Interpretation Methodologies Utilizing 3D Visualization Tools

Edward Jansen, Schlumberger Serviços de Petróleo, Brazil

Copyright 2003, SBGf - Sociedade Brasileira de Geofísica

This paper was prepared for presentation at the 8th International Congress of The Brazilian Geophysical Society held in Rio de Janeiro, Brazil, September, 14-18, 2003.

Contents of this paper were reviewed by The Technical Committee of The 8th International Congress of The Brazilian Geophysical Society and does not necessarily represents any position of the SBGf, its officers or members. Electronic reproduction, or storage of any part of this paper for commercial purposes without the written consent of The Brazilian Geophysical Society is prohibited.

Abstract

New technologies in 3D visualization are improving the way interpreters view and analyze their data. The use of 3D visualization does not automatically result in greater productivity however. One must learn how to use the many tools available and combine the use of those tools into various workflows. Then interpreters will experience a real step change in the interpretation process.

This paper includes examples of the application of various 3D visualization interpretation tools that greatly enhance the interpretation workflow for a quicker and more thorough understanding of the structural and stratigraphic complexities of the data.

Introduction

Interactive workstations had a profound impact on 2D and 3D seismic interpretation efficiencies throughout the 80's and 90's. Initially the methodologies of interpretation used on paper were replicated on the workstation. Gradually new methodologies were adopted as interpreters mastered new software tools. Basic 3D visualization tools were introduced in the early 90's but their use in the interpretation process was generally limited due to hardware and software limitations. Hardware and software have now evolved to the point where seismic interpretation efficiencies in the 3D workspace are producing another step change in the interpretation process.

Fault Interpretation Technique

Fault plane interpretation is one example where efficiencies can be greatly improved and this is especially true in areas of complex faulting. Interactive manipulation of seismic probes and multi-attribute blending of seismic with edge detection data are visualization tools that rapidly build an understanding of the fault relationships. This should be coupled with automatic fault plane gridding and multi-dimensional restricted interpretation displays to allow for a more efficient interpretation workflow.

An example of a useful workflow is illustrated in Figure 1. This tecnique utilizes reflectivity seismic on the vertical panels and blended reflectivity with edge detection data in the time slice orientation. The three panels may be interactively panned individually to investigate fault relationships and make selective interpretation as necessary to define the fault planes. The slice panel can be interactively blended between reflectivity to optimize the visualization of the fault trend. The fault interpretations are displayed using an areal restrict technique to more easily work with many faults simultaneously and with the added information of how the faults are orienting away from the plane of seismic. As the interpretation progresses the fault plane continually updates and may be extrapolated to help with locating the fault in advance of the interpretation.

Rather than following a traditional approach of interpreting sequential lines, a combination of selective vertical interpretations are made combined with slice interpretations guided by the edge dection data. Once an area of faulting has been completed the three panels may be grouped and moved together as a unit to another area of the seismic cube for further interpretation. The resulting interpretations are generally of significantly higher quality and completed in a fraction of the time typically spent.

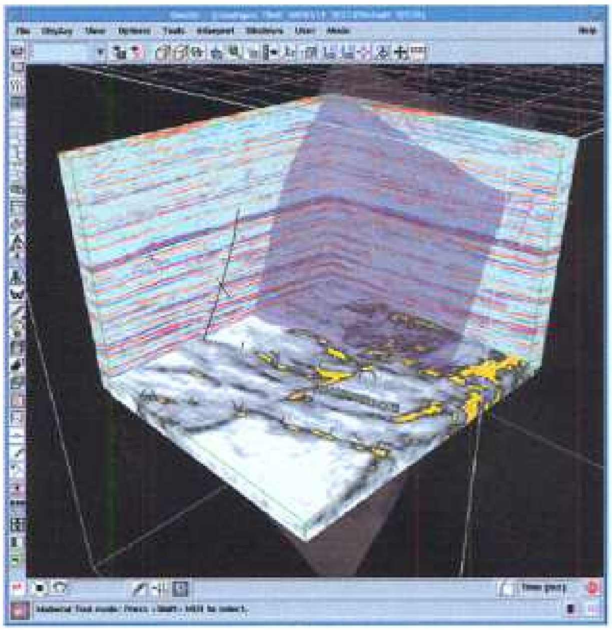

Figure 1. *To facilitate fault interpretation, 3 probes are grouped, fault interpretation are made and fault planes are autimatically updated.*

Structural Surface Interpretation Technique

Horizon surface interpretation technique is highly dependent on data quality and character. Since data characteristics typically vary across the survey for any given reflector, generally a best practice is to use a combination of interpretation tools. The additional advantages of picking in the 3D workspace with 3D volumes are the quick response times of the picking algorithms and the visual tools for quick quality control.

