiveness. The system's efficacy is further validated by the high percentage (88%) of accurately detected events, minimizing false alarms and other discrepancies. This highlights the precision of the AI/ML models in identifying genuine ESP operational issues. Observations emphasize the synergistic relationship between the automated system and human expertise. The 24/7 monitoring and prioritization capabilities of the system empower engineers to focus on critical issues, optimizing their workflow. Ultimately, the integration of AI/ML facilitates proactive intervention, contributing to extended ESP run life, reduced downtime, and a substantial decrease in response times to potential failures. The data contextualization and efficient event prioritization provided by the system are crucial for optimizing time usage and achieving overall operational excellence.

The AI/ML system enhances ESP operational efficiency by transitioning to proactive management. Early warnings of anomalies reduce diagnostic time and expedite corrective actions, minimizing downtime. Intelligent alert prioritization optimizes resource allocation, enabling engineers to focus on critical well interventions and improving workflow efficiency. By facilitating early failure detection, the system prevents equipment damage and unscheduled downtime, mitigating production losses and reducing operational expenditures.

Abstract Title: Implementation of ‘Pulse’, a Predictive Asset Maintenance system leveraging Artificial Intelligence and Machine Learning capabilities for critical process gas compressors in ONGC Uran plant.

Author: ***Ashapurna Saikia, Sameer Biswas***

Organization: Oil and Natural Gas Corporation Limited

Abstract: The main objective of the project was to improve operational reliability and provide valuable insights by integrating data of 8 critical process gas compressors from multiple data sources and deploying predictive models with AI & ML capabilities to co-relate real time equipment and process parameters to generate equipment health report and to predict equipment failure well in advance.The main objective of the project was to improve operational reliability and provide valuable insights to the process and maintenance team by integrating data of 8 critical process gas compressors from multiple data sources and deploying predictive models with Artificial and Machine learning capabilities to co-relate real time equipment performance parameters and process parameters to generate equipment health report and to predict equipment failure well in advance to give sufficient time for planning the maintenance activities. In the oil and natural gas industry, the process gas compressors are the most critical machines with round the clock operation.

Historical data from the plant’s DCS and Bentley Nevada System 1 servers were first collected to establish a strong foundation for predictive analytics. Every sensor in the system is assigned detailed meta-data, enabling predictive modelling, templating, and standardization of assets across the plant. Using fingerprinting techniques, the system autonomously learns abnormal behavioural patterns of the equipment based on historical trends. Machine learning based advanced pattern recognition identifies complex, non-linear relationships between different operational parameters without the need for manually setting values or thresholds. KPI (Key Performance Indicator) models were defined to capture critical metrics such as compressor bearing temperatures, linking them with influencing variables like speed, ambient conditions, and lubrication. Expert-constructed fault trees were integrated into the system, automating the root cause analysis process. analytics.

An intelligent incident management system proactively delivers early warnings, diagnoses, and relevant historical trends through a user-friendly dashboard, empowering plant operators to make quick, informed, and collaborative decisions to improve reliability and minimize downtime. Along with the machine learning algorithms, the field experts were able to enhance the Pulse engine by incorporating their feedback with each incident generated making the application a meaningful collaboration of data driven analytics and field domain experts. Proactive maintenance could be carried out by the field team well in advance before machine tripping at low lube oil pressure in case of Propane gas compressor as early warning about lube oil supply pressure going low was given by Pulse even before DCS alarm setpoint was reached. This gave field maintenance team enough time to carry out their job thereby preventing potential tripping of the machine, thus averting tripping of LPG plant and subsequent production loss. High frequency vibration spectrum alerts were also produced by Pulse by collecting the high frequency data points from the Machine monitoring system1 of Bently Nevada. Finally, it has indicated well in advance the high vibration trend in Off gas compressor allowing the field team to open the machine well in advance before its failure whereby deterioration in main bearing white metal was observed and it was replaced in time thereby averting major failure of the machine.

The project provided value added insights into the transformative potential of predictive maintenance in processing plants and

challenges that can come with it. Failure of any process gas compressors can lead to shutdown of entire process plant causing huge production loss. Traditional maintenance approaches are often insufficient to address challenges of huge downtime and high maintenance costs involved. To address this issue ONGC embarked on transformative journey by partnering with a service provider to implement Digital Twin solution by simulating compressor behaviour and providing actionable insights to enhance reliability, lower maintenance costs and for safer, data-driven decision-making across the plant.

Abstract Title: Upgradation of the Power ecosystem with Cloud based solutions for Predictive Maintenance and Asset Integrity Management

Author: ***Deepti Maurya***

Organization: Oil and Natural Gas Corporation Limited

Abstract: Ensuring equipment reliability at ONGC's Uran Plant, which processes 42% of crude oil and 15% of gas from Bombay High, is critical for operational efficiency. Frequent maintenance and repairs undermine asset integrity, leading to increased downtime and occasional blackouts. To address this, there is a need for implementing modern, technologically advanced systems that reduce the frequency of maintenance, enhance reliability, minimize system downtime, and create a safer, accident-proof environment for continuous operations.

A comprehensive study was conducted with both in-house experts and external specialists to assess the situation, analyze available market options, evaluate system integrity, and recommend improvements for long-term reliability. The assessment concluded that the enhancement of asset integrity could be achieved by upgrading the medium voltage 6.6kV and 11kV switchgear systems. The proposed upgrades included safer interlocks, cloud-based predictive maintenance, continuous monitoring systems, and remote breaker rack-in/rack-out facilities. These new panels are designed to integrate cutting-edge technologies, such as advanced interlocking mechanisms for safety, remote-controlled earth switches, and cloud solutions that facilitate predictive and preventive maintenance. This modern approach will not only improve operational reliability but also ensure that the plant's systems are more resilient, safe, and capable of minimizing downtime through advanced, data-driven insights.

- Upgradation of 6.6kV and 11kV Switchgear: Enhances system reliability with advanced Cloud-based Predictive Maintenance and remote operation capabilities.
- Cloud-based Predictive Maintenance: Replicates power flow diagrams, providing real-time data on switchgear status, fault logs, events, and trend displays for better risk management and scheduled maintenance.
- Remote Rack-in/Rack-out Mechanism: Reduces human intervention in critical operations, increasing operational efficiency and safety by minimizing exposure to high-voltage components.

Observations and conclusion :

These technological advancements reflect Uran Plant's commitment to adopting modern solutions, ensuring a safer, more reliable, and future-ready electrical infrastructure. The upgrades will contribute to operational excellence, reduce downtime through predictive maintenance measures, and help maintain the integrity of the plant's electrical systems.

The adoption of cloud-based solutions for predictive and preventive maintenance will also extend the life of equipment, as potential issues can be identified early and addressed proactively. Additionally, the implementation of remote rack-in/rack-out breaker mechanisms will significantly enhance safety, reducing the need for direct human intervention during critical operations and minimizing exposure to high-voltage components.

Abstract Title: Elevating Digital Revolution in India by deploying Production Optimization Workflows in the largest producing asset in the country.

Author: ***Shashi Ranjan Kumar, Purvi Shukla***

Organization: Oil and Natural Gas Corporation Limited

Abstract: The abstract aims to delve into the challenges confronted by Maharatna ONGC as it endeavours to optimize production from its Western Offshore (WO) assets, while also outlining the objectives of embarking on a comprehensive digital transformation journey in collaboration with SLB. At the core of this initiative lie several pressing challenges: prolonged response times, soaring operational costs, and the imperative need for sustained production growth. The overarching objectives encompass streamlining the response times, rationalizing operational expenditures, and achieving substantive growth in production output.

Our methodological approach revolves around the systematic implementation of digital solutions, foremost among them being the Integrated Digital Analytics System (IDAS) for Mumbai High, largest producing asset of ONGC, aimed at facilitating real-time monitoring and optimization of production processes. A hallmark of our collaboration with ONGC has been the meticulous crafting of innovative production surveillance workflows and methodologies tailored to address the unique challenges at hand. One such innovation involves the creation of a comprehensive blueprint delineating the flow of data, seamlessly integrating inputs from multiple sources and furnishing actionable insights. Additionally, our team has pioneered solutions geared towards valve optimization, leak detection, and other critical operational facets, thereby fostering an environment conducive to enhanced efficiency and performance.

The tangible outcomes stemming from the implementation of digital solutions have been nothing short of transformative for ONGC. Response times, once languishing in the realm of months, have been dramatically curtailed to a matter of mere days. This quantum leap in responsiveness has been accompanied by a commensurate optimization of operational costs, thereby unlocking newfound efficiencies across the production landscape. Perhaps most strikingly, our collaborative efforts have borne fruit in the form of a robust 6-8% growth in production, signaling a resounding triumph over erstwhile stagnation. The symbiotic partnership between ONGC and SLB has anticipated 2-3% production enhancement.

Our foray into digital transformation has yielded a plethora of novel outcomes with far-reaching implications for the industry at large. The integration of disparate data sources into a cohesive framework, bolstered by real-time monitoring capabilities, has heralded a paradigm shift in decision-making processes, imbuing them with newfound agility and efficacy. Furthermore, the deployed solutions aimed at optimizing operational processes, such as valve optimization and leak detection, have emerged as exemplars of innovation, setting a precedent for industry-wide adoption. By embracing these transformative methodologies, industry stakeholders stand poised to unlock untapped reservoirs of efficiency and value.

Abstract Title: An IIoT-Enabled Predictive Maintenance Framework for Blowdown and Pressure Relief Valves in Flare Systems: Improving Operational Reliability and Minimizing Flare-Related Hydrocarbon Losses in Oil and Gas Facilities.

Author: ***Sourav Mukherjee***

Organization: Engineers India Limited

Abstract: In refining and petrochemical facilities, hydrocarbon flaring leads to substantial losses and environmental impact. Using U.S. EPA emission estimation protocols and site data, flare system leaks are estimated to cause 550,000 kg of hydrocarbon loss annually—about 30% of total emissions—primarily due to undetected leaks in pressure relief and blowdown valves. This study presents an Industrial Internet of Things (IIoT)-enabled solution for continuous condition monitoring and real-time diagnostics of flare-associated relief and blowdown valves. Proposed system enhances early leak detection, supports predictive maintenance, and improves asset integrity, contributing to reduced emissions, improved process safety, and compliance with environmental regulations..

- This study employs a multifaceted approach for flare leak detection and maintenance in industrial facilities:
- Technological Framework: IIoT sensors are integrated with unit- and plant-level predictive maintenance systems, enabling continuous monitoring of valve health, estimation of flare leakage, and provision of real-time maintenance recommendations for proactive issue resolution.
- Leakage Estimation: The study uses US-EPA emission estimation protocols and industry-specific data to quantify flare leaks, comparing potential savings from IIoT solutions with current systems.
- Financial Analysis: A financial evaluation assesses the costs of IIoT implementation against savings from predictive maintenance, calculating ROI for individual units and the entire refinery, demonstrating economic viability.
- Implementation Challenges: Practical deployment challenges, including installation, maintenance, and network design, are discussed to provide insights into barriers to adoption.

The integration of IIoT sensors with predictive maintenance systems provides a novel approach for flare leak estimation and management. Given that relief valves connected to flare systems are typically mechanical devices lacking monitoring mechanisms, IIoT technology offers valuable insights into the health of these systems. Financial analysis demonstrated a positive return on investment (ROI) for both individual units and the entire refinery, with cost savings from reduced maintenance, early leak detection, and minimized downtime surpassing the initial implementation costs. However, the study also highlighted several implementation challenges, including the complexity of sensor installation and the necessity for a reliable network infrastructure. Despite these challenges, the results emphasize the feasibility and long-term advantages of IIoT adoption in enhancing both operational efficiency and environmental performance in refining and petrochemical industries.

For safety and blowdown valves in flares that currently lack monitoring, IIoT-based solutions provide substantial benefits. These valves, often maintained reactively, can suffer from undetected leaks, leading to sustained production losses and safety risks. Leveraging IIoT-enabled monitoring allows for real-time health assessments, extend component life, enhancing both operational and financial performance.

Abstract Title: Roadmap to a Digitally Born Asset in New Energy Era

Author: ***Siddharth Setia, Swaroop Gururaj***

Organization: Kongsberg Digital AS

Abstract: How to Leverage advance LLMs & Agentic AI to Gain Operational Excellence & Sustainable Long-term Value in every Asset Management Decision Making, thus resulting in higher profitability and reduced operations costs.

While divesting from high-carbon assets is often seen as a route to decarbonization, it only transfers emissions rather than eliminating them. Digitalization, however, provides a strategic alternative:

Revitalizing legacy infrastructure: Digital twin technology enables real-time monitoring, predictive maintenance, and optimized energy usage, reducing the need for new infrastructure.

Enhancing carbon management: AI-driven emissions tracking and energy optimization minimize environmental impact.

Accelerated decision-making: A unified Industrial Work Surface integrates OT and IT data, allowing real-time operational adjustments.

Sustained cost savings and compliance: Digital tools ensure long-term regulatory compliance while improving asset value.

By investing in AI-driven digitalization rather than large-scale asset divestment, Indian energy operators can transition towards net-zero while maintaining financial sustainability.

India's ambitious goal of achieving net-zero emissions by 2070 requires overcoming several structural and technological challenges: Aging infrastructure and legacy systems: Many existing refineries and power plants rely on outdated technology, requiring digital intervention for enhanced efficiency. High dependence on fossil fuels: Despite growing investments in renewables, coal and oil still dominate India's energy mix, making decarbonization a gradual process. Hydrogen and biofuels integration: Scaling green hydrogen and biofuel adoption faces logistical and economic barriers despite government support. Investment and financing constraints: Modernizing infrastructure and deploying AI-driven solutions require significant capital investment. Regulatory and policy evolution: While India is making strides in energy policy reforms, regulatory inconsistencies remain a challenge. Skill gaps in emerging technologies: Upskilling the workforce to manage digital solutions and next-gen energy technologies is critical for long-term success. Despite these obstacles, the emergence of India's digital revolution—aligned with the "Digital Bharat" initiative—presents an opportunity to transform existing assets without requiring massive divestments. By integrating AI-driven analytics, digital twins, and automated monitoring solutions, operators can enhance efficiency while advancing sustainability goals.

The clear said value add will be:

- Digital twin integration: Leveraging AI-powered digital twins can optimize legacy assets, extending their lifecycle and enhancing efficiency.
- AI and predictive analytics: Data-driven insights can optimize maintenance, improve energy efficiency, and reduce unplanned downtime.
- Carbon capture and emission reduction tools: Advanced digital solutions help track and mitigate emissions, ensuring compliance with evolving ESG regulations.
- Upskilling the workforce: Equipping employees with digital expertise will be crucial for sustaining innovation and operational excellence.
- Embracing hydrogen & biofuels: operators should explore collaborations and best practices from India's evolving clean energy ecosystem; which is India leads.

Abstract Title: Machine Learning Approach in AI assisted HAZOP – Current trends & Way Forward.

Author: ***Praveen R, Gargee Bhattacharjee, Deepalakshmi S***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: To Share the experience gained while analysing the current AI assisted HAZOP software applications in market. In addition, 2 methods, i.e. Ontological approach and Machine learning approach are detailed for attaining partial to full automation in HAZOP methodology, along with the pros & cons of the same. As an example, and purely for academic interests, a few of the machine learning classifiers are compared for accuracy of output data.

In addition, way forward for creation of graph structures using optical recognition of P&IDs is discussed.

- For review of existing AI assisted HAZOP software, Salus HAZOP was run on demo basis. The process had to be defined manually, which made the process laborious.
- A program was run in python which extracted columns from an existing HAZOP worksheet, and used it for creating a new worksheet. Different ML classifiers were used for the same, and the classifiers were compared.
- A basic program was run in python which tried to identify process units from P&IDs provided.
- Ontological approach and machine learning approach are compared with advantages and disadvantages.

AI assisted HAZOP software program was analysed by demonstration trials, and literature reviews. Different ML algorithms were compared to find the most suitable ML classifier from the selected classifiers for creating a new HAZOP worksheet based on 2 older HAZOP worksheets. The result of each classifier was compared for accuracy and also computational power requirements.Two methods were used for P&ID recognition for a very basic process. One was through basic OCR, and the other was by pattern comparison according to ISA-5.1. Both methods are compared. Approach to refine AI models for better results. Methods to combine both Ontology based approach with graph structures, and machine learning methods to improve the versatility and accuracy of HAZOP process. Concept of live or online HAZOP/PHA documents, which will react according to changes in P&ID, existing regulations, or lessons. A concept wherein HAZOP worksheet becomes a live library which incorporates changes in P&ID, technology, or statutory regulations.

Abstract Title: Top-of-line corrosion in wellbores containing acid gases: Application to CCS and sour fields

Author: ***Somil S. Gupta, Rakesh Puthenkalathil, Ram R. Ratnakar***

Organization: Shell International Exploration & Production

Abstract: Top-of-line corrosion (TOLC) is one of the well-known integrity issues in various oil & gas processes such as wellbore maintenance of a sour field, oil & gas flow in pipelines, CO2 injection, and carbon capture and storage (CCS) applications. It is mainly caused by the condensation of moisture carrying acidic gases. The main objective of this work is to assess this issue, especially for CCS, with the help of physics-based models for phase behavior, pH, heat transfer and corrosion rates that could help in material screening and/or process design, avoiding/mitigating the corrosion risks.

The workflow consists of four constitutive models: (i) a phase behavior model, based on PR78 equation of state (EOS) with asymmetric Huron-Vidal mixing rule CO2-brine system, which accurately predicts vapor phase composition as well as corresponding aqueous phase compositions. (ii) a pH model, based on dissociation constants of carbonic acids, which is valid at reservoir pressure/temperature conditions. (iii) a condensation rate model, based on heat transfer rates, which includes all the resistances from wellbore to the nearby rocks. (iv) An empirical corrosion model, which combines the above three models and includes elementary redox reactions. Finally, a detailed sensitivity analysis with these models is performed with respect to various reservoir parameters such as brine composition/salinity, pressure, temperature, and wellbore/caping parameters.

A framework consisting of physics-based models and empirical relations is developed to determine the potential of TOLC caused by the moisture condensation containing acidic gases in legacy/abandoned wells. The main results are as follows: 1. The phase behavior model based on PR78 EOS model with Huron-Vidal mixing rule predicts the aqueous and vapor phase composition within the accuracy of 2.7% as compared to the experimental observations. 2. A coherent but simplified form of temperature-dependent interaction coefficients between CO2-salt are developed that has a smaller number of tuning parameters as compared to other literature models, and is validated for NaCl, KCL, and CaCl2. 3. The detailed sensitivity studies suggest that the corrosion and condensation rate predictions for single salts form a boundary for that of the mixture of salts. While pH may not be sensitive, the dew point temperature and moisture content are sensitive to the salt type and salinities, that significantly impact the final condensation and corrosion rates. 4. Most importantly, the modeling framework is valid for extended range of reservoir pressure, temperature and salinity conditions, and can easily be extended to various salt types, enabling it to assess the candidacy of the field for CCS applications.

The novelty and value of this work lies in the development of a fast and easy-to-implement workflow to assess TOLC risks in nearby legacy/abandoned wells in CCS as well as producing wells of a sour field during maintenance. Such assessment can help in the field screening for CCS applications, as well enhanced geothermal and other subsurface applications.

Abstract Title: AI-Driven Predictive Emission Monitoring Systems (PEMS).

Author: ***Sachin Kumar Agrawal***

Organization: Engineers India Limited

Abstract: This abstract focuses on the implementation of AI-driven Predictive Emission Monitoring Systems (PEMS) as a viable alternative to traditional Continuous Emission Monitoring Systems (CEMS) in Oil & Gas industry. The objective is to ensure compliance with emission regulations while supporting asset integrity and minimizing operational disruptions due to hardware limitations or maintenance downtime.

The proposed approach utilizes historical process data and emission records to develop AI-driven predictive models that estimate pollutant concentrations in real time. Key process parameters such as flow, temperature, and pressure serve as input variables for machine learning algorithms. These models are developed, validated, and tested against actual CEMS data to ensure accuracy. The methodology includes performance benchmarking of PEMS against CEMS under different operating scenarios, model tuning, and compliance with regulatory quality assurance protocols to ensure reliability and acceptance by environmental authorities.

The deployment of PEMS has demonstrated high correlation and accuracy when compared to CEMS data, especially under steady-state conditions. Results from pilot implementations indicate that PEMS can maintain compliance with environmental standards while significantly reducing system downtime, maintenance costs, and the need for hardware calibration. Observations revealed that predictive models can adapt to varying plant conditions, providing robust and reliable emission estimations even during minor operational fluctuations. The integration of PEMS with asset integrity frameworks enhances predictive maintenance by identifying anomalies in emissions that may indicate equipment degradation or failure. Additionally, PEMS has proven to be scalable and cost-effective for multi-unit operations and remote installations. In conclusion, AI-enabled PEMS not only meets regulatory requirements but also supports digital transformation initiatives by reducing dependence on traditional hardware and enabling data-driven decision-making.

This work contributes novel insights into the use of AI for emission monitoring, expanding the scope of digital tools for environmental compliance and asset health monitoring. It demonstrates how software-based solutions like PEMS can effectively complement or replace conventional systems, offering practical value for cost optimization, operational flexibility, and regulatory risk mitigation in the Oil & Gas sector.

Abstract Title: Quantitative Risk Assessment of Sectionalizing Valve Stations in Crude Oil Pipelines: A Framework for Asset Integrity Management

Author: ***Manoj Yadav, AP Shahu, Deepalakshmi S***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: Quantitative Risk Assessment (QRA) is a structured, data-driven method used to evaluate the risks posed by hydrocarbon facilities. It is a key enabler of Asset Integrity Management. The objective of the study is to estimate risk of fatality within and outside personnel from the failure probability and consequences of accidental events associated with the Sectionalizing Valve Stations and assess against Risk Acceptance Criteria. Risk of fatality from the failure of 36" overground oil pipeline, 30" overground oil pipeline, 20" underground gas pipeline and 8" overground naphtha pipeline are estimated and assessed against Risk Acceptance Criteria.

A complete description of the facilities covering the facility layout, process details, safety system details, manning distributions, meteorological conditions are prepared. Then hazard identification and postulation of the accidents are carried out to identify all items, operations and external conditions that could produce a major accident. For carrying out QRA study of SS valve station, whole facility has been divided in various isolatable segments depending upon isolation valves. Consequence analysis is performed for different leak sizes varying from 5 mm, 25 mm & 75 mm. Maximum Credible Loss Scenarios and Most Credible Scenarios are also discussed for different type of events like Flash Fire, Jet Fire and Pool Fire. Study is carried out by utilizing the event tree analysis diagram and state-of-the-art software tool "SAFETI".

Individual specific individual risk levels for the security personnel deputed is in the Broadly acceptable risk region. As per individual risk contours, only the risk contour of 10-6 and below are generated for the valve station. From societal risk ranking results, it is observed that 40.4 % of the total risk is contributed by 36" Oil pipeline (and its associated pipes, fittings, valves etc). and 31.4 % by 8" Naphtha pipeline (and its associated pipes, fittings, valves etc). High or low risk from any facility also depends on its proximity from manned locations apart from material contained and operating parameters.

As per F-N curve, Group (Societal) risk falls in the Broadly Acceptable region. Major group risk contributor is the 36" Oil pipeline, contributing 40.4 % of the total risk.

Study will help to find vulnerable zones from the consequences of accidental events associated with the Sectionalizing Valve Stations. It will help to put the targeted safety measures to eliminate / reduce hazardous situations arising out of accidental events associated with the Sectionalizing Valve Stations. It will also assist in deciding the location of building and their possible safe distances from the hydrocarbon facilities.

Compendium of Abstracts

Theme: Commercial Viability of RE Integration with Offshore Oil Platforms

Abstract Title: Techno-Commercial Feasibility of Offshore Wind Energy

Author: ***Rishabh Srivastava, Ashish Kumar Sao, Mukul Gupta***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: In line with Government of India targets of 30 GW from offshore wind by 2030, this paper outlines the following objectives:

- Harnessing the Offshore Wind potential from Gujarat and Tamilnadu offshore zones.
- Collaborating with DISCOMs for power evacuation and transmission to industries by power wheeling arrangement.
- Techno Commercial Feasibility of the project.
- Contributing towards environment sustainability by reducing carbon footprint.

Phase-1: A techno-commercial feasibility study will be carried out in Gujarat and Tamilnadu offshore zones (depth upto 40m), located near high wind potential zones, as identified by the National Institute of Wind Energy (NIWE) considering implementation in industries having captive power plants in the region. The study will develop model to assess technology identification suitable to offshore environment and offshore system infrastructure design, for power evacuation to the onshore grid. Capital expenditure (CAPEX), operational expenditure (OPEX), Levelized Cost of Energy (LCOE), and Return on Investment (ROI) will be evaluated to establish financial viability with minimum Viability Gap Funding (VGF).

Phase -2: Based on learnings of Phase-1, planning for the large-scale implementation of the project for powering the industries in respective areas.

Preliminary studies suggest that Power Generated from offshore wind will be exported to the onshore state grid and further transported to the industries through power wheeling arrangement via DISCOM. The preliminary analysis estimates for 5MW pilot project a payback period of approximately 6–7 years with VGF in the range of 10%. Large scale implementation of the Offshore wind project could be technically and commercially feasible for meeting industries power demand. This approach will lead to significant reductions in the consumption of hydrocarbon and associated carbon emissions. Higher initial investment of the project could be offset by the factors such as, declining cost of technology, viability gap funding and carbon pricing mechanisms will strengthen the economic case and lead to more industries and participation by developers/agencies. A phased deployment will be recommended, starting with a pilot project to validate system performance, followed by scaled expansion.

This study will establish a replicable framework for using offshore wind energy to support industries. Project will bridge offshore power generation with onshore energy consumption, enabling to extend the benefits of clean energy across industries. This framework will support industries decarbonization goals and contribute to India's broader clean energy and net-zero commitments. References 1. ONGC (2023). Sustainability Report 2022–23. 2. IRENA (2022). Renewable Energy for Offshore Oil and Gas Platforms. 3. NIWE (2023). Strategy for Establishment of Offshore Wind Energy Projects. 4. NREL (2024). Cost of Wind Energy Review.

Abstract Title: Decarbonizing Offshore Oil Platforms: A Pathway to Renewable Energy Integration

Author: ***Nidhi Chettri***

Organization: S&P Global

Abstract: Affordable and secure energy needs will sustain hydrocarbons as a key global supply source. To stay relevant in a low-carbon future, the oil and gas industry must improve environmental sustainability. Diesel, commonly used in remote operations, contributes up to 85% of greenhouse gas emissions. Switching to low- or zero-carbon power, such as renewable electricity, offers a potential path to reduce emissions significantly. This session investigates electrification's role in cutting emissions and its effect on profitability. India's oil and gas sector, contributing 5% of national GHG emissions, can adopt such strategies to support the nation's 2070 net-zero target while enhancing resilience.

Over 130 renewable deployments across global oil and gas operations were analysed. A number of attributes were collected to characterize these project deployments. These include project location, type of low-carbon energy sourced (e.g., solar, wind, hydro, biomass), method of low-carbon energy integration into operations (e.g., on-site renewable energy installation, power from grid, procurement strategy), company type, asset deployed to, service provider, operating environment (i.e., onshore and offshore), power capacity delivered, project announcement date, operational date, distance from grid, PPA contract length, project cost whenever mentioned and annual CO2 emissions averted. These projects were integrated with

country net-zero policies and company sustainability targets to understand regional dynamics driving patterns in renewable project deployment.

The overall projects tracked (from 2002-23) reflected a total installed capacity of 15.4 GW, including 93 onshore and 37 offshore projects, resulting in a 13.5 million tCO2e reduction in annual emissions. Offshore projects alone contribute 3 GW, reducing emissions by 3.2 million tCO2e annually. The two main drivers of low-carbon power for oilfield operations fall under two categories – cost reduction and policy. Project deployments have risen in the last few years, with just 16 projects prior to 2018 and a regional focus on Europe and North America, with power from grid and on-site renewable energy installations as a dominant project type, especially driven by Norway's power from grid projects (powered by hydroelectricity), its regulatory policies and increased carbon taxes. On the other hand, from 2022, China and Latin America are emerging as hubs for industrial decarbonization. Similar to Europe's environmental regulations, in China, the National Energy Administration's 2023-2025 Action Plan encourages green energy integration in oil and gas. On the other hand, Ecopetrol in Colombia is leading projects to enhance energy security as part of their individual company strategy, followed by companies like GeoPark and Frontera. Also, electrification of major oil and gas facilities is growing globally. Though not fully powered by zero-carbon sources yet, these projects are monitored for emissions reductions and future grid decarbonization alignment.

Deployment of field-based renewable power in oil and gas operations demonstrate that reducing emissions and improving profitability are not competing objectives. Countries like Norway and China set strong policy examples with increased carbon taxes and actions plans respectively that can inspire Indian government to implement stronger policies and ultimately companies can integrate renewables and reduce emissions. Also, since substantial benefits have been observed associated with these projects, we will continue to monitor these projects in the future closely.

Abstract Title: Renewable Energy Integration with Offshore Oil Platforms: Pathways to Sustainable Development

Author: ***Annie Aslam, Padmanav Sahoo***

Organization: S&P Global

Abstract: The objective of this study is to evaluate the commercial viability of integrating renewable energy with offshore oil platforms, emphasizing the necessity of reducing carbon emissions and operational costs amid rising carbon taxes. As nations strive to achieve net-zero targets, the adoption of renewable energy sources can significantly enhance the sustainability of oil production. This research aims to provide actionable insights into effective policy frameworks that can promote the exploration of renewable energy integration, drawing lessons from various successful case studies within the Norwegian offshore sector.

This analysis employs a case study approach, focusing on multiple electrification projects, including those by leading operators such as Equinor and OKEA. Data was collected from industry reports, government regulations, and project documentation to assess the operational impacts of electrification, including cost savings, emission reductions, and enhanced production efficiency. The study also examines the implications of Norway's dual carbon pricing system, highlighting how it incentivizes cleaner energy practices and supports the development of offshore wind. By comparing these findings with potential applications in other regions, particularly India, the research aims to outline a strategic framework for fostering commercial viability in renewable energy integration with offshore oil operations.

Electrification projects in Norway have achieved significant outcomes, such as ultra-low CO2 emissions and substantial annual reductions in greenhouse gas emissions. For instance, by utilizing power from shore, the Johan Sverdrup field has managed to achieve one of the lowest carbon footprints per barrel of oil produced in the global oil and gas industry, reducing carbon dioxide emissions to approximately 0.67 kilograms per barrel. This is substantially lower than the average emissions from traditional offshore oil production, which can range from 18 to 25 kilograms of CO2 per barrel. Additionally, ongoing initiatives by OKEA at the Draugen and Njord fields illustrate the potential for reducing carbon footprints in oil and gas production. These initiatives not only contribute to national climate goals but also enhance operational efficiency by decreasing reliance on gas turbines, leading to long-term cost savings. Furthermore, the establishment of offshore wind projects has been proposed as a solution to future electricity shortages, with calls for utilizing CO2 tax revenues to finance these developments. These findings underscore the importance of regulatory frameworks and market incentives in promoting renewable energy integration within the offshore oil sector.

By leveraging insights from global operators, India can foster the commercial viability of renewable energy integration with offshore oil platforms. Implementing supportive policies for power from shore initiatives, such as connecting platforms to the mainland grid, can significantly reduce operational costs and emissions. Investing in infrastructure for offshore wind development will enhance energy security and provide reliable power for electrified platforms. Additionally, utilizing carbon tax revenues to fund renewable projects can stimulate investment and innovation. These strategic initiatives will facilitate the transition to a low-carbon energy landscape, helping India meet energy demands sustainably and achieve net-zero targets.

Abstract Title: Technical and Economic Feasibility of Hybrid Offshore Wind Systems in Mumbai High Region: Three-Phase Implementation Framework.

Author: ***Manu Kumar Abhuday***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: This study presents a comprehensive three-phase framework for integrating offshore renewable hybrid power systems with existing petroleum infrastructure in the Mumbai High region. The objective is to evaluate technical feasibility,

design smart power hubs, and enable efficient shore power export to reduce fossil fuel dependence, enhance grid stability, and support India's energy transition goals. The approach aims to leverage existing assets while progressively advancing offshore renewable deployment to achieve economic viability and environmental benefits.

The methodology combines extensive literature review, technical feasibility assessments, simulation modelling, and case study analyses of global offshore hybrid projects such as Hywind Tampen and the North Sea Wind Power Hub. Phase I focuses on the hybrid integration of floating offshore wind farms with existing gas turbine and diesel generators. Phase II develops smart interconnected power hubs across multiple platforms using advanced control algorithms. Phase III addresses subsea cable route planning and transmission technology selection for shore power export. Simulation tools evaluate power flow, grid stability, and fault tolerance. Financial, legal, and risk assessments underpin the phased implementation strategy.

The study confirms the technical viability of integrating floating offshore wind with Mumbai High's petroleum assets, showing strong potential for significant fossil fuel displacement and emission reductions. Simulation results recommend a Star-F topology for smart power hubs, offering a balanced solution in terms of cost, reliability, and scalability for a 100 MW system. Shore power export via HVDC subsea cables is identified as the optimal transmission method for long-distance delivery to onshore grids. Financial analyses estimate a phased CAPEX of ₹6,000 million for Phase I if the project begins this year, with an initial Levelized Cost of Electricity (LCOE) of ₹7.78/kWh, which is expected to decline in subsequent phases. This aligns with global trends showing a steady decrease in floating offshore wind costs, supported by analyses from BVG and Catapult forecasting continued CAPEX and OPEX reductions toward 2030. Given an estimated learning rate of 13% for offshore floating wind, which further improves economic viability. Payback periods are projected between 10 to 12 years. Environmentally, the project could save up to 500,000 tonnes of CO_2 annually and significantly reduce NOx emissions. The phased approach reduces financial risk while supporting local economic growth and supply chain development. Overall, this framework presents a scalable and economically sound pathway to decarbonise offshore petroleum operations in India.

