Onshore Seismic Processing and Imaging (G081)

Tutor(s)

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Overview

This course will introduce the fundamentals of land seismic acquisition including receiver types and their spectrum indication. Land-based seismic data presents unique challenges, and the course will subsequently follow the processes after acquisition to include all the main processing steps of a modern land 3D dataset.

Duration and Logistics

Fundamental. Intended for geoscientists who work with seismic data and are also required to understand land seismic acquisition and processing projects and work with imaging professionals.

Level and Audience

Classroom version: A 2-day classroom course day including a mix of lectures and exercises. The manual will be provided in digital format and participants will be required to bring a laptop or tablet computer to follow the lectures and exercises.

Virtual version: Four 3.5-hour interactive online sessions presented over four days. Digital course notes and exercise materials will be distributed to participants before the course. Some exercises may be completed by participants off-line.

Objectives

You will learn to:

1. List common onshore seismic source and receiver types and their spectrum indication.
2. Describe source/receiver line spacing & intervals and their relationship to acquisition footprints and seismic resolution.
3. Have a clear picture of main processing steps affecting phase and amplitude and understand the concepts of surface-consistency.
4. Explain in plain language how FWI works and the key factors to velocity model building.
5. List the types of data used in data processing.
6. Identify the main components of the seismic wavefield and what they are used for.
7. Describe the main collections/domains for manipulating seismic data.
8. Explain the main steps in a processing sequence.
9. List the main types of noise and describe attenuation methods for these.
10. Describe the various velocities used in seismic and how to access them.
11. Identify multiples and explain methods to attenuate them.
12. Discuss the need for regularization.

13. Describe the migration process and list the difference between Time/Depth Migrations.

Course Content

Session 1: Onshore seismic data acquisition and processing

We will start with the basics and fundamentals of land seismic acquisition and an overview of basic seismic terms. Common onshore seismic source and receiver types and their spectrum indication will be presented.

We will provide a clear picture of main processing steps affecting phase and amplitude and understand the concepts of surface-consistency. These steps include explanation of all the terms you may have heard of but might not be entirely familiar in understanding including refraction statics, denoise, deconvolution, velocities, and 5D interpolation, as well as many steps that are not as well-known such as: geophone compensation, geometry qc, and residual statics. The main types of noise will be shown and we will describe attenuation methods.

The various data types used in data processing will be presented. Reviewing the main steps included in a processing sequence, data examples will be used. This includes data regularization. The examples include simplified graphics and real-data examples. This behind-the-scenes look is important; decisions made during pre-processing can affect any prospect. You will learn why these steps are run and what to look for when a vendor is processing your land dataset. No math is required.

Session 2: Seismic wave propagation, migration, velocities, anisotropy and model building

We will start this session by reviewing seismic wave propagation in Elastic media. Seismic forward modeling describes wave propagation in the sub-surface is inherent in processing. We will identify the main components of the seismic wavefield and what they are used for.

Using both wave and ray equations, we move to discuss how these equations are used for application of depth migration. We will describe how ray based and wave-based migrations work and will explain the differences between RTM based on the acoustic wave equation and the elastic wave equation. The difference between Time and Depth Migration will be explained.

Next, we will cover the foundations and use of velocity estimation techniques and will analyze the advantages and limitations of each. We will describe the various velocities used in seismic imaging and how to they are constructed from the seismic data. We will demonstrate ray-based reflection tomography as well as wave based Full Waveform Inversion (FWI). Special attention will be given to describe how each method is used in velocity model building.

We will then review anisotropy used in seismic processing and imaging. A complete workflow including all steps used in model building and depth imaging project will be provided.

Session 3: Practical Aspects of Time and Depth Migrations

Several examples of synthetic and real data cases of PSDM will be used to demonstrate the fundamental differences between depth and time migration. Depth migration is especially helpful to resolve lateral velocity variations. This fundamental difference affects key aspects of interpretation: structure, dip, depth to target, as well as location of anticlines and synclines.

The differences between Time and Depth migrations will be demonstrated. Equally important, we will demonstrate why inaccurate depth velocities might jeopardize the sub-surface image. The link between the PSDM image and the underlying geological settings will be reviewed and explained. We will also show a typical step-by-step land PSDM workflow including considerations (and explanations) for delta and epsilon.

Session 4: Post migration processing

Seismic processing is not done after migration. There are numerous signal/noise enhancements that are often applied to both pre-stack gathers and post-stack volumes. Residual NMO, gather flattening, more denoise, demultiple options, mutes, footprint attenuation, spectral whitening.

During both pre-processing and post-processing multiples are identified and method for their attenuation are selected. These will be explained. Several domains for manipulating seismic data are commonly used and these will be presented. In some cases, the acquisition setup might result with acquisition footprint on the final seismic image. We will review source/receiver line spacing and intervals and their relationship to acquisition footprints and seismic resolution. Real-data examples will show how and why these procedures are applied. Typical deliverables are discussed. And it doesn’t end there – it doesn’t end until the ebcdic header and the trace headers are properly completed.