InSite

CWLS Magazine
Sept 2005 Issue 3 Volume 24

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InSite

CWLS Magazine September 2005

Issue 3 Volume 24

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Cover Photos: *Logging crew rigging down a Dual Laterolog sonde. Photo courtesy of Jarad Paul.*

20mmcf/d gas flare during drill of an under balanced horizontal well at Medicine Lodge Hz (14-18) 08-18-053-21W5. The well was drilled by Precision #504 on December 4th, 2000. Photo courtesy of Dennis Winchester.

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 ben@waveformenergy.com. Include a short description of the photo with your submission.

The 2005 - 2006 CWLS Executive:

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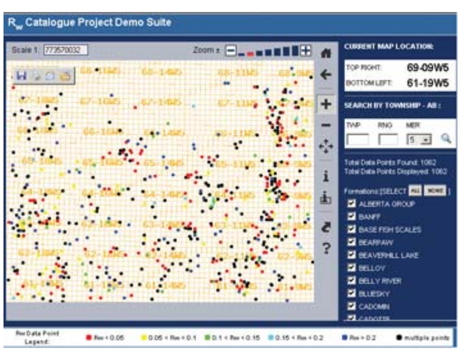
President's Message

The Canadian Well Logging Society is 50 years old and with the latest developments in our 'all-new' website, is preparing for the next 50!

In this edition, I thought I'd use my column to highlight some of the exciting changes to our website that have been taking place over the summer. In my view, we are providing real value to our membership – one of the guiding principles of our Society. Naturally, this comes at a cost – we have spent some $35,000 of CWLS funds, using a local developer Claero Systems to build our site. I think that you'll agree, when you are able to log in to the new features in approximately a month's time, it's a worthwhile expense!

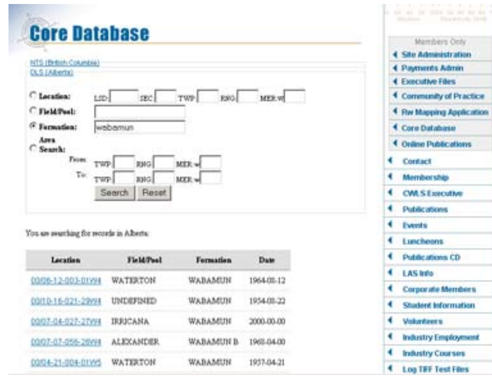
So what's new for your membership dollars?

Firstly, the Rw catalogue has moved from paper and pdf's to a fully searchable GIS-based system which is easy to read and a breeze to use! The picture below gives you a feel for the interface, much like one of the 'internet map tools', you are able to zoom in to your area of interest with a click of the mouse.

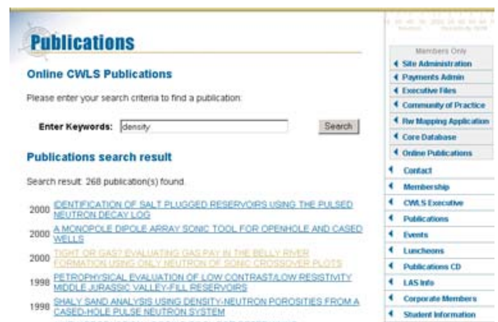


Next, we have refined the interface of the Core Analysis database, once only available to sponsor companies, we are now going to allow access to all paid-up CWLS members.

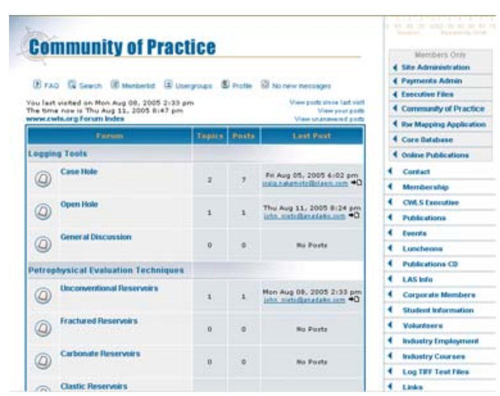
There are thousands of wells available, most with electrical properties measurements which can be searched by Location, Field, or Formation.



Next, we have the searchable Publications database. Members only will have access to a number of free downloads of CWLS transactions papers. The example found below shows 268 hits on 'density' within the database!



Another new addition is the 'Community of Practice' site, where any member can initiate or contribute to a discussion forum. Ever wondered about a particular problem that's been on your mind for years? Bring the full weight of the CWLS membership to bear, just post your question and start a discussion! Several Categories have been designed so far, including Open Hole, Cased Hole, Various Reservoir types – if there are others that I have omitted, please let me know and we can quickly add them!



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Editor's Note

In the last year the oil patch has had a great run. E&P companies are reporting record profits and the need for high quality technical staff continues to grow. Oil prices are moving steeply upwards, having soared approximately 50% over the past six months, and have doubled since mid-2003, breaking the $60 barrier earlier in the year.

However, the price of oil has a long way to go before it reaches the historical all time high. A graph of historical oil prices, converted to 2004 US dollars, indicates that the equivalent record oil price was hit in 1863 during the Pennsylvanian oil boom when oil hit a high of ~$98 USD/bbl. The only other time in history when if came even close was in 1980 during the Iranian Revolution when it spiked to ~$83 USD/bbl. Be that as it may, our society is far more dependent on hydrocarbons than it was in 1863 and higher oil prices have both an ominous side and a silver lining. As oil prices continue to climb, our industry is booming, straining services and personnel to their very limits, but at the same time stimulating our economy. In spite of these seemingly ever increasing energy costs, there has been little decline in energy demand, a sign of a strong economy both here in Canada, and across the line in the United States.

Attempting to tackle this increasing demand, the expansion in oil and gas exploration and development has continued unabated throughout North America, with Canada being on its way to a record drilling season in 2005. To the end of July of this year, over 10,700 wells have been drilled, for a total of just over 12.5 million metres of drilled hole. Drilling rigs are continually in short supply, even with the addition of roughly 400 new rigs (300 in the United States and 100 in Canada), as are the skilled personnel to operate them. This resource shortage, a direct result of our demand, shows little sign of easing through 2006.

Looking at the big picture can also be instructive. In June of 2005, BP released its statistical review of world energy. This report provides a summary of world energy use and production. A number of interesting facts come out of it. In 2004 world energy consumption increased by 4.3%. Much of this increase was due to increased demand and use in China, who's continually and seemingly insatiable, energy demands saw their oil imports increase over 40% in 2004. To ensure a steady supply, China has initiated a Strategic Petroleum Reserve plan with the construction of the first tanks in Ningbo, which will hold upwards of 10 millions barrels of oil. Some other facts of Canadian interest include: In 2004, Canada produced 3, 085, 000 bbl/d of oil (a 3.5% increase from 2003) and 182.8 Bcf/d of gas (less then 1% increase from 2003).

In this issue of the InSite we have a variety of papers and articles of interest. The first is on Quantitative Fluorescence Technique (QFT), an analysis for identifying oil in drill cuttings and core. Our first article is the first in a series designed to entice discussions on log analysis methodology, and log interpretation. This issue's is a discussion on tornado charts, and their ability and/or effectiveness in correcting deep induction readings for obtaining a more accurate true resistivity (Rt) value. We encourage people within the industry to consider writing discussions and/or rebuttals to this series. Our second paper is on the utility of Logging While Tripping (LWT). This method enables a specific logging suite to be obtained while tripping out of the hole at well TD, without the requirement of a specific logging run, therefore saving in rig time and logging costs. Tech Corner is a presentation on a combined carbon oxygen (CO) and pulsed neutron capture (PNC) logging tool, and its practical application in assessing bypassed pay in older generation wells, with specific reference to the Belly River Formation.

Enjoy the InSite!

Robert Bercha
Ben Urlwin
CWLS Publications Co-Chairs

President's Message *... continued from page 3*

And finally, thanks especially to the good work of Dion Lobreau, we present the on-line membership section of our new website. Dion will be demonstrating this at a lunch in the near future, but suffice it to say, we have made it even easier to join the CWLS and renew your membership for existing members!

So, hope to see you all at the next lunch in September!

The famous 50th Anniversary lunch WILL take place, Ken Faurschou has slipped it a month to allow us to get a really great speaker, should be well worth the wait!

As ever, if anyone has any ideas or suggestions to improve the CWLS, please don't hesitate to come forward at the lunch meetings, or email me!

