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An isolated cumulonimbus cloud develops over the Monashee Mountains east of Kelowna producing an evening shower. (Photo courtesy: Rob Tuerum)

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Topic: DHI/AVO Best Practices Methodology and Applications
Illuminating Reservoirs with Electromagnetics

Leonard Srnka
ExxonMobil Corporation (SEG Distinguished Lecturer)

Marine controlled-source electromagnetics (CSEM) has recently become a significant business tool for upstream applications due to the convergence of many technologies. CSEM provides valuable information on subsurface lithology and fluids independently from seismic data; however, its spatial resolution is much lower. Uptake has been dramatic, with more than 200 industry marine CSEM surveys acquired worldwide since late 2000.

This presentation discusses some results that demonstrate both the promise and the challenges that lie ahead. CSEM can detect and map offshore reservoir hydrocarbon resistivity at depths exceeding 2000 meters. But resistivity determination is hardly a fool-proof method for hydrocarbon identification, since many geologic facies are electrically resistive relative to their surroundings. As marine CSEM matures, it may prove to be the most important geophysical technology for probing below the seafloor since the emergence of 3D reflection seismology 30 years ago. The key determinant of commercial success will be whether the value of CSEM information is worth the money spent, relative to what other data can provide.

Leonard Srnka received a B.Sc. in Engineering Science from Purdue University in 1968, graduating summa cum laude. In 1974, he received his PhD in Physics from the University of Newcastle upon Tyne, United Kingdom and from Corpus Christi College, Oxford University, United Kingdom (1970-1973), where he was a Marshall Scholar. Leonard spent his early career working for the NASA Lunar Science Institute as a Postdoctoral Fellow (1974-1976) and as a Staff Scientist (1976-1979) where he researched on the origins and evolution of lunar and planetary electromagnetism. The latter part of his career has been spent working at the ExxonMobil Corporation. From 1979-1993 he was project leader and supervisor with assignments in electromagnetic methods, seismic modeling and inversion, and borehole geophysics. He was a supervisor for gravity, magnetics, and remote sensing research and applications (1993-1998). From 1998 to present, Len has been the project leader for land and marine electromagnetic technology, and serves as a member of the senior technical staff. He championed the Remote Reservoir Resistivity Mapping (“R3M”) breakthrough research project for upstream applications. He has been the Chief Scientist on numerous marine CSEM surveys offshore Europe and West Africa in 2001-2003. Leonard has special interests in marine MT and CSEM acquisition technology, 3D modeling, data interpretation, and imaging/inversion. He has twenty-six refereed publications and numerous patents issued and pending.

MARCH LUNCHEON
DATE: March 26, 2007
TIME: 11:30 A.M. Lunch
LOCATION: Telus Convention Centre, Calgary
TICKETS: Contact CSEG office
TELEPHONE: 262-0015 or Fax: 262-7383

APRIL LUNCHEON
April 23, 2007
“Simultaneous AVO Inversion for Leading Edge – Integrated Seismic Reservoir Characterization”
Dr. Matt Brzostowski
Manager of Reservoir Services for North America, Schlumberger
My first year on the CSEG executive has flown by, and I have enjoyed working with everyone involved. Thank you to Eric Mikkelborg, for being an excellent and prudent Director of Finance and a pleasure to work with. Congratulations to Larry Herd, newly elected incoming Assistant Director of Finance; I look forward to working with you. A lot of effort is put into the various programs of the society by all of the volunteers, and, as one member, I want to thank everyone involved for their time and energy.

I write this having just come back from the 2007 Doodlespiel. It was a very enjoyable and relaxing weekend, and very well run. Kudos to the entire organising committee! It was great to see some old friends and familiar faces again, and it was also great to see new teams coming into the event and having fun. I really appreciate the effort to which the committee has gone in the last few years to allow as many people to participate as possible, such as instituting the hole plug event and formalising fifth players on the teams. I think these initiatives have helped make the Doodlespiel an even better networking event for our society, and a great party!

The finances of our society are in excellent shape right now, due to the current boom in the industry. Last year, following an excellent convention, and an equally successful Doodletrain, we had an excess of revenues over expenses of $298,289. At year end, our cash balance in restricted and non-restricted funds totalled $1,326,505. However, like Eric before me, I must urge caution and balance. It wasn’t very long ago that we had a deficit year, and everyone who’s been around the industry knows that energy fortunes fluctuate. So we must be prudent and save for our less abundant years.

Having said that, our financial strength has allowed the executive to make a substantial donation to the CSEG Foundation. This donation will help get the Foundation going, and begin to build up a corpus from which educational and scientific endeavours can be funded into the longer term future. The plan is that even when the CSEG itself may have a lean year, the Foundation can run many programs that further geophysical education and the science of geophysics, such as the Distinguished Lecturer program, for example. Future executives will continue to donate to the Foundation as they feel is prudent, to build up the Foundation’s ability to run programs.

We have just been through the budget process, and several committees are very active and are increasing their efforts this year. In particular, the Outreach committee is working hard to support people coming into the industry and to attract new members. I look forward to another great year at the CSEG!

Elizabeth Atkinson
Assistant Director of Finance

Crossword Puzzle Answers from last issue
(Created by Helen Isaac)

Across
4. Don’t let your wife see the exotic dancer here (2,3)
5. This will give you the hots (4)
7. Scale it but return to normal (7)
10. Ice miss needs shaking up (7)
13. Did the Scottish all-women hen clan dig themselves into a hole? (7)
15. You’ll get to edit many if you blow them up with this (8)
17. Try a poison strangely in different directions (10)
18. A change in direction comes right between the umpire and the play
19. This guy knows how to enjoy life (5,5)
20. Let man mix up this part of the earth (6)
22. You’ll smile more than once at this acquisition (9)
23. Runs around the world on St Valentine’s Day (4,4)

Down
1. The centre of the decor exhibit (4)
2. What composing this crossword was (6)
3. There’s only room for one to sleep here (4,3)
6. Dim Peter mixes up the inclination measure (8)
8. Love confuses the big town with speed (8)
9. It’s shaping up to be a hoax in becoming self-governed (13)
11. Does this work on a musical mountain? (8)
12. Make a prim file bigger with this (9)
14. Dim pinto clip clops around the middle (8)
16. I thought about bouncing this off you (10)
19. Have an argument about the shape (5)
21. Hater needs to be put right on this planet (5)
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A leader in seismic processing technologies.
The climate conversation continues and has tremendous risk for the Oil Industry. It is worthwhile to gauge this by looking at pieces from the news on the ongoing developments concerning politicians, climate change and the Oil Industry. Sources include the Daily Oil Bulletin and The Economist from various articles that have been published over the past two months.

The wildest card in the energy sector’s outlook is public policy. Opinion polls have repeatedly indicated that climate change will be a pivotal issue in a federal election which is widely expected to occur this year. Unavoidably, oilsands development becomes entangled in any national debate over greenhouse gas emissions. Provincialy, oilsands royalty rates are the hottest topic facing Ed Stelmach, Alberta’s new premier. Although conventional oil and gas activity lies largely outside of those political arguments, the wrangling only adds to the uncertainty confronting the oilfield services sector over the next couple of quarters. NOTE: Recently Stelmach appointed a panel that some critics feel is too industry-oriented.

B.C. Premier Gordon Campbell said the province would build on its reputation for environmental stewardship by establishing targets, actions and processes aimed at reducing B.C.’s greenhouse gases by at least 33% below current levels by 2020. That target will place emissions 10% below 1990 levels.

“We cannot act to stem the growth of global warming and minimize the impacts already unleashed by establishing targets and actions and by working with our national and international neighbours.”

Whatever the government has in mind, “there is no question” the new provisions will be an added cost factor in British Columbia where there is already a high cost to doing business in northeastern B.C., said Alvarez. There has been a large focus in the province towards the non-conventional gas sources and those are even higher cost, he noted.

“We are going to have to sit down with the province and understand what the implications and talk about whether there is going to have to be recognition in the fiscal regime that as industry moves down this road if they don’t want to see activity suffer the government may have to be part of the solution.”

If the government is eying global hard caps on emissions, “the other alternative to meet your targets is you reduce your activity levels,” said Alvarez. “You focus on your big wells and you maybe don’t do as much on the lower productivity, unconventional side.”

Activity in British Columbia has already been declining. In January, 2007 DOB records show the lowest level of wells drilled since 2002.

Concerning Federal Government moves of late – but confronting the issue is one thing, Alvarez added. Dealing with the politics that many industry officials fear will result in government offering up the petroleum industry as fodder for political gain, is quite another. “Where our concern lies is that when you see these issues become as political as they have, when they get used for political purpose, then it gets awkward,” he said.

We’ve been very clear about some of the things we think are important – not buying hot air, not being forced into a domestic emission trading systems, the need to focus on technology. We’ve been heard and I guess we’ll find out whether and how much our proposals have been picked up by the government, CAPP’s Alvarez said.

“For example, (Canada’s overall) GHG emissions in 2004 were 758 million tonnes compared to 599 million tonnes in 1990—that’s a growth of 159 million tonnes in emissions,” he explained. “By my calculations, if we were to just say that in 2004 we were producing about one million bbls per day of oil from the tar sands from in situ methods, that looks like it liberates about 75 kilograms of CO₂ per bbl, on average, so one million bbls would amount to 75,000 tonnes of CO₂ per day, which would equate to about 27.5 million tonnes per year.”

Given the calculated annual amount, Russum said even if the oilsands were issued a complete cease and desist edict, the resulting reduction in GHG emissions would be a relative drop in the bucket compared to the national increase since 1990. “If we were to shut down all our activity in both mining and in situ extraction, that 27.5 million tonnes per year is only about 17% of the growth of greenhouse gases in Canada since 1990,” he said. “Other things we are doing in Canada are responsible for the other 83% of the growth in GHG emissions in the country.”

The UN report on Climate Change was recently released. Its broad conclusion is that something serious is happening and man is very likely to be responsible. Reports to be released later this year will detail the impact of climate change and on what to do about it. These remain the areas where it is difficult to gain consensus. The range of predications for the rise in temperature by 2100 has widened to 1.1 C – 6.4 C. This widening is not surprising given the complexity of climate change. But it does leave plenty of scope for argument about whether it is worth trying to do anything about climate change. R

From the Thursday Files:

Never mistake knowledge for wisdom. One helps you make a living; the other helps you make a life.

– Sandra Carey

Mike Doyle is the President of the CAGC – the Canadian Association of Geophysical Contractors – representing the business interests of the seismic industry within Canada. The CAGC website may be found at www.cagc.ca
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Multiples are a menace and their elimination from the seismic data presents a real challenge to the seismic processors. One of the commonly used tools in the processor’s arsenal is the Radon Transform. However, when it comes to removal of multiples before AVO analysis, reservations are usually expressed for application of this transform, in that it hurts the amplitudes, especially on the near traces in the gather. This apprehension has been cast in the form of the following question and answers were sought from two well-known experts in this area, namely Nurul Kabir (BP) and Eric Verschuur (Delft).

The order of the responses given below is the order in which we received them. We thank the experts for sending in their responses.

Satinder Chopra

Does Parabolic Radon transform multiple removal hurt amplitudes for AVO analysis?

Answer 1

It sounds a simple question but the answer is never a simple yes or no. This underlies most of the questions we face in seismic data processing activities. Do we ever see a process, method or technique that positively answers all our questions? Almost never, right! So, a more appropriate question to ask would be: When or How can we effectively apply Parabolic Radon transform for multiple removal without hurting the amplitudes for AVO analysis?

I will refer to The Leading Edge article ‘Toward true amplitude multiple removal’, Jan., 1999 by Nurul Kabir and Kurt Marfurt for most of my comments and remarks. This article clearly illustrates the element of the parabolic Radon transform that affects the amplitude for AVO analysis. The forward and the inverse Radon transforms are not exact inverses of each other. The most commonly used least-squares implementation generates some artifacts which affect the amplitudes at the near offsets (Figures 7 through 10). The far-offset artifacts are more easily handled with some offset tapering (Figures 4 and 5). Even the more advanced implementation of weighted least-squares or high resolution Radon transform is not completely free from these artifacts (Figure 6).

For AVO analysis, intercept (the amplitude at zero-offset) and gradient of the amplitude with offset are the parameters most commonly used. Synthetic and field data examples in the above article clearly illustrate that the mid- to far- offset amplitudes are not significantly affected by the parabolic Radon based demultiple process. The gradient parameter computed over (sufficiently smoothed) mid- to far- offset amplitudes is expected to be a reliable gradient parameter. However, a reliable estimate of the intercept parameter, based on the near offset amplitude, remains a challenge because of the near offset transform artifacts (Figures 7 through 10, Figures 14 and 16). Special care would be needed for the reliable estimation of the intercept parameter.

For field data, the very near offsets are missing due to the acquisition limitations. Interpolation to zero offset with proper amplitude is a great challenge in itself. Least-squares parabolic Radon transform also assumes a uniform trace geometry and amplitude in the offset direction. Field data not only defy these restrictions but are also very often infested with various types of coherent or incoherent noises. Some kind of amplitude regularization before doing the Radon transform may be useful in certain situations. The gain function may be removed later. Some type of amplitude calibration for the near offsets using well information may be necessary for a reliable estimate of the intercept parameter.

For noisy field data, avoiding the very near offset traces may also provide a practical solution.

All the examples in the above article show illustrations of premigrated gather amplitude analysis. But the application of the parabolic Radon transform to post migrated gathers is also very common. The parabolic Radon transform exploits one of the robust discriminants, the moveout discrimination, between primaries and multiples. The parabolic Radon transform is an effective tool for multiple suppression when a moveout discrimination between the primaries and multiples exists.

Parabolic Radon transform has been widely used in the industry for about a decade now for dealing with multiples at various levels of processing, both pre- and post -migration. This tool will continue to find its wide application because it exploits a robust discriminant between primaries and multiples.

Nurul Kabir

Exploration and Production Technology Group
BP, Houston, USA

Answer 2

Multiple removal via the parabolic Radon transform

Since its introduction (Hampson, 1986) move-out based multiple removal via the parabolic Radon transform has been widely applied. The principle is quite simple: in a CMP gather it is expected that a primary and a multiple have a different move-out. If we apply NMO correction to the CMP gather which flattens the primary, the multiples will show a residual move-out. Under the assumption that these residual move-out curves can be approximated by parabolas, the parabolic Radon transform will map them into different areas in the parabolic Radon domain. Muting the area where the multiples are mapped, and applying an inverse Radon transform gives an estimate of the primaries.

