the residual wavelct at the target zone is removed by fine-tuning remaining amplitude and phase distortions in the available bandwidth. The final result is then the band-limited version of the reflectivity function.

Seismic inversion by modeling is accomplished iteratively using the recursion expression that relates the acoustic impedance with the reflection coefficient. Missing frequencies between the high frequency cut of the low frequency interval velocity model and the low frequency cut of the seismic data are recovered in an iterative manner. This feature provides better resolution through the velocity logs in time and depth. Density logs are then derived by using a relationship between density and velocity.

Seismic porosity and formation pressure are computed against depth making use of the velocity and density logs. Seismic porosities are calculated using bulk densities derived from velocity logs. Appropriate corrections for shale content are generated from well log data at specific vertical locations and applied to the apparent porosity logs. Formation pressure is assumed proportional to the compressional velocity; this proportionality is controlled by the overburden pressure at every sample in depth. The seismic porosity and formation pressure logs are then interpreted for reservoir delineation purposes and detection of abnormally pressured zones. Examples using real data illustrate the complete procedure followed for seismic porosity and formation log calculations.

Ramp Velocity Moveout Model for Layered and Heterogeneous One-Dimensional Media

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Hybrideric moveout models for one-dimensional media with variability of formation or local velocity utilize normal ray time and rms or stacking velocity as parameters. The constant gradient or ramp velocity profile model contains a further parameter which can be assigned so as to considerably improve moveout approximation accuracy. A velocity contrast parameter, rather than the profile velocity gradient directly, has an important role for parameterizing moveout detail and for quantifying velocity heterogeneity. Quantitative heterogeneity and a quantifier of the deviation between a moveout-equivalent canonical profile and the approximating ramp profile are important for linking well sonic profiles to the seismic behavior and for the profile estimation problem on the basis of seismic data.

Seismic Wave Propagation

The Theoretical Investigation of Waves Excited by a Dipole Source in a Fluid-Filled Borehole

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An exact frequency-wavenumber domain representation of the acoustic field in a borehole due to a horizontal dipole source is formulated. Numerical methods are used to compute arrays of full waveforms, as well as individual head wave and mode arrivals at far-field receivers. Analytic methods are used to analyze low frequencies and large offsets, as well as to examine the cut-off frequencies of the modes. A dipole source excites a compressional wave, shear wave, trapped waveguide modes, and a flexural mode. At low frequencies, such that the shear wavelength is much larger than the hole diameter, the full wave field is dominated by a shear wave. At frequencies such that the shear wavelength is on the order of the hole size, the wave field is dominated by the flexural mode. At higher frequencies, the compressional wave is significant and, provided the formation is “fast,” so are the trapped modes.

The flexural mode does not have a cutoff frequency. At low frequencies, this mode travels in tandem with the shear wave at the shear speed. As frequency increases, this mode gradually separates from the shear event. More specifically, the mode begins to travel slower than the shear wave and becomes an order of magnitude stronger. As frequency increases further, the mode weakens again and its speed tends toward that of a Scholte wave on a planar fluid/solid interface.

The Critical Reflection Theorem

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We prove the following theorem: The reflection response of a sequence of plane parallel acoustic layers to an incident plane wave that is critically reflected at any interface in the sequence is white. The proof follows from a consideration of the pressure and normal displacement fields in each layer and the continuity of these fields at the interfaces. At critical incidence at the interface between the nth and n+1st layers, the n+1st layer acts like a rigid plate. Therefore, all the incident energy is reflected. Since none of the layers is an energy source or sink, the flow of energy in every layer above the n+1st layer is the same, independent of frequency. Therefore, at critical incidence, the reflection response is white. The physics of the argument will be identical for the full elastic case, and we expect the theorem to be equally valid for elastic media.

We consider two corollaries of this theorem: (1) At precritical incidence the reflection response is nonwhite. (2) At postcritical incidence at the interface between the nth and n+1st layers, the reflection response is white provided the velocity in any of the deeper layers is not less than that in the n+1st layer. This theorem may be applied to real seismic reflection data after decomposition into plane waves of varying angles of incidence. The spectra of the postcritically reflected waves are the same as the spectra of the source at the corresponding angles of incidence, provided the earth is elastic.