Solutions for Seismic Reservoir Characterization

A
Short Narrative on the Scope of Work Involved in Data Conditioning and Seismic Reservoir Characterization

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Project Goals

1. Rigorous data conditioning to improve the interpretability of the seismic data.
2. Reservoir characterization using an artificial neural network analysis of log-derived modeled synthetics to extract lithological and fluid information from attributes computed from surface seismic data.

Key Advantages of Method

1. Rigorous data processing of seismic and log data to maximize potential of attribute studies.
2. Lithology prediction from well data using Artificial Neural Networks (ANN).
3. Rock Physics modeling to widen calibration range to include all likely reservoir solutions
4. Lithology prediction from seismic attributes, using ANN knowledge base calculated from log-derived modeled synthetics.

General Design Specifications

Rock Solid Images has designed a suite of processing modules that addresses requisite stratigraphic, geologic and lithologic objectives resulting in a data volume that is appropriately conditioned for reservoir characterization. Specifically:

Surface-Consistency.

Issue:

Many conventional processing tools compute only time statics, however, to address stratigraphic objectives it is necessary for the sub-surface to be “illuminated” by a consistent wavefield.

Solution:

Since we are concerned with both amplitude and phase control, we must consider that stacking is a process of summation of vectors. One vector represents the group component and the other, the phase component. For example, if we sum a zero phase wavelet with a 90-degree wavelet, we will obtain a 45-degree phase rotated wavelet. This suggests that we not only control the amplitude and travel time but also the phase of the data.

Rock Solid Images has developed statics computation routines for time, amplitude and phase. These computation procedures provide amplitude, time and phase-balanced pre-stack data. The surface-consistent amplitude computation and correction algorithms are also adapted to perform preliminary data quality control and editing.

Additionally we will employ proprietary technology that conducts wavelet extraction and shaping which, when applied to common shot and common receiver data sets, effects both a uniform illumination of the sub-surface and a uniform reception of the reflected events.

Seismic Resolution.

Issue:

Many conventional processing tools, e.g. spiking deconvolution produce wavelets with an arbitrary phase spectrum. This spectrum is generally controlled by the noise content of the trace, therefore the time-varying application of spiking deconvolution will produce wavelets of differing phase for each trace and for each window. Also, minimum phase or mixed phase wavelets are notoriously difficult to time.

Solution:

We will deliver a product with the highest possible resolution with accurate amplitude and arrival time information. This will be achieved by adopting a seismic wavelet exhibiting a wide band spectrum that fits the original source signature. Of the available wide-bandwidth wavelets, the zero phase wavelet offers the highest resolving power (measured by computing the ratio from main peak to side lobe). Zero phase wavelets are also unambiguous, that is, their main peak corresponds to the travel time of the reflector.

In short, by adopting wide-band zero phase wavelets as our final seismic signature we will produce data that meet our requirements.

Migration, Time or Depth?

Issue:

A key decision is whether the data should be imaged in time or depth, and whether this step should be performed pre-stack or post-stack.

Solution:

We recommend use of the best possible tool to build an optimum velocity-depth model. This velocity-depth model is then used to pre-stack migrate the data in time, prior to subsequent attribute studies. This velocity-depth model can be used again after the attribute study to finally position the data in depth.

There are several reasons for recommending time migration over depth:

1. In many areas, pre-stack time–migration is more than adequate to ensure the data are properly positioned.
2. In cases where pre-stack depth migration is really required (e.g. sub-salt), data quality is often too poor to permit attribute studies to be undertaken with any degree of reliability.
3. Amplitude-preserving time-migration is readily available; this technology has not yet advanced for depth-migration algorithms.
4. Most of our attribute algorithms require data to be linearly sampled in time.
5. Use of pre-stack migration, rather than post-stack, increases the reliability of pre-stack analysis steps such as AVO.

We do recommend depth-imaging tools for production of the initial velocity-depth model. The time –migration step will benefit accordingly, as will other processes which require a optimum velocity-depth model, such as AVO analysis and acoustic-impedance inversion

Proposed Surface Seismic Data Processing Sequence

- Surface consistent amplitude editing and correction
- Reverberation and short period multiple suppression by predictive deconvolution.

  ~The prediction distance will be longer than the wavelet width so that it will not reshape the wavelet
- Wavelet extraction and shaping for source emission and receiver characteristics.

  ~Will be run on common shot data first. The data will then be sorted to the common receiver domain where the wavelet extraction and shaping process will be repeated. Depending upon the data, we may optionally repeat this process for common offset data to minimize the influence of the effects of the exit angle.
- NMO velocity analysis using super gathers generated by dip scanning of common offset gathers.

  ~This will also enable us to determine the severity of any surface statics problems. If the data has severe statics problem, then we will compute short wavelength statics and apply to the data.
- Generate a preliminary stack section.
- Compute and apply surface consistent amplitude, time and phase corrections
- Time migration velocity analysis
- Time migration before stack
- Attribute analysis and generation of attribute sections or volumes
- Lithological classification using attributes
- Check classification against the interpreted well logs.
- Neural network training using existing well information
- Classify the data using the results of the trained neural networks.

Proposed Log Interpretation Sequence

- Compute total, effective and density porosity
- Sw (deep and shallow)
- Vclay

Proposed Rock Physics Modeling Sequence:

- Vs prediction (use dipole Vs if available to help select method)
- Define pay zone boundaries
- Mud invasion correction on wells with pay
- Compute average Sw in pay zones
- Conduct fluid substitution for all wells to 100% Sw
- Conduct fluid substitution for all wells to average pay Sw (oil)
- Conduct fluid substitution for all wells to 50% average pay Sw (oil)
- Conduct fluid substitution for all wells to average pay Sw (gas) (option)

Proposed Synthetics Generation:

- Generate zero-offset and offset synthetics for all wells and fluid saturations.
- Compute attributes on synthetics.
- Convert lithologic boundaries to time domain.
- Train neural network to recognize lithologies from attributes.

Deliverables:

- Reprocessed data using stratigraphic processing tools
- Complete suite of modeled synthetics from well data
- Attribute sections or volumes
- Characterized lithology section or volume