John Nieto, CWLS President.
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As the Winch Turns: Luck in Kazakhstan

About this time last year I was on my way back to Kazakhstan for the second time as a wellsite geologist and company representative for a small Canadian E&P company. Having spent over six months in Kazakhstan the first time, I knew what I was getting myself into. Being able to speak, or should I say "mumble", enough Russian to get along without too many problems also helped. From past experience I already knew what the rig was like. The long rig move from one field to another was bound to have taken its toll on this particular rig. But of course being the optimist that I am, I had not anticipated having quite so much trouble as we encountered on this well.

We were somewhat more organised this time around. As we prepared the rig in the heat of the summer, we had time to organise the traditional sacrifice of a sheep before we set surface casing on the first well. So, very early one fine morning I found myself taking pictures of a sheep having its throat slit in the cellar and its blood poured on the rig. This was not my idea of a fun way to start the day, but one has to do what one has to do. The Muslim part of the crew felt good about the sacrifice and everybody seemed happy when we ate the sheep for dinner. Of course things can never stay that simple.

Kazakhstan is part of the former Soviet Union and even though the original population is Muslin, there is still a strong presence of Christian Russian left from the USSR days. On this rig, half of the drilling crew and all the supervising crew (mostly Serbians) were Christian. I did not realise at that point that the non-Muslims were concerned that the sacrifice would bring us bad luck. As the problems with the rig, and in particular pressure testing, took proportions that nobody in their right mind could have possibly anticipated, one of the men decided to let me know what the problem was: we were jinxed. We had spilled blood and everything would go poorly from now on. Needless to say we were all stressed due to this jinx and the drilling issues. The heat combined with the stress was making everybody irritable and we were making no progress. Each problem confirmed to all that we were deep in bad luck. Old stories and gossip of things that had happened in the area before we started drilling were beginning to surface. In addition, bad omens were starting to appear including viewings of a yurt shaped sun at sunset. A yurt shaped sun could be a good thing in a different setting but wasn't in this case.

Somebody was going to have to do something to lift the morale of the crew and get the operation back on track. Of course that "somebody" would have to be me. In religious matters such as these I knew that I had to be very careful. Being a female on the rig was bad enough. So I approached the eldest Muslin crew worker and asked for his advice. My point to him was – I knew what I had to do, but I didn't want to offend him and his fellow workers. Could I perform a small ceremony, not to cancel the effect of the sacrifice, but to add to it? Luckily the Kazakh Muslins are not very strict and not easy to offend. The old guy assured me that I could do "what was needed " and all would be alright, things would be "balanced".

Before too much discussion took place and the idea got challenged I asked to have a bowl of the cleanest water we could find and a raw egg brought to me. I hadn't thought the thing out, and in retrospect I realise that fresh milk would have been more dramatic than water, but water is what came to mind at the time.

They brought me the water and the egg. I asked to be left alone at the well centre and explained that I would be quick so as not to offend the sacrificed sheep. I didn't want them to expect a huge ceremony. I stood by the well centre pretending to talk, mostly thinking that this was not quite the job I had signed for. Threw the water, then the egg. Stood there a little bit longer and walked back to the crew and told them that I had had a good sign.

Things at the rig did not get significantly better as far as I could tell. None-the-less, everybody disagreed with me on that one. Things were clearly better now! During the entire drilling program I was asked to perform this ceremony only one more time...and yes, I did stick with water for consistency! And yes it was just as efficient in bringing us good luck!

Carole Augereau

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Message from the Secretary

This is my first term as Secretary and it sure has been a truly rewarding experience! With this being the 50th Anniversary of the CWLS, I thought I would take a closer look at the title: "Canadian Well Logging Society."

Core database – files are hosted on the CWLS website. Members can log in and search through a variety of samples at anytime.
Al Brown – the society founder and first President.
New Members – the CWLS is always looking for new members. If you know of anyone who is involved with or would like to increase their knowledge in well log interpretation and formation evaluation, tell them about the benefits of being a CWLS member today!
Advertising in the InSite targets decision makers and key personnel. Contact InSite's advertising manager – Mike Eddy to set up an advertisement for you in the next edition of InSite.
Dry hole- the horrifying word we never like to hear in the industry!
InSite – of course the best publication in the industry, dedicated to providing insightful information on a variety of formation evaluation topics.
Activities – the society is involved in and sponsors many symposiums and exhibits. Check the website for more details.
Natural Gas – without it, we would have a lot of free time on our hands!

Website – go to www.cwls.org for the latest information on the CWLS.
Executive – want to join the CWLS Executive team? Contact our Past President Jeff Levack for more details on how you can be nominated for a variety of positions available for 2006-2007.
LAS Software – the CWLS provides the latest information on LAS software.
Logs – induction logs, neutron density logs, acoustic logs. They all are our passion!

Local talent – the CWLS is always looking for participants to present an interesting technical topic at the luncheons. If you are interested, contact our Vice President Ken Faurschou for more details.
Objective of the society is the furtherance of the science of well log interpretation by: Providing regular meetings with discussion of subjects relating thereto; and encouraging research and study with respect thereto.
Geophysics – the core of the CWLS
Golf – what we do during the summer months?
Industry courses – the CWLS is proud to sponsor and advertise many industry courses like the Borehole Imaging Course this past May. Check out the website for details.
Nineteen fifty five – the year the CWLS began!
Get involved! Volunteering offers many rewards such as meeting new industry contacts, developing or enhancing skills & goals. Plus, it opens the door to many opportunities that may have never been offered to you before! For more information on volunteering, contact Chair of Committees Richard Bishop.

Student benefits – the CWLS offers amazing benefits like free technical lunches, student awards and low membership fees!
Oldest organization – The CWLS is one of the oldest organizations devoted to log analysis, incorporated in Calgary, Canada in 1957.
Corporate Sponsors- Our Corporate members are important to us not only for the financial support they give but also because of the commitment and work of their employees in promoting the society.
Interpretation – always challenging; always interesting!
Emails – make sure and keep your email address current or you may miss out on important events.
Technical luncheons – book off the first Wednesday of every month to attend a variety of interesting, innovative, and knowledgeable talks.
You! With over 525 members from around the world, it is you that make the CWLS. Thanks for all your support!

My responsibility with my role as Secretary, is to make sure our members are fully informed of all technical luncheons and special events. If you are not receiving email notices or mail notifications from the CWLS, we may not have your current contact information or your organization may have antispam software in place!

If this applies to you, please contact Dion Lobreau, Membership Chair to update your information, or add me to your antispam safe list today!

Happy 50th Birthday CWLS!

Carley Gyori
Secretary 2005 -2006

Help Keep the CWLS Strong & Growing

Please think seriously about running for a spot on the CWLS Executive in 2006. The only way our society can keep going is if all members give back to it at some point. Now it is your turn. Please contact Jeff Levack - Past President to talk about how you can participate.

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Quantitative Fluorescence Technique (QFT2™)

Bob Dick, P.Geol.
ECL Canada

Introduction

QFT was developed in the late 1980's by the Surface Logging Group of Texaco's Exploration and Production Technology Department (Texaco EPTD.) This was followed by Texaco's development of QFT2™ in the late 1990's.

QFT™ was developed as an objective method to quantitatively identify oil in drill cuttings and cores. With QFT2™ users can obtain both oil quantity and an estimate of API gravity from emission measurements at two wavelengths. The technique can remove the variation and inconsistency found with the visual methods of identifying oil in drill cuttings. It can be particularly useful when wireline logs are missing or difficult to interpret.

This technique is designed for use at the rig-site by the mud logging technicians. Alternatively, drill cuttings can be analysed back at the lab in town.

Quantitative Fluorescence Technique (QFT and QFT2™)

Quantitative Fluorescence Technique (QFT™) was developed patented and licensed by Texaco and has been used to provide an accurate and quantitative measurement of fluorescence from oil or condensate in drill cuttings and cores.

Studies can be performed on both wet and dry cuttings from vertical, deviated and horizontal wells. Samples can be analysed that were collected a few hours previously or up to 30 years ago.

Since the 1930's, the use of fluoroscope techniques (UV box applications) has been proven to provide qualitative, highly subjective judgments regarding fluorescence intensity.

Since many oils fluoresce outside the visible spectrum, very light oils and condensates could go completely undetected and the hydrocarbons present may not represent the total maximum concentration of the oil in the formation. The intensity of the fluorescence is directly proportional to the amount of oil in the sample.

The original QFT™ process utilised a single point fluorescence measurement to determine quantified oil concentrations and plotted the readings as a function of depth to yield and oil concentration profile. QFT2™ takes the original process a step further. By using the measurement from two UV emission light sources and providing a ratio of the two readings through a computer based data logger program, an estimate of the extracted oil type and its intrinsic fluorescence is provided along with estimated weight % oil and API Gravity.

