Schlumberger

Depth Domain Inversion Services

Quantitative interpretation in the depth domain

APPLICATIONS

- Reservoir characterization in complex geological settings
- Determination of acoustic and elastic rock properties from 2D and 3D seismic data
- Seismic amplitude inversion correcting for space-, depth-, and dip-dependent illumination effects

BENEFITS

- Reduced uncertainty in even the most challenging reservoir environments
- Greater accuracy in defining petroleum system components, including migration pathways and trap and seal mechanisms
- Improved fidelity in the determination of acoustic properties, rock properties, and pore volume estimation for more reliable prospect delineation, reservoir properties, and volumetric calculations
- Extension of the value of seismic data from exploration to appraisal

FEATURES

- Amplitude inversion performed directly in the depth domain
- Point spread functions (PSFs) to handle space-, depth-, and dip-dependent wavelet variations
- Linear or full nonlinear Zoeppritz equations
- Dip-dependent reflectivity
- Preconditioning with steering filters
- Integrated workflows in the Petrel* E&P software platform

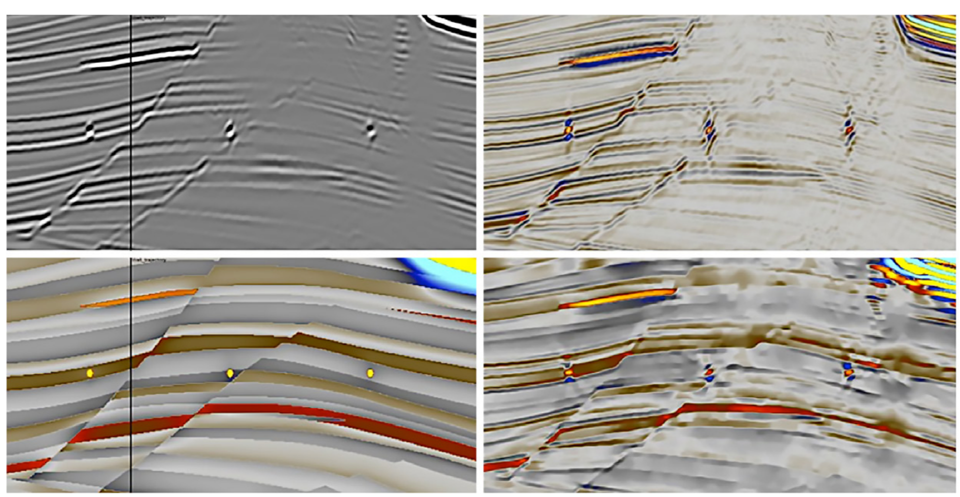
Conventional inversion inadequacies in complex geological settings

Conventional methods of amplitude inversion assume that amplitudes in the seismic image are correctly located and can be inverted to elastic parameters from which a true representation of rock properties can be derived. However, complex geology, combined with limitations imposed by surface seismic acquisition geometries, can lead to inadequate illumination of subsurface targets, which is detrimental to the amplitudes and phase of the migrated image.

Unfortunately, conventional amplitude inversion techniques cannot compensate for these amplitude and phase variations. Consequently, imprints in the seismic inversion of nongeological effects, including illumination, adversely affect the reliability of the estimated acoustic and elastic parameters. In turn, attributes derived from these parameters cannot accurately represent the properties of the corresponding lithology. An additional challenge to accurate amplitude inversion in complex geologic environments is that depth imaging is normally required to obtain a reliable image of the subsurface, whereas current amplitude inversion techniques are usually implemented in the time domain. This difference in approach between the imaging and inversion steps can further compromise the fidelity of the attributes derived from seismic inversion.