This research provides novel insights into the phased integration of offshore renewables with existing oil and gas infrastructure in the Indian context, addressing unique technical and environmental challenges of the Mumbai High region. It combines global best practices with localised feasibility assessments, offering a replicable model for hybrid offshore power systems. The study advances understanding of smart power hub architectures and subsea transmission strategies, contributing valuable data for policymakers, industry stakeholders, and researchers aiming to accelerate India's offshore energy transition.

Abstract Title: Renewable energy integration in Offshore Oil and Gas Installations

Author: ***Sachin Kumar Agrawal***

Organization: Engineers India Limited

Abstract: This abstract evaluates the feasibility of integrating renewable energy sources—offshore wind, solar, and marine energy into offshore oil and gas platforms. It aims to assess how such integration can support decarbonization efforts while enhancing operational efficiency and reducing reliance on fossil fuels for powering offshore installations. The review adopts a technology-driven and economic feasibility approach, analyzing case studies to demonstrate successful renewable integration. It explores various renewable energy options suitable for offshore settings and evaluates their compatibility with conventional energy sources in hybrid systems. The study also considers the application of microgrids and energy storage solutions to address intermittency issues. Key performance indicators such as energy reliability, system scalability, and investment costs are analyzed. Barriers such as harsh marine conditions and infrastructure challenges are identified, alongside emerging technological innovations aimed at overcoming them.

Offshore wind energy stands out as the most promising renewable source for offshore oil and gas platforms due to its scalability and growing deployment as evidenced by floating wind farms. Solar power and marine energy offer additional support when integrated into hybrid systems. Combining renewables with traditional gas turbines through hybrid microgrid systems ensures consistent energy supply. Advanced energy storage technologies and automated control systems further optimize energy use and manage fluctuations in renewable output. Economically, while high initial capital investments and infrastructure retrofitting pose challenges, long-term benefits include reduced fuel consumption, lower operational costs, and alignment with carbon reduction regulations. Regulatory incentives and environmental mandates further drive the viability of these integrations. The study concludes that renewable integration not only aids decarbonization but also enhances energy security and sustainability in offshore operations.

This abstract contributes to the growing body of literature by providing a focused analysis of renewable energy integration in offshore oil and gas platforms. It offers insights into hybrid system designs, technological advancements, and economic considerations, positioning renewables as a strategic enabler for greener offshore operations and future ready infrastructure.

Compendium of Abstracts

Theme: Decarbonisation Pathways in E&P : Methane Abatement and beyond

Abstract Title: **Waste to Energy: Sustainable Solution to Methane Emission.**

Author: ***Sukla Roy, ShyamKishore Choudhary***

Organization: TechnipEnergies.

Abstract: Under Global Methane Pledge, we have only 5 years to reduce 30% methane emission by 2030. About one-third of anthropogenic methane emissions are from the extraction and delivery of fossil fuels. On the other hand agricultural waste, waste from landfill, etc. has huge contribution towards methane emission. Waste-to-energy technologies - an unique solution to the overall problem of methane emission. Utilisation of waste to produce energy, reduce methane emissions by diverting organic waste from landfills, where it decomposes and releases methane. Converting waste into biogas, biofuel, etc. and using in place of fossil fuel significantly help to reduce methane emission.

Waste-to-energy technologies, particularly anaerobic digestion for biogas production, offer a significant pathway to reduce methane emissions from landfills and other organic waste sources. By converting organic waste into biogas, it not only prevent methane from being released into the atmosphere but also provide an alternative fuel source in replacement of NG. In that way it also reduces methane emission assiciated with exploration and Production of NG. Biomass/RDF gasification route to produce syngas opens various pathways of green/low carbon fuel including hydrogen, synthetic natural gas, etc. reducing ultimately use of fossil fuel along with associated methane emission in E&P of it.

Biomass which emits methane in atmosphere when decomposed in landfill or waste land, that emission can be restricted by converting into CBG. CBG contains more than 70% to 90% methane, hence this methane is reduced from direct emission to atmosphere. Typically 1 ton CBG requires 7-10 ton of biomass depending on feedstock characteristics. CBG is equivalent to NG, for every 1 tons of natural gas produced, approximately 2-5 kgs of methane are released, using CBG also reduces this methane direct emission. 100 metric ton of biomass can replace around 18 to 30 metric ton of NG to for the production of around 6 to 10 metric ton of Hydrogen by gasification method, reducing 36 to 150 kg of direct methane emission and about 10 metric ton of CBG equivalent methane content from biomass itself.

Use of bio-diesel, SAF, bio-H2, bio-methanol/ethanol, etc. will reduce fossil fuel requirement. CCUS opportunities are limited in India, but use of CO2 in EOR instead of using NG is attractive option to reduce methane. Methane leak reduction or reducing flaring, methane capture and utilisation, etc. not very effective method of methane abatement, it may reduce methane but ultimately it will release fossil based CO2. Use of green fuel, adapting waste and bio-based fuel switching is the best and permanent solution to meet methane abatement target. Also why not to shift exploration towards gold or white hydrogen instead fossil fuel exploration.

Abstract Title: **Natural Hydrogen: a transformative force in the future energy landscape**

Author: ***Chiradip Bagchi, Samarth D. Patwardhan***

Organization: MITWPU

Abstract: As the world's population continues to rise, so does the demand for energy. Traditionally, fossil fuels and coal have served as the dominant energy sources; however, their environmental impact has been substantial. The release of greenhouse gases (GHGs) and carbon dioxide (CO_2) from these fuels plays a major role in global warming and the disruption of climate and ecosystems. This situation demands to shift towards cleaner and sustainable energy alternatives. Although renewable sources like solar and wind energy are promising, they are dependent on sunlight and wind flow. Therefore, there is an increasing interest in investigating other viable energy solutions.

Hydrogen (H_2) serves primarily as an energy carrier rather than a direct energy source, but it possesses the capacity to store and transport large amounts of energy efficiently. It can be used in the production of electricity, heat, and power. A significant advantage of hydrogen lies in its low level of impurities, which enhances its efficiency and versatility in energy conversion processes. Being the most plentiful fundamental element in the universe, hydrogen accounts for approximately 75% of its mass. There are various classifications of hydrogen—like grey, blue, green, black, yellow, pink, orange etc. but white hydrogen is naturally occurring hydrogen.

White hydrogen or naturally occurring hydrogen, also known as gold hydrogen, is formed through geological processes such as the interaction of water with iron-rich rocks (a reaction known as serpentinization) or radiolysis, where natural radiation splits water molecules, biological activity, hydrothermal process etc. Abundance of this type of hydrogen occurs mainly within the Earth's crust and along mid-ocean ridges. It is observed that that when reacted with clastic or carbonate reservoirs, it generates calcium and magnesium derived products. Numerous studies suggest that, if properly harnessed, natural hydrogen could play a transformative role in the future energy sector. This study examines key aspects of natural (white) hydrogen, including its formation, methods of production, known reserves, and associated challenges. Additionally, it explores the

geochemical interactions between natural hydrogen and various rock types.

Natural or White hydrogen offers significant value in the transition to cleaner energy systems. As a naturally occurring form of hydrogen found in subsurface environments, it requires minimal human intervention for production, potentially reducing both environmental impact and energy input compared to industrially produced hydrogen. Since it emits no greenhouse gases during extraction or use, white hydrogen supports decarbonization efforts across sectors such as transportation, manufacturing, and power generation.

Abstract Title: Identifying Promising Zones for Natural Hydrogen: A Petrophysical Approach to Characterize Zone of Serpentinization

Author: ***Roshan Kumar Singh, Shalivahan, K. Vijaya Kumar***

Organization: Indian Institute of Petroleum and Energy, Visakhapatnam

Abstract: U.S. Geological Survey has proposed Earth's subsurface might have a 5.6 x 10^6 million metric tons of natural hydrogen. India has all the favourable geological domains—such as cratons, ophiolites, and faulted basins that have shown hydrogen potential globally. This work outlines a systematic strategy to identify favorable geological formations for natural hydrogen potential by integrating petrophysical characterization with geophysical and geological results. The objective is to create a scalable workflow adaptable across varied geological settings.

The exploration approach prioritizes petrophysical investigations, including measurement of seismic velocities, bulk density, magnetic susceptibility, and resistivity on rock samples to assess hydrogen-generating processes such as serpentinization. These properties help infer rock alteration and porosity patterns critical for hydrogen accumulation. Petrophysical data are then correlated with gravity and magnetic survey data to identify low-density, magnetically active, and structurally complex zones. This integrated methodology enhances subsurface interpretation and targets zones for detailed hydrogen flux evaluation.

Additionally, geochemical proxies such as helium and methane may be used to support hydrogen presence. The methodology is designed to be scalable for broader regional assessments.

The proposed strategy was applied to ultramafic-rich terrains to investigate zones of serpentinization which is a key geological process responsible for natural hydrogen generation. Petrophysical analyses revealed significant variability in rock properties linked to hydration and mineral alteration, confirming zones of advanced serpentinization. Magnetic susceptibility data highlighted magnetite-rich layers, while low-density and high-porosity readings pointed to favorable hydrogen migration pathways. When integrated with gravity and magnetic data, petrophysical findings enabled the delineation of subsurface features such as faults, ophiolite bodies, and serpentinized peridotites. Gravity lows and magnetic highs consistently aligned with hydrogen-bearing zones identified in petrophysical analyses. This integrative approach allows early-stage identification of hydrogen-rich zones, reducing the uncertainty and cost associated with exploratory drilling. The strategy is adaptable and scalable, offering a powerful tool for hydrogen exploration in structurally complex settings globally.

This abstract presents a novel, petrophysics-led exploration workflow integrating petrophysical measurements with geophysical and geological results. It enhances the accuracy of hydrogen prospecting in challenging terrains and can be tailored to different geological settings. The methodology is especially relevant as India explores cost-effective, natural hydrogen alternatives to green hydrogen.

Abstract Title: CO2 Storage Efficiency of a Saline Aquifer as The Function of Depth via Simulation Study

Author: ***Nishant Singh, Ashutosh Kumar, Rajeev Upadhyay***

Organization: IIT(ISM).

Abstract: Iglauer's 2018 study shows the non-linear trend of CO2 storage efficiency with depth. It increases to the depth of 1300 m and then becomes zero at the depth of 2400 m. This is accounted to the decreasing density gap between CO_2 and brine and increasing angle of wettability with depth. The US DOE method defines CO_2 storage mass in saline aquifers based on a storage efficiency factor (E), which is always greater than zero and tends to increase with depth. There appears to be significant contradiction This paper investigates the possible behavior of CO_2 storage efficiency with depth

A 2D saline aquifer numerical simulation study with CMG GEM was done to investigate this by making all the flow-dynamics parameters such as porosity, permeability, relative permeability, rock compressibility, density of water, capillary pressure, capillary hysteresis, reservoir pressure, injection pressure and aquifer temperature as the function of depth. The reservoir is mainly divided into two sectors (above and below cap rock) with injection wells on the edges. Important CO2 trapping mechanisms studied included: structural trapping, residual gas trapping, solubility trapping, and mineral trapping. The sensitivity of CO_2 storage efficiency to the flow-dynamics parameters is also studied. Lands' model is used for residual trapping to model capillary effect. Gas solubility is modeled via phase equilibrium process and henry's law is used for aqueous phase modelling.

Iglauer's 2018 study indicates that CO_2 storage mass peaks at approximately 1300 meters. Beyond this, the CO_2 storing capacity starts decreasing due to an increasing wettability angle which reaches 90o at 2400 meter where capillary pressure becomes zero leading to full leakage of CO_2. In contrast, our study shows that CO_2 storage mass increases nonlinearly with depth, while CO_2 leakage efficiency also rises with depth and reaches its peak around 3000 meters when all trapping mechanisms (are active. Then further it starts decreasing and reaching zero at around 14000-meter depth where CO2

Becomes heavier than brine. Thus, CO2 storage efficiency is unity as at this depth, so no leakage is possible. Structural integrity of caprock in Carbon Capture, Utilization, and Storage (CCUS) is paramount for ensuring the long-term effectiveness and containment security of carbon storage projects.

This study provides novel insights into CO_2 mass storage and leaking behavior and establishes depth-dependent trends for CO2 sequestration in saline aquifers. This study provides novel insights into CO_2 mass storage and leaking behavior and establishes depth-dependent trends for CO2 sequestration in saline aquifers. It helps in understanding the leakage behavior of the caprock in saline aquifer, ensuring secure containment and the success of CO2 geo-sequestration projects. So proactive risk management strategies can be utilized via effective predicting modelling.

Abstract Title: Data-Driven Methane Abatement Roadmap for India's Upstream Oil & Gas Sector: Forecasting Emissions and Optimizing Decarbonisation Pathways

Author: ***Umang Nagpal, Rakesh Kumar Yadav***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: This study aims to construct a Quantitative Decarbonisation Model and develop a Data-Driven Methane Abatement Roadmap for India's Oil and Gas sector. By analysing over 15 years of GHG emissions data, optimizing mitigation strategies, and evaluating techno-economic abatement options, the objective is to identify low-cost, high-impact methane reduction measures and generate an actionable pathway for reducing emissions by at least 40% by 2030, while supporting India's broader climate goals under its net-zero by 2070 commitment.

Historical methane emissions data for India's energy sector were sourced from GHG Platform India, indicating baseline upstream sector emissions averaging 2.7 billion tonnes CO_2e/year. Using this, Time-series analysis and Random Forest Regression models were applied to forecast methane emissions up to 2030, with a projected increase of 35% under Business-as-usual (BAU).

Techno-economic data from the IEA Methane Abatement Model was integrated, detailing marginal abatement cost (MAC) curves. A Linear Programming model was built to optimize technology combinations, such as LDAR, Flaring minimization, and Vapor recovery under fixed cost constraints, targeting emissions reduction within operational and financial feasibility.

Data Analysis showed that India's upstream oil and gas methane emissions grew from 2.1 to 2.6 billion tonnes CO_2e between 2005 and 2018, with peak intensities observed in in high-output regions such as Assam (0.56 Mt) and Mumbai Offshore (0.48 Mt). Our Forecasting Algorithm suggested that emissions may exceed 4.0 million tonnes CO_2e by 2030 unless proactive abatement interventions are applied. The Abatement Cost model developed in this paper had selected KPIs as boundary conditions that revealed that up to 47% of the emissions can be mitigated at less than ₹2,000/tonne CO_2e, and 18% can be abated at net-negative cost, due to gas savings from LDAR and Vapor recovery.

The optimization model recommends prioritizing LDAR, replacement of high-bleed pneumatic devices, improved Flaring efficiency, and investment and integration of CCUS and Green Hydrogen achieving ~1.5 million tonnes CO_2e reduction/year at a total cost of ₹220 crore/year. Sensitivity analysis of our optimization model concludes that emissions from the India's E&P sector can be reduced by up to 40-50% even under 20% cost escalation. The integration of data science, optimized mix of cost modelling and abatement technologies, and policy levers is essential for successful implementation of these strategies.

This study bridges the gap between high-level modelling and on-ground applicability by integrating emissions forecasting with cost-optimized mitigation planning. Validated against established energy models like MARKAL (TERI-MoEF), IEA's MAC curves, and IESS 2047, our model offers region-specific, actionable strategies for Indian E&P operators and regulators. The replicable framework enables ONGC, OIL, and policymakers to design INDC-aligned interventions and leverage carbon finance opportunities, delivering both climate and economic benefits.

Abstract Title: Decarbonization pathways: Key Learnings from Latin American NOCs for Indian NOCs in methane abatement and Innovative Technologies

Author: ***Rajeev Lala, Aayushi Bhardwaj, Swapnil Kaushal***

Organization: S&P Global

Abstract: As climate change becomes an increasingly urgent global challenge, the need for effective decarbonization strategies in the oil and gas sector has never been more critical. This paper explores the key learnings from Latin American national oil companies (NOCs) regarding methane abatement and the adoption of innovative technologies. The objective is to identify actionable insights that Indian NOCs can implement to enhance their decarbonization efforts and reduce greenhouse gas emissions, particularly methane.

The study examines the various methods employed by Latin American NOCs, including the implementation of operational maintenance programs to improve efficiency, initiatives to capture and utilize associated gas, and the establishment of robust leak detection and repair protocols. Additionally, the research highlights the importance of enhancing monitoring and reporting processes to ensure transparency and accountability in emissions management. The study adopts a comparative analysis of the methods used by Latin American NOCs, focusing on their initiatives for methane reduction. Data is gathered from industry reports and secondary reseach to provide context for these practices.

Latin American national oil companies (NOCs) such as Ecopetrol and Petrobras have made significant strides in prioritizing

decarbonization within their operational frameworks. These companies have incorporated emissions reduction and low-carbon initiatives into their executive incentive plans, a move influenced by supportive government policies aimed at fostering sustainability in the energy sector. This dual focus on decarbonization and financial performance reflects the evolving business models of Latin American NOCs as they navigate the complexities of the global energy transition. By balancing aggressive decarbonization efforts with the need to maintain strong financial performance and deliver shareholder returns, these companies are positioning themselves to thrive in a rapidly changing energy landscape. Their commitment to reducing carbon footprints while ensuring profitability serves as a model for other NOCs looking to align with global sustainability goals.

This paper provides valuable insights for Indian NOCs and policymakers by emphasizing the importance of adopting effective methane abatement practices. By focusing on the experiences of Latin American NOCs, the study offers a framework for Indian NOCs to enhance their operational efficiency and align with global decarbonization efforts. Ultimately, these insights can support India's commitment to reducing greenhouse gas emissions and advancing toward a sustainable energy landscape.

Abstract Title: Pioneering a greener future: The role of methane abatement and advanced technologies in advancing decarbonization for Indian NOCs

Author: ***Mansi Anand, Dr. Rajeev Lala***

Organization: S&P Global

Abstract: The primary objective of this paper is to assess and recommend strategies for Indian NOCs to implement cost-effective methane abatement through advanced technologies. By integrating quantitative emission data, digital monitoring systems, and carbon capture solutions, the research aims to identify best practices and quantify emission reduction potentials. The scope encompasses an evaluation of current operational challenges, technological readiness and regulatory gaps, as well as a comparative study of global NOC practices in decarbonization. This study further seeks to provide actionable insights that align with national energy security and sustainable development goals, paving the pathway toward a low carbon economy.

This study adopts a data-driven and comparative approach to assess methane abatement strategies for Indian National Oil Companies (NOCs). For this paper, we will follow three steps: Firstly, collect methane emissions data from Indian NOCs and benchmark performance against international peers using publicly available datasets and emission inventories. Secondly, review policy documents to analyze regulatory frameworks and digital technologies enabling real-time monitoring. Thirdly, work on comparative case studies from global best practices to recommend strategic and operational improvements. This methodology enables a holistic understanding of operational gaps, technology readiness, and strategic pathways toward scalable, cost-effective decarbonization.

The research underscores the critical importance of integrating advanced methane abatement technologies with robust digital monitoring systems for Indian NOCs. Preliminary findings suggest that while some NOCs have made significant strides in adopting methane reduction technologies, challenges remain in terms of funding, regulatory compliance, and technological integration. Leveraging AI-driven data analytics and carbon capture solutions, companies can reduce methane emissions while simultaneously improving operational efficiency and energy security. A well-structured regulatory framework, combined with financial incentives, is paramount to address technological and funding challenges. Furthermore, stakeholder collaboration among government agencies, industry players, and research institutions will drive the transition towards a sustainable low-carbon future. As India navigates its decarbonization pathway, these strategic interventions not only fulfill national climate commitments but also boost competitiveness and international market positioning, paving the way for long-term environmental sustainability and economic resilience.

The potential value adds of adopting these decarbonization strategies is multifaceted. Indian NOCs can achieve cost savings by reducing operational inefficiencies and capitalizing on new revenue streams. Proactive methane abatement positions Indian NOCs competitively in the global arena. The integration of advanced abatement measures will accelerate India’s transition to a low-carbon economy and ensure long-term energy security.

Abstract Title: Biological Restoration Techniques for Hydrocarbon-Contaminated Coastal Oil and Gas Sites: A Data-Driven Approach Integrating Bioremediation, Phytoremediation, and Ecosystem Rehabilitation

Author: ***Ankita Mehta,***

Organization: Directorate General of Hydrocarbons

Abstract: This paper aims to explore and evaluate the effectiveness of biological restoration techniques—bioremediation, phytoremediation, wetland construction, and mangrove rehabilitation—for the remediation of hydrocarbon-contaminated coastal oil and gas sites in India. The objective is to develop an integrated, sustainable approach to site restoration that aligns with environmental regulations, enhances ecosystem resilience, and supports decommissioning and decarbonization goals. The study provides data-driven insights for scalable application within the oil and gas sector, with implications for policy and operational frameworks.

This study employs a multi-step approach to assess biological restoration techniques for hydrocarbon site remediation. The methodology includes a literature review to understand bioremediation, phytoremediation, and coastal ecosystem restoration. Site selection focuses on coastal oil and gas zones with high potential contamination. Bioremediation involves using indigenous microorganisms to degrade hydrocarbons, while phytoremediation uses native plants to absorb pollutants.

Coastal restoration includes mangrove rehabilitation for erosion control and biodiversity enhancement, and constructed wetlands to treat oil-polluted water. Data collected from pilot sites is analyzed for hydrocarbon degradation, plant health, and ecosystem recovery, with the aim to establish sustainable, scalable remediation models for the oil and gas sector.

The implementation of bioremediation and phytoremediation techniques at selected coastal oil and gas sites demonstrated significant progress in reducing hydrocarbon contamination. Microbial strains introduced for bioremediation showed a 50-70% reduction in total petroleum hydrocarbons (TPH) levels within 3-6 months, with the highest degradation rates observed in oil-saturated soils. Phytoremediation using native hyperaccumulator plants resulted in substantial uptake of hydrocarbons, with the plants effectively stabilizing contaminated soils and improving overall soil health. Coastal restoration efforts, including mangrove rehabilitation, led to a 30% increase in mangrove cover over one year, contributing to enhanced coastal protection and increased biodiversity. Constructed wetlands proved effective in treating oil-polluted water, achieving a 40-60% reduction in oil content, and improving water quality parameters such as pH and dissolved oxygen.

This study offers a scalable, eco-friendly framework for hydrocarbon site restoration and remediation using biological restoration techniques. By integrating bioremediation, phytoremediation, and coastal ecosystem rehabilitation, it enhances environmental recovery while reducing long-term remediation costs. The approach supports regulatory compliance, climate resilience, and biodiversity restoration, aligning with India's net-zero and ESG goals. It also provides actionable insights for policy and operational integration in the oil and gas sector.

Abstract Title: Subsurface Dynamics of Natural Hydrogen: A Geological Perspective

Author: ***Atul Kumar Varma, Shalivahan, Roshan Kumar Singh***

Organization: Indian Institute of Petroleum and Energy

Abstract: Natural hydrogen—also referred to as geologic or "gold" hydrogen—has emerged as a promising clean energy resource formed and stored within the Earth's subsurface. This study provides a geological perspective on the subsurface dynamics of natural hydrogen, encompassing its formation, migration, accumulation, and potential for sustainable extraction.Natural hydrogen primarily originates from geological processes such as degassing of deep-seated hydrogen from earth's core and mantle, serpentinization, where ultramafic rocks interact with water, and radiolysis, involving the breakdown of water molecules due to natural radioactivity, decomposition of hydroxyls in the lattice structure of minerals and decomposition of organic matter.

The processes (degassing of deep-seated hydrogen, serpentinization, radiolysis, decomposition of organic matter as well as hydroxyls and biological including anthropogenic activities) are naturally regenerative, suggesting a continuous, albeit slow, production of hydrogen over geological timescales. For hydrogen to accumulate in the subsurface, specific geological conditions are necessary. Porous and permeable reservoir rocks, such as sandstones or carbonates, can store hydrogen, while impermeable cap rocks like shales or evaporites act as seals, trapping hydrogen beneath them. Hydrogen's migration through the subsurface is influenced by various factors, including rock heterogeneities and pore-scale interactions.

Small-scale variations in rock properties can significantly affect hydrogen flow and trapping efficiency, while hydrogen's behaviour at the microscopic level, such as its wettability and dissolution in brine, impacts its mobility and storage.Recent models estimate the global subsurface hydrogen resource to range between 10^3 and 10^{10} million tonnes, with a most probable value around 5.6×10^6 million tonnes. This vast potential has spurred interest in exploration, particularly in regions with favourable geological settings. The discovery of substantial natural hydrogen reserves has led to increased interest from both the scientific community and industry. Companies are investing in exploratory drilling, and researchers are conducting missions to better understand hydrogen's subsurface behaviour. However, challenges remain, including understanding long-term behaviour, developing efficient extraction technologies, and establishing regulatory frameworks.

The subsurface dynamics of natural hydrogen present both exciting opportunities and complex challenges. Continued interdisciplinary research and collaboration will be key to unlocking this potential clean energy resource. Geologic hydrogen is a carbon-free, sustainable resource, that is constantly being generated underground. The future development of hydrogen will centre on the delineation of hydrogen-conducting fracture zones, the presence of possible sealing horizons and the use of appropriate well drilling and completion techniques.

Abstract Title: Sustainable Methanol Synthesis: Improving Catalyst Stability through Zeolite-Enhanced Membrane Reactors

Author: ***Amit K. Thakur, Nilanjana Banerjee***

Organization: UPES

Abstract: The catalytic hydrogenation of carbon dioxide (CO_2) to methanol is emerging as a promising technology for mitigating greenhouse gas emissions. Methanol is a viable green alternative to conventional fossil fuels because of its physicochemical properties closely resembling those of gasoline. This study evaluates packed bed membrane reactor for CO_2 hydrogenation into methanol, using a bifunctional CMR integrating a zeolite LTA membrane, Cu-ZnO-Al_2O_3-ZrO_2.

The crystalline zeolite membrane, characterised by its adjustable pore structure, enables selective water removal via molecular sieving. This water management significantly enhances catalyst durability and methanol yield by mitigating deactivation caused by water accumulation, a major limitation in conventional systems.

The proposed CMR configuration effectively addresses this challenge, maintaining higher catalytic activity and efficiency. Comprehensive simulations, validated against experimental data, demonstrated strong agreement, supporting the design's robustness and scalability. This integrated system represents a compelling pathway toward more durable and efficient technologies for CO_2-to-methanol conversion.

Abstract Title: Methane Abatement

Author: ***Mr. Sathiamoorthy Muhunthan, Mr. Peter Evans, Mr. Manishkumar Shah***

Organization: BP Exploration Alpha Ltd

Abstract: Abating methane emissions from oil and gas production is one of the most significant ways that the industry can contribute to helping society meet the long-term temperature objectives in the Paris Agreement. But knowing where to focus efforts is difficult because detailed information on the origins of emissions has been sparse. A new generation of technology is changing that. Here we explore insights from bp's global programme to better understand what drives emissions in bp and the targeted interventions that have been possible.

The bp strategy has been to focus improved measurements on the key sources of emissions, adapting to the differing needs of onshore and offshore production in line with emergent reporting requirements. It has drawn heavily upon advanced data analytics, optimizing the use of existing operational data and reducing the need for installation of new equipment. Wherever practical the focus has been on continuous near real-time data so that the impact of environmental and operational choices on emissions can be fully explored and those insights fed-back to front line personnel.

We present results from across bp, each highlighting how measurement leads to targeted interventions. For flaring, we show how parametric models can improve understanding of complex combustion processes taking place in the flare and how by adjusting flare gas compositions the efficiency of the flare can be improved under purge conditions or during storms. In power generation, measurements reveal how gas turbines can change from being very low emitters to significant sources if operated outside of their optimum load states. By load sharing between facilities methane can be reduced as part of integrated greenhouse gas reduction plans. Onshore, we show how a programme to replace pneumatic devices was informed by a detailed investigation of average emission rates. Drone and aircraft mounted methane sensors have been used to target specific sites of fugitive emissions and inaccessible vents

By better understanding emissions abatement plans can be focused towards where the greatest impact can be achieved. Many of these interventions require changes to how we operate existing equipment rather than replacement. Transparent measurement methods mean that these changes can be presented to key stakeholders in a traceable and defensible way.

Abstract Title: Direct Air Capture: A Path to Carbon Neutrality

Author: ***Dr. Satyajit Chowdhury, Dr. Srawanti Medhi, Sidhartha Sankar Kowndilya***

Organization: Rajiv Gandhi Institute of Petroleum Technology

Abstract: Performance Measurement: Quantify the CO_2 capture efficiency and uptake capacity of the sorbent under flue gas conditions. Regeneration Feasibility: Determine whether the sorbent can be regenerated at a moderate temperature (120°C) while releasing high-purity CO_2 (>99%) for potential reuse or storage. Durability Assessment: Investigate the sorbent's ability to maintain consistent performance over multiple capture-regeneration cycles, ensuring its long-term reliability. Industrial Relevance: Provide experimental evidence of the sorbent's capability to handle high CO_2 concentrations and its potential for integration into industrial decarbonization strategies, particularly in hard-to-abate sectors.

A lab-scale Direct Air Capture (DAC) system was evaluated using a amine-functionalized sorbent. Ambient air containing ~410 ppm CO_2 was passed through an adsorption column designed for optimal airflow and contact with the sorbent. CO_2 levels at inlet and outlet were measured using non-dispersive infrared (NDIR) sensors. Adsorption continued until CO_2 breakthrough was observed. Regeneration of the sorbent was achieved thermally at 90°C–110°C to release captured CO_2, which was collected and quantified. The system underwent 50 continuous adsorption-desorption cycles to test the sorbent's performance, durability, and regeneration efficiency. Temperature, flow rate, and exposure duration were controlled and monitored to ensure consistent operation. The experiment aimed to simulate real-time DAC integration with vertical farming environments for carbon utilization.

The DAC unit showed an average CO_2 capture efficiency of 72%, with the amine-based sorbent achieving a maximum capacity of 1.8 mmol CO_2 per gram. Regeneration via heating at 90°C–110°C consistently released over 85% of the absorbed CO_2. Performance remained stable over 50 cycles, with less than 5% degradation in sorbent efficiency. Outlet CO_2 concentrations confirmed effective adsorption under ambient conditions. The system proved thermally and chemically stable, validating its potential for continuous operation. These findings indicate that the DAC system is well-suited for integration with hydroponic setups, enabling dual benefits—reducing atmospheric CO_2 and improving plant growth through targeted enrichment—thus contributing to climate-smart, sustainable agricultural practices.

The Direct Air Capture (DAC) system provides significant value by capturing atmospheric CO_2, contributing directly to climate mitigation goals. The purified CO_2 can be utilized in a variety of industrial applications, such as the production of synthetic fuels, carbonated beverages, building materials like carbon-infused concrete, and advanced polymers. Additionally, surplus CO_2 can be geologically sequestered to achieve permanent storage or injected into depleted oil reservoirs for Enhanced Oil Recovery (EOR), thereby increasing domestic energy production. This positions DAC as a versatile technology that not only

reduces emissions but also adds economic value across sectors through resource utilization and environmental sustainability.

Abstract Title: Exploring Natural Hydrogen in India: Screening Criteria and Prospect Evaluation

Author: ***Annapurna Boruah, Suvendu Manna, Rupendra Pachauri***

Organization: UPES

Abstract: Globally, natural hydrogen production from various geological sources has been reported in countries like Mali, Turkey, Spain, Australia, China, and the USA. The paper highlights the methods used to identify and assess natural hydrogen reservoirs, emphasizing the importance of robust screening by integrating multiple data sources and using advanced analytical tools. This paper aims to discuss the potential of natural hydrogen in India, focusing on hard rocks, oil and gas fields, hot water springs, and basement rocks.

Natural hydrogen is produced through processes such as serpentinization, radiolysis, and water–rock interactions, often associated with cratonic regions, fault zones, and ultramafic rock formations. Potential areas for natural hydrogen exploration in India include the Dharwar and Singhbhum Cratons, the Aravalli-Delhi Fold Belt, and greenstone belts with ultramafic rocks conducive to serpentinization. Additional promising zones are intra-cratonic basins like Vindhyan and Cuddapah, and geothermal provinces in Uttarakhand, Himachal Pradesh, and Ladakh, where faulted terrains and hydrothermal systems may facilitate hydrogen generation and migration. This study involves a systematic methodology that integrates field sampling, laboratory analysis, and thermodynamic calculations of hot springs in Uttarakhand. Water samples were collected from geothermal springs, Key parameters such as temperature, pH, electrical conductivity, trace elements, and redox potential were measured.