The program also calculates UV absorption loss, particularly in heavy oils, and alerts the user that sample extract dilution is required to provide more accurate readings. Further calculations with predetermined formulas involving rock bulk density; oil density and API gravity values will yield volume % oil (oil porosity) values.

QFT2™ was calibrated by analysis of 48 oils ranging from 10-70º API using as a standard the solvent extracts n-heptane and isopropyl alcohol. The standard deviation for weight % oil calculations for oils having gravities of at least 20 degrees (41 oils in total) corresponds to a factor of 1.7 uncertainty in actual oil content. API gravity estimates have a standard deviation of – or + 8 degrees for the same oils. Although the gravity estimates may be subject to some uncertainty, trends in oil character will be correctly identified and any changes can signal reservoir horizons and gas/oil or oil/water contact.

By correlating QFT2™ values with reliable mud gas readings, a more complete evaluation and well profile can be established even when wireline logs are difficult to interpret or unavailable.

Since it provides quantitative and reproducible values, it should be noted that QFT2™ works best when employed as a hydrocarbon survey tool rather than as a substitute for more accurate laboratory analysis.

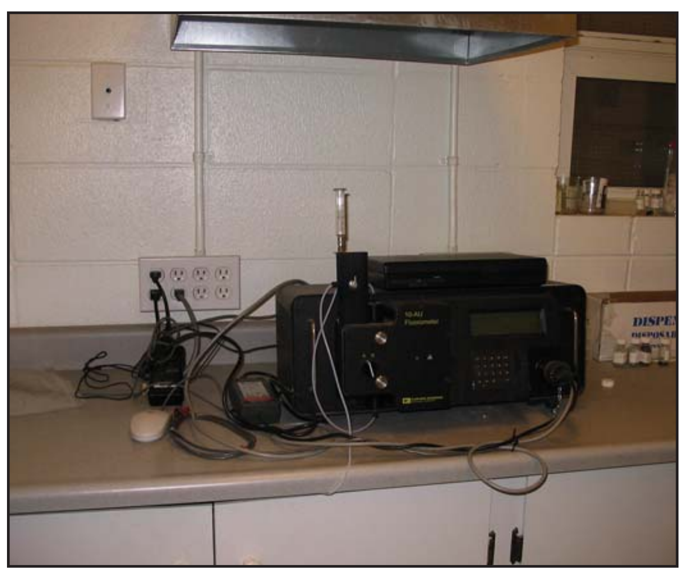

Figure 1: QFT2 Measurement device

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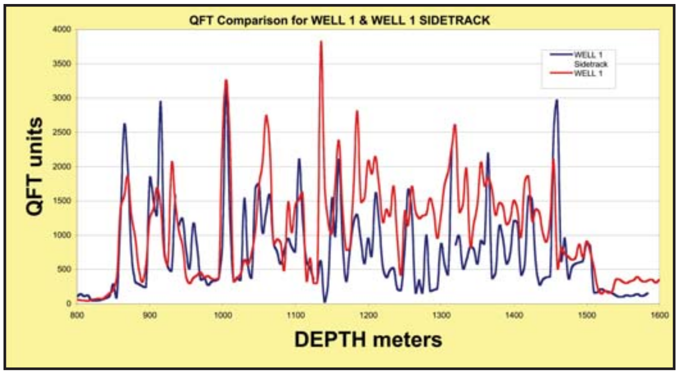
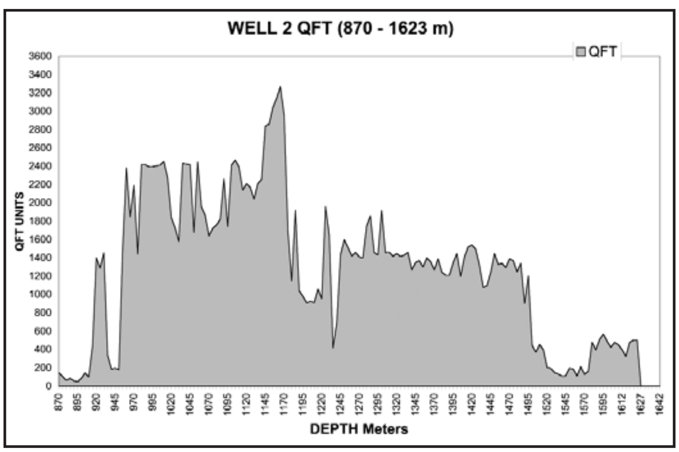
Quantitative Fluorescence Technique … *continued from page 9*



Example 1: (well 1 and well 1 sidetrack). They do track quite well with a couple of notable QFT anomalies between the 2 wells.

QFT2™ has applications in:

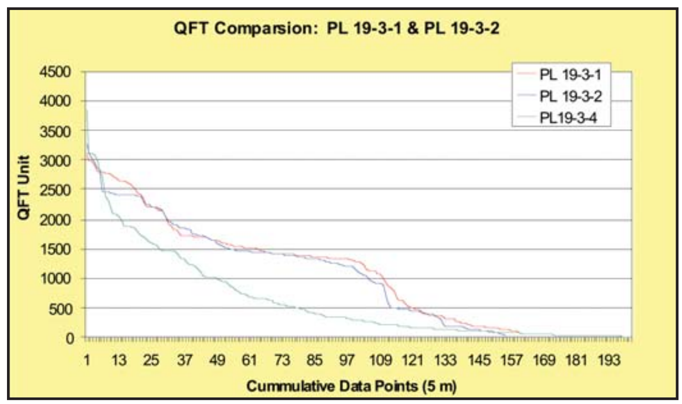
- Identifying potential source rocks and missed pay zones.
- Defining reservoir quality in a horizontal well.
- Picking penetration DST intervals.
- Determining whether to continue a coring program.
- Determining the oil/gas or oil/water contact.

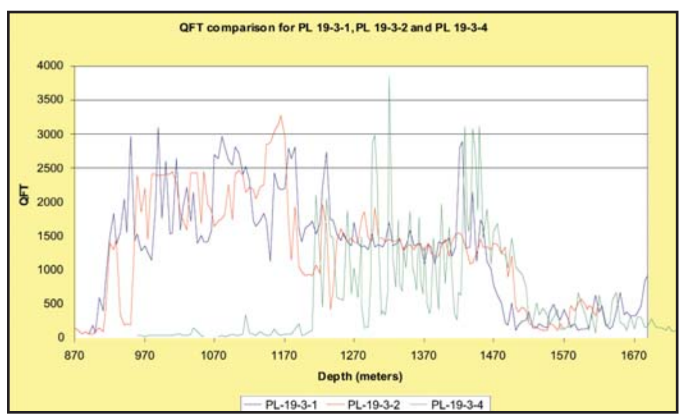


Example 2: Shows a generally high oil concentration profile but with some large increase in zones with very high oil concentrations. This profile is probably indicative of a well with heavy oil concentrations.

QFT2 ™can indicate:

- Oil in low resistivity/low contrast pay zones in intervals that are difficult to evaluate when using wireline or logging while drilling (LWD) tools alone. QFT2™ can identify thin hydrocarbon bearing sand intervals where dispersed clay or shale laminations exist since the process in unaffected by shale content.
- Producible or moveable oil by converting Weight % Oil to oil porosity and plotting this value with hydrocarbon porosity (HCPV) from wireline sources. If the hydrocarbon porosity logs indicate more hydrocarbons than the volume percent oil or oil porosity values presented by QFT2™, it may reflect flushing of the hydrocarbons in the formation during the drilling process.





Example 3: Shows 3 development wells plotted over each other. 2 wells track very well. The other well has some quite distinct differences and QFT anomalies.

Continued on page 11…

Quantitative Fluorescence Technique... *continued from page 10*

QFT2™ will enhance:

- The ability to predict immobile oil by comparing volume percent (oil porosity) with wireline hydrocarbon porosity values. Should an equivalency in values exist, it may indicate very little flushing of the zone(s) suggesting impermeability or the presence of a tar mat.
- The ability to discriminate oil and gas bearing zones through the integration of surface gas and open hole log data.

QFT2™ can be correlated with:

- Open hole, LWD and MWD logs.
- Sidewall and conventional core analysis.
- Drill cutting lithologies.
- Gas readings.

Quantitative Fluorescence Technique provides a much more accurate measurement of fluorescence in the drill cuttings at the wellsite as compared to the subjective nature of the fluoroscope.