Schlumberger Private

The shape of the entire picked areas may be visually observed and slice panning may be used for the comparison of picks to the data.

Where amplitudes are relatively continuous, simple voxel picking techniques may prove sufficient. This technique involves placing one or more seed points on a reflector and using amplitude thresholds to control the picking range. Additionally it is often helpful to include a secondary volume such as edge detection data to introduce additional thresholds to limit the area of picking. Once these areas of more continuous amplitude have been picked, the already picked areas may then be used as the seed points for more sophisticated picking controls. Trace signature comparison based on cross correlation is one of the most useful tools. This should be combined with other controls such as instantaneous phase attribute comparison for more areas of even lesser continuity.

The best approach generally is to begin the volume surface picking with more conservative controls and then adjust the controls using previous attempts as input (seeds) for subsequent iterations. The use of trace array threshold comparisons is an additional control that is useful for this methodology. The picking should begin by using a larger trace array such as 5X5, subsequently reducing to 3X3, and finally terminating with a simple trace comparison.

For areas where horizon quality is extremely poor, polygons may be defined to restrict the picking region. These areas may then be manually picked on an appropriate line increment and then interpolated or gridded. After interpolation an event-snapping algorithm is used to search for the desired event and amplitudes are optionally extracted.

Stratigraphic Interpretation Technique

Stratigraphic Interpretation is greatly facilitated by using the 3D visualization workspace. Many different 3D display techniques may be used to more quickly understand depositional environments and geometries. Subsequently 3D picking techniques may be used to interpret stratigraphic regions and boundaries. The integration of the complete spectrum of geologic data is available so direct correlations can be made with for example, log data, cross-sections, and satellite images.

Volumes-cut displays are useful for searching through volumes parallel to structural interpretation. The seismic volume is stripped away by horizons or faults and then scanned for stratigraphic or fluid features.

Voxel type displays are most powerful for exploring the data for amplitude anomalies and stratigraphic footprints. The opacity of the data is interactively adjusted to explore different regions of the seismic amplitudes. Appropriate color spectrum selection is an integral part of this process. Colors should be graphically adjusted with the displayed regions of interest to help emphasize the seismic character. Regions of the seismic volume can then be explored with the aid of seismic probes or thick slice panning. There is a direct dependency on the graphic display capabilities of the workstation being used so the user must test various software parameters to discover which work best on the particular workstation.

Multiple attribute volumes may be blended using various techniques to help visualize stratigraphic features. The picking on these volumes may be controlled by parametric limits on one or two loaded volumes.

A newer and more powerful technique has more recently been introduced using a third party plug-in application. Rather than manually interpreting anomalies, the program may be used to automatically search for, and interpret all anomalies in a given volume fitting certain user-defined criterion. The interpreter may then use many additional tools to QC and analyze the results. Since these techniques are executed utilizing memory-loaded volumes, the speed of evaluation and analysis are greatly enhanced.

An example of application is illustrated with a South African data set in a turbidite sequence. Here many stratigraphic bodies were easily isolated utilizing automatic volume detection techniques. An illustration of some different isolated features is shown in the figure 2. Separate stratigraphic bodies are analyzed by the software and colored differently to better visualize the results.

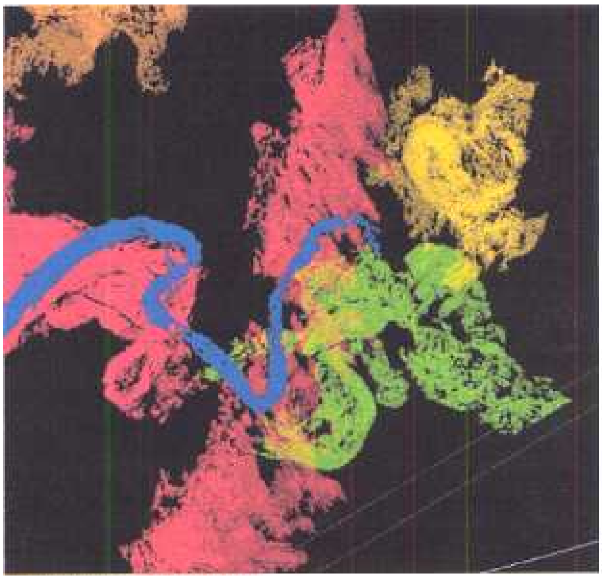

Figure 2. Turbidite channel interpretations that were made with automatic detection algorithms.

Summary and Conclusions

In this paper it is shown that 3D visualization greatly facilitates many phases of the interpretation process, including fault interpretation, structural horizon interpretation and stratigraphic feature interpretation.

Acknowledgments

I would like to acknowledge that this paper utilized the capabilities of commercial applications of Schlumberger and Foster Findlay Associates.