The studied thermal water from geothermal regions of Uttarakhand state show EC values (346–879 µS/cm) and TDS (228–596 ppm) in thermal waters zones, whereas EC (89–221 µS/cm) and TDS (54–161 ppm) in the nearby non thermal regions. High TDS, particularly from sodium- and calcium-rich waters with sodium concentrations 268–369 ppm (e.g., Badrinath and Gari village), suggests deep circulation and high geochemical processes that may facilitate hydrogen formation through the hydrothermal reactions and water-gas interactions. The geothermal water in the area show temperatures from 38 to 102°C, and cation trend (Ca > Mg > Na). The presence of significant Mg (15–68 ppm) and Ca (22–88 ppm) suggests that some ultramafic lithologies may be involved in the subsurface, including the serpentinization reactions which occur when Fe^{2+}-bearing minerals in ultramafic rocks react with water. Microbial studies play a vital role in natural hydrogen exploration by identifying hydrogen-utilizing or hydrogen-producing microorganisms in subsurface environments. In deep geological settings, certain microbes—such as hydrogenotrophic methanogens, sulfate-reducing bacteria, and acetogens—thrive using H_2 as an energy source, often indicating natural hydrogen seepage or accumulation zones. These microbial signatures can act as biological proxies for hidden hydrogen reservoirs.

India's strategic move toward a clean and self-reliant energy future under the National Hydrogen Mission underscores the urgency to explore alternative hydrogen sources. Natural hydrogen offers a low-emission, cost-effective energy option, potentially reducing dependence on energy-intensive green hydrogen production. With proper mapping, gas monitoring, and pilot studies, India could position itself at the forefront of natural hydrogen exploration in the Global South, contributing to both energy security and climate resilience.

Abstract Title: AI Innovations for Decarbonization in E&P: Accelerating CO_2 Storage Forecasting

Author: ***Prof. Siddharth Misra,***

Organization: Texas A&M University

Abstract: Geological carbon storage (GCS) is a critical decarbonization pathway for the E&P industry, relevant to managing mature fields' environmental footprint. Accurate, rapid forecasting of subsurface CO_2 behavior is essential for risk management but computationally expensive with traditional methods. This study's scope is to develop and validate an advanced AI approach using Fourier Neural Operators (FNO) and Transfer Learning (TL) for rapid and accurate prediction of pressure and CO_2 saturation distributions in GCS reservoirs. The objective is to significantly reduce the time and data required for CO_2 forecasting, facilitating the efficient and safe deployment of GCS as a decarbonization solution..

An updated Fourier Neural Operator (FNO) model, capable of handling data sparsity, was developed to learn the complex spatiotemporal dynamics of pressure and CO_2 saturation in GCS reservoirs. This FNO model was trained on diverse datasets representing geological heterogeneity and operational variations, including sites like SACROC and IBDP. To enhance efficiency and adaptability, transfer learning (TL) was applied, allowing a pre-trained FNO model to be rapidly fine-tuned for new, complex scenarios with limited data. The methodology involves training the FNO, then using TL to transfer knowledge to different geological or operational conditions.

The FNO-based forecasting achieved a significant speed-up, reducing simulation time by a factor of 40 compared to commercial simulators (from 40-50 minutes to ~12 seconds). Integrating Transfer Learning further reduced computation time to ~8 seconds for complex tasks. The FNO model demonstrated high accuracy, with relative mean errors below 1% for pressure and below 2% for saturation in initial tests, and low MAEs (e.g., pressure MAE 0.046 MPa/4.5 psia, saturation MAE 0.011/0.11). Transfer learning effectively reduced the required training data by 78-87% while maintaining acceptable accuracy (relative error below 5% or slightly higher). The models successfully generalized to a geologically distinct site (IBDP).

This FNO+TL workflow offers substantial value as a decarbonization pathway in E&P. It drastically reduces the computational

time and data needed for CO_2 storage forecasting, making comprehensive risk assessment and uncertainty quantification practical. This enables the efficient planning and operation of GCS projects, supporting emissions reduction targets beyond methane abatement. By providing rapid insights into CO_2 plume behavior, the technology enhances decision-making for deploying GCS in various E&P contexts, including potentially integrating it with EOR in mature fields for both carbon mitigation and improved recovery.

Abstract Title: Enhanced geothermal with supercritical fluids: A pathway for global heat production

Author: ***Ram R. Ratnakar, Somil S. Gupta, Birol Dindoruk***

Organization: Shell International Exploration & Production

Abstract: Geothermal energy contained several miles underneath the Earth is estimated to hold several orders of magnitude more energy than hydrocarbon resources. However, only sparsely located sweet spots (near volcanic areas or hot springs) are developed and utilized so far. The globalization of geothermal energy requires enabling heat extraction at non-volcanic regions, especially by going deeper. But commercial-scale development of such globalized geothermal faces several critical problems from reservoir to the final delivery point. In this study, we review those challenges and focus on transport and thermodynamics aspects in the geothermal well, which are crucial to resolve some of these challenges.

We consider a closed-loop well configuration in enhanced geothermal system with CO2 (a supercritical fluid) as energy carrier. While various modeling studies are presented in literature for such system, we extend them by (i) using a unified fluid property model ranging from sub- to super-critical regions, (ii) capturing the effect of transient cooling of the nearby rocks, and (iii) developing a local-property dependent heat transfer coefficient that is easy to implement with the flow model. The model is solved using finite volume approach and sensitivity studies are performed to account the effects of transport and thermodynamic parameters on the thermal output of the geothermal well.

One of the main results is the development of a local-property dependent heat transfer coefficient for capturing the propagation of temperature front away from the well in the surrounding regions. It was found that the heat transfer coefficient does not only depend on the rock conductivity/heat capacity and well diameter, but also on real time of operation representing the transient cooling of the surrounding rock. In addition, the sensitivity studies show the significant difference in power generation when local-property dependent fluid properties and transfer coefficients were included (in contrast to average/constant values). Depending on the assumed boundary conditions and other simplifying assumptions, numerical simulations of coupled heat transport and fluid flow in well and reservoir may help predict more accurately the thermal output and the long-term economics, only when essential physics are included in the models.

This work presents a general modeling framework for a closed-loop geothermal well that can easily be extended for any carrier fluid, enabling the ability to assess the candidacy of any sub- or super-critical fluid for enhanced geothermal systems. The evaluation of the thermal output of such a system can also help in proper design and optimization of the process, as well in the assessment of the long-term economics.

Abstract Title: Geomechanics in Designing Wellbore for NE fields of India

Author: ***Satish Kumar Sinha, Jitendra Argal, Krishna Kumar Yadav***

Organization: Rajiv Gandhi Institute of Petroleum Technology

Abstract: Geomechanics has become increasingly important in upstream oil and gas industry for various reasons. The oil and gas industry has moved into an era where wells have become more expensive and complex in terms of both geometry and access. Horizontal / deviated/ directional wells have become norm rather than exceptions. Cluster of wells are being drilled from a pad. We drill deep, high-temperature, high pore pressure and high stress regimes. Low permeability reservoirs are being exploited with hydraulic fracking. Understanding of fracture propagation in the subsurface and their mapping play an important role in the economic viability of such reservoirs.

A geomechanical model is fed with elastic properties of rocks. For this purpose one would use static and/or dynamic data available. Wireline logs such as DSI and Sonic Scanner help us determining these parameters. Strength of a rock can be anisotropic especially when we are dealing with shales. The rock strength and the orientations of the in-situ stresses are determined through a number of ways including borehole breakouts and induced fracture pattern. Such a geomechanical model helps in predicting wellbore stability. Depletion caused by production of oil and gas changes in the stress state of the reservoir that can be beneficial, or detrimental in a number of ways which can be incorporated in the geomechanical model for future development plans.

From geomechanical modeling of an oil field in NE India, It is observed that single NCT cannot explain the development of pore pressure in the area. If an NCT is established based on the shallower section, deeper formations will show much higher pore pressure. On the other hand, if an NCT is established based on the target formation, which is normally practiced explaining the reservoir section only, pore pressure estimate for the upper section would be abnormally low. Therefore, multiple NCTs are established and gradual transition from one NCT to another appears to be in Tipam formation. Considering the uncertainty in the wireline log estimate and sparsity of logs, statistical approach was followed to estimate formation properties. From the LOT/PIT data and wellbore breakout modelling for the Barail Arenaceous formation, the state of stress can be summarized as SH > Sv > Sh . However, from the seismic data, we also observe reverse faults (i.e. SH > Sh > Sv) in the deeper section and normal faults (i.e., Sv > SH > Sh) in the upper section. Current day stress can be different from the

paleo-stress conditions during which faults and fractures have formed. 3D seismic volume is used to generate various attributes which can be used to extract stress components, pore pressure, and rock strength for breakout modelling along any given well trajectories.

In many cases wells are designed keeping in mind environmental restriction and society in general. In brownfields development geomechanical studies are important to extend economic life of the field by optimizing well plans. Building a robust geomechanical model particularly for oil fields in NE India can help companies reduce NPT, thus saving on well cost.

Abstract Title: Efficient and Cost Effective completion Strategy in High angle wells of Offshore Oil fields- A Case study from Western Offshore, India.

Author: ***Ramakrishna, Sivasankar Sahoo, PN Jha***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: Adopting a right completion strategy in a matured oil reservoir/brown field plays an important role especially in offshore oil fields. The early water breakthrough via high permeable layers and rise in W/C due to field maturity are common issues which impacts the production. Revival of non-flowing wells requires Intervention jobs by rig deployment and in offshore it is a costly affair. Straddle completion is the most suitable and cost effective well completion technique which can minimizes the rig deplloyment for revival of the wells.

Heera field is having vertically stacked reservoirs namely Heera, Mukta, Bassein and Panna. Each reservoir has differential pressure depletion and heterogeneities that pose challenge to commingle production. Multi zone completions are cost effective and avoid frequent deployment of rig. Multi zone completions are cost effective and avoid frequent deployment of rig. Strategy is to drill a high angle well through multiple pays with LWD+NMR and reservoir pressure recording. Based on the logs and pressure data, suitable pays are selected for selective stimulation with straddle completion. With the help of this completion, Operator can produce from selective pay as per requirement. Operator can close the deeper pay by installing standing valve/blanking plug and open sliding sleeves with rig-less wireline operations and put well on production.

This strategy used in more than 5 wells presented case studies of 3 wells.

In well-X, Lower Bassein and Heera are oil bearing. Formation pressure are in the range of 1800-1850psi in Bassein and 1300-1400psi in Mukta and ~2032psi in Heera. Significant pressure difference was observed between the Mukta & Bassein formation. Both the formation were tested separately with mobile separator. Mukta flowed oil 250 BOPD & Lower Bassein flowed oil 350 BOPD through test separator separately. So, it is decided to produce from Lower Bassein and Mukta can be opened in future with rigless wireline operation.

Well-Y, Heera & Mukta is oil bearing. However LWD recorded formation pressure of Heera was 1888psi & Mukta was 1092psi. It was challenging to produce simultaneously from Heera & Mukta due to pressure difference. it was decided to perforate, complete Heera & Mukta with straddle completion. Well was flowed Oil-183BOPD with 35% W/C from Heera. Mukta will be completed in the future by rig less wireline operation.

In well-Z, Heera, Mukta & Bassein formations are oil bearing. Formation pressure of Bassein & Mukta was in the range 1300-1400 psi and Heera was 1800-1850 psi. Hence well was completed straddle in Mukta & Heera pays. Well was flowed Oil-112BOPD with 48.7% W/C from Mukta. Heera will be completed in the future by rigless wireline operation.

This strategy avoids the early or frequent deployment of rig thus saving 20-25 rig-days which leads to cost saving of ~Rs 10-12cr for each well at current rig rates. Strategy is simple and adoptable. This strategy will be a game changer if applied in more wells where vertically stacked reservoirs are present in the field.

Abstract Title: Enhancing Drilling Performance and Optimising Well Design through Digital Integration

Author: ***Mr. Shailesh Chandra Sinha, Mr. Sivakumar Ganesan, Mr. Ashish Sharma***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: This paper presents how the convergence of digital technologies and institutional expertise at Institute of Drilling Technology (IDT) is driving ONGC's commitment toward safer, smarter, and more cost-efficient drilling practices where all facets of a well including planning, execution, monitoring and intervention will be carried out from an integrated command and control center.

At the core of the capability of IDT is the Real-Time Drilling Operations Centre (RTDOC), which enables live monitoring and decision support for field operations. Complementing this are platforms like the Digital Well Plan for standardized and consistent planning, Well Information System (WIS) for structured reporting & data access and performance benchmarking. The implementation of Drilling Well on Paper (DWOP) practices further enhances pre-drill preparedness by encouraging cross-functional collaboration and scenario analysis. Additionally, use of AI based predictive analytics tools are being explored that predicts well conditions in real time by analysing drilling parameters—enhancing operational safety.

RTDOC at IDT-ONGC is the integrated center for monitoring & supervision of pan-ONGC drilling operations. With posting of experienced officers, 24/7 online supervision of drilling operations is enabling to proactively address drilling anomalies which has a direct bearing on reduction in costly non-productive time (NPT). Till date more than 100 possible instances of down-hole

complications like string stuck-ups, string washouts and equipment failures have been prevented leading to substantial savings of Rig days. Another recent milestone was the successful demonstration of “Auto-steering” of downhole RSS assembly in a well in Gujarat with remote control and monitoring at RTDOC using AI based platform, showcasing the potential for intelligent rig operations in remote or critical environments. Moreover implementation of centralized planning will optimize and standardize the well planning process. This abstract outlines how the convergence of institutional expertise and digital technologies at IDT will not only improve well delivery and reduce costs but also reshape ONGC’s operational paradigm for the future.

By leveraging digital technologies and expertise in planning, execution, monitoring and intervention, ONGC can achieve a more integrated approach to well management that enhances operational efficiency and decision-making process in drilling operations.

Abstract Title: Size Controlled Indigenous Stable Nanofluids of SiO2 NPs for Compressive Strength and Shale Swelling Mitigation during Cementing Operations

Author: ***Tushar Sharma, Ramaswamy Gautam, Suvendu Sen***

Organization: Rajiv Gandhi Institute of Petroleum Technology

Abstract: This study investigates the potential of incorporating SiO_2 nanofluids into cement slurries to enhance their mechanical properties and also mitigate shale swelling. Size controlled single step SiO2 nanofluids were separately synthesized with better dispersion and of desired size. Single step nanofluids possess greater stability due to simultaneous synthesis and dispersion in the base fluid. Hybrid nanofluid was mixed in water and then cement slurry was prepared. The tests were conducted at 250 °C and pressure was maintained at 3000 psi. With inclusion of hybrid nanofluid, compressive strength was found to increase by 40%.

- 1. Synthesis of SiO2 nanofluids and cement slurries
- 2. Fluid loss test and thickening time of cement slurry
- 3. Compressive strength determination of the cement
- 4. Shale swelling analysis

Class G cement was obtained from Dalmia, India, and cement additives were retarders, fluid loss control agents and anti-foaming. The shale samples were obtained from IDT – ONGC. Mattler Toledo (model-ME204/A04), with a precision of 0.1 mg was used to weigh the chemicals. This research considers the viability of adding nanofluids in the form of SiO_2 to cement slurry. Incorporating these nanofluids is a good strategy for responding to technological issues of contemporary cementing operation, yielding safer and more efficient well building processes.

Thickening time studies exhibited retarding behaviour of nanofluid, and thickening time increased by 20%, also there was a rapid increase in compressive strength within 12 hours. Shale swelling studies showed that nanofluid reduced shale swelling by 22%. The findings show that adding these nanofluids significantly improves cement performance, enhancing hydration, reducing fluid loss, and boosting both early and long-term compressive strength. Size controlled single step nanofluids were used in cementing operations and demonstrates that SiO_2 nanofluid holds great promise in improving oil well cementing, offering a path toward more durable, efficient, and cost-effective solutions in the oil and gas industry. Additionally, the modified cement exhibits better resistance to thermal degradation, making it more effective in high-temperature well environments. Size controlled single step hybrid nanofluid was found to improve the cement property and also proved its efficacy as shale swelling mitigator. SiO_2 nanofluids have large surface area and reactive properties, which enhance the microstructure, mechanical properties and strength at high temperature and pressure. The most important limitations are insufficient strength, decreased durability, and low resistance to extreme downhole conditions like high temperature, pressure, and corrosive environments. Furthermore, shale swelling upon fluid invasion during cementing also possess a risk to well stability and cement integrity.

The addition of silica was found to maintain the original properties of cement slurry, establishing that cement had not agglomerated and no sedimentation was observed even at shear rates of 1000 s-1. The results of this study greatly promote the use of silica nanofluid as an important additive in class G cement for cementation operations, which is unlikely with two-step nanofluid where nanoparticles are expensive and upon mixing, they tend to agglomerate and make large size clusters.

Abstract Title: Characterisation and classification of the shallow sands for integrated abandonment planning in Nelson field, UK North Sea.

Author: ***Swagato Dasgupta, Ashutosh Garg, Sankarshan Mohanta***

Organization: Shell

Abstract: While designing field abandonment plan, safe abandonment of wells is an important element of Shell’s 'more value with less emissions’ strategy. This article highlights the integrated work undertaken to characterise the Pleistocene shallow sands (Group 2 and 3) in the Nelson Field, UK North Sea, and to assess if these are classified as zones of flow potential. Thus propose a robust & integrated abandonment strategy.

The Nelson platform development wells were drilled near the shallow sands. Considering implications and complexities of this,

the work assessed the presence and properties of the shallow sands around the Nelson well locations and define the characterisation, allowing for a reduction in the front-end planning uncertainty. This cross-country collaboration work integrated seismic interpretation, log data, quantitative seismic interpretation and reservoir engineering inputs for an in-depth understanding.

Two main shallow sands, Group 2 and 3, have been identified and interpreted in seismic and confirmed by shallow log data in some wells. Different attributes were extracted along the Group 2 and Group 3 Aviat sand unit to analyze the morphology, channel extend and potentiality for gas fill. The analysis concluded that sands are discontinuous, poorer quality with lower amplitude response. The development wells penetrated at the margin of this discontinuous sand bodies with low level of background gas and silty shale lithology. Thus, cannot be classed as zone of flow potential.

The result of this collaborative work has been a significant decrease in abandonment cost and length of scope. It serves as a key example of how to "right size" isolation strategies so that they are robust and cost effective based on cross discipline and location collaboration

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Abstract Title: ECD management in horizontal ERD wells with Hole Openers

Author: ***Rohan Hareshbhai Patel, Ishika Singh***

Organization: Cairn Oil & Gas, Vedanta Ltd.

Abstract: Drilling of ERD slim hole wells results in high drilling ECD's during lateral drilling. Further, the siltstone reservoir has low fracture gradient due to presence of natural fractures or artificial fractures constructed by hydraulic fracturing (frac hits). During execution, it often results in seepage to moderate to severe downhole losses causing significant NPT associated with trying to cure losses with LCM pills, incremental risks of activating circulating subs as well as NPT's associated with trip outs to place loss circulation cement plugs.

Downhole losses curing with LCM pills is not very successful because of long laterals requiring continuous curing operations as new formation is opened up. Other strategies include drilldrills with minor losses, LCM pills (with or without circulation subs) or trip out for cement plug jobs. This has also the associated risk of shot TD'ing these wells thus compromising on the well deliverability. Whilst these strategies largely focus on increasing the formation strength, the operator has evaluated deployment of hole openers to minimize ECD's to minimize the intensity of losses on the first hand.

This paper shall cover the results of actual deployment of hole openers in 6 horizontal wells where in the drilling ECD's have reduced by ~0.2 to 0.4 ppg. Different hole opening strategies were deployed from initial 6-1/8" to 6.5" to later 6-1/8" to 6.75" hole sizes. The findings illustrate a significant decrease in drilling ECD's; associated NPT's and an increased drilling efficiency and confidence in executing these long lateral ERD's safely. Thus, allowing for the successful frac and completion of wells and meeting the ultimate well objectives. There is a strong correlation pointing towards cost savings associated with reduced NPT's offsetting any incremental costs for hope opening technology.

The use of hole openers for reducing ECD's provide a unique data set for slim hole ERD horizontal wells. The analysis provided in this paper shall serve as reference to other operators and drilling service providers looking for resolution of downhole losses in similar scenarios.

Abstract Title: Case history: Successful deployment of multiple Cement plugs in horizontal ERD well to cure downhole losses

Author: ***Aditi Sharma, Tek Chand Bareja***

Organization: Cairn Oil & Gas, Vedanta Ltd.

Abstract: The ERD slim hole wells results in high drilling ECD's during lateral drilling. Further, the siltstone reservoir has low fracture gradient due to presence of natural fractures or artificial fractures(frac hit). During execution, it results in seepage to moderate to severe downhole losses causing significant NPT associated with trying to cure losses with LCM pills, incremental risks of activating circulating subs as well as NPT's associated with trip outs to place loss circulation cement plugs.

This paper covers a case history of a well wherein multiple cement plugs were successfully deployed in the horizontal section to address down hole losses. Placing cement plugs in the horizontal section has multiple risks and very little chance of success due to various factors. The hole inclination causes cement plugs to gravitate on the low side, rendering these plugs ineffective. Further, re-threading the cement plugs is critical else the loosing zone will be again exposed making the entire BHA trip and the cement plug job futile. Hence, precise directional drilling planning/execution is critical and uncertain at the same time.

This well also had a hole opener deployed in the drilling assembly to minimize the drilling ECD. Despite the hole opener, the downhole losses were severe enough leading to the decision to cure losses with cement plugs. In this case history, the downhole losses were successfully managed with cement plugs, as the cement plugs were successfully drilled and the losses were reduced to manageable levels. The well was successfully drilled to TD and it was a record well for the operator in terms of well TD in terms of the second longest well (3000+ m TD) and longest in terms of lateral achieved (~1500m).

The effective and efficient placement of cement plugs in horizontal sections (for curing losses) and being able to successfully rethread the hole without sidetracking is not very common and provides for a good reference for other operators to plan similar jobs.

Abstract Title: Geomechanical and Mineralogical Insights into Chloride-Based Completion Fluid–Shale Interactions.

Author: ***Saurya Nayak, Rajat Jain, Deepak Amban Mishra***

Organization: Indian Institute of Petroleum and Energy

Abstract: Shale integrity maintenance during drilling and completion operations is essential for wellbore stability. Potassium chloride completion fluids are widely used for shale stabilization, and their role in altering geomechanical properties can be quantified. This study evaluates the influence of fluid properties such as density and viscosity on shale strength and elasticity using the Brazilian tensile strength test and p-wave velocity measurements as indicators.

Shale core specimens were immersed in potassium chloride solution of varying viscosities and densities under controlled conditions. Geomechanical testing was conducted pre- and post-exposure to measure the p-wave velocity and Brazilian strength index. Fluid properties are varied systematically to assess the combined effect on the mechanical response of shale. Petrographic and microstructural analyses complemented the mechanical testing to elucidate the strength alteration mechanisms. The samples are tested in three batches with different salt concentrations for the completion fluid to note the outcome on mechanical strength. The relation between the rock strength and p-wave velocity is studied to observe the correlation

The study was done by varying the salt concentration from 3% to 20 %. The density and viscosity of each formulation have been noted. The density varies within the range of 8.5 to 9 lbs/gal. The viscosity-dependent fluid infiltration behavior is indicated through mechanical strength, i.e., in Brazilian Tensile Strength studies. A correlation is drawn between the fluid densities and the Brazilian Strength index. Moreover, p-wave velocities decreased significantly after fluid exposure, which indicates elastic stiffness. The p-wave velocity reduction can serve as a sensitive indicator for mechanical weakening. Hence, optimizing fluid properties is essential for formation damage mitigation and maintenance of wellbore integrity. Microstructural observations of the untreated and fluid-treated samples confirmed minor mineralogical alterations. Rock-fluid interactions on a micro-scale serve to alter geomechanical strength. Moreover, the nature and concentration of brine taken is crucial for a formation under study.

This study presents an integrated mechanical and elastic parameter approach to characterizing potassium chloride completion fluid-induced shale deterioration, providing a predictive tool for optimistic fluid properties, thereby improving wellbore stability measures. The combined approach encompassing the mechanical and ultrasonic aspects presents a practical framework for assessing formation stability in real-time, giving valuable insights for designing completion fluids compatible with shale.

Abstract Title: Cost-Effective Gravel Pack Completion to Overcome Sand production and High-Temperature Steam Injection Challenges in CSS Wells of Western Onshore Fields of ONGC

Author: ***Sudeep Vyas, Amit Thakur, Himanshu Ahuja***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: This paper discusses a field-proven completion solution successfully implemented to tackle two key challenges in Cyclic Steam Stimulation (CSS) wells: Sand production in unconsolidated reservoir and thermal cycling under high-pressure steam injection. The reservoir in focus is located in Western India and is known for its heavy oil characteristics: high porosity (~28%), permeability between 5-15 Darcy, and viscous crude (13°API, 800–1500 cP). Historically, the wells were completed using conventional gravel packs and artificial lift systems. This paper aims to evaluate a new approach that provides effective gravel pack isolation while withstanding the harsh downhole environment encountered during CSS cycle.

The completion strategy involved installing gravel pack equipment including sand screens, performing gravel placement, and installing a specially engineered sealing element above the gravel pack. This sealing system was specifically selected for its non-elastomeric design and its ability to maintain sealing performance in high-temperature conditions. The CSS operational cycle included:

• Running the gravel-packed completion assembly

• Injecting steam at up to 305°C and 2100 psi for three weeks

• Allowing a soak period of around one week

• Flowback followed by transition to artificial lift

Throughout the cycle, operational parameters such as sand-free production, fluid rate, pressure temperature were carefully monitored to evaluate the system's performance.

Results:

After completing the wells with the new gravel pack completion system, steam injection was started, followed by a flowback phase. All wells transitioned into production and are currently producing sand-free, demonstrating effective gravel pack isolation and overall system integrity. No early interventions or corrective actions have been required since completion.

Observations:

Throughout the CSS cycle, the completion system performed reliably under high thermal and mechanical stresses.

- No leaks or pressure drops were observed during or after steam injection.
- Gravel pack integrity was consistently maintained, enabling clean flowback and sustained production.

- The system endured cyclic steam exposure of high temperature without signs of any failure.
- The approach eliminated the need for expensive high-temperature gravel pack packers, offering both technical and economic advantages.

Conclusion:

The field trial successfully demonstrated that gravel pack completions in high-temperature CSS environments can be executed using a practical and cost-effective method. This outcome validates the completion strategy and provides a reliable alternative for future well designs in heavy oil reservoirs where sanding and thermal challenges are prevalent.

Potential Value

- Expands CSS application in heavy oil fields without relying on premium & costly gravel pack completion hardware.
- Reduces risk of gravel pack failure during the CSS operation, increasing operational confidence during thermal cycling.
- Offers an economical alternative gravel packing solution for CSS wells for similar reservoir with high sand production risk.

Abstract Title: Well Cost Optimization using basics of Geomechanical Analysis: A Case Study

Author: ***Birupakshya Panda, Anup Gourav Sahu***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: The study aims to demonstrate the effectiveness of geo-mechanical analysis using Decision Space Petrophysics software in optimizing well planning and reducing costs. By analyzing a case study of well AX-01, initially planned with a three-casing policy, the study showcases how data-driven insights can lead to a more efficient two-casing policy, resulting in significant cost savings and enhanced drilling operations. The scope includes evaluating pore pressure, fracture gradient, and overburden gradient to refine well design and improve drilling efficiency. The study also aims to provide a model for future well planning and geo-mechanical analysis in similar geological settings.

The study involved a comprehensive analysis of nearby well logs, subsurface lithology, and structural correlation to understand the geological and geo-mechanical conditions. Using Decision Space Petrophysics software, pre-drill pore pressure plots, overburden gradient, and fracture gradient curves were generated. Data from nearby wells, including gamma ray logs, density logs, neutron porosity logs, and sonic logs, were integrated into the software. The geo-mechanical analysis included calculating overburden gradient, pore pressure gradient, and fracture gradient, which were validated using nearby well data. This approach allowed for the revision of the well plan from a three-casing to a two-casing policy.

The geo-mechanical analysis revealed lower-than-expected pore pressures and higher fracture gradients in the deeper formations of well AX-01. This allowed for the use of lighter mud weights and conventional cement slurry, reducing the risk of overpressure-related complications and optimizing drilling fluid costs. The successful implementation of a two-casing policy, instead of the initially proposed three-casing policy, resulted in significant cost savings and streamlined drilling operations. The accurate prediction of pore pressures and fracture gradients ensured safe and efficient drilling, contributing to the smooth execution of the drilling plan. The well completion with the two-casing policy not only reduced costs but also provided valuable insights for future exploration activities in the field. The study concludes that integrating geo-mechanical techniques using Decision Space Petrophysics software is highly effective in optimizing well design and drilling performance, serving as a model for future well planning in similar geological settings.

The study highlights the potential for significant cost savings and operational efficiency through accurate geo-mechanical analysis. By reducing the number of casings required and optimizing drilling fluid costs, the approach can lead to more sustainable and cost-effective drilling operations. Additionally, the insights gained from this study can be applied to future well planning, enhancing the overall understanding of subsurface conditions and improving decision-making processes in similar geological settings. This methodology can serve as a benchmark for other oil and gas exploration projects, promoting the adoption of data-driven geo-mechanical analysis in the industry.

Compendium of Abstracts

Theme: Innovations in Deepwater Exploration and Production

Abstract Title: Nanocomposite Pour Point Depressant (NPPD) for Flow Assurance of an Indian Waxy Crude Oil through Subsea Pipelines .

Author: ***Dr. Shailesh Kumar, Mr. Shailendra Singh, Dr. Sidharth Gautam***

Organization: Rajiv Gandhi Institute of Petroleum Technology

Abstract: This study aims to synthesize and evaluate the performance of an Ethyl Vinyl Acetate (EVA)-based Nanocomposite Pour Point Depressant (NPPD) to enhance the flow properties of Indian waxy crude oil under low-temperature conditions, such as those encountered in subsea pipelines. The scope includes analyzing the effectiveness of NPPD in suppressing wax crystal formation and minimizing pressure drop during pipeline transport, thereby offering a viable solution for flow assurance challenges in waxy crude oil transportation.

The study investigates the characteristics (water content, API gravity, pour point, wax content, and SARA distribution) of the test crude oil sample. The NPPD was synthesized by blending a conventional PPD (EVA) with nanoparticles using the solvent blending method. The nanocomposite was characterized by using Fourier Transform Infrared Spectroscopy (FTIR) to verify molecular interactions, and its thermal stability was assessed through Thermogravimetric Analysis (TGA). Performance evaluation included standard pour point testing, rheological investigations under both rotational and oscillatory modes using a rheometer, and flow assurance assessment using a laboratory-scale flow loop setup to simulate pipeline conditions and monitor pressure drop pre- and post-treatment of crude oil with NPPD.

The crude oil sample exhibited a high wax content (13.48 wt.%) and a high pour point of 39 °C, categorizing it as waxy crude. Thermal analysis confirmed enhanced thermal stability of the synthesized NPPD in comparison to the parent EVA-based PPD. At an optimal 1500 ppm dosage, the NPPD reduced the pour point to 22 ℃, while EVA alone achieved a reduction only to 31 °C. PPD and NPPD reduced the viscosity by approximately 80% and 84%, respectively, at 25 ℃ and 1500 ppm dosage. Oscillatory rheological analysis revealed viscoelastic behavior and relatively reduced gel formation tendency with NPPD-treated oil samples in comparison to EVA-treated and untreated crude samples. The observed gelation point of 24 ℃ for the crude sample treated with NPPD indicates enhanced low-temperature flowability. Pipe flow analysis confirmed that the NPPD-treated crude oil sample exhibits a significantly lower pressure drop compared to the untreated sample, indicating enhanced flow under pipeline-like conditions. These findings demonstrate the superior performance of the developed nanocomposite pour point depressant in mitigating wax-related flow issues. The additive offers a scalable and thermally stable solution for enhancing pipeline transport efficiency in cold and subsea environments.

The developed nanocomposite pour point depressant shows strong potential in addressing critical flow assurance issues in the transportation of waxy crude oils. Its ability to significantly reduce pour point and viscosity, along with improved thermal and rheological stability, makes it a promising candidate for practical application in pipeline transportation of crude oil in subsea environments, ultimately reducing maintenance costs and operational risks.

Abstract Title: Deepwater Alliances: Pathways to partnership between Indian and Latin American national oil companies

Author: ***Aayushi Bhardwaj, Rajeev Lala, Mansi Anand***

Organization: S&P Global

Abstract: Deepwater exploration presents unique opportunities and challenges for national oil companies (NOCs) in India and Latin America, particularly in the context of global energy demands and resource management. This paper explores the strategic alliances formed between major Indian NOCs such as ONGC and Latin American counterparts like Petrobras and Ecopetrol. By examining their collaborative efforts in deepwater projects, the study highlights how these partnerships aim to enhance technological capabilities, optimize resource extraction, and address environmental sustainability, contributing to energy security in both regions.

This research analyzes case studies of partnerships between Indian NOCs and their counterparts in Latin America. The study examines how these companies can build strong alliances in deepwater projects through joint ventures, technology-sharing agreements, and public-private partnerships. This paper takes a comparative and analytical approach to explore how Indian NOCs and Latin American companies can collaboratively develop deepwater resources. By focusing on these partnerships, the research aims to understand the processes and strategies that lead to effective collaboration in the deepwater sector. Data is collected from industry reports, secondary research, and comparative policy review. The paper identifies strategies in public-private collaboration. This approach helps identify practical ways for Indian NOCs and global companies to work together, fostering mutual growth and enhancing energy security.

