HUB TECH IA

Deliverable report 13

AI and IAGEN Application Use Case

Analysis of Geological and Seismic Data for Area Identification with Shale Gas in Vaca Muerta

I. Introduction

1. Sector and Specific Activity

Vaca Muerta, located in the Neuquén Basin of Argentina, is one of the formations of the world's largest shale gas reserves. The exploration and exploitation of these unconventional resources requires a thorough analysis of geological data and seismic to identify areas with high production potential.

In this context, Generative Artificial Intelligence (IAGEN) emerges as a disruptive tool with the potential to revolutionize the oil and gas industry. Companies in the Argentine energy sector are gradually resuming their participation in international debt markets, driven by the growing investor interest in Vaca Muerta and project announcements in the region.

Through IAGEN, companies can optimize data interpretation, improve the accuracy in identifying prospective areas, and ultimately taking more informed decisions that maximize project profitability and minimize operational risks.

In a scenario of growing demand for natural gas worldwide, efficiency in the Identification and exploitation of these resources in Vaca Muerta becomes crucial for the Argentina's competitiveness in the energy market.

II. Application of IAGEN in the Specific Activity

1. How IAGEN is Applied in Geological and Seismic Analysis

Generative Artificial Intelligence (GENAI) is a branch of artificial intelligence that focuses on creating new content, such as models, images, code, or text, from existing data. This technology uses advanced algorithms to analyze large amounts of information, identify patterns and generate new content and original that is often indistinguishable from that created by humans.

IAGEN, through advanced algorithms, can generate predictive models that analyze 3D seismic data and correlate them with historical geological information.
Some of the key applications of IAGEN in shale gas exploration in Vaca Dead include:

- Generation of Synthetic Seismic Models: IAGEN can create simulations realistic subsoil, which allows to predict the presence of shale gas with greater precision.
- Automated Interpretation of Seismic Data: Using networks generative neural networks, IAGEN can identify key geological patterns in seismic data, reducing analysis time and improving efficiency.
- Drilling Optimization: Generative models can suggest optimal locations for drilling, considering factors such as the presence of shale gas, rock permeability and reservoir depth.

A concrete example of the application of IAGEN is the combination of generative models with deep learning algorithms to improve the identification of Structural and stratigraphic "traps." These "traps" are geological formations particulars that, due to their configuration, may contain accumulations of hydrocarbons. IAGEN can analyze seismic images to identify patterns and features that indicate the presence of these traps, such as anticlinal folds, geological faults, or changes in stratigraphy. This information,

combined with geological data, allows experts to determine with greater pinpoint the location of potential shale gas deposits.

2. Technologies and Models Used

IAGEN Technology	Application	Benefits
Networks Generative Adversarial (GANs)	Model generation synthetic geological, refinement of models existing, resolution improvement seismic data	Creation of realistic simulations, prediction of the presence of shale gas, improving the quality of the data
Transformers for Time Series	Data analysis evolving seismic, ID of patterns	Prediction of the evolution of the reservoirs, better understanding of the reservoir dynamics
Diffusion Models	Improved resolution from seismic data of low quality	Obtaining images sharper seismic waves and detailed
Learning by Booster	Dynamic optimization of strategies of drilling based on	Selection of the best locations for drilling, cost minimization

	simulated scenarios	and risks

3. Integration of IAGEN with Other Technologies

IAGEN can be integrated with other data analysis technologies to obtain a A more complete view of the subsoil and optimize shale gas exploration in Vaca Dead. Some of these technologies include:

- Geostatistical Analysis: Geostatistical analysis allows modeling the spatial variability of reservoir properties, such as porosity and permeability. Combining IAGEN with geostatistical analysis can improve the accuracy in predicting shale gas distribution.
- Numerical Reservoir Modeling: Numerical reservoir modeling simulates the behavior of fluids in the reservoir, which allows predicting the gas production over time. The integration of IAGEN with the Numerical modeling can improve the accuracy of simulations and optimize the production strategies.
- Data Visualization and Interpretation Tools: IAGEN can facilitate the visualization and interpretation of geological and seismic data through the generation of maps, 3D models and other graphical representations. These tools allow geologists and engineers to better understand the structure of the subsurface, identify patterns and make more informed decisions.

