TETRA TECH RPS ENERGY | TRAINING

N066: An Objective Approach to Seismic Processing

Instructor(s): Rob Hardy

Format and Duration

Classroom - 5 Days
Virtual - 10 Sessions

Summary

This course covers fundamental issues and linkages involved in acquiring and processing seismic data. The course focuses on the questions that seismic interpreters need to ask to determine whether, and how, to re-acquire or re-process existing seismic data. Participants will interactively process real data from field records to migration and will gain an understanding of the latest techniques and how to apply them effectively and efficiently to meet their objectives. This course is applicable to all parts of the E&P life cycle where new seismic data is required to image, or better image, the subsurface.

Learning Outcomes

Participants will learn how to:

1. Recognise the most common seismic acquisition and processing techniques used in seismic exploration & production.
2. Describe the synergy between newer acquisition & processing techniques alongside their potential benefits & pitfalls.
3. Identify how velocity analysis, anisotropy and selection of migration algorithm can affect accuracy of interpretation in depth.
4. Discuss the impact of seismic processing parameter selection on amplitude interpretation for exploration and reservoir characterisation objectives.
5. Demonstrate the fundamentals of sampling theory and seismic survey design and consequences for acquisition, processing and interpretation objectives.
6. Examine the use of seismic modelling in survey design, processing parameter selection & interpretation verification.
7. Construct a typical seismic processing workflow covering data preparation, parameterisation, noise & multiple suppression, velocity analysis & modelling, the imaging process & likely issues at each step.
8. Illustrate the pitfalls that can be encountered in loading seismic and navigation data to the workstation.
9. Analyse the cost-benefit to interpretation of applying further re-processing to a seismic dataset.
10. Perform appropriate trace scaling to balance amplitudes.
11. Perform simple bandpass, FX and FK filtering techniques to enhance data interpretability.
12. Propose standard pre- and post-stack processing including gather conditioning for quantitative amplitude interpretation

Training Method

This is a five-day classroom course. It consists of lectures and interactive exercises illustrating the basic theory and techniques discussed. The purpose of this course is to teach fundamentals rather than a particular software suite. To this end, the participants will use a specially developed series of web-based software modules to experience the processing options available and learn how to combine the basic

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tools together to build a flow which meets objectives.

Who Should Attend

This course is aimed towards geoscientists seeking an overview of new geophysical techniques and processing methods. A geophysics refresher is provided, but participants should have a basic knowledge of seismic acquisition and processing terminology.

Course Content

Seismic technology is changing continuously in the drive towards better imaging and better amplitude preservation but of course turnaround should be quicker and at lower cost.

The course is divided into two main themes which are not extensively covered in the geophysical literature. Following an overview of relevant theory, the first part addresses in a non-prescriptive way the type of questions geoscientists have to answer to meet objectives. A set of geophysical tools and rules are provided to help assess the quality and value of seismic data in a given area. We then use the methodology to assess the benefits (and costs) of re-processing and re-acquisition using the latest technologies. Seismic modelling provides a central theme to the methodology.

The second main aim of the course is to provide a demonstration of current geophysical and processing techniques that can be applied to seismic data. From a basic knowledge of seismic processing, the attendees will be given an overview of standard practice, and then for each method we will introduce the basic theory (with few equations), parameterisation, benefits, limitations, pitfalls and likely value. Where possible we will focus on the applications of the techniques using real examples and common terminology. The whole processing sequence is extensively covered, including data preparation for land and marine data, noise and multiple suppression, velocity analysis and model building, statics, time and depth imaging including anisotropy and issues affecting resolution. Interactive processing, using land and marine synthetic and real data examples, is provided throughout the course presentation to enable the attendees to grasp the importance of key parameters. We will also cover the generation of specialised outputs used in quantitative interpretation including AVO and inversion volumes.