The forward parabolic Radon transform of a CMP gather \(d(x,t)\), where \(x\) represents the offset, can be written as follows:

\[
m(q,\tau) = \sum_{x = x_{\text{min}}}^{x_{\text{max}}} d(x, t = \tau + qx^2) \Delta x ,
\]

which means stacking the data along parabolic trajectories, where \(q\) represents the curvature of each parabola, \(\tau\) the apex time, \(x_{\text{min}}\) and \(x_{\text{max}}\) represent the minimum and maximum offset in the data and \(\Delta x\) the offset spacing. The inverse
transform can be written as a modeling of parabolas, meaning that each sample in the Radon space represents one parabola in the input space:

$$d(x, t) \approx \max_{q} \sum_{q = q_{\text{min}}}^{q_{\text{max}}} m(q, \tau = t - qx^2) \Delta q$$

The approximation sign is chosen, because the second equation does not describe an exact inversion of the first equation.

If we assume that our seismic data consists of only one event with a perfect parabolic (differential) move-out, such as displayed in Figure 1a, then we would expect only one spike in the parabolic Radon space, at the apex time and curvature of this event. However, when applying the forward transform as described in equation (1) we get a serious smearing in the Radon space, as visible in Figure 2a. This is due to the fact that the input data has limited offsets, generating artefacts in Radon space (see Kabir and Marfurt, 1999; Maeland 2003). Furthermore, when directly applying equation (2) to reconstruct the input, the expected input data is not obtained (Figure 2d). Apparently, this transform pair has to be modified to ensure a reconstruction of the input data in order to make this useful for multiple removal. One can conclude that the problems arise from the forward transform. Hampson (1986) suggested to replace the forward transform by a least-squares inverse of the backward transform. Actually, by doing this, the following inverse problem is solved: which distribution of data in the parabolic Radon space recreates the input data correctly. There are many solutions to this problem, i.e. many distributions in the Radon space will reconstruct the input data. The least-squares approach of Hampson (1986) will give that solution that has the minimum energy in the Radon space. When muting the multiple and inverse transforming the muted result, Figure 3b is obtained. As this is a non-linear optimization process, which is very computation intensive. However, the results are excellent, such as visible in Figure 3c, showing the high-resolution Radon domain of the parabolic event: the event maps onto one curvature parameter. Figure 2f shows a perfect reconstruction of the input event.

Herrmann et al. (2000) showed some impressive results of the use of a high-resolution implementation of parabolic Radon transform for removing multiples in field data. Thus, one might conclude that all problems are solved now: the high-resolution Radon transform will give an excellent focusing in the Radon space and also provides perfect reconstruction. However, this will only be the case if the signal has a perfect parabolic move-out and (2) the wavelet is exactly the same for all offsets and (3) if the AVO is constant. In reality this is never the case. For example, AVO effects on the input data will give varying amplitude and phase along the event, NMO correction will introduce stretch effects, which results in a wavelet variation along the offset, the residual move-out will never be a perfect parabola, especially not when the subsurface has lateral variations (see e.g. Verschuur, 2006). All these effects result in a smearing of the event in the parabolic Radon domain. With other words: for non-perfect constant amplitude events with non-perfect parabolic move-out, we need more parameters in the Radon space to describe one event. You might say that the event becomes “broad-band” in the Radon space.

To demonstrate this, Figure 1b represents a more realistic seismic gather, which is in this case a true NMO-corrected primary and interfering multiple event, obtained from modeling in a horizontally layered medium. The amplitude varies with offset and also stretch effects are visible. Figure 3a shows the least-squares Radon transform of this data. It is clear that the deviation from a perfect constant-amplitude parabola gives additional smearing in Radon space. When muting the multiple and inverse transforming the muted result, Figure 3b is obtained. As this is synthetic data, the difference with the true primary can be calculated, which is shown in Figure 3c. Note that the primary is not fully reconstructed and, furthermore, part of the multiple is also visible, especially at the near offsets. If the multiple would be on top of the primary, this would give an additional amplitude distortion of the AVO from the primary. This observation has

Figure 1. a) Gather with one event which has a perfect parabolic move-out.

b) NMO-corrected CMP gather with two events: a flattened primary and a multiple with residual move-out. Note the AVO and stretch effects on both events.
been reported by Kabir and Marfurt (1999) and they have illustrated this with many examples.

If the high-resolution Radon transform is used, the transform domain is given in Figure 3d, the reconstructed primary after muting in the Radon domain is plotted in Figure 3e and the difference with the true primary is depicted in Figure 3f. Note the improved separation in the Radon space, resulting in a reduced amplitude distortion in the reconstructed primary. However, note the fact that in the high-resolution parabolic Radon space there is smearing of the events, meaning that each event occupies a certain area in Radon space, because of the deviations from the perfect parabolas in the input space. Therefore, there is a principle limitation of primary/multiple separation in the parabolic Radon space, based on the shape and AVO of the seismic events. This means that if this smearing effect is larger than the separation between primaries and multiples, artefacts will occur in the estimated primaries, which can distort the AVO.

To illustrate this, we consider a CMP gather from a deep-water field dataset after NMO correction, as shown in Figure 4a. Primaries are more or less aligned and strong multiples are visible with residual move-out. However, it is also clear that the multiples are not constant amplitude, perfectly parabolic events.

Figure 2. Result of different versions of parabolic Radon transform applied to the data of Figure 1a. a) Straightforward stacking along parabolas. b) Least-squares inversion result. c) High-resolution result. d-f) Reconstruction of the input data from the transforms a-c) respectively.
It can be observed in Figure 4b, showing the L.S. parabolic Radon transform, that multiples and primaries overlap in Radon space. After muting the multiples along the red dashed line, and applying an inverse Radon transform, an estimate of the primaries is obtained. Especially around the near offsets there is residual multiple energy visible, which will have a serious imprint on the primary AVO. Furthermore, it appears that the AVO of the primary events exhibits some lateral smearing.

The use of the high-resolution Radon transform gives an improvement to this example, however, the smearing in Radon space cannot be removed and overlap between multiples and primaries will exist. The leakage around the near offsets, however, is greatly reduced due to the high-resolution Radon transform, but the reliability of the reconstructed primary amplitudes is still questionable.

**Conclusions**

In general it can be stated that multiple removal via the parabolic Radon domain can deliver quite good results. However, we should not expect miracles, as the application of such a tool means continuously making compromises. It will work at its best in areas with a reasonable simple geology without strong lateral
velocity and structural variations, as this will ensure that residual move-outs of the multiples can be approximated with parabolas. Furthermore, the use of a high-resolution version of the parabolic Radon transform increases the separation between primaries and multiples and is therefore advised. Although not addressed in the above, the high-resolution version of parabolic Radon transform is also better capable of handling spatial aliasing effects. However, it is hard to completely avoid cross-talk between primaries and multiples, as AVO on the events and non-parabolic residual move-outs will give an inherent smearing of energy in the Radon domain. Thus, applying a mute in Radon space and inverse transforming the muted result can damage the AVO of the primary events.

D. J. Verschuur
Delft University of Technology

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Maeland, E., 2003, Disruption of seismic images by the parabolic Radon transform: Geophysics, 68 , no.3, 1060-1064.

Figure 4. a) Field data CMP gather after NMO correction. b) Least-squares parabolic Radon transform. c) Result of muting the multiples and applying an inverse Radon transform. The red line in b) represents the mute line.

Figure 5. a) Field data CMP gather after NMO correction (same as Figure 4a). b) High-resolution parabolic Radon transform. c) Result of muting the multiples and applying an inverse Radon transform. The red line in b) represents the mute line.
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“You can continually be awakened to the fun and enjoyment of your jobs.”

– An interview with Lee Hunt

Lee Hunt is an experienced exploration geophysicist and a well known name in the Canadian oil patch. He has become a successful manager of seismic exploration, mostly focused in WCSSB. He believes it is important to adapt the latest available technology into his processing/interpretation workflows and add value to his projects. He has actively participated in the CSEG activities, was the Technical Chairman for the 2001 CSEG Convention, was the co-recipient of the 1997 SEPM Best Paper award as well as the Best Paper award at the 2000 CSEG Convention, and has chaired many Convention technical sessions. Lee very sportingly agreed to be interviewed for the RECORDER, and made the interview a pleasant and interesting discussion by revealing his impressions, opinions and insightful comments on different aspects. Following are excerpts from the interview.

(Sotos courtesy: Penny Colton)

S: Lee, let’s begin by asking you, the first question that I usually ask, tell us about your educational background and your work experience?

L: I already knew I wanted to be a geophysicist in High School, so I knew I had to enroll into a physics program. In point of fact, I did my first year of physics in Fort McMurray’s Keyano College. From there, I transferred into the second year of geophysics at U of A. U of A is very physics oriented, with geophysics placed within the Department of Physics; and I graduated with a B.Sc. with specialization in geophysics.

PanCanadian Petroleum recruited me and fellow U of A 1990 graduate Tom Podavinsky straight out of school. PanCanadian had an excellent training program, and I enjoyed working there for 6 years. Eventually I departed to go to Cimarron Petroleum. I was the third geophysicist there, which was a big contrast from the enormous geophysical college of PanCanadian. Cimarron had been engaging in successful business for 19 years, but ironically they sold within six months of my arrival. I was briefly at Cimarron’s successor, Newport Petroleum, but quickly made the move to another company called Calahoo Petroleum. My role there was as the only geophysicist so that was a whole set of new responsibilities for me. For the first time I had to manage all aspects of geophysics, including the data itself, processing, software, acquisition, and even liability issues related to geophysical activities. I took that job for this new and broader experience alone. From there I have had the privilege of working at a number of small companies, with each move prompted by a series of corporate take-overs. I have been through six of them in all, so I went to Tikal, Ketch Energy, Ketch Resources, and finally Ketch Resources Trust, which was recently acquired by Advantage Energy Income Fund. I enjoyed a new role as a middle manager at Ketch Resources Trust, where I ran their North Business Unit. Now I am consulting under my consulting company Mimir’s Well Exploration Corp.

S: You said you had already made up your mind to go into geophysics. How did you make up your mind?

L: When I was in High School, I recognized there were a few things that I was good at: one of them was writing, and the other was physics. I liked writing; especially creative writing, and I loved literature, but I didn’t think that writing held a realizable career for me. So I visited the school’s career counselor, and we focused on careers in physics, which I hoped would be more tangible. The school had a gigantic book of careers, and we eventually found geophysics. Geophysics looked really good because you didn’t need a PhD. to be a practitioner. It was a practical, applied science and appeared to have a future. That made a lot of sense to me.

S: What were some of the early landmarks in your career that put you on a sound footing?

L: One of them was my ineffable good fortune to be hired by PanCanadian at that time. In those days they had a superlative training program and they also had a number of excellent people such as Lorne Kelsch, and a fellow who stands head and shoulders above most of the rest of us: Bill Goodway. Bill took very active hand in training the new grads and that was probably the best turn of good luck I ever had. He imparted a lot of good advice, particularly emphasizing the need to “question everything”. This often overlooked habit might be one of the key things a person has to learn; especially a new grad that perhaps lacks confidence and experience. The new graduate’s role there was to Q.I. the processing of the seismic data. We worked with both the processor and the interpreter to produce the best image we could for the task at hand. We were encouraged to explore, to investigate, and interrogate any and all aspects

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of acquisition and processing. I was very fortunate that they had that program and role. And there was also time to dig into subjects that interested us. I became very interested in noise attenuation and resolution issues. I recognized that we were in a privileged position to learn about processing for interpretive advantage, and worked hard to make the most of it.

There were some things that we did there that exceeded my regular role. I ran a task force for investigating inter and intra bed multiples. One of the things we did with that task force was form alliances with various big processing houses in town and supported some of their research, both through interpretive input and through actual capital funding. These kinds of activities helped me to appreciate the value of research and development (R&D), and to make contacts with some of the excellent R&D talent that we have in Calgary.

So I have described a little bit about the value of working with a good company that values people. Maybe it is not a landmark that I achieved but I appreciated it- loved it- and did the best I could to take advantage of the privilege of being there. This may sound paradoxical, but one of the most important things that I did was recognize when it was time to leave. And I did this after being there quite along time; 6 and 1/2 years, but there came a time when to continue to grow I had to go. I knew when that time came.

L: Big companies are a great place to start a career. Certainly they are not the only place, and there are new ways for other people, but I doubt that I could have gotten the same technical training anywhere else that I did than at a big company. Also, I gained an appreciation for technology and R&D that may have been difficult to achieve in depth or detail later in a career. In fact it is one of the reasons you go to University and you learn physics or geology first. You are not going to learn that later or at least it would be incredibly difficult. So I think that the technical details needed to be reinforced early. And also it’s very collegiate, so you get to meet a lot of people and contacts.

Some other benefits of a bigger organization are flexibility. It is possible to work on various projects at a big company, you can move around in them. There are also lots of different kinds of people to work with. If you don’t fit in with some, you know there are always other people that you will work well with. And I think not long ago people might have argued that larger companies have greater job security, but I wouldn’t make that argument universally now.

There are some drawbacks to bigger corporations and people are aware of a lot of them. Sometimes individuals feel that their impact is too small at a large company. They like to feel that they have done something to make a difference and that’s important. Sometimes the structure of the company, the bureaucracy that is necessary to go with it, can be stifling for others and it can induce them to leave. Now I wouldn’t say that these kind of frustrations necessarily affect everyone the same way. It is the job of good management teams to try to minimize and mitigate those kinds of effects so they do not cause a problem. Nevertheless, the structure and bureaucracy of bigger firms often do cause issues for entrepreneurial people.

Small companies can be a lot of fun. Individuals almost always feel they have a big impact and they almost always have greater responsibilities. There are fewer people to solve problems for you. If something goes wrong, it needs to be dealt with- often by you. Since there are fewer people or teams every person on the team is essential. There is certainly nowhere to hide. If you get along with the few people around you, it’s the best time of your life and if you don’t it can be terrible. So I think interactions are magnified at smaller companies. Interaction with the executive level is also usually much closer in small companies, so most people can be more engaged with the real business struggle of the company.

