GeoDepth Tomography

Focusing the seismic image for a truer geological understanding of the subsurface

Seismic tomography, part of the state-of-the-art GeoDepth™ velocity modeling system, enables geophysicists to update the industry's largest velocity models - including velocity heterogeneity and anisotropy – efficiently and accurately. The unique set of input data provided by the company's seismic imaging solutions (including full-azimuth image data), together with first break picks, well information and a geologically constrained approach, delivers the most geologically plausible velocity model.

GeoDepth Tomography is designed to handle all velocity environments, including extremely difficult scenarios involving strong lateral heterogeneity and considerable anisotropy, structural model complexity, and shallow velocity anomalies with rough topography. It enables consistent and efficient conversion of isotropic models to VTI/TTI anisotropic models and their update, ensuring the best positioning for reservoir targets. High-resolution calculation grids (depth varying) provide accurate velocity models in surveys of any size, especially in shallow areas.

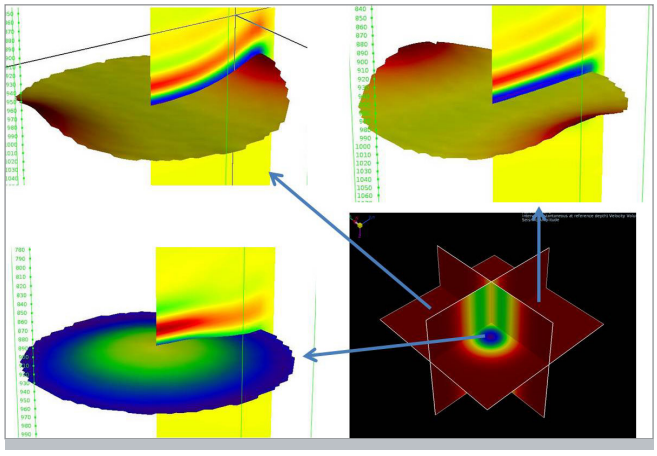
The technology supports 2D multi-line grid-based, 3D grid-based, 3D model-based, and hybrid tomographic methodologies, customized to the problem at hand. Grid-based 2D and 3D tomography share the same workflow, user interface and parameters, making them easier to both learn and use. 2D grid tomography provides a multi-line capability that enables work on a large number of lines (from a few dozen up to several hundred) with minimal user intervention.

GeoDepth Tomography offers a powerful combination of high-performance cluster computing, rich bottom-up reflection ray tracing in all azimuths and angles, automatic reflection patch picking (poststack) and residual moveout picking (prestack), and anisotropic model parameter picking. Supported prestack data includes 2D offset/angle gathers, 3D full-azimuth reflection angle gathers, and sectored offset/angle gathers.

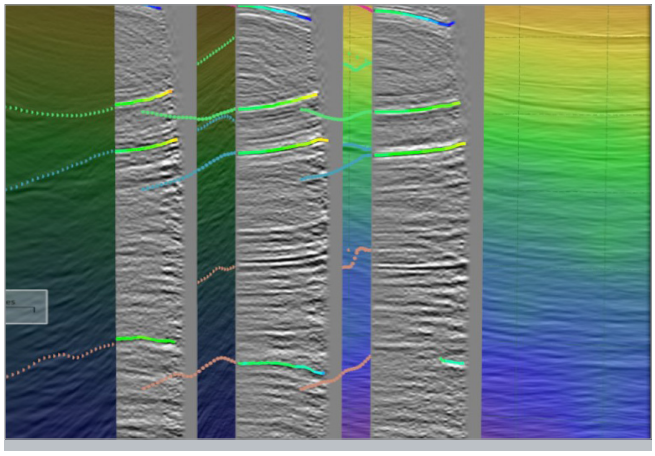
Comprehensive Visualization and Interpretation

The 3D Canvas window provides a comprehensive visualization and interpretation system to analyze, QC and edit the automated RMO picked data. The rich 3D environment enables the display of RMO curves along a massive amount of gathers, and enables filtering out outliers according to predefined QC attributes.

All information, including picks and associated attributes such as dip, azimuth and continuity of reflecting surfaces, surface



▲ Wide-azimuth EarthStudy 360 gathers used for high-resolution velocity updates



▲ 2D grid tomography

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ID, residual velocity and others, is stored in a Pencil Database. The information can be extracted using either volume-based (ImageDAC) or reflector-based (ImagePICK) operations. The extraction procedure is parallelized, for added efficiency.

