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# Artificial General Intelligence (AGI) Applications and Prospect in Oil and Gas Reservoir Development

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**Abstract:** The cornerstone of the global economy, oil and gas reservoir development, faces numerous challenges such as resource depletion, operational inefficiencies, safety concerns, and environmental impacts. In recent years, the integration of artificial intelligence (AI), particularly artificial general intelligence (AGI), has gained significant attention for its potential to address these challenges. This review explores the current state of AGI applications in the oil and gas sector, focusing on key areas such as data analysis, optimized decision and knowledge management, etc. AGIs, leveraging vast datasets and advanced retrieval-augmented generation (RAG) capabilities, have demonstrated remarkable success in automating data-driven decision-making processes, enhancing predictive analytics, and optimizing operational workflows. In exploration, AGIs assist in interpreting seismic data and geophysical surveys, providing insights into subsurface reservoirs with higher accuracy. During production, AGIs enable real-time analysis of operational data, predicting equipment failures, optimizing drilling parameters, and increasing production efficiency. Despite the promising applications, several challenges remain, including data quality, model interpretability, and the need for high-performance computing resources. This paper also discusses the future prospects of AGI in oil and gas reservoir development, highlighting the potential for multi-modal AI systems, which combine textual, numerical, and visual data to further enhance decision-making processes. In conclusion, AGIs have the potential to revolutionize oil and gas reservoir development by driving automation, enhancing operational efficiency, and improving safety. However, overcoming existing technical and organizational challenges will be essential for realizing the full potential of AI in this sector.

**Keywords:** large language models; artificial intelligence; oil and gas reservoir development

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## 1. Introduction

Oil and gas reservoir development plays a pivotal role in powering the global economy, contributing significantly to energy production, transportation, and industrial processes [1]. However, the sector faces increasing pressures driven by resource depletion, volatile market conditions, stringent environmental regulations, and the demand for greater efficiency and safety. Traditional methods of exploration, production, and maintenance are becoming insufficient in addressing the rising complexity and scale of operations. To meet these challenges, the industry has begun embracing technological advancements, with artificial intelligence (AI) emerging as a transformative force [2–11].

Among the various AI technologies, artificial general intelligences (AGIs) have gained remarkable attention due to their powerful capabilities in processing vast amounts of unstructured data, extracting meaningful patterns, and enabling advanced decision-making [12,13]. AGIs, primarily designed for natural language processing (NLP), have demonstrated their potential in automating processes, enhancing predictive capabilities and driving intelligent decision-making in multiple sectors, including healthcare, finance, and retail [14,15]. In the context of oil and gas reservoir development, the application of AGI offers a compelling avenue to address long-standing challenges such as inefficiencies in data interpretation, predictive maintenance, optimization of production processes, and environmental safety [16–18].

This review aims to explore the current applications of AGIs in the oil and gas sector, focusing on their deployment across various stages of the industry's operations. The paper provides an in-depth examination of the capabilities and challenges associated with the integration of AGIs in exploration and production optimization. Moreover, it discusses the future potential of AGIs to transform the industry and highlights areas where research and development could further enhance their effectiveness.

### *1.1. Oil and Gas Reservoir Development: Challenges and Technological Demands*

Oil and gas reservoir development is characterized by its high capital investment, complex infrastructure, and operational risks. Exploration, drilling, extraction, transportation, refining, and distribution processes all require sophisticated technologies and expert knowledge to ensure efficiency, safety, and sustainability. Despite the significant advances made in the past few decades, several challenges continue to hinder the sector's progress:

1. Resource depletion: As conventional reserves are exhausted, the industry is increasingly turning to more complex and costly unconventional resources such as shale, deepwater, and Arctic oil. Extracting these resources demands higher technical expertise and more advanced technologies;
2. Operational inefficiency: The oil and gas sector faces substantial inefficiencies, with significant energy waste, equipment failure rates, and lengthy downtime. Traditional methods of monitoring and optimizing production often result in suboptimal performance and high operational costs;
3. Safety and risk management: Oil and gas operations are inherently risky, with potential for catastrophic accidents such as oil spills, equipment failures, and explosions. The sector requires advanced risk assessment and safety management tools to mitigate these hazards;
4. Environmental concerns: With growing global concern about climate change and sustainability, oil and gas reservoir development faces increased scrutiny. Regulatory compliance, reducing carbon emissions, and managing environmental impacts have become central to industry operations;
5. These challenges present an urgent need for innovation, particularly in the areas of data processing, predictive maintenance, operational optimization, and risk management. Artificial intelligence, and more specifically AGI, has the potential to address these issues through its ability to process large volumes of complex data and generate actionable insights in real time.

### *1.2. Artificial Intelligence and AGI*

Artificial intelligence encompasses a broad range of technologies aimed at simulating human intelligence, such as machine learning (ML), deep learning (DL), and natural language processing (NLP). Machine learning algorithms enable computers to learn from data

without being explicitly programmed, making them highly effective in solving complex problems where traditional algorithms may fail [19–24].

AGIs are a subclass of machine learning models designed to understand, generate, and analyze human language. These models, which include architectures such as OpenAI's GPT-3, Google's BERT, and others, have revolutionized natural language processing tasks such as text generation, translation, summarization, sentiment analysis, and question answering. The most notable feature of AGIs is their ability to handle massive amounts of unstructured textual data and extract meaningful patterns and insights, which makes them highly applicable in industries like healthcare, finance, law, and energy [25–29].

