CREWES NEWS

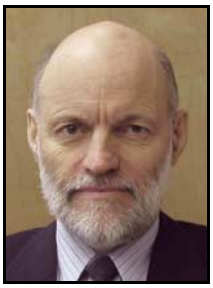
The Consortium for Research in Elastic Wave Exploration Seismology

Congratulations to Award Winners

Six members of CREWES were recipients of awards for presentations at this year's CSEG convention.

Faranak Mahmoudian

Gary Margrave



Arnim Haase

Graduate student Faranak Mahmoudian received Honorable Mention for Best Student paper with her advisor Gary Margrave for "AVO inversion of multicomponent data for P and S impedance". Andrew Royle also received Honorable mention for Best Student paper for "AVO investigation of the Ben Nevis reservoir at the Hebron asset" with advisor Larry Lines and with John Logel of Anadarko Canada Corp.

Andrew Royle

Larry Lines

Jon Downton

Arnim Haase received Honorable Mention for Best Poster Presentation for "Spherical Wave AVO Modeling of Converted Waves in Elastic Isotropic Media". Jon Downton and Larry Lines received Honorable Mention for Best Paper for "Three term AVO waveform inversion".

The awards were presented at the CSEG luncheon in June. ***CN***

New Graduates of CREWES

We are pleased to announce three new graduates of CREWES. These are Andrew Royle, Alex Vant, and Jeffrey Beckett. Their theses are now available at www.crewes.org, and abstracts are given within this issue of CREWES News.

We wish each of these graduates the best of success as they go forward with their careers. ***CN***

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In This Issue...

Sponsors Meeting Website

We wish to remind all of our sponsors of the Sponsors Meeting to be held November 17-19 in Banff, Alberta, and to extend an invitation to all interested members of sponsoring companies to attend this technical meeting.

The Banff Centre
Photo: Scott Rowed

A website with information on the meeting is now available at www.crewes.org. Details will be added there as they become available. ***CN***

Three parameter AVO inversion with PP and PS data

Faranak Mahmoudian and Gary F. Margrave

We have investigated a method of inverting amplitudes of both PP and converted PS reflections to 3 parameters - the P- and S-wave impedance, and the density. The linear Aki and Richards approximation to the Zoeppritz equations for the P-wave reflection coefficient, R_{PP}, and the reflection coefficient for a P-wave converted to an S-wave, R_{PS}, can be reformulated as functions of P- and S-wave impedance (I,J), and density (ρ), (Larsen, 1999) as

$$R_{PP} = A\frac{\Delta I}{I} + B\frac{\Delta J}{J} + C\frac{\Delta \rho}{\rho}, \quad (1)$$

$$R_{PS} = E\frac{\Delta J}{J} + D\frac{\Delta \rho}{\rho}. \quad (2)$$

Inverting equations (1-2) to obtain three parameters, $\Delta I/I$, $\Delta J/J$ and $\Delta\rho/\rho$, can be done with a singular value decomposition (SVD) method. We call this method ***3-parameter joint inversion***. Assumption of Gardner's rule between density and P-wave velocity will reduce equations (1) and (2) to two unknown parameters, $\Delta I/I$ and $\Delta J/J$. In this case, inverting equations (1-2) to obtain two parameters ($\Delta I/I$ and $\Delta J/J$) is called ***2-parameter joint inversion***. Assuming that the PP and PS reflection data provide estimates of R_{PP} and R_{PS} over a range of source-receiver offsets, the Aki and Richards approximations for different offsets at a certain depth can be expressed as a matrix equation, $y = Ax$, where

$$y = (R_{PP1} \quad \dots \quad R_{PPm} \quad R_{PS1} \quad \dots \quad R_{PSm})^T$$

is the reflection data vector, matrix A is the matrix of known coefficients computed by ray-tracing through a smoothed background velocity, and $x = (\Delta I/I, \Delta J/J, \Delta\rho/\rho)^T$ is the vector of unknown parameters. The AVO inversion problem is thus reduced to solving a matrix equation to obtain the parameter vector x. To find the inverse of the non-square matrix A, the SVD method is used. The estimated reflectivity results, ($\Delta I/I$, $\Delta J/J$ and $\Delta\rho/\rho$), are integrated to I, J and ρ using the band limited impedance routine (BLIMP) from the CREWES MATLAB library.

To demonstrate the advantages of 3-parameter joint inversion over 2-parameter joint inversion, the inversion result for a sample log model (Figure 1) is shown in Figure 2. In this example, the density log does not obey Gardner's relation. In Figure (2), I, J and ρ estimations from 2 and 3-parameter joint inversion are compared. Note that in 2-parameter joint inversion, the estimated ρ comes from the estimated I by using Gardner's rule. Figure (2) clearly shows that 3-parameter joint inversion can estimate density even when density is uncorrelated with P-wave velocity.

