InSite

CWLS Newsletter
DECEMBER 2004

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Cover Photos: *Drilling rig at sunset in the Buckinghorse area, N.E. B.C. Photo Courtesy Jim Signer.*

If you have a photo that the CWLS can use on it's next InSite cover please send a high resolution jpeg format version to Robert_Bercha@anadarko.com or meddy@varco.com. Include a short description of the photo with your submission.

President's Message

In October I attended a summit organized by the Canadian Geoscience Council (CGC). The CWLS is a member of this group along with the CSPG, the CSEG, the CIM and a host of other geotechnical societies.

Two discussion topics caught my attention. The first of these was the apparent demographic crunch that our industry will be facing. People have been talking about this for a while. Essentially, the current group of geoscience students and junior geoscientists are not anywhere near enough to replace the Baby-Boomer geoscientists expected to retire in the next ten to fifteen years.

The consensus of the discussion and presentations was that we have to work to attract more young people into geoscience. I wasn't convinced. One statistic presented was that while engineering enrolment increased 61% from 1995 to 1998, geology enrolment only increased 8%. These stats were meant to illustrate the need to attract more geoscience students. But they also beg the question, " What drew all those students into engineering?" I suspect that the trend was mostly due to large-scale societal forces. I don't think the CGC has enough people and money to have a significant effect on these forces.

Another reason I wasn't convinced that a demographic crisis was looming was that improvements in technology were not considered. I heard a comment that one geologist could now do the work that five geologists used to do 20 years ago. If this trend continues we will soon have too many geoscientists, not too few.

Other factors that I didn't see addressed were:

- If demand for geoscientists increases, compensation will increase and the retirement rate will probably decrease.
- There seems to be plenty of technically qualified immigrants to fill in if there is a shortage of new graduates. It may take a few years for them to gain local knowledge but that is better than the nine years it takes to graduate a student and get them some experience.

So, I don't see a need to worry about a worker shortage.

What will be a shame is that much of the experience and knowledge that the industry has acquired will be lost because there are not enough people to pass it on to. This is probably even more true in petrophysics than in geoscience in general. How many people in senior petrophysical positions are currently training a non Baby-Boomer replacement? I don't know of any.

The goal of the CWLS is the furtherance of the science of formation evaluation. We, as a group, should be concerned that, someday, much of the body of knowledge we have built up will be lost. I'm not talking about the things that have been written up, but about the stuff we carry around in our heads. I don't know what we can do as a group to create junior petrophysical positions in the industry. As individuals though, our members that are counting down to retirement and are in a position to influence hiring may want to support the creation of junior, mentored positions. Please give it some thought.

Also, our VP, John Nieto has recently put forward the idea of an online CWLS formation evaluation forum. The Society of Core Analysts has one. It looks to be a nifty way for people to pass on their experience to others. This is something we will be looking into.

The other interesting topic at the CGC Summit was the influence that professional registration requirements can have on our industry. There were quite a few attendees representing academia. Their story was that the courses they choose to offer do not necessarily reflect the needs of industry, nor do they reflect what is current in geology and geophysics as scientific pursuits. Instead they are based on what is specified for professional registration by licensing bodies such as APEGGA. This got me thinking more about how our sector of the industry is affected by APEGGA licensing requirements. APEGGA's professional experience requirements state specifically that well logging may not be accepted as adequate experience for registration. I know first-hand of people who (a) have chosen to leave the logging business because APEGGA would not accept their experience (as they had presented it) or (b) never got into the business because it was unclear if they would be able to become registered. I brought this up at a recent APEGGA Geoscience Liaison meeting and was assured that the key word was "may." APEGGA's Deputy Registrar offered to meet with me to help clear up any misconceptions about APEGGA's views on well logging as engineering experience. I will report on that meeting in a future InSite.

The CWLS and APEGGA have looked at this issue before in the 1980's. I think it is time to look at it again. We don't want to be discouraging the best and brightest from getting into the logging industry because of unwarranted concerns about professional registration.

If anyone has any comments or ideas please contact me at (403) 232-1705 or jlevack@tuckerenergy.com.

Jeff Levack, CWLS President

Editor's Note

Over the past year it seems as though every editorial we write has us recording a new oil patch high. In the past it has been the number of rigs currently working or the record number of wells drilled. This time it is record oil prices reaching over fifty-five dollars US per barrel. Even oil and gas analysts could not have predicted such a huge spike in world oil prices. Gas prices also continue to be strong as we head into the time of year when prices traditionally hit their highs. The Canadian dollar is trading over eighty cents on the American dollar, closing at a sixteen year high. Much of this is due to the US dollar slumping which inversely increases the Canadian dollar and the price of oil. The rig count for this year has already been pushing 540 rigs and it would be higher if the weather would cooperate. All of this can only mean one thing for the upcoming drilling season......BUSY!!

The CWLS is busy as well. We encourage you to volunteer, nominate a member for the executive, or write a paper for the InSite. You probably have noticed the InSite has grown in size and improved in content over the past year. This growth has resulted in increased costs for publication and we are looking for advertisers. We would like to thank everyone who has contributed to this success. Also, if you or a coworker has a paper or article to share please submit it for publication. Contact information can be found through out the InSite and on our website (www.cwls.org).

This issue we have two papers in the InSite, covering a wide spectrum of content. The first paper looks at the Milk River Formation in S.E. Alberta and S.W. Saskatchewan. The authors have developed a method/model that allows for the semi-automated log analysis of a wide spread gas charged sand body. The second paper provides a review of geo-steering in horizontal wells. With the current industry focus on improved well performance and cost reduction understanding this technology is crucial to continued success. Maybe it can be used in the Milk River?

Enjoy the InSite.

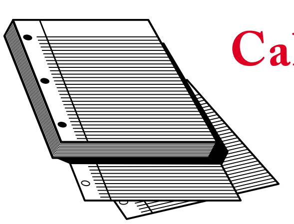
Robert Bercha
Mike Eddy
CWLS Publication Co-Chairs

As The Winch Turns

In the mid 80's, when I was a logging field engineer, I played a small part in helping some researchers from a large, multinational oil company debug a new technique they were developing. The researchers wanted to see if they could do cross-well tomography using sound. The idea was to place a regular wireline sonic tool in one well and a wireline geophone in an offset well. Because you could move the source tool and the geophone to any number of depths you could get enough data points to draw a detailed acoustic cross-section of the stratigraphy between the wells. The researchers had determined that for this to work, the logging tool acoustic signal would have to have a particular frequency spectrum. This is where I came in.

They had arranged a trial run at a test well facility that had two adjacent wells. Three of the researchers showed up with a geophone and a spectrum analyzer. I brought the source logging tool. The first part of the test would be to set up on surface to make sure everything was working and then we would run the stuff in the wells. I had my equipment all set up and ready to go before they did so I went to grab a coffee. When I came back the three were inside by the computer huddled around the spectrum analyzer. They were oohing and ahhing over the quality of the signal they were seeing. This surprised me, not because I didn't expect our transmitter to be up to their exacting standards, but because I hadn't turned the tool on yet. I went outside to see where this beautiful signal was coming from and there on the ground next to the geophone was a little cricket.

Jeff Levack
Tucker Wireline



Call for Papers

The CWLS is always seeking materials for publication. We are seeking both full papers and short articles for the InSite Newsletter. Please share your knowledge and observations with the rest of the membership/petrophysical community. Contact publications co-chairs Mike Eddy (meddy@varco.com) at (403) 230-0630 or Robert Bercha (robert_bercha@anadarko.com) at (403) 231-0249.

New Members

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Oresegun babatunde Azeez,
Shell Petroleum Development
Tye Barrett
Alex Bolinger
Mike Brown, Schlumberger
Glenn Buchanan, Recon Petrotechnologies
David Cailliav
Samuel Chang, Encana Corp
Greg Chapin
Brian Coffey, Simon Fraser University
David Colborne, Schlumberger
Eric Denne
Jim Durward, Unitech Energy Corp.
Innocent Emesibe
Darren Fichter, Canadian Natural Resources Ltd.
Konstantin Franovskiy
Reha Hanif, LMK Resources
John Hanko, Ryder Scott Company
Vlad Iglesias, Tucker Wireline
James Jone
Andrew Jones, Schlumberger
Xue (Hugh) Jun Li, Pure Energy Services Ltd.
Sergei Kazakoff, Halliburton
Salman Khalid, Schlumberger Canada
Gord Kiteley
John Kovats, Schlumberger
Khaled Latif, Chapman Engineering
Dana Pettigrew, Nexen Petroleum Intl. Ltd.
Gordon Pluffe, EnCana Corporation
Dell Pohlman, Burmis Energy
Elham Samari, Halliburton
Andy Shaw, Baker Atlas
Ogunnubi Sunday
Linton Swanson, Schlumberger
Nitsuhwork Tafesse
Martin Tang, Technology Services Group Inc,
Precision Drilling Corporation
Robin Upham
Lloyd Utke, Advance Wireline Inc.
Lloyd Wedon, SAIT

Members on the Move…

Wayne Dwyer to Husky Energy

A working gas trap and dryer assembly fastened to the 'possum belly' of the shaker.

Photo Courtesy John Nieto.

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Message from the Vice President

Well the year is almost over, only one more technical luncheon talk to go!

I have to say that it's been a rewarding job, organizing the lunches this year. I have been impressed with the willingness of people both in Calgary and the USA to share their work with our membership – often at the first time of asking!

So how are we doing as a society? Lunch attendance has been used in the past to gauge the health of the CWLS. I can report that we are alive and kicking! Attendances have been up considerably over the past 2 years. In fact, 5 meetings this year have had more than 150 attendees, the record being 190 attendees in November! This is tremendous, it would be great to keep it going!

I have to say though, that after nearly 12 months in the job, I now have a finger on the 'pulse' of the membership. As VP of the CWLS and a practicing petrophysicist, I'm interested in a wide range of topics. Many of you are in agreement, I know, as I've polled the membership on more than one occasion. It has become clear though, that "Integrated topics and International topics" are not high on the 'approval list' with the majority of members.....what really makes you tick are "Unconventional" reservoirs, tight gas, CBM, and fracture talks. So my challenge to you is to volunteer to talk on any of the above "Unconventional"reservoir topics! This year, we've had 5 talks around tight gas reservoirs, I know you'd like more.

Next month's talk is an excellent Petro-Geo-physical talk by one of the leading Geophysicists in Calgary. John Logel has presented this paper to the SEG, CSEG, and the CSPG — and soon, by their request, to the University of Houston and Denver Geophysical Society – Topic, "Pitfalls of detecting porosity in carbonate reservoirs from seismic amplitudes."

We're back in with the Palliser too. After some negotiations with the General Manager, Jeff and I are happy that the Palliser has our interests in mind. So we'll be back there for our Fall Social, December and January lunch talks, and of course the AGM. On the subject of the AGM, I've booked General Lewis Mackenzie to be our Dinner Speaker. I've had a quick chat with "Lew" and he's looking forward to addressing us on February 9th – should be a great talk!

Lastly, I've tried to maintain links with the SPWLA, especially the Denver chapter, currently lead by Dominic Holmes. We have many interests in common with Denver, for obvious reasons; it would be great to share speakers even more than we already have with this energetic SPWLA chapter. In addition, I've been speaking to the SPWLA about assisting in the Fall Topical conference in Kananaskis in March. This will be a 4 day informal conference and an Unconventional type reservoir theme has been proposed by myself. I'm hopeful that the CWLS members will rise to the occasion, giving talks and taking part in the discussions. (I'm asking the SPWLA about a day rate for those who would rather stay at home!)

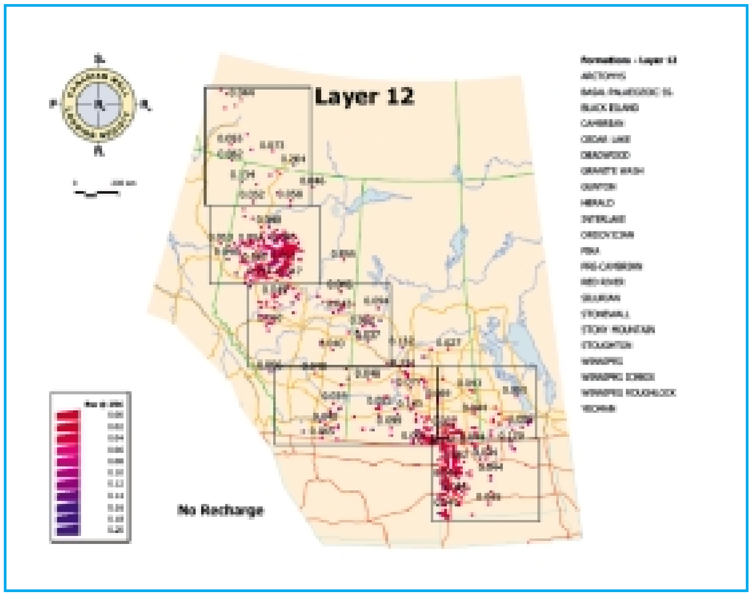
2005 promises to be an exciting 50th year for the CWLS...Happy Christmas!

John Nieto

Summer drilling in the Willesden Green Area, AB.

Photo Courtesy Sean Heffernan.

