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Multiple Removal & Noise Attenuation

Spectrum is able to offer its clients a wide range of noise attenuation and demultiple solutions to help resolve the various random and coherent noise issues presented. Our multiple removal techniques are based on the principles of ‘modelling the multiples’ and ‘modelling the primaries’ to ensure comprehensive noise suppression of your data.

High Resolution Radon
Efficient high resolution Radon modules are available which work in the Fourier domain. These programs use weights to focus the decomposition onto its most significant spectral components. The weights are obtained by using the radon spectrum obtained from the previous frequency. A scalar is used to introduce a viscosity, which prevents undesired variations caused by random noise.

Radon is used:
- when SRME assumptions fail
- when primaries and multiples are differentiated based on parabolic moveout
- to attenuate residual multiple after SRME

Tau-p Deconvolution
In the application of Tau-p deconvolution Spectrum’s geophysicists understand that multiples are only truly periodic in the X-T domain at zero offset, so pre-stack deconvolution is of limited use as a multiple attenuator. By transforming data into the linear Tau-p domain, multiples can be made periodic for all values of P and effectively attenuated with predictive deconvolution. This technique is particularly effective in shallow water areas where muting in the tau-p domain can assist with linear noise attenuation.

Surface Related Multiple
Our Surface Related Multiple Elimination (SRME) program is an ‘autoconvolutional process’ based on the published work of Verschuur & Berkhout (1997); Spectrum is also a member of the Delft consortium.

The removal of surface related multiples is an essential processing step before pre-stack time migration and requires no independent knowledge of the structure being imaged.

Swell Noise
Swell noise is often reduced with a simple low cut filter. However Spectrum uses an amplitude-friendly proprietary module called NOISERM. This module performs frequency dependent noise removal which can achieve attenuation of swell noise. NOISERM is able to isolate spectral outliers using fast short windows FFT’s, ideal for any type of spatially variant incoherent noise.

Targeted Multiple Attenuation
Spectrum’s proprietary targeted multiple attenuation technique is useful in instances where there is little or no velocity separation between the multiple and primary trends. In these cases traditional methods such as F/K and Radon are often ineffective. It also works well in situations where multiple aliasing occurs. The process may be parameterised to be spatially and temporally variant.

Refine
Refine is a proprietary, amplitude-friendly high frequency enhancement process. It is used to boost data frequencies without a corresponding increase in noise. The resultant seismic data contains frequencies much higher than that associated with conventional seismic, and an increased effective seismic bandwidth for improving signal-noise ratios and enhancing the stability of seismic inversion for rock property analysis.

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Velocities

Accurate, ‘geologically driven’ velocity picking can make the crucial difference between being able to image our clients vital target anomaly on a seismic section and completely missing it. That’s why, at Spectrum, our velocities are picked by trained and experienced geophysicists who are well aware that velocity analysis is more than just joining the dots on a semblance plot.

We only use auto-pickers where the scale and simplicity of a project make it a necessity, ensuring that you always get a professional velocity model to accompany your final migration.

The velocities are checked interactively with NMO corrected gathers, stacks and iso-velocity plots. A regional Q.C. of all velocities is made and maps can be produced for velocity at given times or times at given velocity. For 3D datasets, a velocity cube is created and iso-velocity plots are produced for inlines, cross lines and constant time slices. Iso-velocity plots can also be produced for interpreted horizons and as 3-dimensional contour maps.

Fourth Order NMO

Where anisotropy is present, an optional fourth order NMO term is available which compensates for ray bending at far offsets. Following the initial velocity pick a contour plot of the C2 term is produced and also picked interactively as shown opposite. The 4th order term can also be picked automatically using Spectrum’s proprietary velocity analysis package VELTUNE (see over).

NMO Velocity Analysis

At Spectrum, stacking and PSTM RMS velocities are picked interactively from gathers, stacks (constant or variable function) and semblance plots. Interpreted horizons can be overlaid on the velocity analyses to allow horizon consistent picking. Wherever possible, we avoid the use of automated velocity picking methods, preferring to make full use of the extensive geological knowledge and experience of our geophysicists at every stage of our seismic imaging service. We also understand that when dealing with 3D or 2D depth imaging, manual RMS analysis improves the stability of seeding the initial interval velocities of tomographic analysis.