In the context of oil and gas reservoir development, AGIs can be employed in a variety of ways to process unstructured textual data (e.g., reports, maintenance logs, seismic readings, and social media posts) and generate predictive models, improve decision-making, and optimize workflows. These models' ability to analyze text-based and numerical data, coupled with their potential for real-time learning and adaptation, makes them a powerful tool for transforming the industry [30–32].

### *1.3. Current Applications of AGI in Oil and Gas Reservoir Development*

Oil and gas reservoir development generates enormous volumes of data through sensors, instruments, and digital records across its operations. Much of these data are unstructured, consisting of text-heavy documents such as drilling reports, maintenance logs, safety records, and regulatory filings. Extracting actionable insights from these data can be time-consuming and prone to human error. AGIs offer a promising solution by processing and analyzing such data in a way that enhances operational decision-making [26,33–40].

1. Exploration and geophysics: Exploration is the first and perhaps most critical stage in the oil and gas value chain. Traditional exploration methods, such as seismic surveys and geological modeling, often generate large volumes of data that require expert interpretation. AGIs can assist in this domain by automating the interpretation of geophysical reports, seismic data, and geological surveys, providing insights that would take human experts significantly longer to analyze. Additionally, AGIs can be used to predict the potential location of new oil and gas reserves by identifying patterns in historical exploration data [37,41–43];
2. Production optimization and maintenance: Once an oil or gas field is operational, the focus shifts to optimizing production and ensuring the efficiency of the extraction process. AGIs can assist in the analysis of real-time sensor data, predicting potential equipment failures, and recommending corrective actions. They can process vast amounts of operational data to identify patterns that indicate potential inefficiencies or risks, such as machinery wear, pressure fluctuations, or irregular temperature readings. By providing predictive maintenance capabilities, AGIs can significantly reduce downtime, extend the lifespan of critical equipment, and increase overall production efficiency [44–48];
3. Refining and distribution: In the refining process, oil and gas companies face the challenge of managing complex chemical processes to maximize yields and reduce costs. AGIs can be deployed to analyze process data, predict the outcome of refining operations, and optimize production schedules. By automating real-time decision-making, AGIs can help refineries improve product quality and reduce energy consumption. Additionally, AGIs can aid in optimizing supply chains by predicting demand fluctuations and adjusting distribution schedules to minimize operational costs [49–51].

While the potential applications of AGIs in oil and gas reservoir development are vast, several challenges remain in their implementation. The effectiveness of AGIs depends on the quality and comprehensiveness of the data trained on. In the oil and gas sector, data

may be incomplete, inconsistent, or noisy, which can hinder model performance. One of the concerns with AGIs is their lack of transparency and interpretability [52]. In safety-critical industries like oil and gas, decision-makers need to understand how models arrive at their conclusions to trust their recommendations. Training and deploying large-scale AI models requires significant computational resources, which may be cost-prohibitive for many oil and gas companies. Many oil and gas companies rely on legacy systems that may not be compatible with advanced AI models. The integration of AGI with these systems requires significant investment in infrastructure and training [53].

Despite these challenges, the future of AGI in oil and gas reservoir development looks promising. As the industry continues to generate more data and the capabilities of AI models improve, the potential for AGI to drive efficiencies, enhance safety, and optimize operations will only grow. Future research should focus on improving model interpretability, reducing computational requirements, and developing industry-specific solutions that integrate seamlessly with existing systems. On 4 November 2024, Abu Dhabi National Oil Company (ADNOC), the UAE oil giant, announced the launch of ENERGYai at the 2024 Abu Dhabi Oil Show (ADIPEC), which is the world's first oilfield large model product that integrates AGI and proxy artificial intelligence. Then, the Kunlun Large Model, led by China National Petroleum Corporation, was officially released on 28 November 2024. Jianghan Oilfield Research Institute has developed the logging interpretation software MicRange based on the domestic large-scale model DeepSeek, which utilizes convolutional neural network (CNN) and natural language processing (NLP) techniques to achieve rapid inversion and evaluation of reservoir parameters such as lithology and physical properties. This technology has been applied in major blocks such as Red Star and Fuxing, which can reduce costs by more than 30% and increase efficiency by nearly 60%.

In conclusion, AGIs represent a transformative technology for oil and gas reservoir development. The application of AGIs in oil and gas field development is gradually shifting from exploration to large-scale implementation, which covers multiple aspects such as exploration, production optimization, equipment management, and safety monitoring, significantly improving efficiency, safety, and economic benefits. By automating complex tasks, enhancing predictive capabilities, and optimizing workflows, AGIs have the potential to revolutionize how the sector operates, leading to greater efficiency, safety, and environmental sustainability. As the technology matures, the integration of AGI into the oil and gas value chain will become increasingly indispensable.

## 2. The Current Status and Key Technologies of AGI

### *2.1. Current Status of AGI*

AGI refers to a deep learning model trained on a large amount of textual data, which enables the model to generate natural language text or understand the meaning of language text. These models can provide in-depth knowledge and language production on various topics by training on large datasets. The core idea is to learn the patterns and structures of natural language through large-scale unsupervised training, to some extent simulating human language cognition and generation processes. AGIs adopt a Transformer architecture and pre-training objectives similar to the small model, with the main difference being the increase in model size, training data, and computing resources. AGIs can not only perform simple language tasks such as spell checking and grammar correction but also handle complex tasks such as text summarization, machine translation, sentiment analysis, dialogue generation, and content recommendation. By pre-training on large-scale datasets, AGIs have gained powerful general modeling and generalization abilities.