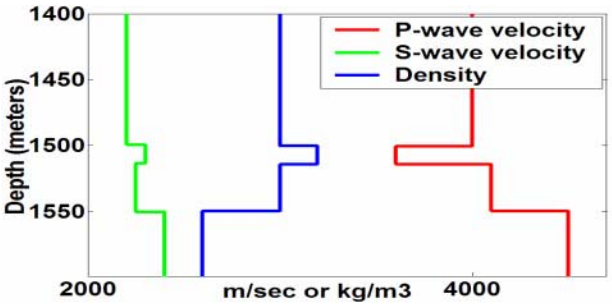

Figure 1: A simple log model in depth

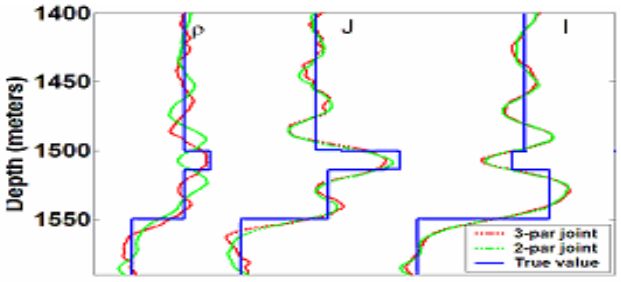

Figure 2: Comparing the estimated I, J *and* ρ *from 2- and 3-parameter joint inversion. The red lines represent 3-parameter joint inversion, the green lines represent 2-parameter joint inversion, and the blue lines represent the true values.*

The advantage of 3-parameter joint inversion over 3-parameter PP inversion is shown in Figure 3, using the sample log model in Figure 1. Figure 3 shows that 3-parameter joint inversion can estimate I, J and ρ, better than 3-parameter PP inversion alone.

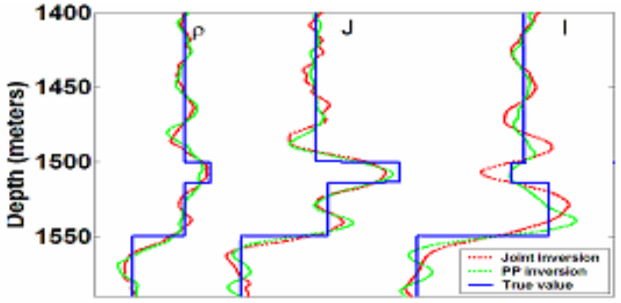

Figure 3: Comparing the estimated I, J *and* ρ *from 3-parameter PP inversion and 3-parameter joint PP and PS inversion. The red lines represent 3-parameter joint inversion, the green lines represent 3-parameeter PP inversion, and the blue line reppresents the true values.*

Larsen, J. A., 1999, M.Sc. Thesis, "AVO Inversion by Simultaneous P-P and P-S Inversion" (available at www.crewes.org). ***CN***

New Theses Available Online

Theses corresponding to the abstracts below are now available at www.crewes.org. They, along with other new theses, will also be provided on CD to attendees of the Sponsors Meeting in November.

The Differentiation Mapping of Oil Gravity Using Amplitude Variation with Offset, Hebron Ben Nevis Field, Offshore Newfoundland, Canada
Andrew John Royle

This paper investigates the amplitude variation with offset (AVO) behaviour at the Ben Nevis reservoir zone in an attempt to predict API oil gravity variations. Intercept, gradient, fluid factor, and density reflectivity attribute volumes were extracted to observe the AVO effects at the reservoir zone. These attributes isolated the oil zones associated with the Ben Nevis reservoir and showed differences between the adjacent fault block reservoir zones. Detailed crossplotting at the oil bearing well locations isolated anomalous zones associated with the response at the top of the reservoir. Simultaneous inversion methods were applied to the dataset, which provided useful information on the nature of the lithology and pore fluids. The AVO and inversion attributes were then used as inputs in a neural network analysis for porosity and fluid density. The porosity volume correlated closely with the well data across the asset and the fluid density volume accurately portrayed the variations in oil density across the asset.

Studies of multicomponent seismic polarity and amplitude
Alexandru Vant

Assuming the SEG (Society of Exploration Geophysics) polarity standard is followed, there are some cases in which reflections on the compressional (P-P) and converted-wave (P-S) sections show opposite polarities. This situation makes the correlation and interpretation processes more difficult.

To find conditions that relate polarity to elastic parameters, I derived a new approximation for the P-S reflection coefficient (R_{PS}) and also modelled seismic responses from a wide range of geologically plausible interfaces using acoustic P- and S-wave velocities and densities. I also investigate the polarity consistency with offset and how missing velocity or density well-logs used to create synthetic shot-gathers and stacks affect the interpretation process.

As a side result, I show that, with small changes, the new R_{PS} approximation is suitable for AVO (amplitude variation with offset) studies and also describe a more accurate way of computing the theoretical AVO attributes.

Opposite polarities on P-P and P-S sections were found to be associated with situations where not all the rock parameters change in the same direction (e.g. velocities increase and density decreases) across the interface.

Seismic imaging using matched filters for operator weighting
Jeffrey Karl Beckett

Given a particular statistical measure of signal to noise (S/N), the 'matched filter' is an ideal linear filter for maximizing the S/N ratio of a signal amongst random, white noise. A matched filter approach to event detection in prestack migration is proposed, where 'signal' is defined as a particular amplitude variation with offset (AVO) reflection coefficient surface, and all other AVO response surfaces are considered 'noise'. Matched filtering of the prestack data with the signal illuminates reflection events whose AVO response curve matches that of the signal; other reflection energy is suppressed. Matched filter imaging enhances the detection of Class 2 AVO events, and results in an overall S/N improvement over conventional P-SV wave prestack migration.

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