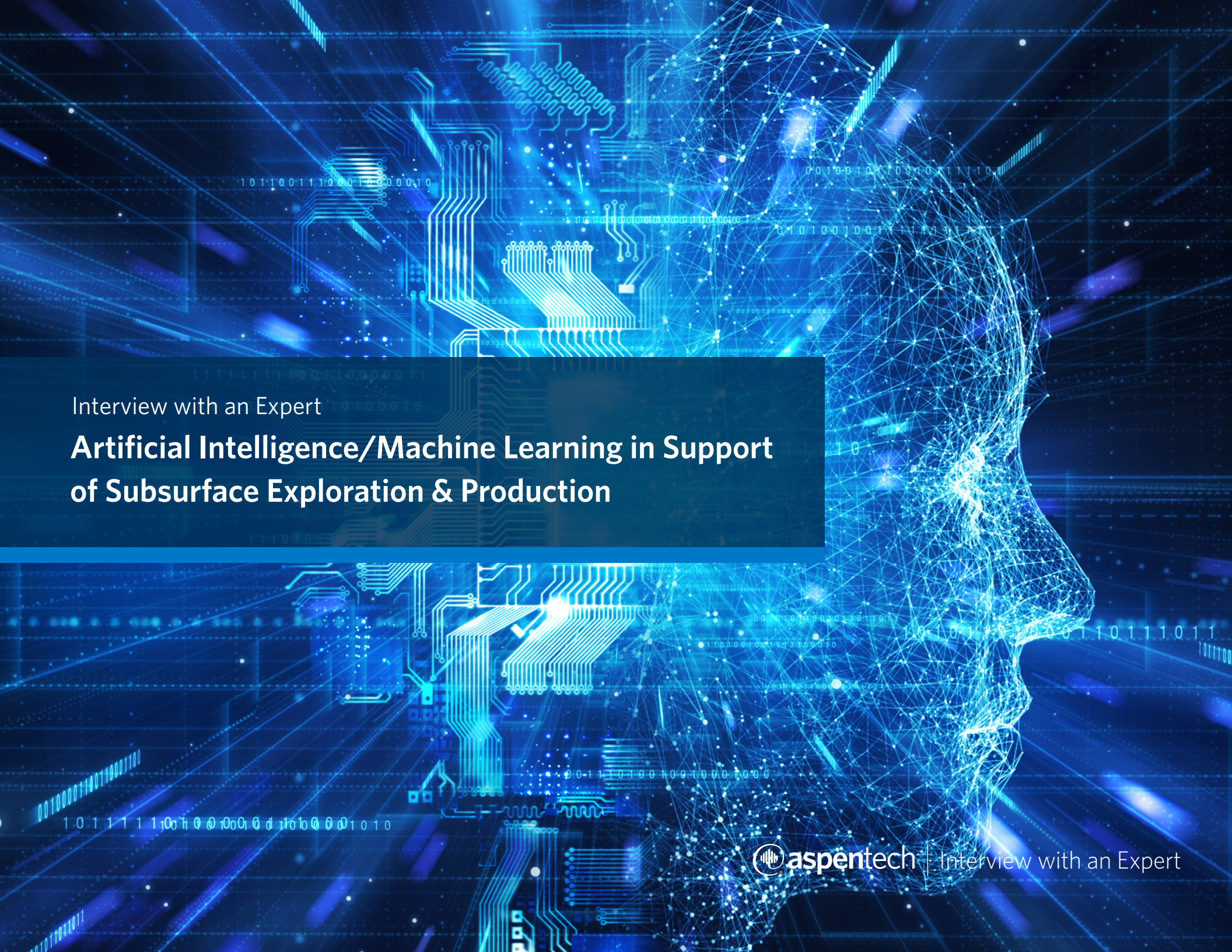


Interview with an Expert

Artificial Intelligence/Machine Learning in Support of Subsurface Exploration & Production

Dr. Bruno de Ribet

Subsurface Science & Engineering Solution Advisor
Aspen Technology, Inc.

Dr. Bruno de Ribet, Subsurface Science & Engineering Solution Advisor, leads Interpretation and Reservoir Characterization customer-related activities at AspenTech. His main role is to advise on developing workflows that take full advantage of the AspenTech SSE suite of geophysical and geological solutions, to optimize asset performance.

Dr. de Ribet holds a Ph.D. in Geophysics from the Institute du Physique du Globe, Paris University. He has over 30 years of experience in the upstream oil and gas industry.

In this interview, Dr. Bruno de Ribet, a long-time expert in the oil and gas E&P industry, explains how machine learning (MI)/artificial intelligence (AI) techniques have led to deeper insights into relationships in geological data, helping to understand the risks and prospectivity of reservoirs. Through mitigating risk, the ML techniques offered by AspenTech help enhance user confidence in the decision-making process when characterizing a reservoir or planning new well placement.