III. Application of agents powered by IAGEN for the activity

1. Concept of IAGEN agents

In recent years, generative artificial intelligence (GAI) has revolutionized the way we interact with technology, enabling the development of systems capable of generating content, answering complex questions and assisting with tasks high-demand cognitive skills. From this capacity, a new architecture emerges

Technological: IAGen-powered agents. These agents are not simple conversational interfaces, but autonomous systems that can interpret instructions, make decisions, execute tasks and learn from their interactions with the around.

An IAGen agent combines large language models with components additional features such as external tools, memory, planning and autonomous execution. This allows them to operate in complex environments, with the ability to break down objectives in steps, coordinate multiple actions, interact with digital systems (such as databases, APIs or documents) and adapt to changes in context in real time. These qualities distinguish them from traditional chatbots, and open up a spectrum of more sophisticated and customizable applications.

At the organizational level, these agents are being used to automate processes, generate data analysis, assist in decision making and improve the user experience, both internally and externally. For example, they can assume human resources, legal, financial or logistical tasks, and even those linked to the technical areas of production processes, acting as intelligent assistants that collaborate with human teams. This ability to integrate knowledge and execute tasks autonomously transforms the way organizations can scale your operations without losing quality or control.

In addition, agentic workflows—structures where multiple agents collaborate each other to solve complex problems—allows for the distribution of responsibilities among different agent profiles, each with specific functions. This generates Hybrid work environments where humans and agents coexist, optimizing times, costs, and results. The ability to connect agents with tools such as Google Drive, CRMs or document management platforms further expands its capabilities.

The development of IAGen-powered agents represents a crucial step towards a new era of intelligent automation.

Among the benefits of authentic workflows driven by business models generative artificial intelligence, the possibility of automating processes is found complete, end-to-end production systems, and even add value from the leveraging the skills of language models based on these technologies.

However, its implementation also poses technical, ethical and legal challenges, from responsible design to human oversight. Therefore, understanding your architecture, its operational logic and potential impacts are essential for its effective and safe adoption in diverse professional contexts.

2. Proposed Workflow Design for IAGEN Implementation

The implementation of IAGEN in shale gas exploration in Vaca Muerta requires a structured workflow that ensures data quality, efficiency of the process and the accuracy of predictions. A possible workflow includes the following stages:

1. IAGEN Workflow a. Data Collection: Integration of seismic, geological, well and groundwater data. production.

b. Data Preprocessing: Data cleaning, structuring and normalization information to ensure compatibility with IAGEN models.

c. Generative Model Training: Selection and training of the most appropriate IAGEN models for the task, using techniques such as GANs, Transformers or diffusion models.

d. Prediction Generation: Using the trained model to generate predictions about the presence of shale gas, rock permeability and others variables of interest.

e. Validation with Real Data: Comparison of the predictions generated by the

IAGEN with existing well data to evaluate model accuracy.

f. Decision Making: Using validated predictions to optimize the location of drilling wells, extraction strategies and management of the resources.

IV. Opportunities and challenges

The application of IAGEN in shale gas exploration in Vaca Muerta presents both challenges as opportunities. The analysis of geological and seismic data is a complex process that involves the management of large volumes of information, often unstructured and with a high degree of uncertainty. Seismic information, In particular, it can be "noisy", with complex interpretation and subject to a significant geological variability.

1. Opportunities

- Automation of seismic analysis: IAGEN allows you to automate tasks repetitive tasks, freeing up experts to focus on more demanding tasks. added value.
- Uncertainty reduction: Generative models can help reduce uncertainty. uncertainty in the interpretation of geological and seismic data, improving the precision in the identification of prospective areas.
- Drilling Optimization: IAGEN can be used to optimize drilling location of drilling wells, minimizing costs and impact environmental.