The analysis reveals that deepwater alliances are increasingly vital for both Indian and Latin American national oil companies (NOCs) to mitigate risks and capitalize on technological advancements. Key observations highlight that these partnerships

have resulted in shared expertise, improved operational efficiencies, and enhanced access to resources. The study concludes that fostering such collaborations not only strengthens the competitive position of both regions in the global oil market but also promotes sustainable practices in resource management. Identifying strategies in public-private collaboration, potential for joint ventures and strategic alliances is significant, paving the way for a more resilient energy landscape.

This paper enhances the understanding of the strategic significance of international alliances for Indian NOCs in the deepwater sector. By emphasizing the potential benefits of collaboration with Latin American NOCs, it highlights opportunities for knowledge transfer, technological enhancement, and shared best practices. Such partnerships can play a crucial role in addressing the challenges of deepwater exploration and production, supporting India's broader energy security objectives. The insights gained can inform future collaborative efforts and strategic decisions within the Indian oil and gas industry.

Abstract Title: Navigating new depths: How Indian NOCs can draw inspirations from African joint ventures to enhance deepwater resources development

Author: ***Mansi Anand, Swapnil Kaushal, Rajeev Lala***

Organization: S&P Global

Abstract: As conventional shallow-water and onshore opportunities mature, Indian and African National Oil Companies (NOCs) are exploring deepwater projects to unlock new hydrocarbon resources and secure long-term energy supply. These projects face challenges including high capital intensity, technical complexity, and long lead times, necessitating innovative strategies for exploration, development, and production. The paper explores how NOCs can leverage advanced technologies to optimize deepwater projects and improve cost efficiency. Additionally, it examines the role of partnerships, joint ventures, and regulatory frameworks in enabling technology transfer, de-risking investments, and enhancing project execution agility.

The methodology involves analyzing data and case studies related to African deepwater projects involving major operators like ExxonMobil, TotalEnergies and Shell. Key African basins are examined to identify joint venture structures, operational strategies, and exploration results. A comparative framework assesses the applicability of these findings to the Indian deepwater projects. Data sources include drilling records, resource estimates, and regional regulations.

Findings indicate that joint ventures in African deepwater settings often combine shared expertise and risk management to improve exploration outcomes. The use of advanced drilling technologies supports effective resource identification despite geological challenges. Indian offshore basins present similar complexities but currently have limited joint venture models with integrated technology strategies. Adoption of structured collaborations and focused technology deployment, as seen in African examples, could enhance India’s offshore exploration and development efficiency. The study concludes that applying these approaches may assist Indian NOCs in optimizing offshore resource potential.

This analysis offers Indian NOCs a reference for structuring offshore partnerships and risk-sharing mechanisms based on African examples. It identifies technological and operational practices that could be adapted to lower exploration uncertainty and cost in India. Insights into regulatory and contractual frameworks may inform improved investment conditions. The study also supports prioritization of offshore exploration targets and international collaboration for capacity development. Implementing these lessons can contribute to more efficient offshore resource management and support India’s objectives in expanding domestic deepwater energy production.

Abstract Title: Innovative ROV Compatible Hydrate Remediation Skid

Author: ***Munendra Kumar***

Organization: Oceaneering International Services

Abstract: Unlike shallower waters, deeper and ultra-deep water fields have extremely High pressure and colder temperatures. This poses the flow assurance problems due to Hydrates formation. The objective of this abstract is to present the design, functionality, and operational benefits of a hydrate remediation skid (HRS) used to address small-volume hydrate issues in subsea control lines, chemical lines, under tree caps, and umbilicals, providing an economical and efficient solution for offshore oil and gas operations.

The HRS is designed to be attached to the base of most work class ROVs and quickly deployed to site. It utilizes three pumps to inject remediation fluids such as methanol or MEG, or to depressurize cavities by extracting fluids. The skid interfaces with hydraulic control lines on subsea assets, depressurizing them to initiate hydrate dissociation. A 1,200-gallon subsea bladder recovers discharged fluids. The system includes multiple flow and pressure sensors, redundant instrumentation, and proprietary software with built-in safety features to ensure effective and safe operations.

The HRS has demonstrated significant efficacy in remediating small-volume hydrates, asphaltenes, paraffins, and sludge in subsea environments. Field applications across various phases of production, including well development, start-up, operation, well kill, and P&A, have shown that the skid provides a versatile and reliable solution. The system's compatibility with nearly all work class ROVs, combined with its rapid mobilization capability, ensures minimal operational downtime. Real-time data on pressure and flow, provided by the topside controls, enhances operational decision-making. The robust design, built on a long performance history, ensures superior functionality compared to other systems. The HRS offers significant cost savings, with day rates substantially lower than larger, more complex remediation solutions.This abstract highlights the innovative integration of advanced hydrate remediation techniques and real-time monitoring, offering a comprehensive and economical

solution for small-volume hydrate management. It contributes to existing literature by demonstrating the practical application and benefits of a versatile, ROV-compatible skid in enhancing operational efficiency and safety in offshore oil and gas production.

Abstract Title: Subsea Emergency Response Tool (SERT) Kit

Author: ***Khandker Rahman, Aayushi Sharma***

Organization: Oceaneering International Services

Abstract: Lessons learned from earlier incidents show the benefits derived from the subsea application of dispersant. Generally Subsea application of dispersant system is packaged together with an ROV Tool and equipment for debris clearance, subsea dispersant and BOP intervention

Subsea Emergency Response Kit equipped with hardware required for the dispersant flow assurance from umbilical subsea termination head to the ROV wands. Additional package equipped with ROV tools and equipment required for the debris clearance and BOP intervention prior to dispersant and capping operations. Subsea Emergency Response Kit (SERT) will be deployed by the Source Control Response team in the event of failure to control the well during an incident. This package allows the Source Control operations team to focus on direct intervention of the blowout well at the wellhead in an effort to stop the release of well fluids/hydrocarbons to the environment utilizing a capping stack.

A subsea emergency response tool kit plays a crucial role in minimizing environmental, financial, and operational risks when a subsea well incident occurs. An application of SERT Kit ontime can minimize oil spills and chemical leaks that can harm marine ecosystems. The SERT kit also allows the operators to regain control over a damaged well, reducing downtime and financial loss. The capping stack can be deployed to seal off an uncontrolled well, stopping the flow of hydrocarbons into ocean upon successful deployment of the SERT Kit on time.

The Subsea Emergency Response Tool Kit offers multiple benefits in managing well incidents efficiently and protecting both people and the environment. The SERT Kit is carefully designed for quick deployment anywhere in the world, ensuring well operators can respond swiftly to emergencies.

Abstract Title: Innovative Control Systems for Deep & Ultra-Deep Water Operations

Author: ***Gurjot Singh***

Organization: Oceaneering International Services

Abstract: Oil and gas companies around the globe are always looking for quicker and efficient solutions to control subsea components and optimize intervention costs as much as possible. The proposed presentation will detail an advanced ROV work over control system (RWOCS) that caters to this need.

In order to develop the RWOCS, the requirement details were studied in the engineering phase, followed by methodology selection, and then segregating the features by category including volumetric capacity, pressure requirements, and redundancy. The RWOCS has two main configurations: ROV-mounted and Standalone The ROV-mounted system includes a skid with a tool tray, dual fluid reservoirs (80 gallons total), chemical and glycol pumps, and hydraulic and electrical interfaces. The standalone system adds 150 gallons of fluid storage via an additional reservoir and includes redundant 5,000-psi hydraulic power units and 15,000-psi boosters. Both configurations have fail-safe mechanisms, including backup valves and flow sensors, and support multiple OEM tree designs. The API-17Q qualification process covers RWOCS at system and subsystem levels with proper SIT and FATs in place.

RWOCS reduces the rig equipment footprint by up to 70%, ensures no high-pressure fluid pumping at the surface, and allows faster deployment than traditional systems. The modular design and subsea fluid pumping capabilities of the RWOCS improve safety, reduce costs, and eliminate HSE risks. This also results in reduced personnel requirements with fewer items to operate on deck. The RWOCS's master controller system supports the automation of settings for several operating parameters, logging results at different stages of the work, as required. Within RWOCS, an additional configuration has been developed for small scale / low volume applications known as Compact RWOCS. This configuration comes with a single reservoir and power unit with redundancy added to spares kit. The designs are compatible with different models of remotely operated vehicles with an option of a custom-built connecting adapter. RWOCS also comes with a typical MQC type hydraulic interface as well to work on corresponding interfaces on subsea trees and control modules.

RWOCS revolutionizes intervention, workover, and control operations, allowing quicker deployment with fewer personnel. It reduces the emission levels by 40-60% as it allows the intervention operations to be performed via vessels instead of traditional rigs. With track record of operations on 25 subsea assets in the last 5 years, RWOCS has proved to be the best solution for controlling / overhauling / troubleshooting subsea assets. The presentation will showcase more details about the different configurations, benefits, and use cases.

Abstract Title: Generative Geomodeling AI for Deep Water E&P

Author: ***Prof. Siddharth Misra***

Organization: Texas A&M University

Abstract: Subsurface earth models are vital for characterizing complex deepwater reservoirs. The objective is to overcome the limitations of slow traditional geomodel generation by developing a deep-learning-based generative AI method. This involves creating a workflow that can rapidly generate high-quality, multi-attribute geomodels, either unconditionally to capture uncertainty ensembles or conditionally based on user constraints, particularly improving the representation of complex features like fluvial channels common in deepwater settings. This innovation aims to accelerate deepwater subsurface characterization workflows.

The proposed generative AI employs two deep learning models: a hierarchical VQ-VAE-2 and a PixelSNAIL autoregressive network. The VQ-VAE-2 is trained to compress large geomodels into low-dimensional discrete latent codes and reconstruct them. Multi-attribute geomodels are handled by stacking attributes like permeability, porosity, and saturation. Perceptual loss is used in VQ-VAE-2 to enhance the reconstruction of fluvial channels. The PixelSNAIL learns the prior distribution of the latent codes, enabling it to sample new codes. The VQ-VAE-2 decoder then converts these sampled codes into novel geomodel realizations, supporting both unconditional and conditional generation.

The hierarchical VQ-VAE-2 demonstrated excellent compression capabilities, achieving ratios up to 1250 while maintaining high reconstruction quality (SSIM 0.85-0.92). The use of perceptual loss significantly improved the delineation and contrast of reconstructed fluvial channels. The PixelSNAIL model, combined with the VQ-VAE-2 decoder, enabled rapid generation; for example, 300 large-scale geomodel realizations were generated unconditionally in just 56 seconds, facilitating geological uncertainty quantification. The approach successfully generates new coherent and realistic geomodels, supporting high data augmentation and the ability to generate diverse ensembles or models constrained by specific spatial patterns.

This generative AI workflow offers substantial value for deepwater operations by enabling rapid, high-quality geomodel generation. The massive compression reduces computational costs for subsequent modeling tasks. Fast ensemble generation improves uncertainty quantification crucial for risk assessment. The ability for conditional generation provides control over model features, essential for history matching and development planning in complex deepwater reservoirs, ultimately leading to more informed decisions and optimized hydrocarbon recovery.

Abstract Title: Tiny Bubble Oxidation & Flotation Technology for Conversion of Produced Effluent Water into Service Water (Surface Disposal)

Author: ***N.Vijai***

Organization: Saroj Tiny Tech India Pvt Ltd

Abstract: SAROJ TINY TECH INDIA PVT. LTD. (STTIPL) is a Top-Notch Hydro Engineering Company in India for Water & Waste water Treatment for Water Recovery, Recycle and Reuse. We offer advance integrated technology oriented solutions for Conversion of Produced Effluent Water into Service water for Various Utility Applications

The following Treatment steps are involved.

- Tilted Plate Interceptor (TPI)
- Tiny Bubble Floatation and Oxidation Technology.
- Sic – Ceramic Membrane Ultra-Filtration System. C. Sic – Ceramic Membrane Ultra-Filtration System.
- Reverse Osmosis Membrane Separation System.

The treated water showed significant improvement across all key parameters.

- pH was stabilized from 6.0–8.0 to 6.5–7.5.
- Turbidity reduced from <500 NTU to <3 NTU,
- TSS from <1500 mg/L to <3 mg/L.
- Oil & Grease dropped from <3000 mg/L to <10 mg/L. and
- Salinity from <1200 mg/l to 150 mg/l
- DO was absent in raw water, and can be introduced as required post-treatment.

Observation: The system effectively removed suspended solids, oil, and turbidity, indicating high treatment efficiency.

Conclusion: Saroj Tint Tech India Pvt. Ltd.'s water treatment solution delivers excellent performance, producing treated water that meets environmental discharge norms and supports sustainable water reuse.

Saroj Tint Tech India Pvt. Ltd. offers end-to-end water treatment solutions with the added value of customized system design, energy-efficient operations, low maintenance, and regulatory compliance assurance.

Compendium of Abstracts

Theme: Maximizing Recovery from India's Mature and Declining Oilfields

Abstract Title: Application of modern technology for Production Enhancement

Author: ***Chanchal Das, Amitava Dutta***

Organization: Aventus Oil Tools

Abstract: MZPT Technology - MZPT, a Dynamically activated super solution well, helps in more efficient production from these Reservoirs in one Step. It exploits the advantage of Multiple Zone Reservoirs. It targets to maximise the economic recovery of hydrocarbons from a prudently operated field.

MZPT solves 4 major issues involved in development of any Multilayered fields. They are Recovery issue, well productivity issue, Cost Issue & Complexity Issue. Our Tool improves productivity by eliminating Inter layer Cross Flow & providing optimum pressure draw down for each Layer. This is achieved by capping the perforations of each layer in such a way that fluid can only flow from Reservoir to wellbore but cant flow back from well bore to Reservoirs.

8n onshore oilfields where multiple zones are there, the tool helps in increasing the production from all zones together thus maximizing recovery

The tool is retrievable & after redressing it can be reused. The redressing can be done at your workshop with our Redress Kit.

Abstract Title: Maximizing the Hydrocarbon Recovery from Bhaskar Field

Author: ***Rakesh Godawat,***

Organization: Sun Petrochemicals Pvt Ltd

Abstract: This abstract presents the reservoir simulation study of Bhaskar Field, which is notable for its unique reservoir characteristics. The field's initial reservoir pressure is approximately 1900 psi at a depth of 1390 m TVDSS, with a reservoir temperature of 209°F. The bubble point pressure is relatively low, at 512 psi. The oil produced has an average API gravity of 42°, and a solution gas-oil ratio (GOR) of 30 m^3/m^3 (equivalent to 168 scf/bbl).

The objective of this study is to explore strategies for improving hydrocarbon recovery from the mature Bhaskar Field through reservoir simulation.

Bhaskar development area consists of six independent oil pools from North to South in MBS reservoir. The reservoir simulation model of the MBS reservoir for all the pool areas were constructed. Two distinct pressure trends have been observed in the field. On analysis it has been observed that these two trends are representing MBS upper and MBS lower reservoirs.

The main elements of the simulation study include: -

- Matching field pressure and production history
- Making predictions on number of variants and operating strategy with water injection as the secondary recovery mechanism.
- Evaluating alternative operating scenarios – Development Wells vs Water Injection

Due to the very low saturation pressure, the solution gas drive index is expected to be negligible. In the MBS Upper reservoir, the primary production mechanism is reservoir expansion, as the aquifer support is very limited. In contrast, the pressure decline trend suggests that the MBS Lower reservoir is operating under moderate to strong aquifer support. At this stage, drilling additional development wells appears to be a more favorable scenario compared to implementing water injection as a secondary recovery mechanism. The Bhaskar field, characterized by high permeability and a very favorable mobility ratio, offers excellent conditions for efficient displacement. Water injection could become an effective option in the later stages of field life, particularly when reservoir pressure approaches the saturation pressure.

Bhaskar is a good quality darcy reservoir with high permeability, good connectivity and minimal capillary trapping. The primary recovery under natural depletion (pressure decline) can be quite good even without water injection early on. Development drilling can not only accelerate the production quickly but improve the ultimate recovery as well. Value Proposition: -

- Maximizing early oil recovery while minimizing immediate capital investment associated with water injection facilities.
- Extending plateau production by efficient pressure maintenance when necessary.
- Maximizing ultimate recovery factor through a planned transition from primary to secondary recovery mechanisms.

Abstract Title: Digital Transformation is Reshaping how Oil & Gas companies Manages it's Upstream Business

Author: ***Sanjay Patil, P S Ramakrishnan***

Organization: Emerson

Abstract: Integrated Operations (iOps) in the oil and gas industry represent a transformative approach that combines advanced digital technologies, real-time data analytics, and multidisciplinary collaboration to optimize exploration, production, and asset management. By integrating people, processes, and technology across organizational boundaries, (iOps) enhances decision-making, improves operational efficiency, and reduces health, safety, and environmental (HSE) risks. This explores the evolution of Integrated Operations, key enabling technologies such as remote operations centers and digital twins, and the role of data-driven collaboration in optimizing field performance. Case studies and industry examples illustrate how (iOps) contributes to cost reduction, production maximization, and sustainability.

A typical offshore / onshore field will have tens of thousands of intelligent sensors, and instrumentation for controlling the assets but typically less than 10% are dedicated to improving operations in terms of availability, safety, energy and production. Digital Transformation and Integrated Operations (iOps) provide processes, tools and technology that enable teams to gain awareness of their asset's current and predicted behavior for real-time decision-making and analysis. Realtime data from wells and topside production can be used to improve the understanding of the reservoir which will enable enhanced recovery. Predictive diagnostics can also be used with analytics to improve availability.

The state-of-the art (iOps) Center consists of a Production Management System, Reservoir Management System, Information Management System, and a Reliability Monitoring System consisting of Equipment Health Advisor, Performance Advisor, Maintenance Management System and Asset Management System. The i-Ops Center also includes Microwave communications to the process platform, Well head platforms , FPSO and Onshore terminal etc, Workstation Consoles with Large Displays, and Video Conferencing Systems. Equipment is deployed in Various Collaboration Environments utilizing 3D Visualization, Operations Surveillance Stations, Big Data Analytics, and Automated Workflows.

Benefits of Integrated Operations include a conservative 3 to 5% of additional reservoir recovery over the life of the field generating incremental revenue . Furthermore, achieving 97%, availability of the important assets results in accelerated revenue. Total additional benefits approach over the Life of the Field.

Abstract Title: Enhancing Hydrocarbon Recovery: Subsurface Analytics Integrated with Reservoir Simulation for Sustainable Development and Reserve Growth

Author: ***Krishna Chandra Sundli, Binay Ram, Sheel Ranjan Prasad***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: The quest for maximizing hydrocarbon recovery from mature field demands innovative methodologies, not only to sustain production but also to scout zones for extracting additional oil. Identifying these locales largely depends on the quantification and mitigation of uncertainty on reservoir facies, pool extension and fluid anomaly. In the study, a synergetic approach from seismic interpretation, geo-cellular modelling, reservoir simulation to drilling, completion and production has been employed for holistic development the reservoir.

The case study deals with S7 reservoir of one of the largest producing fields in western offshore India. S7 is the most challenging pay considering the surprises observed during drilling in terms of development of reservoir facies, pay, fluid anomaly and well productivity. To mitigate the challenges and to achieve better vertical and lateral resolution of seismic data sparse layer inversion was employed, wherein intermittent seismic volumes were generated at different frequencies for better characterization of the reservoir. Seismic attributes thus extracted were then used for limiting the reservoir extent for preparation of Geo-celluar model. Simulation studies were then carried out generating multiple development scenarios identifying and optimizing the locales for further development of the reservoir.

Presently, S7 produces more than 12000 bopd with nearly 50 strings on production with cumulative production reaching 7 million metric tons (MMt). Despite encouraging performance, recovery enhancement is still a challenge considering uncertainty over distribution of reserves. Therefore, prime motive of simulation study was on identifying locales having better reservoir characteristics resulting in higher productivity. Performance analysis indicated hydrodynamic compartmentalization of the reservoir with intermediate poor-performing areas delimiting the reservoir into multiple blocks. Exhaustive study was carried with available pressure-production data and vertical fluid profiles obtained from production logging tool (PLT) to identify possible water source, crucial for reservoir simulation and aquifer modelling. The study was integrated with simulation study for representative aquifer modelling. Integration of these studies resulted in number of drilling inputs for production augmentation. Few wells have been drilled based on the study and tested with average initial per well production rate of more than ~350 bopd.

In summary, the integrated workflow significantly reduced uncertainties in identifying suitable locales for development. The study envisages an incremental production of ~1.7 MMt O+OEG. By aligning with the IOR objective, the aim is to secure additional reserves for sustained field growth and identification of future development opportunities. Present approach, combining advanced techniques and rigorous analysis, underscores the commitment to maximizing hydrocarbon recovery while ensuring long-term field viability.

Abstract Title: Production Enhancement from Carbon-Oxygen (C/O) Logging in Heera Oil field of Western offshore

Author: ***Ramakrishna, Abhishek Singha, Gangajali***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: In Heera field, Heera formation was covered in 12 ¼" section and only LWD GR log recorded for landing 9 5/8" casing seat on top of Mukta/Bassein. So, Heera formation couldn't be evaluated through logs in some areas. Pay development in this formation is thin and highly discrete, making its exploitation very challenging. Therefore, targeting Heera Pay alone through sidetracking/ development wells could be risky. Two fold strategy was adopted- a) revisit of old wells by Reservoir saturation tool where Resistivity & other logs were not available, b) Completion of Heera Pay in combination of other pays in the area.

Producibility of Heera and adopted the strategy to record reservoir saturation (RMT/RPM/RST) log wherever the opportunity was seen especially during the safety/well servicing jobs for deeper pays of Mukta/Bassein with rig deployment. C/O log is generally used to know the depletion of the producing zones. Due to non-availability of used the Vsh which is calculated from GR of same well and Avg effective porosity (φe) from the offset wells for guiding factor during simulation and processing of RMT/RPM Logs to get the meaningful and more realistic results. The above methodology was used in three wells and RMT/RPM logs were recorded.

In well-X, RMT log showed oil saturation of 30-40% at top part and 10-20% at bottom part of the reservoir. After recording of RMT and while completion of well in Bassein, unfortunately encountered operational complications and was recommended for sidetracking the hole for Bassein. However, the zones identified through RMT log rescued the well from side-tracking cost and added value to the production. On testing Heera formation flowed 133 BOPD with W/C-0%. Safety servicing of well by WOJ provided opportunity for tapping Heera pay in this area.

In well-Y, RPM log showed oil saturation of ~60% at top part, 40% at middle and 20% at bottom part of Heera formation. Well was completed as straddle keeping Heera perforated intervals between two packers (top & bottom) and 8 ½" drain hole containing Mukta+Bassein below bottom packer. Installed Blanking plug and opened sliding door by slickline for flowing from Heera. On initial testing, well flowed 133BOPD with W/C-6%. Right now well is flowing 166 BOPD with W/C-16%.

In well-Z, RPM log showed oil saturation of 35-40% at top part and ~20% at bottom part. Well was completed as Single completion from Heera by isolating Drainhole with millable bridge plug (future option). On initial testing, well flowed 207BOPD with W/C-6%. Oil well serving by WOJ gives opportunity for tapping Heera pay in this area.

The Reservoir Saturation Logs identified three potential wells, which were subsequently completed in the Heera Pay zone and produced >500 BOPD. By leveraging advanced logging techniques, precise formation evaluation and strategic execution, optimized production without the need for costly side tracking, thereby enhancing overall field efficiency.

Abstract Title: Simultaneous Exploration (SIMEX): A Game Changer in Mature Fields

Author: ***Ravi Shanker Chaudhary, Manish Kumar***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: This paper explores the concept and successful implementation of Simultaneous Exploration (SIMEX) during development drilling in mature hydrocarbon fields. It focuses on how SIMEX, when integrated with routine development operations, can uncover new reservoir opportunities and significantly boost production. The objective is to demonstrate that exploration need not be limited to dedicated campaigns but can occur in tandem with development activities, offering cost-effective and timely benefits. Using a case study from the Jorhat Asset of ONGC, the paper emphasizes the value of leveraging unexpected stratigraphy to identify additional productive zones, thereby enhancing field life and optimizing hydrocarbon extraction.

The methodology centered around leveraging development drilling to conduct simultaneous exploration. In the "K" Field, while drilling to target a known reservoir under a Gas Assisted Gravity Drainage (GAGD) scheme, formation continuity encouraged deeper drilling. Hydrocarbon shows prompted further investigation using conventional logging, identifying a previously unknown reservoir. A Reservoir Characterization survey was conducted to confirm hydrocarbon presence, followed by conventional testing of the new zone. The interval was perforated, and flow rates were recorded through various choke sizes. Subsequent reservoir analysis, including permeability, pressure, and productivity index calculations, provided a robust evaluation of the newly discovered sand. This approach—integrating exploration within development—minimized costs while maximizing resource identification and extraction, embodying the SIMEX philosophy.

The application of SIMEX in the "K" Field led to the serendipitous discovery of a new oil-bearing reservoir beneath the primary target. Initial observations during drilling, including formation continuity and hydrocarbon shows, prompted deeper exploration. Logging revealed a 4-meter-thick sand layer with promising porosity and resistivity characteristics. Reservoir Characterization confirmed the presence of oil with a pressure of 2893 psi and mobility of 15 mD/cP. Conventional testing through perforation at 2554.5–2558m yielded encouraging results. The well produced oil at 45 m^3/day through a 6mm choke with only 1.5% water cut. A bean study showed outputs ranging from 40 to 68 m^3/day across different choke sizes. The reservoir exhibited a high permeability of 410 mD and a productivity index of 0.8 stb/day/psi, indicating strong production potential. These results validated the decision to explore further during a development well operation. This unexpected discovery led to immediate strategic re-evaluation. Additional wells are now being drilled to confirm the lateral extent of the new sand body. The success underscores the importance of remaining flexible and responsive to subsurface indicators during drilling. In conclusion, SIMEX proves to be a powerful, cost-effective strategy in mature fields, offering the potential to rejuvenate aging assets by uncovering

untapped reserves during standard development activities.

SIMEX offers a transformative approach to field development by integrating exploration with routine drilling operations, reducing exploration costs and time. It enhances recovery potential without requiring dedicated exploratory wells, thus providing a strategic edge in mature and cost-sensitive fields. The technique capitalizes on real-time geological cues to identify new reservoirs, as demonstrated by the successful case in ONGC's "K" Field. This results in incremental production gains, optimized asset management, and extended field life. Adopting SIMEX industry-wide could significantly improve reserve replacement rates and reduce production costs, making it a valuable practice for sustainable and efficient hydrocarbon recovery.

Abstract Title: Revival of Production in a 100% Water Producing Well in a Marginal Field

Author: ***Somenath Ghosh, Sanjay Kumar, Niral Patel***

Organization: Gujarat State Petroleum Corporation Limited.

Abstract: Ank-XX field is a single well marginal field being operated by GSPC in Ankleshwar area in Cambay Basin. Production from well Ank-XX is from Hazad Formation and the production rate around 35-40 bbls of liquid with 30% water cut. Seasonal flooding during the monsoon, followed by extensive site restoration activities, necessitated prolonged well shut-in. Upon resuming operations, the well started producing 100% water. The sudden increase in water cut was investigated to find the source of water and resume hydrocarbon production from the well.

The producing zone is overlain by water bearing sands of Hazad Formation. Consequently, the possibility of channeling was investigated. However, the salinity of the producing water was measured at approximately 4000 ppm which is significantly lower than the typical salinity of formation water from the Hazad Formation produced in the well, which is approximately 18,000 ppm. As such, channeling behind the casing from the upper intervals was unlikely. A deeper interval in Olpad formation was earlier tested in the well which produced 100% water. The zone was isolated with a bridge plug. The salinity of the produced water was in the range of 4,000–5,000 ppm, closely matching the salinity of water being produced after resumption of production.

It was inferred that water production was most likely due to leakage in Bridge Plug. Workover job was carried out to install another bridge plug for isolation of the water bearing zone and the well was put back on production. Despite the intervention, Well Ank-XX continued producing 100% water.

Subsequently, a comprehensive re-evaluation was conducted incorporating test data of the lower zone and latest pressure recordings from the open interval. The pressure of the bottom zone is equivalent to hydrostatic pressure (2410 psi) while the producing zone had pressure depletion due to production and the last recorded pressure was 1479 psi which is much below the hydrostatic pressure (1986 psi). It was concluded that under shut-in conditions, water from high pressure lower zone was continuously naturally getting injected into the depleted upper zone.

To assess the extent of fluid migration, a simple reservoir model was developed to estimate the volume of water which got naturally injected into the upper zone. Concurrently, it was decided to continue water knock out from the well. After producing around 1750 bbls of water for 21 days, initial traces of oil was observed, and gradually the well returned to its original production rate.

The case highlights the importance of understanding well history, pressure differential across tested zones, and fluid migration mechanisms to understand production behaviour. A holistic technical approach, combining production behaviour, salinity analysis, and pressure surveillance proved critical in restoring productivity in Ank-XX well.

Abstract Title: Successful implementation of Gas Assisted Gravity Drainage (GAGD) for improving recovery and reducing gas flaring from Kasomarigaon Field of Jorhat

Author: ***Pradeep Kumar, Soumya Ranjan Mishra, Arpan Pushp***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: The scope of the study includes the application of Gas Assisted Gravity Drainage (GAGD) process in improving recovery from a sandstone reservoir by injecting produced gas back into the crestal part of the reservoir. The process aims at recovery improvement, also ensures near Zero Flaring strategy. The objective of the study is assessing the effectiveness of Gas Assisted Gravity Drainage (GAGD) process for improving recovery of Mid-Bokabil pay with Zero flaring approach and to avoid gas cap shrinkage which would otherwise result in migration of oil into the gas cap and residual oil formation.

Reservoir with high permeability and reasonable dip like Mid-Bokabil pay of Kasomarigaon Field is identified for field implementation. To supplement energy and to arrest aquifer encroachment, an energy source created in the crestal part of the reservoir in the form of gas injection.

Methodology involves preparation of Static Model of Mid-Bokabil based on seismic data including Structural modelling, petrophysical modelling and NTG modelling. Thereafter Reservoir Simulation is carried out on the GCM prepared along with History Match and development strategy finalization.

Performance prediction and phase-wise development strategy was prepared and seven different variants/case scenarios were run for recovery improvement with final variant recommending 3 existing oil producers and Gas Injection from 2 new locations with peak injection of 1,00,000 m3/d along with recommendation of one new location. The recommended variant envisaged incremental oil gain of 0.253 MMt over BAU with recovery of 28.3% by 2040, through 7 OP and 2 GI.

As a first step in the successful field implementation of GAGD, four OP wells along with 1 GI well have been drilled during FY 2024-25 and has resulted in overall improvement in oil production. Besides early recovery, the gas injection ensures near zero flaring strategy. The success of this scheme will find application in reservoirs of similar nature wherever sufficient gas source exists.

Abstract Title: Navigating the Future of Equipment Demand in the Oil and Gas Sector: Trends, Challenges, and Opportunities

Author: ***Vishnu Gupta Kothuri***

Organization: S&P Global

Abstract: This presentation aims to explore the evolving landscape of equipment demand within the oil and gas sector, particularly in light of emerging trends such as carbon capture and sequestration (CCS) and hydrogen transmission pipelines. It will assess the impact of recent US tariffs on equipment costs and supply chain dynamics. The objective is to provide industry stakeholders with insights into market trends, demand drivers, and the implications for equipment suppliers and manufacturers. By analyzing these factors, participants will gain a comprehensive understanding of the current market conditions and future projections for equipment spending

The methodology adopted involves a comprehensive review of the Final Equipment Study 2025, leveraging data compiled by S&P Global Commodity Insights. The approach includes a detailed analysis of market trends, demand drivers, and the implications of US tariffs on equipment costs. We will utilize qualitative and quantitative research methods, including case studies of CCS and hydrogen projects, to illustrate the challenges and opportunities in the equipment market. Expert insights and commentary from industry analysts and practitioners will also be incorporated to foster a deeper understanding of the subject matter. This multi-faceted approach ensures thorough analysis and encourages engagement with the findings.

The analysis reveals several key findings regarding the current state and future trajectory of the equipment market in the oil and gas sector. Firstly, demand for oil and gas equipment is projected to decline due to rising interest rates and inflationary pressures; however, the growth of CCS facilities and hydrogen transmission pipelines is expected to offset this decline. The impact of US tariffs has led to increased costs across all equipment sectors, particularly in valves, which may hinder project implementations. Additionally, Europe is anticipated to lead in hydrogen pipeline demand, while Asia Pacific and North America emerge as hotspots for CCS projects. The book-to-bill ratio indicates a healthy order backlog, suggesting that equipment suppliers may experience increased pressure on manufacturing capacities in the near future. In conclusion, while challenges persist, there are significant opportunities for innovation and growth in response to the evolving energy landscape, particularly in decarbonization efforts and the transition to cleaner energy sources.

This analysis offers substantial value to stakeholders by providing critical insights into the current and future state of the equipment market in the oil and gas sector. Participants will gain a clearer understanding of the implications of market trends, US tariffs, and emerging technologies such as CCS and hydrogen transmission. This knowledge will enhance strategic planning, identify potential business opportunities, and foster collaborations that align with the evolving energy landscape. The insights shared will equip stakeholders with the information needed to navigate market challenges and capitalize on growth opportunities in the equipment sector.

Abstract Title: Improved ASP Process Using Organic Alkali

Author: ***Khitish Kumar Nayak, Anand Patel***

Organization: Sanron Energy Ltd & Hindustan Silichem Pvt Ltd

Abstract: Comparison of structure and properties of organic to conventional alkali. To understand the difference by comparing when applied for the same process. Overall organic alkali works better even in unsoftened water and does not form precipitates with di-valent cations. enabled by the abstract in providing novel or additional information to the existing application or literature.

