TETRA TECH RPS ENERGY | TRAINING

N659: The Interpreter's Guide to Depth Imaging

Instructor(s): Scott MacKay

Format and Duration

Classroom - 2 Days
Virtual - 4 Sessions

Summary

The course begins with understanding the nature of velocities and reviews time-to-depth conversion as a prelude to understanding the limits of time migration. Next, is an intuitive overview of migration theory, Kirchhoff (ray) versus RTM (wave) algorithms, tomographic velocity updates, and advances in full-waveform inversion for the near-surface velocity model and deep velocity updating. It introduces intuitive quality controls and quantitative spreadsheet analysis to plan and ensure stable depth solutions during the iterative depth-imaging process. Advanced database-validation methods, such as cross plots between horizon interpretations and well tops, are used to identify and remove inconsistencies before deriving anisotropic parameters. A related database topic is defining the polarity and phase of the seismic and investigating the importance and precision of synthetic seismogram ties using P Impedance volumes and logs. The course continues with a robust approach to well-top calibration of the final depth deliverables. Additionally, freeware is provided to provide a statistical method for estimating depth uncertainty. Finally, the course reviews advanced attributes derived from depth imaging, including azimuthal inversion to yield lithologic and stress-field (fracture) properties, plus practical aspects of implementing machine learning for classification and estimation.

Business Impact: This comprehensive course equips participants with an interpreter-oriented approach to effectively utilize depth imaging in various geologic settings. Attendees will develop a solid understanding of the theory, practical application, and interpretive aspects of depth imaging, enabling them to expertly design, guide, and quality control depth-imaging projects.

Learning Outcomes

Participants will learn to:

1. Appreciate time-to-depth conversion methodologies.
2. Differentiate between time and depth migration.
3. Distinguish between commonly used migration algorithms.
4. Appraise methods for velocity updating (tomography/FWI) appropriate for the geology.
5. Define target velocity resolution for tomography and related imaging grids.
6. Establish consistency between well tops and horizons in an interpretive database.
7. Plan and review QCs for iterative velocity updates.
8. Assess the methods used for determining anisotropic parameters.
9. Perform well-top calibration of depth-imaging volumes.
10. Evaluate the validity/uncertainty of advanced seismic attributes.
11. Review practical aspects of machine-learning classification and estimation.

Training Method

This is an instructor-led course of 2 days or 4 on-line sessions. Training is conducted with a combination of lectures, demonstrations, and illustrative datasets.

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Who Should Attend

Seismic interpreters incorporating depth imaging into their evaluations, and depth-processing imagers looking to better interact with interpreters. .

Course Content

1. Review of Vertical Time-to-Depth Methods
    - Basic Concepts
    - Velocity field representation
    - Single-layer depth conversion
    - Uncertainty analysis and pitfalls
2. Time and Depth Migration: Comparisons
    - Concepts in time and depth migration theory
    - Contrasts between time and depth imaging
3. Migration Algorithms: Theory and Practice
    - Kirchhoff, Gaussian Beam, 1-way and 2-way (Reverse Time) Wave Equation
    - Offset and angle domains for Common Image Point (CIP) Gathers
    - Anisotropy and Multi-component considerations
4. Migration: Parameter Selection
    - Kirchhoff travel times and Wave Equation imaging conditions
    - Amplitudes, aliasing, and aperture
    - Regularization (interpolation) and equalization (migration weighting)
5. Tomographic Velocity Analysis and FWI
    - Layer- and grid-based ray methods
    - Full waveform inversion (FWI) and FWI imaging
6. Depth Imaging Grids
    - Depth/Velocity: Visualization (imaging) and velocity representation
    - Travel times/Propagation: Summation curves and/or wavefield extrapolation
    - CIP picking/Tomography: Data input to tomography and velocity-update equations
7. Well/Seismic Database Validation
    - Determine data polarity and phase
    - Creating synthetic seismogram ties: "Wiggle" and P Impedance
    - QCs to detect/resolve database discrepancies
8. Iterative Depth Imaging: Quality Control
    - Creation and QC of the initial velocity model
    - Forming the near-surface model: Full-wave form inversion and refraction solutions
    - Iterative tomographic updates and target-velocity resolution
    - Case histories
    - Setting up an intuitive review of the iterative velocity-update process
9. Anisotropy
    - Anisotropic parameterization (Vz, Delta, Epsilon, VTI/TTI…)

- Initial Vz model, velocity and parameter updates

10. Well Calibration
    - Working in the time domain and updating the time/velocity (Vz) model
    - Conversion of time data to calibrated depth
    - Uncertainty measures (Stochastic modeling, freeware supplied and demonstrated)
11. Depth-Imaging Attributes
    - Poststack: Amplitudes, curvature, coherence
    - Prestack: Elastic inversion and forming geomechanical volumes (Young's, Poisson's,)
    - AVO with Azimuth and other HTI property cubes
    - Practical applications of machine-learning algorithms