What is subsurface geological characterization? Why and how is it performed?

Subsurface geological characterization aims to identify formations and zones in the geological subsurface that are suitable either for the extraction of resources like oil, gas, minerals and heat, or the storage of industrially produced gasses like hydrogen and carbon dioxide. The challenge here is to determine the properties and structure of multiple geologic layers located several kilometers below ground. Every location for a proposed well needs proper characterization so drillers can anticipate the rock types, entrained fluids and geostatic pressures potentially encountered during drilling. Additionally, operators need to be confident that their operations will be economically viable and safe. The time from exploration to production is critical, and optimizing each stage of a project is a basic requirement for success.

What is machine learning, and what value do artificial intelligence/machine learning technologies bring in subsurface geological characterization?

Great question. We often speak of AI and ML interchangeably without clarifying what we mean. Artificial intelligence, or AI, plays a critical role in enhancing exploration. It is dedicated to creating systems or machines capable of performing tasks that typically require human intelligence. The aim of AI is to imitate cognitive functions such as recognizing patterns, making decisions, and analyzing complex datasets, enhancing various aspects of the exploration and production workflow.

Machine Learning, or ML, is a branch of AI in which the application of algorithms, statistical methods and computational engines are used to develop data-driven models. ML focuses on techniques that allow machines to learn from previously gathered data from multiple sources. Systems are enabled to learn and improve from experience without the need for programming.

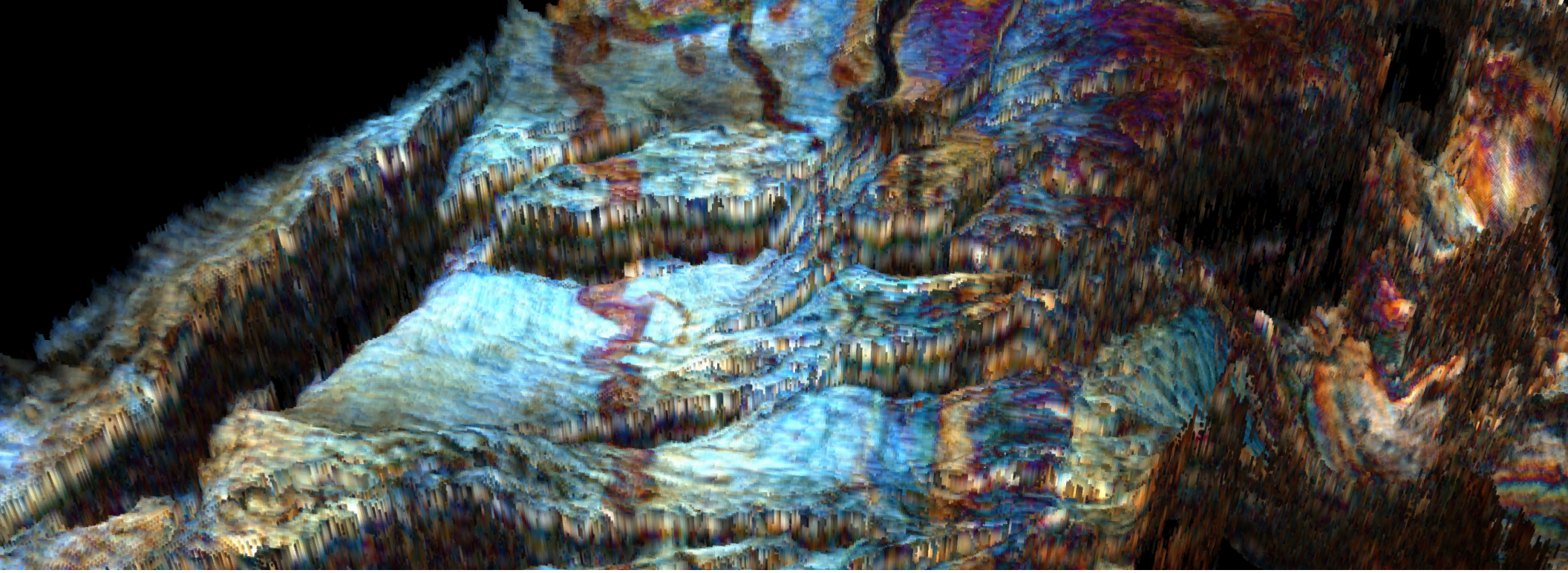
In our industry, we deal with enormous amounts of data. I'm talking about petabytes of data and it's only increasing every year as new technologies are introduced to the industry. For example, a single modern 3D seismic survey can generate hundreds of terabytes of data, and individual drilling rigs might produce over a terabyte of data per day! ML algorithms are incredibly useful here because they can identify complex patterns in geological data that might not be obvious to human analysts. Additionally, AI can detect anomalies in this data, which can indicate the presence of valuable resources or potential hazards.