In 2020, OpenAI released GPT-3, which was a groundbreaking event that marked the true emergence of AGI in the field of natural language processing, officially ushering in

the era of AGI. Afterwards, global high-tech companies and research institutions began to develop their own AGIs. Currently, the most successful research and application of AGIs is in the United States and China. The latest global ranking of AGIs on Chatbot Arena shows that Grok 3 scored 1402 points, becoming the first model to break through 1400 points, surpassing GPT-4o and DeepSeek-R1, as shown in Tables 1 and 2.

**Table 1.** Global AGI models ranking (20 February 2025).

| Model | Arena Elo | Coding | Vision | Arena Hard | MMLU | Votes | Organization | License |
|---|---|---|---|---|---|---|---|---|
| chocolate (early Grok 3) | 1402 | 1399 | | | | 7829 | xAI | Proprietary |
| Gemini-2.0-Flash-Thinking-Exp-01-21 | 1385 | 1368 | 1280 | | | 13,336 | Google | Proprietary |
| Gemini-2.0-Pro-Exp-02-05 | 1379 | 1372 | 1252 | | | 11,197 | Google | Proprietary |
| ChatGPT-4o-latest (29 January 2025) | 1377 | 1360 | 1276 | | | 10,529 | OpenAI | Proprietary |
| DeepSeek-R1 | 1361 | 1362 | | | | 5079 | DeepSeek | MIT |
| Gemini-2.0-Flash-001 | 1356 | 1353 | 1243 | | | 9092 | Google | Proprietary |
| ChatGPT-o1-2024-12-17 | 1353 | 1363 | | 90.4 | | 15,437 | OpenAI | Proprietary |
| Qwen2.5-Max | 1332 | 1335 | | | | 7370 | Alibaba | Proprietary |
| DeepSeek-V3 | 1317 | 1317 | | | | 17,717 | DeepSeek | Proprietary |
| Qwen2.5-Plus-0125 | 1313 | 1316 | | | | 3682 | Alibaba | Proprietary |
| Gemini-2.0-Flash-Lite-Preview-02-05 | 1310 | 1322 | 1153 | | | 8465 | Google | Proprietary |
| GLM-4-Plus-0111 | 1308 | 1291 | | | | 4171 | Zhipu | Proprietary |

**Table 2.** Strengths and weaknesses of AGI models.

| Model | Strengths | Weaknesses |
|---|---|---|
| chocolate (early Grok 3) | Creative outputs, rapid prototyping | Limited multimodal support, unstable API |
| Gemini-2.0-Flash-Thinking-Exp-01-21 | Fast response time, cost-effective | Limited context retention, basic reasoning |
| Gemini-2.0-Pro-Exp-02-05 | High accuracy, strong reasoning | Slower inference, higher resource usage |
| ChatGPT-4o-latest (29 January 2025) | Multimodal integration, updated training | High computational cost, licensing fees |
| DeepSeek-R1 | Strong math/logic focus, open-source | Weak multilingual support, niche use cases |
| Gemini-2.0-Flash-001 | Low latency, scalable for simple tasks | Struggles with ambiguity, shallow outputs |
| ChatGPT-o1-2024-12-17 | Stable API, conversational fluency | Outdated knowledge, lacks newer features |
| Qwen2.5-Max | Robust for complex tasks, large context | High inference cost, slow for real time |
| DeepSeek-V3 | Optimized for code/STEM, fine-tuned | Limited creativity, rigid responses |
| Qwen2.5-Plus-0125 | Balanced performance, API-friendly | Moderate accuracy in niche domains |
| Gemini-2.0-Flash-Lite-Preview-02-05 | Lightweight, mobile-friendly | Minimal customization, low-depth analysis |
| GLM-4-Plus-0111 | Strong Chinese NLP, affordable | Limited non-Chinese support, fewer tools |

### *2.2. Transformer Model Architecture*

The Transformer model architecture is widely used in various natural language processing (NLP) tasks and has revolutionized the field of deep learning. It was introduced in the paper "Attention Is All You Need" by Vaswani et al. (2017) [54]. The Transformer model is a neural network that learns context and meaning by tracking relationships in sequential data, such as the words in this sentence. The Transformer model architecture uses the self-attention structure instead of the commonly used RNN network structure in NLP tasks. The self-attention mechanism is crucial because it allows each token to interact with every other token in the sequence, capturing long-range dependencies effectively. Compared to RNN network structures, the biggest advantage is the ability for parallel computing. The model can be scaled up to handle large datasets, which is why it has become the backbone of AGI. The transformer model architecture diagram is shown in Figure 1.

Its core structure consists of an encoder–decoder stack, where each layer in the encoder employs multi-head self-attention to capture global dependencies between input tokens and a position-wise feed-forward network for nonlinear transformations. The decoder similarly layers self-attention with masked attention to prevent future token visibility during autoregressive generation. Key theoretical innovations include scaled dot-product attention, which weights token interactions via query-key similarity while mitigating

gradient issues through scaling, and positional encoding, which injects sequential order information using sinusoidal or learned embeddings. By eliminating sequential recurrence, Transformers enable parallel computation and efficient training on long sequences. The architecture's modularity, combined with residual connections and layer normalization, optimizes gradient flow and stabilizes deep networks, forming the foundation for modern large language models.