The author notes that this information is reproduced and presented as a summary from the following Technical Publications and References:

Delaune, P.L., Surface Techniques to Measure Oil Concentration While Drilling, SPWLA 33rd Annual Logging Symposium, June 14-17, 1992

Delaune, P.L. and Spilker, K.K., Texaco Upstream Technology and Wright, A.C., Consultant, Enhanced Wellsite Technique for Oil Detection and Characterization, SPE 56802 presented at the SPE Annual Conference, Houston, Texas USA, October 3-6, 1999

Turner Designs, Model 10-AU-005 Field Fluorometer User's Manual, 1992

Texaco Inc., User's Guide, QFT2™, Quantitative Fluorescence Technique 2, 1999

Canadian Well Logging History – Technical Meetings

In the first ten years of its existence the society hosted 85 technical meetings. Meetings occurred on a regular basis each month with a break in July and August. In June of 1960, these meetings were moved to the Calgary Professional Club on the second Wednesday of each month. The 1964 – 1965 season was a particularity good year for the CWLS as it celebrated its 10th anniversary. Some of the events in 1964 – 1965 are summarized by E.T. Connolly (then vice-president) as follows:

"This has been the society's finest season. The last 10 meetings have averaged 78 in attendance. One hundred and thirty-seven people attended an "Introduction to logging Basics" run by two service companies – Welex and Schlumberger. This was a double film session. The highest attendance was at the meeting where Mr. R. O. Lindseth, Engineering Data Processors, Calgary, gave a talk on "Development and Application of Digitized Well Logs". Attendance at this meeting was 155. It is interesting to note that four of the last ten meetings were computer oriented, and three of these were the highest attendance records. Not included in the above statistics was the joint meeting held with The Alberta Society of Petroleum Geologists featuring that world authority on logging ailments and geological wizardry, Mr. W. A. "Bill" Heck, Petroleum Geologist, Midland, Texas. Over 204 people heard Mr. Heck present his paper at the Calgary Inn. A second paper was presented at the University of Alberta science building in the evening.

On Wednesday August 11, 1965, at the A1 San Club in Calgary, the Canadian Well Logging Society held its 10th Anniversary meeting. It is fitting that the guest speaker for this meeting was Mr. A.E. Breitenbach, Marathon Research Center, Littleton, Colorado, USA. Why fitting? Because one of the aims of the CWLS was to provide speakers of national and international stature giving papers of wide and varied interest to log analysts. And what better way to round out ten years of papers, both Canadian and American, for the first speaker was also an American – Mr. Andre A. Perebinossoff, Mobil International, New York, New York."

Also in 1965 corporate memberships were introduced by Ed Burge (past president) in an attempt to increase attendance at technical meetings and pay for out-of-town speaker expenses. This idea is now part of the CWLS's bylaws. The CWLS currently enjoys strong support from industry with 36 corporate members, which is a far cry from the 7 original corporate sponsors in 1965. The original corporate sponsors of the CWLS were Schlumberger, Welex, Shell, Triad, Imperial, French Petroleum and Pan American.

The following is an exert from a letter written on January 14, 1966 by the CWLS's Mr. James Brown (the CWLS President) to Mr. G.E. Dawson-Grove of the Home Oil Company, soliciting a corporate membership.

"I am writing on behalf of the Canadian Well Logging Society. Ours is the oldest logging society in the world – in August of 1965 we celebrate our tenth anniversary. During 1965 we had sixty-seven individual members and seven corporate members in Calgary, while the recently reactivated Edmonton group has approximately 40 members.

Outside interest in our meetings is at a high level: we have sixty-seven regular members in Calgary, but our average attendance was seventy-eight for the first ten meetings of last year. (One of our

Continued on page 13…

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 Ken Faurschou at (403) 509-4073 or faurschouk@slb.com.

Canadian Well Logging History … *continued from page 12*

Corporate Members has regularly boosted our attendance by ten or twenty persons.) We hope to make our meetings even more valuable in the future by inviting out-of-town speakers on an expenses-paid basis. The reactivation of the Edmonton group is particularly fortunate in this regard because the speakers and the expenses can be shared with the Edmonton group. For instance, Mr. Bob Wynn of Welex in Duncan, Oklahoma, addressed the Calgary and Edmonton groups on succeeding days earlier this month.

Funds derived from Corporate Memberships will be earmarked for speakers only and will in no case be used for any other purpose.

The cost of Corporate Membership in not fixed, though heretofore the service companies have contributed $25.00 and the oil companies have contributed $25.00 to $75.00. I would most earnestly ask that you consider supporting our society in this way."

To provide a different spin on the CWLS's history a short quiz has been attached below. Please e-mail your answers to Carley Gyori, CWLS Secretary at Carley.Gyori@bakeratlas.com. We will draw from the names of everybody who answers all 10 questions correctly on October 12 and a small prize will be awarded to the winner.

Robert Bercha & Carley Gyori

HISTORY QUIZ:

1. Who was the society's founder?
2. Where and when was the CWLS incorporated?
3. What was the CWLS' original name?
4. What is the society's objective?
5. How many technical luncheons have there been in 2005 as of August 1st?
6. How many CWLS papers are there on the past publications CD and when were they published?
7. What is written and maintained as public domain software by the CWLS?
8. The society opened a chapter in Regina between what years?
9. When was the first Rw catalog published?
10. How many honorary members does the CWLS have?

Myth-Interpretation

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Spectrum 2000 Mindware
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This series on interpretation myths is intended to provoke discussion, rebuttal, dialog, or solutions. I do not contend that my views are the only possible views, or even a correct view, on the subject. Responses should be addressed to editor@cwls.org.

Myth #1: Tornado Charts Correct for Invasion

The invasion correction for induction logs, as defined by service company tornado charts (see Figure 1), are supposed to correct the deep induction reading (RESD) to obtain a better value for true resistivity (Rt), based on the additional information contained in the shallow resistivity (RESS) and the medium resistivity (RESM). Most log analysis software packages have approximations to these charts built into the environmental correction module.

In a typical fresh mud scenario with invasion into a formation containing only salty formation water, the induction log curves are usually in the order RESD <= RESM <= RESS. The tornado chart computes a value for Rt that is less than or equal to RESD. This is a very rational solution.

However, if the resistivity curves are not in the order given above, no correction is applied and Rt = RESD. This can occur in a water zone if a low resistivity annulus occurs. In this scenario, RESM <= RESD <= RESS and these data points do not fall on typical tornado charts. So the tornado chart (and its equivalent computer algorithm) makes no correction and the Rt is not correct.

Worse yet, invasion into an oil or gas zone usually creates data sets that also do not fall on the tornado chart, so again, no correction is made, even if one is actually needed. If by chance the curves are in the order RESD <= RESM <= RESS, a correction will be made, but in the wrong direction – Rt will be made less than RESD. This is counter-intuitive, as invasion of even relatively fresh mud filtrate into an oil or gas zone will reduce resistivity. The tornado chart should increase Rt derived from RESD, not lower it or do nothing.

Below is a sample sensitivity analysis that shows that the correction factor (Rt/RESD) is greater than 1.0 for many real situations. Note that the same factor (Rt/Rild) on Figure 1 is never greater than 1.0. I have assumed a simplified step invasion model and the math model I used is shown below. You might want to try the math in a spreadsheet and see for yourself what happens. This work is taken from an unpublished research project that attempted to solve the invasion problem in Belly River sands in Alberta.