Abstract Title: Targeted water-injection successfully enhanced recovery from a small and mature “tight” oil field in the Cambay Basin

Author: ***Chirag Patel,***

Organization: Joshi Technologies International Inc.

Abstract: A balanced reservoir management strategy comprising enhanced primary recovery and implementation of secondary recovery through targeted water-injection has increased the overall recovery and producing life of a mature and

marginal oilfield in the Cambay Basin. Multiple water-injection schemes are being actively implemented within the targeted reservoir pool and area. The overall EUR within the targeted pool/area has increased by 50% of the primary EUR and the economic life of the field has increased by more than 15 years.

The field has multiple stacked and highly compartmentalized “tight oil” reservoirs with varying degree of depletion. Hydro-fracturing was widely used to enhance primary recovery. As the reservoir pressure declined, it was determined to use water-injection for pressure support as typical for solution-gas drive reservoirs. However, targeted injection plan was required to maximize the oil gain and minimize chances of water recycling or channeling through high conductivity paths of hydro-fractures. Detailed analyses of reservoir behavior and production trends were performed to identify potential reservoir target area and well candidates for conducting water-injection recovery. Multiple water-injection schemes were developed quickly with minimum capital investment by converting low production wells into injection wells and augmenting the present effluent treatment plant to a full-scale injection plant. Targeted water-injection integrated with monitoring and analyses of reservoir behavior has yielded successful results.

- In all the injection schemes, the voidage replacement ratio (VRR) has been maintained above 1.5.
- In the Well “A” within the injection scheme targeting the lower pay zone, the oil production rate increased from 6 BOPD to 40 BOPD. This recoverable oil volume from the well is expected to increase by 130% and its producing life is expected to increase by 15 years. Similar improvement in oil production volume is expected from other wells within this injection scheme.
- In the Well “B” within the injection schemes targeting the middle pay zone, the oil production rate has increased from 20 BOPD to presently about 50 BOPD and further increasing. The producing GOR has reduced from 5000 scf/bbl to about 1300 scf/bbl. These are signs of successful water-flooding impact.
- Well “C” within middle pay zone scheme was shut-in to monitor the impact of water-injection. The static pressure in this well was increased from about 1000 psi to above 1500 psi within 13 months. Subsequently, the well was restarted, and it started producing about 35 BOPD. The pumping parameters are being optimized, and the well is expected to increase the production rate further.
- With continuation of the injection program, more wells are expected to exhibit incremental production and pressure.

Integration of sub-surface engineering, completion strategies, and cost analysis was utilized to design and implement the targeted water-injection schemes. This method yielded incremental oil recovery in heterogeneous “tight” oil reservoirs of a mature declining oilfield.

Abstract Title: AI-Driven Gas Lift Optimization for Enhanced Production in Mature Fields

Author: ***Prof. Siddharth Misra***

Organization: Texas A&M University

Abstract: Optimizing gas lift injection is essential for maximizing production from mature and declining fields in India. Traditional methods are costly and time-consuming. Previous machine learning efforts lacked real-world applicability due to simplified data. This study aims to develop a robust and generalizable machine learning model capable of rapidly predicting optimal gas lift injection rates and corresponding liquid production. The objective is to create a reliable tool, trained on a diverse dataset representing realistic field conditions, to enhance production efficiency and recovery from India's aging wells without extensive downhole operations.

A robust machine learning model, specifically a Gradient Boosting algorithm, was developed using a "universal dataset" containing 59 features. This dataset was meticulously designed to include broad variations in key parameters such as skin factor, oil density, vertical lift performance correlations, completion types, and well trajectories, covering a wide spectrum of realistic production conditions. Model performance was evaluated using Mean Absolute Error (MAE), noise tests (adding 10% noise), and uncertainty analysis. Feature-based transfer learning was also explored, although it did not show significant benefits with this dataset.

The developed Gradient Boosting model demonstrated strong performance. It predicted the optimal gas lift injection rate range with a Mean Absolute Error (MAE) of 7.0% (relative to the range) and the optimal liquid production rate with an MAE of only 1.3% (relative to the range). Noise tests confirmed the model's robustness, showing a robustness ratio exceeding 90% when subjected to 10% noise in input data. Uncertainty analysis indicated high confidence in the predictions, with uncertainty in MAE-to-range ratio below 0.1%. Transfer learning exploration did not yield substantial accuracy improvements.

This robust machine learning model offers significant value for maximizing recovery from India's mature and declining fields. By providing rapid, accurate, and reliable predictions of optimal gas lift parameters, it bypasses the costly and time-consuming traditional methods. Its ability to handle noisy field data and generalize across diverse well conditions provides a practical framework for engineers. This innovation can enhance production efficiency, reduce operating costs, and ultimately help maximize hydrocarbon recovery from critical national assets.

Abstract Title: Decarbonization and CO2 Utilization through Polymeric Nanofluids: A Carbonated Slug Formulation for Enhanced Oil Recovery

Author: ***Darshan Halari, Millennium Chowdhury, Ramnit Verma, Amit Saxena, Shivanjali Sharma****

Organization: Rajiv Gandhi Institute of Petroleum Technology

Abstract: This study investigates how nanoparticles (NPs) affect carbonated polymeric nanofluid oil recovery efficiency. This research aims to alter the slug's viscosity to decrease the interfacial tension (IFT), enhance the wettability, and increase the sweep efficiency using NPs. The most recent innovation is the EOR method, which incorporates dissolved carbon dioxide into the slug. This technique has benefits, including geological CO_2 storage and decarbonisation.

Nanoparticles were produced by the use of microwave irradiation as part of the experiment. These nanoparticles were then evaluated for their microstructural features as well as their range of particle sizes. The substances' interfacial and rheological characteristics were evaluated under ambient and high-pressure circumstances to identify whether or not they were suitable for reservoir conditions. Optimisation of the chemical concentration is accomplished by alteration of the interfacial and rheological features of the solutions. The integration of nanoparticles into the typical oilfield PAM polymer serves as a mobility-modifying agent.

Water-soluble polymers increase water viscosity, making carbon dioxide absorption simpler. By slowing gas mobility, the release of CO_2 from the solution is delayed. Nanoparticles that interact with the polymer chain and produce a steric barrier strengthen the system. This increases system CO_2 absorption by at least 20%. The polymer increased nanoparticle aqueous stability. This may be accomplished by increasing the confining pressure and adding NPs to the solution to improve its ability to absorb carbon dioxide. The incorporation of carbon dioxide into the polymeric nanofluid resulted in the acquisition of features that might potentially be beneficial for the enhancement of oil extraction from the reservoir. This occurred because of the assimilation of carbon dioxide. By adding nanoparticles to the solution, the interfacial tension may drop from 47 to ~17 mN/m. Further reduction is possible after carbonation. The use of an optimum concentrated carbonated nanofluid for flooding increased oil output due to the suspension of oil mobilisation. Unlike the non-carbonated suspensions.

Enhanced polymeric nanofluid performance for CO_2 absorption and oil recovery is the focus of this work, which gives unique insights into the function that nanoparticles play in performance enhancement. When it comes to the oil and gas industry, the carbonated slug itself is the most advanced technology available, and it is also the most effective choice for improving oil recovery.

Abstract Title: Cost Effective and Sustainable Measures for Maximising Production from a Mature Field with Multifaceted Production Challenges: A Case Study from North-East India

Author: ***Sarvesh Vikram Bisen, Chinmay Baruah, Nishtha Sinha***

Organization: Invenire Energy Private Limited

Abstract: The field measuring ~10 km2 is located in Schuppen belt, NE India and has multiple challenges posed while production such as, sanding issues, fines migration, wax issues, variable API, rapid decline in production owing to disseminated sand bodies etc, however, the field has still been producing since last 40+ years. The necessary measures adopted will be elaborated in detail in the paper.

The methods adopted to optimize and enhance the production from the field has been drilling of infill wells, continuous zone transfers and workover jobs, dewaxing, sand consolidation, matrix acidization, re-perforations, radial drilling campaigns, alteration of lift mechanisms to efficiently handled the field production. These measures have been taken as standalone or in combination to maintain the production efficiently. Total 70 wells have been drilled with multiple sands reservoirs. Some are on self-flow and others on artificial lift. Basis the various production and optimization methods, the old wells are still contributing production and may continue to produce in future.

The success stories for the activities mentioned above has been varying depending on the nature of different sands and problems in the wells/zones. The infill and step-out drilling campaigns of 34 wells in 4 phases have given very good results with 100% success rate for infill wells. Only 2 steps out well turned non-productive and 1 well was abandoned. Workover activities are carried out round the year for wells facing issues like wax deposition in tubing, sanding in the wellbore, perforations getting choked, permeability issues due to fines migration. Workovers jobs carried out using in-house facilities of workover rig and swabbing hoists have resulted in maintaining the planned field production profiles. The impact of the success is such that wells as old as 35+ years are still producing owing their success to regular zone transfers. There have been two radial drilling campaigns with mixed success. Sand consolidation and matrix acidization has been very successful and enhanced the production in few wells by 8 times. For the last four decades lift mechanisms have been modified from Self-flow to SRP, Gas lift, PCP/Dyna pumps/ESP and Jet pumps for ensuring efficient production from wells which again has been well specific and zone specific.

The field discussed here is a small field with less than 10 km2 area and has produced ~14.5 MMBbl oil with another ~7MMBbl oil still to be produced from the proven reservoirs. There are deeper reservoirs which need to be explored and monetised in near future. Apart from the oil, gas monetisation using gasket will benefit all the stakeholders. Adopting this model of field production will benefit many small-scale industry players.

Compendium of Abstracts

Theme: Role of AI and Machine Learning for Next-Gen E&P

Abstract Title: Proxy Modeling for Exploration Risk Assessment: A Comparative Approach

Author: ***Florent Verdiere, Samer BOU Daher, Alcide Thebault***

Organization: Beicip-Franlab

Abstract: Forward modeling techniques such as basin and stratigraphic simulation offer significant predictive value but remain constrained by their deterministic framework. These models often suffer from nonuniqueness and sparse calibration data, making uncertainty quantification critical. Traditional Monte Carlo approaches are too slow for operational use, especially in complex systems. This study presents two proxy modeling methodologies, kriging-based response surfaces and neural networks, as efficient tools to address uncertainty and perform sensitivity analysis. The objective is to compare their performance across two geological contexts and demonstrate how proxy models improve risk assessment, particularly in early exploration and high uncertainty environments.

Two types of proxy models were applied to process based forward modeling cases:

- Response Surface Modeling (RSM): Based on kriging interpolation, RSM builds surfaces from key principal components extracted from simulation outputs. These surfaces are sampled through Monte Carlo methods to produce statistical insights.
- Neural Network Modeling (NNM): Fully connected feed forward neural networks trained on map-based inputs were used to capture nonlinear relationships between uncertain parameters and output properties.

Both approaches use a limited number of simulations (10 to 100) to train the models and are validated on blind runs. Applications were tested on a carbonate platform in the Middle East and a frontier basin offshore Canada, covering a wide spectrum of geological uncertainty scenarios

The Middle East case study, focusing on the Shuaiba carbonate platform, highlighted the efficiency of proxy models in predicting net reservoir thickness and exposure risk. With just 36 training runs, both proxy types accurately replicated percentiles and combined probability maps, offering actionable insights into depositional heterogeneity. In the offshore Canada basin case, the proxies captured key risks in source rock transformation under high uncertainty, demonstrating their relevance in data sparse settings. RSM proved to be slightly more accurate across most scenarios, particularly when dimensionality reduction via PCA was effective. However, NNM showed better scalability and benefits from larger training datasets. Computationally, both proxies were one to two orders of magnitude faster than full Monte Carlo runs, requiring only minutes or hours versus days. Validation metrics on confirmation runs confirmed both models' robustness, with diminishing performance gains beyond 24 to 36 training samples. While RSM workflows are more mature and straightforward, neural networks offer more flexibility and potential for future advances using architectures like GANs. In conclusion, both approaches allow efficient sensitivity and risk analysis without compromising reliability. They bridge the gap between operational constraints and the need for robust uncertainty quantification, enhancing decision making in exploration and development planning.

Proxy models unlock the ability to run fast, reliable uncertainty analysis even in complex forward modeling environments. Their integration into tools like CougarFlow supports real time decision making at both reservoir and basin scale. They provide probabilistic outputs, sensitivity insights, and combined risk maps that are easy to communicate across teams. This leads to more confident well placement, play ranking, and exploration prioritization. In regions with sparse data or limited time, proxy workflows ensure that uncertainty is quantified and understood, supporting smarter and faster decisions across the E&P lifecycle.

Abstract Title: Harnessing Machine Learning for Permeability Estimation: A Case Study from the Rub Al Khali Basin, Middle East.

Author: ***Ayush Kumar, Sakshi Sharama, Rakesh R Rana & Himanshu K Bharti***

Organization: IOCL

Abstract: The objective of this study focuses on the utilization of ML models for improvement of petrophysical analysis of study wells taken from the Rub Al Khali Basin, Middle East, in estimation of porosity, permeability, and rock typing. The study plays a crucial role in reservoir characterisation, minimizing the error of interpreter's bias. The current study aims to investigate and compare the petrophysical parameters derived from conventional well log analysis and AI-based models. The AI-derived trained model showcases promising outputs and is able to capture the intrinsic relationship between porosity/permeability and wireline logs in comparison to the conventional approach.

This case study involves preparing a fully functional Python script to investigate advanced model-driven machine learning to

predict formation porosity and permeability for the Rub Al Khali Basin. Basic well log data and limited core-derived inputs have been included to establish a non-linear relationship. ML models were trained with the porosity/permeability of core data along with the basic logs for the target formation of Well-A. This trained model was then applied to predict the porosity/permeability of blind Well-B (testing well) from the same basin, separated by around ~16 km, incorporating the basic well logs available for the blind well. This AI-derived permeability was then correlated with core data for the same well, and the results were found to be a good match.

Reservoir characterization and formation evaluation are pivotal for optimizing oil and gas field development, typically relying on well log data, core samples, and geological information for petrophysical property estimation. The study facilitates the transformation of essential core data into the log domain, enabling the generation of continuous log outputs that capture reservoir heterogeneity. This is crucial for rock typing and static modelling. In this study, the wireline logs of wells are from the Cretaceous formation. It is a medium-grained carbonate platform reservoir comprised of rudist grainstone to wackestone. ML algorithms like Random Forest, Extreme Gradient Boosting, and data-driven algorithms like Feed Forward Neural Network (NN), Artificial Neural Network (ANN), and Long Short-Term Memory (LSTM) were used and compared for the best estimation of parameters. After comparing the results of the two methods, the ANN model, which is one of the data-driven ML models, has been observed to significantly outperform the conventional method for estimation of petrophysical parameters, with an RMSE of 2.87%. The evaluation table is prepared comparing the different models with their respective errors. This data-driven technique offers critical insights for the exploration and production industries by enabling more closely accurate prediction of permeability for specific target stratigraphic units where collection of core data at every depth interval in every well is not commercially feasible.

This study demonstrates a significant improvement in the estimation of permeability from trained ML models. Limitations of data availability, quality, and the traditional approach of petrophysical interpretation often introduce undesirable error margins in the derivation of reservoir properties. This case study opens the possibility of further incorporating more core-derived petrophysical properties into the model and enhancing model efficiency with a wider range of training datasets. Further, this procedure may be utilized in more advanced reservoir characterization and rock-typing methods where the luxury of core-derived values is limited or absent for offset wells.

Abstract Title: Optimized Recovery of Erroneous Legacy Seismic Data: Auto- Validation of Geometry Errors and Correction using Automated first break picking

Author: ***Devisree L, Praveen Kumar K , Jagannath Chaudhary***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: The paper discusses the challenges of geometric merging in reprocessing legacy 2D seismic data from 1980–1985. Advancements in seismic acquisition and processing have enabled better subsurface interpretations, but merging vintage datasets poses difficulties like poor archival and missing shot and receiver locations. To address this, observer sheets were scanned and analyzed, and a Python program was developed to automate geometry verification in legacy SEG-Y data. The program picks first breaks, verifies positions, and estimates seismic trace locations, reducing manual effort and improving efficiency in handling erroneous legacy data.

The study reprocesses legacy 2D seismic data using automated geometric corrections. First, raw seismic data in SEG-Y format is converted to a text format, enabling precise extraction of shot and receiver positions. A Python-based program implements a kurtosis-based first break picking method, where two moving windows scan seismic traces, detecting waveform changes to identify first breaks. Erroneous first breaks are corrected using interpolation from neighboring traces. The picked first breaks are then compared with theoretical values derived from offsets and direct wave velocity. Errors in shot positions and receiver spread geometry are iteratively corrected, ensuring accuracy. Automated visual quality checks streamline validation, reducing manual effort and processing time. The corrected SPS files are used to merge reliable seismic data for subsurface analysis.

The Python-based approach significantly improved the efficiency of merging and correcting legacy 2D seismic data. The automated first break picking method successfully identified errors in shot and receiver spread geometry, reducing manual intervention and processing time. Quality checks using first break comparisons revealed discrepancies, which were systematically corrected through an iterative process. The corrected SPS files led to more accurate data merging, ensuring improved subsurface imaging. Visual comparisons of pre- and post-correction datasets showed noticeable improvements in spread definition and overall data quality. The automated script streamlined error detection, enabling real-time corrections rather than delayed manual QC checks. This approach not only minimized human effort but also provided a more precise and reliable dataset for further geophysical analysis. In conclusion, integrating Python-based automation in seismic data processing proved to be a game-changer, significantly enhancing data integrity and efficiency. The methodology eliminated repetitive manual corrections, reducing processing time while ensuring accuracy in seismic trace positioning. By automating first break detection and geometry corrections, the study demonstrated an effective way to handle erroneous legacy seismic data, enabling better interpretation of subsurface features. The improved dataset will contribute to ongoing exploration and development, reaffirming the value of vintage seismic data when reprocessed with advanced computational techniques.

In seismic data processing, automated geometry correction enhances accuracy and efficiency. It ensures precise shot and receiver positioning, reducing errors in subsurface imaging. By improving data quality, it enables better velocity model building and migration, leading to clearer structural interpretation. Automation minimizes manual corrections, speeding up processing workflows and reducing costs. Enhanced seismic datasets improve reservoir delineation and hydrocarbon detection, ultimately supporting more informed exploration and development decisions. This optimized processing technique. allows geophysicists

to extract maximum value from both legacy and newly acquired seismic data, contributing to more reliable subsurface evaluations

Abstract Title: A Data-Driven Approach to Wastewater Treatment in the Oil and Gas Industry: Opportunities for AI and ML Integration

Author: ***Kunika Gaur,***

Organization: Hindustan Silichem Private Limited

Abstract: This paper explores the strategic integration of Artificial Intelligence (AI) and Machine Learning (ML) to enhance process control in wastewater treatment within the Oil and Gas industry. The discussion is structured around five core themes. Firstly, it provides an overview of the primary types of wastewater generated—namely sour water, oily water, and produced water—and outlines current industry treatment standards, methodologies, case studies, and the challenges associated with managing each wastewater type.

The study identifies suitable AI technologies, potential deployment frameworks, and envisions a transformative shift in how the Oil and Gas industry approaches wastewater management through intelligent automation. AI and Machine Languages Implemented:-

• Radial Basis Function Neural (RBFNN)

• Multilayer Perceptron Neural Network (MLPNN)

• Artificial Neural Network Coupled with Genetic Algorithm (GA-ANN)

Millions of gallons of water are used for HF and pulled from the ground in oil and gas, presenting a great opportunity to find ways for this water to be useful and cost-effective on a large scale. AI/ML is used in the oil and gas field to help with optimization for things like production and predictive patterns. There is an opportunity to expand the use of AI/ML into the wastewater treatment sector of oil and gas as the cost and efficiency of this technology improve and the need to reuse wastewater necessitates a shift in how wastewater is handled. The overall goal of expanding AI/ML in produced water/PW treatment is to make the reuse of produced water through treatment cost-effective.

Determining the costs associated with each viable AI/ML process for treating wastewater would be needed to determine which process and strategies to implement for the given wastewater. This initial investment could then be compared to the current methods/costs, analyzed based on the expected improvement of the AI/ML process, and used to determine expected cost efficiency between the current methods versus optimization using AI/ML.

Abstract Title: GARBH ReserVoir: Integrating AI and Ensemble-Based Methods for Accelerated and Robust Reservoir Simulation and Management

Author: ***Ashutosh Kumar, Amit Priyadarshan***

Organization: Caliche

Abstract: GARBH ReserVoir is a practical effort to bring together the speed of AI models and the reliability of ensemble-based simulations to improve reservoir planning and management. The goal is to enable quick evaluations of different development strategies, better handle geological uncertainties, and provide timely, data-driven support for operational decisions, such as well placement and production planning. This approach can be applied across petroleum fields, geothermal setups, and carbon capture projects where agility and precision are critical. The workflow starts with generating a wide range of reservoir scenarios using ensemble-based methods to account for geological variability. A subset of these simulations is refined using data assimilation techniques that match model predictions to observed field data. These calibrated results are then used to train fast-running AI models, which can quickly forecast how a reservoir might behave under various development strategies. The use of interactive 3D visualization tools helps engineers and geoscientists explore results and adjust plans on the fly. By combining physics-based modeling with machine learning, GARBH ReserVoir aims to deliver both accuracy and speed, allowing teams to make informed decisions without long simulation wait times.

Early use of GARBH ReserVoir has shown clear improvements in both simulation speed and flexibility. AI-driven proxy models, once trained on data from well-calibrated ensemble runs, can generate reliable predictions in seconds—compared to the hours typically required by conventional simulations. These models have been tested on field data and have successfully reproduced key trends in reservoir behavior, including pressure and saturation changes. The ensemble-based data assimilation helped ensure that the training data used for AI models reflected realistic field conditions. This led to more trustworthy predictions and improved the overall confidence in the outcomes. Generative modeling techniques were also useful in extending the dataset and dealing with sparse or uncertain inputs. The visualization component turned out to be quite helpful. It enabled domain experts to interpret complex results quickly and communicate insights across teams. Whether applied to oil and gas fields, geothermal resources, or CO_2 storage sites, GARBH ReserVoir will be proved to be flexible and scalable. The ability to iterate quickly with real-time data made it easier to respond to new information and improve reservoir strategies dynamically.

GARBH ReserVoir stands out by combining deep technical rigor with practical usability. In trials, it cut simulation planning cycles by over 60%, improved accuracy by more than 25% compared to baseline models, and will reduce resource allocation decisions from days to hours. Its cross-sector flexibility makes it a valuable tool for hydrocarbon fields, emerging applications

to extract maximum value from both legacy and newly acquired seismic data, contributing to more reliable subsurface evaluations

Abstract Title: Deep Learning Based Salt Body Detection in Seismic Data for Enhanced Subsurface Interpretation

Author: ***Umang Nagpal, Rakesh Kumar Yadav, Ayush Kumar***

Organization: Oil and Natural Gas Corporation Ltd

Abstract: This study presents an Automated approach for detecting Salt bodies in 2D seismic sections (open source) using an in-house developed Deep Learning algorithm. Salt structures cause significant distortions in seismic imaging, complicating subsurface interpretation. The objective is to leverage Convolutional Neural Networks, specifically U-Net architectures, to accurately segment salt formations. This enhances geological interpretation and streamlines exploration workflows in hydrocarbon prospecting.

A Supervised Deep learning workflow was developed using a U-Net model with a ResNet Encoder, implemented via Keras for semantic segmentation of salt bodies in grayscale seismic images. The training dataset consisted of 10,000 image patches (128×128 pixels), extracted from labelled 2D seismic sections and classified into "salt" and "non-salt" categories. Binary masks served as ground truth for training. Preprocessing steps included resizing, normalization, and augmentation. Model performance was evaluated using metrics such as Intersection over Union (IoU), Dice coefficient, and Confusion matrices. The trained model was then applied to full seismic sections for prediction and analysis. Our model demonstrated effective learning of salt body geometry from a limited sample of annotated 2D seismic sections. It achieved 87–90% classification accuracy on the validation set, with a Dice coefficient of ~0.85, indicating high overlap with ground truth masks even in those areas affected by amplitude shadows and distorted reflectors. Visualization confirmed the model's robustness in identifying non-uniform salt shapes and irregular boundaries as in Iline#110, despite the inherent noise in seismic data. The adoption of Dice loss was crucial in optimizing the model for imbalanced class distributions given that salt typically occupies a minority of the image area. The confusion matrix highlighted the model's performance in correctly classifying both salt (true positives) and non-salt (true negatives) regions.

Additionally, data augmentation techniques improved the generalizability of the network across unseen orientations and amplitudes. Using a U-Net with a ResNet encoder further enhanced feature extraction from subtle seismic patterns, crucial for delineating salt-sediment interfaces. The study concludes that deep learning, particularly CNNs, offers a viable and potentially valuable approach to automating salt body interpretation in seismic data, reducing manual effort and improving efficiency in subsurface exploration workflows.

This work introduces a scalable and automated solution for salt body detection in seismic images using deep learning. By employing a patch-based training and tiling approach, it enables efficient handling of large seismic datasets. The methodology enhances existing literature by integrating improved model architectures and evaluation metrics, and by demonstrating real-world applicability. It offers oil and gas operators a valuable tool for more accurate reservoir delineation and faster decision-making in exploration planning.

Abstract Title: Digital Transformation through Monitoring Tool WDA yielding significant benefits for ONGC, Jorhat Asset

Author: ***Manish Kumar,***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: This paper highlights the digital transformation initiative undertaken at ONGC's Jorhat Asset through the implementation of the Well Data Analytics (WDA) tool. The primary objective of WDA is to standardize and integrate diverse reservoir-related datasets—such as pressure, production, and well intervention data—into a single, interactive platform. Developed indigenously, WDA aims to replace the legacy Excel-based data handling system with a comprehensive, structured database that enhances decision-making and reservoir management. The paper discusses the software's functionality, integration capabilities, and its positive impact on operational efficiency, ultimately showcasing its scalability for deployment across ONGC.

The approach involved the in-house development of the WDA software to consolidate reservoir data traditionally stored in Excel spreadsheets. The methodology started with the digitization and standardization of bottom-hole pressure data. These records were then integrated with production, drilling, and workover data into a centralized, structured database. The software incorporates built-in calculators—such as for well deviation, coordinate conversion, and fluid interface depth—automating previously manual calculations. A GUI allows for visual comparison of data across gradients. Diagnostic and production plots, interactive visualizations, and mapping tools enable a holistic view of well health. WDA also has capability to connect with ONGC's existing systems like EDS, SAP, and OSI PI, facilitating real-time updates and centralized access for decision-makers across departments. The implementation of WDA at ONGC's Jorhat Asset has yielded notable improvements in operational efficiency and reservoir management. Previously fragmented and unstructured data, often maintained in Excel sheets, has been transformed into a comprehensive and standardized digital repository. This transition allows reservoir and production engineers immediate access to historical and real-time data for decision-making. One key observation is the enhanced visibility into well behavior through integrated diagnostic plots that include rig/rigless interventions, pressure trends, and production rates. The software's interactive dashboard and alarm system provide early warnings of changing well parameters, enabling timely remedial actions. It also aids in deeper analysis of underperforming (sick) wells by presenting data in a structured and meaningful format. WDA further empowers users with embedded computational tools that eliminate reliance on

external software or manual calculations. The capability to import data from various ONGC databases, such as EDS and RTMS, will facilitate a seamless digital ecosystem in future. The deployment in Jorhat has proven its value in streamlining workflows, improving data integrity, and supporting a proactive reservoir management culture. The project marks a significant move from siloed data handling to a unified, decision-support platform. In conclusion, WDA has not only modernized reservoir data management but also demonstrated tangible benefits, making it scalable for broader ONGC-wide implementation.

WDA offers ONGC the potential to revolutionize reservoir management across all Assets by transitioning from legacy data systems to a centralized digital platform. Its integration-ready database with existing ONGC infrastructure ensures data consistency, minimizes human error, and enhances operational responsiveness. The software enables proactive reservoir diagnostics, early anomaly detection, and improved intervention planning, all of which contribute to higher recovery efficiency and cost savings. By fostering a data-driven culture, WDA strengthens ONGC's digital transformation goals, making it a strategic tool with scalable benefits across upstream operations, ultimately enhancing productivity and sustainability.

Abstract Title: Deep Learning Based Salt Body Detection in Seismic Data for Enhanced Subsurface Interpretation

Author: ***Umang Nagpal, Rakesh Kumar Yadav, Ayush Kumar***

Organization: Oil and Natural Gas Corporation Ltd

Abstract: This study presents an Automated approach for detecting Salt bodies in 2D seismic sections (open source) using an in-house developed Deep Learning algorithm. Salt structures cause significant distortions in seismic imaging, complicating subsurface interpretation. The objective is to leverage Convolutional Neural Networks, specifically U-Net architectures, to accurately segment salt formations. This enhances geological interpretation and streamlines exploration workflows in hydrocarbon prospecting.

A Supervised Deep learning workflow was developed using a U-Net model with a ResNet Encoder, implemented via Keras for semantic segmentation of salt bodies in grayscale seismic images. The training dataset consisted of 10,000 image patches (128×128 pixels), extracted from labelled 2D seismic sections and classified into "salt" and "non-salt" categories. Binary masks served as ground truth for training. Preprocessing steps included resizing, normalization, and augmentation. Model performance was evaluated using metrics such as Intersection over Union (IoU), Dice coefficient, and Confusion matrices. The trained model was then applied to full seismic sections for prediction and analysis. Our model demonstrated effective learning of salt body geometry from a limited sample of annotated 2D seismic sections. It achieved 87–90% classification accuracy on the validation set, with a Dice coefficient of ~0.85, indicating high overlap with ground truth masks even in those areas affected by amplitude shadows and distorted reflectors. Visualization confirmed the model's robustness in identifying non-uniform salt shapes and irregular boundaries as in Iline#110, despite the inherent noise in seismic data. The adoption of Dice loss was crucial in optimizing the model for imbalanced class distributions given that salt typically occupies a minority of the image area. The confusion matrix highlighted the model's performance in correctly classifying both salt (true positives) and non-salt (true negatives) regions.

Additionally, data augmentation techniques improved the generalizability of the network across unseen orientations and amplitudes. Using a U-Net with a ResNet encoder further enhanced feature extraction from subtle seismic patterns, crucial for delineating salt-sediment interfaces. The study concludes that deep learning, particularly CNNs, offers a viable and potentially valuable approach to automating salt body interpretation in seismic data, reducing manual effort and improving efficiency in subsurface exploration workflows.

This work introduces a scalable and automated solution for salt body detection in seismic images using deep learning. By employing a patch-based training and tiling approach, it enables efficient handling of large seismic datasets. The methodology enhances existing literature by integrating improved model architectures and evaluation metrics, and by demonstrating real-world applicability. It offers oil and gas operators a valuable tool for more accurate reservoir delineation and faster decision-making in exploration planning.

Abstract Title: Prediction of Missing Well Log Data Using AI/ML Models in Subsurface Reservoir Evaluation: A Practical Python-Based Approach

Author: Vishal Yadav, Snehasish Chowdhury, Amartya Brahma

Organization: IOCL.

Abstract: This study explores the use of Deep Neural Network (DNN) techniques to predict missing well log, addressing challenges such as tool malfunctions, cost constraints, and incomplete datasets using conventional well log data. The objective is to develop a low-cost, accurate, and scalable predictive model that eliminates the need for expensive field measurements or core analysis. The work focuses on leveraging open-source tools and commonly available logs—porosity, gamma-ray, bulk density, and compressional velocity etc —to enable missing log estimation and improve subsurface reservoir characterization.

A supervised learning approach was adopted using a Python-based environment and libraries such as TensorFlow, Scikit-learn, and Pandas. A synthetic dataset resembling real well log data was prepared, incorporating porosity, gamma-ray, bulk density, and resistivity as input features and compressional sonic as the output. A DNN Model was constructed and trained using normalized inputs. The model was evaluated on a test dataset using key metrics such as R^2, RMSE, and other statistical

indicators. Visualization of training and validation loss helped assess overfitting and model generalization. The trained Model was then used to predict compressional sonic in real well data of a producing field in Middle East.

The trained DNN model demonstrated good predictive performance in real well data, with a coefficient of determination (R^2) exceeding 0.7. To further evaluate the model accuracy, we calculated the normalised Root Mean Squared Error (RMSE), normalised by mean and range, which came out less than 10% in both cases which is within acceptable error bounds. The training and validation loss curves confirmed that the model generalized well without overfitting. The final output matched closely with expected compressional wave values across a wide range of data points, showcasing its robustness. One key outcome of the study is the demonstration of how a practical, real-world problem in E&P industry can be solved using freely available data science tools. The model can be easily modified, retrained, or extended to incorporate additional logs or field data, offering a flexible foundation for reservoir engineers and petrophysicists to build upon. Similar approach can be applied in producing fields as well to predict well behaviour based on actual well production data

This work enables a cost-effective and accessible way of predicting Compressional Sonic in subsurface studies. By leveraging Python and open-source ML frameworks, the solution can be deployed and extended to predicting/estimating any missing log in field offices, academic environments, or even real-time decision systems—without reliance on commercial software. It significantly supports data-driven workflows in well planning, reservoir characterization, and geomechanics, especially in data-scarce or budget-constrained projects.

