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Data-Centric Seismic Interpretation

Key Technologies That Enhance Reservoir Recoverability

WHITE PAPER

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IN THIS WHITE PAPER

Technology and Seismic Interpretation

The oil and gas industry is faced with the immense responsibility of fulfilling world oil demand that is expected to grow from 83 million barrels of oil per day (mbopd) in 2005 to 119mbopd in 2025. A diminishing workforce of experienced geological and geophysical (G&G) professionals is responding to this challenge by combining their ever-increasing scientific and engineering understanding of subsurface geology, reservoir modeling and simulation with technological advancements in the fields of visualization, high-performance computing (HPC), and storage. The impact of information technology on identifying new reservoirs and enhancing reservoir recoverability has become increasingly tangible, and, as a result, investments in new IT advancements are being earmarked by the exploration industry for paths to sustained profitability.

This white paper highlights the significance and challenges of accelerating seismic interpretation with data-centric approaches. It then explains how technology can empower engineers and scientists to create a true picture of the reservoir model in a time-sensitive and cost-effective manner.

SITUATION OVERVIEW

Current Role of the Exploration Industry

The pressure to increase daily production and quickly replenish reserves is driving merger and acquisition activity and an increase in exploration. In order to stay ahead of the curve, national oil companies and majors are embarking on risky exploration projects in deep water and at remote land locations, while independents are acquiring producing assets from smaller producers and major oil companies. The pressure to find new reserves can be mitigated by increasing the quantity of oil that can be recovered from reservoirs and maximizing the speed at which oil can be extracted without damaging the reservoir.

Hundreds of billions of dollars are spent worldwide on drilling, wireline and perforation activities, injection and fracturing projects, and other secondary and tertiary recovery means. Exploration spending can be optimized by expediting the process of pinpointing the exact subsurface location where extraction measures are applied.

Rapid and accurate interpretation of seismic data enables more accurate reservoir modeling and simulation. Today's advanced methods take into account the impact of every possible data element to create a spatial and dynamic geological and geophysical picture of the reservoir, increasing final interpretation accuracy.

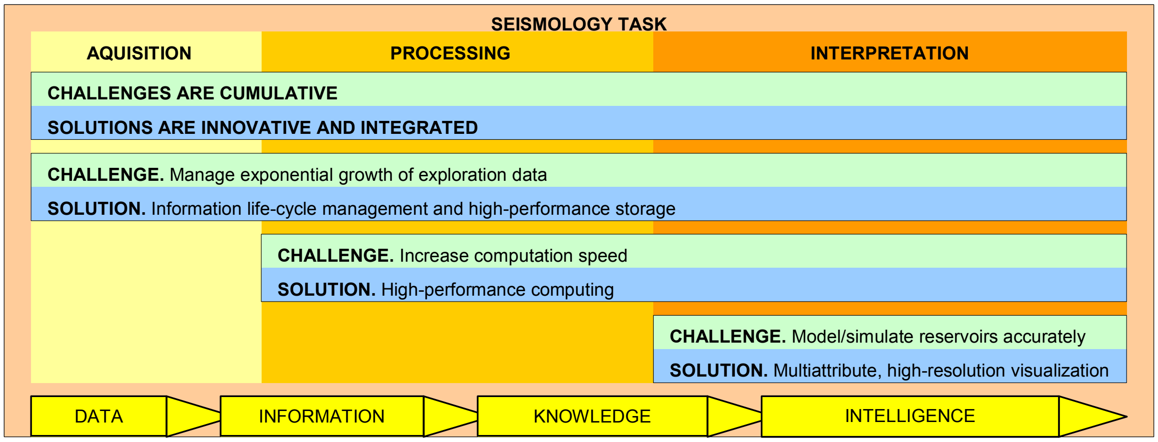
Challenges and Solutions — Accelerating Data-Centric Seismic Interpretation

The basic purpose of seismic interpretation is to extract all available geological information (e.g., structure, stratigraphy, rock properties, and reservoir changes in space and time) from the seismic data for reservoir modeling and simulation. The knowledge of experts in different fields of seismology needs to be synthesized in order to gain insight into a comprehensive and accurate picture of the reservoir.