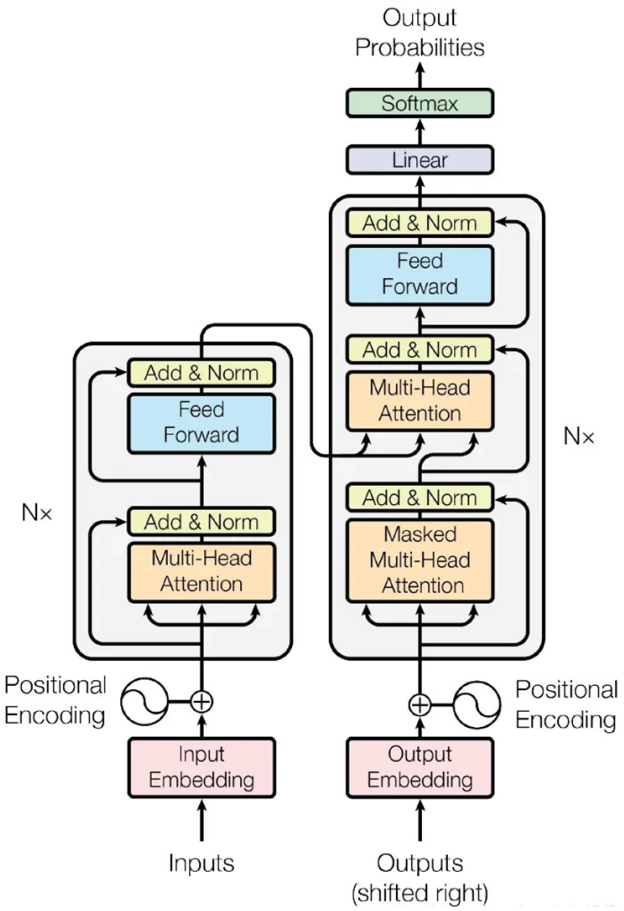



**Figure 1.** The Transformer model architecture diagram.

Nowadays, almost all cutting-edge AGI products and models adopt Transformer architecture, such as GPT-4, DeepSeek, LLaMA, Gemini, Claude, and others. As well as the underlying technologies of text to speech, automatic speech recognition, image generation, and text-to-video models are also based on Transformer.

### *2.3. Retrieval-Augmented Generation (RAG)*

RAG is one of the popular cutting-edge technologies for AGI at present. The RAG model combines language models and information retrieval techniques. Specifically, when the model needs to generate text or answer questions, it first retrieves relevant information from a large collection of documents, and then uses this retrieved information to guide text generation, thereby improving the quality and accuracy of predictions. RAG is a model that combines retrieval and generation techniques. It generates answers or content by referencing information from external knowledge bases, with strong interpretability and customization capabilities, suitable for multiple natural language processing tasks such as question answering systems, document generation, and intelligent assistants. The advantages of the RAG model lie in its strong universality, the ability to achieve real-time knowledge updates, and the provision of more efficient and accurate information

services through end-to-end evaluation methods. The general RAG workflow is as shown in Figure 2.

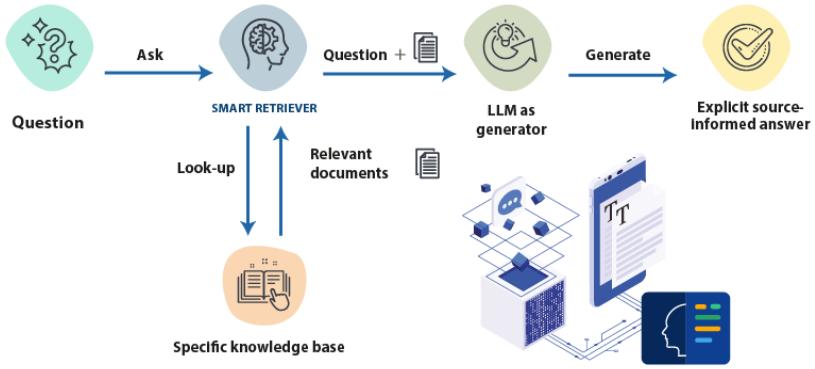



**Figure 2.** General RAG workflow.

However, human knowledge in complex formats like tables, figures, audio, video, and more limit LLMs' reach. A total of 80% of enterprise data are in difficult-to-use formats for AGI integration. In addition, unstructured data ingestion is a critical bottleneck for production-grade RAG workflows. In this background, technicians have constructed a new RAG model to solve complex data through process optimization and technological updates. The improved RAG process is as shown in Figure 3.