2002 CWLS Rw Catalog



Information included on CD:

- 2002 Rw Catalog
  (Over 50,000 Data Points)
  – PDF Format
  – Spreadsheet (XLS) Format

- 1987 Rw Catalog
  (5,600 Data Points)
  – PDF format
  – Original "Data on Disk" Digital Format

- LAS 2.0 and 3.0

Prices (Shipping Not Included):

Members:	$25.00 CDN (limit one per member, two per corporate member)
Non-members:	$65.00 CDN

Network License (corporate members):	$500 CDN
Network License (non-members):	$1000 CDN

To order contact the CWLS office at (403) 269-9366.

A high resolution copy of the latest newsletter is posted on the CWLS web site at www.cwls.org. For this and other information about the CWLS visit the web site on a regular basis.

Please forward this newsletter to any potentially interested co-workers. We would appreciate any feed back on anything you've read in the InSite and any suggestions on how this newsletter can better serve the interests of the formation evaluation community. Feel free to contact anyone on the CWLS executive with your comments.

B & W TIFF Standard

The CWLS is proposing a TIFF standard for log graphic files that represent 8.5" wide black & white logs. All logging companies can currently provide logs in formats meeting this standard.

The Standard

Required

- Group 4 TIFF containing all tags required for a baseline TIFF
- XResolution such that a 1728 dot wide file of a standard three track log prints at 8.25" wide from outside track edge to outside track edge with a 0.75" depth track or 8.00" wide with a 0.50" depth track. (this equates to a resolution of approximately 203 dpi)

Recommended* but not required:

- FillOrder = Most significant to least significant
- Orientation = Top left
- YResolution = XResolution

* Including the recommended tags ensures that TIFF's will be compatible with current viewers even though the viewers are deficient w.r.t. the general TIFF standard.

Test Files

Examples of each company's version of TIFF's meeting this standard are located at:

http://www.cwls.org/logtests.htm

Comments/Questions

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Executive Memo
September 28, 2004

Productivity Estimation in the Milk River Laminated Shaly Sand, Southeast Alberta and Southwest Saskatchewan

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D. W. (Dave) Hume, P.Geol. Rakhit Petroleum Consultants Ltd

Abstract

We have developed an open hole log analysis procedure that permits semi-automatic analysis of wells in the Milk River formation in southeast Alberta and southwest Saskatchewan. The results include reservoir properties and a productivity estimate that can be used to aid in evaluation of shallow gas prospects in this area. Reservoir properties were calibrated to available core analysis and productivity was calibrated to actual initial production.

The Milk River is a laminated shaly sand and is not amenable to conventional log analysis because of the way that logging tools average laminated rock properties. These sands are classic low-resistivity pay zones. There are a number of unconventional methods, three of which were tested in this project. Only one model proved to be useful.

Various reservoir quality estimates were developed, such as net reservoir, pore volume, hydrocarbon pore volume, and flow capacity, as well as a few less well known parameters such as Hester's quality number and a productivity estimate developed by one of the authors. All of these estimators correlated with normalized 3-month initial production with an R-squared between 0.837 and 0.906.

The laminated sand models do not distinguish water bearing from gas bearing zones very effectively, so hydrodynamics and geological mapping are used for this purpose.

This is a reconnaissance log analysis model designed to assist in resource estimates of large pervasive reservoirs. When high grade targets are selected, more detailed work must be performed to refine each potential gas interval.

Introduction

For several years we have been developing custom built software, nicknamed LOGFUSION, to perform semi-automatic log analysis for large shallow gas and coal bed methane projects. Since several thousand wells are involved in each project, with up to 60 separate stratigraphic horizons, individual log analyses are not practical. All of these projects involved conventional dispersed shaly sands in southern and central Alberta. The log analysis model for each project is prototyped in a spreadsheet and calibrated to ground truth. The parameters and model are then hard coded into our LOGFUSION software.

We have now extended this technique to include the laminated shaly sands of the Milk River formation in southeast Alberta and southwest Saskatchewan. The log analysis model is unique to this formation and no doubt will require re-calibration for other areas. A total of 28 wells were analyzed to prototype the models. Nine wells with a full log suite had considerable core data for calibrating log analysis porosity. Thirty additional wells had good core data, which was used to generate the porosity-permeability transform.

Seventeen wells (eight were cored) were selected that had a reasonable spread in 3-month initial production data and a full log suite. Nine of these were used to calibrate the log analysis results to production. The remaining 8 producing wells were used as test wells to see if "randomly" selected wells could be processed without changing the calibration parameters.

An estimated productivity index was calculated for all wells and compared to actual production on the 17 wells with IP data. There is a remarkable correlation between actual and estimated productivity, but only when using one of the three laminated sand models and only when a full suite of logs was available. The correlation between estimated and actual production had a correlation coefficient (R-squared) of 0.906.

Six other productivity indicators were tested, including a reservoir quality indicator proposed by Hester (1999), which gave R-squared values between 0.837 and 0.903. Average shale volume was also tested but the R-squared is only 0.296.

The core analyses had a total of about 600 valid porosity – permeability pairs. These were crossplotted to obtain a permeability from porosity transform. The best fit regression equation was:

1. Perm = 10^(13.5 * PHIe – 2.10)

An eyeball best fit line that seems to be appropriate is:

2. Perm = 10^(18.3 * PHIe – 3.00)

The second equation was used in the analysis. The locations of all cored wells are shown on Figure 1. A graph of the data with both regression lines is shown in Figure 2.

Continued on page 11…

Productivity Estimation *… continued from page 10*

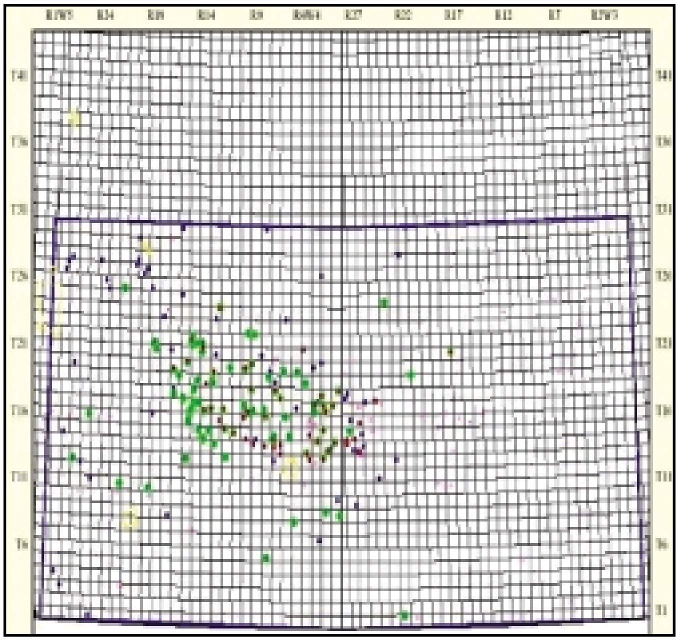

Figure 1: Area map showing wells cored in Milk River formation

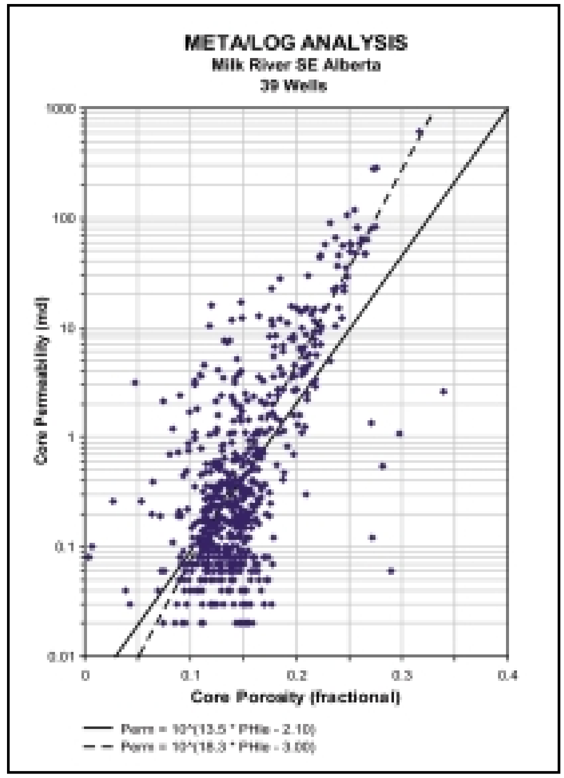

Figure 2: Core porosity – permeability crossplot

Log Analysis In Laminated Sands

The analysis models for laminated shaly sands are quite varied and none are perfect solutions. The problem lies in how logs average laminations that are thinner than the tool resolution. Most logs average the data in a linear fashion, but resistivity must be averaged as conductivity and then converted back to resistivity. This is the situation with most so-called "low-resistivity" pay zones around the world.

To illustrate, assume a laminated sequence with shale laminations equal in thickness to the sand laminations. This gives a shale volume (Vsh) averaged over the interval of 50%. Assume the porosity and resistivity values are as shown below:

In the early days of log analysis, this phenomenon was attributed to many different, almost mystical, reasons because the parallel nature of the conductive paths was not understood by many analysts. Note, too, that the resistivity contrast between a water zone and a gas zone is small, so it may not be possible to recognize gas when it is present, especially if water resistivity varies between one hydrodynamic regime and another.

*	GR	PHIN	PHID	RESD	COND	RESD from COND
Shale	90	0.45	0.15	4.0	250	
Gas Sand	40	0.25	0.35	200	5.0	
Average	65	0.30	0.25	102	122	8.1

*	GR	PHIN	PHID	RESD	COND	RESD from COND
Shale	90	0.45	0.15	4.0	250	
Water Sand	40	0.30	0.30	5.0	200	
Average	65	0.37	0.22	4.5	222	4.2

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Productivity Estimation … *continued from page 11*

Comparison of Conventional and Laminated Shaly Sand Models

In this study, we have contrasted four different models, two of which were known in advance to be inappropriate or pessimistic in laminated shaly sands. They were run in order to emphasize the modeling problem and illustrate the quantitative differences in the methods.

MODEL A: Conventional Dispersed Shaly Sand Model
This model is the one we run in most shaly sands, but it is not appropriate for laminated shaly sands:

1. Vsh = Minimum from GR, Neutron-density crosssplit, resistivity methods
2. PHIe = (PHID * PHINSH - PHIN * PHIDSH) / (PHINSH - PHIDSH)
3. Sw = Dual Water, Simandoux, or Buckles model if gas; Sw = 1.0 if not gas
4. Perm = porosity vs permeability transform from core data

Sums and averages for reservoir properties are determined in the usual way. The conventional model may fail to find any net reservoir unless cutoffs, especially shale cutoffs, are very liberal. Even if net reservoir is found, it will be smaller than the true net reservoir and rock properties are likely to be pessimistic. The model requires a full log suite.

MODEL B: Laminated Shaly Sand – Pessimistic Version
Most laminated shaly sand models use the shale volume from a conventional analysis averaged over the gross interval (VSHgross). Net reservoir thickness (NetRes) is then found by multiplying (1 – VSHgross) times the gross thickness. The model then derives everything else from empirical rules. One such set of rules is to use the rock properties (porosity, saturation, permeability) from the conventional analysis.

1. VSHgross = SUM (Vsh * INCR) / Gross
2. NetRes = Gross * (1 - VSHgross)
3. PHIavg, SWavg, PERMavg = Values from Conventional Analysis

Cumulative reservoir properties are found in an unconventional way:

4. PV = PHIavg * NetRes
5. HPV = PHIavg * (1 – SWavg) * NetRes
6. KH = PERMavg * NetRes

This model will usually find more net reservoir than the conventional shaly sand model, but rock properties and hence reserves are still pessimistic because they come from the conventional analysis. Some authors have used the density log porosity instead of the shaly sand crossplot porosity. Neither approach is recommended as they give pessimistic porosity values in laminated sands.

MODEL C: Laminated Shaly Sand – Realistic Version
A more realistic model uses different rules for finding the rock properties, usually based on shale volume rules or constants based on core analysis. These empirical rules can also be calibrated to core and then used where there is no core data. The PHIMAX porosity equation and Buckles water saturation equation given below are widely used in normal shaly sands where the log suite is at a minimum:

1. VSHgross = SUM (Vsh * INCR) / Gross
2. NetRes = Gross * (1 – VSHgross)
3. PHIavg = PHIMAX * (1 – VSHgross ^ 3)
4. SWavg = KBUCKL / PHIavg / (1 – VSHgross)
5. PERMavg = MIN (2000, 10^(CPERM * PHIavg + DPERM))
6. PV = PHIavg * NetRes
7. HPV = PHIavg * (1 – SWavg) * NetRes
8. KH = PERMavg * NetRes

The PHIMAX value is the critical factor. If a moderate amount of core data is available for the sand fraction of the laminated sand, this data can be mapped and used in a batch processing environment. The exponent on VSHgross in equation 3 also needs tuning and can range from 1.0 to 3.0.

A very minimum log suite can be used, since the only curve required is a gamma ray shale indicator, but only if there are no radioactive elements other than clay. This is not the case in the Milk River, so a minimum log suite will not work here. We have used the minimum suite successfully in laminated shaly sands in Lake Maracaibo.

In the current Milk River study, this model appears to be the most effective in predicting reasonable reservoir properties. PHIMAX was set at 0.20, based on core data, and KBUCKL was set at 0.40, based on experience. CPERM and DPERM were chosen as 18.3 and -3.00 respectively from the core data crossplot shown earlier.

