Seismic Velocities and Depth Conversion

Level
Skill (5-10 years’ experience)

Instructor
Scott MacKay
MacKay Consulting Corporation, Inc.
Oil and Gas Consultant

Scott MacKay is an independent consultant with 35 years of experience. He is an acknowledged expert in interpretation, depth conversion, and depth imaging.

His career as an explorationist began with Tenneco Oil after graduating from Colorado School of Mines with an M.Sc. in Geophysics (’79). After 10 years, Scott joined Western Geophysical R&D where he became Manager of R&D and a Schlumberger Advisor. His roles included World-wide Coordinator for Depth Imaging, Time-lapse Reservoir Characterization, and Multi-component Imaging. Scott earned a Ph. D. in Geology and Geophysics from the University of Houston (’91). He has five U.S. patents and numerous publications on applying innovative and practical solutions to exploration and exploitation challenges.

Scott currently works domestic and international projects and advises on the application of new technologies and their impact on risk reduction. His main specialty is the application of depth imaging to unconventional plays to quantify reservoir quality. He is also a NExT Instructor in Geophysics.

Course Objective and Outcome

Depth conversion (domain conversion) of seismic time interpretations is a critical skill for interpreters. To impart an effective approach to depth conversion, the first part of this course prioritizes understanding the nature of velocity fields and practical approaches to velocity representation. Next, appropriate depth-conversion methods are presented in case history and exercise form using the Petrel Software Platform. Single-layer and more sophisticated multi-layer velocity-modeling approaches are reviewed along with structural uncertainty analysis. Interpretive skills linked to depth conversion, such as synthetic seismic ties to identify reflectors, are included.

Pre-stack depth migration is now commonplace. Basic ray- and wave-theory migration algorithms are introduced in an intuitive fashion. The formation of the initial velocity model for depth migration, and QCs to ensure stable tomographic velocity updates are introduced. The same basic QCs and methods used for vertical time-to-depth conversion
introduced early in the course will also be used to validate the ties between the formation tops and the seismic surfaces used for well-top calibration of depth migration cubes. The depth-calibration process is covered in detail with a case history in Petrel.

Agenda

Module 1: Overview of Depth Conversion
* Learning Objectives and Importance:
  - Discuss goals for vertical time-to-depth conversion
* Topics:
  - Accuracies needed for relative structure, well prognoses, volumetric estimates, and reservoir models
  - Indicators for prestack depth migration (PSDM)
* Exercises: Discussions on participant goals and experiences with time-to-depth conversion

Module 2: Defining Velocity Types
* Learning Objectives and Importance:
  - Review definitions and characteristics of velocities
* Topics:
  - Types of velocities (with Petrel template equivalents)
  - Conversion of velocity types to a form suitable for velocity modeling
* Exercises: Various problems on relating velocity types and conversions. Petrel exercises.

Module 3: Functional Representation of Velocities
* Learning Objectives and Importance:
  - Define velocities fields using vertical functions
* Topics:
  - Velocity as a function of time and depth
  - Implicit velocity representation via T-D functions
  - Petrel Velocity Models with time and depth functions
* Exercises: Various problems defining velocity fields in various domains

Module 4: Gridded Representation of Velocities
* Learning Objectives and Importance:
  - Define velocities fields using grids
* Topics:
  - Creating an edited PSTM velocity model in Petrel
* Exercises: Import SEG Y velocities to Petrel and forming a gridded model
Module 5: Well and Seismic Data Integration
* Learning Objectives and Importance:
  • Understand methods for linking well and seismic information in Petrel
* Topics:
  • Establishing seismic data polarity and phase
  • Creating synthetic ties to identify reflectors with well tops
* Exercises: Problem sets and interactive work sessions

Module 6: Vertical Time-to-Depth Conversion (Single Layer)
* Learning Objectives and Importance:
  • Implement basic depth conversion using T/Z functions and/or Petrel Velocity Models
* Topics:
  • Simple, intuitive depth conversion (no velocity model)
  • QC methods that define Time Depth Relationships (TDRs)
  • Basic Petrel Velocity Models
* Exercises: Problem sets and interactive work sessions

Module 7: Vertical Time-to-Depth Conversion (Multi Layer)
* Learning Objectives and Importance:
  • Explore advanced depth conversion with layer-based Petrel Velocity Models
* Topics:
  • Geologic and data-driven modeling considerations
  • Multi-layer options
  • “Simple” thrust models
  • Advanced Petrel Velocity Models
* Exercises: Problem sets and interactive work sessions

Module 8: Depth Migration Algorithms: Theory and Practice
* Learning Objectives and Importance:
  • Convey an intuitive understanding of the different depth migration algorithms and basic intuitive QCs for the interpreter.
* Topics:
  • Ray-based Kirchhoff and 2-way Wave Equation (Reverse Time) algorithms
* Exercises: Case history reviews

Module 9: Petrel Models and Uncertainty Analysis
* Learning Objectives and Importance:
  • Implement domain conversion and uncertainty analysis with Petrel Velocity and 3D Models
* Topics:
  • Evaluating depth uncertainty
    • Mean and standard deviation workflow (from depth conversion portfolio)
* Exercises: Various Petrel exercises
Module 10: Calibration of Depth Migration with Wells

* Learning Objectives and Importance:
  - Learn basic approach for stable integration of depth-domain seismic (PSDM) with well control

* Topics:
  - Working in the time domain
  - Updating the time/velocity model
  - Conversion of time data to calibrated depth

* Exercises: Petrel Case History calibration exercises

Target Audience

This course is of importance to geoscientists involved in seismic interpretation and subsequent time-to-depth conversion. The course is also oriented towards persons performing well calibration of depth migration data and other attributes prior to reservoir modeling.

Prerequisites

Petrel Fundamentals course.

Note: For those participants who do not have experience with Petrel, Schlumberger will provide basic Petrel usage training prior to the course at no cost.

12/4（火）にPetrelの事前講習を行います。（希望者）