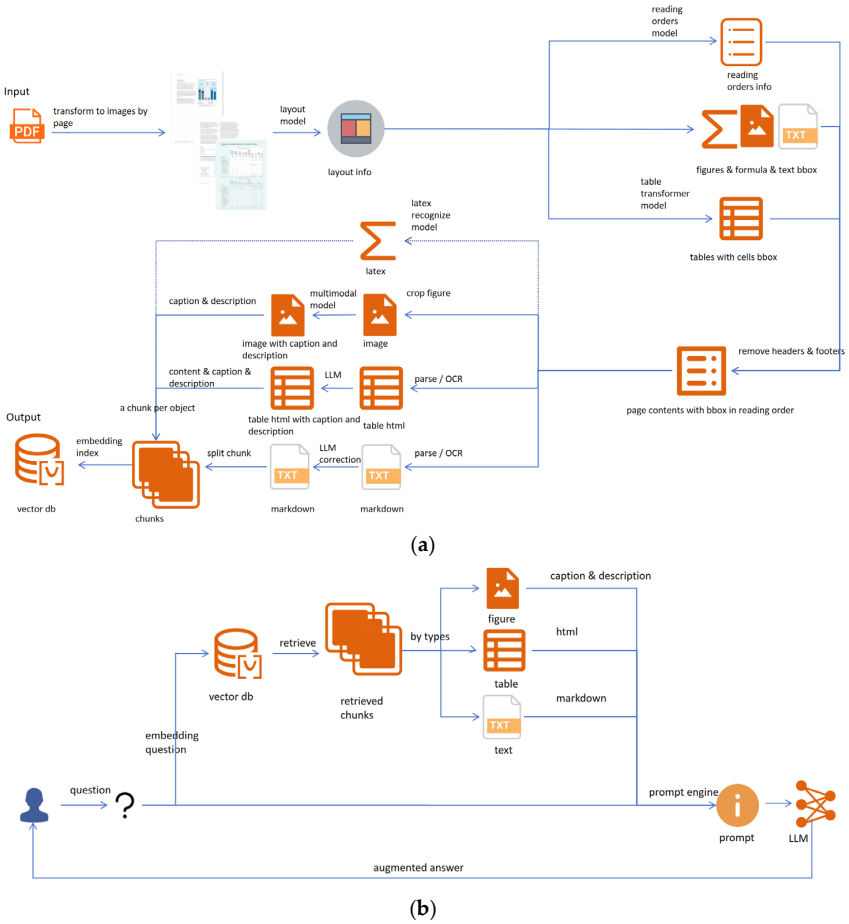



**Figure 3.** Improved RAG process. (**a**) Data processing workflow, (**b**) RAG workflow.

## 3. Applications of AGI in Oil and Gas Reservoir Development

Oil and gas reservoir development has a long chain, wide business scope, and strong professionalism. Compared to traditional fields, oil and gas reservoir development has shown some peculiarities in the development of industrial AGI. Firstly, the data sources in the oil and gas industry are highly heterogeneous, with data links involving exploration, development, production, storage, transportation, and sales, as well as encompassing multiple fields such as geology, geophysics, drilling engineering, and production dynamics, such as seismic waveforms, logging curves, core analysis, and equipment sensor data, with significant format differences. The data range from real-time drilling data at the second level to geological historical data at the hundredth level, with a spatial span from micro-pore structure to regional reservoir distribution. Traditional data processing techniques cannot meet the needs of data governance, and AGI can achieve rapid fusion and integration of multi-source and multimodal data. Secondly, professional knowledge is intensive, and oil and gas reservoir development have strong specialization, involving multiple disciplines such as geology, reservoir engineering, and chemical engineering. Traditional data analysis and task scheduling methods cannot meet the needs of large-scale, multi-scenario data mining. AGI achieves rapid analysis and application of complex scenarios in the oil and gas industry by integrating its powerful semantic recognition, knowledge summarization, knowledge mining, and integrated scheduling with professional knowledge. Based on the powerful functions of AGI and the characteristics of oil and gas reservoir development, this paper introduces several typical applications and achievements of AGI technology in oil and gas reservoir development.

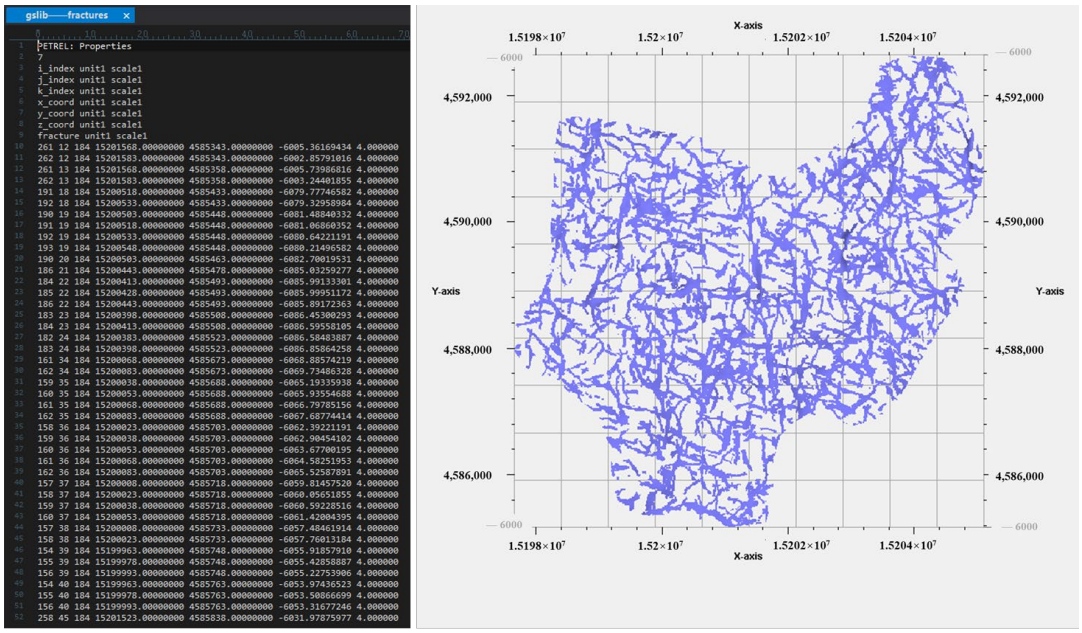
### *3.1. Data Analysis and Interpretation*

**Seismic data analysis:** Seismic data are crucial for exploring oil and gas reservoirs. AGI can be used to enhance the interpretation of seismic data by identifying subtle patterns and correlations that may not be evident through traditional analysis methods. For example, we can analyze the vast amount of seismic data to predict the location and quality of potential reservoirs, helping companies make more informed decisions about where to drill. This can lead to more accurate subsurface models and better-informed exploration decisions, reducing the risk of dry wells and increasing the success rate of exploration activities. As shown in Figure 4, we are able to quickly analyze and interpret seismic data of reservoir fractures in a certain block based on AGI.