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Productivity Estimation ... *continued from page 12*

MODEL D: Laminated Shaly Sand – Response Equation Version

Another model uses the linear log response equation to back-out the clean sand fraction rock properties from the actual log readings and the shale properties. The response equations are used on the average of the log curves over the gross sand interval. We still assume:

1. VSHgross = SUM (Vsh * INCR) / Gross.
2. PHINsand
 = (PHINavg - VSHgross * PHINSH) / (1 - VSHgross)
3. PHIDsand
 = (PHIDavg - VSHgross * PHIDSH) / (1 - VSHgross)
4. CONDsand = (CONDavg - VSHgross * 1000 / RSH) / (1 - VSHgross)
5. PHIavg = (PHINsand + PHIDsand) / 2
6. RESDsand = 1000 / CONDsand
7. NetRes = Gross * (1 - VSHgross)
8. PHIavg = PHIsand
9. SWavg = KBUCKL / PHIavg OR
 SWavg = (RW / ((PHIavg^2) * RESDavg))^0.5
10. PERMavg = MIN (2000, 10^(CPERM * PHIavg + DPERM))

Summations are calculated as in Model C. Note that the (1 – Vsh) term is not included in the Buckles water saturation equation since the method has generated clean sand porosity. For the same reason, the Archie water saturation equation can be used instead.

This model has the advantage of using fewer arbitrary rules and more log data. The critical values are PHINSH and PHIDSH, which are picked by observation of the log above the zone. It can still be calibrated to core by adjusting these two parameters.

The layer average PHIDsand and PHINsand can be compared to see if they are close to each other. They could cross over if gas effect is strong enough. Our results showed a 0.02 porosity unit variation on the best behaved wells, indicating that the inversion of the response equations is working well. However, on some intervals in some wells, the results are not nearly so good. In some cases, nonsensical negative answers are obtained, and in others the porosity results are unrealistically high.

This model is very noisy and ill-behaved except in rare circumstances, so it is not recommended for this study. It may have application in the analysis of shorter discrete zones in individual log analyses but it is not appropriate for batch processing. CONDsand is quite sensitive to RSH and impossible negative answers can result if RSH is too low. In this project, we found that the RSH needed to obtain rational results was twice the value of RSH in the overlying shale. If one wished to do so, RSH could be optimized in a few iterations by giving some reasonable constraints on CONDsand.

The equations become unstable at very high values of VSHgross, so there should be a VSH limit above which the calculation will be bypassed. It might be better to use the Buckles approach to avoid this problem, but the chance of distinguishing gas from water zones will be lost.

It is important to eliminate pure shale beds from the gross interval of the laminated shaly sand by careful zonation; including them will distort the final reservoir volume. This is true for all three laminated sand models.

Reservoir Quality Methods for Laminated Shaly Sands

There are a number of ways to assess reservoir quality. In laminated sands, one approach is to correlate first three months or first year production with net reservoir properties from the laminated models described above. We chose to use the first 8760 hours of production (365 days at 24 hours each) divided by 4 (3 months of continuous production) as our "actual" production figure. This normalizes the effects of testing and remedial activities that might interrupt normal production.

A. Reservoir Quality from Net Reservoir Data

The normalized initial production was correlated with net reservoir thickness, pore volume (PV), hydrocarbon pore volume (HPV), and flow capacity (KH) from the laminated Model C. Correlation coefficients (R-squared) are 0.852, 0.876, 0.903, and 0.906 respectively. The correlation is made using data calculated over the total perforated interval. The other three analysis models did not give useful correlations nor did model C when only a single shale indicator was used. Results of the correlations are shown in Figure 7A and 7B.

Average shale volume was correlated with actual production but the correlation coefficient was only 0.296, although the trend of the data is quite clear.

Continued on page 14…

Productivity Estimation *... continued from page 13*

B. Reservoir Quality from an Enhanced Shale Indicator

Another approach is to calculate a quality curve:

1. Qual2 = RSH * GR / RESD

This amplifies the shale indicator in cleaner zones and is scaled the same as the GR curve. A net reservoir cutoff of Qual2 <= 50 on this curve was a rough indicator of first three months production, but the correlation coefficient was as poor as for average shale volume. QUAL2 does make a useful curve on a depth plot as it shows the best places to perforate when density and neutron data are missing.

C. Reservoir Quality from Hester's Number

Another quality indicator was proposed by Hester (1999). It related neutron-density porosity separation and gamma ray response to production, based on the graph in Figure 3.

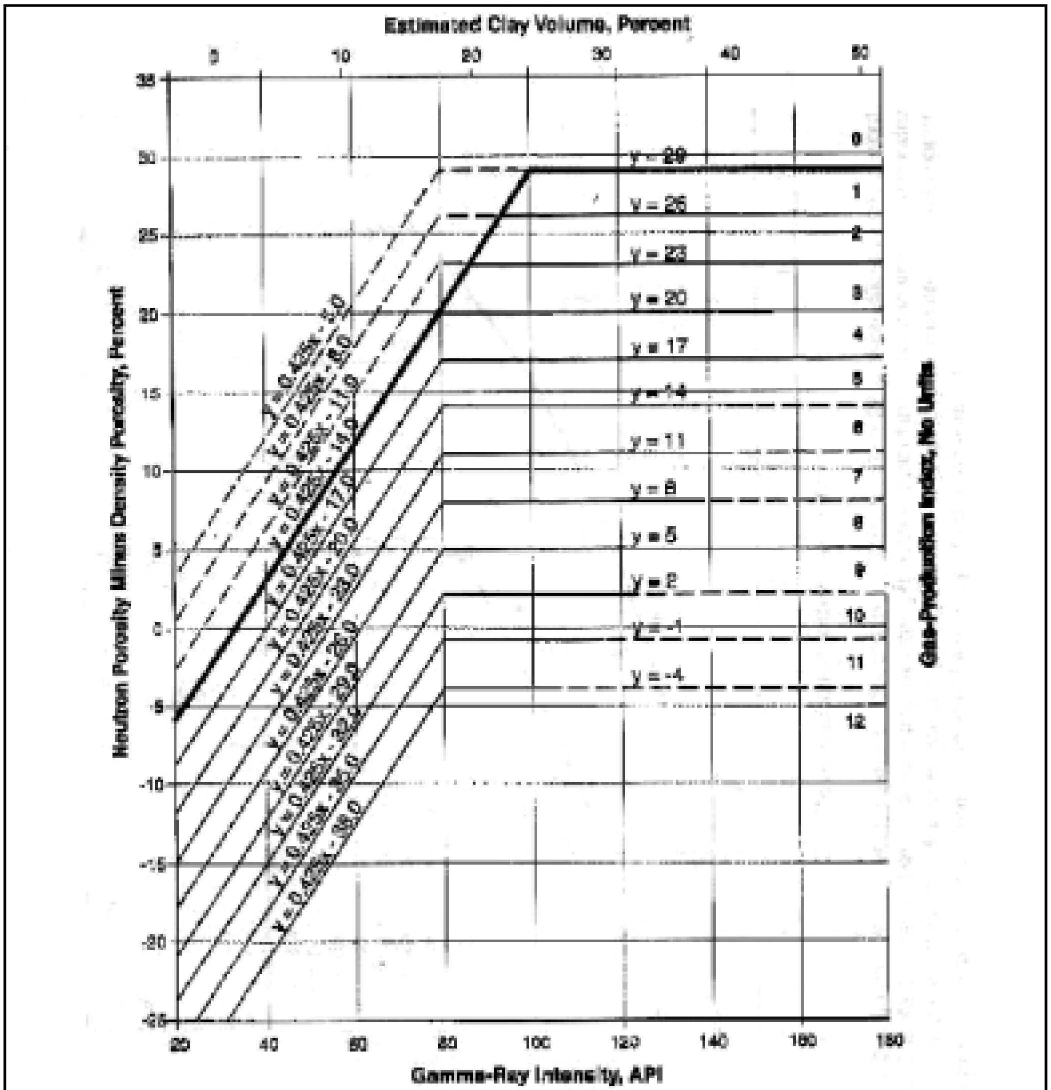


Figure 1. Neutron porosity minus density porosity versus gamma-ray intensity crossplot showing equations for line segments that make up the gas-production index. Thin, solid lines show 12 indexed levels of gas-production potential. Level one has the least potential for gas production; level 12 has the greatest potential. Bold line is an empirically-determined "cut-off", above which commercial volumes of gas are unlikely. Dashed lines are inferred.

Figure 3:
Hester's reservoir quality indicator (QUAL1)

Continued on page 15...

Productivity Estimation *... continued from page 14*

This graph is converted to a numerical quality indicator (Qual1) in a complex series of equations that represents predicted flow rate. There is a flaw in Hester's paper that can be cured. He does not account for zone thickness or attempt to find a net reservoir number. He uses only the average quality number over the zone, which presupposes that all perforated intervals are equal in thickness. To overcome this, we can use a quality cutoff and obtain a thickness weighted quality and correlate this to actual production.

A quality of 4.0 or higher reflects similar net reservoir thickness as the previous indicators. Graphs showing the correlation of actual production to net reservoir with QUAL1 >=5 and >=4 are shown in Figure 7B. The regression coefficients are 0.856 and 0.837 respectively. Although this looks pretty good, the low rate data is clustered very badly and other indicators work better in low rate wells.

D. Reservoir Quality from Productivity Estimates

A productivity estimate based on a log analysis version of the productivity equation has been included on each summary table, as illustrated in Figure 5. The equation used was:

1. Est_Prod = 6.1*10E-6 * KH * ((PF - PS)^2) / (TF + 273) * FR * 90

The leading constant takes into account borehole radius, drainage radius, viscosity, and units conversions. KH is flow capacity in md-meters. (PF – PS) is the difference between formation pressure and surface pressure in KPa. A constant value of 1300 KPa was assumed for this study. Clearly, more detailed data could be used if time permits. TF was chosen constant at 20 degrees Celcius.

FR is a hydraulic fracture multiplier, chosen as 2.0 for this study, based on the 9 wells used to calibrate to 3-month initial production data. The constant 90 converts e3m3/day into an estimated 3-month production for comparison to actual. The 3 month numbers were chosen instead of daily rate as they have more "heft" and can be equated to income more readily.

The correlation graph is in the top left of Figure 7A. Note that the equation used is a constant scaling of KH, so the correlation coefficient is the same as the KH graph at 0.906.

Discussion of Results

The sample depth plot in Figure 4 shows typical results of the prototype analysis. The majority of the results are from the conventional analysis Model A, including the PayFlag. Some of the input curves are shown in Tracks 1 and 2. Hester's quality factor (QUAL1) and the GR/RESD quality factor (QUAL2) are shown in Track 4. This is a gas producing well with an excellent set of perforations, shown on the right-hand edge of Track 2.

The conventional analysis, plotted in Track 5, gives a clear picture of why the conventional approach is so discouraging. Unfortunately, the laminated models do not create output curves that are consistent with a depth plot, so it is impossible to make pretty pictures of the results except in map form.

A sample Net Reservoir summary from the prototype program is shown in Figure 5. The changes in Net Reservoir and average rock properties between the models illustrate the need to find an appropriate model for laminated reservoirs. This work has been calibrated to core and production data, but the results shown here are still tentative. Each well can be tuned to match ground truth more closely.

A total of 10 reservoir quality indicators for each of 3 reservoir layers, plus the cored interval and the perforated interval are given for each of 4 different analysis models. The best model for predicting productivity is Model C, using the minimum of 3 shale indicators. The density neutron porosity separation indicator is essential to the success of Model C.

The best productivity indicator is the flow capacity (KH) or its equivalent productivity estimate in e3m3 for 90 days (1st 3 months production estimate). Five other indicators have strong correlations with productivity (Net Reservoir, PV, HPV, Hester's QUAL1 >=5, and QUAL1 >=4). Hester's number does not have much resolution at low flow rates, but clearly separates poor from good wells.

An important use of the summary tables is to determine whether a well is under-achieving due to limited perforation interval or a poor frac job. A comparison of the total KH for the Milk River compared to the KH for the perforated interval will point out any problem wells. Even if KH is badly miscalibrated, the comparison is useful. Over-achievers may be producing commingled, intentionally or otherwise, from deeper horizons or may point to log data or analytical difficulties.

Continued on page 16...