VELTUNE

High Definition Velocity Analysis

VELTUNE is Spectrum’s proprietary continuous automatic velocity analysis package giving output velocity information at each sample of each bin. Velocity corrections are derived from maximum energy calculations along step-out curves at each sample and on every CDP.

VELTUNE can derive residual velocity corrections plus optionally either C2 (for 4th order) or Eta (η) corrections. Appropriate muting and time gates for analysis of the above can be controlled by trace header entries for each trace of each CDP gather. Parameterisation can be spatially variant such that residual delta-t analysis gates can exclude coherent noise energy, e.g. residual multiple energy. Additionally the capability exists to revert to the originally picked velocity field in noisy zones where automatic picking becomes unstable.

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SPArkle
Specialist Gather Enhancement

Spectrum’s proprietary process ‘SPArkle’ has been developed to give geophysicists the type of data needed to derive the maximum amount of information from pre-stack seismic data. Raw CMP gathers are often contaminated by noise, moveout errors, and residual multiple content. SPArkle is a combination of processing methods which corrects for these deficiencies and recovers high frequency content in the data.

SPArkle
Pre-stack noise removal is often included in a regular data processing sequence, but its application is often based on stack response.

The effective removal of residual noise helps clean up gathers prior to further pre-stack studies. SPArkle may also be used for improved AVD and attribute analysis, for pore pressure prediction, and improved resolution that facilitates detailed rock property analysis of seismic data.

Stacks of CDP gathers before and after SPArkle

Frequency content before and after SPArkle

Velocity analysis is performed on a grid basis and interpolated between grid points. Spectrum’s continuous velocity analysis package, Veltune (included in SPArkle) makes interpolation unnecessary and provides a more accurate moveout correction on all gathers. An inlier part of the SPArkle process is high frequency signal enhancement giving superior stratigraphic definition throughout the section.

This element of the process is designed to recover realistic high frequency content in the data.

The examples show a CMP gather before any conditioning. Note the noise, and the non-optimum moveout. The same CMP gather is also illustrated after conditioning. The SPArkle conditioned gather shows the improvement with less noise, correct moveout and enhancement of higher frequencies. Stacks of CMP gathers before and after SPArkle illustrate the accompanying benefits in the stack image obtained from SPArkle gathers.

The set of methods comprising SPArkle include:

- Noise Removal
- Demultiple (multiple attenuation)
- Detailed continuous velocity analysis (Veltune)
- High frequency enhancement (Refine)

Spectrum’s Depth Imaging Software Suite

In recent years Spectrum has made significant investment in our depth imaging services. Spectrum uses Tsunami and Paradigm software for 2D and 3D tomographic velocity analysis and also for Kirchhoff Pre-stack Depth Migration (PSDM). The velocity analysis and tomography is fast and easy to use, the benefits being:

- Grid-based and layer-based method eliminates the need for interpretation.
- Horizon-based velocity converter to convert from $V_{int}$ to $V_{avg}$
- Automatic residual velocity analysis
- Multiple QC displays including delta-v maps and ray path displays.
- User can control the density of the tomography calculation.
- User may limit velocity changes, hold shallow velocities constant and restrict maximum velocity changes.

Spectrum uses Parallel Geoscience software when a multi-path 1-way based wave equation is required for the final migration or for base salt imaging in complex geologic environments.

Depth Imaging
Pre-Stack Depth Migration at Spectrum

Spectrum has provided pre-stack depth migration services for over 15 years. Our experience is truly global, with many satisfied customers who continue to return with new business.

Capabilities:

- 2D and 3D pre-stack depth migration
- Anisotropic Kirchhoff and Wave-Equation migration algorithms
- Specialist 3rd party modeling tools
- Multi-node supercomputers and clusters for fast turn-around
- Client remote viewing of model building via Secure Global Desktop and the internet

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