To demonstrate AGI's advantages over conventional seismic interpretation methods—including coherence-based fracture detection, wavelet transform analysis, and physics-driven inversion—we conducted comparative experiments under standardized workflows. AGI achieved 60%−faster interpretation speeds than manual feature engineering approaches while maintaining >90% alignment with expert evaluations in fracture identification. Its multi-scale attention mechanisms enabled superior detection of micro-fractures, validated through downhole imaging with statistically stronger correlations than traditional techniques. AGI also exhibited 20−25% greater robustness in high-noise environments compared to conventional methods and uncovered previously undocumented fracture-orientation relationships, later confirmed by field stress analysis. These results underscore AGI's capacity to overcome the hypothesis-driven constraints and labor-intensive workflows of traditional approaches, particularly in complex, noise-prone reservoir settings.

**Production data analysis:** AGI can analyze production data from wells to forecast future output. By examining historical production records and various factors that may affect production, such as reservoir pressure, fluid properties, and equipment performance, these models can provide accurate predictions of future production trends. This enables companies to plan their operations and investments more effectively, optimize produc-

tion strategies, and allocate resources rationally to maximize production efficiency and economic benefits. In this study, AGI's primary focus lies in establishing a collaborative framework between large foundational models and domain-specific small models to enhance adaptability and interpretability in production forecasting [55]. As shown in Figure 5, we developed a large model product based on a knowledge base constructed from data from a certain block of coalbed methane in China. Then, we quickly predicted the production changes of a certain well in the next 10 years through question and answer and conducted a detailed analysis.




(a) Raw seismic data (b) Explained fracture data

**Figure 4.** Rapid interpretation and analysis of fracture seismic data based on AGI.

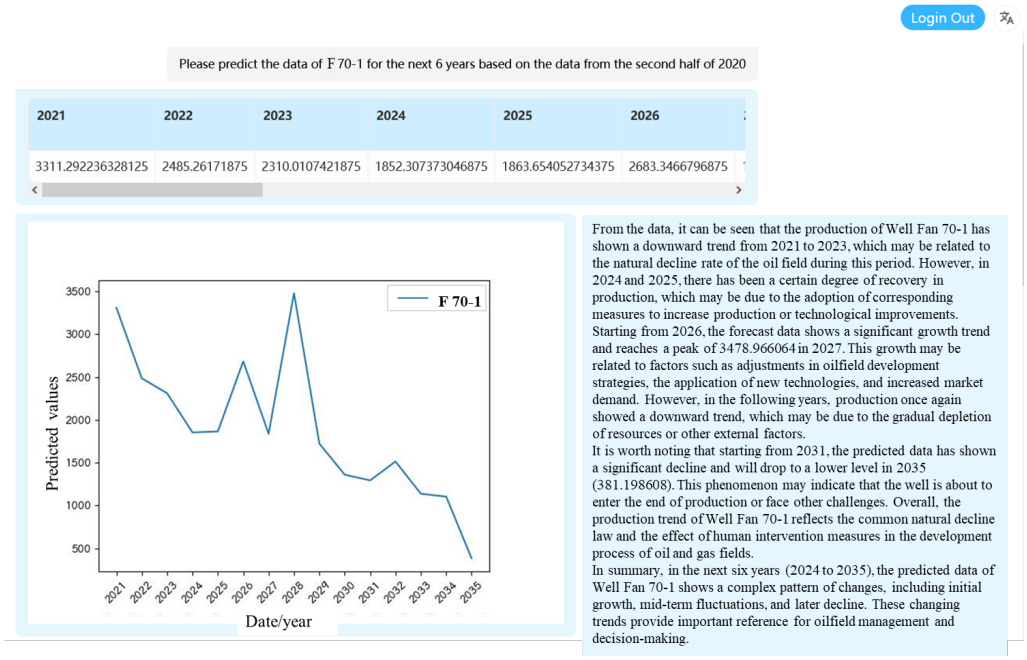



**Figure 5.** Oil and gas production prediction based on AGI.

In addition, based on strong knowledge fusion and analysis capabilities, AGI can predict oil and gas price fluctuations and market demand changes by analyzing historical market demand and price data, as well as combining multidimensional data such as domestic and international macroeconomic data, industry dynamics, policy changes, and technological innovation that affect the demand and prices of finished oil and gas products. This model can predict fluctuations in oil and gas prices and changes in market demand, and then provide a basis for enterprise management decisions by generating industry and market analysis reports.

### *3.2. Operational Optimization*

AGI can dynamically adjust production parameters and optimize oil and gas extraction efficiency based on real-time analysis of production data such as flow rate, pressure, etc. For example, in water injection oilfield development, the model recommends the optimal water injection allocation by simulating the effects of different water injection schemes, as shown in Figure 6.