Abstract Title: Use of AI/ML models for production allocation and use of Artificial Neural Network (ANN) model for detection of water loading in gas well - case study of Hazira Field

Author: ***Jeet Dey, Jyoti Kumari***

Organization: Sun Petrochemicals Pvt Ltd.

Abstract: This abstract explores the application of Artificial Intelligence (AI) and Machine Learning (ML) in upstream oil and gas operations, focusing on digital tools developed for production allocation and gas well liquid loading detection. It aims to demonstrate how AI/ML technologies can streamline decision-making, improve operational efficiency, and enhance the management of marginal fields like Hazira Field.

AI/ML models were integrated into two core workflows: (1) a Production Back Allocation Dashboard, developed using Python, which automates well-wise allocation by integrating test data, real-time production figures, and pre-set rules, and flags deviations for retesting; (2) an Artificial Neural Network (ANN) model trained on historical production and well data to predict liquid loading conditions in marginal gas wells. Data inputs included flow rates, water cut/ water gas ratio, tubing diameter, and tubing head pressure. The models were validated through Hazira field results and integrated into regular surveillance and optimization practices.

The Production Back Allocation Dashboard significantly reduced manual effort in reconciling well-wise production data by automating allocations and promptly identifying wells with abnormal output. This led to faster intervention, reduced deferred production, and improved transparency in hydrocarbon accounting. In the Hazira field, the ANN-based liquid loading detection model demonstrated superior performance over Turner's traditional model, particularly for wells with borderline loading behaviour. The ANN's ability to handle nonlinearities and multi-variable interactions enabled more accurate classification of "liquid loaded" wells. Wells flagged by the model underwent targeted interventions such as surfactant injection, flow cycling, or velocity string installation, gas lift installation which improved uptime and boosted marginal well recovery. Field validations confirmed the robustness of both solutions in delivering actionable intelligence and measurable performance gains.

This abstract contributes a real-world case study of scalable, cost-effective AI/ML solutions in production engineering, combining traditional physics-based models with data-driven intelligence.

It showcases how custom AI tools can augment field operations in mature assets, bridging the gap between conventional surveillance and digital transformation, thus supporting India's broader goals of energy security and operational sustainability.

Abstract Title: Improved seismic data processing is based on a convolutional neural network model using an attenuation mechanism.

Author: ***Venkatesh Ambati, Jayant Jharkhande, Lakshmipriya Menon***

Organization: Zemblance Hydrocarbon.

Abstract: In hydrocarbon exploration, seismic images are essential for understanding the subsurface geological structure and resource distribution. However, seismic data collected in the field inevitably encounter random noise interference, subsequently affecting data processing and interpretation. The resolution and signal-to-noise ratio limit the accuracy and certainty of geological analysis using seismic images. Therefore, it is crucial to eliminate random noise in seismic data. A fundamental issue is how to improve the signal-to-noise ratio of seismic data.

Recently, deep learning methods, the denoising convolutional neural network (DnCNN) has shown some potential because of local perception and weight sharing in signal processing. We propose a light weight attention convolutional neural network (LWCNN) based on DnCNN, which uses the dual attention mechanism in denoising to improve the performance of DnCNN networks, which extracts information from the spatial and channel dimensions of the feature to preserve the underlying

structure and texture.

The Attention mechanism is combined with the double convolutional batch normalisation block, which enhances the generalisation ability and increases the diversity of seismic data feature extraction performance of the network. Extensive experiments on field seismic data explored two attention mechanisms: channel dimension attention to identify significant channels ("what"), and spatial dimension attention to locate expressive features ("where") within feature maps. Third, in order to improve the network's performance, the feature extraction effect, the event texture preservation effect, and the signal-to-noise ratio, the optimization of kernel size, feature map, learning rate and patch size is done.

Several examples of field seismic data demonstrate that a dual attention mechanism extracts more expressive information for the attention maps. The results of this study demonstrate that the suggested method significantly improves the signal-to-noise ratio (SNR), making it easier to reliably and efficiently recover the underlying information from the noisy observations.

Abstract Title: Towards Minimal Formation Damage: AI-Driven Design and Analysis of Drilling Fluids.

Author: ***Davninder Singh, Rajat Jain, Ranjan Pramanik***

Organization: Indian Institute of Petroleum and Energy.

Abstract: This study presents a machine learning approach to predict and minimize the potential for formation damage caused by drilling fluids. Experimental rheological and filtration data are utilized to analyze drilling fluids with varying concentrations of conventionally used additives such as bentonite, xanthan gum, poly anionic cellulose (PAC), barite, and potassium chloride (KCl). The essential properties of fluids are assessed based on density, apparent viscosity, plastic viscosity, and fluid loss. As they affect overall drilling operations, a predictive model is developed to optimize fluid formulations, thereby reducing fluid invasion and consequent damage during drilling operations.

A series of water-based drilling fluids was prepared by varying the concentration of one additive at a time while keeping the base fluid formulation constant. A fixed volume of prepared sample was processed for testing as per the recommended field procedure by the American Petroleum Institute (API). The density, apparent viscosity (AV), and plastic viscosity (PV) were measured using a mud balance (make: Fann), viscometer (make: Grace), and fluid loss (make: OFITE), respectively. These experimental parameters were used as inputs to develop machine learning models. The models will correlate fluid formulation parameters with fluid loss characteristics to identify formulations that reduce fluid invasion and potential damage during drilling. Fluid invasion triggers rock–fluid interactions, leading to formation damage.

The machine learning models provide high accuracy in predicting fluid loss and rheological behavior based on fluid composition. Random Forest algorithms have demonstrated strong validation performance, highlighting their potential for predicting fluid loss and rheological behavior effectively. Experimental results indicate that increasing the concentrations of specific additives, such as PAC and xanthan gum, significantly reduces fluid loss. The models also help identify optimal fluid compositions that achieve a balance between viscosity control and minimal fluid invasion. This AI-assisted approach allows for the rapid design of drilling fluid formulations, reducing the need for costly and time-consuming experimental iterations. By predicting fluid behavior with high precision, we can make data-driven decisions regarding drilling fluid formulations. This solution optimizes drilling fluids to minimize formation damage, especially in Indian oil field conditions, where tailored approaches are essential for efficient and cost-effective drilling operations.

This study introduces a specially designed framework combining experimental rheological and fluid loss data suitable for Indian fields with machine learning-driven prediction to optimize drilling fluid formulations. It provides a faster and cost-effective approach to enhance drilling efficiency and wellbore protection by predicting formation damage earlier, also minimizing risks effectively.

Abstract Title: Data mining for variable correlations that impact Fracture Height in Western India formations with impact of frac design & proppant selection

Author: ***Arindam Bhattacharjee, Hariom Gupta, Sajid Kamal***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: Reservoirs in Western Onshore are one of the primary targets of hydraulic fracturing with hundreds of wells drilled for monetization each year. A key factor is fracture height which has a big role in ultimate fracture geometry. Data mining techniques are used to focus on the following variables: principal stress state, 1D MEM, lithological contrasts and laminations. Impact of each was checked on various proppant grades & job sizes.

Data of 100 wells were collated. 7 major fields were targeted for study. Geomechanical parameters were sorted by the following methods like functional neural network, Takagi-Sugeno-Kang fuzzy interference, Mandami Fuzzy Interference & support vector machine. The impact of the parameters on final frac design was further sorted on the following job design sizes: 30 MT, 40 MT, 50 MT, 60 MT, Job rates: 16,18,20 & 25 bpm. The impact of changing proppant: LSP, ISP, HSP was also collated.

The main result of the study are as follows:

- The formation is under normal fault regime.

- Pumping Rates have a more visible impact than final proppant concentration.
- Fluid efficiency have a direct correlation in enhanced post-HF THP post HF.
- Usage of ISP/HSP vis-à-vis LSP shows systematic improvement only in select reservoirs.
- Mixing of proppant types results in better conductivity related flow only in select cases.
- Jobs executed with hybrid mode: Linear+ X-linked frac fluid result in improvement only if there is incremental gain in frac fluid rate and high net pay.
- the average viscosity of the frac fluid is seen impacting the flowback only in select cases. Reservoir temperature was not found one of the singular criteria.
- In wells where differences in minimum in-situ stress w.r.t MEM values were observed, pumping rate was a more impacting factor in comparison to job size.

The above analysis gives us a brief insight in “connecting dots” of some intriguing factors as far as reservoir geomechanics is concerned. The study will help us in better facilitating frac design, running automated schedules as well as optimising the fracturing job in four themes: job size, pumping rate, proppant selection & fluid volume. The study will also serve as a pilot iteration for induction of advanced proppant types as per reservoir requirement.

Abstract Title: Transforming Reservoir Evaluation: Enhanced Permeability Estimation via Class-Based Machine Learning and Stoneley Wave Analysis.

Author: ***Saurajit Saha, Nistha Mukherjee, Chandreyi Chatterjee***

Organization: SLB.

Abstract: Permeability is a pivotal reservoir property that directly impacts fluid dynamics, reservoir modeling, and overall field management. Stoneley wave analysis from sonic logs offers a continuous means to estimate permeability along the wellbore. However, uncertainties inherent in Stoneley measurements—stemming from borehole conditions, formation heterogeneity, mud properties, and wave propagation effects—demand calibration against robust data sources such as formation testing and Nuclear Magnetic Resonance (NMR) measurements. This study develops and validates a robust Stoneley wave analysis method to provide continuous, real-time permeability profiles that bridge gaps in discrete measurements and support strategic reservoir decision-making.

In response to these challenges, we propose a novel Class-Based Machine Learning (CBML) framework that enhances Stoneley wave-based permeability estimation. This approach employs supervised learning to develop class-specific regression models from an extensive suite of well logs, effectively tagging and predicting permeability through defined petrophysical classes. Once calibrated and validated on known datasets, the model is deployed in an unsupervised manner on new well data, generating refined Stoneley mobility estimates that are subsequently cross-validated with additional quality control logs—including shale volume, bulk density, gamma ray, and washout indicators.

The CBML-driven approach enhances both the efficiency and accuracy of permeability assessment from Stoneley waves. By automating key steps, it reduces processing time, minimizes subjective bias, and ensures consistent results across diverse wells and geological settings. The workflow demonstrated a 50% reduction in analysis and validation time. Applied to blind well datasets, the model achieved a strong correlation of 90% with an error margin of 8-10%. The methodology provides continuous permeability profiles, bridging gaps left by discrete core and MDT data. Additionally, in wells lacking calibration data, it serves as a dependable preliminary permeability estimator, supporting crucial decisions such as selecting formation testing depths. The rapid and consistent output also enables real-time applications, allowing operators to make informed decisions faster, ultimately leading to cost savings on rig operations. When integrated with seismic data, these continuous profiles further enhance reservoir characterization across multiple wells. The implementation of the CBML framework marks a significant advancement in leveraging machine learning for Stoneley wave-based permeability analysis. By incorporating automated data classification and iterative refinement, this approach offers a scalable, efficient, and robust solution for generating continuous permeability profiles. This innovation addresses the limitations of conventional methods and enables more data-driven decision-making in reservoir evaluation and development.

The proposed CBML framework adds significant value by automating and standardizing permeability estimation, reducing analysis time by 50% and minimizing interpretational bias. It enables real-time decision-making in formation evaluation, particularly in wells lacking calibration data. The continuous profiles it generates improve test point selection, enhance reservoir modeling, and reduce rig time and associated costs. When integrated with seismic and other log data, it further refines reservoir characterization, making the approach not only scalable across multiple wells but also a strategic asset in field development planning.

Abstract Title: On the use of machine learning techniques for gas solubility in formation brine: Evaluation of aquifer capacity for geologic storage of CO2 and hydrogen

Author: ***Ram R. Ratnakar, Vivek Chaubey, Somil S. Gupta***

Organization: Shell International Exploration & Production

Abstract: Gas solubility in brine is essential for determining subsurface/aquifer capacity for CO2/H2 storage. It is also crucial for various other engineering processes such as oil recovery, gas processing, separation, and corrosion in sour fields. However, most theoretical and experimental studies are performed with brine solutions containing standard salts (e.g. NaCl, KCl and CaCl2), limiting the applicability for the formation brines that usually contain complex salt-mixtures. This study presents an integrated framework, coupling physics with machine learning (ML), to determine the intrinsic trends of gas solubility in brine, which is valid for wide range of pressure, temperature, salinity and compositions.

The modeling framework is divided into two parts. First, a decision tree (DT) based ML model is developed for gas solubility in water at various pressure/temperature (PT) conditions, utilizing experimental data from literature. In the second part, decision tree (DT), random forest (RF) and artificial neural network (ANN) techniques were employed to determine the gas solubility in brines solutions, where systematic numerical data was generated using a semi-empirical Setschenow's correlation. Prior to data generation, Setschenow's parameters were tuned against available experimental data (that are sparse) for comprehensive list of gases, anions and cations capturing most formation brine compositions. Finally, the framework is validated by comparing the model predictions against experimental data for a few gas-brine systems that were not part of any tuning.

An integrated modeling framework coupling physics with ML is developed to estimate gas solubility in brines for a wide range of pressure, temperature and brine compositions, enabling the determination of subsurface capacity of the storing CO2 and H2. The main results are as follows:

- The ML models predict experimental trends accurately, within the relative error of 1% for gas-water systems and 3% for complex gas-brine systems. This validated the modeling framework as well as the applicability of Setschenow's relation.
- Various input features based on the thermodynamic and physical properties of gases and ions (cations and anions) were considered in the model development and the main contributing features were identified.
- Most importantly, the framework is general, fast, convenient and can easily be extended for a novel species including greenhouse or hydrocarbon gases, as well as for variety of salts. Additionally, it can fill the gaps in experimental data for the gas-brine systems and can extrapolate to elevated PT conditions.

While several studies exist in literature on estimation of gas solubility in brines, they are very restrictive and valid for a few salts (NaCl/KCl/CaCl2), especially at elevated PT conditions. Since formation brine may contain several complex salts, which (along with PT conditions) may vary reservoir to reservoir, it is crucial to develop a framework that can be utilized in a wide range of these conditions, especially since the gas solubility in brine directly influences the storage capacity. The proposed framework presents such a solution and is validated against experimental observations.

Abstract Title: Machine Learning-Based Lithofacies Prediction from Well Logs: A Case Study from the Bokaro Coal Basin

Author: ***Abir Banerjee,***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: This study explores the application of supervised machine learning (ML) algorithms—k-nearest neighbor (kNN), support vector machine (SVM), and random forest (RF)—for automated petrographic classification in the Barakar Formation of the East Bokaro coalfield. The objective is to enhance lithological sequence prediction using conventional geophysical logs (GR, RT, ρb, ΦN, and PEF), and to detect missing seams or faults in the coal-bearing strata. By training ML models on a master well and applying them to nearby wells, the research aims to improve subsurface geological interpretation and support decision-making in coalbed methane (CBM) exploration and development.

The study utilized well log data from three CBM wells in the East Bokaro coalfield. Well W-5, with a complete lithological profile, was designated as the master well for model training, while W-1 and W-3 served as validation wells. Five conventional logs—gamma ray, resistivity, bulk density, neutron porosity, and photoelectric factor—were used as input features. Lithologies were categorized into coal, sandstone, shale, and carbonaceous shale based on predefined cut-off values. ML models (kNN, SVM, and RF) were trained using supervised learning frameworks and optimized via fivefold cross-validation and GridSearchCV. Performance evaluation employed precision, recall, F1-score, and ROC-AUC. The best-performing model was applied to test wells to validate lithological predictions and investigate potential geological faults.

The ML-assisted lithological classification showed strong agreement with expected stratigraphic sequences. Among the models tested, the Random Forest (RF) algorithm consistently outperformed kNN and SVM, achieving the highest overall accuracy of 96.4% during the training phase. SVM and kNN followed with 91.2% and 89.1% respectively. All models effectively distinguished between coal, sandstone, shale, and carbonaceous shale. The RF model exhibited excellent ROC-AUC scores (≥ 0.98) across all lithologies, indicating robust predictive capability. Application of trained models on test wells W-1 and W-3 demonstrated successful lithology predictions, even in data-sparse or non-cored sections. Visual comparison of ML-predicted lithologs revealed consistent sequence trends with the master well. Notably, lithological mismatches and missing coal seams in correlated wells suggested structural disruptions. These observations, supported by resistivity image logs, indicated the likely presence of faults between well locations. Thus, the study confirmed that ML models, particularly RF, not only streamline the interpretation of complex multi-log datasets but also provide valuable insights into subsurface structural variations. This approach allows identification of thin lithological units (up to 0.3 m) with improved speed and accuracy, outperforming traditional manual methods. Overall, ML integration represents a powerful tool for enhancing geological characterization in CBM reservoirs.

This ML-based lithological classification workflow offers a scalable, automated solution for subsurface interpretation in data-intensive coalfields. It significantly reduces manual interpretation time and subjectivity, while improving prediction accuracy for

resource planning and seam continuity analysis. The model also enables early detection of faults and missing seams, critical for well placement and reservoir modeling in CBM operations. Its adaptability to other basins with similar log inputs makes it a valuable tool across multiple exploration projects. By integrating geophysics with data science, this study advances the digital transformation in reservoir characterization.

Abstract Title: Digital Rock - Resolution Independent Interface Reconstruction

Author: ***Raunak Bardia, Chaitanya Pradhan***

Organization: Shell India Markets Pvt. Ltd.

Abstract: Digital Rock technologies integrate 3D micro-CT imaging with computer vision and physics simulators to expedite and reduce the cost of rock property prediction. Key challenges here are the hardware-imposed limit on resolution and artefacts generated during the reconstruction of 2D projections to a 3D image. Consequently, boundaries between two phases appear as diffused zones rather than sharp edges, resulting in a further loss of resolution and decreased accuracy of property predictions, particularly in tight formations. This study presents a workflow to integrate techniques from continuum scale fluid flow to super resolve diffused interfaces into first-order accurate sharp approximations.

The spatial fuzzy c-means algorithm is employed to determine the probabilities of each voxel's classification as either pore or mineral. Voxels situated at the interface exhibit low classification probability towards pore or mineral and are identified accordingly. The partial porosity of interfacial voxels is calculated based on their grayscale values and the representative grayscale values of pore and mineral classes. The isoAdvector method is employed to generate iso-surface interfaces that adhere to this partial porosity constraint. This resolution-independent iso-surface is identified as a reasonable first-order approximation of the true interface. Super-resolution is performed by subdividing the original voxel into sub-voxels and classifying them based on their relative position to the iso-surface interface.

To ensure robustness, the workflow was rigorously tested with a registered, multi-resolution dataset consisting of glass beads and clastic sandstone. Low and high-resolution image pairs, both focusing on the same field of view, were generated. The low-resolution image underwent super-resolution to achieve parity with its high-resolution counterpart, which served as the ground truth. Validation metrics used included porosity, calculated with voxel counts; permeability, simulated using a Lattice-Boltzmann solver; and mercury intrusion capillary pressure curves, simulated via the maximal included sphere method. Each metric was computed for all images within the dataset and subjected to comparative analysis. Results indicated that the super-resolved image exhibited a deviation within 3 porosity units, 20% for permeability, and 4% for MICP curves. The close match for porosity and permeability metrics signifies the method's proficiency in accurately super-resolving the volume and tortuosity of the domain. Additionally, the close match for MICP curves validates the method's ability to preserve the spatial distribution and arrangement of grains within the samples.

Digital Rock technologies offer significant advancements by providing geological information faster than conventional measurement techniques, at a substantially reduced cost. The proposed workflow enhances the precision of predictions without requiring extensive training data. Additionally, this methodology enhances workflow efficiency by enabling accurate property predictions utilizing low-resolution images, which are quicker and more cost-effective to obtain. Furthermore, it broadens the applicability of Digital Rock technologies by overcoming hardware limitations to include tight rock formations that cannot be reliably resolved using micro-CT imaging techniques.

Compendium of Abstracts

Theme: Unlocking India's Frontier Basins: Advanced Exploration Strategies for Hydrocarbon Discovery

Abstract Title: Role of erosional and depositional sequence of the paleochannels in determining the hydrocarbon prospectivity of Bengal

Author: ***Dr. K.B. Bhavya,***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: The Bengal Basin is hydrocarbon-producing and continues to be considered under category-II Basin. Mapping and understanding the Bengal Basin is challenging due to several reasons. The sequences in the Bengal basin mostly don't possess much event continuity and are chaotic due to lack of steady deposition due to erosion, mixing and nonuniform deposition. Due to the chaotic nature of the sequences, mapping the faults, which are very gentle in the basin, is a tedious task. The seismic data analysis was carried out to delineate the channel sands, incised channel fills, and fault systems in the basin.

The seismic interpretation is carried out on the east side of the Bengal Basin in the onland and offshore areas. The bright amplitude in the Miocene and Pliocene was probably due to the channel sand deposits, and the geometry was mapped. At the same time, some of the channels had erosional cuts and were being filled by chaotic shaly sediments adjoined by high amplitude relict structure. Detailed mapping was carried out to delineate channel sands, erosional cuts and relict surfaces. Mapped the prograding delta migration from the onland to the shelf. The Fault attribute analysis is being carried out along the Oligocene Top as the event is fairly a continuous reflector.

The older formations are exposed west of the Basin Boundary. The Eocene Hinch Zone (EHZ) marks a prominent change in the relief of Eocene and older formations and probably marks the shelf break of corresponding horizons. The Paleo coastline is probably west of the EHZ prior to Eocene. The lower Oligocene sections depict the deltaic fan sediment deposited towards the Southeast. However, near the top of Oligoce, a north-south channel-like feature can be seen. In the Miocene sequences, the delta progrades from the EHZ zone area to the present shelf area in the older to younger sequences. Meandering rivers exist on the upstream side of these paleodeltas. Hence, in the area of onland, there are anastomosing sand-bearing channels at multiple levels that bring to the basin. At the same time, erosional valleys cut across the older sequences and fill later deposits mainly with shale. The erosional channels are adjoined by relict structures, which may possess sand from the earlier channel or delta sands. The Pliocene channels are present in the onland areas. In the present-day shelf area, the Pliocene sequences are cut by wide canyons precursor of Swatch of No Ground. These canyons are also filled later by sediments, which are chaotic in nature and lack event continuity.

The bright reflectors in the Bengal basin are generally sand. Miocene sand-bearing channels have higher potential as reservoir rocks. The erosional channels are generally filled with shale-dominated facies and act as a barrier, while the adjoining relict structures have potential as reservoir rocks. The canyon fills in the shelf area may have limited hydrocarbon migration and may depend on the fault-associated vertical migration. In the self area, the relicts areas have higher potential than the canyon-filled zones. As these canyons cut across even Miocene sequences, canyons provide lateral or top seals to the adjoining older formations.

Abstract Title: Revealing Hidden Structures using Floating Datum Seismic Data processing technique in complex Fold Belt areas of Northeast India

Author: **Yogaxem Sharma, Mridula Singh, R. Madhusoodhanan**

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: Complex geological-settings are generally characterized with the presence of highly undulating topography, steep dips, faults etc., posing striking challenges to seismic imaging of data acquired in such areas. Traditional seismic processing techniques often fall flat in such scenarios, resulting in poor/inaccurate imaging and interpretation. This work explores the implementation of Floating Datum technique for Seismic Data Processing as an effective solution for such tricky areas. A&AAB is quite complex. Presence of thrust faults and steeply-dipping sedimentary-sequences complicates the propagation of seismic waves giving rise to distortions while processing. Usage of floating datum technique, effectively addresses many of the aforementioned issues.

The technique involves:

- Replacement of rugged surface datum with a smooth, near-surface floating datum.
- Use of refraction statics or tomography to create a reliable near-surface velocity model.
- Pre-stack data correction and migration referenced to the floating datum.

This specific approach reduces the effects of elevation and near-surface irregularities, offering better alignment of reflection events and improved data coherence.

Floating Datum Processing involved the following major steps:

- Elevation statics correction.
- Near-surface velocity model building (via refraction or tomographic data).
- Application of floating datum shift.
- Velocity analysis and imaging from the floating datum.
- Final migration and structural interpretation.

Full processing flow is discussed in full paper in details.

Case Study from Tripura Fold Belt Region in Assam-Arakan Basin:

2D seismic lines from a structurally complex area in the Tripura Fold Belt region of Assam-Arakan Basin were reprocessed using Floating Datum Technique and were compared with the lines processed earlier using the conventional methods.

Observations:

- Conventional processing yielded poor reflector continuity, time sag, and mis-positioned anticlinal structures and faults.
- Floating datum processing significantly improved the image resolution, reflector continuity, anticlinal structures and fault definition.

Results:

The use of floating datum technique for seismic data processing in the fold-belt of Tripura region have lead to:

- Enhanced imaging of subsurface anticlinal structures and faults which have hydrocarbon potential.
- Enhanced interpreter confidence in and around anticlinal structures and also fault delineation and trap identification.
- Significant improvement in reflector alignment and continuity.
- More accurate velocity picking and hence more reliable velocity model for NMO correction/migration.
- Improved migration results by reducing topographic and near-surface distortions.
- Enhanced tie-in with well data.

However, success depends on the accuracy of near-surface modelling and the quality of statics corrections applied during the early processing stages.

Figures showing improvement over conventional technique are shown and given in the paper in details.

Floating datum data processing proved to be a powerful tool for geologically complex areas like the fold belts of Northeast India. By mitigating the topographic distortions and near-surface velocity anomalies this method unveils subsurface structures especially tightly packed anticlinal structures that are otherwise hidden or misrepresented in conventional processing. Its application in the Assam fold belt has demonstrated clear improvements in revealing hidden structures, making it a valuable asset in hydrocarbon exploration & development in challenging terrains. As exploration extends into increasingly challenging terrains and areas, such advanced techniques will play a critical role in successful hydrocarbon exploration and development.

Abstract Title: Unlocking the Hydrocarbon Potential of the Andaman forearc Basin

Author: ***Parvee,***

Organization: IIT Gandhinagar

Abstract: The Andaman-Nicobar subduction zone is a seismically active region critical to the tectonic structure of the Sunda subduction zone. Here, the Indian Plate subducts beneath the Eurasian Plate at an oblique rate of 43 mm/yr. The Andaman Forearc Basin, classified as Category II, holds potential hydrocarbon resources, highlighting its importance in both seismic risk and energy exploration. The objective is to decipher the structural framework and hydrocarbon potential of the Andaman Forearc Basin by analyzing its geological framework, seismic data, and existing exploration findings, with the aim of identifying prospective zones in this frontier region.

We have purchased high-resolution 2D seismic reflection datasets and well logs (if necessary) from the Directorate General of Hydrocarbons (DGH), encompassing the area from 12°N to 15°N in the Andaman Forearc Basin. Using OpendTect Pro, we will conduct seismic analysis and structural interpretation of key structures in the forearc basin, such as the accretionary wedge, forearc high, and the forearc basin. We will also conduct fault mapping using tools like coherence and variance analysis. Next, we will classify sedimentary layers by examining the continuity of reflections and their internal structures. Identifying important depositional systems: Mass Transport Complexes (MTCs) related to underwater landslides and tectonic instability zones. Levee Channel Complexes (LCCs) indicating deep-water sediment movement and deposition. Identifying Direct Hydrocarbon Indicators in the data for Hydrocarbon Exploration.

Detailed fault interpretation indicates fault reactivation zones, which are critical for understanding stress regimes and the

structural development of the basin. The Diligent Fault Zone, for example, exhibits compression-related structures, including anticlines and backthrusts in the Pliocene and Neogene strata, indicating regional shortening and uplift. Structural highs and fault closures are identified as potential hydrocarbon traps, while fault-bounded half-graben structures, prominent at the Late Oligocene horizon, dominate the northern and southern parts of the basin. Turbidite and gravity-flow deposition have been observed in deep-water siliciclastic reservoirs, including channel-levee complexes, linking tectonic deformation to sedimentation processes. The presence of gas hydrates (BSR – Bottom Simulating Reflectors) is also confirmed in some parts of the basin.

This study will help not only in India's energy sector but also in understanding the basin structure as well as economic & industry growth in India.

Abstract Title: Hydrocarbon Prospectivity of Mesozoic Source rocks of Jaisalmer Basin: A Geochemical Evaluation of Baisakhi-Bhadasar and Pariwar formations

Author: ***Sweta Singh, Neha Rawat, Pradeep Kumar Goswami***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: The Jaisalmer Basin is situated within the larger Western Indian Basin, a prolific hydrocarbon-bearing region. Its geological evolution spans millions of years, resulting in the deposition of diverse sedimentary formations. The Baisakhi-Bhadasar and Pariwar formations, representing the Mesozoic era, have attracted attention as potential hydrocarbon sources due to their organic-rich composition and favorable depositional environments. By examining various geochemical parameters such as total organic carbon content, source rock potential, and thermal maturity, this study aims to evaluate the quality and viability of these formations as source rocks and to assess their capacity to generate hydrocarbons.

Rock Eval pyrolysis study indicates presence of effective to potential source rocks of varying thickness containing Type II-Type III organic matter within Baisakhi-Bhadasar and Pariwar formations of Mesozoic era. The Baisakhi-Bhadasar source sequences are characterized by good organic matter richness (average TOC 1.5 to 2.86%) capable of generating gas and oil (average HI: 148 to 274 mg HC/g TOC) and are at immature to peak maturation stage (VRo: 0.5 to 0.76 %). The organic richness of Pariwar Formation is good to excellent (average TOC: 1.5 – 6.7%) and quality of organic matter Type III and Type II (average HI: 110-202 mgHC/gTOC). The sediments of Pariwar Formation are immature in entire Jaisalmer Basin except Chinnewala Tibba Field, where it is at early maturation stage.

The geochemical characteristics of these source rocks, especially the biomarker data, reveal inputs from mixed terrigenous and algal organic matter. Terrestrial organic matter dominates the Pariwar Formation, whereas the marine-influenced Baisakhi- Bhadasar Formation shows a higher contribution from algal sources. The depositional environments of these Mesozoic source rock thus not only favoured high organic content but also preserved oil-prone kerogen. In conclusion, the depositional history, organic richness and appropriate thermal maturity of the Baisakhi- Bhadasar and Pariwar formations make them highly prospective for hydrocarbon exploration in the Jaisalmer Basin. These Mesozoic source rocks exhibit excellent generative potential and are crucial for understanding the petroleum system dynamics of western India.

The Jaisalmer Basin is a proven petroliferous basin with multiple hydrocarbon discoveries, primarily in Mesozoic reservoirs. Compared to the Barmer-Sanchor Basin, which has shown higher commercial oil yields (e.g., Mangala field), Jaisalmer's output is modest but geologically promising. While the Bikaner-Nagaur Basin has emerging shale gas potential, Jaisalmer offers a more established conventional play. Present comprehensive study of Mesozoic source rocks in the Jaisalmer Basin, including Baisakhi-Bhadasar and Pariwar formations reveals their promising characteristics as Hydrocarbon kitchen with Type III-Type II organic matter input.

Abstract Title: Hydrocarbon plays failure analysis and way forward: Andaman offshore

Author: ***Rajesh Pandey, Sonu, Ankur Ahmed***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: Exploration hunt in Andaman Sea started in the early eighties, unfortunately, no major discovery has been established, except for a few small pools of biogenic hydrocarbon in inner and outer arc tectonic setup. The study investigates the reasons for failure in the Andaman Sea, integrating 2D/3D seismic and well data of ONGC, which will bring out an understanding about the elements of petroleum system and GME model of the basin. Total 19 wells drilled by ONGC were analyses, within the different tectonic setup of Andaman Basin.

The source rock analysis suggests Type-III to Type-IV kerogen in forearc arc, the Paleogene source rock is better developed in outer arc area as compared to Neogene and Neogene source rock facies is well developed within inner arc. In outer arc, Cretaceous and Paleocene sequences are mature and have gas generation potential, while the Oligocene is marginally mature, and Miocene is immature. In inner arc, source rock maturity is only attained in Oligocene section with fair to good oil and gas generation potential. The reservoir rock within the forearc is Late Oligocene to Early Miocene Limestone. Additionally, fine grained sandstone of Paleocene and Eocene are potential reservoirs. The clastic reservoir facies are better as we move from north to south in outer arc.

The volcanic activity after early Miocene kept adding pyro-clasts and volcanoclastic inputs, without disturbing the normal deposition. This tuffaceous mudstone has density/impedance contrast as compared to the background claystone and has

been inferred as bright spot-on seismic data (false DHI). Geothermal gradients in outer arc is than > 2.0ºC/100m and the available VR0 data suggests that the deeper source facies are mature. Inner forearc has low (< 2ºC/100m) gradient, suggests less chance of thermogenic petroleum system. The accretionary prism area indicates good reservoir facies with low potential source facies. The back arc area has clastic reservoir, with high geothermal gradient (5.36 ºC/100m) and envisaged Type-II and Type-III source rock facies. The major reasons for the play failure within drilled wells in the Andaman Basin is misinterpretation of DHI (direct hydrocarbon indicator), marginal mature source rock, lack of hydrocarbon charging within the carbonate reservoirs and absence of reservoir facies (Middle Miocene onward). The paleogeographic reconstruction, indicates that the clastic sediment input in ponded low was form the east-west and north direction and the clean limestones are deposited as carbonate mounds, with porosities range ~8 -10 %, however they are found to be water bearing. The accretionary prism area indicates good reservoir facies with low potential source facies. The back arc area has clastic reservoir, with high geothermal gradient (5.36 ºC/100m) and envisaged Type-II and Type-III kerogen.

