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Interpretation of Very Large Datasets in a High-Performance Visualization Environment

Robert S. Hobbs and Dan F. Knupp

Veritas Exploration Services, Houston, USA

ABSTRACT

The necessity to interpret massive 3D datasets has created a need for new innovative ways to visualize, and interpret these volumes. Time constraints placed upon explorationists to evaluate large exploration blocks on a very tight time schedule has also required a paradigm shift in the way datasets are evaluated. The need to shorten cycle time between seismic data acquisition and well location determination requires a facility and environment in which multi-disciplinary teams can integrate various data types into a unified interpretation. New interpretation techniques combined with careful calibration of rock properties with seismic also are enabling interpreters to extract more information than ever before from 3D datasets. To implement these new interpretation techniques however, careful consideration should be made on facilities design as well as computer architecture. This paper will present a collaborative interpretation and visualization environment and discuss ways in which super-large 3D datasets are being rapidly interpreted in that environment**.**

INTRODUCTION

The sizes of 3D seismic datasets that exploration organizations are charged with interpreting are becoming ever larger. This is especially true in areas such as the deepwater Gulf of Mexico where the availability of regional, non-exclusive 3D datasets of up to 4000 km^2 have become available and are in common use by mid to large size exploration organizations. Many of these companies partition these datasets into smaller volumes in order to conserve computing resources or to more efficiently allocate manpower to unique geologic subareas. While this partitioning might seemingly allow for more effective resource management, it creates the inability to interpret the dataset in a regional context.

In the offshore of Latin America and West Africa, several proprietary 3D datasets of comparable scale have been acquired or are in progress. The cost of acquiring and processing these 3D's can reach US $5000 / km^2. The concessions on which these datasets will be acquired face extremely short exploration periods. With traditional methods of interpretation, a significant portion of the acquired volume often remains uninterpreted due to limitations in the ability to rapidly visualize the data. Any interpretation method that can shorten cycle time from seismic processing to lead identification, and at the same time, assure that the entire data asset has been examined, has value.

Several software applications are available that allow volume visualization and interpretation of 3D volumes. Each application is fundamentally similar. The primary difference between these applications is the ability to handle differing volume sizes. Typically missing in organizations that are using such software, is a facility where entire asset teams can interact with the same dataset and arrive at a single unified interpretation.

SEISMIC VOLUME VISUALIZATION

Until recently, 3D seismic datasets have been interpreted in much the same way as 2D datasets. 2D slices from the 3D volume are displayed from any orientation (time slices, inlines, crosslines, and traverses). The use of computer workstations has increased flexibility in the way that the 2D seismic slices are displayed. These workstations have also dramatically improved the speed at which the 2D slices can be pulled from the dataset and digitized. The digitized surfaces are then loaded to mapping software and 3D structure maps or attribute maps are made.

Recent software available on the market has now made it possible to visualize 3D datasets as voxel volumes in which the data is represented as discrete 3-dimensional pixels. Great care must be made to scale the seismic and accurately tie available well data into the 3D voxel volume. Once this scaling is properly performed, any seismic attribute response or waveform can be visualized and matched with a predetermined color signature identical to synthetic modeled responses. The techniques for calibration of the well and seismic data are highly model driven, and high quality seismic and log data integrity are critical success factors in obtaining reliable results. Color variations in the visualization volumes can be adjusted to reflect subtle changes in amplitude. These variations can reflect reservoir fluid content or variations in physical properties such as reservoir porosity, sand percentage thickness, and other lithologic variables. These data volumes are displayed with varying amplitude ranges excluded so that the interpreter can actually see deep down into the volume and isolate (in 3-dimensions) zones of anomalous amplitude (fig 1).

Seismic volumes can also be co-rendered together. This is especially useful where velocity models for depth migrations must be checked against the actual seismic data, such as in a post-stack depth migration. The velocity model and depth migrated dataset are loaded as SEG-Y files and then displayed as voxel volumes in the same 3D space. The display of structural horizons and the ability to illuminate and manipulate those horizons in 3D space are also critical for the QC of the seismic interpretation. Where non-geologic features are observed in the interpretation, the seismic is displayed in voxel format and the horizons are then edited until a geologically reasonable answer is obtained.

Super-large 3D volumes that cover over 4000 km^2 are routinely interpreted in the visualization center in this manner. Where it might take an asset team weeks to arrive at a regional structural interpretation on such datasets, by visualizing the properly scaled data as voxel volumes of varying opacity, regional structural interpretation and lead reconnaissance can be accomplished in a matter of days and sometimes, hours. Application of this visualization technique dramatically increases the amount of information that the interpreter can extract from the dataset as opacity and color settings can be adjusted in real time to enhance very subtle features in the seismic data. Structural relationships between these geologic features become immediately obvious when these opacity volumes are rotated in three dimensions. After this regional reconnaissance, datasets are then often partitioned and distributed between individual interpreters for more detailed work. This partitioning has the benefit of being based upon geologic information derived from the dataset itself rather than being related to more arbitrary criteria such as political or data boundaries.

