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SPECIAL FOCUS: UPSTREAM PRACTICES

From data to discovery: AI-assisted identification of missed-pay opportunities

Mature basins can contain overlooked hydrocarbons where prospectivity indicators are scattered across wells, seismic surveys and historical interpretations. As operators manage decades of legacy data, AI may help extract more value, since it can be impractical for geoscientists to evaluate such broad datasets through traditional workflows. The following Norwegian Continental Shelf demonstration and Byrding case study show how an integrated, AI-assisted workflow can connect these fragmented datasets, identify potential missed-pay intervals, and support geological validation.

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INTRODUCTION: HIDDEN OPPORTUNITIES IN MATURE BASINS

In mature basins, valuable hydrocarbon accumulations are not always missed because of a lack of data. Increasingly, these opportunities are missed, because relevant evidence is spread across thousands of wells, seismic surveys, geological interpretations, technical reports and historical studies that are rarely evaluated together. The energy industry has accumulated extraordinary subsurface knowledge and legacy datasets, yet much of that knowledge remains fragmented across systems, disciplines and generations of interpretation, making important connections harder to see.

This creates a practical problem for operators, potentially delaying the identification of hydrocarbon-bearing intervals. Geoscientists may spend significant time locating well data, reconciling inconsistent well-log curves, reviewing legacy interpretations and deciding which interpretation should be trusted before they can begin evaluating an opportunity. Intervals that appear marginal in one dataset may become compelling when tied to regional context, nearby reservoir behavior or seismic-scale evidence. Conversely, an apparent anomaly may lose significance when viewed within the broader subsurface context.

Overlooked hydrocarbon-bearing intervals, known as missed pay, present both a petrophysical challenge and an integration challenge. Reservoir zones may be bypassed, because they were evaluated with limited information, screened using earlier workflows, or interpreted before the relevant geological context was available. Missed opportunities are particularly important to identify in mature basins, where existing infrastructure can reduce development cost and shorten the path from technical recognition to production impact.

Artificial intelligence (AI) and machine learning offer new ways to reevaluate missed pay intervals. Beyond isolated predictive models, the greatest value comes when these technologies are embedded in integrated subsurface workflows that combine well data, seismic information, geological interpretation and expert review. AI can then help identify patterns and prioritize potential opportunities, while geoscientists remain essential for judging whether those patterns are meaningful. Figure 1 summarizes this integrated data-to-insight approach.

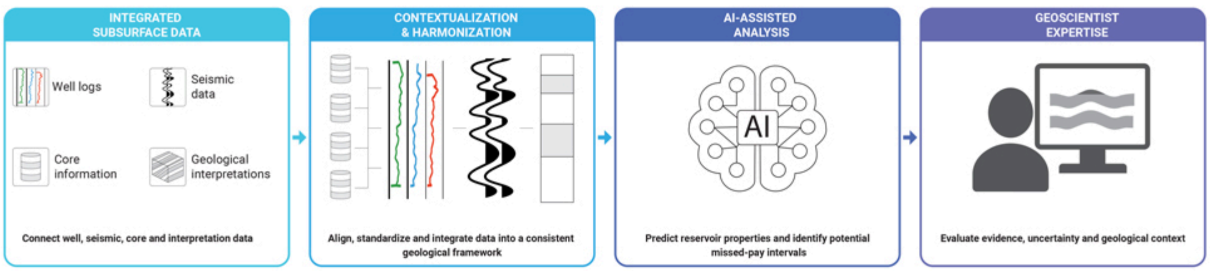

Fig. 1. Integrated workflow connecting subsurface data, contextualization and harmonization, AI-assisted analysis and geoscientist review for missed-pay identification.

WHY INTEGRATED SUBSURFACE DATA MATTERS

Subsurface evaluation has traditionally been organized around discipline-specific workflows. Petrophysicists focus on well logs, geologists interpret depositional systems, geophysicists analyze seismic volumes, and reservoir engineers evaluate production behavior. Each discipline produces valuable insight, but opportunities can be missed when these insights remain disconnected.

The disconnect deepens as assets mature. Many fields and basins contain decades of legacy subsurface data, including well penetrations, historical seismic surveys, core descriptions, laboratory measurements, stratigraphic markers, production histories and regional studies. Well logs provide high-resolution vertical information but limited spatial coverage. Seismic surveys reveal regional context but with indirect measurements of rock and fluid properties. Core data provide high-confidence rock information but only over limited intervals. Each source captures only one part of the geological story.