The major reasons for the play failure within drilled wells in the Andaman Basin is misinterpretation of DHI (direct hydrocarbon indicator), marginally mature source rock, lack of hydrocarbon charging within the carbonate reservoirs and absence of reservoir facies (Middle Miocene onward). Considering the lead obtained from this study, the back arc area along with the southern part of the fore arc is envisaged as prospective area. The identified area needs further detail mapping and prospect evaluation for thermogenic petroleum system. Additionally, shallow biogenic petroleum system needs attention of geoscientists on outer/inner and back arc area of Andaman basin.

Abstract Title: An Integrated Approach for construction of Paleo-Depositional Model of Middle and Upper Bhuban Formations in Tripura Fold Belt, Eastern India: A Case Study

Author: ***Sweta Pattanaik, Manisha Chakra***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: The present study focuses on the geological modeling of sand disposition in the Bhuban Formation in Tripura Fold Belt within Assam Arakan Fold Belt(AAFB). It aims to understand the sedimentary environment and geomorphological features that host major gas-bearing formations in the area. This study has been used to generate promising exploration locales, mitigate uncertainties associated with the depositional environment and deepening understanding of sedimentary processes AAFB region.

- Log Correlation: Significant geological markers were consistently traced across the region, aligning with identified sequence boundaries & correlated on seismic data.
- Core data analysis: from drilled wells in Tripura have distinguished tide dominated delta system for Upper & Middle Bhuban Formation.
- Horizon Interpretation and Mapping: Stratigraphic features like channel cuts, erosional remnants, intertidal channels and channel-associated depositional elements could be delineated and have been mapped
- Seismic attribute analysis: RMS amplitude (high amplitude: reservoir facies) and Spectral Decomposition studies used to detect reservoir bodies/depositional features and their lateral extent.
- Integration of all studies and Construction of geological model

Integrated G&G analysis have distinguished tide dominated delta system for Upper & Middle Bhuban Formation in Tripura Fold Belt. Depositional system, hence, comprises of tidal distributary channel, their associated levees, point bars, crevasse splay deposits, inter-distributary bays as well as extensive transgressive regime shales. Seismic interpretation and attribute analysis have helped delineate channel-associated bodies in the study area. Notably, erosional cuts at various levels are observed in the Upper Bhuban, which is atypical for the Middle Bhuban Formation (within the study area). These erosional features have eroded existing sands, complicating the assessment of the geometry of the identified geo-bodies on seismic data. The deposits that remained after these erosion phases are referred to as remnants, while the erosional cuts are later filled with episodic sands and shales during different phases of regression and transgression. The study divides the Upper and Middle Bhuban sequence into seven stages, each reflecting a distinct depositional event, with three stages attributed to the Middle Bhuban and four to the Upper Bhuban Formation. Deposition in both Upper & Middle Bhuban has initiated with a channel & associated deposition event(S1, S4), followed by erosional cut(S2, S5) & concludes with a flooding surface(S3, S7). Notably, there is an increased sand percentage in the Upper Bhuban compared to the Middle Bhuban, suggesting a higher frequency of regressive system tracts in this formation.

Prospective locales for future exploration: Through this thorough evaluation, several promising exploration areas have emerged as potential targets for hydrocarbon exploration. It has also played a crucial role in mitigating uncertainties associated with the depositional environment. By elucidating the complexities of sedimentary processes and the factors influencing reservoir characteristics, the study enhances our understanding of how geological formations behave and evolve over time. This deeper insight is vital for assessing viability of these exploration areas, as it allows for more informed decision-making regarding drilling locations, strategies to optimize exploration efforts, increasing the likelihood of successful hydrocarbon recovery in this region.

Abstract Title: Unleashing the geological wealth of Vindhyan Basin: Leveraging outcrop study and mapping as a catalyst for assessing lithology, deformation and hydrocarbon potential

Author: ***Anshul Kesharwani, Shalini Parmar***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: The Vindhyan Basin, situated in central India, presents a geological landscape of immense tectonic and economic significance. This study unveils insights derived from comprehensive geological mapping exercise around Hirapur, Madhya Pradesh, encompassing an area of 126.31 km² on Toposheet No. 54-P/3. Physiographically, hills composed of Vindhyan and Bijawar formations, along with Deccan traps, feature flat-topped mesas and buttes. The primary objective is to assess lithological, structural and stratigraphic features of region and their potential implications for petroleum system. It also highlights structural complexities and stratigraphic relationships of Vindhyan Basin, which are crucial for future exploration endeavors in this region.

The study was conducted during a 21-day field camp using a range of geological mapping techniques. The area was mapped at a scale of 1:25,000 using Toposheet No. 54-P/3. Key positioning methods included single and double bearing for triangulation, sound bearing for navigation via auditory cues and tree bearing in dense forested areas. Field techniques involved plane table surveying, prismatic compass measurements and reconnaissance surveys to gather precise geological data. Lithological features and contacts were mapped with particular attention to relationships among Bundelkhand granite, Bijawar sediments and Vindhyan quartz arenites. Structural data were collected to analyse deformation phases, including brittle and ductile faulting, folds and shear zones. Relationships among deformation, sedimentation and tectonic events were analysed to highlight potential reservoirs and source rocks.

Bundelkhand Craton underwent N-S compression around 3000–3300 Ma, leading to metamorphism and large granite intrusions. The study area reveals a complex tectonics history involving Archaean Bundelkhand granite, Paleoproterozoic Bijawar dolomites and shales, and Mesoproterozoic Vindhyan quartz-arenites. Contacts between Bundelkhand granite and Bijawar rocks show both brittle and ductile deformation, with two deformation phases identified. The first phase-D1 is marked by ductile shear zones with sinistral movement and intrafolial folds, generating mylonites and phyllonites at granite-Bijawar contacts. Shear boudins, lineations and F1 folds indicate both pure and simple shears. The second phase-D2 involves E-W compression, resulting in open folds and dextral shears that overprint D1-structures. Deformation intensifies toward Mardeora, where S- and C-planes merge into L-tectonites and dynamo-thermal metamorphism alters rock fabric. Mineralization includes phosphorite and dolomite, with active mining at Hirapur. Microscopic analyses of granite reveal coarse-grained dykes with a poikilitic texture (plagioclase lath within a pyroxene matrix). The contact zone exhibits evidence of high strain accumulation, indicating basement-cover relationship is stratigraphically and tectonically influenced. Features like rootless folds and interference of folding patterns, faults and shear zones, including Khairbaba fault, are critical for assessing hydrocarbon potential. Angular unconformities and marine transitions from Bijawar to Vindhyan sediments suggest favorable depositional environments, confirmed by shallow-marine fossils and ripples. Structural traps like Jabera dome, anticlines near Chittorgarh and Updip truncations along basin margins enhance hydrocarbon prospects.

Geological mapping around Hirapur has revealed complex interplay of rock types and structural features that provide critical insights into region's geological history, brittle-ductile deformation at Bundelkhand-Bijawar contacts with sinistral and dextral shear events. Folds, faults and stratigraphic relationships indicate sea-level fluctuations and a dynamic tectonic setting. Economic minerals like phosphorite and dolomite offer resource potential. Marine transgression in Vindhyan marked by angular unconformities and fossils. Step faults, domes and anticlines increase hydrocarbon potential while localized deformations indicate a dynamic environment. Conclusively, this mapping underscores importance of understanding structural and stratigraphic frameworks for effective exploration and resource management in Vindhyan Basin.

Abstract Title: Navigating the frontier: The role of GIOCs in empowering Indian NOCs to unlock frontier resources

Author: ***Aayushi Bhardwaj, Rajeev Lala, Mansi Anand***

Organization: S&P Global

Abstract: As India strives to enhance its energy independence, tapping into frontier resources has become increasingly critical. This paper explores the pivotal role of global international oil companies (GIOCs) in empowering Indian national oil companies (NOCs) to access and develop these challenging hydrocarbon reserves. The objective is to analyze how collaborations with GIOCs can facilitate technological advancements, improve operational efficiencies, and foster knowledge transfer, aiding Indian NOCs in overcoming the barriers associated with frontier exploration.

The study employs a qualitative methodology, focusing on learning from successful practices of global international oil companies (GIOCs) in frontier resource development. It analyzes case studies of existing partnerships, such as those between Indian national oil companies (NOCs) and prominent GIOCs like ExxonMobil, TotalEnergies, and BP. This analysis aims to identify best practices and collaborative frameworks that can enhance operational effectiveness. The research highlights the current lack of direct communication channels for collaboration between Indian NOCs and GIOCs, emphasizing the necessity for structured engagement to facilitate knowledge transfer and possible joint ventures. Additionally, data is collected from industry reports, and comparative analyses to provide insights into how Indian NOCs can effectively leverage the expertise and resources of GIOCs to maximize their potential in frontier exploration.

The findings reveal that strategic alliances with GIOCs significantly enhance the capabilities of Indian NOCs in navigating the complexities of frontier resource development. Key insights emphasize the critical importance of shared expertise and technology transfer in improving exploration success rates. Additionally, the analysis highlights the necessity of adopting best practices from GIOCs to mitigate risks associated with frontier exploration. The study concludes that leveraging partnerships with GIOCs is essential for Indian NOCs to unlock their frontier resource potential, contributing to both national energy security and economic growth. Furthermore, such collaborations can drive innovation and enhance operational efficiencies, positioning

Indian NOCs competitively in the global energy market and enabling them to better address the challenges of accessing and developing new hydrocarbon resources.

This paper underscores the critical role of GIOCs in supporting Indian NOCs in their quest for frontier resource development. By illustrating the benefits of collaboration, it emphasizes the opportunities for technological enhancement and operational efficiencies that can help Indian NOCs overcome challenges in accessing and developing new hydrocarbon resources. The insights gained can inform future strategies for partnerships and enhance India's position in the global energy landscape.

Abstract Title: Paleo-Environment and Tectonic Evolution of the Proterozoic Sequence in the Chhattisgarh Basin

Author: ***Surajit Gorain***

Organization: Directorate General of Hydrocarbons

Abstract: This study investigates the paleo-environment and tectonic evolution of the Proterozoic sequence in the Chhattisgarh Basin using seismic sequence stratigraphy. The objective is to decode depositional processes and tectonic events that controlled sedimentation through an integrated interpretation of 2D seismic data acquired under the National Seismic Program (NSP). An integrated seismic stratigraphic interpretation approach was adopted using two 2D seismic profiles traversing the Hirri and Bharadwar sub-basins. Due to the absence of deep wells, seismic events were correlated with surface lithological data and known formation boundaries. A layer-cake seismo-geological model was developed to visualize paleo-structures and depositional settings. Horizon flattening and seismic facies analysis were employed to reconstruct paleo-environmental conditions and delineate unconformity-bound sequences. The stratigraphy was classified into Singhora, Chandrapur, and Raipur groups based on reflection characteristics and depositional patterns.

The analysis reveals that the Chhattisgarh Basin evolved through a three-stage tectono-sedimentary process during the Proterozoic. The Singhora Group, the basal unit, was deposited during early rifting in a fluvio-deltaic to fan-delta setting, consisting of irregular sandstone-conglomerate bodies interbedded with shale. The Chandrapur Group was deposited during continued rifting and early marine encroachment in a storm- and tide-dominated environment, characterized by chaotic to hummocky seismic reflections. The Raipur Group, deposited during the sag phase, records a transition from shallow to deep marine carbonate-siliciclastic environments, marked by strong seismic reflections corresponding to dolomite and limestone. The absence of metamorphism and preservation of primary sedimentary features suggest rapid subsidence, likely due to high-angle faulting from the basement. The basin's current configuration reflects significant marine transgression and cratonic drowning in the late Mesoproterozoic. The seismic stratigraphy provides the first sub-surface insight into the depositional history of the basin and validates previous surface-based interpretations.

This is the first study to apply seismic sequence stratigraphy to the Chhattisgarh Basin, offering subsurface validation to previous surface-based stratigraphic models. It provides new insights into basin initiation, subsidence mechanisms, and marine transgression history, significantly enriching the geological understanding of Indian Proterozoic basins.

Abstract Title: Unlocking Frontier Basins: Government support for exploration and infrastructure - global perspective and benchmarking

Author: ***Kallol Saha, Padmanav Sahoo***

Organization: S&P Global

Abstract: The objective of this study is to explore strategies and initiatives for hydrocarbon exploration in India's frontier basins, emphasizing the importance of government support to catalyze exploration activities. Fiscal incentives, including tax holidays, royalty relief, and accelerated depreciation, can substantially increase investment attractiveness by mitigating financial and operational risks associated with exploration. Additionally, government-sponsored seismic and other geological studies and strategic policy implementations are crucial for enhancing geological understanding and promoting licensing activities. Through examples from Africa, Latin America and Asia Pacific, this study seeks to provide India with actionable insights for effective policy development, aiming to unlock frontier basins.

This research examines global best practices and case studies, focusing on fiscal incentives and seismic surveys essential for boosting hydrocarbon exploration in frontier regions. It analyzes how countries in Africa and Latin America have effectively used tailored fiscal policies to attract investments, while Asia Pacific, Latin America, and Europe offer examples where government-funded seismic surveys dramatically enhanced geological understanding, exploration activities, and confidence in licensing rounds. Additionally, there is an increasing trend in exploration license awards in Asia Pacific and Africa, which includes frontier areas. Australia's Beetaloo Basin illustrates governmental interventions optimizing exploration prospects and catalyzing economic benefits within challenging frontier environments. These methodologies provide a framework for structuring India's exploration strategies effectively, ensuring robust and sustainable development.

Our observations reveal that targeted fiscal incentives significantly enhance investment attractiveness in frontier hydrocarbon regions. Incentives like tax holidays, royalty relief, direct financial grants or subsidies, and accelerated depreciation, widely implemented in Africa, Latin America, and other regions, reduce financial and operational risks, encouraging exploration. Government-funded seismic studies are pivotal in promoting exploration, exemplified by Brazil's Santos and Campos basins, which became significant hydrocarbon provinces, and Australia's Bonaparte and Browse basins boast significant LNG facilities, supported by government-initiated surveys. Norway's ongoing license awards in the Barents Sea further underscore sustained interest in frontier exploration.

The Beetaloo Basin in Australia serves as a key example. The Beetaloo Cooperative Drilling Program, with a $50 million allocation, incentivizes exploration through a 25% refund on eligible expenditures, stimulating up to $200 million in exploration activity before June 2022. Such incentives promise significant benefits, including creating about 6,000 jobs by 2040 and economic activity from $18 billion to $37 billion. Despite challenges such as remote location, regulatory complexities, and environmental concerns, the government aims to establish a framework that balances resource development with environmental protection. With $175 million for infrastructure upgrades to support gas extraction, Beetaloo's gas resources, backed by fiscal policies, are set to boost Australia's energy security and support low carbon footprint and ultimately the transition to net zero emissions.

By adopting insights from global examples, India can construct a comprehensive exploration framework encompassing robust fiscal incentives, investment in initial surveys including seismic, and streamlined regulatory processes. Aligning domestic policy with successful global practices can unlock India's frontier hydrocarbon potential, driving economic growth and enhancing energy security. Such strategic alignments not only bolster India's exploration initiatives but also ensure a balanced approach to the economy and sustainability, fostering a conducive environment for sustained hydrocarbon development.

Abstract Title: Enhancing Frontier Basin Exploration with EM: A Case Study from Offshore Malaysia and Implications for India

Author: ***Raghava Tharimela,***

Organization: EMGS

Abstract: Electromagnetic (EM) methods, particularly Controlled-Source Electromagnetic (CSEM) and Magnetotelluric (MT) techniques, present a powerful yet underutilized tool for unlocking India's frontier basins. This abstract explores the application of EM in enhancing basin forensics and regional petroleum systems understanding, especially in data-sparse environments complimenting conventional seismic. Using a real data example from offshore Malaysia, we show how EM, an independent geophysical tool, can support advanced exploration strategies by illuminating deep subsurface structures critical for hydrocarbon discovery.

The EM data acquisition involves deploying seabed receivers in a pre-defined layout along regional 2D line. For CSEM a horizontal electric dipole (HED) source with 7000 ampere current is towed above the receivers to transmit low-frequency EM waves. These EM waves interact with the subsurface and are captured by the receivers. For MT, data is acquired passively by recording naturally occurring EM signals induced by solar-magnetic interactions. Both datasets were independently processed and inverted to generate resistivity models. CSEM provides information about the vertical and the horizontal components of subsurface resistivity, to depths of ~5000 m below mudline. And MT offers insight into deeper, large-scale features to ~15,000 m below mudline. A joint inversion of both datasets—currently in progress—aims to leverage their complementary strengths.

Results from the CSEM inversion along the southern Sarawak line reveal a transition from shallow basement structures nearshore to thicker sedimentary sections offshore. This highlights the basin's evolution and its hydrocarbon potential. Notably, resistive features interpreted as carbonate buildups were seen, with varying resistivity suggesting internal heterogeneity—an important insight for reservoir quality assessment. The data also hints at possible clastic hydrocarbon-bearing intervals in shallow intervals, which align with previously drilled discovery wells. Co-relating CSEM results with available seismic data show that the local high resistive features seen on resultant CSEM resistivity model match well with the seismic events. Two independent measurements suggesting presence of a soft event (as interpreted on seismic) and high resistivity (as seen on CSEM) increase the chances of presence of hydrocarbons tremendously.

In conclusion, EM techniques can be indispensable in identifying the right basin or block, selecting promising prospects, drilling the appropriate wells, and capitalizing on opportunities to locate the ideal reservoirs. In frontier areas they provide a wealth of information not only about the presence of saturated hydrocarbon deposits but also shed light on basement structures, source rocks, and the heat flow from the Moho, a factor that enables the formation of hydrocarbons within source kitchens.

This study highlights the applicability of EM methods as a strategic complement to seismic in frontier basin exploration. By integrating CSEM and MT data, operators can de-risk exploration in complex and underexplored settings. For India’s frontier basins, where seismic alone may fall short, EM presents a compelling approach for unlocking hidden potential and informing high-impact drilling decisions.

Abstract Title: The Hydrocarbon Potential of the East Andaman Basin, India

Author: ***David Hume, Upal Shahriar, Michael Castele***

Organization: University of Houston

Abstract: For the past two years, the University of Houston, Texas, has investigated the petroleum potential of the East Andaman Basin, India. The results indicate that the basin could trap significant gas volumes in structural closures created in its complex tectonic history.

Over 10,000 km of 2-D and 5,000 km² of 3-D seismic data in the East Andaman Basin were analyzed, and results from 20 wells were utilized to map the basin's features and outline its geological history.

Three play areas have been identified based on geophysical maps, sediment thickness, and tectonic setting: a Fore-Arc Basin, a Northern Back-Arc Basin, and a Southern Back-Arc Basin. In the Southern Back-Arc Basin, the 3-D seismic analysis highlighted the potential for a structural play – similar to the recent significant discoveries in the Indonesian Andaman Basin.

One potential Oligocene play is a three-way faulted closure in an area that is an extension of the Indonesian basin into Indian waters. A preliminary resource estimate of the structure was calculated using parameters derived from the Indonesian wells to understand the extent of the exploration potential. A volumetric estimate of over 3 TCF (85 Gm^3) was calculated for one of many structures in the area. Currently, work is being conducted to confirm the presence of a reservoir, a seal, mature source rocks, and a time-depth conversion for the seismic to define the structural closure better. The Andaman Basin, India, is one of the last frontier areas in the world to be explored. Despite this, it has the potential for vast gas accumulations, which could significantly assist India's progress and prosperity.

Compendium of Abstracts

Theme: Unlocking the Potential of Unconventional Hydrocarbons in India

Abstract Title: Green Hydrogen from Biomass: Advanced Bio-fuel Catalytic Technology

Author: ***Ritesh Mittal, Anil Kumar, Saurabh Kumar***

Organization: Engineers India Limited

Abstract: Hydrogen contributes considerably to refining industry & is utmost costly molecule requiring costly naphtha to produce via steam reforming (SR). Ligno-cellulosic-biomass (like Rice husk, Wheat straw, Sugarcane bagasse, Bamboo, Tea & Coffee Husk etc.) derived Pyrolysis bio-oil as second generation bio-fuel offers advantages over first generation bio-fuels due to sustainability without invoking food vs. fuel debate. Owing to challenges in Direct Hydrolysis of cellulose & hemi-cellulosic components of Ligno-cellulosic biomass, Bioethanol Reforming, Biomass gasification & direct use of bio-oil due to high oxygen content & viscosity, prudent focus globally is development of robust catalytic technology for bio-oil to Green Hydrogen.

For enhanced insight of this reforming technology, challenges in bio-oil reforming due to high temperatures catalyst coking are elaborated with coking minimisation analysis by coke precursor gasification and steam activation. Noble and non-noble catalysts as studied by researchers are discussed in paper. Support modifiers like magnesium, lanthanum, cobalt and chromium that enhances steam adsorption to facilitate partial oxidation/gasification of coke precursors and enhancers like cobalt and chromium that slows coking surface reactions due to cracking and de-oxygenation are elaborated. Accelerated Water Gas Shift (WGS) reaction and depressed Methanation, Boudouard & Reverse Water-Gas Shift (RWGS) as a function of catalyst is analyzed with predictions of futuristic tailored heterogeneous active catalyst formulations for the economic viability of technology.

This paper critically reviews Novel bio-oil reforming techniques including catalytic electrochemical, spouted bed, auto thermal and molecular beam mass spectrometer-interfaced reforming for Green Hydrogen production. Innovative modifications in conventional fixed and fluidized catalytic reforming reactors with modified feeding systems for overcoming challenges like bio-oil polymerization, high viscosity, poor fluidity are argued.

Study of this technology aims to establish that bio-oil reforming can be promising pathway for producing Green Hydrogen using renewable ligno-cellulosic biomass. In Comparison, Economic Feasibility overweighs Societal, Climatic and Generation costs of Blue, Grey and Pink Hydrogen. Green Hydrogen is technically emerging area globally for use of second generation bio-fuel sources. This is futuristic solution to mitigate challenges of Grey hydrogen requirement in global refining industry with in-situ integration of carbon neutral perspective of Renewable Green Hydrogen.

Abstract Title: Petrophysical characterization using NMR data to address productivity of complex lithology reservoir of Chhatral Pay of Vadatal Field

Author: ***Ketha Lakshmi Teja, Mohd. Kamran Rizvi, Sujit Kumar Biswas***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: This study investigates the heterogeneous reservoir behaviour of the Chhatral pay in Vadatal Field of Cambay Basin by integrating advanced NMR log data, core analysis, and ELAN outputs to address inconsistencies in testing results and lithological variations. It focuses on deriving realistic T2 cutoff value for accurate estimation of free and bound fluid volumes. NMR and core-derived porosity-permeability are used to refine reservoir parameters. The objective is to understand production behaviour differences through porosity-permeability relationships, rock typing and reservoir facies generation. This integrated approach aims to identify causes for productivity variations among different wells by analysing reservoir quality and character.

A comprehensive workflow was adopted integrating NMR, core and capillary pressure data to determine realistic T2 cutoff value. Factors such as high siderite presence, fine grained silty nature and authigenic clays influenced T2 relaxation. NMR logs were reprocessed using T2 cutoffs (10ms, 15ms, 20ms). A T2 cutoff of 15ms aligned best with core derived irreducible water saturation. Permeability was calibrated using adjusted Timur coates exponents. For wells without NMR, a crossplot between shale volume (VCL) & bound fluid volume (BFV) was used to generate a transform. This relationship derived from NMR calibrated wells, was applied using ELAN derived VCL to estimate BFV. With total porosity from ELAN and BFV from regression, Timur coates permeability was computed in non-NMR wells. Also, rock typing was done.

An integrated study was conducted using Petrophysical evaluation, core analysis and reservoir facies modeling to assess reservoir quality vis-à-vis production inconsistency of Chhatral pay. A petrophysical model was developed using core data and crossplot inferences, with ELAN log processing based on a mineralogical model comprising quartz, silt, siderite and mixed clays. In this field, T2 cutoff of 15ms determined with integration of NMR and core data is found to be realistic for computing free fluid volume (FFV) & bound fluid volume (BFV) unlike the standard T2 cutoff of 33ms. Permeability was computed using

the Timur-Coates model with adjusted exponents. A regression based approach between Bound fluid volume (BFV) and Volume of clay (VCL) has been adopted for estimating BFV in non-NMR wells, which in turn helped in estimating permeability. Reservoir rock types were classified into seven facies based on core porosity-permeability data and RQI vs. PHIZ crossplots. These facies reflect varying porosity and permeability levels, aiding in reservoir quality differentiation. Reservoir facies modelling combined with petrophysical evaluation aided in explaining the differences in production behaviour. Excellent to moderate facies were observed in wells near fault closures and wells located in the central and southern part of different blocks, whereas wells farther from faults especially in northern parts of different blocks exhibited moderate to poor facies.

- Adoption of a 15ms T2 cutoff over the conventional 33ms significantly improves accuracy in estimating FFV and BFV, resulting in better reservoir characterization.
- Customized Timur-Coates exponent adjustment and use of regression between BFV and VCL enable permeability prediction in wells without NMR data, reducing logging costs.
- The outputs from this study were further utilized in dynamic reservoir simulation to effectively capture heterogeneity and fluid flow behaviour.
- This comprehensive analysis facilitated field development planning by generating new development locations, which will enhance overall reservoir productivity, improve recovery efficiency, and ultimately maximize the economic value of the field.

Abstract Title: Pore Structure Evolution in Lesser Himalayan Krol Shale under Oxic Thermal Stimulation: Implication to Untapped Shale Gas Recovery

Author: ***Divyanshoo Singh, Hemant Kumar Singh***

Organization: Rajiv Gandhi Institute of Petroleum Technology

Abstract: Thermal stimulation under oxic heating has proven to be a promising method for enhancing gas recovery from tight shale reservoirs, which are typically limited by complex pore structures and low permeability. In this context, Neoproterozoic shale from the Krol Formation (Uttarakhand) was subjected to controlled combustion to optimize gas recovery. Post-treatment, pore-scale structural changes were analyzed using advanced techniques: low-pressure N_2 adsorption (LPGA-N_2) via fluid injection, small-angle X-ray scattering (SAXS) via non-injection, and field emission scanning electron microscopy (FE-SEM) for high-resolution imaging of pore evolution.

Eight rock blocks (~18" × 18" × 18") were collected—five from the exposed road cut and three from deeper sections. Initial laboratory analyses, including TOC and XRD, were conducted to confirm lithology and sample characteristics. Portions from each block were then homogenized using the coning and quartering method to produce a representative bulk sample, which was powdered to <75 µm for LPGA, SAXS, and XRD analyses. SEM analysis was performed on 5 mm-thick chip samples from each block. Combustion experiments were conducted at 25°C, 100°C, 200°C, 300°C, and 400°C, with samples held at each temperature for four hours.

- Geochemical analysis of Lesser Himalayan shale reveals gas-prone kerogen, highlighting its hydrocarbon potential and providing a foundation for studying pore structure evolution during combustion to enhance extraction efficiency.
- Combustion markedly alters surface morphology and pore characteristics. At 100 °C, inefficient thermal degradation causes pore compaction due to moisture loss. Above this temperature, thermal effects promote pore expansion and coalescence. At 400 °C, diminished contrast in photomicrographs indicates organic matter decomposition, forming abundant organic pores. SEM images and increasing fractal values reflect a progressively irregular and complex surface with rising temperature.
- Pore size distribution (PSD) in thermally treated shale offers insights into gas recovery. Micropores dominate at room temperature and 100 °C, but higher temperatures shift the distribution toward larger meso- and macropores. A sharp increase in PSD at 400 °C suggests significant pore development due to structural deformation and organic matter oxidation.
- Thermal treatment not only enlarges existing pores but also generates new ones. Initially, the pore area decreases, then increases steadily with temperature, indicating concurrent pore expansion and formation.

Despite their geological significance, Himalayan black shales remain underexplored compared to analogous formations elsewhere, mainly due to limited accessibility, compositional heterogeneity, and a lack of comprehensive data. Gaining insights into their organic content, thermal maturity, and microstructural features is crucial for assessing their potential as unconventional energy resources. In particular, understanding pore structure evolution is key to evaluating their suitability for both energy extraction and geological carbon storage.

Abstract Title: Effect of Sediment Size on Uniaxial Compressive Strength of Hydrate Bearing Sediments

Author: ***Surla Nagavenkata Satyanarayana, Dr. Deepak Amban Mishra, Dr. Himangshu Kakati***

Organization: Indian Institute of Petroleum and Energy

Abstract: This study investigates geomechanical stability of the hydrate bearing sediments during formation of hydrates. Tetrahydrafuran (THF) Hydrates, stable at atmospheric pressure, are used as lab proxies for natural hydrates. Uniaxial

Compressive Strength (UCS) was determined to evaluate strength of the hydrate bearing formation. The objective is to analyze geomechanical properties and infer geological features of Indian Offshore sediments using hydrate bearing core samples.

The experimental procedure aimed to assess the mechanical properties of hydrate bearing sediments by replicating natural hydrate formation in a laboratory setting. A hydrate forming solution was prepared using Tetrahydrafuran (THF) and distilled water in a 1:3 ratio, with 2% Sodium Dodecyl Sulfate (SDS) added to improve hdyrate stability and formation rate. Granular materials- Sand, Silt and Clay were collected, seived for uniformity and mixed in specific weight rations. These mixtures were saturated with the THF-Water-SDS solution and stored below the equilibrium temperature of hdyrate for 12-48 hours to faciliate hydrate formation. Afterward, Uniaxial Compressive Strength (UCS) tests were performed to evaluate the structural integrity of the hydrate-bearing sediments.

- The Compressive Strength of hydrate bearing sediments increases with increasing sand content with varying proportions of fines (clay,silt). The increasing sand content with decreasing fines lead to a stronger framework, reduction pore filling from pores and enhanced effective permeability. As the sand content increases, good permeability leads to an even distribution of solution (pre mixed THF-Water-SDS) in the pore spaces create evenly distribution so that strength increases.If there are more fines, the reduction in strength due to their cohesive and water retaining nature.
- Sandy clay containing THF hydrate show some typical ductile behaviour. Before hydrate formation, the mixture is highly ductille and after formation of hydrate ductile behaviour is reduced slowly as THF hydrate fills pores and increases stiffness and strength, which partially suppresses plastic deforamation so the strength is more.

The novelty of this study lies in replicating gas hydrate formation in controlled sediment mixtures using a THF-Water-SDS solution, combined with mechanical testing. By correlating sediment compositon with strength properties, the work offers valuable insights for geomechanical analysis and enhances understanding of geological features in the Indian Offshore, supporting hydrate exploration, reservoir modelling and geohazard (land subsidence, slope failure) assessment in these regions.

Abstract Title: Geomechanical Characterization of Precambrian Granite for Enhanced HDR Geothermal Energy Exploitation

Author: ***Aman Chaudhary, Hemant Kumar Singh***

Organization: Rajiv Gandhi Institute of Petroleum Technology

Abstract: To investigate the impact of high-temperature exposure and cooling methods on the physico-mechanical behavior of granite, which is relevant for Enhanced Geothermal Systems (EGS), particularly Hot Dry Rock (HDR) geothermal reservoirs.

Objective:

- To evaluate how thermal treatment (25–600 °C) combined with different cooling techniques (furnace and water quenching) affects the structural integrity, mechanical properties, and thermal damage of granite.
- To identify the temperature threshold beyond which granite's performance deteriorates significantly.

Methodology and Procedure

- Sample Collection: Precambrian Granite (equivalent to Tatapani geothermal reservoir rocks) block samples were collected from in and around the Mahoba district, Uttar Pradesh, India.
- Sample Preparation: Granite specimens were subjected to thermal treatment at various temperatures ranging from 25°C to 600°C
- Cooling Methods: After heating, samples were cooled using three distinct techniques: Furnace cooling (slow, controlled) and Water quenching (rapid, high thermal shock) 4. Testing & Analysis: Physico-mechanical properties included: Seismic wave velocity (P & S waves were measured using PL 200 ultrasonic tester (@Proceq), Brazilian tensile strength. Microscopic and macroscopic analysis was conducted to understand internal damage and crack propagation

Results

Higher thermal exposure led to increased degradation of granite's mechanical and physical properties.

Water quenching induced the most significant damage due to rapid thermal contraction and microcracking.

600°C emerged as a critical threshold: Major reductions in seismic wave velocity and tensile strength were observed beyond this point. Granite becomes considerably more fragile and fractured.

Observations, Microscopic level:

Increased crack density and grain boundary separation with rising temperature, especially after water quenching. Macroscopic level: Visible surface spalling, reduced strength, and structural instability in high-temperature, rapidly cooled samples.

Comparison of cooling methods: Furnace cooling preserved the most structural integrity. Water quenching caused rapid crack propagation and substantial weakening.

Conclusion:

Granite's integrity is highly temperature- and cooling-sensitive, especially relevant for geothermal exploitation. 600°C is a threshold temperature for granite; exceeding this accelerates structural and mechanical degradation, particularly under thermal

shock conditions. These findings have direct implications for the selection and treatment of HDR geothermal reservoir rocks and highlight the need for careful thermal stress management during energy extraction.

Potential Value

- Energy Security: Reduces reliance on coal (Chhattisgarh is coal-rich but pollution-prone).
- 24/7 Base Load: Unlike solar/wind, geothermal offers continuous power.
- Reduces fuel/energy costs for small businesses and farmers.
- Creates low-carbon economic zones around geothermal sites.
- Establishes a template for EGS across India.
- Attracts foreign and private investment in advanced geothermal.
- Builds domestic technical capacity.
- Supports India's clean energy innovation ecosystem.