Sensitivity Analysis
Water Saturation and Resistivity with Invasion

Archie's Equation
  Sw = (A * RW@FT / (PHIe ^ M) / Rt) ^ (1 / N)

Assume A=1.0, M = N = 2.0
  Sw = (RW@FT / (PHIe ^ 2) / Rt) ^ 0.5

Rearrange terms
  Sw^2 = (RW@FT / (PHIe ^ 2) / Rt)

Solve for Rt in uninvaded oil zone
  Rt = (RW@FT / (PHIe ^ 2) / Sw^2)

Solve for Rxo in invaded oil zone
  Rxo= (RMF@FT / (PHIe ^ 2) / Sxo^2)

Solve for R0 in uninvaded water zone
  R0= (RW@FT / (PHIe ^ 2)

Assume RESD gets 50% of signal from invaded zone and 50% from uninvaded zone
  RESD = 1 / ((1 / Rt + 1 / Rxo) / 2)

Solve for SWa in invaded oil or water zone
  Swa = (RW@FT / (PHIe ^ 2) / RESD) ^ 0.5

Multiply deep resistivity (RESD) by Rt/RESD ratio to obtain Rt from RESD

Continued on page 15…

Myth-Interpretation *… continued from page 14*

INVADED OIL ZONE Sw=0.25 RMF@FT=1.000

RW@FT	PHIe	Rt	Rxo	R0	RESD	SWa	Sxo=0.6 Rt/RESD	Sxo=0.8 Rt/RESD	Sxo=1.0 Rt/RESD	Sw=1.0 Rt/RESD
0.25	0.25	64.0	44.4	4.0	52.5	0.28	1.22	1.78	2.50	0.63
0.25	0.15	177.8	123.5	11.1	145.7	0.28	1.22	1.78	2.50	0.63
0.10	0.25	25.6	44.4	1.6	32.5	0.22	0.79	1.01	1.30	0.55
0.10	0.15	71.1	123.5	4.4	90.2	0.22	0.79	1.01	1.30	0.55
0.03	0.25	7.7	44.4	0.5	13.1	0.19	0.59	0.65	0.74	0.52
0.03	0.15	21.3	123.5	1.3	36.4	0.19	0.59	0.65	0.74	0.52

INVADED OIL ZONE Sw=0.25 RMF@FT=0.50

RW@FT	PHIe	Rt	Rxo	R0	RESD	SWa	Sxo=0.6 Rt/RESD	Sxo=0.8 Rt/RESD	Sxo=1.0 Rt/RESD	Sw=1.0 Rt/RESD
0.25	0.25	64.0	22.2	4.0	33.0	0.35	1.94	3.06	4.50	0.75
0.25	0.15	177.8	61.7	11.1	91.6	0.35	1.94	3.06	4.50	0.75
0.10	0.25	25.6	22.2	1.6	23.8	0.26	1.08	1.52	2.10	0.60
0.10	0.15	71.1	61.7	4.4	66.1	0.26	1.08	1.52	2.10	0.60
0.03	0.25	7.7	22.2	0.5	11.4	0.21	0.67	0.81	0.98	0.53
0.03	0.15	21.3	61.7	1.3	31.7	0.21	0.67	0.81	0.98	0.56

INVADED OIL ZONE Sw=0.25 RMF@FT=0.25

RW@FT	PHIe	Rt	Rxo	R0	RESD	SWa	Sxo=0.6 Rt/RESD	Sxo=0.8 Rt/RESD	Sxo=1.0 Rt/RESD	Sw=1.0 Rt/RESD
0.25	0.25	64.0	11.1	4.0	18.9	0.46	3.38	5.62	8.50	1.00
0.25	0.15	177.8	30.9	11.1	52.6	0.46	3.38	5.62	8.50	1.00
0.10	0.25	25.6	11.1	1.6	15.5	0.32	1.65	2.55	3.70	0.70
0.10	0.15	71.1	30.9	4.4	43.0	0.32	1.65	2.55	3.70	0.70
0.03	0.25	7.7	11.1	0.5	9.1	0.23	0.85	1.11	1.46	0.56
0.03	0.15	21.3	30.9	1.3	25.2	0.23	0.85	1.11	1.46	0.56

INVADED OIL ZONE Sw=0.25 RMF@FT=0.10

RW@FT	PHIe	Rt	Rxo	R0	RESD	SWa	Sxo=0.6 Rt/RESD	Sxo=0.8 Rt/RESD	Sxo=1.0 Rt/RESD	Sw=1.0 Rt/RESD
0.25	0.25	64.0	4.4	4.0	8.3	0.69	7.70	13.30	20.5	1.75
0.25	0.15	177.8	12.3	11.1	23.1	0.69	7.70	13.30	20.5	1.75
0.10	0.25	25.6	4.4	1.6	7.6	0.46	3.38	5.62	8.50	1.00
0.10	0.15	71.1	12.3	4.4	21.0	0.46	3.38	5.62	8.50	1.00
0.03	0.25	7.7	4.4	0.5	5.6	0.29	1.36	2.04	2.90	0.65
0.03	0.15	21.3	12.3	1.3	15.6	0.29	1.36	2.04	2.90	0.65

Continued on page 16…

Myth-Interpretation *... continued from page 15*

In all four tables, SW is assumed to be 0.25 and Sxo has values of 0.6, 0.8, and 1.0. The ratio Rt/RESD is the correction factor to find Rt for various RW and porosity values (assumed in the left hand columns of each table). The four tables represent four different RMF values. Rt, Rxo, and R0 are computed from the given data. RESD is computed from Rt and Rxo. SWa is calculated from this RESD and the given porosity and RW. You can see that the apparent water saturation (SWa) is too high compared to SW (0.25 for all tables). The right hand column labeled Sw=1.0 is the Rt/RESD for an equivalent water zone – this approximates the correction factor from a tornado chart.

As you can see, the correction factor Rt/RESD is greater than 1.0 for many real scenarios whereas the tornado chart would give a value of 1.0 or less.

Are there correction algorithms out there that can really do invasion corrections in oil and gas zones? I believe the answer is "Yes". Some modern induction logs present computed values for Rt based on the three (or more) induction curves that were recorded. These results are derived from "invisible" 3-D inversion software inside the service company wellsite computer. But I don't think you will find such corrections in typical "off the shelf" software.

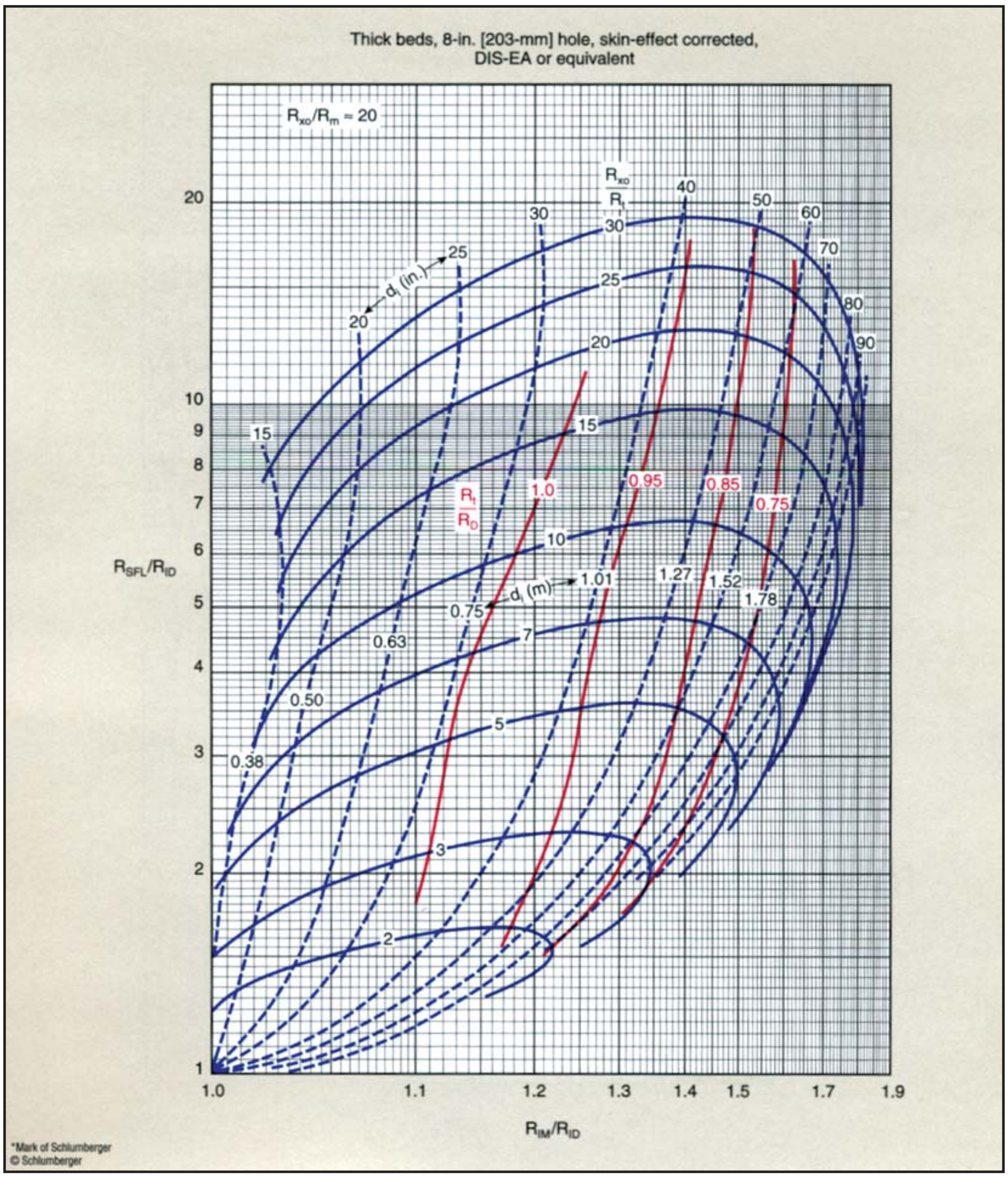

Figure 1: Typical Tornado Chart for an Induction Log (courtesy Schlumberger)

Logging While Tripping

Ramin Zamani, Datalog LWT Limited
and Dave Kelly, Anadarko Canada

Introduction

The exploration and production industry has always sought to reduce drilling costs through innovation and improvement in current practices. Logging While Tripping (LWT) is a recent advancement in evaluation methods, which aims at reducing logging time. In this method memory based slim logging tools are used in special receiver subs. The sensor package and electronics are not in the wellbore while drilling. This leads to the electronics being subjected to less shock and vibration compared to normal Logging While Drilling (LWD) tools. Less vibration rating makes LWT electronics cost an order of magnitude less than LWD. The combination of equipment cost reduction and rig timesavings makes LWT a valuable tool in formation evaluation.