Once this basic knowledge is obtained, it can be used to make decisions and to enhance reservoir recoverability. A number of IT challenges must be overcome to improve the accuracy and speed of seismic interpretations. These challenges include managing dynamic access patterns to exponentially growing long-term storage, increasing the computation speed for seismic processing and reservoir simulations, and visualizing complex multiattribute data sets at very fine granularities. Figure 1 illustrates how it is possible to address these challenges by integrating recent technological innovation in information life-cycle management (ILM), high-performance storage, HPC, and visualization into solutions that accelerate the end-to-end workflow.

FIGURE 1

Leveraging Innovation in Technology and Integrated Workflow to Meet Data-Centric Seismic Interpretation Challenges



Source: Energy Insights, 2006

Information Life-Cycle Management

One global major oil and gas company has reported data volumes of greater than 350TB for 50 3D seismic projects and in excess of 10TB for 100 reservoir simulation models. With the advent of production optimization techniques that leverage seismic surveys from different times during the life of a field, it is increasingly important to have previous generation seismic surveys and reservoir models available to asset teams.

ILM allows oil and gas companies to maximize the business value of information while minimizing the total cost of ownership (TCO) by ensuring that data is stored in a service-level tier appropriate for its business value, and that it is accessible according to the needs of the business at any point in time during its life cycle. A tiered storage architecture coupled with hierarchical storage management, backup and disaster recovery software will allow the industry to manage large amounts of seismic data, increase I/O performance, improve reliability, and reduce the cost of system outages.

High-Performance Storage

Today, acquired, processed, and interpreted seismic data is stored in a wide range of devices and locations within a company. Efforts to improve workflows and maximize geoscientist productivity create a very strong need for multiple systems from multiple vendors to access information from large, common file systems. Seismic processing and reservoir simulations require very fast I/O rates from disks to single systems and clusters of blade computers, while geoscientists need to access those results from their desks and team-room environments.

Seismic information can be accessed at fast I/O rates by both seismic processing systems and interpreters with scalable network-attached storage (NAS) solutions or storage area network (SAN) solutions that allow much faster access to data when systems and storage are located in close proximity to each other. Optimal solutions can be created that combine SAN and NAS functionality, allow direct access from multiple systems from multiple vendors, and eliminate the storage capacity and I/O limits found on most NAS-only solutions. These solutions enable simultaneous reading from and writing to multiple parallel redundant arrays of independent disks (RAID), substantially increasing overall I/O capability.

High-Performance Computing

Seismic processing of acquired data involves wavelet adjustments, travel time corrections, amplitude corrections, and noise reduction. Additionally, during the interpretation phase, image processing is required for edge detection, coherency, Hilbert attributes, shadow processing, smoothing, lateral gradient operations, and convolution. A medium-size 3D prestack depth migration data set can involve floating-point operations to the tune of 10^{14}. This might take a PC nearly an entire year to process. Certain types of operations such as prestack migration and advanced tomography require the entire data set to be held in memory (i.e., RAM). The inability to do so leads to significant processing bottlenecks and disk I/O issues.

In order to reduce the time taken to process data at various stages of the seismic processing and interpretation workflow, it is critical to increase the number of floating-point operations per second (FLOPS) available to a range of seismic processing and interpretation applications. Since not all applications have the same compute, I/O, memory, and communications profiles, a mix of symmetric multiple processors (SMP), cluster, and hybrid SMP/cluster systems that are capable of leveraging high per CPU performance and interconnect bandwidth will be required.