One of the drawbacks of a small company is its limited financial resources. It is not uncommon for a small company to overspend on a major property (often follow-up to an acquisition) and the debt levels come up too high. The limited financial resources of the smaller organization then make it very difficult to execute other programs. This is a straight jacket that any company can get into, and you really feel that struggle at a small company. Just as you can have a bigger impact at a small organization, you cannot withstand as many problems. If you thrive on that kind of a struggle, it’s great, if it drives you insane, maybe a smaller firm is not the place for you.

The main difference that I would point out is that you are close to the heartbeat of the corporation at all times, almost in all ways. I’d say lastly that flexibility and efficiency are key elements at a small company. I knew when I was leaving PanCanadian to go to that very first small company role at Cimarron, I had to change. Instead of having a single large project area for years, three or more geologists would show up at your door every day with new projects. One had to think about how to be flexible and how to learn things quickly, so I’d say to be at a small company you have to be very adaptable and efficient. Some might argue though that that is true everywhere, but it is most obvious in the smaller firms.

L: I didn’t have one at first. You start with desire, and I think most people have the desire to do a good job. This is fundamental to professionalism, even if in the beginning we don’t always appreciate everything it takes to do a good job. With some experience and guidance, we all learn how to perform better in our roles, and can better ponder the elusive dream of professionalism.

Some of the things that I felt were important for this process were not being afraid to change roles. You don’t want to become stale. A professional should be a very bright, dangerous, active person, so you can’t be doing the same things over and over and if it seems that way, maybe you’ve
 interviewer: Geophysics is fantastic for so many reasons, but one of the most enduring and intriguing challenges is its lack of complete certainty in the real world. Even as far back as in university, we recognized that flaws in either our experimental set-up, or simplification in our physical methods, formulae, objective functions, etc, meant that there were many ways to solve a problem. This also meant that there would be endless ways of improving what we were doing. There was no denying we were working in a causal world, but the uncertainty, error, and the ill-posed nature of our problems meant that there was also room for art in the science. Whether a geophysicist is estimating a Fourier transform, the time or depth structure of an event, informal (human) interpretation, or the formal interpretation of an algorithmic inversion, there would always be a better or different way to approach the problem. I fell in love with this idea, and I believed that the clever, creative, use of technology would bring advantage.

Interviewer: I overestimated the importance and universality of technology, and probably did not follow through on my hopes and thoughts regarding technology with a rigorous enough analysis of its real economic value. So, I loved technology, and was biased towards its uses. I think that in those early days, I lacked that cold, skeptical view that was needed to make economic decisions. It took me a long time to fully realize that the discipline of the scientific method was required in all aspects of our work – particularly business and decision-making. The bridge between loving technology in a biased way, to loving the larger science of decision making was built by the experience I later had at small companies.

Interviewer: The MBA guys, or business people from other programs, all study strategy, competition, and economics. Most geophysical programs do not go anywhere near these subjects, so it is left for us to discover this important knowledge through our own means. I suppose that it is probably fitting that we learn the physics first, since our mathematics is far more complex and mind-bending than anything found in a business class. But just because geophysics is more difficult to learn conceptually does not mean that business principles are trivial or unimportant. Ultimately, all geoscientists learn about the business side, often through on the job (experiential) training. But I have to come back to my point that we don’t generally learn about decision making as a disciplined process, and we should. Geoscientists either make or advise on enormous, corporately material decisions every day. And we may be good scientists, but we start as amateur business people and amateur decision makers.

Interviewer: As I went to smaller companies, I inevitably became closer to the real business effect of the decisions I made or influenced. Not all the companies did well, and, as I said, we feel that failure or that success and you can start to ask – okay, how much of a difference did I really make? Or did I lead us the wrong way? – So every company gave me a deeper glimpse into these matters and I began to see flaws in my ways of thinking and I will admit to another one of them: confirmation bias. Confirmation bias occurs ubiquitously. It is seen when you are looking back upon what happened or you are looking ahead, and you look for things that confirm what you want to believe. Most people are also too impatient in their decision-making processes, and this tends to direct them towards their biases as well.

Interviewer: I have had the privilege of seeing different executive teams and their decision-making processes. Every time you move you learn something from other people. I became awakened to the fact the technology itself is not so important, but that it’s real value comes instead from how well or appropriately it is used. This sounds pretty obvious, but true appreciation of this simple idea could only come when I abandoned some of my old biases. My point is definitely not that technology and decision-making are at loggerheads, but rather that bringing these two disciplines into union is the true goal of the applied scientist. Eventually I took on a role as a manager, and experienced the decision making side more fully.

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Our success acquiring high quality data in North America's geographically diverse terrain isn’t surprising given our high channel count crews and unrivaled industry experience, but you might not know about PGS’ commitment to Core Values.

Our focus on Leadership in HSE, People and Integrity, Initiative and Innovation, and Delivery and Reliability is the building block of our organization.
L: Well, I was a middle manager, so I had to do both technical work as well as management work and this is not a realistic goal. Generally something gives and there are a few things that can happen: you can lose the personality side, the business side, the technical side, or do poorly at all three. Never the less, I pursued everything as hard as I could. The problem was exasperated by the chronic understaffing most of us find ourselves in. It is hard to find good professionals, and many people try to do too much to make up for the problem. Corporate changes tend to exaggerate these kinds of issues because there tends to be fewer people to go around, but an even greater desire by everyone to somehow make it all work. My experience as a manager was probably the worst grind of my career, both for the dual nature of the role as well as the staffing issues.

On the other hand, I also learned a lot in that role. I enjoyed organizing things the way I wanted them, and dealing with strategic issues. I learned to abandon my biases, learn more from honest look-backs, and finally to appreciate decision making as a discipline and a thing in itself.

S: What are you planning for your next move?

L: I am not sure in the near-term. I don’t have a big plan at this time. I am consulting right now and I find it to be a breath of fresh air. It has been excellent for the short time I have been doing it. Whether I continue to do that, or take on a larger role with one of my clients or someone else, remains to be seen.

S: Tell us about some of your memorable moments in your professional life and also a success story that you might want to share with us if the two are different?

L: Sure. One of them that you are aware of would be in 2001 when I was the convention technical chair. It was memorable because we felt that we were able to unleash a little bit of our own creativity, particularly through the vehicle of the Greek theme we used. One of the things I remember most of all was a discussion amongst the technical team regarding whether we would have awards that year. There are always a variety of opinions on whether we should have a Best Paper Award, or if there even can be a Best Paper Award. We decided to be very aggressive with it: we gave away some very cool and interesting looking swords. I loved doing that because the people that had the courage to get up and contribute to the CSEG were awarded in a way that they had to remember for a long time.

There was also one pretty good example at Ketch Trust where we tried to put it all together. A few of the most basic and important business concepts are those of understanding your own competitive strengths, those of your competitors, and create a truly advantageous position within a market. People talk about positioning and advantage, but aren’t always able to execute. The really great companies succeed often. So, in this example, we had an area with the only plant nearby, and there was an enormous amount of open Crown Land. The area had multizone potential, but had not been drilled with repeatable success by anyone to date. It was obvious that we had an area that we could dominate with our plant, and that the land position was such that if we could drill successfully, would scale nicely. What was missing was an ability to drill with certainty. We uncovered a combined technical method to crack the area— a combination of statics work with AVO—and were (for a short time) probably the only local operator who could predict the structure properly. Once we had the technical...
advantage to back up our dominant infrastructure, the business success was virtually assured. This became one of the few organic growth area in the Trust, and the team was very proud to have pulled it all together so well.

Another example occurred at Ketch Resources, and concerned the challenge of making targets. It is critical every quarter to make targets at these publicly traded companies, because analysts and shareholders have to be able to trust your guidance. I remember we were behind going into one very critical quarter and there were a couple of decisions that we made that were both gutsy and exhibited a true awareness of the situation. We made our targets for a couple of reasons. Firstly, we pushed to drill two particular wells that were not well regarded at the time but the team had a strong feeling about them, and secondly we recognized certain tie-in issues. The team was very much on top of that as they raced to solve some of these problems and there was this vast sense of awareness of what needed to be done, of everybody working together. We executed uniformly and the wells came on at a prolific rate and we made our targets. It was a fantastic moment that I am sure has been experienced in some similar fashion by many of the geoscientists in town, particularly those who have been in either tight teams, or smaller companies.

S: Wonderful. Tell us about the most difficult challenge that you may have faced in your professional life.

L: Okay, I will give you an ongoing challenge and sort of philosophical. It is two-fold. One is to keep thinking critically. It is very easy to relax and become complacent. Humility is required- you needed to scare us enough that we always should wonder what we might have missed, what could be wrong and if we’ve asked the right questions. At the heart of this is the humility of the scientific method, which is suggesting that we are trying to go against our biases and not be complacent.

The second thing is balancing your emotions, and I don’t mean that I am a fly-off-the-handle emotional guy. We are all emotional and we need them to make any decisions- you can’t break through logic without emotions. As I have stressed earlier, we usually have a (emotional) bias of some kind and this sometimes helps us and sometimes doesn’t, so we need to be disciplined in our decision making methods. On the other hand, if we aren’t still passionate in what we are doing, we may never fight for an outcome, which is also important. So what I have just said sounds contradictory, but I guess what I am saying is that you’ve got to balance these things. Discipline must be in union with enthusiasm; and this is not a trivial process. Both are required and I’d say this is an ongoing challenge.

S: I am reminded of a very good article that you published in the RECORDER on black box technology. What you had intended to convey in the article was that geoscientists should not get carried away by any technology, but try and understand what it is essentially doing to the data and accept it on its merits. Now there are geophysicists who would like to try out new technology, whether it is black box or anything else and if they see that at the control that they are getting favorable results, they’ll likely accept it and go on with its application. What is your opinion on this?

L: I will only answer to black box technology. I have no issues with new technology where we can talk about and challenge the theoretical framework. On the other hand, if we run into a
product or service whose theoretic framework has not been adequately explained, then I would say that it's not a good idea to pursue it. In fact, I'll go so far as to say it is unprofessional. So I will see if I can back that up.

We are investment advisors, and tremendous amounts of money ride on our advice. One of the very few reasons that the professional designation of APEGGA has any meaning for geoscientists is the trust that the public and the private shareholders put in our expertise. We have a duty to the public to provide scientific advice, and it's not a trivial duty. I can think of no excuse not to use scientific methods or to use black box technology. Put it in a different way, the scientific method is a discipline – it's not an answer – it's a process. It is designed to help separate us from our biases and designed to test hypotheses. It's the method that's moved us ahead as a species from the middle ages. We don't make predictions made on faith, but on methods that can survive the crucible of what is essentially a very harsh discipline. The scientific method is trying to prove you wrong, or it's not scientific.

I'd say also that tying an a posteriori test is nice, and we all do it, but it's not necessarily meaningful. Unless you can make a priori predictions, your work is not useful. In fact, I can make all kinds of meaningless functions that can be created to match old data points. Predicting new independent points is entirely different, so I don't like the argument that a method can be "proven" by tying old points.

Let me reinforce this by adding that if we don't know the theoretic framework behind a process, how can we question it? How can we be sure we have the correct parameterization, how do we know its weaknesses or its pitfalls, how can we claim to be responsible for the result or comment on their meaningfulness or certainty? Can we say anything at all about a process we do not understand? Do you trust the salesman? The salesman is not responsible for the result, you are. And if we can't be responsible for the result, but yet we make a recommendation on it, then we are irresponsible. And that is unprofessional.

P: As a listener, I would like to make some notes, add some information here. You mentioned APEGGA, and because of my other connections I am aware that about a year ago, APEGGA issued a new guideline on use of soft-ware as a practice standard, and there was at least one geophysicist on that committee and I read it about six months or so ago and it actually does indicate that in the engineering and geoscience world the professionals are actually responsible for verifying that the soft-ware that they are using actually works the way they expect it, so did that entirely back up what you were saying? We don't normally find time to read some of those guidelines but it might be interesting to follow up in light of what they have suggested.

S: For protecting technology, some service companies, like to patent their technology. Do you think that is a fair thing to do?

L: Absolutely. You know you can't tell people they can't use black box technology and then tell the researcher who spent all kinds of money that they cannot protect themselves. I am not a fan of litigation- and sometimes I have a little feeling of insecurity over how general a patent award might be- but all that aside, absolutely, you should be able to reap the fruits of your labor as a research developer and that's a great legal way to do that and stay within the scientific framework.

S: I would be curious to see how you react to that. The moment you patent any technology, the patent information is there on the website and once you pick that up you can always come up with something similar or better, bypass that particular approach, but still get down to the root of it. This is going on. How would you say people will protect if they keep on patenting and then giving out information in the public domain?

L: It is very rare that a company will develop something new without able competitors also doing similar work. It is not the old days where Chevron had developed the Fourier Transform, and it took a long time for other people to get it. That's a very rare occurrence and I don't think it happens today. So I think there is a bit of falseness in thinking that you are really going to keep a secret for a very long time and nobody else is going to get it. I think that companies can reap the rewards of their developments without excess secrecy through appropriate marketing methods. Processing companies that invest in technology are known for it, and they tend to gain a kind of brand recognition that is comforting and useful to their clients. I always give consideration to people that do put money in research and development, and have a good reputation for these sorts of things, and I steer my processing dollars preferentially to those with a good technical track record. I do this because I know I may have to utilize their inventive ingenuity at any time. When you develop something excellent, you will be respected and sought out for it.

S: Some geophysicists deliver well when they are given responsibility. Others excel when they are team players. So in this regard, what is your take and where do you belong?

L: I am not sure that there is a conflict between our responsibility and teamwork. I will try to say a few things around that.

Firstly, everybody on a team should feel responsible. They should all feel they are a source of what they are doing. Now I don't mean we always try to do each other's jobs, but we are certainly a source for our own work. Consider a baseball team where you may be trying to catch a ball in the outfield. You see another player running behind you in case you miss it. That's good teamwork, right? And that doesn't mean everybody is not responsible.

Secondly also, you want to think about humility. Humility tells us the truth which is that no one person, no matter how smart or skilled, knows it all and can do it all. This means that you must be working on a team, and if you are responsible you should not isolate yourself from the team. Remember humility and talk to these people and work in a very team-oriented manner to do a better job. Engaging other people almost always makes better decisions. Sometimes folks will fail to talk to their teammates because they think asking questions is a
sign of weakness, or they are protective and proud. This can happen, but it’s not a good thing. I think this is forgetting about that humility and our need to work together.