2. Direct Benefits

The application of IAGEN in shale gas exploration in Vaca Muerta offers a series of direct benefits for companies in the sector:

- Greater Accuracy in Reserve Identification: IAGEN allows for reducing errors in the selection of drilling zones, which translates into greater

efficiency in the exploration and exploitation of resources.

- Cost and Resource Optimization: By improving the accuracy of identifying prospective areas, IAGEN reduces the need for unnecessary exploratory drilling, resulting in significant cost savings and better resource management. In addition, extraction costs in Vaca Muerta are lower than in other shale gas formations, such as the basin Permian in the United States. This is due in part to the high productivity of the wells in Vaca Muerta, which are approximately 30% more productive than the from the Permian Basin.
- Environmental Risk Reduction: IAGEN contributes to minimizing the impact environmental impact of shale gas exploration by reducing the amount of drilling and the intervention in the subsoil.
- Reduction in Exploration Time: Automation of data analysis and drilling optimization allow for shorter lead times from prospecting initial to the extraction phase, accelerating project development.
- Employment Generation and Capacity Development: The implementation of the IAGEN in Vaca Muerta can generate new employment opportunities and capacity building in the region. Professionals with skills will be required in: Data Science: For the development and training of IAGEN models; Software engineering: For the implementation and maintenance of AI platforms; Geology and petroleum engineering: For the interpretation of the results and decision-making. It is essential to invest in the training of professionals in these areas to take full advantage of the potential of IAGEN in Vaca Muerta.

3. Impact

IAGEN has the potential to generate a measurable impact on shale exploration gas in Vaca Muerta. Some examples of this impact include:

- 30-50% reduction in geological analysis time: Automation of the Data analysis using IAGEN can significantly reduce the time that geologists dedicate to the interpretation of seismic and geological data.
- 20-40% savings in operating costs through drilling optimization: By improving the accuracy of well placement, IAGEN reduces the amount of failed drilling, which translates into considerable cost savings operatives.
- 15-25% increase in drilling success rate: IAGEN increases the probability of finding shale gas in the drilled areas, improving the exploration efficiency.
- Reduction of environmental impact by reducing unnecessary drilling in up to 35%: Drilling optimization using IAGEN minimizes the intervention in the subsoil, reducing the environmental impact of exploration.

4. Comparison with Traditional Methods

Traditional methods of geological and seismic data analysis are largely based on extent in the manual interpretation of information, which can be a process slow, expensive and error-prone. IAGEN, on the other hand, allows for the automation of data interpretation, improving speed, accuracy and efficiency in decision making decisions.

Method	Precision	Efficiency	Cost	Impact Environmental

Traditional	Minor	Minor	Elderly	Elderly
IAGEN	Elderly	Elderly	Minor	Minor

V. Challenges and Strategies to Overcome Them

1. Challenges

- Data complexity: Seismic information can be difficult to interpret.
  interpretation and with significant geological variability.
- Integration of historical data: Validation of the predictions generated by the
  IAGEN requires the integration of historical data, which in many cases may
  be of uneven quality or incomplete.
- Interpretation of results: It is essential that the IAGEN is translated into
  actionable information that geologists and engineers can interpret and apply
  in decision-making.

2. Barriers

Despite the potential benefits of IAGEN, there are some barriers that may
hinder its implementation in shale gas exploration in Vaca Muerta:

- Resistance to change: The introduction of new technologies such as IAGEN
  can generate resistance among professionals in the sector, who may be
  reluctant to adopt new ways of working.
- Regulatory limitations: The lack of a clear regulatory framework for the use of AI
  in hydrocarbon exploration can generate uncertainty and make it difficult
  investment in these technologies.
- Data quality: IAGEN requires high quality data to generate
  accurate predictions. The availability of incomplete or historical data

outdated may limit the effectiveness of IAGEN.