When it comes to predictive modeling, ML can analyze seismic, well log and production data to predict the location and quality of oil and gas reservoirs. Meanwhile, AI can improve the accuracy of models predicting the distribution and flow of groundwater resources.

In terms of automation and efficiency, machine learning can streamline the processing of large datasets, like those from seismic surveys and well logs, significantly reducing the time required for analysis. At the same time, AI systems can provide real-time monitoring and decision support during drilling operations, which enhance both safety and productivity.

What challenges need to be overcome to integrate geological and geophysical interpretation information, and what ML solution does AspenTech propose?

Integrating geological and geophysical interpretation information involves several challenges. When performing reservoir characterization, the elastic properties of a reservoir—essentially how the rocks deform and respond to stress—are derived mainly from well logs and seismic data. "Derived" in this context means that these properties are inferred or calculated based on the data collected from these sources.



The traditional reservoir characterization workflow is quite time-consuming and prone to error. It relies heavily on seismic data, which may not always clearly discriminate between different rock types or lithologies. Another challenge is that while we have accurate knowledge about subsurface characteristics, such as lithology, porosity, permeability and hydrocarbon presence, this accuracy is confined to the borehole. This is because high-resolution measurements are performed directly at the well. However, this data is sparse over the broader area of interest. On the flip side, seismic data is recorded over the entire study area but has low resolution.

Given these challenges, there's a clear need to integrate the high-resolution, localized data from well logs with the broader, low-resolution seismic data. AspenTech proposes an ML-based solution to tackle this issue. Our technologies help study the relationship between these two types of data and integrate them to provide an accurate description of the reservoir properties at a geological scale.

While ML isn't a magic bullet, it significantly strengthens exploration and development proposals by enabling us to better understand the risks and prospectivity of targets. The ML techniques offered by AspenTech help mitigate risk when deciding on well placement, thus enhancing user confidence in the decision-making process.

Can you give some examples of widely used AspenTech Subsurface Science & Engineering (SSE) machine learning algorithms?

Sure. When it comes to our ML methods, two leading examples of our well-proven techniques come to mind. One is our patented Multi-Resolution Graphic Clustering (MRGC) algorithm, and the other is supervised Rock Type Classification. MRGC can identify clusters within the data that might be missed by single-resolution clustering algorithms, and which can be especially valuable for identifying geological features or anomalies that occur at different scales.

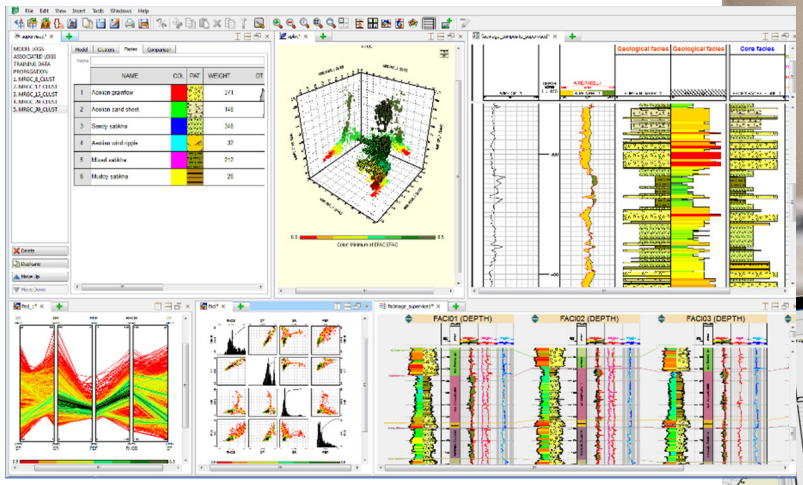


Figure 1. Multi-Resolution Graphic Clustering (MRGC)

Based on an ensemble of Neural Networks, Rock Type Classification establishes the relation between well rock types and seismic data to create the most probable rock type distribution at seismic grid scale. This method helps identify the most appropriate subsurface geologic environment for optimal well placement.

How receptive is the industry to the introduction of artificial intelligence and machine learning into their working processes?

In my opinion, the industry has shown remarkable receptivity to the introduction of AI and ML. The best proof of the success of these technologies is that they have been adopted by major industry players, who are systematically applying them across various geologic contexts worldwide. This widespread adoption demonstrates their proven ability to enhance operational efficiency, optimize resource exploration and improve decision-making processes. It is unquestionably clear that the industry accepts AI/ML as pivotal tools for achieving greater opportunities and innovation.

