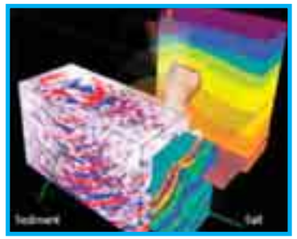
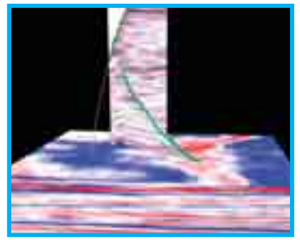
Data Visualization and Integration

Model and post migration image data is displayed in 3D using the VISUS 3D visualization tool designed by VSFusion geophysicists and built by GeoTomo LLC. VSFusion geophysicists use VISUS to view the post-migration 3DVSP image displayed with the wellbore, well logs, source and receiver information, geological model, and if available, the surface seismic data volume.



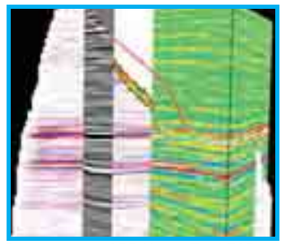
VSP and Surface Seismic and S wave VSP data



VSP and Surface Seismic 3D volume

EasyViz[3D] Interactive 3D Visualization

VSFusion can also provide the migrated seismic image volume as a 3D interactive data file. This is a single data file that when executed will display the 3D VSP image data embedded in the GeoTomo LLC VISUS 3D visualization program. The patent pending EasyViz[3D] interactive 3D dataset is a revolutionary way to present VSP data. The file allows the customer to not only view data in 3D, but to manipulate the 3D datasets interactively for presentations, displays, and interpretation.



Data courtesy of BP Norge, Total E&P Norge, Amerada Norge, Norske Shell

The VSFusion VS3[SM] system contains all of the tools necessary for optimal 3D VSP processing in a single integrated system.

Quick data turnaround, full waveform vector imaging, and 3D data presentation combine to make the 3D VSP survey a practical technology for enhanced subsurface understanding.

VSfusion
A Baker Hughes - CGG Company

GeoTomo

www.vsfusion.com
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VSFusion VS3[SM] System

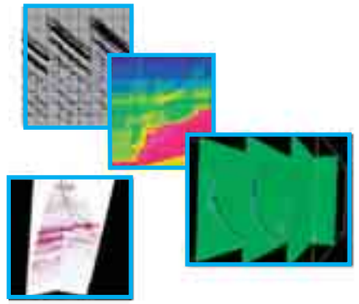
Practical 3D VSP Processing

VSFusion VS3SM System - Practical 3D VSP Processing

VSFusion has designed and integrated several component systems into the VS3SM 3D VSP processing system to provide a superior image and rapid 3D VSP survey turnaround.

VS3SM focuses on:

- Detailed 3D pre-survey modeling
- Efficient and accurate data pre-processing
- Optimizing the velocity model for more accurate imaging
- Anisotropic Wave Equation Migration and 3C-3D Vector Migration
- Flexible 3D image presentation



Pre-Survey Design

The first priority in any 3D VSP project is to ensure that the objective will be met by the acquisition design. To accomplish this task, an accurate and flexible modeling tool must be used to design the VSP survey geometry. The VSFusion VS3SM system utilizes the GeoTomo LLC VECON system. VECON is a built-for-purpose 2D/3D VSP modeling system designed by VSFusion geophysicists.

- The 3D model can be quickly built using all types of available geologic and geophysical support data.
- Source and receiver geometry configurations are easily specified and modified.
- Ray tracing (isotropic and anisotropic) is performed to verify target resolution and map subsurface illumination.
- Full wave elastic finite difference modeling can produce 3C synthetic seismograms.

VECON 3D Salt Model showing 3D VSP raytracing.

VSP Pre-Processing

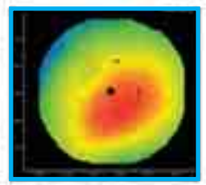
Geocluster™ is the industry-leading comprehensive seismic processing system designed and owned by CGG. It contains hundreds of seismic processing modules designed for 2D and 3D seismic processing. In addition to these modules, Geocluster contains a full suite of borehole seismic-specific processing modules. Geocluster utilizes the speed of Linux PC clusters to quickly run the most demanding seismic processing functions. A full suite of analytical tools are also available in Geocluster to extract the information inherent within a 3D VSP, such as travel time maps, rock property maps, and inversion.