COLLABORATIVE ENVIRONMENT

A flexible computing environment that is centered around high capacity graphics supercomputers has been built to visualize and interpret these very large 3D datasets. The network allows for datasets as large as 12 Giga-bytes to be held in memory and visualized in real time. The backbone of this network is a Silicon Graphics Onyx2^{TM} RealityMonster^{TM} graphics supercomputer. The Onyx2^{TM} has a 16 Gigabytes of RAM and three graphics pipes. This computer is connected by fiber link to a 2.2 Terabyte RAID Disk array. In addition to the Onyx2^{TM}, Silicon Graphics Octane^{TM} workstations are tied to the network and used to interpret and visualize smaller data volumes.

Connected with the network, a facility has been built to allow multi-disciplinary teams to interact with integrated datasets. At the center of this environment is a visualization theater with an 18-foot by 7-foot flat screen. The flat screen gives the advantage of minimizing distortion regardless of the observer's viewpoint, making this center more suitable for collaboration. Images are projected from behind the screen to allow for entire groups of people to gather and discuss details regarding the dataset without the users themselves casting a shadow on the image (fig. 2). Two LCD projectors, that operate at 1024 by 1280 resolution, cast images onto the screen. Each projector can display a single image (as if the screen were a double-headed workstation) or a single image can be stretched across the entire screen for the visualization of large volumes or regional slices. The high resolution and large screen format allow for detailed interpretation of the data (for example the interpretation of subtle amplitude variations) while still not sacrificing the regional context of the dataset.

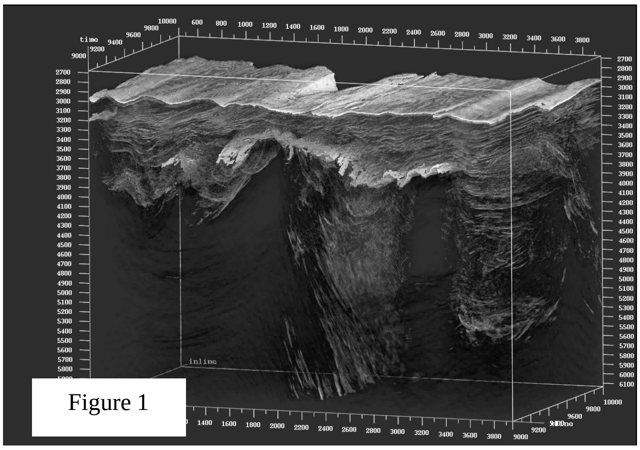

Figure 1

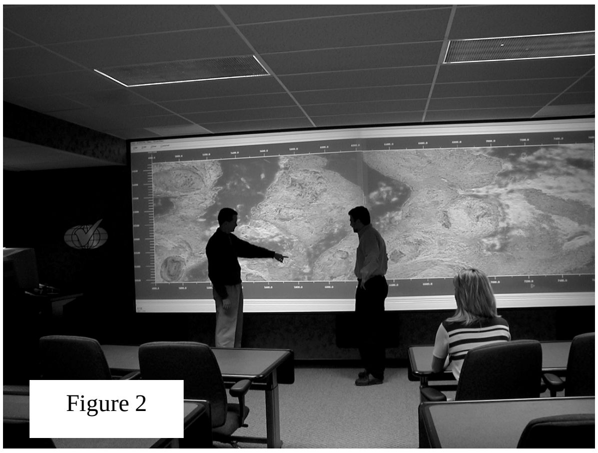

Figure 2

Keyboards and mice are distributed throughout the theater and allow multiple users to interact with the data being displayed on the screen. Up to 35 interpreters can participate in the visualization of data in the theater and up to nine users can interact with the data in an interpretation session.

For the benefit of smaller asset teams that require a more intimate interpretation environment, private workrooms have been constructed. In each of the workrooms, 37" data monitors allow high-resolution visualization in a private setting. All of the workstations in the private rooms are tied to the Onyx2^{TM} via a matrix switching system. This configuration enables a user to work on any or all of the Onyx2^{TM} graphics pipes or Octane^{TM} computers from a single seat.

CONCLUSIONS

The speed and efficiency of interpreting large 3D seismic datasets is dramatically enhanced through the architecture and environment of the visualization center described in this presentation. A truly collaborative environment has been created where multi-disciplinary teams can gather and create unified interpretations of large 3D datasets. The network architecture allows for huge volumes to be loaded into memory and visualized so that voxel displays can be manipulated in 3D space and complex structures can be rapidly understood prior to more detailed mapping. Calibration and scaling of the seismic data with available well control is essential. Visualizing accurately scaled datasets in the appropriate environment with proper interpretation and systems expertise dramatically shortens cycle time between seismic acquisition and lead identification.

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