HUB TECH IA

Deliverable report 12

AI and IAGEN Application Use Case

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

I. Introduction.

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 globally, the efficiency in the identification and exploitation of these resources in Vaca Muerta becomes crucial for Argentina's competitiveness in the market energetic.

1. Challenges and Opportunities

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.

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.

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.

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 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.

II. Application of IAGEN in the Specific Activity

1. How IAGEN is Applied in Geological and Seismic Analysis

IAGEN, through advanced algorithms, can generate predictive models that They analyze 3D seismic data and correlate it 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 in Vaca Muerta is the combination of generative models with deep learning algorithms to improve the identification of structural and stratigraphic "traps."

These "traps" are particular geological formations that, due to their configuration, may contain hydrocarbon accumulations. IAGEN may 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 scientists to Experts to determine more precisely the location of potential shale deposits gas.

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,

	simulated scenarios	cost minimization and risks

III. Application of AI agents powered by IAGEN

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 in 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 its potential impacts is fundamental to its effective and safe adoption in various professional contexts.

2. Proposed Workflow Design for IAGEN Implementation

It is possible to design agents to assist geologists and engineers in the interpretation of geological and seismic data, automatically generating maps, 3D models and graphical representations to facilitate decision-making in exploration, characterization and planning of hydraulic fracturing.

1. Proposal

a. Data ingestion and preprocessing

- Receives geological and seismic datasets in multiple formats (SEG-Y, LAS,

shapefiles, satellite images, well data, etc.). • Performs
data cleaning, temporal and spatial alignment.
• Integrates information from different sources: well logs, data
petrophysical, microseismic and topographical.

b. Automatic visualization generation

• Create maps of isopachs, structures and facies.
• Build 3D models of the subsurface with fault information, layers of
rock and relevant horizons.
• Overlays areas of geomechanical interest with operational information
(fractures, active wells, pressures, etc.).

c. AI-guided analysis

• Detects patterns of geological structures and areas with potential for
hydrocarbons through segmentation and clustering.
• Associates seismic signals with formation properties (porosity,
pressure, saturation).
• Suggests areas of interest for drilling or fracturing based on
correlation between data.

d. Interaction with users

• Allows queries of the following type:

"Show me the structure of the reservoir in the western area with high pressure
"pore".
"Identify possible natural fracture zones in the Vaca horizon
"Dead."

e. Export and communication

• Export visualizations in formats compatible with software
geosciences (Petrel, Kingdom, ArcGIS).
• Generate automatic reports with maps, graphs and findings
featured.
• Connects with operational dashboards or planning software

wells.

2. IAGEN flow architecture

a. Sensing and Collection Agent:

Captures seismic, geological, well log, and reservoir model data.

b. Geoscientific Analytical Agent:

Applies signal processing, spectral analysis and machine learning to detect relevant structures.

c. 3D Visualization Agent:

Convert results into interactive visual models using libraries graphics (e.g. Plotly, VTK, Three.js).

d. Geostrategic Recommendation Agent:

Suggests exploration or fracturing actions based on the analysis.

e. Technical Feedback Agent:

Learn from feedback from geologists and engineers to improve accuracy in future visualizations and recommendations.

3. Suggested technologies

- Machine Learning: CNNs for seismic images, geospatial clustering.
- Visualization: Plotly, Dash, CesiumJS, Blender for interactive 3D.
- Data: SEG-Y, LAS, GeoTIFF, shapefiles.
- Platform: Integration with platforms such as Petrel or Python environments (Jupyter, Dash).

IV. 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 the errors in the selection of drilling areas, which results in 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 States1 . 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.

1. Possible measurable 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.

2. 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. 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.

2. 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 pilot testing is required. The focus here must be on training the talent to implement, since There is a trend towards cost reduction in systems that allow "no code" and "low code" automation. For the first stage, we also recommends using teams with experience in design and implementation AI agents. Finally, it is key to form an in-house team to support and adopt 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 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 to be obtained.
- Hybrid Systems Development: Combining IAGEN with validation Human can improve the acceptance of technology and ensure the reliability of predictions.

VI. 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.

To fully exploit the potential of IAGEN in Vaca Muerta, it is crucial that the companies in the sector invest in the acquisition of high-quality data, in the training of its professionals and in the development of a regulatory framework that foster innovation and responsible use of AI. Collaboration between industry, academia and government is critical to ensuring that IAGEN is used in responsible manner and contribute to the sustainable development of Vaca Muerta and Argentina. Experience in other shale gas fields, such as the Permian Basin in the United States, demonstrates that the application of advanced technologies such as IAGEN can generate significant economic and environmental benefits. Vaca Muerta has the potential to become an engine of growth for Argentina, driving the economy, generating employment and contributing to the country's energy security. IAGEN can play a key role in this process, as long as its application is carried out responsibly and with a focus on sustainability.

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