Productivity Estimation *… continued from page 15*

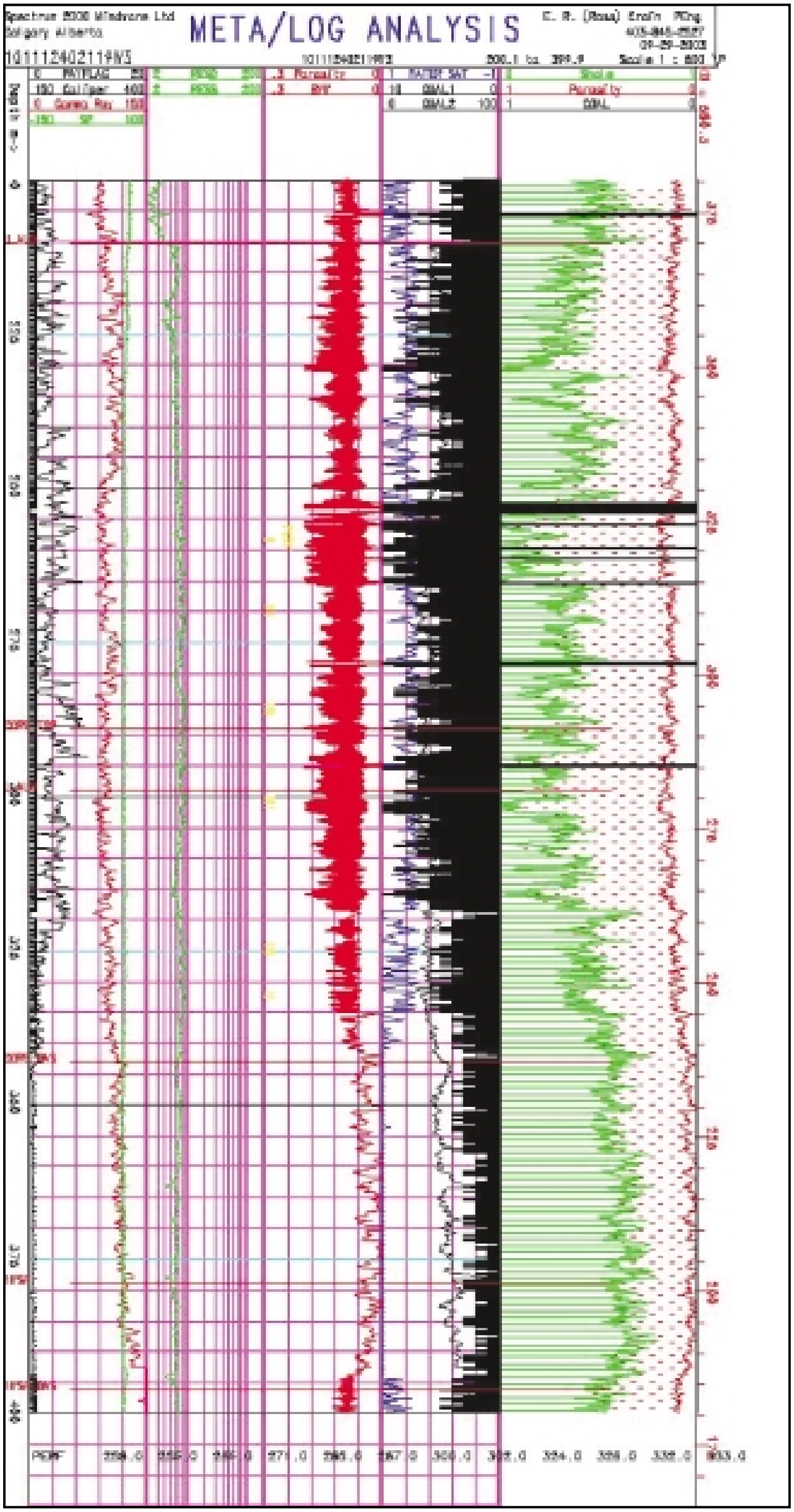


Figure 4:
Depth plot showing Hester quality Factor in Track 4 (shaded black)

Continued on page 17…

Productivity Estimation *… continued from page 16*

META/LOG HYDROCARBON SUMMARY RAKHIT MILK RIVER PROJECT												
101112402119W3		Analyst: E.R. Crain, P.Eng.					28-Sep	2003				
				SHALY SAND		CONVENTIONAL MODEL "A"						
ZONE	ZN_TOP	ZN_BOT	PHIavg	SWavg	PERMavg	PV	HPV	KH	NetRes	VSHgross	NetCoal	CoalSh
U_ALD	210.2	299.0	0.138	0.44	0.7	11.75	6.63	56	85.3	0.31	2.9	0.08
L_ALD	299.0	379.0	0.127	0.50	0.5	4.56	2.27	17	36.0	0.49	0.0	0.00
1WSP	379.0	396.0	0.094	0.87	0.1	0.19	0.02	0	2.0	0.63	0.0	0.00
1WSP_BASE	396.0											
CORE_TOP	289.0	343.0	0.131	0.47	0.5	5.93	3.12	24	45.3	0.37	0.5	0.17
CORE_BASE	343.0	Core Avg	0.242		NA							
IP_e3m3	1145.1	Est Prod	309.1	e3m3 estimated from KH over perfed interval								
CUM_e3m3	2971.0			with frac multiplier c		2.0						
PERF	258.0	333.0	0.139	0.43	0.7	9.89	5.68	49	71.2	0.31	1.4	0.08
				SHALY SAND		LAMINATED MODEL "B"					NetRes with	
ZONE	ZN_TOP	ZN_BOT	PHIavg	SWavg	PERMavg	PV	HPV	KH	NetRes	VSHgross	Q1>=5	Q1>=4
U_ALD	210.2	299.0	0.138	0.44	0.7	8.50	4.79	41	61.7	0.31	71.5	82.6
L_ALD	299.0	379.0	0.127	0.50	0.5	5.16	2.57	19	40.7	0.49	23.3	35.4
1WSP	379.0	396.0	0.094	0.87	0.1	0.60	0.08	0	6.4	0.63	0.0	0.8
1WSP_BASE	396.0											
CORE_TOP	289.0	343.0	0.131	0.47	0.5	4.45	2.34	18	34.0	0.37	32.3	43.1
CORE_BASE	343.0	Core Avg	0.242		NA							
IP_e3m3	1145.1	Est Prod	225.5	e3m3 estimated from KH over perfed interval								
CUM_e3m3	2971.0			with frac multiplier c		2.0						
PERF	258.0	333.0	0.139	0.43	0.7	7.21	4.14	36	51.9	0.31	59.7	69.6
				CLEAN SAND		LAMINATED MODEL "C"					NetRes with	
ZONE	ZN_TOP	ZN_BOT	PHIavg	SWavg	PERMavg	PV	HPV	KH	NetRes	VSHgross	Q1>=5	Q1>=4
U_ALD	210.2	299.0	0.194	0.30	3.6	11.99	8.44	222	61.7	0.31	71.5	82.6
L_ALD	299.0	379.0	0.176	0.45	1.7	7.18	3.98	69	40.7	0.49	23.3	35.4
1WSP	379.0	396.0	0.151	0.71	0.6	0.96	0.28	4	6.4	0.63	0.0	0.8
1WSP_BASE	396.0											
CORE_TOP	289.0	343.0	0.190	0.33	3.0	6.45	4.29	101	34.0	0.37	32.3	43.1
CORE_BASE	343.0	Core Avg	0.242		NA							
IP_e3m3	1145.1	Est Prod	1176.0	e3m3 estimated from KH over perfed interval								
CUM_e3m3	2971.0			with frac multiplier c		2.0						
PERF	258.0	333.0	0.194	0.30	3.6	10.08	7.08	186	51.9	0.31	59.7	69.6
	RESPONSE EQUATION			CLEAN SAND		LAMINATED MODEL "D"					NetRes with	
ZONE	ZN_TOP	ZN_BOT	PHIavg	SWavg	PERMavg	PV	HPV	KH	NetRes	VSHgross	Q1>=5	Q1>=4
U_ALD	210.2	299.0	0.350	0.17	2000.0	21.61	18.00	**********	61.7	0.31	71.5	82.6
L_ALD	299.0	379.0	0.195	0.31	3.7	7.95	5.49	151.8	40.7	0.49	23.3	35.4
1WSP	379.0	396.0	0.123	0.59	0.2	0.78	0.32	1.1	6.4	0.63	0.0	0.8
1WSP_BASE	396.0											
CORE_TOP	289.0	343.0	0.275	0.20	109.1	9.35	7.46	3707.4	34.0	0.37	32.3	43.1
CORE_BASE	343.0	Core Avg	0.242		NA							
IP_e3m3	1145.1	Est Prod	175243	e3m3 estimated from KH over perfed interval								
CUM_e3m3	2971.0			with frac multiplier c		2.0						
PERF	258.0	333.0	0.313	0.18	532.9	16.25	13.40	27670.6	51.9	0.31	59.7	69.6

Figure 5: Sample Net Reservoir calculations for four shaly sand models.

Continued on page 18…

Productivity Estimation … *continued from page 17*

		META/LOG ANALYSIS						
121111202318W300								
PERF INTERVAL FOR Q1 >= 4			PERF INTERVAL Vsh <= 0.65			PERF INTERVAL ACTUAL		
PRF TOP	PRF BOT	NET INTR	PRF TOP	PRF BOT	NET INTR	PRF TOP	PRF BOT	NET INT
540.9	541.8	0.9	541.1	541.6	0.5			0.0
531.0	531.1	0.1	531.0	531.1	0.1			0.0
478.8	479.4	0.6	478.2	479.3	1.1	477.0	479.0	2.0
464.0	464.3	0.3	464.1	464.3	0.2			0.0
463.4	463.7	0.3	457.3	457.4	0.1			0.0
462.1	462.2	0.1	388.2	388.4	0.2			0.0
457.3	457.7	0.4	386.4	387.6	1.2	384.5	388.5	4.0
388.1	388.5	0.4	385.2	385.9	0.7			0.0
386.2	387.7	1.5	381.4	382.4	1.0	381.0	383.0	2.0
385.1	386.1	1.0	378.2	379.6	1.4			0.0
381.4	382.4	1.0	376.1	376.6	0.5	375.0	380.0	5.0
378.2	379.6	1.4	375.7	376.0	0.3			0.0
375.6	376.7	1.1	371.3	371.6	0.3	370.0	371.0	1.0
371.3	371.7	0.4	370.0	370.8	0.8			0.0
370.0	370.8	0.8	369.1	369.3	0.2			0.0
369.0	369.4	0.4	366.2	366.5	0.3	366.0	367.0	1.0
368.3	368.4	0.1	365.6	365.8	0.2			0.0
366.2	366.7	0.5	354.7	355.2	0.5	353.0	355.0	2.0
365.5	366.1	0.6	352.0	353.0	1.0			0.0
364.9	365.0	0.1	350.4	351.4	1.0	350.5	351.5	1.0
354.7	355.2	0.5	348.9	350.2	1.3	345.0	350.0	5.0
352.0	353.1	1.1	345.2	345.3	0.1			0.0
350.3	351.4	1.1	338.6	340.5	1.9	338.0	342.0	4.0
348.8	350.2	1.4	336.1	337.1	1.0			0.0
347.7	347.9	0.2	334.4	334.6	0.2	333.0	334.0	1.0
345.2	345.4	0.2	330.7	332.0	1.3			0.0
343.1	343.4	0.3	327.1	327.6	0.5			0.0
341.1	341.5	0.4	323.1	323.2	0.1			0.0
338.4	340.6	2.2	318.7	320.2	1.5			0.0
336.1	337.1	1.0	317.3	317.4	0.1			0.0
334.4	334.7	0.3	316.3	316.9	0.6			0.0
333.4	333.7	0.3	314.2	315.5	1.3			0.0
330.0	332.1	2.1	311.8	312.8	1.0			0.0
327.1	327.6	0.5	310.1	311.1	1.0			0.0

Figure 6: Portion of unfiltered perforation list generated by the prototype program

The models can be used to generate a perforation list from Hester's quality number or from VSHminimum. A portion of such a list is shown in Figure 6. An acceptance/rejection filter on the list will shorten it considerably. This will eliminate intervals that are too thin to bother with and group intervals that are close enough to be considered as single intervals.

Plots of first 3-month production versus various reservoir quality parameters are given in the graphs in Figures 7A and 7B for the 17 wells with production data and a full log suite. All graphs show a reasonable trend. Correlation coefficients were given earlier in this report.

The numerical data for these graphs is shown in Figure 8. These tables and the graphs in Figure 7 summarize the 17 wells with full log suites and reasonable initial production numbers. Results are based on the laminated shaly sand Model C using the minimum of three shale volume indicators, namely gamma ray, resistivity, and density-neutron separation. Results from the other three numerical models described earlier have not been summarized because the models are either inappropriate, pessimistic, or too erratic in their predictions.