Figure 1: Rigging up a LWT tool.

Method

LWT equipment is divided in two major categories: 1) LWT receiver subs – that are an integral part of the Bottom Hole Assembly (BHA) and 2) electronics – the sensor package. LWT subs are installed in the BHA before drilling. This can be done on the last bit run or whenever it suits the drilling operation. Drilling progresses with LWT subs in the BHA and the borehole is drilled to the desired depth. When logging depth is reached, the sensor package and electronics are lowered into the drill string (Figure 1). In the case of a horizontal well, rig pumps are used to push the electronics package into the drill string. The electronics package and sensors are landed in the LWT subs. Electronics start operation at a preset time. Drill pipes are moved across the zone of interest and logs are recorded on downhole memory. A surface depth recorder attached to the draw works or crown records the depth information on a recording system synchronized with the down hole recorders. At the end of logging, downhole tools are retrieved either at surface or in the well bore using an overshot. At surface, data is down loaded from the onboard memory and merged with the surface depth system and the logs are generated. At this point drilling can continue if the drill string has not been tripped all the way to surface.

Safety

Use of radioactive sources for logging imposes an overall risk to drilling operations. If Wireline tools are stuck in the hole, radioactive sources can only be retrieved by a successful fishing operation. This mandatory fishing operation can become long and expensive and may lead to hole abandonment if radioactive sources are not recovered. Since radioactive sources used in the LWT sensor package can be removed from the drill string, the above-mentioned risk is minimized. The LWT method has successfully been used in contingency planning for high risk drilling operations. For contingency planning LWT subs can be used in the BHA and sensor packages only sent down for logging if conventional wireline logging is deemed too risky.

Well control

Planning and care are the main ingredients of drilling depleted zones and reservoirs. The LWT method significantly reduces the risks involved with logging operations when high differential pressure exists. In this method there is virtually no restriction to mud flow inside the drill string before electronics pack-

Continued on page 18…

Logging While Tripping *… continued from page 17*

age deployment. This leaves many options open to the operator for mud loss management. The electronics and sensor package can be introduced when the well is under control. While logging, the drilling rigs Blowout Preventer (BOP) remains fully functional and mud circulation can be established as necessary. The same method applies to under-balanced drilling. The LWT method is can be the most cost effective way of obtaining formation resistivity when drilling under balanced wells.

Efficiency

In the case of conventional wireline logging methods, the sequence of drilling operations is as follows. First the wellbore is drilled to TD, then a dummy trip is completed prior to logging. Next, the logging operation is completed. This is followed by a clean out trip to prepare the hole for casing. If the wellbore bridges off or bad hole conditions are encountered an additional trip maybe necessary in between logging runs.

In the LWT method, logging is performed after total depth is reached without any hole-conditioning trip. Since the last trip out is with the bit at the end of the string, the hole can be cleaned while logging. Therefore, casing can be run directly after logging. This eliminates the dummy trip and casing clean out trip. Rig time savings can add up to tens of thousands of dollars depending on the type of rig and depth of the well. Figure 2 is a rig time saving comparison between the wireline method and LWT. Time savings become more significant as depth and deviation increases. In the case of extended reach and multilateral holes using LWT simplifies the operation and increases the chance of success. LWT can also help in reducing the cost of reconnaissance logs. Sometimes logging information is needed to help make a casing point determination. With LWT tools can be retrieved with the drill bit near TD. In this case drilling can be resumed shortly after logs are generated at surface if required. LWT units are also more mobile than their wireline counterpart. With no heavy wireline to be carried around LWT units are least affected by road bans. Timesavings are also significant for high efficiency shallow gas environments. If casedhole logs are replaced by LWT logs the elapsed time between well completion and perforation can be significantly reduced. This translates directly into reduced costs and earlier on production dates.

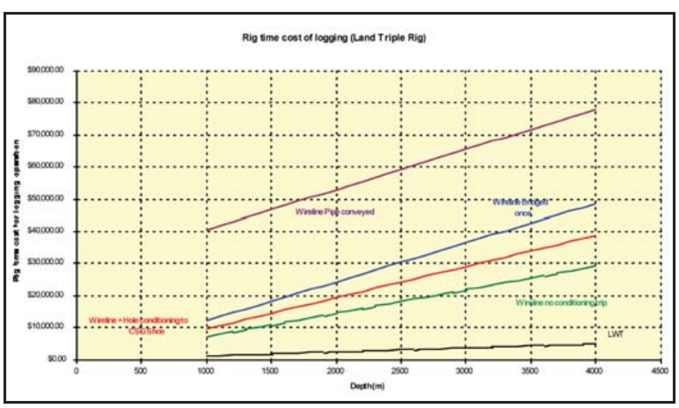

Figure 2: Graph comparing cost of logging using different methods. Note the LWT curve in black at the bottom of the graph.

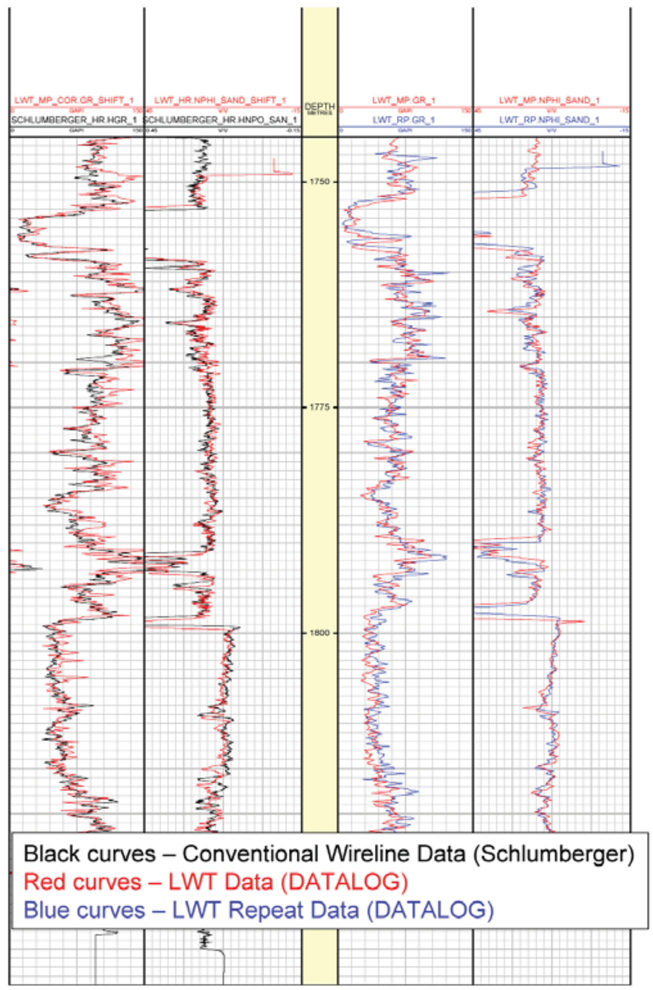

Figure 3: Comparison of conventional wireline date to LWT data in a clastic interval.

Continued on page 19…

Logging While Tripping *… continued from page 18*

Measurements

The LWT sensor package is confined to work within the drill string. This imposes limitations on measurements as pad type tools such as density or dipmeters cannot operate in this mode. Currently Compensated Neutron Log, Gamma Ray, Spectrum Gamma Ray and Induction have been tested with the LWT system. Induction measurement is done through non-conductive composite LWT subs. The addition of any pad tool requires opening ports in the drill string for logging.