Another example is rock climbing. Rock climbing is an activity best described as interdependent. We are neither fully dependent nor independent. When one fellow is climbing, he’s got to climb. The belayer cannot climb for him. The belayer has other responsibilities that are equally important. If the climber falls, the belayer has to protect him, right? And second, he can also point out holds that the climber misses. This is a lot about how a team should work. We are interdependent and we have to work together, but we do have slightly different roles. We always support each other.

When you have a team that’s functioning very well you will often see that they take turns being the team leader. During the early the G&G phase, the geologist or geophysicist may take turns leading the ship, and eventually the engineer and operation’s person may take the front. A good team will naturally move that leadership role around if they are working well together.

As for my personal take on team and leadership? I don’t have to be the leader, but I will lead if it’s required and the primary goal that I would have is that the job is completed and completed well. You do what you have to do with your team to get it done.

S: Knowing you and also as you just mentioned, you are a firm believer in new technology, so over the years what new technology ideas you have assimilated in your interpretation, which others didn’t adopt at the time, what was the outcome of that, and why do you believe so?

L: How about a failure and a success story related, kind of tie that thing together.

I remember some years ago there was a paper that was out on AVO inversion for Triassic sand and this paper invoked all kinds of multi-linear regression. Everything was coming up roses for finding gas sands for the Triassic, so I was quite excited. The authors were some pretty reputable people and I thought I must try this technique. I had always been interested in AVO because of Bill Goodway’s influence, and I had a similar problem as the authors’ to deal with. I went ahead and did this work with Jonathon Downton, who was one of the gentlemen who wrote the paper. We performed the work, and we all thought we did the job properly.

The project was a failure on an exploration level. Our failure had two principal causes. One was the unfortunate fact that the multi variable regression that we performed was invalid: we were using dependent variables and we cooked the statistics. I think that same mistake had been made in the original paper too. You’ve got to be a little careful that you know what you are putting into a multi linear regression. Second is that we had sampling problems. We utilized every local well we could on our modeling and within the 3D that we are using. We had a significant number of control points, and it seemed like there was good sampling but when we really thought about it, we realized we never had a really porous, wet well. We had both members: might have been wet, kind of tight, maybe porous, but we never had that really singing wet sand. So, we drilled some wet wells, and I got my comeuppance. This was an important, although painful moment. I was so confident, but there was a fundamental flaw in what I was doing in that sampling. I learned a valuable set of lessons regarding critical thinking and applicability, but I didn’t give up on AVO.

Jon Downton and Yongyi Li and I kept coming back to the question of physics in AVO and we performed more sophisticated forward modeling. I think we came to appreciate how difficult it would be to perform AVO on Triassic sands as you are coming out of a lot of very hard rocks and anhydrates and going into sands. This produces some responses that are very difficult to measure accurately.

Eventually I found an area where we could create significant practical advantages via a combined AVO project. And in this case, the team was working on the Cretaceous in the Peace River Arch. I combined AVO and another piece of technology, which Kim Head spoke of at one of the CSEG conventions, called replacement velocity optimization. What I wanted to find was a subtle structural high that would be in a ubiquitous reservoir rock. All of our efforts to find the highs were stymied by an area wide problem with the statics. I remembered that Kim Head had done some very simple, but excellent, work with replacement velocity optimization to find better structures. We followed Kim Head’s method to produce a new static solution for the area, and also performed some simple AVO work. This was particularly effective because these two methods were entirely independent. The AVO in the Cretaceous was much more tractable than it was for the Triassic, and whenever the structure would line up with the AVO, we would take action. We nailed every well that relied on that method, and had a very successful program.

S: Coming back to searching for jobs in our industry, if it is a planned move, one may not lose time, unless you wanted to take some time off. Another aspect is when its a management decision for laying people off as a result of merger, or a takeover or something else and that is quite common these days. Then it could take the individuals some time to land up with the AVO, we would take action. We nailed every well that relied on that method, and had a very successful program.

L: I don’t think there is a really good general answer for this. Everybody endures a different set of circumstances. Assuming you are giving adequate notice, which is a legal professional thing, this isn’t something I want to make sweeping generalization on.

Generally though, we really want to act as team players with the people around us, especially around these kinds of things. A lot of people profit from corporate take-overs, and there may be stiff financial penalties for leaving the corporation...
“You can continually be awakened…”
Continued from Page 23

prematurely. Regardless of the financial details around a deal, I recommend as a point of integrity that people do everything they feel they can afford to do to help both corporate entities complete any friendly change in control. On the other hand, there is nothing wrong with putting feelers out and talking honestly with the company’s involved and other people. You do have to look after yourself first. Always. You know, you may have a family, whatever. So that’s all I can say about that.

S: That’s a nice diplomatic answer. What new technology ideas do you have in your mind at present that once you get an opportunity you would like to apply them to real data?

L: I recently tried a plains depth migration and found it an immensely difficult task to get the fidelity I needed. I followed up with various people in the CSEG- people like Peter Cary, Scott Cheadle, Jonathon Downton, Stuart Trickett, Brian Link, and others. We were all interested in the fact that we do not yet use all of the (resolution and noise) tricks from time processing when we move to depth processing. The depth paradigm tends to abandon vertical resolution after a certain point, and this needs to be addressed. I will look for the time when vertical resolution is critical on a play that also requires depth migration. The goal will be to try to bring all the tricks of time processing into a depth flow and yet to see that happen as aggressively as I think it needs to. This involves talking about a whole processing flow.

So I will just mention a couple of things that might be important on processes within the larger flow. One of them is pre-stack interpolation. I was recently involved in a paper that examined pre-stack interpolation. We were initially looking at pre-stack time migration but we found that the interpolation of even tightly shot 3Ds helped in stabilizing the last ten or so hertz of the bandwidth. This actually enabled us to produce a higher frequency product. The impact was greater than we expected, and quite applicable.

I would also still look at minimizing stretch. There is stretch with migration operators. There are all kinds of little things of this nature that we can try to put together in the larger flow. I know that a number of companies are working on some of these problems, including yours.

S: Let’s talk about the future of the Canadian Oil Industry. You know WCSB wells are getting mature, so what would you think?

L: Well, fundamentally geoscientists and particularly geophysicists always find more than others thought they could.

S: Yes, this has been going on.

L: We are going to continue doing that. Some of the improved processes we have spoken about will help us, as well as more 3D seismic data. In some cases, 3D data will be re-shot more expensively to deal with more difficult issues. There is also the endless opportunity of reprocessing old data. This is a reason we should continue supporting the R&D companies that will help us make those more subtle discoveries.

I have also been interested in fracture detection, and although I am no expert on it, I think that it is going to become more important in the future in some of our non-conventional reservoirs.

S: You are a member of the CSEG and APEGGA. What made you get interested in CSEG for example?

L: We all have to come together somewhere and this is our society. You know we all have to work together. There has to be an ethic and policy around that and you need a group that helps make that happen. The CSEG does so many things around bringing us together and it prevents us from being isolated. So for that reason, I love the CSEG.

APEGGA is also important. We are not all engineers, and it’s not always obvious why we should be associated with APEGGA. APEGGA’s relevance becomes clear when we stop and think about just how much money and how many people’s fortunes and savings plans- their livelihood- are tied up in the things that we do. So the society brings us together, but APEGGA helps us to think about professionalism and assures other people that we are professional. I think they are both really important to our place in the world.

S: How do you think the CSEG can get more youngsters interested in our industry?

L: The CSEG has a scholarship program. Things like that are great. I think that the more the Outreach program can do, the better. This is a very important and useful function of the CSEG, and we should support it. Since geophysics is still not a career that is commonly known, the more information we can get to high schools and colleges, the better for our industry.

S: Have you had any experience with some of the new graduates from UofC or UofA in particular because they have had record enrolments? There was a combined job ballpark for the last two or three years.

L: I had a geophysical summer student at one of the small companies I worked at. She was very close to graduating from the U of C. She had a few courses to complete and was a very professional lady. Remembering my own mentoring at the foot of Bill Goodway, I was concerned about my ability to mentor her. It accentuated the importance of training and mentorship to me in a very clear manner. I was fortunate in that she had a very good attitude and outlook, which makes any relationship of that nature more productive.

S: What words of advice would you have or inspiration, what words of inspiration for young people considering a career in geophysics?

L: Well, I guess maybe three things. One is – there is an unending flexibility in our careers and the challenges ahead of us. You can continually be awakened to the fun and enjoyment of your jobs. It is great for that reason. Look for that.

Continued on Page 25
The second thing is: if you have a skill there is a way to use it in our industry. There is a way. And lastly I’d say: be courageous. You know we talked a lot today about business, economics, we talked about the need to be skeptical, but in the end it requires courage to do our jobs well. When people will eventually look back on their careers they can see that courage hopefully and be proud of it.

S: One last question, apart from professional work what other interests do you have?

L: Well, I do a little bit of weight lifting in the mornings, also a little triathlon.

S: Do you still go to the YMCA?

L: Yes, there are a few characters I work out with. This is important for me. A little triathlon I mentioned, my wife kind of got me into that. I like to read, do some writing; I actually wrote a book.

S: You did?

L: Yes, unpublished – but I finished it. I am trying to do some re-writes on it so I can push it to be published.

S: What is it about?

L: The book is a work of fiction, set in a medieval era. The story revolves around attitudes about change and perception of the future. The characters in the story stand to be hugely impacted by changes going on around them, and they take on familiar attitudes. Some people are very enthusiastic about the future, while others fear it and initiate plans to recapture the so-called “old ways”. The deus ex Machina of the story is an entity that represents the fear of change, Nimrheal. If for instance, you are an inventor, or creator, even a poet in this world, this demon Nimrheal will find you and kill you. Nimrheal becomes a major threat and obstacle for the main characters of the story. The fantastic setting allows the story to play out some of our current struggles regarding technology, religion, and change in an entertaining fashion.

S: Well Lee, thank you very much for giving us this opportunity to sit down and talk with you. It has been a pleasure.

L: It has been an honor. Thank you.

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Offshore BC – Current Status

Bill Phelan
Director, BC Offshore Oil and Gas Branch,
Ministry of Energy Mines and Petroleum Resources, Victoria, British Columbia, Canada

British Columbia remains committed to the responsible development of the Province’s offshore oil and gas resources. The Geological Survey of Canada estimates the Queen Charlotte Basin (the largest and most commercially prospective of four basins off the west coast of British Columbia) could contain 25.9 trillion cubic feet of natural gas and 9.8 billion barrels of oil.

In 2004, a Royal Society of Canada Expert Panel in a Report on Science Issues Related to Oil and Gas Activities Offshore British Columbia estimated the value of the oil and gas resources in the Queen Charlotte Basin at $110 billion. This report was commissioned by Natural Resources Canada. The economic benefits for First Nations, coastal communities and British Columbians in general from offshore oil and gas development could be significant.

Several scientific and technical reports commissioned by both the B.C. and the Federal Governments have been completed. These include an Offshore Oil and Gas Technology Report (October 2001), an independent three-member British Columbia Scientific Review Panel Report (January 2002). The Federal Government and the Royal Society Report in 2004, the Pridge Review of the Federal Moratorium on Oil and Gas Activity in Offshore British Columbia Report, and the Brooks Report “A First Nations Perspective on the Lifting of the Federal Moratorium on Offshore Oil & Gas Exploration in the Queen Charlotte Basin of British Columbia”. Although the reports identified science gaps that must be addressed prior to activity taking place, no scientific or technical barriers were found that warrant a blanket moratorium over west coast offshore oil and gas development activities. In addition, B.C. provided a $2 million grant to the University of Northern British Columbia to complete a number of reports that review and document the state of knowledge about the environment and the socio-economic conditions in the area of the Queen Charlotte Basin.
The Province is undertaking a number of initiatives intended to enable offshore oil and gas development to occur in British Columbia. The Ministry of Energy, Mines and Petroleum resources is researching management and regulatory regimes in other jurisdictions in order to determine what could be most appropriate for west coast offshore development. The Offshore Oil and Gas Branch within the Ministry is working to identify potential risks and benefits of offshore development, to develop a comprehensive fiscal and regulatory regime, and to advance scientific knowledge of offshore oil and gas development.

The Province is investing in research and partnering with the University of Victoria (UVic) to address a number of the research gaps identified in the science reviews. Economists at UVic with colleagues at Memorial University of Newfoundland are completing an economic evaluation of a number of oil and gas scenarios that are based on the size of the expected oil and gas pools in the Queen Charlotte Basin. The report will discuss the economic viability of the expected economic rents that accrue to governments under various scenarios.

A Protocol Agreement signed with the Nisga’a Nation in 2005 has government working collaboratively on offshore issues, including a project to collect and disseminate information to their membership on the risks and benefits of offshore oil and gas development.

Several First Nations and coastal community leaders have participated in fact-finding missions to offshore oil and gas production facilities in Cook Inlet, Alaska as well as the Gulf of Mexico. Plans are underway to bring coastal community and First Nations leaders together to work on a number of matters related to offshore development, including regulatory frameworks, benefits, risks and opportunities. The Ministry actively participates in a number of federal and provincial ocean planning initiatives, including a newly launched planning process called the Pacific North Coast Integrated Management Area (PNCIMA), to ensure offshore oil and gas development opportunities are accounted for in marine management decision-making. The PNCIMA process will involve Federal, Provincial and First Nations governments working with stakeholders. PNCIMA involves a large geographic area that covers ~60% of the BC Coast and all of the prospective Queen Charlotte Basin.

In December 2006, the Premier publicly reaffirmed the importance of British Columbia’s offshore oil and gas as a future source of energy and economic growth. In the newly released BC Energy Plan (February 2007) the Province re-affirmed its commitment to offshore oil and gas exploration and development, its request to Canada to lift the federal moratorium and reiterated that the provincial moratorium will be lifted at the same time (see: http://www.energyplan.gov.bc.ca).
Summary of a recent study of seismic airgun survey noise propagation in Queen Charlotte Basin

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In recent years there has been renewed interest in offshore oil and gas exploration and development in British Columbia. Particular attention has focused on the Queen Charlotte Basin (QCB) where the largest hydrocarbon deposits are believed to be located. Potential oil and gas exploration in this area will expose marine mammals and fish to heightened levels of underwater noise from seismic airgun activity. Very little is currently known about the effects of seismic airgun noise on marine mammals and fish, including at what noise levels these effects are “biologically significant” (see, e.g., NRC, 2004), but it is believed potential effects can be both physiological and behavioural. Among the most basic questions that require answers are: “How loud is an airgun array?” and “What sound levels are generated by an airgun survey at location X?”