GeoDepth tomography enables the performance of multiple inversions to solve the tomography equations, with different geological constraints applied independently to each geological layer or model creation of complex geology.

Velocity Model Updates for Complex Models

Enhanced integration between GeoDepth and SKUA™ structural and stratigraphic modeling enable model-based tomography to be run on complex SKUA-generated models, including faults and multi-value surfaces, for structural and stratigraphically constrained velocity models. Three component displacements from model-based tomography can be used to generate updated depth T-surfaces for horizons/faults, and then used in SKUA to rebuild the model. The geologically-consistent updated velocity model fully honors the structural complexity of the subsurface.

GeoDepth is uniquely able to integrate well information (check shots, VSP data, and well markers) into tomography equations for solving and controlling anisotropic inverted parameters. Integrating VSP data reduces uncertainty in the model building process, resulting in fewer iterations and quicker delivery of the final model.

Tying the horizons interpreted on the seismic image to well markers plays a critical role in the velocity model building workflow, especially in the presence of anisotropy. The aim is to find a velocity model that yields flat gathers after depth migration, and ties to the well markers. Subsurface velocities cannot be uniquely determined by the surface recorded seismic data alone; in such cases, it's possible to find a velocity that will flatten the gathers but not tie to the wells. Well information is used to reduce this ambiguity.

Mis-ties between seismic horizons and well markers are calculated and used as input to well tie tomography to update the velocity/anisotropic parameters, resulting in a velocity model that minimizes the input mis-ties.

Time-preserving Tomography

GeoDepth also offers time-preserving tomography, an efficient and accurate application for simulating different scenarios of isotropic/anisotropic velocity-depth models which are consistent with a given background model. Re-depthing using time-preserving tomography systematically reduces depth seismic-to-well marker mis-ties.

The accuracy and quality of the subsurface seismic image, in particular, the structure, size and shape of the target reservoirs, are highly dependent on the ability to accurately model the velocity distribution of the shallow model.

Refraction and Joint Refraction-reflection Tomography

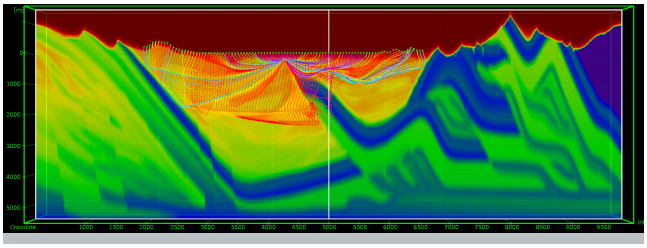
GeoDepth 3D refraction tomography is an accurate and efficient inversion tool for defining shallow high-resolution velocity distribution. Using the two-point ray tracing method to uncover areas with vertical velocity inversions and local lateral anomalies, it is possible to detect shallow velocity complexities, such as hidden channels, gas pockets, permafrost sheets, small faults, etc.

GeoDepth joint refraction-reflection tomography enables consistent construction of the velocity model in both the shallow and deep sections. This strategy increases accuracy, plausibility and resolution in the velocity model and can result in much-improved migrated images.

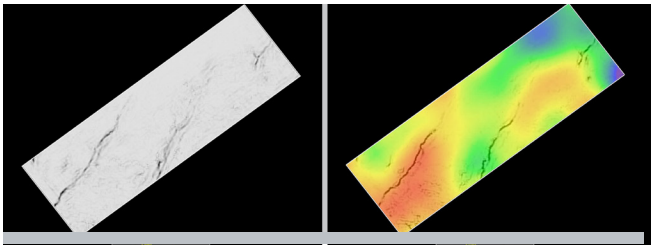
Q Tomography

3D Q Tomography is used to update subsurface attenuation parameters (Q factor). GeoDepth grid-based 3D Q Tomography, the newest addition to the GeoDepth tomography portfolio, provides an accurate Q representation. When input to EarthStudy 360™ Imager, which supports Q compensation, the result is higher-resolution images.

Input to the Q tomography workflow is a measured attenuation property of full-azimuth angle domain gathers from EarthStudy 360. These gathers are 3D in nature and are optimal for this type of calculation. 3D Q Tomography is a global updating method that simultaneously considers input from many subsurface locations, enabling it to produce highly accurate results. 3D Grid Tomography output is an updated Q factor model.



Ray tracing simulating diving waves used for refraction tomography



Left: Coherence attribute run on imaging result without Q compensation. Right: With Q compensation overlayed with updated Q volume. Note improvement to the image and geologically consistent Q result.

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