Case History

A major E&P company (Anadarko) has used LWT technology on two development wells in the Western Canada Sedimentary Basin to evaluate this method for its logging requirements. Normal and high-resolution tool response in both shaly sands and carbonate formations were obtained and compared favorably to conventional openhole wireline logs. Operational aspects of drilling with LWT subs, depth control, circulation and hole clean out while logging with LWT were successfully demonstrated. The following examples are logs overlays from these wells.

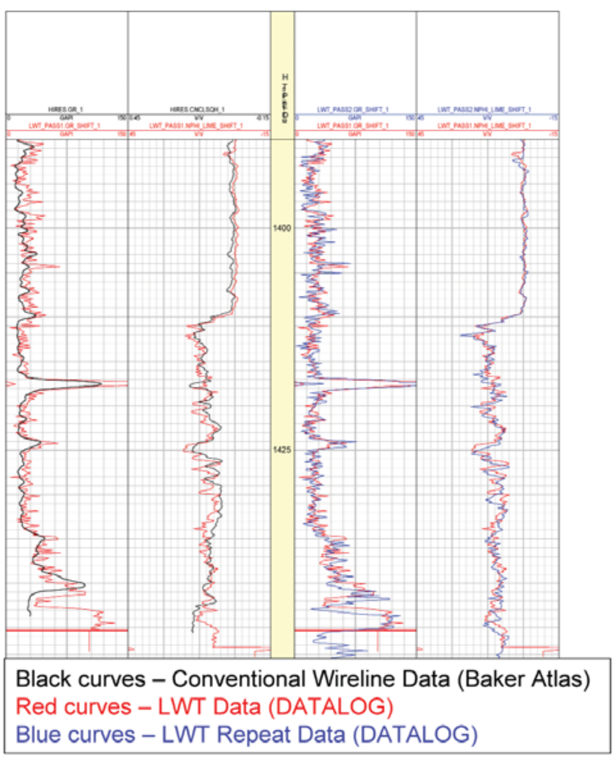

Figure 4: Comparison of conventional Wireline date to LWT data in a carbonate interval.

About the Authors

Ramin Zamani is Division Manager for Datalog LWT Limited. In Calgary, Alberta. He is currently developing all aspects of LWT technology for Datalog. He started his oilfield career with Schlumberger in 1991. Mr. Zamani is a Sharif University of Technology graduate with a B.Sc. degree in Petroleum Process.

Dave Kelly has been a geologist with Anadarko Canada Corporation since graduating from the University of Calgary in 2000. His experience with Logging while Tripping began while working in Anadarko's Petrophysics department.

New Members

Edward Bell, TransGlobe Energy Corp
Douglas Boyd, ZADCO
Gary Bugden, MD Totco
Addy Chow, BP Canada Energy Company
Bob Cluff, The Discovery Group
Sheldon Ligad, Burlington Resources Ltd.
Kent Newsham, Apache Canada Ltd.
Ronald Quillian, Pangaea Consulting Inc
Byron Veilleux
Janet Wegner, BP Canada Energy Company
Tony Grimison, Burlington
Kathleen Matthews
Howard Brekke, Western Energy Corporation
Terry Gardner, Schlumberger Information Solutions
Milovan Fustic, University of Calgary, Geology & Geophysics
John Hull, Hotwell Canada Ltd.
Bill Brown, Snake Oil Inc
Saeed Davari

Dion R. Lobreau
CWLS Membership Chairman

WHAT'S NEXT? Where is our Industry Heading?

CSPG • CSEG • CWLS Joint Convention
May 15 – 18, 2006

Call For Abstracts

The 2006 convention will be a joint meeting of the Canadian Association of Petroleum Geologists (CSPG), the Canadian Society of Exploration Geophysicists (CSEG) and the Canadian Well Logging Society (CWLS). It will be the first time since 1998 that these three Societies have teamed up to present a joint convention.

The Oil & Gas industry has been on a wild ride over the past few years, and with this in mind we chose as our theme WHAT'S NEXT? Where is Our Industry Heading? These questions are on the on the mind of everyone who works in the exploration industry, and it is hoped that our exhibitors, the technical programme and the social events will showcase this theme and light the way forward.

The technical programme is soliciting scientific, technical and business presentations that address the "What Next" for Canada's upstream petroleum industry in a sustainable and socially responsible manner. The "Key Challenges" to what's next are posed as a series of thematic questions intended to motivate contributors to address the issues of replacing production, finding new reserves, and identifying future resources in a variety of settings. Please join us in this quest to create a roadmap to the future, with your contributions to the oral, poster, core, short course and field trip components of the meeting.

Invitation to Submit

You are invited to submit a paper abstract to the following proposed oral and poster sessions:

- Unconventional Gas
  - -Can unconventional gas compete?
  - -How can we evaluate potential without production testing?
- Tar Sand & Heavy Oil
  - -What are the limits on production?
- Offshore, Arctic, Foothills & Deep Carbonates (Frontiers)
  - -Is the Arctic the next Saudi Arabia?
  - -Will Canada's Offshore realize it's dreams?
  - -Is there additional deep gas in the foothills & deep carbonates?
- New Petroleum from Old Basin Plays
  - -What can we bring from old plays and old basins?
- Business
  - -How long can this continue?
- New Technologies & Techniques
  - -The tools in the toolbox – what's new?
- International
  - -Can Canadian companies compete internationally?
- Environmental
  - -Can companies respond to and anticipate the environmental challenges today and tomorrow?
  - -How can we minimize the environmental impact of heavy oil operations?
- What's Next?

Submittal Process

You must submit an abstract in conformity with the requirements below if your presentation is to be accepted. The deadline to submit abstracts for oral, poster and core presentations is **JANUARY 31, 2006.** Late submissions will not be accepted.

All abstracts should be submitted online at www.GEOconvention.org. Only electronic submissions will be accepted.

Abstracts submitted by the deadline should be either a short abstract of 250 words or less or a final extended abstract, not exceeding four pages, following instructions and format that will be available on the convention website at www.GEOconvention.org. Authors of accepted presentations who submitted short abstracts by the January 31st dead line will have the opportunity to submit extended abstracts, prior to a later date for inclusion on the conference CD-ROM. To maintain a high quality within the 2006 Technical Programme, abstracts will be accepted based on the review and recommendations of session chairpersons and the availability of oral and poster session slots. All accepted abstracts will be published on the CD-Rom for distribution to delegates attending the 2006 Convention. Abstracts may also appear on-line on the convention website. Abstracts **will not** be edited before publishing so please ensure you have edited it prior to submittal.

Oral Presentations

Oral presentations will be 25 minutes in length with a short question and answer period. Presentations should be prepared in single screen electronic format (i.e. power point presentation) exclusively.

Poster Presentations

Poster Presentations will be set out for the duration of the convention. Posters will be presented as either one (1) or two (2) 4' x 8' panels. Presenters are required to indicate their preference for the number of poster boards with their abstract submission by the January 31st deadline. They are also responsible for additional materials including laptops, spot lights, microscopes etc., at poster booths.

Core Presentations

Core presentations may also be submitted online. Submission procedures and deadlines are the same as those for Oral and Poster Presentations. Core samples will be presented at the AEUB Core Research Centre on Wednesday, May 17 & Thursday, May 18.

Field Trips & Short Courses

Individuals interested in leading a field trip or delivering a short course are encouraged to contact the Technical Co-Chairs.

For More Information, please contact

Mark Cooper
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WHAT'S NEXT? Where is our Industry Heading?
2006 CSPG CSEG CWLS Joint Convention
c/o CSPG Office
#160, 540 – 5th Ave SW
Calgary, AB T2P 0M2
(403) 264-5610
www.GEOconvention.org

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 MasterCard, AMEX 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____

BUSINESS
PHONE:...

RESIDENCE
PHONE:...

PROFESSIONAL
DISCIPLINE:..

....

SIGNATURE:..

DATE:.. , 20 ....

CWLS SPONSORS: (Members in good standing)

Name: ....

Phone:..

Name: ....

Phone:..