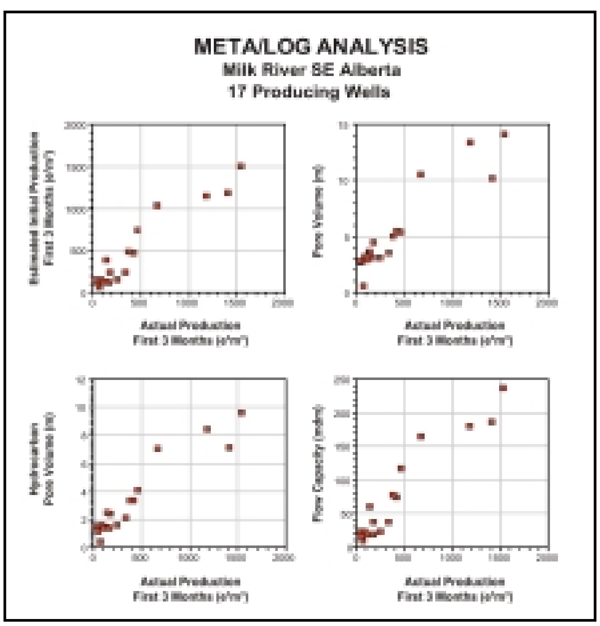


Figure 7A: Comparison of Actual 3-month initial production with reservoir quality indicators

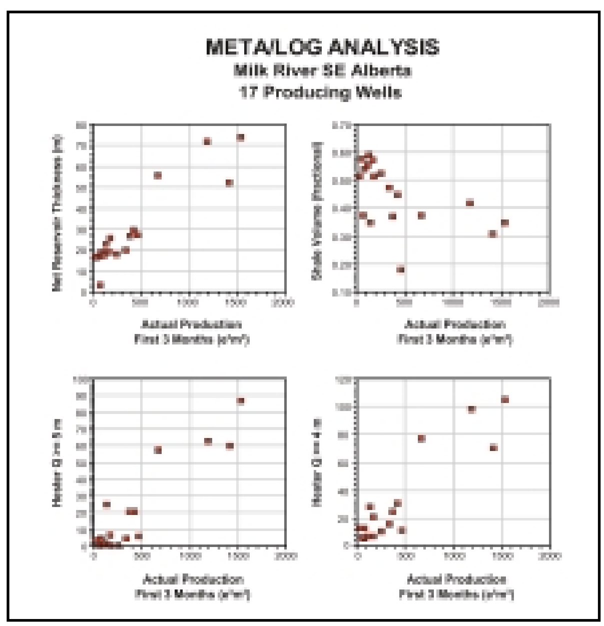


Figure 7B: Comparison of Actual 3-month initial production with reservoir quality indicators

Continued on page 19…

Productivity Estimation *… continued from page 18*

META/LOG ANALYSIS RESULTS Milk River Project												
	Averagge Porosity			Actual	Est Prod	PV	HPV	KH	NetRes	VSHavg	Q1>=5	Q1>=4
Well Location	Over Cored Interval		Perfed	IP_E3M3		----- Over Perfed Interval -----						
	Log	Core	Interval	1st 3 MO	1st 3 MO							
					2x Frac Multiplier							
100/04-03-015-03W4/00	0.175	0.137	0.179	341.3	235.4	3.52	2.03	37	19.7	0.47	4.1	15.5
100/06-26-015-14W4/00			0.190	77.5	58.4	0.59	0.39	9	3.1	0.37	4.1	5.0
100/07-36-018-10W4/00	0.170	0.126	0.173	181.5	236.9	4.42	2.32	37	25.5	0.51	6.0	20.6
100/08-13-022-16W4/00	0.168	0.039	0.171	254.8	150.3	3.01	1.53	24	17.6	0.52	0.0	10.5
100/14-28-018-07W4/00	0.153	0.138	0.159	133.9	116.6	3.56	1.39	18	22.4	0.59	1.4	6.6
100/16-27-020-16W4/00	0.161	0.094	0.162	56.7	90.0	2.79	1.14	15	16.7	0.57	0.2	5.6
101/11-24-021-19W3/00	0.196	0.242	0.194	1416.7	1176.0	10.89	7.08	186	51.9	0.31	59.7	69.6
102/08-08-020-17W4/00	0.192	0.159	0.192	144.8	379.2	3.57	2.43	60	18.6	0.35	24.5	28.0
102/10-27-018-01W4/00	0.169	0.145	0.169	87.9	147.9	3.17	1.56	23	18.8	0.54	3.0	12.6
100/06-20-015-11W1/00	0.196	0.149	0.189	383.1	483.3	4.99	3.29	76	26.4	0.37	20.1	24.4
100/06-27-016-09W4/00			0.190	673.9	1035.9	10.52	6.98	164	55.5	0.37	57.3	76.7
100/06-29-023-03W4/00			0.173	31.5	148.2	2.77	1.45	23	16.0	0.51	3.4	12.8
100/07-27-020-16W4/00			0.163	176.8	114.5	3.07	1.32	18	18.8	0.57	0.3	6.4
111/06-04-023-17W3/00			0.199	472.6	741.2	5.33	4.03	117	26.8	0.10	5.6	10.8
111/11-32-021-19W3/00			0.185	1190.3	1135.9	13.31	8.41	179	71.7	0.41	62.3	97.7
121/06-18-018-25W3/00			0.166	118.4	120.0	2.88	1.33	19	17.3	0.55	0.7	6.5
141/11-11-021-19W3/00			0.182	1541.2	1497.9	14.12	9.60	237	73.7	0.35	86.6	104.4
AVERAGE 17 WELLS	0.174	0.140	0.179	428.4	463.3	5.39	3.31	73	29.4	0.44	20.0	30.2

Figure 8A: Numerical data for initial production comparison

META/LOG ANALYSIS TOPS and TESTS Milk River Project											
Long Well ID	KB Elev	U_ALD	L_ALD	1WSP	1WSP_BASE	CORE_TOP	CORE_BASE	IP_E3M3 1st 3 MO	CUM_E3M3	PERF TOP	PERF BASE
CORED, PERFED, PRODUCED - CALIBRATION WELLS											
100/04-03-015-03W4/00	744.3	337.1	378.0	436.5		354.2	416.7	341.3	11328	377.3	414.5
100/06-26-015-14W4/00	747.6	273.0	315.0	361.0	373.0			77.5	452	277.0	282.0
100/07-36-018-10W4/00	768.9	320.0	363.9	417.6		365.8	384.1	181.5	7420	350.5	402.9
100/08-13-022-16W4/00	733.5	392.0	437.0	494.0	502.0	394.9	478.9	254.8	8801	418.5	528.0
100/14-28-018-07W4/00	776.8	346.0	396.0	450.0		352.0	442.0	133.9	4530	379.1	433.4
100/16-27-020-16W4/00	770.2	402.3	447.4	495.6		448.4	458.1	56.7	3769	428.5	467.6
101/11-24-021-19W3/00	580.3	210.2	299.0	379.0	396.0	289.0	343.0	1416.7	2971	258.0	333.0
102/08-08-020-17W4/00	791.4	443.0	489.0	526.0	554.0	467.3	509.0	144.8	936	402.0	573.0
102/10-27-018-01W4/00	751.6	358.1	420.6	479.1		411.5	429.8	87.9	5156	411.2	451.7
PERFED, PRODUCED - MODEL TESTING WELLS											
100/06-20-015-11W1/00	748.8	262.1	284.8	295.7	304.2	294.1	318.5	383.1	9007	282.5	325.0
100/06-27-016-09W4/00	773.0	304.8	348.7	399.3	417.9			673.9	24594	331.3	625.4
100/06-29-023-03W4/00	736.7	344.4	408.4	466.6	490.4			31.5	70.1	395.6	428.5
100/07-27-020-16W4/00	763.5	396.2	443.2	487.7	445.0			176.8	7137.5	446.2	462.1
111/06-04-023-17W3/00	597.1	234.0	309.0	411.0	433.0			472.6	323.6	320.5	353.0
111/11-32-021-19W3/00	594.7	225.5	315.0	395.0	410.0			1190.3	2794	231.5	354.0
121/06-18-018-25W3/00	719.0	344.4	417.5	478.0	494.0			118.4	4129.8	401.7	440.4
141/11-11-021-19W3/00	609.9	239.8	330.0	409.0	425.0			1541.2	3611	246.0	359.0
AVERAGE 17 WELLS	718.1	319.6	376.6	433.6	308.5	375.2	420.0	428.4	5707.7	350.4	425.5

Figure 8B: Stratigraphic data for initial production comparison

Continued on page 20…

Productivity Estimation *... continued from page 20*

Conclusions

The Laminated Sand Model C works very well with a full log suite, possibly because the gas effect on the density and neutron log curves enhances their ability to detect sands. It does not have any significant predictive capability with a minimum log suite, ie. a suite missing both density and neutron log curves.

Because a full log suite was available in the 9 wells used for calibration, we have obtained the most likely shale volume (Vsh) result. The 8 wells held in reserve to test the model also showed very good agreement with initial production. One well that calculated an IP higher than actual can be brought into line with a small tune-up of the shale density parameter.

Hester's quality number (QUAL1) is computable when a full log suite is present. It is a good visual indicator of reservoir quality on a depth plot. If we move to poorer log suites, Vsh from density neutron crossplot will not be available, nor will Hester's quality number. This degrades results dramatically. Using the models with a minimum log suite is not recommended.

The most rigorous model, theoretically, is the Response Equation Model D. It requires a full suite of open hole logs but results were quite erratic. This model is not recommended for this project. The Conventional Shaly Sand Model A and the Laminated Model B should be avoided as the assumptions behind the models are inappropriate for this environment.

The log analysis results in the Milk River laminated sands from Model C should be considered as reasonable approximations for reservoir quality assessments and resource estimates. Considerably more detailed analysis may be required to refine the evaluation for individual wells after high-grade sweet spots are located.

References

Hester, T. C., 1999, An algorithm for Estimating Gas Production Potential Using Digital Well Log Data, Cretaceous of North Montana, USGS Open File Report 01-12

Acknowledgements

Thanks to Jerome Goodman for coding the LOGFUSION program in spite of some terrible data, Jason Johnson and Dan Block for locating and prepping the data used in the prototype analysis, and Kaush Rakhit for the inspiration to attempt this work in the laminated sand environment.

About the Authors

E. R. (Ross) Crain, P.Eng. is a Consulting Petrophysicist and a Professional Engineer with over 35 years of experience in reservoir description, petrophysical analysis, and management. He has been a specialist in the integration of well log analysis and petrophysics with geophysical, geological, engineering, and simulation phases of oil and gas exploration and exploitation, with widespread Canadian and Overseas experience.

His textbook, "Crain's Petrophysical Handbook on CD-ROM" is widely used as a reference to practical log analysis. Mr. Crain is an Honourary Member and Past President of the Canadian Well Logging Society (CWLS), a Member of Society of Professional Well Log Analysts (SPWLA), and a Registered Professional Engineer with Alberta Professional Engineers, Geologists and Geophysicists (APEGGA).

David W. Hume, P.Geol., Vice President/Senior Geologist, has been in the petroleum industry since 1983. Prior to that, he spent three years as a field geologist in the mining industry. Dave is the project manager for all geological studies at RPCL and has conducted exploration and development projects in Western Canada, the United States, Indonesia, Pakistan, Venezuela, Argentina, Syria, West Africa and Great Britain. His expertise straddles clastic sedimentology and sequence stratigraphy as it relates to geological reservoir modelling and the characterization of flow units in exploration and development. Some of Dave's other duties include the evaluation of oil and gas reserves and upside potential of properties involved in investiture and divestiture; as well as the training of geological personnel in reservoir characterization and hydrogeological techniques.

Announcement - Talk is No Longer Cheap

Local talent has been under represented at our monthly technical luncheons. So, in addition to the usual President's Award for the year's best technical luncheon presentation there will be a new Vice-President's Award. This award, in the amount of $500, will be for the best luncheon talk by a Canadian-based speaker who is from an oil company or from a university or college.

Anyone who is considering presenting at a luncheon or who has a suggestion for an interesting topic should contact John Nieto at (403) 231-0276 or john_nieto@anadarko.com.

2004 Annual Fall Social

The Annual Fall Social was held in the Palliser Penthouse again this year and was well attended. All those who attended had a fantastic time networking and talking to acquaintances. The Hotel catering staff prepared an amazing spread again. The food ranged from shrimp dumplings to roast beef. Attendance was a little lower than last year with 64 people present. The CWLS raised $940 for charity and the door prize was won by Wayne Dwyer at Husky Energy. Over all a great time was had by everyone.

Lorne Slusarchuk and Jim Earley enjoying a beverage at the Fall Social.

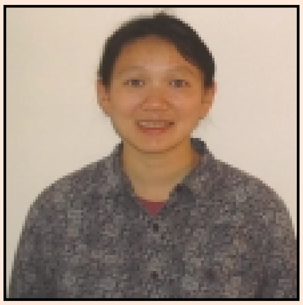
Photo Courtesy Jeff Levack.

Line up for the 5 star food. Photo Courtesy Jeff Levack.

2004 Student Awards

The first CWLS student awards were presented at the luncheon meeting on Sept. 8/2004. Two awards of $2000 were presented to University of Calgary students to support their research leading to MSc degrees.

Following are the winners of CWLS awards and a brief description of their thesis proposals:



Ms Yanping Niu

Thesis title:
Determining the content of bitumen, water and clay in oil sands by using low field Nuclear Magnetic Resonance (NMR) relaxometry.

Thesis Adviser: Dr. Apostolos Kantzas

This work will include integration of Dean-Stark analysis, oil extraction by centrifuge, grain size analysis and Nuclear Magnetic Resonance (NMR) laboratory measurements.

The final objective is to develop models from lab results that can be transferred to interpretation of wireline NMR data.

Mr. John Zhang

Thesis title:
Seismic monitoring of heavy oil recovery.

Thesis Advisor: Dr. Larry Bentley

The thesis research will first consist of reservoir characterization based on well logs and core data. Secondly, seismic attributes will be calculated based on the reservoir character. Finally, the time - lapse seismic modeling will simulate the seismic response during the oil recovery.

Peter Kubica
Student Awards Committee

Real-Time Drilling and Horizontal Well Geo-Navigation: A Planning, Monitoring and Geo-steering Road Map

Rocky Mottahedeh, P.Geol., P.Eng.
United Oil & Gas Consulting Ltd.,
Calgary, Alberta, Canada
November 2004

Geo-steering Technology

The geo-steering process should not be seen as a process solely designated for the most expensive or highest profile horizontal wells. It can be regarded as another tool for improving the odds of success by remaining for longer periods of drilling in the productive zone. Also it can be used to optimize the positioning of a horizontal well bore in the sweet spots within the reservoir.

Exploration and Production (E&P) companies are continuously being driven to reduce the cost per BOE. Convergence of E&P needs and technologies related to advanced and accurate directional drilling, communication of vital data in real-time through the internet, as well as reduced cycle time associated with advanced forward-looking 3D geo-modelling and visualization technologies (Figure 1) are currently aligned. These have been advancing the horizontal well geo-steering process using Measurement While Drilling (MWD) into mainstream drilling practices.