Having access to CGG's extensive experience in 3D seismic processing has allowed VSFusion to set up an extensive library of job-flow templates. This allows us to apply the proper processes to the data and easily manage large volumes of data. This drastically cuts the cycle time from raw data to reflection data ready for imaging.

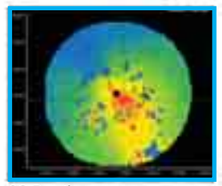
CGG Geocluster – flexible and powerful seismic processing system

- Rapid turnaround of large datasets using optimized batch processing flows
- Full suite of analytical tools for data QC and information extraction

Amplitudes



Arrival Times

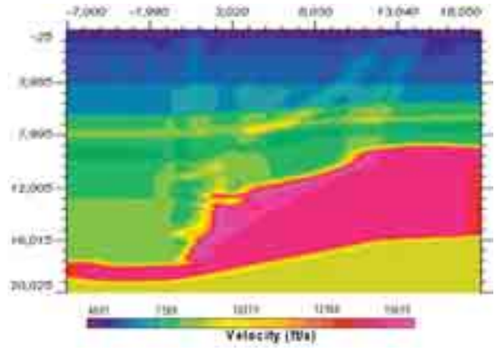


3C Rotations

Model Update and Validation

After the 3D VSP is acquired, additional information is available to either corroborate the model or to suggest changes. First arrival times as well as reflection arrival times contain valuable information that can be used to provide better velocity and structural resolution than was previously available before the survey was acquired.

The VS3SM system uses the GeoTomo LLC VELMAP program to perform 3D non-linear travel time tomography and refine the original pre-survey velocity model. Since all of the VS3 modeling software is integrated, this becomes an efficient process. While the 3D VSP data is being processed, the travel time data can be read into VELMAP and 3D travel time tomography used to update the velocity field around the well. The resulting high resolution velocity model will be used for imaging the 3D VSP data.



Travel time tomographic model construction - 2D and 3D.

3D VSP Migration

The heart of any 3D VSP processing system is the 3D migration imaging application. VSFusion offers two state-of-the-art solutions for 3D VSP migration.

WaveVista

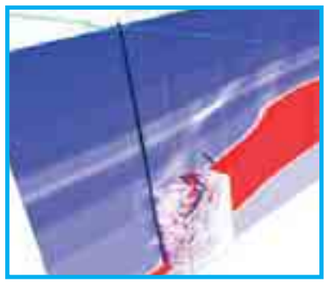
Wave equation migration has become the industry standard for accurate depth migration. Its ability to preserve the shorter wavelength, higher resolution seismic characteristic of 3D VSP data, together with the potential to resolve very complex structures, make this technique far superior to standard single component Kirchhoff migration. Wave equation migration is very efficient for 3D VSP geometries where there are typically few receivers and many sources. VSFusion is proud to offer the VSP industry the CGG WaveVista™ anisotropic wave equation migration for 3D VSP imaging.

VS3SM 3C-3D VSP Vector Migration

The multi-component, 3C-3D VSP Vector Migration, offered exclusively by VSFusion, is a patent pending, proprietary application developed to maximize the full potential of the 3-Component vector wavefield data. The VSFusion vector migration produces a true directional 3D depth migration image.

The VSFusion vector migration uses a dynamic, vector energy mapping method to position each time sample to its true reflected 3D image point, instead of positioning the sample uniformly at each point on the 3D diffraction spheroid. This reduces unwanted data smearing and eliminates the mirror image reflection points inherent to standard 3D Kirchhoff migration. This method likewise overcomes the weaknesses of using only a single component trace, or in using pre-rotated three-component traces. The result is a less ambiguous, full amplitude 3D image of the subsurface.

3C-3D Vector Migration of 3D VSP using S-Wave (salt flank) and P-Wave (sediments). Courtesy of OPEX.



3C-3D Vector Migration results from two line walkaway and offset VSP data. Courtesy of Anadarko.

Geocluster and Wavevista are trademarks of CGG.