Part 1: Workstation Based Workflow: Objective Setting

- Geophysics refresher: an acquisition and processing primer including a brief overview of basic wave theory, noise suppression, velocity analysis, stacking, imaging and factors affecting resolution.
- Seismic data formats: seismic and navigation formats, pitfalls and quality control.
- Data loading: dynamic range (bit precision), reconciling navigation and seismic data, common pitfalls when loading depth data, land data and gathers with recommended quality controls. Seismic display and colour-bars.
- Understanding the data you have: setting objectives
- Meeting project requirements and defining objectives
    - Can longer offsets be obtained?
    - Can the bandwidth be improved?

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  - Will amplitude versus offset analysis be worthwhile?
  - Will depth imaging be required?
  - Re-shoot versus re-process using modelling
  - Cost-benefit analysis: measure data against objectives
- Scaling: trace scaling, automatic gain control, offset scaling.
- Data enhancement: frequency, FK, FX filtering.
- Processing tenders: a brief overview of tendering of processing contracts.

Part 2: Basic Building Blocks

- Basic convolution, Fourier Transform
- Sampling and temporal aliasing
- Spatial aliasing
- Inverse theory

Technical Aspects of Survey Design

- Basic survey design, workflow and rules of thumb
- Sampling, deciding survey orientation or azimuthal coverage
- Broadband methodologies and simultaneous shooting strategies
- The effect of field parameters on processing route and vice versa
- Differences between land, marine streamer and OBN
- Case histories: Scott Field, cost-benefit analysis

Signal Processing Workflow

- Amplitudes, frequency and wavelet processing
- Designature, phase and wavelet processing
- Attenuation compensation
- Obtaining broader bandwidth: combining acquisition and processing solutions

Part 3: Noise and Multiple Suppression Workflow

- Noise: types and suppression in Marine and Land seismic data
- Geometry: shot, receiver, offset, midpoint domains; sorting, statics
- Mathematical domains: FK, tau-p analysis
- Aliasing of data, regularisation and interpolation
- FK and Radon: Basic theory, analysis and QC displays, interactive demonstration.
- Multiple suppression. This important area is covered in some detail, comprising:
  - Predictive methods: deconvolution, shallow water demultiple
  - Moveout methods: FK, Radon, hi-res radon domains
  - Wavefield: free surface multiple removal (2D and 3D SRME)
  - Interbed multiples - identification and removal.

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    - Interpreting data affected by multiples
- Basic prestack inversion analysis: Angle gathers and AVO compliant gather conditioning, generation of angle stack and fluid/lithology prediction volumes

Part 4: Imaging Workflow Including Velocity Model Building

- Basic migration: correcting for velocity variation and complex sub-surface.
- Prestack time migration and gather generation. Prestack depth migration:
    - Algorithm choice: Kirchhoff single/multi arrival, Beam versus wavefield methods (including reverse time migration), least-squares migration.
    - Imaging with multiples, Elastic imaging and Future developments.
- Anisotropy including VTI, TTI, orthorhombic cases.
- Velocity model construction for depth imaging
    - Role of interpreter in velocity model building and quality control
    - Full-Waveform Inversion
        - Data preparation and initial quality controls
        - Diving wave and reflection based inversion schemes
        - Quality control and common pitfalls.
        - Tomography – grid or layer based, hybrid methods
    - Case histories: Scott Field, North Sea Gas Basin, Sub-salt Gulf of Mexico.
    - Additional uses of seismic velocities: e.g. imaging, pore pressure, depthing.

Part 5: Land Processing Workflow

- Statics: elevation, refraction, tomographic based statics are compared using a series of synthetic and real data examples. Marine statics solutions are also discussed as are statics and layer replacement schemes versus full depth imaging.
- Case history: complex topography

Amplitude and Amplitude Extraction Workflows

- Processing Requirements and Techniques for reservoir characterisation
    - Data conditioning and resolution enhancement and attribute extraction.
    - Conventional and Machine Learning based classifications.
    - Attributes for conventional and unconventional reservoir characterisation.

Conclusions and Recap

- Processing sequence (includes an overview of processing styles between 1990 to present day) Rules of thumb for data assessment and novel less subjective data comparisons
- Specialised processing: Single sensor, OBC, Elastic and 4D methodologies
- Summary and the Future: Recap. Acquisition and processing methods on the horizon

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