Machine learning algorithms are constantly evolving. How do AspenTech's SSE ML and AI applications remain competitive?

Remaining competitive is key. It's how companies thrive. AspenTech's SSE business unit has consistently been a pioneer in delivering advanced, proven and reliable ML solutions. Our ML-based technology excels in integrating extensive datasets of multiple data types to provide comprehensive subsurface descriptions and predict analytics for both hydrocarbon and low-carbon solutions. Since our industry has incorporated ML techniques into its daily work, we at AspenTech have accelerated our research and development aimed at providing geoscientists with powerful technologies that will allow them to perform complex tasks. Looking ahead, I believe staying competitive means continually exploring new ideas while promoting our proven ML-based solutions.

Now that the subsurface resource industry is heavily focused on energy transition, how can the tools originally developed for identifying and extracting hydrocarbons contribute to this shift?

I believe that the technologies we use daily in the O&G industry to explore the subsurface are perfectly adaptable to energy transition projects. Geothermal, carbon geo-sequestration, nuclear waste, natural gas and hydrogen storage, and even wind farms are activities where our technology is already contributing. Geoscience is and will continue to be a major contributor to the sustainable net-zero carbon energy systems of tomorrow. The energy transition is today's most important challenge, and we are actively working to do our part.

How has machine learning aided Carbon Capture & Storage (CCS) workflows?

It's widely acknowledged that CCS is a key technology for achieving carbon neutrality by capturing and storing CO_2 emissions. In carbon geo-sequestration projects, it is essential to monitor select storage sites both during and after CO_2 injection to ensure effective containment. In a CCS project, a baseline survey is executed before CO_2 injection, and this is followed by additional surveys made during or after injection, to detect possible leakage.

We have a technology that enables us to cross-equalize different vintages of seismic data. This can be followed by AspenTech's Self-Growing Neural Network unsupervised ML technique, used to analyze which attribute or series of attributes contributes the most to defining the differences or similarities in the seismic data, and then derive a seismic facies volume and associated probability volumes. We can interpret each cluster as a particular response to the CO_2 injection and look for suspicious anomalies.

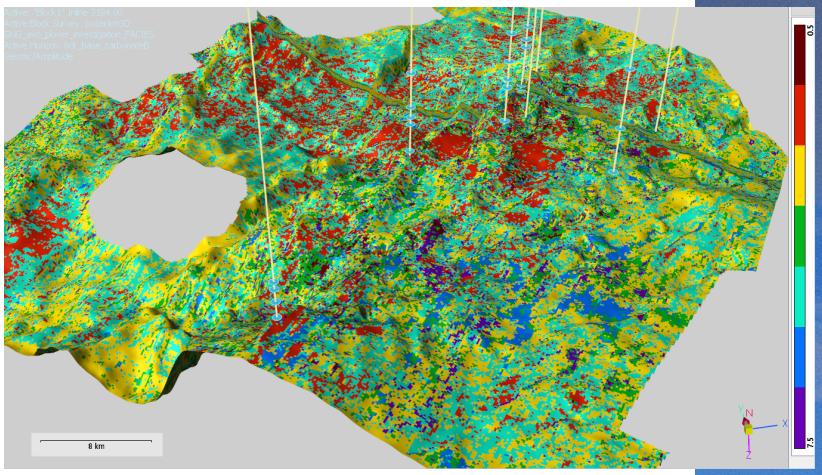


Figure 2. Self-Growing Neural Network

How do you envision ML and AI further impacting the upstream industry?

In the past decade, we've witnessed a rapid evolution in AI/ML technologies, with the upstream sector clearly identifying them as essential tools for E&P operations. These advancements are seen as technological upgrades for collaboration between the different components of our community: energy operators, technology and services providers, the R&D community and others. ML's ability to analyze enormous data sets and discover complex relationships and patterns, supported by the power of high-performance computing (HPC), is unprecedented.

I foresee AI and ML techniques expanding until they become a daily part of our efforts to efficiently uncover relationships in subsurface-related data. This technological progression will not only streamline operational processes but also unlock new insights into reservoir characterization, drilling optimization, and environmental impact assessment, contributing to sustainable and efficient energy practices worldwide.

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About Aspen Technology

Aspen Technology, Inc. (NASDAQ: AZPN) is a global software leader helping industries at the forefront of the world's dual challenge meet the increasing demand for resources from a rapidly growing population in a profitable and sustainable manner. AspenTech solutions address complex environments where it is critical to optimize the asset design, operation and maintenance life-cycle. Through our unique combination of deep domain expertise and innovation, customers in asset-intensive industries can run their assets safer, greener, longer and faster to improve their operational excellence.

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