3. Strategies

To overcome these barriers, it is necessary to implement strategies that facilitate the Adoption of IAGEN in shale gas exploration in Vaca Muerta:

- Short-term investment in AI agent implementation teams
  Technology and training: Investment in proof of concept and testing is required pilot. The focus here has to be on training the talent to implement, since A trend towards cost reduction is observed in systems that allow “no code” and “low code” automation. For the first stage, it is also recommends using teams with experience in design and implementation AI agents. Finally, it is key to form an in-house team for the accompaniment and appropriation of an agentic culture that redefines the human-computer interaction.
- Training and Progressive Adoption: It is essential to train geologists and engineers in the use of IAGEN and promote its progressive adoption, starting with pilot projects that demonstrate the benefits of the technology.
- Alliances with Regulatory Institutions: It is necessary to work together with the regulatory institutions to develop a regulatory framework that promotes innovation and the responsible use of AI in hydrocarbon exploration.
- Improved Data Collection: It is crucial to invest in data collection. high quality, using advanced sensors and data acquisition technologies that allow for more accurate and complete information.
- Hybrid Systems Development: Combining IAGEN with validation
  Humans can improve technology acceptance and ensure reliability of the predictions.
- Collaboration between Industry, Academia and Government: The successful implementation of IAGEN in Vaca Muerta requires collaboration between industry, academia and government. academia and government. This collaboration can facilitate:

- Research and development of new technologies: The academy can contribute to the research and development of new IAGEN models adapted to the specific characteristics of Vaca Muerta.
- Professional training: Universities and training centers can train industry professionals in the use of IAGEN.
- The development of a regulatory framework: The government can work together with industry and academia to develop a regulatory framework that promotes innovation and the responsible use of AI in hydrocarbon exploration.

VI. Sustainability and Environment in Vaca Muerta

Shale gas exploitation in Vaca Muerta raises environmental concerns that must be addressed responsibly. The technique of hydraulic fracturing ("fracking"), used to extract gas, requires large volumes of water and can generate impacts on soil, groundwater and air quality.

A study by the organization Sustainable Energy for All (SEforALL) highlights the importance of assessing the environmental risks of shale gas exploitation in Vaca Muerta. The study proposes the use of an "Environmental Risk Index" that considers the proximity of wells to water sources, agricultural areas and populations, to identify areas with the highest risk of contamination.

Research conducted by Earthworks, an organization dedicated to the protection of the environment, have documented evidence of contamination in Vaca Muerta, including methane leaks, oil spills, and the presence of toxic waste in the air and soil. These findings highlight the need to implement measures Mitigation and monitoring to minimize the environmental impact of shale exploitation gas.

IAGEN can help minimize the environmental impact of shale exploitation gas in Vaca Muerta in various ways:

- Drilling optimization: By improving the accuracy of well placement,

IAGEN reduces the need for unnecessary drilling by minimizing intervention in the subsoil and water consumption.

- Environmental monitoring: The IAGEN can be used to monitor environmental conditions in real time, detecting possible gas leaks or contamination of the water.
- Risk assessment: Generative models can simulate different exploitation scenarios and predict potential environmental impacts, which allows preventive measures to be taken to minimize risks.

It is essential that the implementation of the IAGEN in Vaca Muerta be carried out with a sustainability approach, considering not only the economic benefits, but also environmental and social impacts. IAGEN offers an opportunity to improve the efficiency and sustainability of shale gas exploitation, but it is crucial that its application is carried out responsibly and with a focus on protection of the environment.

VII. Conclusion

The application of IAGEN in the analysis of geological and seismic data in Vaca Muerta represents a strategic opportunity to optimize shale gas exploration, reduce costs, improve operational efficiency and minimize environmental impact. Effective implementation of IAGEN requires overcoming technical, regulatory and ethical, but the potential benefits, such as increased productivity, Cost reduction and minimization of environmental impact justify investment in this technology.

Collaboration between industry, academia and government is essential to ensure that IAGEN is used responsibly and contributes to development Sustainable development of Vaca Muerta and Argentina. Experience in other shale deposits gas, demonstrates that the application of advanced technologies such as IAGEN can generate significant economic and environmental benefits.

Vaca Muerta has the potential to become a growth engine for Argentina, boosting the economy, creating jobs, and contributing to security country's energy sector. IAGEN can play a key role in this process, provided when its application is carried out responsibly and with a focus on sustainability.

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