Preface

This report summarizes the 1997 midyear research efforts of the UTAM researchers. Thirteen companies have joined for 1997: Advance Geophysical, Amerada Hess, Amoco, Arco, Chevron, Conoco, Exxon, Japan National Oil Co., Mobil, Noranda, Pan Canadian (recommended but not yet approved), Phillips, and Western Atlas.

A major effort by our group this summer was to solve the problem of the recording footprint noise in 3-D migrated sections. We attacked this problem in a number of ways.

- Footprint suppression by better survey design. We now clearly understand why seismic surveys on an uniform \( (dx_g = dx_s = dy_g = dy_s) \) orthogonal grid produce more migration artifacts than regular \( (dx_g \neq dx_s \neq dy_g \neq dy_s) \) orthogonal surveys. The uniform survey will lead to migrated sections where the grating lobes are super-amplified, compared to the regular survey where the grating lobes are mostly suppressed. Jing Chen verifies this claim by both theoretical formulae and tests on synthetic and field data. He also uses the W. Texas data to show that quasi-Monte Carlo migration (QM) is better than regular grid migration and uniform grid migration. His next step is to explain the reason why QM images were of the same quality as the standard migration images for the Alberta data.

- Zhaojun Liu used the Seismic Array Theorem to quickly evaluate the point scatterer migration responses for different Arco arrays. The computed responses readily distinguished the good survey geometries from the bad survey geometries. It also led to a conjecture as to why one survey might be better than the other: greater regularity in survey geometries lead to stronger grating lobes in the migrated section. Thus, the Seismic Array theorem can be used with trial and error methods to rapidly find better survey geometries.

- Zhaojun also used the Array theorem and optimization theory to automatically design the optimal survey for a given number of traces and aperture area. This optimization procedure appears to be quite promising, and overcomes some of the limitations involved in trial and error procedures.

- Footprint suppression by deconvolution of migrated sections. The theory of footprint deconvolution is presented by Hu, and some synthetic and field data
examples are presented. The deconvolved sections typically show much better resolution and fewer migration artifacts.

- Hu and Schuster derive analytical formulae for 3-D migration Greens functions. These formulae not only provide a computationally convenient modeling tool, but also give new fundamental insights into migration artifacts. For example, an orthogonal recording array has special directions of sampling resonances. These resonant directions map into linear features in the migrated section, which can be incorrectly interpreted as geological trends. The conjecture is that we should recognize these resonant directions and orient our arrays so they are not parallel to the major geological trends.

- Schuster derives an analytic formula for the migration Green’s function for inhomogeneous media and high frequencies. Its chief merit is that it relatively inexpensive to compute and is valid for inhomogeneous media. Schuster speculates that it can possibly be used for remigration, velocity analysis, filtering etc. However, we still don’t know if it works with realistic field data where the source frequency range is limited.

- Footprint suppression by least squares migration. Schuster uses synthetic data to show that the 3-D recording footprint noise is almost completely eliminated by 3-D least squares migration (LSM). This is really not surprising because Nemeth’s PhD thesis convincingly showed that 2-D LSM can eliminate many migration artifacts due to poor sampling geometries. Further tests on the SEG overthrust 2-D data show that LSM has problems when the data contain multiples not modeled by the forward modeling operator. The major drawback is that LSM is at least an order of magnitude more computationally expensive than standard migration. But Hu’s new results suggest some approximations that speed up LSM by an order of magnitude. Stay tuned.

It will be interesting to see which of the above approaches proves to give the best quality and most cost-effective images. It may be that each of these approaches will find their special niche.

The other research projects include some rather interesting developments.

- Dr. Jeff Thorson ported the TI Finite Difference code to PROMAX, and the module will be distributed to the sponsors at the annual meeting. Dr. Thorson will also offer a proposal to the sponsors, where he will port selected UTAM codes to PROMAX for a fixed fee. His consulting business is aimed at code development and will provide a stable platform for porting and maintaining UTAM codes for the sponsors.
• Some of our UTAM modeling codes have been integrated into the GOCAD model building package. A 3-D earth model can be designed in GOCAD, a UTAM modeling code can be launched from GOCAD, and the computed seismograms can be displayed in GOCAD. The GOCAD modules will be distributed to the sponsors at the annual meeting.

• A 3-D seismic experiment (approximately 100,000 traces) was performed by U of U students over the Oquirrh Fault in May-June, 1996. The objective was to assess the effectiveness of the 3-D QM method and 3-D tomography. New reprocessing of the traveltime data by Morey yields tomographic images that clearly represent the sought after colluvial wedge. This is the first time that a seismic method has clearly imaged a colluvial wedge, and (we believe) represents an important breakthrough in Paleoseismology. We can now perform seismic CAT scans of ancient earthquakes instead of using expensive trenching methods.

