Novosibirsk State University
*THE REAL SCIENCE

SEISMIC DATA PROCESSING

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Scientific interests include fast algorithms of reflection-seismic data processing and imaging, microseismic monitoring of hydrofrac, studying physical properties of gas-hydrate bearing sediments.

Course Goal

Seismic data processing of is one of the key methods in exploration geophysics. This course will discuss the basic principles of processing reflection-seismic data. It combines two educational formats: explanation of theoretical foundations and practical training in seismic data processing using modern software packages. This course provides participants with a working knowledge of seismic processing that can serve as a starting point for a career in seismic exploration.

Course Objectives:
- understanding basic principles of seismic wave propagation;
- acquisition systems and technologies in 2D and 3D reflection seismic;
- seismic-processing graph and principles of main processing;
- practical skills in seismic processing using specialized packages.

Course Outline:

1. Introduction
Main principles of seismic reflection. Seismic data processing, main objectives and expected results. Field seismic data and it's preparation for processing. Standard processing graph and its variants. Vertical and horizontal resolution of seismic reflection. Computational burden of seismic processing and required resources. Industrial processing packages.

2. Fundamentals of Signal Processing
Forward and inverse Fourier transform. Fast Fourier Transform. Main characteristics and properties of Fourier spectra. Amplitude and phase spectrum, minimum-phase and zero-phase signals. Discrete signal,

sampling theorem, aliasing, Nyquist frequency. Basics of Fourier filters, main filter types, filter characteristics.

3. Fundamentals of Seismic Processing
Main stages of the seismic processing graph. Express processing graph, kinematic, and signal processing. Amplitude-preserving processing. Regular and random noise, objectives, and methods of noise suppression. Statistic corrections, methods of estimation. Velocity analysis and kinematic corrections.

4**. Seismic Survey Design**
2D acquisition system. Acquisition system for 3D seismic surveys. Binning, estimating the folding parameter and azimuth coverage for typical 3D acquisition systems. Special features of processing, regularization and migration of 3D seismic data.

5. Quality Control of Seismic Data
Seismic data formats. Import of seismic data. Geometry assignment for seismic data. Calculation of quality attributes of seismic data. Automatic gain control, normalization and balancing of traces. Data visualization and editing.

6. Near-surface Structure and a Priori Static Correction
Calculation of prior static corrections. Static correction for floating reference level. Building a model of the near-surface from the first-break traveltimes, estimating prior static corrections. Correcting distortions caused by the complicated structure of the near-surface. Estimation of long-period static corrections.

7. Velocity Analysis
Common-midpoint (CMP) gathers and moveout of reflected waves. Semblance, measuring similarity between traces. Velocity analysis of CMP gathers, horizontal and vertical velocity spectrum. Interpretation of velocity spectrums, picking RMS velocities. Estimating normal moveout corrections.

8. Noise Suppression
Objectives of noise suppression, improving signal-to-noise ratio. Spectral methods: bandpass filtering, notch filtering. F-K filtering of seismic data. Wave separation by apparent velocity and polarization: grouping, slat-stacking, polarization filters for 3-component data. Suppression of waves in the parabolic or hyperbolic Radon domain.

9. Deconvolution
Bandwidth of the signal spectrum. Convolutional model of seismic trace. Deconvolution –inverse. Stationary deconvolution: deterministic, compression. Non-stationary (predictive) deconvolution. Shaping deconvolution: correction of amplitude and phase spectra. Correlation of vibroseismic records.

10. Residual Static Correction.

Models for static corrections: 2-, 3-, and 4-factor models. Estimation of the residual static corrections in the common-midpoint gathers based on the common-shot and common-receiver gathers. Automatic estimation of time residuals by cross-correlation methods. Use of a priori information for resolving non-uniqueness in estimating static corrections.

11. Multiple Elimination
Multiple waves (full, partial). Manifestation of multiples in common-midpoint gathers and seismic sections. Multiple-wave model building and adaptive subtraction. Multiple suppression methods: in tau-pi domain, in parabolic or hyperbolic Radon domain. Surface-related multiple-wave elimination.

12. Normal Moveout and Summation
Traveltimes of reflected waves in layered models. Converting root-mean-square velocities to normal moveout corrections. Normal moveout corrections and the signal stretching. Applying muting and auto-muting. Summation of CMP gathers.

13. Velocity Model Building
Notions of velocity in seismic processing: stacking velocity, effective velocity, interval velocity. Methods for estimating interval and average velocities. Conversion of effective velocities into interval velocities, the Dix formula. Types of velocity models: interval velocity model, migration velocity model.

14. Seismic Migration
Seismic migration principles. Time migration and depth migration. Pre- and post-stack migration. Migration by the Kirchhoff integral method. Finite-difference migration methods. Seismic migration in the Fourier domain.

15. Additional Chapters in Seismic Processing
AVO analysis. Seismic inversion – estimation of acoustic impedance. Vertical seismic profiling. Seismic monitoring. Processing of shear and converted seismic waves. Estimation of seismic anisotropy. Goals of seismic inversion.