Connecting these sources into a comprehensive interpretation of the subsurface can help operators screen opportunities more efficiently, focus specialist effort on the most promising intervals and extract more value from existing data and infrastructure. However, data availability alone is not enough. The key is transforming disparate evidence into a decision-support framework that can evaluate large numbers of possible intervals, identify repeatable patterns and focus expert interpretation on the most promising opportunities. This is where AI-assisted workflows can support more subsurface intelligence: combining subsurface data, geological expertise and advanced analytics to support better decisions.

AI-ASSISTED WORKFLOW FOR MISSED-PAY IDENTIFICATION

The presented AI-assisted workflow converts existing subsurface information into a ranked set of potential missed-pay opportunities for expert geological review. It begins by consolidating legacy data and checking log curve names, units, depth references, stratigraphic markers and data sources. This provides a technical foundation that directly supports the reliability of subsequent interpretations. For example, inconsistencies between depth references, units or log-curve naming conventions can lead to reservoir intervals being positioned or interpreted incorrectly if left unresolved.

Once the data have been consolidated, machine learning models can predict properties linked to reservoir quality and hydrocarbon potential, including lithology, porosity, water saturation, shale volume, missing log curves and hydrocarbon-pay indicators. These predictions are most useful when evaluated together, rather than as isolated model outputs.

Potential missed-pay intervals can then be ranked, using multiple lines of evidence, including predicted reservoir quality, fluid response, stratigraphic position, nearby geological analogs, seismic context and prediction uncertainty. The supporting source data, model context and review history should remain associated with each interval, so that the ranking logic can be inspected, challenged and updated. A ranked AI prediction is not, by itself, a validated opportunity. Confidence depends on retaining the connection between the model's prediction and its supporting evidence, including the source data, model context, uncertainty, stratigraphic position and geological review. This prevents a model output or ranking score from automatically being treated as a subsurface decision.

Human-in-the-loop validation remains essential throughout the process. Expert review determines whether a model prediction is geologically plausible. More reliable decisions can then be made about whether an identified interval should be advanced, deprioritized or investigated through additional data and interpretation. Recording that judgment, together with the main uncertainty and supporting evidence, makes the result more useful for later technical and investment review.

NORWEGIAN CONTINENTAL SHELF DEMONSTRATION

This AI-assisted workflow was demonstrated using publicly available Norwegian Continental Shelf (NCS) data. The NCS is well suited to this type of study, because it combines extensive high-quality subsurface data with a long exploration and development history. It is also a mature hydrocarbon province where operators continue to seek additional value from existing offshore infrastructure and previously evaluated assets.

The aim was to investigate whether an integrated AI-assisted workflow could identify intervals that merit renewed geological attention. Integrating public well data, stratigraphic information, well results and regional geological context into a single evaluation framework allowed relationships to be identified across a broader population of wells and reservoir intervals, rather than one well at a time.

The study dataset shown in Fig. 2 comprises 2,205 wells distributed across the Barents Sea, Norwegian Sea and northern and southern North Sea. The workflow first expanded the usable well dataset through missing-log prediction, which involved estimating missing well-log curves. It then predicted reservoir-related properties including lithology, effective porosity, water saturation and associated hydrocarbon-pay indicators. Outputs supported systematic screening of Norwegian exploration wells, using reservoir quality, thickness, continuity and prediction uncertainty.