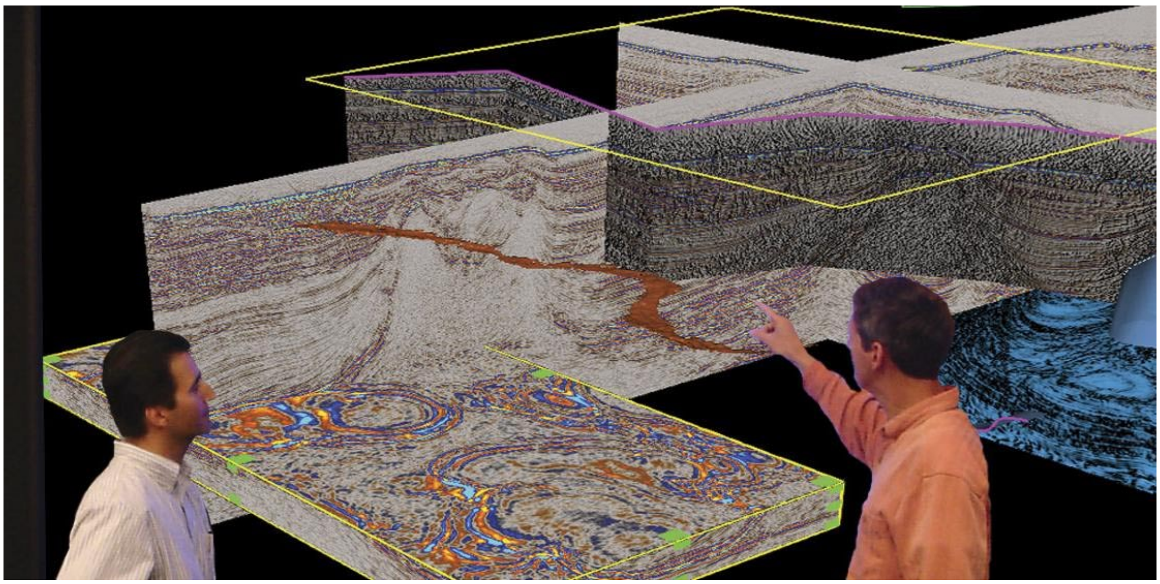
Multiattribute High-Resolution Visualization

The ability to visualize reservoir properties at high resolutions allows the geological and geophysical community to make accurate geo-spatial predictions. This technology has been critical in extracting knowledge from exploding amounts of subsurface data and reservoir simulations, has resulted in more accurate drilling and higher recovery rates, and has reduced ecological impacts in sensitive locations.

The next frontiers in visualization are to combine multiple seismic attributes into a single virtual attribute, to do this over regional distances, and to make these combined capabilities available to every person and team that needs them. When combined with increasingly affordable group visualization environments, oil and gas companies of all sizes should be able to exploit collaborative synergies that result in better decision making and increased operational efficiency. Figure 2 illustrates how visualization, high-performance storage, HPC, and visual area networking can be orchestrated to render powerful images in a team room visualization theatre.

FIGURE 2

Accurate and Timely Interpretation Resulting from Innovation and Enhanced Workflow



Note: An interpreter explains the presence of sandy flow channels within a reservoir to other experts within a team room. Seismic processing is done on an SGI Altix HPC system, while the visualization is created using a Silicon Graphics Prism and Visual Area Networking delivers it to individual desktop users.

Source: Landmark Graphics, 2006

Innovation Through Integration and Intuitive Workflow

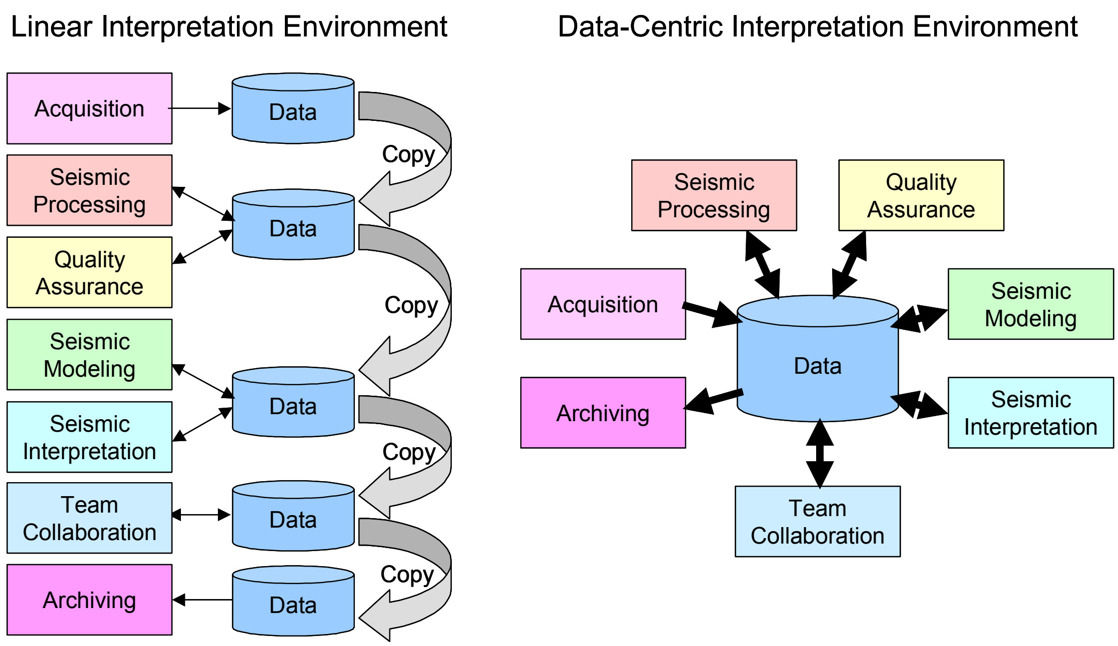
Oil and gas companies are simultaneously addressing workforce shortage issues and the demand for more oil by optimizing the collaborative efforts of subject matter experts on a wide range of reservoir projects. The industry is aggressively working toward reducing the total time from acquisition of seismic data to final interpretation. Simultaneously, a push to increase ROI from IT investments is leading to standardization initiatives that simplify end-user computer hardware throughout organizations. These business drivers often appear to be in conflict, but the previously mentioned solutions in the areas of storage, computing, and visualization are presenting new ways to integrate existing technologies and address these problems.

