CREWES NEWS

The Consortium for Research in Elastic Wave Exploration Seismology

CREWES at the CSEG and EAGE Conventions

This year the CSEG (Canadian Society of Exploration Geophysicists) will be holding its convention May 10-13 in Calgary, Canada. Talks and exhibitions will be held at the Telus Convention Center. CREWES members will present 27 talks and posters. Extended abstracts of these presentations are available on our website. Feel free to come by and say hello at the CREWES booth (No. 300). We look forward to seeing you there!

The annual EAGE convention will be held June 7-10 in Paris, France. CREWES will be represented there with three presentations (abstracts are again available at our website). ***CN***

Deployment of Wireless Sensors for Passive Monitoring

CREWES personnel have, over the past two years, participated in the development of wireless multicomponent geophone stations. These autonomous stations are currently being tested.

Each station includes a power source (solar panels and wind turbines), sensors, recorders, and transmitters. The sensors include a string of bunched and cemented 3-C geophones. These geophones are connected to the A/D conversion boards, controller, and wireless transmitter. A central receiving station receives, stores and analyses the seismic data. ***CN***

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In This Issue...

CREWES Member to Oversee Energy and Environment Research

CREWES faculty member Dr. Larry Bentley has been appointed Assistant Dean in the Faculty of Science at the University of Calgary. His particular area of responsibility will be for research in the fields of Energy and Environment. As a part time appointment, this will allow Dr. Bentley to bring his extensive background to facilitate energy research at the university, while maintaining his current research. We congratulate Larry on this recognition of his skills. ***CN***

CREWES Presentations at the 2004 CSEG Convention

CREWES members will be presenting twenty-seven papers on a variety of subjects at this year's CSEG convention. These are listed below:

Tuesday - Thursday	**Posters**	**Palomino A**
	Recovering a signal with deconvolution and the importance of phase in a signal	Amber Kelter
2:00	A new migration method using a finite element and finite difference approach	Xiang Du, John C. Bancroft, Yuan Dong
2:30	Wave Equation Datuming	Saleh M. Al-Saleh, John C. Bancroft
3:00	Spherical wave AVO modeling of converted waves in elastic isotropic media	Arnim B. Haase
3:30	Estimation of Q using crosscorrelation	Pavan Elapavuluri, John C. Bancroft
Tuesday A.M.	**Vertical Seismic Profiles**	**Macleod A**
9:10	Synthetic zero-offset VSP including attenuation	Linping Dong, Gary F. Margrave
9:40	Attenuation (Q) from VSP and log data: Ross Lake, Saskatchewan	Arnim B. Haase, Robert R. Stewart
Tuesday A.M.	**Reservoir Characterization**	**Macleod B**
9:10	Reservoir characterization in Leming Lake, Alberta	John J. Zhang
Tuesday A.M.	**Acquisition / Depth**	**Macleod C**
10:40	GPR imaging and interpretation at a Maya plaza ruin: Maíax Na, Belize, Central America	Julie A. Aitken, Robert R. Stewart
Tuesday A.M.	**Seismic Inversion / Anisotropy**	**Macleod D**
10:10	Reflection traveltime inversions in VTI media	Chunyan (Mary) Xiao, John C. Bancroft, R. James Brown
10:40	Deconvolution with multigrid	John Millar, John C. Bancroft
Tuesday P.M.	**Seismic Processing I**	**Macleod A**
2:40	More processing in the radial trace domain	David C. Henley
Tuesday P.M.	**Migration and Imaging I**	**Macleod B**
3:10	Migration with compensation in a viscoacoustic medium	Jianjun Cui, Wenyan Xie, Robert R. Stewart, Gary F. Margrave
3:40	Adaptive tapering in the wavefield extrapolation	Kun Liu, Hugh D. Geiger, John C. Bancroft, Gary F. Margrave
Tuesday P.M.	**Multicomponent Seismic**	**Macleod C**
1:40	A sand channel interpretation using 3D multi-component seismic data: Ross Lake, Saskatchewan	Chuandong (Richard) Xu, Robert R. Stewart
2:40	Prestack Vp/Vs scanning and automatic PS-to-PP time mapping using multicomponent seismic data	Christopher O. Ogiesoba, Robert R. Stewart