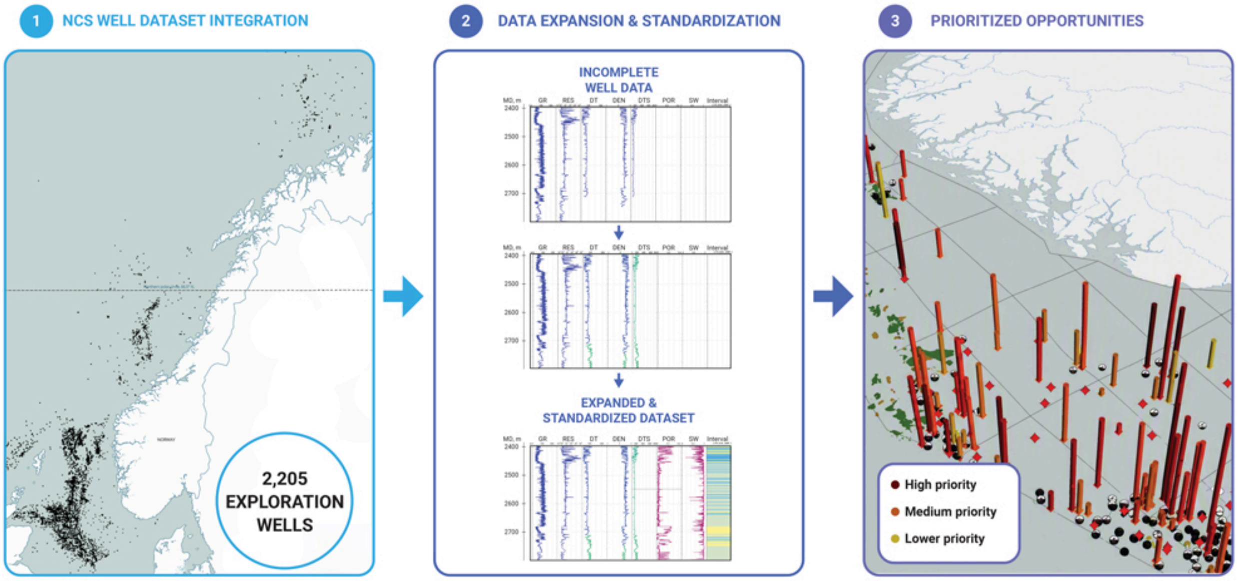

Fig. 2. Data expansion, petrophysical property prediction and opportunity prioritization across Norwegian exploration wells. The study dataset comprises 2,205 wells across the Barents Sea, Norwegian Sea and northern and southern North Sea. The EarthNET AI Wells workflow predicts missing log curves and reservoir-related properties through evaluated intervals.

Basin-scale screening generated a ranked set of potential missed-pay intervals with similar characteristics to known hydrocarbon-bearing reservoirs. Some intervals had received limited attention in historical interpretation, while others highlighted opportunities where existing evidence supported an alternative geological view. The value of the workflow lay not only in the predictions themselves, but in its ability to show geoscientists where focused review could add the most value.

BYRDING CASE STUDY: FROM WELL PREDICTION TO GEOLOGICAL UNDERSTANDING

The Byrding case study illustrates how the AI-assisted prediction of geological properties from well logs can be integrated with seismic data and geological interpretation to support the evaluation of overlooked reservoir opportunities.

In well 35/11-13, the AI-assisted workflow reproduced the known hydrocarbon-bearing Intra-Heather sandstone interval. It also identified additional Intra-Draupne sandstone intervals that appeared relatively thin in the well, but with favorable predicted reservoir and fluid properties. Geologists interpreted the well results, using seismic-scale structural and stratigraphic interpretation, assessing continuity, reservoir distribution and geological plausibility beyond the well itself.

Geoscientists then used seismic-property prediction to analyze the potential distribution of lithology, porosity and water saturation away from the well. The combined well and seismic analysis provided a more complete understanding of the opportunity than either dataset could independently. The combined analysis suggested that the Intra-Draupne interval could be thicker and more laterally extensive than indicated by the discovery well alone.

Development drilling supported the predicted Intra-Draupne pay interval, encountering an approximately 20-m oil-filled Intra-Draupne sandstone, revealing the interval's significance. This example shows how AI-assisted prediction, when integrated with seismic interpretation and geological review, can help to focus attention on intervals that warrant further evaluation and improve understanding of subsurface opportunities. The progression from well-scale prediction through seismic interpretation and drilling-supported validation is illustrated in Fig. 3.