• Fanlin Meng showed in the 1996 annual report that tube wave responses in Noranda’s crosswell data can be processed to yield transmitted arrivals that originate from the tube wave generator (e.g., an obstruction) in the source well. He now shows that tube wave responses in McElroy’s crosswell data can be processed to yield reflection arrivals that originate from the tube wave generator in the source well. A potentially useful application of this method is to perform crosswell surve ys with sources at the surface that generate tube waves at obstructions in the borehole. These tube waves can be used as sources that scatter body wave energy from one borehole to another borehole.

• Yue Wang claims that AVO with both shear waves and P waves can be accurately computed using viscoelastic waveform inversion. He supports this claim with a crosswell example, but we believe that such success can be achieved with a CDP example as well. This result largely overcomes our failure to invert for shear velocities with elastic waveform inversion. Jing Chen also demonstrates the possibilities of using LSM with VSP synthetic data.

• Yue Wang and Hongchuan Sun demonstrate the success of using LSM filtering of surface waves and P and S separation on both synthetic and field data examples. There appears to be some improvement in filtering compared to FK pie-slice filtering, but the cost of LSM filtering is more than an order of magnitude more expensive. Thus, LSM filtering might be restricted to solving really tough filtering problems where FK filtering fails to perform properly.

• Yue Wang and Fuhao Qin develop a better absorbing boundary condition for the UTAM codes. However, this absorbing condition works well for acoustic codes but we are having trouble getting it to work as well for elastic codes. If successful, this will be very important for the 3-D modeling codes in the UTAM package.
• Fanlin Meng shows that migration of RVSP autocorrelograms yields reflectivity images that agree quite well with the sonic log. In fact, the standard migration result did not fare so well compared to the autocorrelogram image. This may have important implications for using the drill bit as a source for IVSP experiments. Using autocorrelograms avoids the need for recording the wavelet.

Some new news:

• We accepted a new postdoc, Jianxing Hu, in April of 1996. He has done outstanding work on developing the migration deconvolution method.

• Yue Wang worked for Amerada Hess this last summer, and Dave Morey began full-time work for ARCO this November. Dave successfully defended his MS thesis in October, 1997. Ji Xu worked for Western Atlas this summer, and on Feb. 11 successfully defended his MS thesis in computer science. He will work for B^2 Co. in the Seattle area.

• Fanlin Meng has taken a leave of absence due to illness. We all wish him a speedy recovery.

• 1998 Summer jobs: Jing Chen will be working for AHC, Yue Wang will work for Chevron, Dave Sheley will work for Arco, and Prof. Jianxing Hu (developer of migration deconvolution) would like to work for a summer with some oil company.

I would like to point out our homepage "http://utam.gg.utah.edu" where the 1997 annual report (click on "Annual Reports") is on-line with the username and the password that will be sent to sponsors.

If your company plans to join the UTAM consortium for 1998, please submit the signed agreement and the fee of $18,000 as soon as possible. This will help me plan properly for the 1998 year.

Thanks for your support.

Jerry Schuster (schuster@mines.utah.edu)
University of Utah
Tomography And Modeling/Migration Research Development Project
1998

This Gift Agreement outlines the project to be performed by Professor Gerard T. Schuster and his students under the support of $18,000.00 provided by each sponsor of the Research Development Project for the year 1998.

- After the end of 1998 an annual report will be provided to each sponsor. This report and an annual review will be given in February, 1999.

- Any papers related to modeling, migration and tomography research that we submit for publication will be sent to each sponsor at the time of submission, unless the basis for this research was previously published in our annual or mid-year reports. This will give the sponsors approximately a one year lead time prior to the date of journal publication.

- Computer programs developed in 1998 will be available to 1998 sponsors. Payment of the $18,000. will be in the form of a check to be sent to Donna Thomas 717 Browning Bldg., payable to the University of Utah. The money is to be specifically designated for the Tomography and Modeling/Migration Research Development Project.

The period of the Gift Agreement shall be January 1, 1998 to December 31, 1998. An optional one-time fee of an extra $20,000. will allow the new sponsor free access to our previously developed Fortran codes for modeling and imaging (http://utam.gg.utah.edu/codes/fortran.html). All monies from this Gift will be utilized by the Tomography and Modeling/Migration Research group. Funds will be primarily used to pay for student and researcher salaries, with secondary expenses in the form of books, supplies, computers, xeroxing, field equipment, travel, and administrative support.

I have read the above Gift Agreement and agree to the conditions stated herein.

Sponsor: University of Utah
By: 
Date: 