Convergence of Technologies for Geo-steering

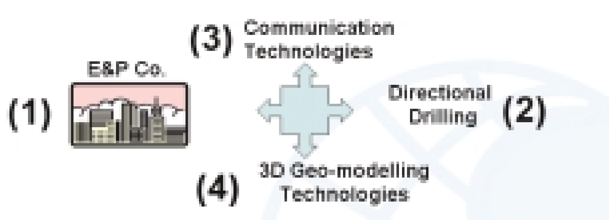


Figure 1

The universal economic benefits gained can be found in all resource play types (conventional oil and gas, heavy oil, tight gas and coal bed methane).

It is important to note that the process described here is essentially collaborative. For best results, there must be cooperation between the E&P operational staff, wellsite geologist, directional driller and geo-modelling staff as well as the consultants involved in the project (i.e. the team as a whole).

Reducing Costs and Increasing Performance for Optimal Well Results

Whether drilling a long reach horizontal in heavy oil or a tight gas play, the basic requirements for a successful well are:

1. Planning the optimal path based on the current knowledge of integrated geological / geophysical models.
2. Monitoring the progress of the well through real-time updates.
3. Continuously remapping to identify the true stratigraphic position (TSP) of the bit relative to the reservoir. This information is used to provide advice to the drilling team for staying in the zone of interest while drilling.
4. Timely reporting on the updated road map for the horizontal well to provide the information necessary for drilling ahead of the bit.

Depending on the depth and/or rock type the speed of drilling can range from very fast (200 m/hr in shallow heavy oil horizontals) to very slow (3-10 m/hr in tight formations). For fast or slower drilling, the geo-steering process is used as a planning and monitoring tool. This reduces guess work in the drilling process which translates into less drilling time for a given well ultimately decreasing the total cost and increasing profits. The 3D geo-models can be updated every few minutes for structural changes and periodically for characterization of the gamma ray (GR) and other reservoir attributes.

Another benefit for operators working in reservoirs that have multiple rigs drilling is that the information gathered and processed will influence and change the 3D mapping window (or highway) for current or subsequent wells. 'Just in time' modelling reduces re-drill costs associated with sidetracks.

Geo-steering a horizontal well while drilling is not only important, it is also profitable. The controlled placement of wells for mitigation of water or gas is another reason why geo-steering can be important for operation geologists, reservoir engineers as well as E&P companies. Although the complexity of the geological structures and changes in the reservoir quality can be overwhelming, automated gathering of MWD data, monitoring, frequent 3D mapping / characterization / visualization and reporting is now achievable and easier to use with current advanced systems.

Continued on page 24…

A Planning, Monitoring and Geo-steering Road Map *… continued from page 23*

There are also other operational cost savings associated with this 'just in time' mapping process. Faster and more productive drilling through the sweet spots in a reservoir can mean: operational time saving. This is particularly true in tight gas wells and in hard formations. Longer productive reservoir intervals are exposed in the wellbore resulting in higher productivity. Also drill bits last longer resulting in more cost savings.

Advanced Directional Drilling Technologies

Advances in directional drilling aiming at geological targets are well recognized today. These include increased accuracy in the placement of extended horizontal wellbores according to initial specks. 'Just in time' 3D mapping is a promising area that can add value to E&P's by reducing the inherent geological risk / uncertainty with any drilling.

Communication Technology

A key component of the current synergy is advanced communication technology. Data must be available as soon as it is needed. Until recently, real-time requirements meant twice a day reporting. Current needs require immediate data access to vital well information in order for effective decision-making to influence the path of horizontal wellbores. There are currently systems that deliver the data from the well site (in the format of Wellsite Information Transfer Standard (WITS)) through Electronic Data Retrieval systems or Electronic Drilling Recorders (EDR). Data from EDR systems is accessible through secured websites in an LAS or 1D report format.

The WITS format has been upgraded to WITSML (ML stands for Markup Language) that has been used in Europe for over two years. This format is now available in North America. The future of data acquisition has been initiated by operators such as Statoil, BP and Shell, who have been joined by several major service companies. The WITSML process is consumer driven (E&P) and its interfaces are comprised of two types, publish/subscribe and store. For more information on the WITSML format visit the website www.witsml.org.

The significance of this type of access is that its subscribe format is comparable to an electronic news service where information is continuously updated, allowing the consumer to choose the frequency and type of information they would like updated.

Using horizontal well drilling as an example, several types of data streams that may need frequent updating for geo-steering, such as gamma ray (GR), well trajectory data and rate of penetration (ROP) can be delivered to the dynamic geo-steering / geo-model on a 'while drilling basis'. This allows for real-time monitoring and subsequent re-mappings.

Disadvantages of 1D & 2D Systems

1D geo-steering / geo-navigation processes offer a rear view mirror perspective from the drill bit. While they may provide an image for what has already occurred, they do not allow for a window to future geo-steering processes. Apparent dip is extracted from the derivative of the point-to-point interpolation. 2D systems are based on prospective offset wells. They provide the apparent dip for the active face of the horizontal well, and can be updated to keep the well in the zone. This provides some forward-looking benefits while drilling. The learning in such systems are typically extracted manually and transferred to 3D geo-models. With 2-D systems, geo-steering more than one well in an active field can become quite cumbersome and impractical. Also, 2D systems do not make full use of the 3rd dimension perpendicular to the well's path. As a result issues with structure such as faults that run near-parallel to the horizontal wellbore may create a blind spot for geo-steering purposes.

Benefits of Advanced 3D Geo-modelling Technology

The E&P or consulting / service companies initially produce integrated geo-models using geological and geophysical data. The 'pre-drill' models integrate all available data from the rig and collaboration between the team.

While Drilling Visualization & Characterization
Visualizing trajectory and trace data from MWD

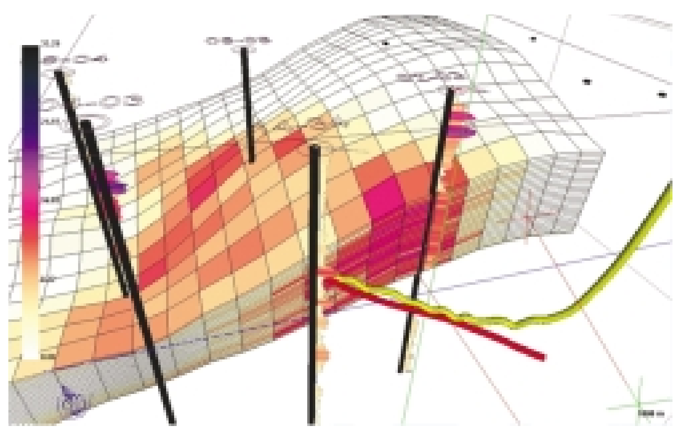


Figure 2

Continued on page 25…

A Planning, Monitoring and Geo-steering Road Map *… continued from page 24*

These geo-models can contain as few as three wells to over 1000 wells. The above example illustrates a horizontal injector in a small oil reservoir. The pre-drill model had eight wells and a 3D seismic generated surface (Figure 2). This model also integrated strip log porosity data for enhancing the model.

At the outset, the geo-model is used to plan the path of the heavy oil or tight gas horizontal wells through previously mapped out characterizations.

Example 1 below shows a proposed and actual well through hydrocarbon pore volume (HCPV) of a heavy oil well in southern Alberta (Figure 3).

Example 1: Heavy Oil Geo-modelling
Horizontal well trajectory with HCPV zone data

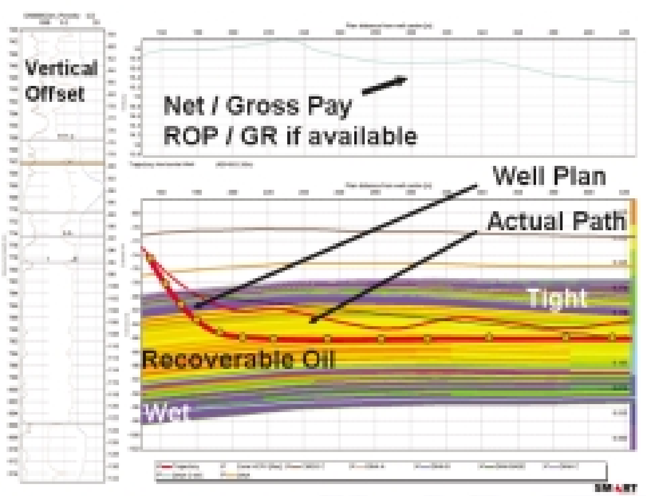


Figure 3

The frequently monitored and tested automated 3D mapping, characterization and visualization are accomplished in commercially available 3D geo-modelling software / technology where the pre-drill model is updated at required frequencies.

Several features of these models include:

1. The enabling of accurate well planning for horizontals through the 3D reservoir target window.
2. Monitoring capability with real-time data using standards such as WITSML.
3. The geological context for determining the true stratigraphic position of the bit.
4. Forward-looking window, providing the driller with a view to the target.

Periodically, strip-log data from the well site geologist is integrated into the geo-modelling / geo-steering profile while drilling. The geo-model results are provided as a report back to the clients. These reports consist not only of 3D views of the planned and actual drilling but also along the length and plan distance from well center. After drilling, newly acquired logs are incorporated back into the model. A final report on the well is provided for completion and other purposes.

Case Studies

The following heavy oil example in northeast Alberta shows the degree of mapping details for the path of a horizontal well. The reservoir contains hundreds of extended horizontals. Most wells have tops implemented at every 50m of length.

Example 2 (Figure 4) shows that once geologists implement the tops by positioning an independent marker above and below the trajectory (using the gamma ray log response, offset well info and trajectory position), the automated geo-model implements the top within a few minutes (continuous surfaces mapped in the example as top and base). Once this mapping process is completed, it creates the window for drilling the next infills prognosis.

To illustrate the point, example 3 (Figure 5) in the same reservoir shows existing wells with no tops implemented at this stage of mapping. These are already drilled and logged locations for which data has not been incorporated into the model and yet the previous prognosis is consistent with the actual results. Therefore, example 2 indicates a proactive process that maps out the road map for the next set of infills. The increase of the gamma ray log response corresponds well with the mapped surfaces and the trajectory path, even without a single implemented top.

This textbook example is a result of conducting a detailed pre-drill model, which can pay dividends for infill drilling programs. The economic benefits are obvious when the outcome can assist in longer time spent in the pay zone and avert costs associated with sidetracks, etc.

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A Planning, Monitoring and Geo-steering Road Map *… continued from page 25*

Example 2: Heavy Oil Geo-modelling
Refreshed HW profile with control points.

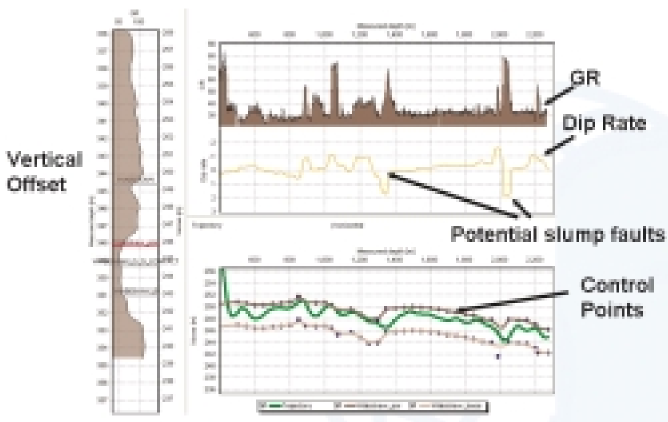

Figure 4

Example 3: Heavy Oil Geo-modelling
Refreshed HW profile with NO control points.

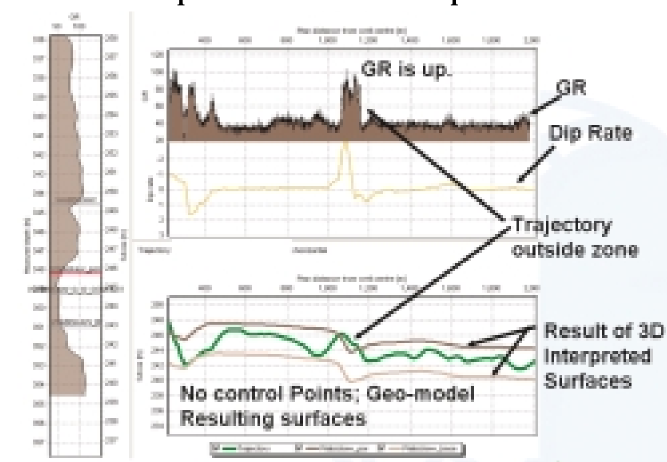

Figure 5

The next examples are cases of tight gas in the Jean Marie (Figure 6) formation in N.E. British Columbia and the Shunda (Figure 7) formation in Central Alberta. The geo-steering process is the same; a pre-drill model is used in the starting position of drilling, while trajectory and other log data such as GR and ROP, gas shows, etc. are updated while drilling.

The well planning and monitoring capabilities are used and the geo-steering process proves beneficial for providing additional guidance for the remaining well length thereby optimizing the path when it is most advantageous to do so. The well placement is monitored continuously through top views (Figure 8) and side views along the length (Figure 9). Also a plan distance from the well center is detailed (Figure 10).