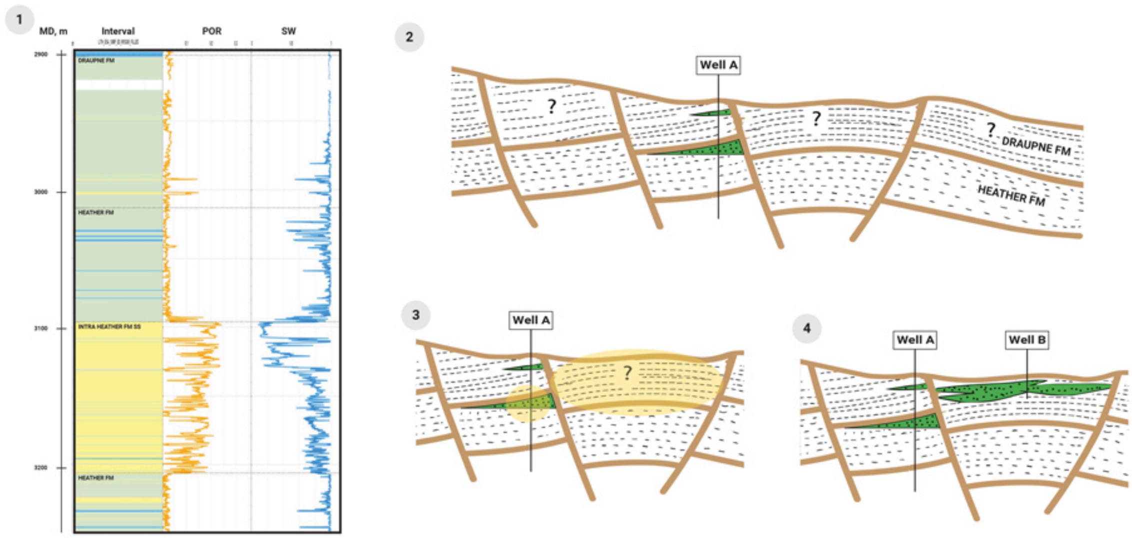

Fig. 3. Exploration case study: (1) Property predictions in Well A reproduced the established hydrocarbon-bearing Intra-Heather sandstone interval and highlighted additional Intra-Draupne sandstones for evaluation. (2, 3) Geological interpretation and property prediction from seismic indicated that the Intra-Draupne interval could extend beyond the discovery well and increase in thickness laterally. (4) Subsequent drilling (Well B) encountered an approximately 20-m oil-filled Intra-Draupne sandstone.

LESSONS FOR MATURE BASINS

The NCS demonstration and Byrding case study highlight several practical lessons for operators working in mature basins. Overlooked opportunities may still exist within datasets that have already been collected and interpreted. The key challenge is the difficulty of integrating evidence from wells, seismic surveys and historical interpretations into a comprehensive geological framework.

AI-assisted workflows can help geoscientists evaluate substantially larger volumes of information than would be practical through manual review alone. By screening, ranking and characterizing candidate intervals, these workflows can help geoscientists prioritize them for detailed investigation.

Greater value is achieved when well-scale observations are integrated with seismic and geological context. In the Byrding example, thin sandstone intervals identified in the discovery well gained significance, only when evaluated within a broader structural and stratigraphic framework.

Overall, successful application of AI-assisted workflows depends on expert interpretation. AI can identify patterns and relationships within large datasets, but geological understanding remains essential for assessing reservoir quality, trap integrity, charge risk and development potential. The role of AI is, therefore, to support decision-making, not replace it.

CONCLUSION: FROM DATA ABUNDANCE TO DISCOVERY

Mature basins can still contain overlooked opportunities within subsurface data that have long been collected, interpreted and archived. Integrated AI-assisted workflows provide a practical means of revisiting that evidence, identifying candidate intervals and directing geoscientists toward possible pay zones that merit further investigation.

The Norwegian Continental Shelf and Byrding examples show how well-log prediction, seismic-property prediction and geological interpretation can be combined through AI-assisted workflows to improve understanding of remaining exploration potential. In the Byrding case, thin sandstone intervals identified in the discovery well were subsequently evaluated within their broader geological framework, supporting the interpretation of a more extensive hydrocarbon accumulation than indicated by the discovery well alone.

As mature basins enter a new phase of value creation, opportunity lies in extracting more insight from readily available knowledge. AI-assisted workflows enable geoscientists to reevaluate basin-scale datasets, identify overlooked patterns and prioritize candidates for further review. Yet, the most valuable outcomes remain grounded in geological understanding. Predictions gain significance only when supported by evidence, tested against geological reality and evaluated within their broader subsurface context.

The future is not about autonomous exploration or replacing geologists' expertise. It must involve an effective partnership between AI and geoscientists, combining computational scale with expert judgment to accelerate the identification, validation and maturation of commercially meaningful opportunities, especially in mature basins that have a wealth of pre-existing data. **WO**

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