A recent University of Victoria thesis project (co-sponsored by the B.C. Offshore Oil and Gas Team and JASCO Research Ltd) has presented a general method for predicting airgun survey sound levels in the marine environment and has applied this method to the QCB (MacGillivray and Chapman 2005, MacGillivray, 2006). The method developed in this thesis has used (1) an airgun array source model and (2) a parabolic-equation based acoustic propagation model to estimate sound levels generated in the vicinity of a marine seismic survey. The airgun array source model, which was developed as part of the thesis project, is a full-waveform source signature model, based on a physical simulation of air injection into the water, and the subsequent oscillations and acoustic radiation of the generated air bubbles. The acoustic propagation model, RAM (which was developed at the US Naval Research Laboratory) is a parabolic-equation based model that predicts sound transmission through a range-varying, inhomogeneous water column over an elastic seabed (Collins, 1991). RAM was modified to include shear wave losses in bottom sediments using a complex bottom density approach (Zhang and Tindle, 1995). The airgun array and sound propagation models used several databases describing the acoustic environment in QCB (including seabed bathymetry, seasonal sound speed profiles in the water and geoacoustic profiles of the sub-bottom) to calculate sound fields generated by an airgun survey (see Figure 1). Underwater sound levels for a 3000 cubic inches airgun array were modelled at 9 different locations in QCB, over regions of the basin with high potential for oil and gas deposits. Key findings from this thesis project included the following:

1. Received underwater noise levels from the airgun array were dependent on the location of the survey vessel within the basin; water depth, geoacoustic environment and water sound speed profile strongly influenced the distances to given noise levels.

Figure 1. Noise level contour plot for the Queen Charlotte Basin, showing sound level isopleths in 10 dB increments. Airgun array heading is oriented along a SW–NE track line. Inset shows magnified contours within 10 km range of the airgun array.
2. Short range sound levels (<1 km) were most strongly influenced by the water depth at the airgun array location; sound levels were over 6 decibels greater in shallow water than in deep water.

3. At long range the seasonal sound speed profile had a strong influence on received levels. Winter sound levels were observed to be 20 dB greater than summer levels at distances beyond 100 km from the array.

4. Sound levels varied significantly with azimuthal direction from the airgun array, with highest sound levels observed in the broadside direction from the array.

The method developed in this thesis project can be applied to an arbitrary airgun survey at any location for which the appropriate environmental data are available and will thus facilitate future seismic survey noise level predictions for the BC offshore and elsewhere.

**Literature Cited**


The Pacific North Coast Integrated Management Area (PNCIMA) is one of five pilot Integrated Management Planning initiatives being led by the federal Department of Fisheries and Oceans in Canada. Based primarily on ecological characteristics including oceanic currents, physiographic considerations, the PNCIMA extends from the Canada-Alaska border in the north to Brooks peninsula, Northwest Vancouver Island and Quadra Island and Bute Inlet in the south. The planning area extends seaward to the foot of the continental slope and to the headwaters of coastal watersheds. Although terrestrial and freshwater components are not subject to planning within this initiative, these areas play a critical role in defining ecosystem characteristics and ecological function. Linkages will be forged to complement and ideally, over the long-term, augment existing and future upland planning and management.

This area is important for food, social and ceremonial fisheries for First Nations, as well as commercial fisheries and recreational fisheries. Aquaculture development is also a key issue in the area, as are tourism, transportation, and potential offshore energy development. A particular feature of the PNCIMA initiative is the proactive involvement of First Nations in coastal and marine resource planning and management.

The overarching goal of PNCIMA is the development of a framework for addressing issues relating to the multiple-use of marine areas, sustainability and conservation. This will be achieved through the development of governance mechanisms, institutional arrangements and a management plan for the area. The intent is to develop an approach that is accepted by stakeholders, endorsed by legislative and regulatory authorities, supported by First Nations and approved by the governments of Canada and British Columbia.

More specifically the PNCIMA initiative has four key objectives:

1. To promote ocean management decisions based on shared understanding and appreciation of the ecological, cultural and socio-economic characteristics of the PNCIMA.
2. Design an integrated decision making framework for management across sectors.
3. Develop institutional arrangements that bring together governments, First Nations, user groups and other interests, resource management, conservation and economic development and enter into agreements on oceans management with specific responsibilities, powers and obligations.
4. Contribute to social, cultural, and economic well-being for coastal communities and stakeholders

At the heart of Canada’s vision of Ocean Management is a commitment to citizen engagement in the broadest sense, that is governments at all levels, Aboriginal groups, corporate and sectoral interests, community interests, non-governmental organizations, and Canadians generally. The overall objective is to create governance mechanisms that foster a greater involvement of the people most affected by decisions.

Managing for Sustainability

The Integrated Management approach in the PNCIMA will:

- Identify ocean resources and economic and other opportunities through an ecosystem overview and marine-use analysis.
- Identify the interests and priorities of community, First Nation’s, industry and economic development of the region.
• Assess ecosystems to determine current and emerging threats to ecosystem health and determine a broad system of ecosystem and socio-economic objectives for planning and management responses to those threats;

• Identify the requirements and priorities for monitoring and research in support of the Integrated Management Plan;

• Identify priorities and strategies for conservation.

The PNCIMA framework will reduce conflict between different sectors over resource access and use, while providing increased certainty and long-term security for marine-based industries. A set of long-term, overarching ecosystem and human use objectives to support agreed upon outcomes for environmental, economic, social and institutional sustainability will be identified. These high-level objectives will, in turn, be supported by operational objectives. Examples of ecosystem and human use objectives include:

**Ecosystem Objectives**

- healthy benthic and pelagic communities and species, species at risk and invasive species
- maintain marine ecosystem productivity,
- sustain ocean and coastal habitats, including physical, geochemical and biological components

**Human Use Objectives**

- community well-being
- economic well-being
- industrial capacity and assets
- integrated management processes

This objectives-based approach will ensure that interrelationships among ecosystem and human use objectives are recognized and reflected in management strategies and actions. The PNCIMA framework will identify common goals, respect the jurisdictional responsibilities of the various levels of government, adapt to issues of regional importance while recognizing the economic, environmental and social values of coastal communities. In this environment, coastal communities will be actively involved in the development, promotion, and implementation of sustainable oceans activities leading to a more viable “on the ground” planning, implementation monitoring and compliance process.

1 Canada’s five Integrated Management Planning Priority Areas include: Pacific North Coast (British Columbia), Eastern Scotian Shelf (Nova Scotia), Gulf of St. Lawrence, The Beaufort Sea (Inuvialuit Settlement Region), Placentia Bay and the Grand Banks (Newfoundland and Labrador)

2 For more detailed description of PNCIMA boundaries refer to the PNCIMA Boundary Paper

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Benefiting from 3-D AVO by using adaptive supergathers

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Introduction

3-D surface seismic data has many useful features that include fine sampling, better resolution, better and accurate visualization and volume interpretation of structural and stratigraphic features. All these help in providing a vivid picture of the geologic features in the subsurface. These characteristic qualities of 3D seismic data, coupled with the fact that 3-D prestack time or depth migration yield accurate imaging of subsurface features, represent sufficient ground and reason to expect AVO analysis to be carried out on 3-D data.

Figure 1 shows a generic AVO flow that is used on prestack data, especially for stratigraphic objectives. After the data has been put through an AVO friendly processing (that restores true amplitudes) supergathers (gathers generated by collecting traces from adjacent CMPs) and Ostrander gathers (gathers generated from supergathers by stacking traces with similar offset intervals) are generated. Next, AVO attribute pairs are extracted, such as Rp and Rs or intercept and gradient, etc.

While interpretation can be directly carried out on the intercept and gradient attributes, Rp and Rs attributes are put through impedance inversion and extraction of LMR (Lambda-Mu-Rho) attributes which are then interpreted. Such a processing flow is followed for 2-D as well as 3-D datasets without differentiation though there are more traces in a 3-D dataset than a 2-D dataset.

However, there are many differences between the two. A comprehensive study was conducted at Arcis to investigate such differences and explore for ways to improve 3-D AVO analysis. The impact of the geometry of a 3D dataset is being reported in this paper.

For 2-D surface seismic data, the fold and offset are usually found to have a one-to-one correlation. Unfortunately, this is not true for most 3-D seismic datasets. Figure 2 shows some gathers from a 3-D dataset, where the offset variation is shown in red and the fold variation in blue. One notices at a glance that for near and far offsets, the coverage is low and traces with intermediate offsets dominate the overall coverage in this set of gathers. It is advisable to try and understand the impact of such a variation of coverage with offset on the extraction of AVO attributes.

Investigation on synthetic data

To investigate this, synthetic gathers were generated using log data as input. Figure 3 shows the log curves and an angle domain gather generated from them. Two gathers were generated with the same number of traces in each and 0-30 degree angle coverage, but their fold distributions were different, more like 3-D and 2-D and indicated as A and B and shown in Figure 4. Random noise was added to these two gathers. These gathers represent the supergathers in real seismic data, and so for convenience we refer to them as 3-D and 2-D supergathers. Next, Ostrander gatherers were generated from the two supergathers by stacking traces with the same angle into a single trace.

As the objective is to understand the effect of this variation of coverage with offset on AVO attributes, P-reflectivity (Rp) and S-reflectivity (Rs) were extracted from the gathers using Fatti’s approximation and least-squares fitting, and the results were compared.

Figure 5 shows two panels; the left panel compares the S-reflectivity extracted from the different gathers, while the right panel compares the P-reflectivity. Trace 1 represents the true answer, trace 2 is from 3-D supergather, trace 3 is from the Ostrander gather, trace 4 is from the Ostrander gather with weights based on the local fold applied in a least squares sense, trace 5 is from the 2-D supergather and trace 6 from 2-D Ostrander gather.

Left panel comparison: Comparing traces 2 and 5, one notices that 2-D supergather appears to be more reliable. Comparing
traces 2, 3 and 4, Ostrander gathers on 3-D appears worse than the supergather. However, the weighted Ostrander gather tends to improve the result. For the 2-D case, only subtle differences can be noticed.

**Right panel comparison:** Comparison of the different P-reflectivity traces shows that they all look quite similar, with the exception of trace 3, corresponding to Rp extracted directly from 3-D Ostrander gather.

The above observations may be summarized as follows:

1. Although useful for quality control and the understanding of AVO responses, Ostrander gathers may not improve AVO extraction for 3-D data.

2. An even distribution of fold with offset/angle results in a better extraction of AVO attributes.

The above exercise on synthetic data has demonstrated that while generating supergathers in 3-D seismic data is necessary to improve the signal-to-noise ratio, its drawback is that events get smeared, which could be a problem for subtle AVO anomalies. To address the issue of uneven fold-distribution in supergathers, an adaptive approach to supergathers is suggested. It entails borrowing of traces from adjacent CMP locations depending on the fold distribution and so includes an effect of an even fold distribution with offset.

**Application on real data**

The adaptive supergather approach mentioned above was applied on a 3-D seismic data volume from Alberta, Canada, to see the impact it has on extraction of AVO attributes. Figure 6 shows the survey map for the 3-D seismic volume, and also indicates the location of a gas well and a dry well on it. It may be noticed that the top left corner has a fold higher than the rest of the survey.

To make a fair comparison, AVO extraction was done on three different types of gathers:

(a) 3 x 3 supergathers

(b) Ostrander gathers generated from 3x3 supergathers,

(c) Adaptive supergathers.

Figure 7 shows the P-reflectivity horizon slices at the target level extracted from these three types of gathers. Though the noise level and acquisition footprint patterns are somewhat more pronounced, the P-reflectivity from Ostrander gathers (Figure 7b) is as good as that extracted from the supergathers (Figure 7a). P-Reflectivity extracted from adaptive supergathers retains most of its original features.

**Figure 3. A synthetic gather (right) generated from the log curves shown to the left.**

**Figure 4. Fold distribution shown for the 3-D and 2-D supergathers as well as for the Ostrander gathers derived there from.**

**Figure 5. Comparison of P-reflectivity and S-reflectivity extraction from different supergathers and Ostrander gathers.**

**Figure 6. Survey map for a 3-D data volume from Alberta, Canada. Two wells (one is a gas well and the other is dry).**
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Figure 7. P-reflectivity horizon slices from three different types of gathers (a) 3x3 supergather (b) Ostrander gather derived from the 3x3 supergather, and (c) adaptive supergather.

Figure 8. Comparison of fluid factor horizon slices from (a) 3x3 supergathers (b) adaptive supergathers.

Figure 9. Comparison of reliability horizon slices from (a) 3x3 supergathers (b) adaptive supergathers.
of the character seen on the other two and more, but its noise level and footprint is subdued.

In Figure 8, we compare the fluid factor horizon slices at the target level, for (a) 3x3 supergather and (b) adaptive supergather. The red color is indicative of potential pay. Notice, the fluid factor display in Figure 8a from 3x3 supergather shows anomalies in the form of round red patches which do not match the production from the two wells. The equivalent display from the adaptive supergathers shown in Figure 8b provides a much better match with well production.

Besides this match with production data, the size of the anomalies seen on both displays are quite different, Figure 8a showing stronger anomalies except the one around the gas well.

In an attempt to understand the difference in the anomalies caused by different supergather schemes, a reliability analysis of the AVO inversion was carried out. A reliability function (R) was defined depending on the geometry parameters, data error and uncertainty in the extraction:

\[ R = F (\text{Fold}, \text{Fold distribution, Data error, singularity}) \]

Figure 9 shows the equivalent horizon slices to those shown in Figure 8, with again red color indicating higher unreliability. Apparently, adaptive supergathers improve the reliability for different portions as shown in black rings on the slices. Comparing the reliability maps with the fluid factor maps, it is seen that reliability difference has good correlation with fluid factor difference.

Conclusions

Based on our analysis of 3-D adaptive supergathers approach and its comparison with 3-D conventional supergather or Ostrander gather approach, we arrive at the following conclusions:

1. The usual 3-D fold distribution may lower the reliability of AVO extraction compared with 2-D. Adaptive supergather approach provides superior results over 3-D supergather approach.