For instance, oil and gas companies that take a data-centric approach to their upstream workflow can use a SAN to integrate and simplify their data archives while eliminating data access bottlenecks between seismic processing and interpretation. By then using visualization servers connected to the same SAN and visual area networking (VAN) technologies running on those servers, end users are able to visualize extremely large data sets without copying the data to individual desktops. This approach leads to acceleration of the entire seismic interpretation process because of reduced network traffic.

At the same time, IT departments are able to meet their ROI and efficiency standards by replacing expensive workstations historically used by the interpretation community with lighter, cheaper desktops. Figure 3 illustrates the difference between traditional, linear seismic interpretation and data-centric seismic interpretation.

FIGURE 3

Traditional, Linear Seismic Interpretation Compared with a Data-Centric Approach



Note: Data Centric Seismic Interpretation makes data uniformly available throughout the enterprise, eliminates data copying, simplifies data management and accelerates the interpretation of regional, multi-attribute seismic surveys.

Source: Energy Insights, 2006

CONCLUSION

Key Technologies Enhance Interpretation

The four key technology fields — information life-cycle management (ILM), high-performance storage, high-performance computing (HPC), and visualization — play a pivotal role in increasing the speed and accuracy of seismic interpretations. To maximize ROI, it is important to build an innovative workflow on a foundation that integrates these technologies.

- ILM can help increase labor productivity and reduce labor costs by reducing the time spent by technical staff finding and manipulating data. ILM also serves as a useful methodology for controlling the cost of procuring and managing storage systems.

- High-performance storage and SAN technologies reduce disk I/O bottlenecks that can undermine the gains realized through HPC and interpretation.

- HPC can significantly reduce the time taken for seismic processing and interpretation. This allows interpreters to iterate and fine tune geologic models, the resulting reservoir model, and its long-term simulation multiple times leading to more accurate interpretations. Cutting processing time has an immediate and direct impact on costs as well as on the productivity of G&G professionals.

- High-resolution, multiattribute visualization improves the accuracy of pinpointing geological features and helps develop a better understanding of reservoir dynamics. Visual area networking allows end users to take advantage of centralized visual servers with fast I/O, scalable compute, and large memory so they can visualize large data sets on light-weight desktops without moving the entire data set across the network. The collaboration capabilities of VAN also foster collaboration among a shrinking workforce of domain experts.

In summary, data-centric seismic interpretation can lead to reduced interpretation times, greater leverage of experts, increased recoverability and reduced exploration costs. This drives increased revenue at a lower cost per barrel of oil, thereby paving the way for sustained profitability and competitive advantage.

Next Steps to Empower G&G Professionals

Management at oil and gas companies should review their needs to increase productivity from an increasingly scarce pool of geophysical experts and determine what role a data-centric seismic interpretation workflow should play. They should then work with their existing vendors to see how existing resources can be molded into an environment that supports a data-centric workflow and evaluate the impact of additional technology investments on productivity, operating efficiency, and total exploration costs. Finally, they should develop feedback mechanisms involving the IT support staff, engineers, and scientists to qualitatively and quantitatively assess the impact that new technology investments have on accelerating and improving the accuracy of seismic interpretation.