continued on next page with Wednesday sessions

CREWES Presentations, cont'd

Wednesday A.M.	**Time Lapse / Seismic Monitoring**	**Macleod A**
9:40	Integration of reservoir simulation with time-lapse seismic modeling	Ying Zou, Laurence R. Bentley, Laurence R. Lines
10:10	Use of time-lapse analysis to predict fluid changes in a carbonate pool: a case study of the Rainbow B pool	Hannah Tran, Laurence R. Bentley, Edward S. Krebes
Wednesday A.M.	**Workshop: Exploration for Heavy Oil / Oil Sands**	**Macleod D**
10:40	Do wormholes play a role in heavy oil cold production?	Q. (Sandy) Chen, Laurence R. Lines, Patrick F. Daley
Wednesday P.M.	**AVO**	**Macleod A**
2:10	Three term AVO waveform inversion	Jonathan Downton, Laurence R. Lines
3:10	Two new approximations for AVO inversion	Charles Ursenbach
4:10	AVO inversion of multicomponent data for P and S impedance	Faranak Mahmoudian, Gary F. Margrave
Wednesday P.M.	**Workshop: Integration of Disciplines and Reservoir Characterization**	**Macleod D**
2:40	Reservoir characterization and heavy oil production	Laurence R. Lines, Joan Embleton,Ying Zou
3:10	Characterization of a heavy-oil reservoir at Pikes Peak, SK	Ian A. Watson, Laurence R. Lines
Thursday A.M.	**Special Sessions**	**Macleod C & D**
8:00	Seismic modelling: An essential interpreterís tool	Gary F. Margrave, Peter M. Manning
Thursday P.M.	**Workshop: AVO/Rock Physics/Lithology Prediction**	**Macleod D**
3:10	AVO investigation of the Ben Nevis reservoir at the Hebron asset	Andrew J. Royle, John D. Logel, Laurence R. Lines
Thursday P.M.	**Seismic Processing II**	**Macleod C**
4:40	A comparison of CMP and EO gathers for multiple-attenuation	John C. Bancroft, Zhihong (Nancy) Cao

CREWES Presentations at the 2003 EAGE Convention

The following three papers are being presented in June at the EAGE convention in Paris.

Time and Session	Title	Authors
10:20 Tuesday, June 8 Seismic Data Processing: Q Estimation & Compensation	Gabor deconvolution: theory and practice	G. F. Margrave, P. C. Gibson, J. P. Grossman, D. C. Henley, M. P. Lamoureux
14:10 Thursday, June 10 Rock Physics - Elastic Properties	Foamy Oil and Wormhole Footprints in a Heavy Oil Cold Production Reservoir, Western Canada	S. Chen, L. Lines, P. F. Daley
14:35 Thursday, June 10 Seismic Interpretation	Using 3D Multi-component Seismic Data, Logs and VSP to Interpret a Sand-Shale Oil Reservoir	C. Xu, R. R. Stewart

Non-linear AVO methods which can be solved non-iteratively

Chuck Ursenbach

AVO is a method for estimating elastic property contrasts across the interface, e.g., $\Delta\alpha/\alpha$. The most common AVO methods involve linear approximations of the reflectivity. Linearizing in all three variables yields the well-known Aki-Richards approximation, which can be written in this form:

$$R_{PP}^{A\text{-}R}(\theta) \approx A_\alpha \frac{\Delta\alpha}{\alpha} + A_\beta \frac{\Delta\beta}{\beta} + A_\rho \frac{\Delta\rho}{\rho}$$

Here the A_i are coefficients which depend on angle and on the ratio β/α. Further approximation to reduce to two variables yields methods which are more stable in the presence of noise, such as the method of Smith and Gidlow (Geoph., 1987):

$$R_{PP}^{S\text{-}G}(\theta) \approx B_\alpha \frac{\Delta\alpha}{\alpha} + B_\beta \frac{\Delta\beta}{\beta}$$

In either case, linearity is appealing because it allows an inversion to be carried out in a direct, straightforward fashion.

More accurate non-linear AVO methods involving the exact Zoeppritz equations are also known, but must generally be solved in an iterative fashion. One therefore must deal with convergence issues.

In previous work (CREWES Research Report, 2003) we have shown that the error in contrast prediction generally varies as $(\Delta\beta/\beta)^2$. This observation has led us in the present work to create new approximations which include this term, such as

$$R_{PP}(\theta) \approx B_\alpha \frac{\Delta\alpha}{\alpha} + B_\beta^{(1)} \frac{\Delta\beta}{\beta} + B_\beta^{(2)} \left(\frac{\Delta\beta}{\beta}\right)^2$$

and similarly for the three-parameter methods. There are two features that make these particularly unique: (1) The quadratic term accounts for the most of the difference between the Zoeppritz equations and linear theories (even the Fatti equation when $\Delta\rho/\rho$ is small), and (2) the resulting AVO inversions can be carried out exactly without recourse to iterative techniques. (The mathematical details of (2) are discussed in an extended version of a CSEG abstract available only to sponsors at www.crewes.org.)

Figures 1 and 2 illustrate the value of these methods. In Figure 1 we see that, in the Fatti method, errors in prediction of shear-wave impedance contrast (R_J) are strongly correlated with R_J^2. Adding a quadratic term to the theory removes this error. The few remaining outliers represent interfaces with large density contrasts. A three term method is required to treat such systems.