2. Trace fold distribution in AVO gathers has a direct influence on the reliability of AVO extraction.

3. Reliability mapping helps evaluate meaningful AVO anomalies and confirms conclusion 1 above. \( R \)

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Long-spreadlength approximations to NMO function for a multi-layered subsurface

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Introduction

Conventional approximations of the NMO function assume a modest offset/depth ratio. Similarly conventional velocity analysis uses a hyperbolic approximation for the reflection travel times:

\[ t(x) = \sqrt{t_0^2 + \frac{x^2}{V_{NMO}^2}} \]  

(1)

Here \( t_0 \) is a zero-offset time, \( x \) is an offset and \( V_{NMO} \) is NMO velocity. It is worth mentioning that velocity analysis does not give us an RMS velocity. The RMS velocity is a velocity defined by a mathematical formula (see formula (14)) and the NMO (stacking) velocity is a velocity from the hyperbolic approximation of an actual non-hyperbolic NMO curve, \( t(x) \). Even in theory, they are equal only for the homogeneous subsurface with a horizontal boundary. For any different subsurface model, the NMO velocity is not equal to the RMS velocity. However, in many practical cases, for example the vertically heterogeneous subsurface with conventional spreadlengths close to the reflector depth, the NMO velocity is close to the RMS velocity. Then we can use the NMO velocity as a reasonable estimation of the RMS velocity. At the same time, we should remember that these two velocities represent different notions and have different meanings.

With increasing offsets of up to double the reflector depth and greater, the hyperbolic NMO function exhibits errors in the reflection traveltime approximation. The hyperbolic NMO approximation does not fully account for velocity analysis and stacking of long-offset reflection data. Non-hyperbolic NMO approximations have been considered in many papers (Al-Chalabi, 1973, 1974, Malovichko, 1978, Blias, 1982, Goldin, 1986, Castle, 1994, Alkhalifah and Tsvankin, 1995, Taner et al, 2005). Instead of the conventional two-term hyperbolic approximation, a three-term approximation is proposed to improve NMO representation and to lead to a more accurate RMS velocity estimation. Since an exact NMO representation can be written only in a parametric form, all the proposed explicit NMO functions are approximate. A higher-order term NMO approximation enables a more accurate approximation of the observed travel times, but different NMO functions have different limitations with respect to the spreadlength/depth ratio.

An NMO formula is an approximate equation that connects offsets and travel times. Using more than two terms improves its accuracy, but at the same time creates some problems for velocity estimation. Adding an extra parameter leads to a more expensive velocity analysis and increases the RMS velocity variance by approximately 10 times. This was noticed by Al-Chalabi through random modeling (1974, fig. B3) and can be proved analytically. Because adding a fourth term again increases RMS velocity variance about 10 times, from a practical point of view the maximum number of estimated coefficients for one gather should be 3. For long offsets (offset/depth = 1.5 – 2.5) we can expect significant improvement of \( V_{RMS} \) estimation using a three-term velocity analysis, even though it leads to a larger standard deviation.

For the longer offsets, three-term approximations do not correct travel times and sometimes residual corrections are needed. Some of the functions need fewer corrections and some need more. In this paper, we describe an approach for an approximate NMO formula derivation. Three new NMO formulae are derived using this approach. We test the accuracy of known NMO approximations as well as the new ones on different model data.

There are two main problems with respect to the NMO function application. The first problem is connected with the accuracy of this function as an approximation to the observed travel times. The second problem is connected with velocity inversion and interval velocity estimation using the Dix formula or its generalization. For horizontally stratified media, the accuracy of the interval velocity determination is directly connected with the accuracy of the RMS velocity estimation. Using different models, we will investigate both problems for the known and new NMO formulae.

Method

The traveltime function \( t(x) \) can be expanded into a Taylor series of \( x^2 \). It was first done by Bolshih (1956):

\[ t(x) = a_0 + a_1 x^2 + a_2 x^4 + a_3 x^6 + \ldots \]  

(2)

where

\[ a_0 = \frac{1}{2} \sum_{j=1}^{n} h_j v_j \]  

\[ a_j = \frac{1}{2} \sum_{j=1}^{n} h_j v_j \]  

\[ a_2 = -\frac{1}{64} \sum_{j=1}^{n} h_j v_j \]  

(3)

where \( h_j \) is a thickness of the \( k \)-th layer and \( v_j \) is its interval velocity; \( n \) is a number of layers above a reflector. He gave formulas for the first four coefficients \( a_k \) in terms of interval velocities and indicated that all coefficients \( a_k \) might be derived one at a time (one after another). Taner and Koehler (1969) suggested representing \( t^2 \) as a series expansion of \( x^2 \):
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\[ t^2(x) = c_0 + c_1x^2 + c_2x^4 + c_3x^6 + \ldots \]  

(4)

Equations (4) can be obtained by squaring equation (2), which gives:

\[ c_0 = a_0^2, \quad c_1 = 2a_0a_1, \quad c_2 = 2a_0a_2 + a_1^2 \]

When the above is combined with (3), we obtain:

\[ c_0 = 4\left(\sum_{k=1}^{n} \frac{h_k}{v_k}\right)^2, \quad c_1 = \frac{1}{\nu_{RMS}^3}, \quad c_2 = -\frac{\sum_{k=1}^{n} h_k v_k^3}{16\left(\sum_{k=1}^{n} h_k v_k\right)^4} \]

(5)

Formula (4) is more accurate than formula (2) since for a one layer model, (4) gives exact times for \( t(x) \) while (2) remains as an infinite series. For the long offsets, the hyperbolic approximation (1) is not accurate enough. Because the exact formula for traveltimes is an infinite series, many authors have proposed some improvements to the hyperbola, using more than two parameters. In this paper, we will derive several new three-parameter NMO formulae and compare different approximations.

Equations (2) or (4) enable us to find derivatives of time \( t \) or \( t^2 \) with respect to \( x^2 \) at \( x = 0 \):

\[ \frac{dt}{dx^2}(x = 0) = \frac{1}{4\sum_{k=1}^{n} h_k v_k^3}, \quad \frac{d^2t}{dx^2}(x = 0) = -\frac{\sum_{k=1}^{n} h_k v_k^3}{32\left(\sum_{k=1}^{n} h_k v_k\right)^4} \]

There are different forms of approximations, proposed by several researchers, but the main idea of all NMO approximations is to keep time \( t \) and its two derivatives at \( x = 0 \) the same as the exact travel time function \( t(x) \).

Let’s consider any three-term approximation of the NMO function

\[ t(x) = F(a,b,c,x^2) \]  

(6)

where \( F \) is a function of four variables; \( a, b \) and \( c \) are the NMO parameters, \( x \) is an offset. To calculate coefficients \( a, b \) and \( c \), we have to solve the system of three equations with respect to \( a, b \) and \( c \):

\[ F(a,b,c,x = 0) = t_0, \quad \frac{\partial F(a,b,c,x = 0)}{\partial (x^2)} = a_1, \quad \frac{\partial^2 F(a,b,c,x = 0)}{\partial (x^2)^2} = 2a_2 \]

(*)

where \( a_0, a_1 \) and \( a_2 \) are determined by (3). From the system (*), we can determine \( a, b \) and \( c \) and find the explicit approximation (2). The main problem here is to choose the function \( F(a,b,c,x) \) so that we can find the explicit solution of the last system.

Different NMO approximations

Let \( S \) be a dimensionless parameter, defined by the formula

\[ S = \frac{n}{\sum_{k=1}^{n} \frac{n}{h_k v_k^3}} > 1 \]

\[ \left(\sum_{k=1}^{n} h_k v_k\right)^2 \]

We will consider the three-term approximation (4). Using parameter \( S \), we can rewrite the three-term approximation (4) as:

\[ t(x) = \sqrt{t^2(0) + \frac{x^2}{\nu_{RMS}^2} + \frac{S - 1}{4t_0^2 \nu_{RMS}^4} x^4} \quad (7) \]

Continued on Page 38
Long-spreadlength approximations to NMO function...

Continued from Page 37

For a homogeneous medium, S = 1. The greater the heterogeneity, the larger the value of S, so we can consider the difference (S-1) as a measure of the vertical velocity heterogeneity. Malovichko (1979) derived a representation of NMO in the form of a shifted hyperbola:

\[ t(x) = t_0 \left( 1 - \frac{1}{S} \right) + \frac{1}{S} \sqrt{t_0^2 + \frac{x^2}{V_{\text{RMS}}^2}} \]  

where \( V_{\text{Ave}} \) is an average velocity given by

\[ V_{\text{Ave}} = \frac{\sum h_k}{\sum v_k} \]

where \( H \) is reflector depth. For a layered medium, this NMO formula should be corrected for the vertical heterogeneity. For this, let’s consider a rational function

\[ t(x) = \sqrt{\frac{t_0^2 + \frac{x^2}{V_{\text{Ave}}^2}}{1 + aV_{\text{Ave}}^2}} \]

with an unknown coefficient “a”. To find coefficient “a”, we use the last equation (*), which leads to solution:

\[ t(x) = \frac{t_0^2 + \frac{x^2}{V_{\text{Ave}}^2}}{1 + aV_{\text{Ave}}^2} \]  

where \( g \) is a vertical heterogeneity factor, suggested by Al-Chalabi (1973, 1974):

\[ g = \frac{V_{\text{RMS}}^2}{V_{\text{Ave}}^2} - 1 \]  

The heterogeneity factor \( g \) is equal to 0 for homogeneous media. Thus, it is a measure of the vertical heterogeneity, in addition to the parameter \( S \). The difference between the parameter \( S \) and the heterogeneity factor \( g \) is that \( S \) connects first and third moments of interval velocities, while the factor \( g \) corresponds to average and RMS velocities which is more convenient from practical point of view.

We can improve (11) by using an additional term. After some mathematical transformation, using an approximate formula

\[ S \approx 2 \frac{V_{\text{RMS}}^2}{V_{\text{Ave}}^2} - 1 = 2(1 + g)^2 - 1 \]

we obtain another NMO approximation:

\[ t(x) = \frac{t_0^2 + \frac{x^2}{V_{\text{Ave}}^2}}{1 + \frac{gx^2}{2V_{\text{RMS}}^2(t_0^2 + \frac{x^2}{V_{\text{Ave}}^2} + (1 + g^2)x^2)}} \]  

Because the RMS velocity is connected with the average velocity and the heterogeneity factor \( g \) (formula (g)), the last formula also actually depends on three parameters: \( t_0, V_{\text{Ave}} \) and \( g \).

Let us consider another NMO function in the form:

\[ t(x) = \sqrt{\frac{a}{b + cx^2}} \]
Long-spreadlength approximations to NMO function...  
Continued from Page 38

Using the same approach, and based on system (*), we come to the NMO expression:

\[ t(x) = \sqrt{t_0^2 + \frac{x^2}{V_{RMS}^2 + \frac{S-1}{4t_0^2}x^2}} \]  

\[(13)\]

Accuracy of different NMO approximations

All of the NMO functions (7) – (13) were tested on different depth velocity models. All of them show that expressions (10) – (13) have the highest accuracy for long spreadlength. For example, let’s consider a layered depth model with moderate vertical heterogeneity \( g = 0.103, S = 1.408 \) (fig. 1). For this model, I calculated the NMO functions using hyperbola (1) and equations (7) – (13). The exact NMO function was calculated through raytracing, and the residual traveltimes were computed for each NMO approximation. Figure 2 displays the approximation errors. Comparing the different NMO approximations with respect to residual moveout; which affects the quality of stacked data, for the offset/depth less than 1, all the approximations are accurate enough. The new approximations (11) – (13) and the approximation (10) fit the exact traveltimes very well at large offsets up to 3.5 x depth.

![Figure 1. Depth velocity model with a modest vertical heterogeneity: \( g = 0.103, S = 1.408 \).](image1)

![Figure 2. Traveltine residuals for different NMO approximations. Numbers coincide with formula numerations.](image2)

The least square approximations for three-term velocity analysis

Here we consider the accuracy of the various NMO functions as an approximation to observed travel times for a three term velocity analysis. To investigate the errors of each NMO approximation to fit actual traveltimes, we used several models with different heterogeneity. Even for the models with a large vertical heterogeneity and offsets up to 3 times reflector depth, the new approximations (11) – (13) were observed to fit the actual NMO curve with a high degree of accuracy. Figure 3 displays a depth velocity model with large vertical heterogeneity \( g = 0.255, S = 1.88 \).

Continued on Page 40
For this model, we calculated NMO functions through raytracing. Each NMO approximation (7) – (13) was used to approximate the NMO curve using the least-squares method for three parameters. Figure 4 shows the residual NMO time for the spreadlength equal to 3 times reflector depth. We see that even for this depth velocity model with large vertical heterogeneity, equations (10) – (13) fit the exact NMO curve very closely. For the spreadlength/depth less than 2.0, the approximation error of these approximations does not exceed 1 ms.

RMS velocity estimation

All the above NMO approximations can be used to estimate the RMS velocity through three-term velocity analysis. All of these equations represent different RMS velocity estimations with different statistical properties. Each of these formulae correspond to an NMO approximation that can be used in velocity analysis. For fixed $t_0$, each NMO formula (except hyperbola (1)) depends on two parameters. We can estimate the RMS velocity using NMO formulae (7) – (13) by performing three-term velocity analysis. Because all the formulae are approximate, these estimations will be different with respect to VRMS bias and standard deviation. To investigate the accuracy of RMS velocity estimation using different NMO approximations in the presence of random noise, we simulate the scenario with random time shifts (Al-Chalabi, 1974). To test the various NMO approximations, we used the model as shown in Figure 1. Traveltimes were calculated using raytracing, and a random time jitter with standard deviation of 3 ms was added to the NMO functions. I then determined three coefficients of each approximation using the
least squares method for the spreadlength equal to two reflector depths. Figure 5 displays the result of 180 trials. We see that formula (11) and formula (13) give the most accurate estimation of RMS velocity.