Accurate inversion performed in the depth domain

To improve consistency between structural imaging and rock property estimation, Schlumberger has developed Depth Domain Inversion Services. Our petrotechnical experts apply a new workflow for performing amplitude inversion directly in the depth domain. The Depth Domain Inversion Services workflow uses point spread functions (PSFs) to capture and correct for space-, depth-, and dip-dependent illumination effects resulting from the acquisition geometry and complex geology. The PSFs are a representation of the spatially and depth-variant 3D wavelet embedded in the migrated image that replaces the 1D wavelet used in conventional amplitude inversion. The output from Depth Domain Inversion Services is a reflectivity image corrected for illumination effects, and if appropriate well data is available for calibration, a reflectivity image and the associated absolute acoustic impedance (AI) volume are also produced.



In this synthetic example (subsalt RTM), Depth Domain Inversion Services (bottom right) output a better estimate of the acoustic impedance (bottom left) compared with the conventional time domain inversion (top right), both of which resulted from the migrated image (top left).

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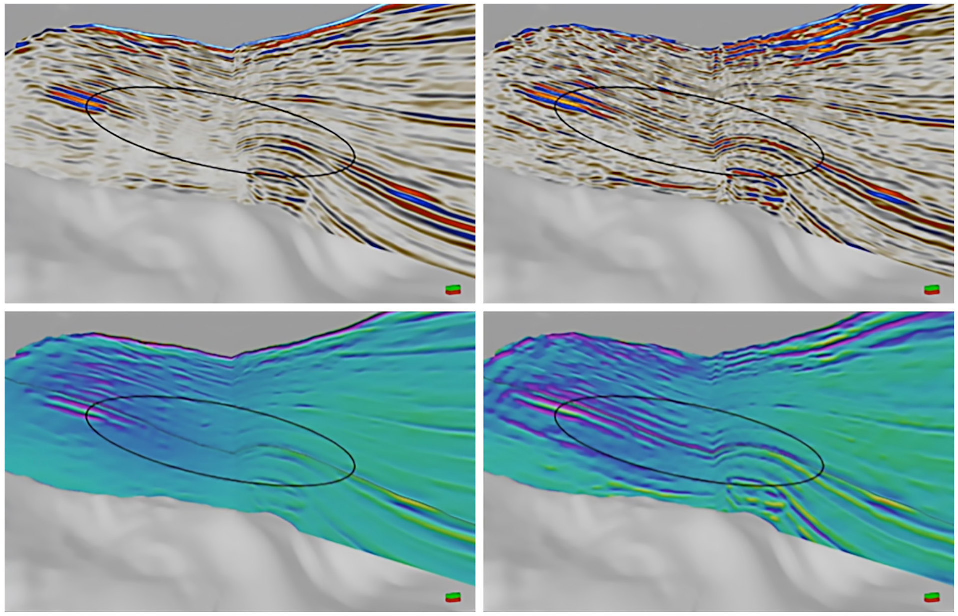
Additional constraints that can be included in the objective function relate to the sparsity of the reflectivity model, lateral continuity of the output along the geological structure, and deviation from a prior low-frequency model. There is also the option to include more sophisticated physics to incorporate ghost effects or attenuation effects. Including such aspects within the inversion provides a mechanism to produce an even higher fidelity inversion output.

Using Depth Domain Inversion Services corrects for illumination effects caused by complex overburden and acquisition geometry to provide a much sharper reflectivity image with better event continuity, more reliable seismic amplitudes, and a higher-fidelity acoustic impedance volume. Our petrotechnical experts perform Depth Domain Inversion Services primarily for poststack acoustic impedance inversion after reverse-time migration (RTM), with extension to perform amplitude variation with offset (AVO) inversion of partial stacks after RTM as well as Kirchhoff depth migration.



Top left: RTM image amplitudes are negatively affected by illumination effects caused by the complex salt overburden. Top right: Comparatively, the reflectivity image output from Depth Domain Inversion Services is significantly corrected for such illumination effects to provide a much clearer interpretation. Bottom: The acoustic impedance volume from the time domain inversion (left) is not reliable—especially around the annotated horizons—compared with the higher-fidelity inversion produced by Depth Domain Inversion Services (right). Data courtesy of Schlumberger Multiclient.

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