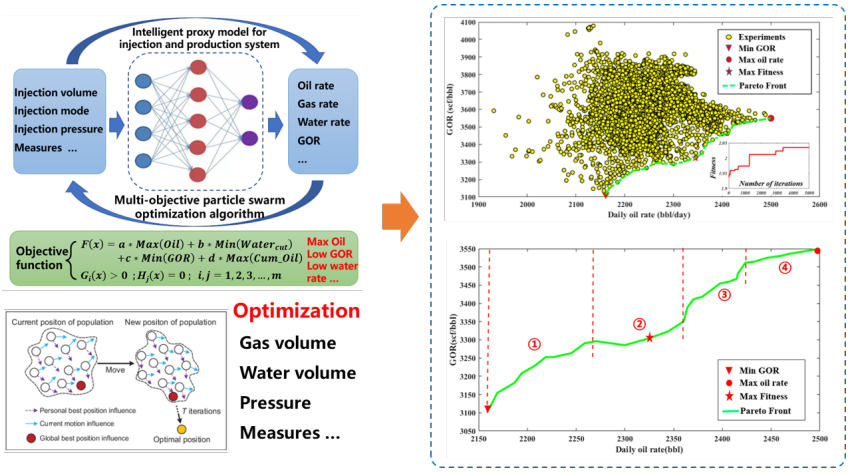



**Figure 6.** Intelligent optimization of production process for water injection oilfields.

In addition, drilling is a critical and costly process in oil and gas reservoir development, and there are many optimization tasks involved in the process. AGIs can optimize drilling parameters in real time by analyzing data from past drilling operations. They can take into account factors such as formation properties, drilling equipment performance, and drilling fluid parameters to determine the optimal drilling speed, pressure, and other parameters, improving drilling efficiency and reducing the likelihood of costly errors. This not only saves time and costs but also helps to avoid potential drilling accidents and ensure the safety of drilling operations.

Moreover, oil and gas reservoir development involves much equipment, and the efficient operation of the equipment is related to the efficiency of production. Equipment failure can cause significant disruptions and costs in oil and gas operations. AGIs can be used for predictive maintenance by analyzing historical failure patterns of equipment and cross-checking with current sensor readings. They can detect early warning signs of mechanical failure, allowing companies to schedule maintenance in a timely manner and avoid unexpected downtime. This helps to extend the life of expensive equipment, minimize repair costs, and improve overall operational efficiency.

### *3.3. Knowledge Management and Employee Training*

Firstly, we build an industry knowledge base based on a large amount of management, technical, and production data. Then, we can form an AI assistant deployed within the enterprise

using AGI. It can realize quick response to technical consultation, such as troubleshooting steps, equipment operating specifications, etc., and it supports multi-language Q&A and document retrieval-augmented generation. In addition, by integrating technical manuals and historical employee case libraries, the model provides new employees with periodic personalized training and process learning content. AGI can automatically generate technical documents such as exploration reports and production logs, and support tasks such as contract review and compliance checks. For example, extracting key information from professional papers to generate standardized reports reduces manual writing time. As shown in Figure 7, based on the AGI and RAG technology, relevant tables, images, and key data in the paper can be quickly obtained.