Depth estimation

Conventional NMO functions provide us only with an RMS velocity but not the average velocity. For the vertically heterogeneous layers, the Dix formula gives us an estimation of the RMS interval velocity but not the average interval velocity. By RMS velocity we mean velocity as defined by formula (Taner and Koehler, 1969):

\[
V_{RMS}^2 = \sum_{k=1}^{n} \frac{h_k v_k}{\Delta t_k} = \sum_{k=1}^{n} \frac{\Delta t_k v_k^2}{\Delta t_k}
\]

(14)

where \(\Delta t_k\) is a vertical one-way time in the \(k\)-th layer. Average velocity \(V_{Ave}\) is determined by formula:

\[
V_{Ave} = \sum_{k=1}^{n} \frac{h_k}{\Delta t_k v_k} = \frac{H}{\Delta T} = \frac{H}{T}
\]

where \(H\) is a reflector depth and \(T\) is the one-way vertical time. If an estimated layer is heterogeneous (includes several horizontal layers) then Dix formula estimates RMS interval velocity in this layer but not average interval velocity (Al-Chalabi, 1974). The difference between RMS and average velocities in the layer is described using the heterogeneity factor \(g\), (recall formula (g)) (Al-Chalabi, 1974). The heterogeneity factor \(g\) is always positive (0 for homogeneous layer) and can be as large as 0.1 (and greater). For a highly heterogeneous layer, the difference between the interval velocity, estimated through the Dix formula (that is interval RMS velocity) and average interval velocity may be as great as 10\%, and possibly more. It may lead to significant errors in the depth estimation as made with Dix interval velocities even if the RMS velocities were obtained with very high accuracy.

Two new NMO expressions (11) and (12) refer directly to the average velocity instead of the RMS velocity. It implies that this average velocity can be estimated directly from a long-offset velocity analysis, using these NMO representations. This enables an estimate of average velocity from long-offset velocity analysis, and thus the determination of reflector depth with more accuracy. This implies that we can determine a reflector depth using average velocity instead of RMS velocity, and it might lead us to a more accurate depth estimation from seismic data. Formulae (11) and (12) can be rewritten using reflector depth \(H\) and the heterogeneity factor \(g\):

Continued on Page 42

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Each of the above NMO approximations include three parameters: \( t_0, g \) and \( H \), which can be determined through three-term NMO analysis. Using these formulae, we can consider three-term velocity in terms of the depth \( H \), zero-offset time \( t_0 \) and the heterogeneity factor \( g \).

To test this approach to depth estimation, a depth velocity model was created from real sonic log data. Figure 6 shows the depth velocity model with high velocity layers, which affect the Dix velocity estimations and cause significant differences between average and RMS interval velocities. For the approximations (1), (7) – (10) and (13), the RMS velocity was estimated through three-term velocity analysis for five reflectors at the depths 0.5, 1.0, 1.5, 2.0 and 2.5 km. Subsequently the Dix formula was applied to estimate interval velocities and thickness for each of the five layers. The reflector depth was estimated as the sum of five layer thicknesses.

Figure 7 shows depths as estimated from the different NMO approximations for the spreadlength equal to 2 times the reflector depth for 180 trials with the added standard deviation of random NMO time jitter of 4 ms. This figure shows that expressions (11) and (12) give the most accurate depth estimation.

Conclusions

We have presented an approach to derive several different NMO approximations for horizontally stratified isotropic media. This approach is based on keeping time \( t(x^2) \) and its first and second derivatives with respect to \( x^2 \) at offset \( x = 0 \) the same as for exact NMO function. Three new NMO functions have been derived and tested on model data together with the known ones. The new approximations appear to be the most accurate in terms of residual traveltimes and RMS velocity estimations, particularly at large offsets. Two of the new NMO approximations include average velocity as one of the parameters. This enables an estimate of reflector depth directly from velocity analysis rather than depth estimation through the Dix formula and RMS velocities.

References


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2006 Honorary Membership Recipient: Perry Kotkas
Citation by Geoffrey Wilcox

Whether working in geophysical exploration, the service sector, or as a volunteer, Perry Kotkas, P.Geoph. has always conducted himself with thoughtful dedication, insight and a most friendly demeanor. Perry’s leadership, generosity and engaging spirit with individuals of all ages make him a most deserving recipient of the 2006 Honourary Membership Award.

Born and raised in the agricultural community of Barons, in southern Alberta, Perry the farmer went on to become Perry the geophysicist, graduating with a B.Sc. in Geology (Geophysics) from the University of Calgary in 1972. Perry elected to make Calgary home, and for the first two thirds of his career, worked in both domestic and international venues of the exploration sector as an interpreter, chief geophysicist and exploration manager. Perry went on to become President and co-owner of SourceX Geophysical, a well known, Alberta based, data acquisition company. Subsequently, SourceX was acquired by Arcis Corporation, where Perry worked until early retirement in 2003, assuming various senior roles, most recently as Senior Vice President, Services and Development.

Perry claims that he “had to” join the Canadian Society of Exploration Geophysicists in 1974, in order to be allowed to curl in the Doodlespiel. It is a marvelous thing that he did, because the Society caught his interest and has benefited from his lengthy involvement. Kotkas spent five years on the Doodlespiel committee, and also served on the Doodlebug and the CSEG/APEGGA Liaison and Geosciences committees. He has served on numerous CSEG convention committees, including GeoTriad. Perry went on to serve as a popular Vice President, President and Past President of our society and while President, particularly enjoyed representing the CSEG as it celebrated its 50th Anniversary and the SEG 2000 Conference in Calgary. A second highlight of his term was being involved in the hiring of Jim Racette, CSEG Managing Director.

Since his retirement in 2003 Perry has been even more active in CSEG activities, including responsibilities on the President’s Advisory Council, and in particular, involvement in the CSEG Outreach Committee, where he is currently Student Outreach Coordinator. In many ways his current

Perry in action at the 2006 CSEG/CSPG Convention.
involvement in the CSEG represents a second career for Perry. The CSEG and society in general is benefiting greatly from his efforts.

I personally have had the privilege of crossing paths with Perry twice in my career. The first time, as an aspiring seismic broker, I “cold called” Perry. He very kindly took the time to schedule a face-to-face meeting, and I was treated by someone whom I’d never met to tons of professional advice, encouragement and with all the warmth of an old friend. Happily, five years later, Perry and I ended up working together at Arcis, where we all benefited from his thorough yet outgoing style and the wisdom that comes from experience and maturity.

Perry is also active outside of the geophysical community and has dedicated a huge amount of time and effort to Scout’s Canada. He sings with the St. Thomas United Church choir and enjoys hunting, fishing and golf. Since retirement, through a healthy regimen of daily exercise, he has regained the physique of a younger man while maintaining the mind of an experienced senior. Perry is married to Karen and they have two grown children, Jillian and Stephen.

Perry’s dedicated service to the CSEG, his unique and successful work history, his generosity with time and knowledge and his ongoing contribution to the CSEG and the community at large make him an outstanding recipient of the Honourary Membership Award.
Dr. Michael Enachescu is a key player in the exploration and development of offshore petroleum resources of East Coast Canada, particularly Newfoundland and Labrador, for more than two decades. As a leading member of Suncor’s and then Husky’s frontier exploration teams from 1981 to 2003, he was involved in a number of discoveries in Atlantic Canada (including both White Rose and Terra Nova). His detailed geological map of the Grand Banks, compiled over several years, is the standard reference for both industry and government, and the starting point for any company considering acquiring lands or drilling offshore in the area.

Since undertaking his post at Memorial University in 2003, Dr. Enachescu’s research output has been even more impressive. His students at Memorial benefit greatly from his scholarly rigor, which instills excellent research and presentation skills: several of his students have gone on to receive national awards for papers developed under his mentorship and guidance.

In addition to his professional and scholarly work, Dr. Enachescu contributes energetically in academic, industry and community organizations, including the Canadian Society of Exploration Geophysicists (CSEG), Canadian Society of Petroleum Geologists (CSPG), American Association of Petroleum Geologists (AAPG), Society of Exploration Geophysicists (SEG), Petroleum Research Atlantic Canada (PRAC), Atlantic Energy Roundtable (AER) Exploration Committee and several immigrant aid organizations.

Dr. Enachescu is a tireless champion of Newfoundland and Labrador’s petroleum industry. His work, especially his publications on East Coast basins (Jeanne d’Arc, Grand Banks, Orphan and Hopedale basins), has exponentially increased our understanding of the region’s geology, dramatically improved our chances of new discoveries and re-captured the attention of explorers – which, of course, represents our industry’s future.

**NOIA Outstanding Contribution Award**

The NOIA Outstanding Contribution Award was initiated in 2002, to recognize those who have made exceptional contributions to the development and success of Newfoundland and Labrador’s petroleum industry. As part of NOIA’s 25th Anniversary celebrations, 12 awards were presented in honour of those whose work over that quarter century laid the foundations of our industry and paved the way for its future success.

Presented annually, NOIA’s Outstanding Contribution Award recognizes an individual’s contribution, within this province’s petroleum industry, to:

- project or infrastructure development
- petroleum business development
- human resource development
- technology development
- promotion and marketing of the industry
- development of petroleum-related legislation and/or regulations
- length (number of years) of involvement
- industry-related volunteerism

**The award:**

A powerful storm wave is completely contained within a tetrahedron, the strongest and most stable of structures, set on a thick triangular base.

The artist, Newfoundlander Jim Maunder, carefully selected materials to reflect the distinctive character of this province’s petroleum industry. The tetrahedron is fashioned from laser-cut stainless steel, suggesting the achievements of engineering and technology. The powerful storm wave is fired clay glazed in blue, sea green and white; contained within the tetrahedron, the adverse environment it represents is tamed. The triangular base is cut from Labrador Anorthosite, which

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Dr. Michael Enachescu receiving the NOIA Outstanding Contribution Award from Tony Goobie, chair of the Outstanding Contribution Award Selection Committee.
The 2007 Annual CSPG CSEG Convention is truly underway, with exciting new developments in Special Events and the Technical Sessions joining old favourites such as the Core Meltdown. Watch out for the Final Circular being mailed to you shortly – this will contain everything you need to know about our first class offering of oral presentations, poster sessions, core presentations, field trips and short courses, as well as the Convention schedule and information on registration!

REGISTRATION OPENS MONDAY MARCH 19, 2007

Registration fees for this year’s convention are as follows: (Please note prices do not include GST)

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<tr>
<th>Early Bird Registration</th>
<th>Regular Registration</th>
<th>On-Site Registration</th>
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<tbody>
<tr>
<td>Member (CSPG/CSEG/CWLS)</td>
<td>$285</td>
<td>$385</td>
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<tr>
<td>Non-Member</td>
<td>$385</td>
<td>$485</td>
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<tr>
<td>Retired Members (CSPG/CSEG/CWLS)</td>
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<td>Student</td>
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Day Pass – Exhibition Hall Only: $50/day
Luncheon Tickets: $50 each
Flowdown Reception Tickets: $35 each
Core Meltdown Tickets: $15 each

Avoid the Monday morning on-site registration rush….REGISTER EARLY!

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Registrations received after 6:00 pm (MST) Friday April 27, 2007 will be held and processed on-site. On-site registration fees will be applied.

Luncheon Speaker - Biography

Rex Murphy was born and raised in St. John’s, Newfoundland, where he graduated from Memorial University. A Rhodes Scholar, he attended Oxford University (along with U.S. President Bill Clinton). When he returned to Newfoundland he was soon established as a quick-witted and accomplished writer, broadcaster and teacher.

Murphy contributes extensively to CBC on many current affairs issues. For The National Magazine he created a number of documentaries from Newfoundland, including the highly acclaimed “Unpeopled Shores,” about the tragedy of the disappearing cod, and human interest pieces on writer Annie Proulx, World War II, and scientist Hubert Reeves.

He contributes a regular essay to The National Magazine, dealing with topics as diverse as the Royal Family, smoking, and Quebec politics and writes a weekly column for the Globe and Mail. Murphy is also the author of the book, Points of View, a collection of his best writing spanning 30 years. The selection includes an assortment of topics, from his hard-hitting political commentaries, book reviews, and hilarious satires, to warm memories of Newfoundland.

An award-winning broadcaster, Murphy is the regular host of CBC Radio’s Cross Country Checkup and commentator on the CBC Radio show Definitely Not the Opera. He has also contributed to Morningside, Land and Sea, The Journal, Midday, and Sunday Report.

His endearing style showcases a sarcastic intellect and deep insight into issues affecting all Canadian individuals and businesses. Graced with his own brand of persuasion, no one walks away not knowing exactly what Rex Murphy thinks.
anchors the other elements to our onshore strength and reliability while its iridescent crystals reflect the changing colours of sea and sky and speak of creativity.

Combined in a single award, these three elements beautifully represent the outstanding achievement of an industry that has persevered, prospered, and promises still more.

**Enachescu Recipient of NOIA Outstanding Contribution Award**

Dr. Michael Enachescu, Husky Energy Senior Fellow for Exploration Geophysics and Associate Professor in the Department of Earth Sciences at Memorial University and a member of CSEG, is the recipient of NOIA’s Outstanding Contribution Award for 2007. In choosing Dr. Enachescu, the
industry association pointed out that he has been a key player in the exploration and development of the offshore petroleum resources of East Coast Canada, particularly Newfoundland and Labrador, for more than two decades. “His work, especially his publications on East Coast basins, has exponentially increased our understanding of the region’s geology, dramatically improved our chances of new discoveries and re-captured the attention of explorers – which, of course, represents our industry’s future,” said NOIA.

Michael was a co-author of the Development Plan Aplications for both White Rose and Terra Nova fields, now significant oil producers for the Province of Newfoundland and Labrador.

“I humbly accept this 2007 NOIA Outstanding Contribution award as a recognition to all geologists and geophysicists, who for more than 40 years now have worked and researched for petroleum exploration and development offshore Newfoundland and Labrador, always an uphill battle fraught with many obstacles, but rewarded with great successes and now with the province being a significant Canadian oil producing province,” said Dr. Enachescu on accepting the award at NOIA’s Annual General Meeting and Award Dinner in early February.

Continued Enachescu, “It is well known ... that behind every offshore mega-project are daring geoscience employees in the industry, universities and government offices dreaming of first subsea hydrocarbon accumulations, convincing their employers to collect geophysical and geological data, mapping the subsurface and a few of them recommending expensive drilling locations with a predicted success ratio of 1 in 10. (Not a profession for the weak of heart!) These honest and hard-working geoscience professionals and scientists are rarely recognized outside their professional and scientific organizations, they never participate to ribbon cutting ceremonies when ‘first oil’ is produced, nor do they make the front page of business magazines!”

The geoscientist went on to thank his colleagues and graduate students at Memorial, his previous colleagues and managers at Husky Energy, companies who have donated seismic data to MUN (GSI and WesternGeco), research sponsors (NSERC, PPSC, PRAC, Chevron ConocoPhillips, and Landmark Graphics/Halliburton), his family and NOIA executives, employees, award selection committee and members Patrick Laracy and Phonse Fagan who nominated him for the award. R
Capo Restaurant

Most likely you’ve already heard of Capo Restaurant even though it’s only been around for a year now.