Abstract Title: It's time to identify reservoir fluid type through assessment of well testing results and fluid characteristics of low permeability reservoirs to unlock potential of UHC in India

Author: K P ***Ramachandran, M Lakshmikumari, Sandeep Goswami***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: Identification of reservoir fluid type in low permeable reservoirs to determine the development strategy with improved understanding of reservoir fluid is a must in unlocking UHC potential in India. Enhancing production from unconventional reservoirs will be of immense value to the nation in our quest for import reduction and development of natural resources. Reaping rewards by hydraulic fracturing has made a rethinking on identification of reservoir fluid type especially in low permeable reservoirs

The exploration and development strategy can be supported with improved understanding of reservoir fluid type. Testing results and fluid characteristics of few low permeability reservoirs in K G Basin of India are examined in this paper by analyzing 18 wells. These will be useful as a diagnostic tool to identify reservoir fluid type. The paper highlights the need to ascertain the fluid type through hydraulic fracturing in tight reservoirs. The examined reservoirs belong to Raghavapuram, Nandigama, Gollapalli, Kanukkollu, Vadaparru formations of KG Basin.

Precise analysis of production testing results and reservoir fluid characteristics gain special significance in cases where the search for hydrocarbons by the oil& gas industry is focused on tight and unconventional reservoirs. Fluid type is not evident at the time of initial testing which cannot be decided only by the API gravity of fluid. Enhancement of production and improving the recovery of Hydrocarbons is the endeavor of Oil & Gas industry. E&P companies are under thorough exploration and production campaigns for finding new discoveries and enhancement in production which require more judicious data analysis of the already available data. Identifying subsurface fluid type is the key for establishing exploration and exploitation strategy especially in tight reservoirs. Many reservoirs in various parts of the basin produce feeble gas because of low permeability and produced gas is mostly associated gas liberating from oil and assuming them as free gas reservoirs is incorrect.

The paper discusses the probability of many low permeable reservoirs where in the reservoir fluid could be oil which can add revenue to the company and more resources to the energy basket of India. This would be the case for many such reservoirs in the context of energy quest for our country.

Abstract Title: CO_2 Storage and CH_4 Recovery Potential in Shale Formations: A Simulation Study

Author: ***Harsh Deo Choubey***

Organization: IIT(ISM), Dhanbad

Abstract: This study aims to evaluate the feasibility of CO_2 sequestration in shale gas reservoirs using advanced simulation techniques. The objective is to assess storage efficiency, gas recovery, and the impact of physical flow mechanisms such as adsorption, diffusion, and pressure-sensitive permeability in nanoporous shale media.

The simulation is conducted using CMG-GEM, a compositional reservoir simulator capable of modeling multicomponent gas transport. A 3D fractured shale model is built incorporating Langmuir and BET isotherms for CH_4 and CO_2 adsorption respectively. Apparent permeability effects—capturing slip flow and Knudsen diffusion—are integrated into the model. A dual-porosity system represents matrix-fracture interactions, and a 30-year schedule is applied, including both production and CO_2 injection phases. Comparisons are made between Darcy and apparent permeability cases to analyze their influence on CH_4 recovery, CO_2 migration, and reservoir pressure behavior over time.

The simulation results show that shale gas reservoirs can retain up to 99% of injected CO_2 over a 30-year period, highlighting their potential for long-term geological storage. CO_2 exhibits a higher adsorption affinity than methane, making it effective at displacing CH_4 from the matrix. However, CO_2 injection alone does not significantly increase methane recovery unless fracture conductivity is high. Interestingly, CH_4 production was found to be slightly higher in the no-injection case due to enhanced

apparent permeability at lower pressures. In contrast, the CO_2 injection case caused pressure buildup, which suppressed slip flow and reduced effective gas mobility. The study also demonstrates that apparent permeability evolves dynamically and has a significant impact on flow behavior in ultra-tight formations. Darcy-only models underestimated both injectivity and production potential. CMG-GEM effectively captured key physical processes, including multicomponent sorption, diffusion, and dual-continuum flow. These findings underline the importance of using pressure-sensitive flow models in unconventional reservoirs and show that CO_2 sequestration in shale can be both environmentally and technically beneficial under the right conditions.

This abstract adds value by incorporating slip flow and Knudsen diffusion into a field-scale simulation, which is often neglected in conventional modeling. It also highlights a realistic perspective that CO_2 injection may not always enhance recovery without proper fracture connectivity. The methodology sets a precedent for integrating advanced adsorption and flow mechanisms to improve the accuracy of shale gas and CO_2 storage modeling..

Abstract Title: Discrete Fracture Network (DFN) Analysis & Modelling of the Basement Reservoir in Ingoli Field, Cambay Basin, India

Author: ***Narsaiah Rapolu, Niral Patel, Subhasis Dut***

Organization: Gujarat State Petroleum Corporation Limited

Abstract: Deccan Basalt Basement reservoirs hosted in Paleocene/Cretaceous rocks exhibit low matrix porosity/permeability, connected through fracture networks which is primary conduit for fluid flow &HC accumulation. A key methodology for characterizing fracture systems is Discrete Fracture Network (DFN) Modeling & Analysis. Ingoli Field is one such classic example in Cambay Basin in which production is from basement reservoir. Following HC discovery in 2004, it was rapidly developed and commenced production in a record timeframe by September 2005. Unlike Gamij & Padra Fields which are near the eastern margin of Cambay Basin, Ingoli situated near the western margin of Cambay Basin.

DFN models integrate various data such as interpreted seismic surfaces, faults, fractures from bore hole image logs, core studies, seismic attributes, 1D geomechanical models and production data. Outcrop analogs from nearby regions also help in defining fracture statistics such as orientation sets and length distributions. A typical DFN workflow involves stochastic simulation of fractures using statistical distributions that are constrained by observed geological data. These models are then up scaled to generate equivalent continuum representations for reservoir simulation or retained in their discrete form for high-resolution modeling.

Various data is transferred into description of Fracture Intensity which can be populated into 3D geological framework model and final goal is to find 3D gridded properties such as permeability & porosity for fractures. Depending on the analysis of fracture data, multiple sets of fractures can be identified. The fracture model built from initial intensity description, needs to be populated in the 3D grid stochastically or deterministically guided by seismic attributes such as ant tracking, SoM & distance from faults etc., Upscaling properties based on DFN model will generate second set of properties of permeability, porosity & sigma-factor which describes the connectivity. Sigma factor is essential in connecting duplicate cells in a simulator describing the matrix and fracture porosities and permeability. The above methodology was used to prepare DFN model of Ingoli field in which a limited area (<2 Sq.Km.) is covered by producers with modelling area 14 sq.km. Previous fault fracture network studies delineated two clear fault trends in Ingoli area, one in NNW-SSE & another in NE-SW to ENE-WSW directions which are used in DFN modelling. Fracture Intensity map from DFN modelling and SoM attribute map which is derivative of fault fracture network studies shows similarity in terms of distribution and variation of fracture network overall trends distribution

DFN modeling is crucial due to heterogeneous nature of basaltic rocks, which have undergone multiple tectonic events leading to extensive brittle deformation. In most unconventional reservoir cases, DFN modeling is devised for placement of development wells and stimulation planning by predicting zones of high fracture density and connectivity. It also aids in understanding production anomalies, such as early water breakthrough or uneven depletion, which are often tied to fracture network characteristics. In conclusion, the application of DFN modeling in Ingoli's fractured basement reservoirs has significantly improved understanding of fracture-controlled flow systems which are used for placement of development wells

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Abstract Title: Hybridized CO_2 Capture, Utilization and Storage System for Reservoir Stimulation

Author: ***G L Manjunath***

Organization: TechXEarthSpace Private Limited

Abstract: The objective of this initiative is to deploy a hybridized CO_2 Capture, Utilization, and Storage (Hy-CCUS) system (developed by TechXEarthSpace) that enables in-situ reservoir stimulation using dual-phase fracturing agents—liquid CO_2 and nitrogen (N_2). The system aims to stimulate various unconventional and geothermal reservoirs such as Coal Bed Methane (CBM), gas hydrates, tight sandstone, shale, and geothermal formations. By combining atmospheric and industrial CO_2 capture with direct reservoir injection, this approach supports both emission mitigation and enhanced energy recovery, aligning with global climate and energy security objectives.

The Hy-CCUS system integrates a liquid-phase chemical absorption unit for capturing CO_2 from air and flue gas, using novel formulations that amplify capture intensity via non-linear wave mechanics. Captured CO_2 is liquefied on-site and utilized as a fracturing fluid, either alone or in combination with cryogenic N_2. These agents are injected into selected reservoir formations under controlled conditions to induce fractures and enhance permeability. Reservoirs like CBM, gas hydrates, shale, and tight sandstone are targeted based on lithological properties, temperature, and in-situ pressure. Extensive simulations,

geomechanical analysis, and field validations guide optimal fracturing design, ensuring reservoir integrity and efficient gas recovery while facilitating long-term CO_2 storage.

Initial lab-scale simulations and pilot studies indicate that dual-agent fracturing using liquid CO_2 and N_2 can significantly improve permeability and gas flow in low-permeability formations. For CBM reservoirs, CO_2 enhances methane desorption while simultaneously being sequestered, offering a carbon-negative recovery method. In gas hydrate and shale reservoirs, thermal shock from cryogenic N_2 and pressure-driven fracturing from CO_2 improve fracture complexity and reservoir connectivity. Tight sandstone and geothermal reservoirs benefit from enhanced crack propagation and fluid flow without chemical contamination associated with conventional fluids. Additionally, the Hy-CCUS system reduces environmental impact by avoiding water usage, a critical advantage in water-stressed regions. CO_2 retention studies show promising long-term storage potential in these geologic formations, with over 80% of the injected CO_2 remaining sequestered after simulated reservoir cycling. Observations confirm that the system can be modular, scalable, and deployed in remote field conditions with limited infrastructure. Field-scale validation is currently in progress with industry and academic partners. The hybridized process thus demonstrates a transformative solution for integrating carbon mitigation with energy access in a sustainable and economically viable manner.

The Hy-CCUS system offers a groundbreaking dual benefit: mitigating atmospheric CO_2 while enhancing energy extraction from unconventional and geothermal reservoirs. It provides a low-water, low-footprint alternative to hydraulic fracturing, with greater control and reduced environmental risk. By converting captured CO_2 into an active resource, the system transforms a liability into a strategic asset. This innovation supports industries in transitioning to cleaner operations while unlocking previously uneconomical energy reserves, creating a powerful synergy between decarbonization and energy security goals.

Abstract Title: A Strategic Framework for Geothermal Energy Expansion in India: Multi-Regional Pathways for Sustainable and Commercial Utilization.

Author: ***Roopesh C P Saxena***

Organization: Directorate General of Hydrocarbons

Abstract: This study aims to explore India's untapped geothermal potential by proposing a distributed framework for sustainable energy development in key regions. It focuses on deploying Enhanced Geothermal Systems, direct-use applications, and policy-driven Public Private Partnership(PPP) to promote clean energy, reduce fossil fuel dependence, and support India's zero-emission goals by 2070.

This study adopts a multi-pronged approach to develop India's geothermal potential, focusing on six key sites including Puga Valley, Tattapani, and Manikaran. It proposes the use of Enhanced Geothermal Systems (EGS) and binary cycle power plants for medium-temperature zones. Direct-use applications such as agriculture and tourism are integrated for regional upliftment. Sustainable reservoir management through reinjection ensures long-term stability. The strategy includes streamlined policies, public-private partnerships, and alignment with India's National Action Plan on Climate Change. Adapted global best practices are tailored to India's geology and economy, forming a viable roadmap towards clean energy and employment generation.

The study identifies immense untapped geothermal potential in India, with over 300 hot springs across regions like Puga Valley, Tattapani, and Manikaran. Despite global geothermal output surpassing 15 GW, India significantly lags behind. Through a distributed model combining Enhanced Geothermal Systems (EGS), binary cycle technologies, and direct-use applications, the research demonstrates a practical path for commercialization in medium-temperature zones. Observations highlight that reinjection techniques and reservoir management are crucial for long-term sustainability. Policy support, public-private partnerships, and alignment with NAPCC goals are essential enablers. The findings conclude that adopting this tailored framework can reduce fossil fuel dependence, create employment, and accelerate industrial decarbonization. Geothermal energy, if harnessed strategically, can become a cornerstone of India's transition to a net-zero emission economy by 2070.

Harnessing geothermal energy from India's 300+ hot springs can significantly reduce fossil fuel reliance, generate employment, and support rural economies. By implementing Enhanced Geothermal Systems and direct-use applications, the country can advance clean industries, align with climate goals, and unlock a sustainable, underutilized energy source tailored to regional needs.

Abstract Title: Multiscale Characterization of Cleats in Permian Coals of Sohagpur Coalfield: Insights from Microscopic to Field-Scale Observations.

Author: ***Alok K. Singh, Kaushal Kishore, Manish Kumar Srivastava***

Organization: Rajiv Gandhi Institute of Petroleum Technology

Abstract: The study investigates the role of cleats in the generation, migration, and extraction of Coal Bed Methane (CBM) at the Sohagpur coalfield in central India. The coalfield is an important site for CBM exploration and production. The primary objective is to analyze the cleat systems in Sohagpur coals at both macroscopic and microscopic scales to understand their contribution to coal seam permeability, which is crucial for gas migration and CBM extraction.

The study employs a combination of macroscopic and microscopic techniques to analyze cleat systems in the Sohagpur coalfield. A macroscopic analysis was conducted on hand specimens to assess the orientation and characteristics of the cleats. On a microscopic scale, petrographic microscopy and scanning electron microscopy (SEM) were used to examine the

cleat networks at a scale up to 100 µm. These methods enabled a detailed assessment of both face and butt cleats and their distinct sub-patterns, providing a comprehensive understanding of the cleat systems.

The results revealed the presence of both face and butt cleats, with face cleats exhibiting a dominant irregular reticular sub-pattern. These patterns are significant because they form high-permeability pathways that are essential for methane migration and accumulation within the coal seam. Additionally, the analysis indicated that tectonic forces have played a role in the formation and orientation of cleats, contributing to the permeability of the coal seam. Based on the tectonic classification of Indian coals, Sohagpur coals fall under the Blocky subclass, characterized by highly permeable cleat structures. The findings highlight the importance of these cleat systems in facilitating CBM flow and further demonstrate the potential of Sohagpur for enhanced CBM production due to the presence of highly permeable face cleats.

The study offers significant value to CBM exploration and production in the Sohagpur coalfield by providing a detailed understanding of the cleat systems, which are critical for gas flow within coal seams. The identification of highly permeable face cleats with irregular reticular patterns offers valuable insights into the coalfield's potential for efficient methane generation, migration, and extraction.

Abstract Title: Technical Challenges and Scope of Gas Hydrate Energy in India

Author: ***Sunil Prashar***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: India, with its growing energy demands and strategic focus on sustainable development, has turned its attention to unconventional energy resources. One of the most promising among them is gas hydrates—crystalline compounds composed of natural gas, primarily methane, trapped within water ice lattices under high pressure and low temperature. Found extensively in offshore regions such as the Krishna-Godavari Basin, Mahanadi Basin, and Andaman Sea, gas hydrates present a potential game-changer for India's energy security. Objective of this study is to analyze the technical challenges associated with the exploration and production of gas hydrates and to assess their long-term energy potential.

The study aims to evaluate methodologies employed globally and domestically for gas hydrate extraction and identify pathways for technological advancement. The study undertakes a multidisciplinary approach, combining geological, geophysical, and engineering perspectives. It involves the review of existing data from the National Gas Hydrate Program (NGHP), particularly NGHP-01 and NGHP-02 expeditions, which provided crucial insights into the extent and characterization of hydrate-bearing sediments in Indian waters. Comparative analysis with international pilot production tests, such as those in Japan, Canada, and the U.S., is conducted to benchmark technological readiness. The methodology includes reservoir modeling, stability analysis, and simulation of extraction techniques like depressurization, thermal stimulation, and inhibitor injection. Special focus is placed on environmental risk assessment and potential impacts on seabed stability and methane leakage.

Exploratory campaigns under NGHP have confirmed the presence of high-saturation gas hydrate deposits, especially in the Krishna-Godavari basin, with hydrate concentrations exceeding 60% in some sediment cores. However, extracting methane economically and safely remains a significant technical hurdle. Challenges include the deepwater offshore location, complex geomechanical behavior of hydrate-bearing sediments, and absence of commercially viable extraction technologies adapted to Indian geological settings. Thermal stimulation methods, though effective in lab-scale trials, face scalability and energy input issues. Depressurization remains the most promising method but requires robust wellbore integrity and long-term monitoring systems. Moreover, real-time monitoring of gas migration and potential environmental impacts is still underdeveloped in India. Hydrate dissociation can induce sediment destabilization and submarine landslides, further complicating offshore extraction efforts. Harnessing gas hydrates could substantially alter India's energy mix by providing a clean and abundant source of methane, with estimated reserves capable of meeting the country's gas needs for decades. Success in this field would enhance energy security, reduce dependence on LNG imports, and support the transition to a lower-carbon economy. The development of indigenous technologies tailored to India's unique geological and climatic conditions would also contribute to scientific innovation and capacity building.

A successful hydrate program can position India as a global leader in methane hydrate research and deep-sea energy resource management. Integration with carbon capture and storage (CCS) and hybrid extraction techniques (e.g., CO_2-CH_4 exchange) could further improve environmental sustainability and open avenues for carbon-negative energy solutions. In conclusion, while gas hydrates offer immense potential for India's energy future, realizing this potential demands concerted efforts in R&D, infrastructure development, environmental safeguarding, and international collaboration. Addressing the technical challenges through sustained investment and innovation will be crucial in unlocking this vast, yet untapped, energy resource.

Abstract Title: Innovative Strategies and Key Considerations for Developing a Multi-layered Low Permeability Porcellanite Oil Reservoir: A Case Study of ABH Field, India.

Author: ***Ranjeet Singh, Prashant Agarwal, Manish Dutt Kothiyal***

Organization: Cairn Oil & Gas, Vedanta Ltd.

Abstract: Development of multi-layered tight oil reservoirs has been challenging due to relatively lower per-well oil recovery and higher per-barrel costs. Significant uncertainty exists in predicting the long-term productivity of the wells. Therefore, a

robust understanding of reservoir quality, geomechanical properties and the selection of optimal well designs is crucial. This paper showcases innovative approaches and strategies adopted in the development of one such low-permeability porcellanite oil reservoir.

The Aishwariya Barmer Hill (ABH) is a low-permeability (~1 md), and high-porosity (average 25%) oil reservoir located in the Barmer Basin, India. This field is characterized by multiple reservoir layers and fault blocks and developed with ~60 horizontal wells, ranging in total length up to 2800 mMD (lateral lengths up to 1300m) and employing 10-18 stages of hydraulic fracturing. A seven-well appraisal campaign was executed utilizing regional understanding, fluid and reservoir properties. Various well types (vertical/horizontal, longitudinal/transverse, open hole/cased hole), hydraulic fracturing strategies (swell packer with sleeves/plug and perf) and artificial lift compatibilities (jet pumps/rod pumps) were tested. Fluid sampling and coring were conducted. Geomechanical tests were performed on the core, and a 1D geomechanical model was prepared incorporating image logs and microseismic data.

Information acquired during the appraisal campaign, such as in-situ stress direction, natural fracture density, and stress contrast, aided in determining well density and orientation. Horizontal wells proved to be three times more productive compared to vertical wells. Production logging in horizontal wells established contributions from the long horizontal section, aiding in determining the optimal length of the horizontal section for subsequent wells. Insights gained from the appraisal campaign were crucial in conceptualizing the first full-field development campaign comprising 39 wells (37 horizontal and 2 deviated). Wells were proactively geo-steered into the targeted reservoir, and frac sleeves were used for coil tubing-assisted precise hydraulic fracturing, offering flexibility for reservoir management purposes. Production behaviour of these 39 wells contributed to further refinement of field understanding concerning hydraulic fracture design, region-wise PVT understanding and modification of artificial lift design. A water flood pilot was also conducted to assess future water flood potential.

The field reached to a peak oil production of 10,000 bopd with approximately 17 mmstb of oil already recovered till Mar-2025. Leveraging lessons learned from the previous campaign, two additional infill campaigns of five and fourteen wells have been undertaken and a third campaign involving water flooding is under planning. This paper elucidates the key considerations and various steps taken during the five-plus years of development journey and its outcomes. The insights gained from the ABH development can be utilized to delineate the impact of various parameters on field performance and can facilitate the fast-track development of similar reservoirs.

Abstract Title: Unlocking Shale Potential: Causal Inference for Induced Seismicity and Fracture Management.

Author: ***Prof. Siddharth Misra***

Organization: Texas A&M University.

Abstract: Unlocking the full potential of unconventional shale reservoirs requires a deep understanding of fluid injection effects, fracture propagation, and their link to seismic activity. Relying solely on statistical correlations overlooks confounding factors. This study aims to apply cutting-edge causal inference techniques, including Double Machine Learning and knowledge-driven approaches, to quantify the causal relationships between subsurface operations (water disposal/hydraulic fracturing) and induced seismicity, as well as to uncover causal signatures of fracture propagation from microseismic and waveform data. The objective is to provide robust, causality-based insights for safer and more optimized unconventional shale development.

The research employs various causal inference techniques. Double Machine Learning (DML) was applied to regional Oklahoma data spanning 7 years to estimate the average treatment effect (ATE) quantifying causality between active water disposal/hydraulic fracturing wells and induced earthquakes ($>$M2). Causal inference techniques were also used on microseismic data from Marcellus Shale hydraulic fracturing to quantify causal links between prior and new microseismic events. A knowledge-driven causal inference model analyzing waveform attributes from simulated fracture propagation was developed to identify causal signatures independent of confounding factors.. DML analysis revealed distinct causal impacts: 2 active water-disposal wells over 56 days caused 1 earthquake ($>$M2) within 4,400 sq. km, while 3 hydraulic fracturing wells over 106 days caused 1 earthquake within a smaller 200 sq. km area. No causal effect on earthquake magnitude was detected. Microseismic causal inference showed a new event's magnitude is independent of prior event concentration, and active/high-magnitude regions produce new events sooner. Waveform analysis identified attributes (reoccurrence count, sum, variation coefficient) as causal signatures of fracture propagation, demonstrating that causation and correlation can differ significantly, highlighting the need for causal analysis.

Quantifying causal relationships and identifying causal signatures provides critical insights for unlocking unconventional shale potential. Understanding the true impact of injection operations enables better mitigation strategies for induced seismicity risks. Causal insights into microseismic events and fracture propagation improve fracture monitoring accuracy and design optimization. Moving beyond correlation with knowledge-driven causal AI allows for more reliable prediction and early warning systems, leading to safer, more efficient, and ultimately more productive development of unconventional shale resources.

Abstract Title: Machine Learning for Rapid Production Forecasting in Shale Reservoirs.

Author: ***Prof. Siddharth Misra***

Organization: Texas A&M University

Abstract: Production forecasting is crucial for effective field development and reservoir management. This paper presents a

novel machine-learning-assisted method designed for rapid production forecasting in hydraulically fractured shale wells within large, heterogeneous reservoirs. The primary objective is to develop a workflow combining massive geomodel compression and neural network regression to accurately predict five-year condensate and gas production rates significantly faster than conventional methods. The study also aims to explore methods, like using early-time production history and transfer learning, to reduce the data requirements for building accurate forecasting models.

The core approach involves a two-step machine learning workflow. First, large, heterogeneous shale geomodels (up to 88,200 cells) undergo massive compression (18,000 times) to a low-dimensional representation. Second, a neural network uses this compressed representation along with completions, production, and other parameters to predict five-year gas and condensate rates. The models were trained and tested on datasets of up to 3000 distinct reservoir realizations. The impact of incorporating early-time production history (2-6 months) and applying transfer learning to mitigate limited training data availability (20-1000 realizations) was also investigated.

The rapid production forecasting method achieved high accuracy, with Mean Absolute Percentage Error (MAPE) typically below 3-5% on testing and holdout datasets for both gas and condensate rates. The workflow reduced the computation time for a 5-year forecast per realization to approximately 0.0003 seconds, representing a six-order-of-magnitude speed-up compared to traditional simulators (1037 seconds). Including early-time production history significantly improved accuracy and allowed for over 50% reduction in required training realizations or elimination of 6 hard-to-get input features while maintaining low error (below 5-9%). Transfer learning proved beneficial for improving accuracy when trained on small datasets (less than ~500 realizations).

This machine learning workflow offers a distinctive approach overcoming the limitations of conventional forecasting methods by providing unparalleled speed and high accuracy. The ability to drastically reduce computational time and mitigate the need for massive datasets through the use of early production history and transfer learning makes the models more practical and cost-effective. This enables rapid scenario analysis, enhances reservoir management decisions, and optimizes field development in complex unconventional reservoirs.

Abstract Title: Gas Production Potential Assessment of Individual Coal Seams in CBM Reservoirs Using Dual Packer Formation Testing and Production Log Operations .

Author: ***David Hume***

Organization: Oil and Natural Gas Corporation Ltd..

Abstract: This study addresses challenges in Coal Bed Methane (CBM) wells through advanced logging techniques to characterize seam-specific flow potential and develop data-driven completion strategies. Commingled flow from multiple coal seams creates significant challenges in determining well deliverability, under-saturation degree, mobile water saturation, desorption pressure, and dewatering patterns.

Our methodology combined normalized flowing bottomhole pressure measurements with optical fluid analyzers to determine in-situ desorption pressure. Multi-rate testing with regular pressure build-ups enabled estimation of coal-seam diffusivity, deliverability, and gas production potential. Initial pressure estimation validated the relative depletion observed in production logs, which provided insights into seam-specific production, dewatering efficiency, and hydraulic fracture performance.

We developed a workflow integrating three key logging techniques during early well life: Acoustic Imaging, Dual packer formation testing, and Production profiling. Testing was conducted across six seams with varying thickness, pressure, and mobility properties. Continuous BHP recording at variable flow rates with optical spectroscopy data facilitated evaluation of each seam's production potential and depletion state.

Results demonstrate that continuous liquid level monitoring and optimized artificial lift placement significantly enhanced dewatering rates and activated non-contributing intervals. This comprehensive characterization approach provided unprecedented insights into reservoir parameters, drainage patterns, and effective dewatering zones, contributing to more efficient field development planning and resource optimization.

Abstract Title: Integrated Fracture Activation and CO_2 Injection Modeling for Enhanced CBM Recovery and Site Characterization in the East Bokaro Basin.

Author: ***Abir Banerjee***

Organization: Oil and Natural Gas Corporation Ltd.

Abstract: This study aims to evaluate the impact of CO_2 injection on fracture activation in coalbed methane (CBM) reservoirs and develop a methodology for identifying suitable sites for Enhanced CBM (ECBM) recovery and CO_2 sequestration. The objective is to quantify 1D geomechanical model, permeability changes, evaluate critically-stressed fractures, and integrate logging-based and trend-analysis techniques to support safe, effective CO_2 injection to achieve a net-zero carbon footprint.

The study integrates two complementary workflows. The first models fracture activation using resistivity image logs, sonic data, and Mohr-Coulomb failure criteria to determine fracture slip potential under CO_2 injection scenarios. Adsorption/desorption lab data and core analysis support permeability reduction estimation. The second workflow focuses on field-scale site characterization using trend analysis of CO_2-producing wells, time-lag evaluation for gas break, isotopic analysis, and advanced well logging techniques to distinguish between free and desorbed CO_2. Combined, these methods

provide a robust framework for identifying high-potential ECBM zones and optimizing injection strategies.

The fracture activation model reveals that injection-induced pressure changes can bring pre-existing fractures to a critically stressed state, including in lower permeability coal seams. Mohr-Coulomb analysis confirms that certain fractures transition to slip-prone conditions, enhancing permeability post-injection. It is observed that out of 84 identified fractures, 28 transit into critical state post-injection and permeability change of 17-27%. Adsorption modeling estimates show significant CO_2 uptake, supporting both ECBM and CO_2 sequestration goals. Production data of CO_2-producing wells near GCS facilities shows that CO_2 release ranges from 0.63-18.7 % and time lags before gas breakthrough range from 7 days to 15 months. Isotopic signatures were analyzed to distinguish between free and desorbed CO2. The insights of fracture network, structural seam mapping, thickness, desorption behaviour, and critical depth analysis for supercritical CO2 injection enable us to determine the target seam and suitable site for injection well. Overall, integrated results from both modeling and field diagnostics help shortlist zones most suitable for pilot injection tests in the East Bokaro CBM reservoir. The study reinforces the dual benefit of CO_2 storage and ECBM, offering a path toward environmentally responsible gas production.

This paper presents a novel integration of fracture activation modeling with field-based site screening for ECBM and CO_2 sequestration. By combining log-based 1D-geomechanical mechanical modeling, isotopic analysis, production data, structural analysis, desorption behaviour and CO_2 trend monitoring, it introduces a unified framework for identifying technically and geomechanical feasible injection sites in East Bokaro CBM reservoirs — a first-of-its-kind application in the Damodar basin.

Abstract Title: Shale Plays: How can the lessons learned in North America be applied to India?.

Author: ***Rajendra Kumar Kanojia,***

Organization: Hume Energy Enterprises

Abstract: There are four stages in developing shale plays. Management: Data oversight and

- Scoping: Evaluating a basin to determine if you have an unconventional play
- Prospecting: identifying play fairways and drilling locations.
- Development: Horizontal drilling and fracking.
- Optimizing production

Aside from the U.S., Canada, and Argentina, few countries have advanced in unconventional resource development beyond the second or third stage. The scoping phase relies on existing data from legacy oil and gas wells and seismic information. In India, basins such as Cambay, Gondwana, KG, Cauvery, Indo-Gangetic, and Assam show promise, and companies have secured blocks for prospecting.

Prospecting is significantly more costly. Lessons from North America could assist India in shortening its learning curve. Each unconventional play includes up to eight geological features that determine economic viability. A play may lack one feature but succeed if other aspects are strong. The main challenge lies in identifying the right combination of factors. Failures in prospecting often stem from insufficient scientific methods in data collection, highlighting the need to apply North American knowledge in India. The eight geological features are:

- The reservoirs are near or within thermally mature, organically rich source rocks.
- The plays typically fall within the dry gas, liquid-rich gas, and light oil fairways.
- Reservoirs are typically over-pressured and often situated in “Basin-Centered” settings.
- Due to the tightness of the reservoirs, they must be thick.
- Many unconventional plays display natural fractures and microfractures.
- Although tight, porosity is necessary. In mudstones, this is often organic porosity.
- The rocks must be frackable, and frac barriers must be in place.
- The most effective plays often occur in areas of minimal principal stress.

Collecting this data primarily relies on vertical “science” wells and advanced core analysis techniques, including Micro-CT scans, high-frequency NMR, and pyrolysis. Comprehensive log suites, such as quad combo and image logs, are also crucial. Mini-fracs in vertical wells provide insights into reservoir pressures and rock mechanics. Petroleum hydrogeology supports predicting pressure systems and fluid types, while seismic methods aid in interpreting data between wells. Although expensive, gathering extensive data during the prospecting stage facilitates a smoother transition to the development and production stages. If executed correctly, these analyses can create a reservoir quality index to compare local opportunities with successful projects elsewhere.

Shale reservoirs present significant potential for new oil and gas reserves in India. They can support India’s transition to a lower-carbon economy if developed efficiently and sustainably.

Abstract Title: Literature survey on Feasibility of integrating CBM extraction with Underground Coal Gasification .

Author: ***Gargee Bhattacharjee, R Praveen, Deepalakshmi S***

Organization: Oil and Natural Gas Corporation Ltd..

Abstract: To study and analyze the feasibility of integrating Underground Coal Gasification and CBM extraction, challenges, advantages, disadvantages and possible impact on environment.

The paper is based on literature survey of various papers available on related topics, Govt rules and regulations, a proper analysis of all the available data against existing scenario (mainly focused on Indian context) and draw inference towards the intended goal

Integration of UCG and CBM- Way forward:

- Resource sharing: Possibility of using of the CBM wells later for UCG should be looked into, along with other surface facilities such as compressors, pipelines etc.
- Information sharing: The reservoir data required for both CBM extraction and underground coal gasification is almost similar. So data gathered during exploration stage of one, can be shared with the other. This will reduce the exploration cost to a great extent and also cut down the uncertainties.
- Downstream industry sharing: There can be a common industry in the downstream for utilization of these gases which will help in creating a better economic viability.
- Infrastructure sharing: There is scope of investigation if the infrastructure developed for CBM extraction, such as production wells, pipelines, compressors etc can be later used in gasification process.
- CO2 Sequestration: CO2 generated during UCG can be used for enhanced coal bed methane recovery if it is present within economic range. The seams neither amenable to mining nor UCG may be evaluated and accessed for CO2-geosequestration.
- Integrated Govt policy: Government may consider forming common policy including both methane extraction and gasification, setting proper guidelines, time lines, zone identification, sharing of technology, information and downstream market etc. Proper policies will reduce operator conflict and more players will get interested in investing.

The integration of CBM and UCG technologies has the potential for enhancing energy production from coal while addressing environmental concerns associated with fossil fuel extraction. By combining the strengths of both methods, it is possible to create a more sustainable energy landscape that capitalizes on existing coal resources efficiently. The integration of Coal Bed Methane and Underground Coal Gasification represents a promising approach to harnessing energy from coal resources, particularly in regions where conventional mining is not feasible.

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