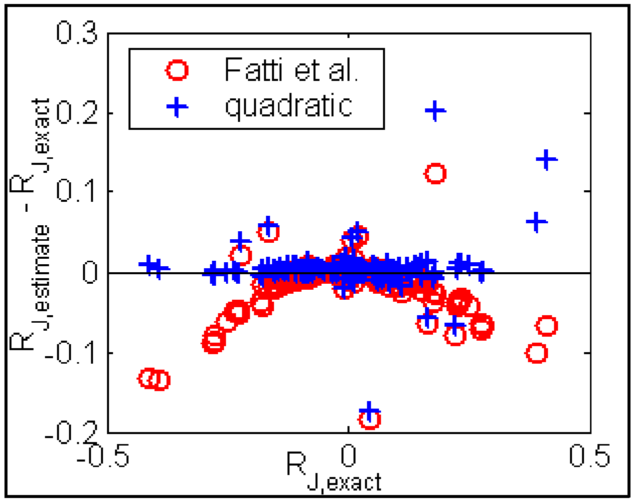

Figure 1. The error in predicted shear-impedance contrast (R_J) versus exact R_J for 125 different interfaces. The quadratic method removes the quadratic error in the Fatti result. The inversion used synthetic, noise-free data.

In Figure 2 we illustrate the value of the square term in stabilizing three-parameter AVO inversions in the presence of noise. We compare results from an Aki-Richards inversion to the analogous quadratic method. It is evident that noise has a deleterious effect on the former inversion. When the maximum angle is extended to 45° (not shown), then the Aki-Richards results is considerably stabilized. It is still less accurate than the quadratic result, which changes little. This is of practical significance as it suggests that long offsets may not be as critical to obtaining density information as is generally assumed at present. ***CN***

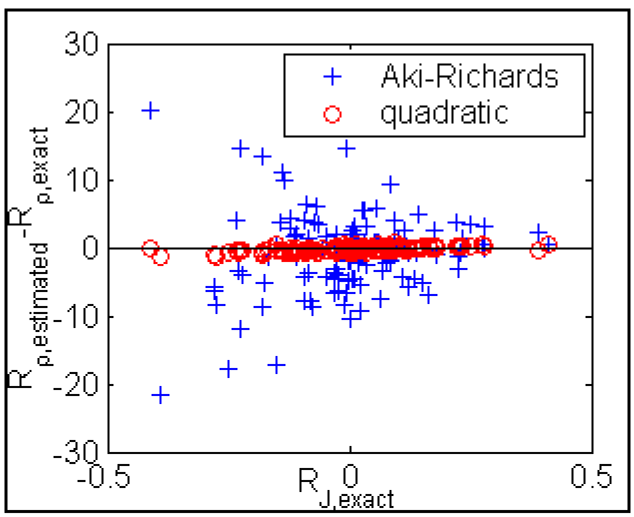

Figure 2. The error in predicted density contrast versus exact R_J for 125 different interfaces. The inversion used noisy data, which severely degraded the Aki-Richards result. The quadratic result however is much more stable.

New Theses Available

We are pleased to announce that Chris Ogiesoba and Linping Dong have successfully defended their theses and have been awarded the Master of Science in Geophysics. We give their abstracts below. ***CN***

Prestack Vp/Vs scanning and automatic PS-to-PP time mapping using multicomponent seismic data

Osareni Christopher Ogiesoba

This thesis discusses the development, testing, and application of prestack methods that scan for the average vertical velocity ratio γ_0, and the stacking velocities of multicomponent seismic (MCS) data using a converted-wave (PS) non-hyperbolic traveltime equation. The procedure entails computing semblance as a function of two variables namely, the PS velocity Vps and γ_0 with respect to the PS zero-offset time t_{ps0}. The results are displayed in 2D and 3D plots. The scanning procedure is tested using numerical data sets and real MCS data sets from the Blackfoot Field in southern Alberta. The algorithms work well with either the shot gathers or the asymptotic conversion point (ACP) gathers. The accuracy increases with increasingly fine sampling of each variable. It is observed that the γ_0-log from the scanning procedure, agrees very well with the Vp/Vs values from the well log of Well-09-08. In addition, when this γ_0 estimate is used for PS-to-PP time mapping, the time difference between the computed and actual PP time at the target level is found to be 20 ms; being an error of less than 6%.

Nonstationary wavelet simulation and estimation

Linping Dong

Nonstationary wavelet simulation and estimation methods are closely related to nonstationary seismic modeling and nonstationary deconvolution. Conventional wavelet estimation and deconvolution do not deal with the nonstationarity of the wavelet. This thesis begins with an investigation of the methods for nonstationary wavelet simulation that can be used to generate realistic synthetic seismograms. Then this thesis examines methods of wavelet estimation using 1-D attenuated synthetic data and real data. These estimation approaches are the basis for Wiener deconvolution (time domain), Wiener deconvolution (frequency domain), and Gabor deconvolution. For comparison, the wavelet is also estimated from downgoing waves isolated from a VSP experiment which gives direct recordings of the nonstationary wavelet. Finally, a new approach is provided for evaluating the accuracy of the nonstationary wavelet estimates by the VSP downgoing wavelets. This result shows that the wavelets estimated from Gabor deconvolution are more stable and closer to the wavelet estimates from VSP data than those from multi-window Wiener and frequency-domain spiking deconvolution.

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