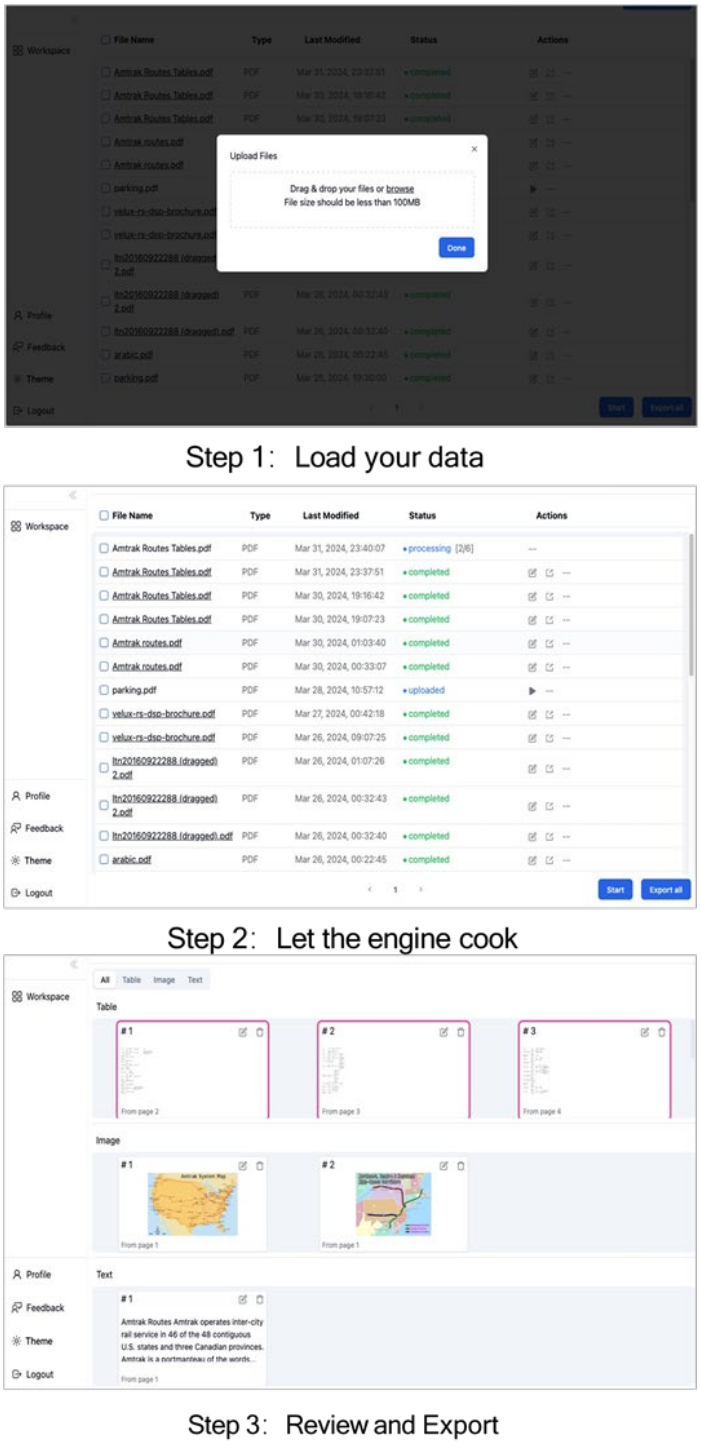



**Figure 7.** Knowledge management, data extraction, and automatic document generation based on AGI.

## 4. Prospect of AGI in Oil and Gas Reservoir Development

AGIs have shown tremendous promise in various sectors, and the application in oil and gas reservoir development presents several new opportunities and challenges. Oil and gas reservoir development generates a large amount of unstructured data, such as technical reports, drilling logs, production data, etc. LLMs can effectively process these textual data, extract key information, and help engineers and decision-makers make data-driven decisions more quickly. For example, LLMs can be used to automate the generation of reports, analyze historical production data, and even help identify potential oil and gas reservoirs during oil and gas exploration. In addition, work in oil and gas reservoir development often relies on highly specialized knowledge. LLMs can help companies build intelligent knowledge bases, achieve automated classification and fast querying of technical documents, operation manuals, and other materials, improve information flow efficiency, reduce knowledge loss, and are particularly important in high employee turnover and project team changes. AGIs can improve operational efficiency, for example, in drilling and production processes, can help predict equipment failures, optimize operational processes, and provide intelligent recommendations by analyzing real-time data. For example, LLMs can process sensor data, maintenance records, and other information to provide real-time feedback on machine operation status, thereby improving equipment reliability and production efficiency. At the same time, compliance reports, environmental assessment reports, and other documents in oil and gas reservoir development typically require a significant amount of work. LLMs can automatically generate these documents, reducing manual input and improving the accuracy and consistency of document generation.

Artificial general intelligence (AGI) technology demonstrates considerable promise for applications within oil and gas reservoir development. However, several critical challenges and constraints exist that must be explicitly acknowledged to understand its realistic implementation. Firstly, a significant operational risk in oil production is reservoir underperformance. Reservoirs frequently exhibit higher levels of compartmentalization than initially expected, posing severe limitations on accurate modeling and predictions. Particularly in high-cost markets such as deepwater operations, the accurate identification and management of reservoir compartmentalization remain paramount.

AGI models face difficulties in adequately processing complex, specialized data frequently encountered in reservoir development, including geological exploration, petrophysics, formation evaluation, reservoir fluid characteristics, and geomechanics. Specifically, critical datasets such as wireline logging and logging while drilling (LWD), essential in conventional reservoirs, present significant complexities that AGIs must manage. These datasets capture vital information regarding geology, petrophysics, large-scale reservoir architecture, and fluid properties, which are fundamental to reservoir appraisal and management. Additionally, AGIs must efficiently integrate data from laboratory analyses on reservoir fluids, sidewall cores, and whole cores, which vary widely in format and scale. These complex and diverse datasets require substantial domain-specific fine-tuning of AGI models, often necessitating collaboration with domain experts for effective interpretation and integration.

A considerable constraint for AGIs in reservoir management arises from data availability and confidentiality. Organizations typically have restricted access to data from a limited number of reservoirs due to proprietary considerations. The highly segmented nature of the oil and gas industry further exacerbates this issue, as operating companies rarely share reservoir data with competitors. Thus, each organization's dataset may not sufficiently represent the diverse geological and physical properties encountered in unexplored reservoirs. Consequently, applying AI-trained models to new reservoirs often

results in limited reliability due to discrepancies between training datasets and real-world conditions, undermining the generalizability of AGI techniques.

Additionally, the effectiveness of AGI significantly differs between well optimization tasks and reservoir-scale evaluations. While well-level optimization, particularly where large numbers of wells are involved, such as in unconventional reservoirs, might be effectively managed by AGI technologies, reservoir-scale optimization presents substantial challenges due to limited reservoir instances available for training.

Transparency and interpretability represent another critical issue restricting broader AGI adoption in oil and gas reservoir management. AGIs and large language models inherently function as "black boxes", providing limited insight into their internal reasoning processes. Subsurface managers require clear, transparent analyses to ensure the reliability, safety, and strategic soundness of decisions, making the opaque nature of AGI-generated insights problematic. Without enhanced interpretability, industry-wide acceptance of AGI technologies will remain limited.

Furthermore, implementing AGI necessitates advanced technical skills in artificial intelligence and machine learning among oil and gas professionals. The current scarcity of personnel proficient in both domain-specific knowledge and advanced AI technologies creates a significant barrier, especially in regions where AI expertise is less developed. Thus, widespread AGI adoption in reservoir management will require substantial investment in training and education, emphasizing interdisciplinary expertise development.

However, with the continuous development of artificial intelligence technology in the future, the continuous reduction of computing power costs, and the deep integration of knowledge, the application of big language models in oil and gas reservoir development will become more successful and widespread.

## 5. Conclusions

This review examines the transformative potential of artificial general intelligence (AGI) in oil and gas reservoir development, emphasizing its capacity to address complex data challenges through advanced natural language processing. AGI enables efficient knowledge management, automated technical report generation, and predictive maintenance while optimizing drilling strategies by analyzing datasets beyond traditional methods' capabilities. Key innovations include enhanced decision-making through unstructured data interpretation and operational efficiency gains. However, challenges persist in domain-specific data quality, model interpretability ("black-box" limitations), and computational demands. Successful integration requires improved AGI adaptability to sector-specific workflows, transparent decision logic, and resource-efficient deployment frameworks. Future research should prioritize hybrid human–AI collaboration systems, explainable model architectures, and scalable solutions tailored to reservoir engineering's technical rigor. By addressing these barriers, AGI could revolutionize reservoir management, balancing its analytical prowess with industry demands for reliability and operational practicality, ultimately driving innovation in exploration and production efficiency.

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