For new restaurants it was rated the best in Calgary by The Globe and Mail and Where Magazine, and second in Canada by Enroute.

Chef and Owner Giuseppe Di Gennaro is meticulous with his ingredients and it shows in his dishes. You may know Giuseppe from Il Sogno in Bridgeland where he wowed us since 2001 with his vision of “new” Italian food. He ventured out into Inglewood in March 2006 to open Capo. With only 32 seats in the main restaurant there is a feeling of closeness but comfort and coziness. The room is surrounded by high banquettes in addition to a few tables in the middle, with the showcase being a pass-through where you can see Giuseppe finalizing his creations.

We booked in a table for eight and had the choice of being in the main dining room where the maximum size for a group is eight, or booking the private dining room, which is in the back and will hold a maximum of sixteen. The separate dining room would be great for business dinners or a family gathering but I was glad we chose to be in the main dining room where all the action was. If you book the separate dining room you must go with the Chef’s Table which is a menu put together by Giuseppe for that night and it starts at $85 per person for dinner.

Now, onto the most important part, the food. Di Gennaro uses only the finest and freshest of ingredients. We started with the amuse which was a trio: a panko coated fried mascarpone risotto on gorgonzola cheese, duck prosciutto rolled around goat cheese and citrus poached shrimp.

You have a choice of a few antipasti (appetizers $13), a few pasti (pasta $16), and some secondi (main courses $32-$36), as well as dolce (dessert $9.50). You’ll definitely find something to your liking. Since we had a large table we were able to sample a good variety of the menu. The antipasti caserole of prawns, clams, cannellini beans and cherry tomato coulis served in a small warm copper pot was reminiscent of my all time favorite calamari appetizer of Giuseppe’s at Il Sogno. The butternut squash soup was served from a copper kettle at your table. We all got a good laugh when our server said that it was rated the best in Canada by Chatelaine magazine. I’m not sure why we found that so amusing.

My choice for the secondi was the seasonal fresh fish, which happened to be Chilean Sea Bass that night, and was done perfectly. Others at the table had the AAA beef tenderloin with young gorgonzola mousse, port reduction and sautéed broccoli rabe ($36), roasted pheasant breast, Muscat wine and rosemary reduction with morel mushrooms and parsnip puree ($35) or thyme-marinated grilled prawns with shellfish saffron cream and pan-seared spicy micro mushrooms ($32). All of these were served with small warm cast iron pots of grilled vegetables. Everyone agreed that their meal was delicious. It definitely shows when particular attention is paid to the ingredients. Unfortunately we were too full to finish off with dessert which all looked wonderful, but the expressos were outstanding.

There is no shortage of excellent staff in this place but never do you feel that you are being overwhelmed by their presence. At a time when staffing is so problematic in Calgary, Capo stands out from others with its service. The food was excellent but be prepared to pay for it. Dinner for two was around $200. Enjoy!

1420 9th Avenue SE
Phone: 264-2276
CSEG Luncheon (February 12, 2007)

Speaker: Rainer Tonn

(Photos courtesy: Penny Colton)

CSEG AWARDS 2006


The 2006 CSEG Best Technical Luncheon award went to: Henry Posamentier for his talk entitled, ‘Reducing reservoir risk using 3D seismic based stratigraphic and geomorphologic analysis’ (collected by John Logel on Henry’s behalf as seen in the picture above).
Wow, it is hard to believe that it is March already. I took the month of February off and it flew by! I have never had a chance to take a holiday like that before and I highly recommend it. As of March 1st, I have started my new business venture and my announcement is below.

I am still looking for people that want to highlight their charity work outside the geophysical industry. As always, new job, birth, transfer and retirement announcements are most welcome and are free. Send your announcement to carmen.swalwell@shaw.ca or carmen_swalwell@yahoo.com You can also contact me at (403) 560-8431.

The 2007 joint CSEG/CSPG convention will soon be upon us. It would be interesting to have new graduate write about their experiences and impressions of this convention. So if you are a new graduate that has never attended a convention before please contact me. Your story will appear in this column in the September 2007 issue of the RECORDER. If you know someone that you think would be interested in writing this piece, please pass this request on!

ON THE MOVE...

Kevin Frankiw is pleased and excited to announce that he has moved to Penn West Energy Trust and will be working out of the Swan Hills group. Kevin thoroughly enjoyed his time at Kelman and wishes them all the best. Kevin can now be reached by e-mail at kevin.frankiw@pennwest.com or by phone directly at 777-3332.

Carmen Swalwell would like to announce that she has started a new company, Swalwell Resource Consulting Inc. (in bold), recruiting for the oil and gas industry, specializing in Geology and Geophysics. You can contact me at carmen.swalwell@shaw.ca or (403) 560-8431. I look forward to doing what I can to help people achieve their career goals. I would like to thank all my past clients; it has been a pleasure working with you. I hope to do so again in the future. I would also like to thank David Nordin for all his help. It is greatly appreciated.

Mike Burianyk has left Calgary, and Shell Canada, to take a position with Shell International at their research lab in Rijswijk (The Hague) in The Netherlands. He’ll be working in the Exploration R&D group doing research in potential fields (gravity and magnetism). Mike’s e-mail remains the same: michael.burianyk@shell.com

Paradigm Geophysical (Canada) Limited is pleased to announce two new members to our Marine Processing Team - Valmore Ceilis and Hotma Siagian. Valmore has his Masters Degree from the Colorado School of Mines and specializes in 3D depth imaging and seismic processing in structurally complex areas, both in Land and Marine. He brings over 15 years of experience working on projects around the globe. Hotma has over 22 years experience in geophysics, predominantly as a Senior geophysicist running large Marine and Land projects. Valmore can be reached at 403-571-1611 and Hotma at 403-571-1589. These two individuals will be great additions to our expanding Reservoir Studies and Processing teams!

New start-up processing center, Absolute Imaging Inc., is pleased to announce commencement of seismic data processing operations at their new location: L120, Mission Centre, 2303 – 4th Street SW, Calgary, T2S 2S7. Absolute Imaging began processing 2D and 3D seismic data January 2, 2007. Gerry Schlosser (gerry@absoluteimaging.ca), Des Maguire (des@absoluteimaging.ca) and Gordon Dyck (gord@absoluteimaging.ca) are looking forward to their new challenge and would like to let their clients, colleagues and friends know that they can be reached at (403) 245-3001 or fax (403) 245-3002.

Absolute Imaging Inc. is extremely pleased to announce that Mike Gervais has joined their organization. Mike brings 21 years of experience to the team and the company is excited to have him participate in the growth and prosperity of the newly founded business. Mike would like to let his friends and colleagues know that he can be reached at mike@absoluteimaging.ca or at (403) 245-3001.

HOW I GOT INVOLVED IN THE SEISMIC INDUSTRY...

Damien Thenin – Paradigm/Sales Manager Canada

I grew up in Paris, and started to get interested in geology while learning things about tectonics and volcanism. I originally intended to work in the food processing industry, as biology was my favorite school class. But after spending three years specializing in this area, I realized that I had more fun learning geology than biology. So I took a master’s degree in petroleum geology at the Nancy School of Geology in France. During the 3 years spent in Nancy, I studied many aspects of geology. Not only petroleum geology, but also mining geology, geophysics, civil engineering, etc... This was a great opportunity to understand the different disciplines linked to the subsurface knowledge.

After several internships in the mining and the oil industry, plus some research work done with Pr. Mallet’s team (gOcad Consortium), I decided to move to Dubai to join Earth Decision Sciences as a consultant in 2003. My job was to provide support, training and consultancy to GOCAD users throughout the Middle East. This was a very fun time, with a lot of travels, where I had the opportunity to meet many great people. I spent most of my time in Saudi Arabia. On a personal side, it was an opportunity to work with integrated asset teams, from interpretation to flow simulation. And on a personal side, a great chance to discover a very nice culture (very different from what was shown on TV at that time). It is during that time that I started to work more and more on the geophysical side, as we integrated seismic data into reservoir modeling studies.

In 2005 I was transferred to Calgary with Earth Decision, in order to provide consultancy in reservoir modeling. And after only few months, I was in charge of the Canadian operations of Earth Decision, dealing with both the services & sales activities. This is when I started to get more involved in the seismic side of the industry, by providing solution for seismic

Continued on Page 55
IHS GeoSyn™

“GeoSyn is a technically strong geophysical tool written by a geophysical interpreter...and the only synthetic modeling tool I need”

Carol Lawes
Geophysical Consultant

GeoSyn takes the strength of being extremely straight-forward and quick to use with substantial new development.
Continued from Page 54

What did that little rodent say back in February about Spring being around the corner? Because right now, I’m freezing and my tolerance for tales of little groundhogs coming out to see their shadows and forecasting our weather is wearing a little thin. I apologize, as I write this, it’s -20, I’m a little cranky, my skin is cracking it’s so dry and my core body temperature hasn’t been the same since September. Oh well, to quote Bridget Fonda in Point of No Return, “I’ll just smile a little smile and say, I never did mind about the little things”. (If you’ve ever seen the movie you know you say this when things are really starting to tick you off). Have a great month!

If you have any company news, please send me an email at gina.schiltz@ihsenergy.com or call me at 770-4450. Thanks!

Friends of Science

The Friends of Science is holding a very special Luncheon Event with guest speaker R. Tim Patterson, PhD, Professor and Director Ottawa-Carleton Geoscience Centre

“The Sun as the Primary Driver of Climate Change?”

Date and Time: Wednesday, May 16, 2007 at 11:30 am
Where: Metropolitan Conference Centre
333, 4th Avenue SW Calgary, AB
Advance Tickets are $50
Phone: 403-236-4203
Email: fos@telus.net

For more information on the event or the non-profit group Friends of Science, please visit their website at www.friendsofscience.org

Calgary Mining Forum Final Reminder

The 16th Calgary Mining Forum, “Building the Future” will be held this year March 20-23, 2007 at the Ramada Hotel, Downtown Calgary, featuring presentations by mineral exploration companies, mining service companies, and provincial and federal geological surveys. Topics will include minerals exploration projects, exploration methods, current research and investment opportunities. Also included are a Keynote Address, short courses and a poster session.

Early Registration Deadline is March 5, 2007.

For more information and registration forms, booth information and short course information, contact:

Glen Jones: 403-202-8683
Henry Lyatsky: 403-282-5873
www.meg.calgary.ab.ca

IHS

Englewood, Colo. (Jan. 11, 2007) – IHS Inc. (NYSE: IHS), a global provider of integrated oil and gas information, software and consulting services, announced today it has acquired Geological Data Services Inc. (GDS) of Addison, Texas, a provider of interpreted subsurface data “formation-tops” covering the Permian Basin, U.S. mid-continent and Rocky Mountain regions. The GDS dataset provides correlated formation-tops data for more than 640,000 wells, which are picked by geologists using a consistent and rigorous methodology.

The GDS tops will be integrated with the IHS E&P data and software solutions, including PETRA®, a leading software tool for geologic interpretation acquired from GeoPLUS in April of 2006. This integrated solution will further enhance IHS datasets and tools, increasing the value to IHS customers. For example, integrating the GDS formation tops data with the

### 2007 Calendar

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<tr>
<td>1 – 4</td>
<td>AAPG Annual Convention &amp; Exhibition</td>
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<td>30 – May 3</td>
<td>Offshore Technology Conference</td>
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<td>29 – June 1</td>
<td>CGU Annual Meeting</td>
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<td>11 – 14</td>
<td>EAGE 69th Annual Conference and Exhibition</td>
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<td>23 – 28</td>
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IHS datasets will simplify the delivery of data, allowing the customer to spend more time generating prospects and less time loading data and manipulating multiple datasets.

“We are pleased to acquire such a valuable interpreted dataset that will combine with our other rich datasets to aid geoscientists striving to better understand subsurface geology and generate prospects,” said Mark Rose, senior vice president of the U.S. Energy Business Unit for IHS. “This acquisition is one of several recent acquisitions of companies or assets intended specifically to increase the value we deliver to our customers by deepening our U.S. content offering and enhancing the decision-support tools our customers use to analyze that information.”

“We had numerous suitors seeking to buy GDS, but we chose IHS because of its longstanding reputation for providing quality data, and for being good stewards of vital E&P information,” said Joe Haynes, CEO of GDS. “IHS and GDS have a long history of collaboration, and IHS was the only company we felt we could entrust with our data and customers. We began building these interpreted data sets more than 20 years ago — so it was very important to us that they continue to be improved and maintained, and our customers be supported. Since many of our customers are also IHS customers, we knew it would be a fairly smooth transition, and for our customers not familiar with IHS, we felt strongly that they would benefit from the additional support resources and complimentary products that IHS provides.”

**CGGVeritas**

CGGVeritas announced today its participation in the launch of the Republic of Guinea-Bissau’s 3rd Licence Round. Petroguin, the National Oil Company, is concessionaire for Guinea-Bissau and has retained CGGVeritas and First Exchange Corporation to manage data packages and distribute all technical and legal information related to the round.

The round will run from now until April 30, 2007 and covers key acreage, both onshore and offshore Guinea-Bissau. Commenting on the round, Jim Gulland, CGGVeritas Business Development Manager, EAME Data Library, stated, “This is an important chance for the industry to participate in the exploration of this key region. The potential of the acreage in the round is clearly highlighted by the data package being offered. The seismic, the well correlation studies and the geologic interpretation give unrivalled insight into these under-explored structures.”

New opportunities for exploring open acreage are scarce and this round brings a welcome spotlight onto Guinea-Bissau’s potential.

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**Tracing the Industry**

**Continued from Page 52**

interpretation and visualization, and advanced velocity workflows. But that was not the end of the reservoir modeling for me! I truly believe the industry will benefit more and more from integrated studies with multidisciplinary teams: geophysicists, geologists and reservoir engineers contributing together to build more realistic reservoir models, for example in the heavy oil.

In 2006 Paradigm acquired Earth Decision. Thanks to its seismic processing and software portfolio, the concept of integrated services became even more obvious. It is now time for me to learn more science and technology linked with the seismic industry! R

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**Start Your Career with CGGVeritas**

Canadian operations are currently seeking talented people to join their progressive team! For more information: cggveritas.com
CSEG New Members

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