While Drilling Reservoir & Trajectory Visualization
Incorporating real time EDR data.

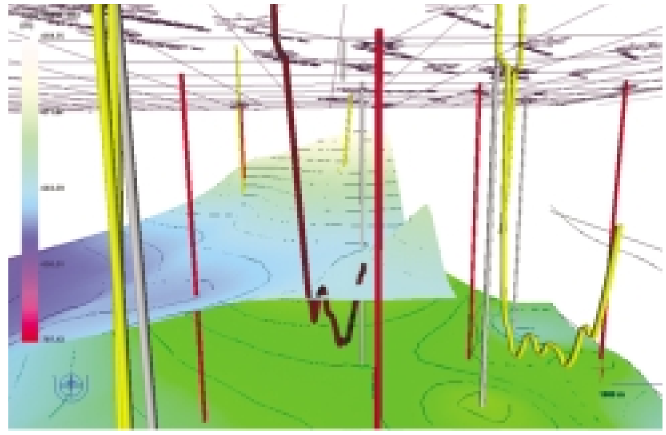

Figure 6

Time Based Model of Structure and Porosity

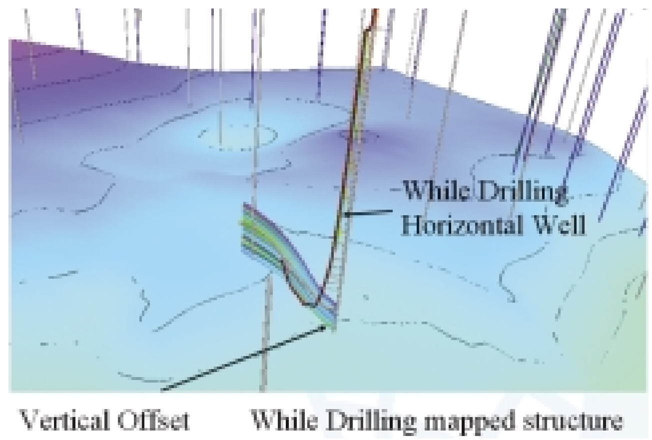

Figure 7

Time Based Model of Proposed vs Actual Trajectories

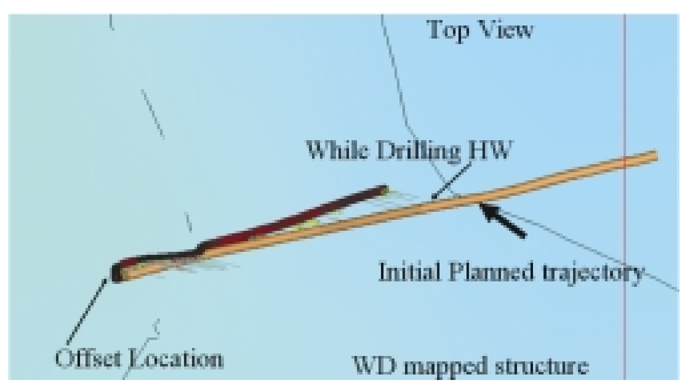

Figure 8

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A Planning, Monitoring and Geo-steering Road Map *… continued from page 26*

Time Based Model of Structure and Porosity along the Horizontal

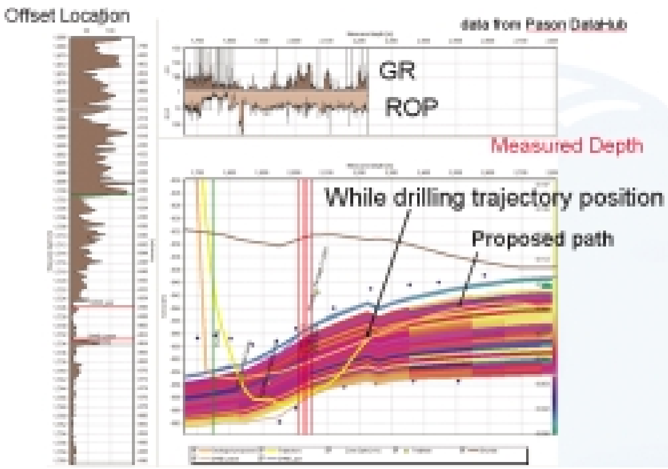

Figure 9

Time Based Model of Structure and Porosity along the Horizontal

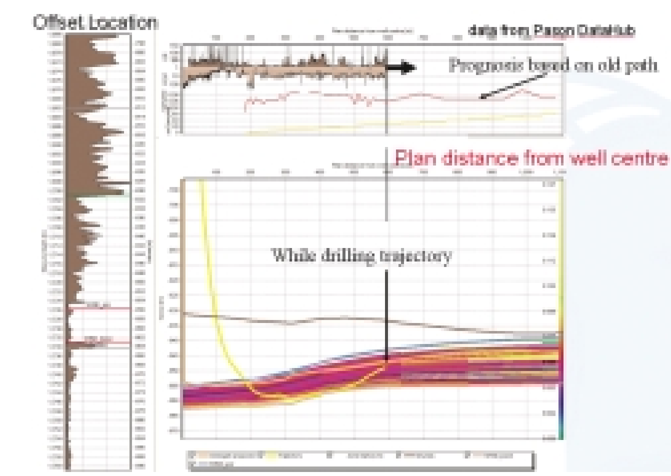

Figure 10

Collision Avoidance

Collision avoidance in tightly spaced and extended horizontal wells is a real issue. Its importance extends to any reservoir, whether oil or gas. Safety and operational cost considerations are major concerns to operators and field personnel. The risk of losing an existing oil producer or getting 'stuck in the hole' leads to costly down time as well as lost revenue from poor well placement on the new drill. Other concerns include the additional cost of sidetracks, drill bit damage and equipment loss.

While drilling, the geo-model visualization provides the visual check for errors associated with the surveys of horizontal wells.

The example below is from the Dina sands reservoir in the Hayter Field, southeast Alberta. Development in the field has progressed to the point that there are several dozen horizontal wells within a section (one square mile) (Figure 11).

A typical long reach horizontal well (~1500m) with an average survey error uncertainty of one degree from the kick off point can have up to 25 m of potential drift (Figure 12).

Figure 13 shows a perspective view of porosity distribution and trajectories in this reservoir.

Visualizing the Trajectories on Horizontal Wells

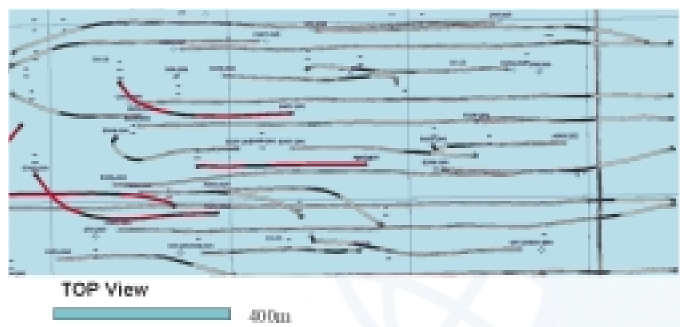

Figure 11

HW Trajectory Detailed View Cones of Uncertainty around the survey from Kick Off Point (KOP) – Top view

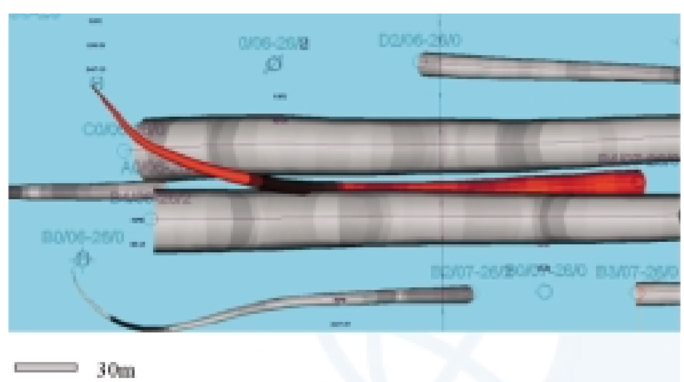

Figure 12

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A Planning, Monitoring and Geo-steering Road Map … *continued from page 27*

Visualization of Survey Errors for Mitigating Wellbore Collision

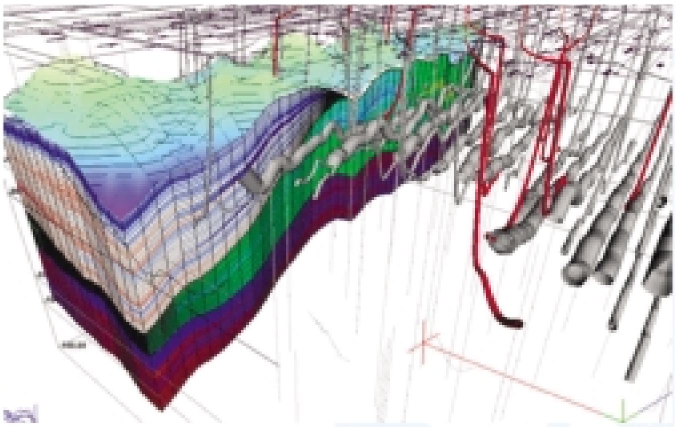


Figure 13

Conclusions

Available technologies and services have converged to provide on-demand mapping for better resulting horizontal wells. E&P companies who use advanced directional drilling, communication and 3D geo-modelling technologies and services can take advantage of this.

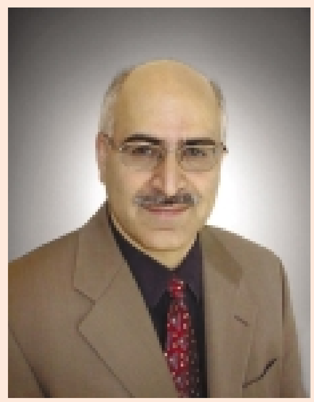
Real-time planning and monitoring capabilities for faster drilling of horizontal wells and geo-steering capability for slower drilling (hard formations) are accessible for all horizontal wells. The geo-steering capabilities have advanced to the point that they should be incorporated into the work process of any horizontal or directional drilling in order to increase operational efficiencies and profitability.

Mitigation of gas and water in oil reservoirs and collision avoidance are two more reasons for incorporating geo-steering into the drilling process.

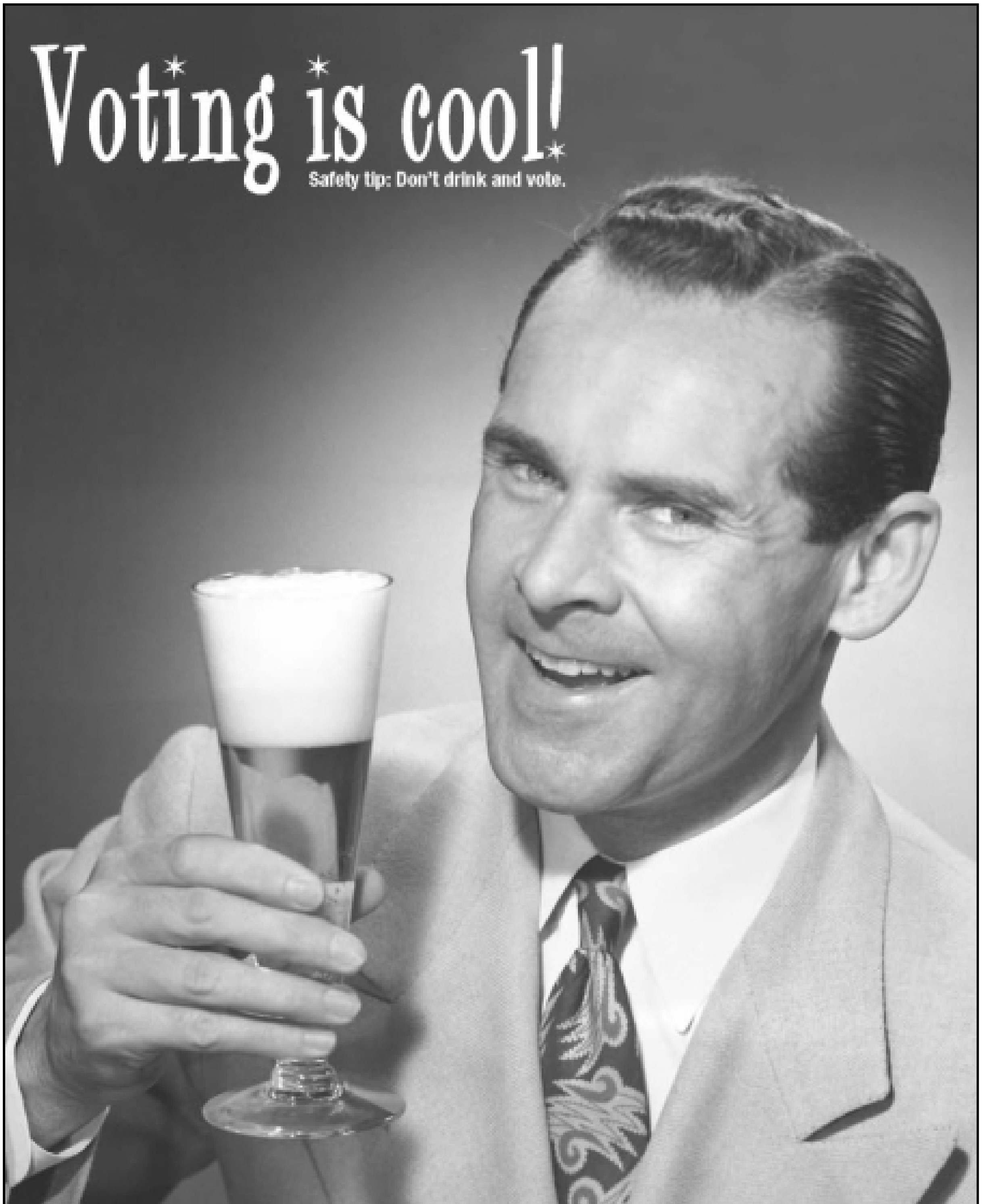
The collaborative process between E&P operational staff, consultants / geo-steering services, directional drillers and real-time data providers is required in every stage of drilling operations for successful geo-steering.

The cost-savings and the improved communication that new technology has brought provide key benefits to a team in the field and in the office.

When compared to current 1D and 2D modelling systems with applications for geo-steering, new 3D systems provide better modelling. This leads to an enhanced "forward looking window for drilling", cost effectiveness, better communication and an enhanced bottom line.



Rocky Mottahedeh is a P. Eng. and P.Geol. He is currently the President of United Oil & Gas Consulting Ltd. Rocky graduated from the University of Toronto in 1981 with a B.Sc., Geological Engineering. He has 23 years of oil and gas experience with emphasis on new technology and integrated reservoir studies in gas, coal bed methane, oil sands and heavy oil at E&P companies in Canada and internationally. In the past 8 years Rocky has been involved in technology development focused on geo-modelling and geo-navigation (Smart 4-D Modelling®) through his company, United Oil and Gas Consulting Ltd.



The Canadian Well Logging Society
General Election

Ballots Mailed to All Members the First Week of January

Informational Memorandum from the Alberta Energy and Utility Board (EUB)

Now Accepting CD Submission Of Digital Well Log Data

The Alberta Energy and Utilities Board (EUB) requires industry submission of digital log data pursuant to section 11.140 of the Oil and Gas Regulations for all new wells drilled in the province of Alberta.

In addition to the submission of paper logs, the Resource Information Section of the EUB is now accepting submission of digital log data on CD. Diskettes will also continue to be accepted.

Requirements For CD Submission

Ensure that there is only one well per CD. Each CD must be clearly marked with UWI of well logged, licensee name and licence number. Please refer to *Guide 21, Standards for the Submission of Digital Log Data to the ERCB*, for data capture and format.

CD’s, diskettes and paper logs should be forwarded to:

EUB
Resource Information Section
4th Floor, 640 – 5 Ave. S.W
Calgary Alberta T2P 3G4

Any questions or comments may be directed to either:

Abby Cook	(403) 297-2581	abby.cook@gov.ab.ca
Angela Campanelli	(403) 297-8574	angela.campanelli@gov.ab.ca

Abby Cook, Team Leader
EUB, Resource Information
Information & Systems Services Branch

Canadian Well Logging Society

Wednesday, January 12th, 2005

CWLS Technical Luncheon Presentation
Fairmont Palliser Hotel 133 – 9th Avenue S.W., Calgary

Time:	**12:00 pm (Cocktails at 11:30 am)**
Reservations By:	**Friday, January 7, 2005, (noon) - Call 269-9366 to Confirm a Seat**
Cost:	**Members reserved meal (with confirmed seat): $25.00; Members at the door: $30.00** **Non-Members reserved meal: $30.00; Non-Members at the door: $30.00** **(Special needs meals available with advanced booking only)**
Topic:	**Enhanced Petrophysical Interpretation Utilizing Digital Sonic Shear and Stoneley Wave Data**
Speaker:	**Douglas L. Hardman, P.Eng. – Petro-Canada Oil & Gas**

Abstract:

This presentation will examine the benefits of shear and stoneley wave interpretation in both clastic and carbonate reservoirs in Canada.

Integration of shear and stoneley wave information can not only help identify permeable formations – but also characterize the permeability type as to matrix or fracture. Understanding the permeability fabric facilitates the best completion practices, thereby minimizing risk and increasing your success factor.

Digital sonic tools have advanced significantly in the last 20 years. Tool designs, acquisition modes, combined with state of the art digital processing techniques have led to measurements of not only compressional (p) and shear (s) velocities, but also stoneley wave velocities and attenuations.

In the case of shear velocity measurements it is now possible to acquire azimuthal shear velocities, which can be used to determine the fast and slow shear directions, as well as the magnitude of the difference, commonly termed the anisotropy. The amount of anisotropy can be used along with other data to understand structural information on a sub seismic level. Anisotropy also can be used to infer natural fracturing or in the case of planned fracture stimulations the estimate of fracture propagation direction (strike of fractures).

Stoneley wave acquisition and interpretation is a more recent advancement and continues to evolve through inversion techniques. The stoneley wave is a guided tube wave at the borehole – formation interface, with the velocity, attenuation and frequency being related to the permeability/mobility of the formation it transverses. Fracture detection is also possible by analysis of the energy loss and waveform reflections.

Biography:

Doug Hardman is a senior Petrophysicist with Petro-Canada.. Doug graduated from Lakehead University in Thunder Bay, Ontario in 1984 with a degree in Mechanical Engineering. He spent 15 years with Schlumberger Oilfield Services, having held various positions including, open and cased hole wireline engineer, technical staff engineer, sales engineer, account and district and manager.

His recent responsibilities include formation evaluation for Petro-Canada in their northern business units, including the Artic and Alaska. Doug is a long standing member of the CWLS, APEGGA and was president and vice president of the Fort Worth chapter of the SPWLA.

Notes: Please forward this notice to any potentially interested co-workers. Thank you.

Please see the CWLS Website at www.cwls.org for information regarding a Corporate Network License for the recently published CWLS Formation Water (RW) Catalog CD.

CWLS GENERAL INFORMATION

INCORPORATED – January 21, 1957

Objective

The objective of The Society (as stated in the Letter of Incorporation) is the furtherance of the science of well log interpretation, by:

(A) Providing regular meetings with discussion of subjects relating thereto; and

(B) Encouraging research and study with respect thereto.

MEMBERSHIP

Active membership is open to those within the oil and gas industries whose work is primarily well log interpretation or those who have a genuine interest in formation evaluation and wish to increase their knowledge of logging methods.

FEES

The CWLS fiscal year commences February 1, and all fees are due at this time.

Initiation Fee (including first year's membership fees) : $40.00
Annual Dues : $30.00
Student (no initiation fee) : $10.00

Memberships not renewed on or before June 30 of each year will be dropped from the roster and reinstatement of such a membership will only be made by re-application, which will require re-payment of the initiation fee plus the annual dues. All dues (Canadian Funds) should be submitted with the application or renewal of membership (Cheque, money order or Visa).

ACTIVITIES

The Society also furthers its objectives by sponsoring symposiums and exhibits.

Research committees encourage and support research on relevant problems.

The Society is the spokesman to industry and government on topics pertaining to well logging and formation evaluation.

The Society holds a monthly luncheon meeting (except July / August) to hear an address on a relevant topic.

Each active member will automatically receive the CWLS Journal, 'InSite' newsletter and Annual Report.

APPLICATION

Should our activities interest you we invite you to complete the attached application form and forward it to the CWLS membership Chair.

CWLS MEMBERSHIP APPLICATION FORM

To apply for membership to the CWLS, please complete this application form in detail.

NAME:...

COMPANY:...

COMPANY
ADDRESS:...

....

HOME
ADDRESS:...

....

E-MAIL ADDRESS:...

PREFERRED MAILING ADDRESS:

E-MAIL____ OFFICE____ HOME____

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FEES

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Tech Corner: Cuttings Analysis – Old Technique, New Application

In the world of geophysics and geology, never the twain shall meet ... or so we are sometimes told. The truth of the matter is that cross-culture blending can have some interesting and useful outcomes. Such is the case of utilizing a testing method, old to the geology trade, but now applied to geophysics. That method is one of X-Ray Diffractometry (XRD).

Conventional analysis of rocks involves porosity and permeability measurements on core, plugs and sometimes irregularly-shaped pieces of core. One of the derived measurements of the method is grain density, which is useful to the log analyst for the purpose of evaluating and calibrating logs. But what happens when no core has been drilled, and it's too late, or cost prohibitive, to capture sidewall plugs to analyze in a conventional fashion. Here's where cuttings can come to the rescue.

XRD bulk powder analysis has traditionally been used as a semi-quantitative technique to provide information about the basic lithology of the rock being analyzed. XRD provides weight percentages of the minerals in that rock. Knowing the grain densities of standard minerals detected allows calculation of the weighted average of the grain densities of the sample.

Bulk XRD analysis can be completed on very small samples, thus cuttings can provide the raw material for derivation of grain densities. Amounts as small as a few cuttings can be used to prepare the XRD sample, and these can usually be readily acquired from in-house, Alberta Energy Utilities Board Core Research Centre, British Columbia Government or Geological Survey of Canada repositories.

Users of this technique must keep several things in mind. It is assumed that sampling at the drilling sight has been done in a conscientious manner, that sub-sampling from archived material by trained individuals provides good representation of the lithology of the host rock, and that XRD analysis is a semi-quantitative technique. In most cases, careful attention to details can assist in providing valid and useful data. Many service labs are equipped to provide XRD results, and the analyst is free to use his or her favourite provider.

Keep the wiggles productive.

Write-up by:
Raymond Strom, General Manager
Continental Rocktell Service

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Logging operations in the Brazeau / Columbia Area, Alberta during summer 2004. Photo Courtesy Scott Hadley

UPCOMING EVENTS

December 15, 2004

CWLS TECHNICAL LUNCHEON PRESENTATION

Fairmont Palliser Hotel, Calgary, AB

John Logel, Anadarko Canada

Resolving the discrepancies between Vertical Seismic Profiles (VSP) and Petrophysical logs.

January 12, 2005

CWLS TECHINICAL LUNCHEON PRESENTATION

Fairmont Palliser Hotel, Calgary, AB

Douglas Hardman, Petro Canada Oil & Gas

Enhanced petrophysical interpretation utilizing digital sonic shear and stoneley wave data.

January 30 – February 2, 2005

SPWLA ABU DHABI TOPICAL CONFERENCE

Royal Meridian Hotel, Abu Dhabi, UAE

Enhanced petrophysical interpretation utilizing digital sonic shear and stoneley wave data.

February 9, 2005

CWLS ANNUAL GENERAL MEETING

Fairmount Palliser Hotel, Calgary, AB

Guest speaker - General Lewis MacKenzie.

For information on advertising in the InSite, please contact either of the publications co-chairs:

Mike Eddy (meddy@varco.com) at (403) 230-0630.

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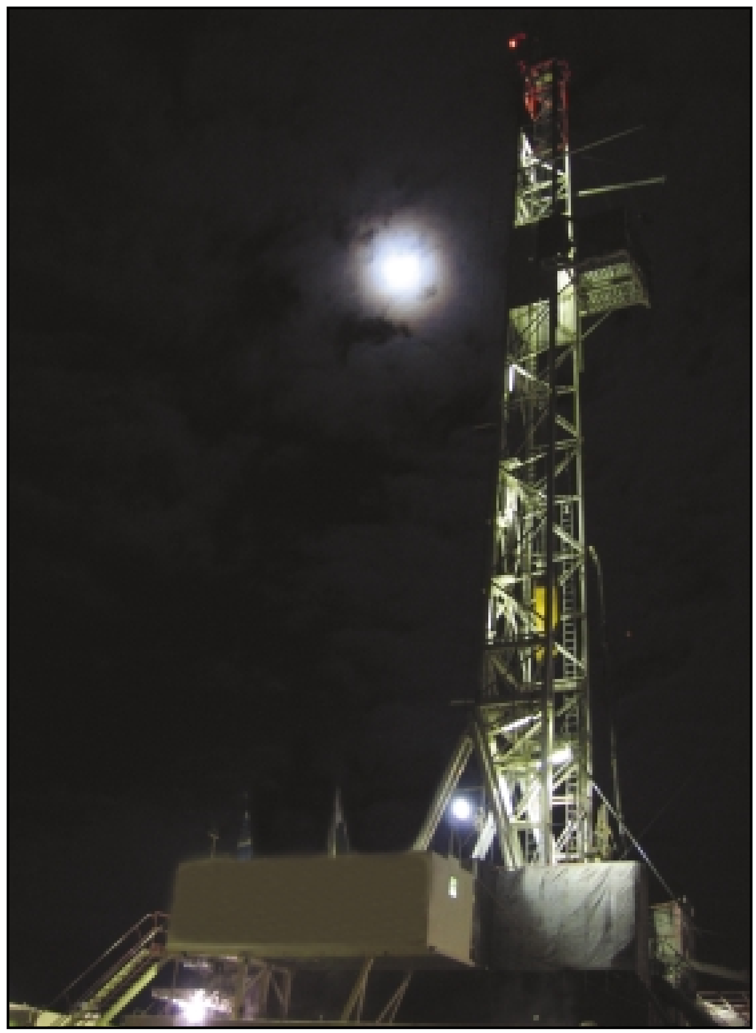
Discounts on business card advertisement for members.

The remains of brand new rollercone bit after drilling 15m through the Cadomin and 15m into the Fernie. Only 20 hours on the bit and it's more than a centimeter under gauge.

Photo Courtesy Dave Kelly.

Night time drilling operations in the Wildriver Area, AB.

Photo Courtesy John Nieto.



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