FEES

Please enclose initiation fees (Cheque, money order, MasterCard, AMEX or Visa) with the application of membership and mail to:

Membership Chairman
The Canadian Well Logging Society
2200, 700 – 2nd Street S.W.
Calgary, Alberta T2P 2W1
Canada

Tech Corner: Efficient Evaluation of Existing and Bypassed Pay in Older Generation Wells – A Case History

A. Shaw, S. Ahloy, G. Horel – Baker Atlas, B. Urlwin, Waveform Energy

Overview

This case history describes the use of a 43mm (1-11/16 inch) combined carbon oxygen (CO) and pulsed neutron capture (PNC) instrument to evaluate existing and bypassed pay in older generation wells. Two wells are used to illustrate the data analysis techniques that quantified current producing oil from the Basal Belly River formation (Upper Cretaceous sand), highlighted additional potential commercial oil bearing formations, and finally located bypassed gas which produced in commercial quantities when perforated.

Background

Within the Pembina field (Twp. 47 Range: 4W5) a number of wells drilled in the early 1960's, and some drilled as recently as 1992, are currently producing oil, on pump, from the Basal Belly River formation, an Upper Cretaceous predominantly continental sandstone. The operator of the field wanted to optimize existing production by quantifying reserves through re-evaluation of water / oil saturations after years of historical production. In addition the potential of bypassed pay – both oil and gas – was to be investigated, occurring in the Lower and Upper Belly River formations (Figure 1).

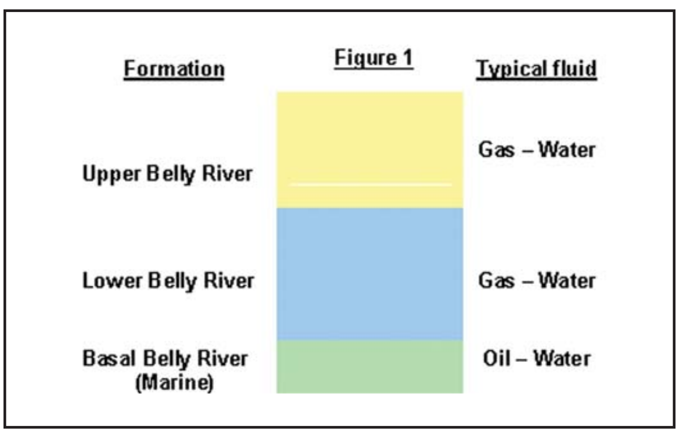

Figure 1

The challenge in this environment is to distinguish oil from fresh water (R_w between 0.48 to 0.56 Ohm-meters @ 25°C) and identify bypassed gas in sand formations with typical porosities in the range of 18-20%. Due to the 1960's vintage of most of the wells, the original open hole wireline data is limited to an Induction Log (IEL) and MiniLogs (ML). No information about the borehole or cement quality exists on most of these well in the area of interest.

The Reservoir Performance Monitor (RPM-C series) was selected as the means to provide an efficient cased hole evaluation of bypassed and existing pay in a series of wells. The RPM is a 43 mm diameter by 9.1 m in length logging instrument, making it flexible in terms of rig up from a mast or crane and providing maximum ability to enter the majority of well and tubular geometries.

The through-tubing multifunction pulsed neutron instrument has varied operating modes allowing pulsed neutron decay (PNC), pulsed neutron spectrometry (CO), pulsed neutron holdup, neutron activation water flow, and radioisotope measurements. The modes of operation can be selected from the surface. The instrument offers improved CO and PNC measurements due to an innovative 3 detector design which offers additional response ratios. The instrument is much less statistical than previous generation pulse neutron devices due to higher count rates and improved detector design.

Instrument Theory and Concepts

The downhole instrumentation consists of a telemetry section containing the telemetry and a gamma ray detector for correlation, a detector section also containing three NaI gamma-ray detectors (short space SS, long space LS, and extra long space XLS) arrayed above a new neutron generator source section containing the pulsed neutron source with its associated electronics. The selection of the operating mode is made with the surface software, which automatically selects the pulsing mode for the source and the timing gates for the detector data acquisition.

The high-output source and fast detector electronics of the RPM produce high gamma ray count rates. This is particularly important for the CO and PNC modes where high precision is desired. The statistical precision of the C/O log is approximately 0.004, reducing the statistical uncertainty in the saturation measurement to approximately 5%. In the PNC mode inelastic count rates of over one million counts per second yield a precision in the sigma log approaching 0.1 capture units.

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In the pulsed neutron capture mode (PNC) the source is pulsed at 1 kHz with a source burst width of 60 microseconds and records a complete time spectrum for each detector. An energy spectrum is also recorded for maintaining energy discrimination levels. Time spectra from short-spaced and long-spaced detectors can be processed individually to provide traditional thermal neutron capture cross section information, or the two spectra can be used together to automatically correct for borehole and diffusion effects and produce results that are very close to intrinsic formation values.

In the pulsed neutron spectrometry mode, the instrument pulses at 10 kHz with a burst width of 40 microseconds, and records full inelastic and capture gamma ray energy spectra from each detector. These data are processed to determine critical elemental ratios including carbon/oxygen and calcium/silicon from the inelastic spectra and silicon/calcium from the capture spectra.

Instrument Theory – Pulsed Neutron Capture

The RPM-C tool uses a neutron generator which emits fast, 14 MeV (Million electron Volt) neutrons. The neutrons enter the formation and borehole where they undergo several types of interactions. Each source pulse is timed to last 60 microseconds and pulsed every 1000 microseconds. A neutron cloud is generated with particles emanating from the source and radiating out in to the formation. The neutrons interact with the cement, formation, and borehole / formation fluids. As the neutrons spread out and collide with surrounding molecules they loose energy. Once the neutron particle is of sufficiently low energy it is captured by a surrounding molecule. Different materials have different abilities to capture neutrons (capture cross-section). When neutrons are captured gamma rays are generated. It is when, and how many, of these capture gamma rays reach the detector, which is measured by the RPM tool.

The rate at which the thermal neutron population is captured can be determined from the total number of capture gamma rays recorded as a function of time. This time decay spectrum can provide information about those elements with large cross sections for (or high probabilities of) thermal neutron capture. Chlorine has a high thermal neutron capture cross section, and of the common elements, it plays the most important role in pulsed neutron capture logging. A formation with a high thermal neutron capture cross section, ∑ usually contains a high saturation of salt water, while a formation with a low value of ∑ can be hydrocarbon bearing or tight.

In the Pulsed Neutron Capture (PNC) logging mode, the detectors record the arrival time of the gamma rays, from which the formation Sigma (∑) is determined. Time spectra from short-spaced and long-spaced detectors can be processed individually to provide traditional ∑ information. The multiple spectra are processed simultaneously to correct for borehole and diffusion effects, producing a real-time corrected formation ∑ measurement. In addition to sigma measurements, a number of auxiliary curves are available such as RIN, RICS, and RATO, a porosity indicator.

Instrument Theory -Carbon/Oxygen Logging

Since oil contains carbon and no oxygen, while water contains oxygen and no carbon, a ratio of carbon over oxygen can be used to distinguish between oil and water regardless of the water salinity (Figure 2). The RPM-C/O acquisition mode is used to detect hydrocarbons when formation waters are fresh, brackish, or of mixed or unknown salinity. In this mode, direct measurements of the oxygen and carbon content of the reservoir are made, allowing differentiation of hydrocarbon zones from water-bearing zones. The plots shown in Figure 2 are for a 6-inch borehole. In a larger borehole, there will be more difference between the pairs of curves for the water-filled and oil-filled boreholes.

The right plot shows similar information for a sandstone formation. The basic response is about the same, but the C/O values are lower since there is no carbon in the sandstone rock.

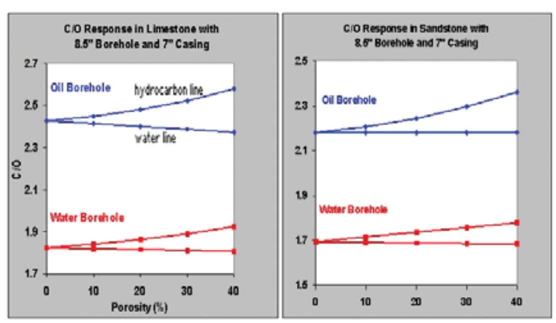

Figure 2: These "fan plots" illustrate the principle of the C/O saturation measurement. Generally speaking, the C/O ratio will be higher in hydrocarbon zones than it is in water zones. Other factors such as oil in the borehole and carbon in the rock minerals also affect the measurement. The left plot here shows expected C/O values for water and oil saturated limestones. The lower pair of curves, shown in red, are for a water-filled borehole, and the upper pair, shown in blue, are for an oil-filled borehole.

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Logging Strategy

The optimum number of passes and logging speed was determined using Baker Atlas' proprietary CO well planner. The well planner incorporates borehole geometry, mineralogy, porosity and CO detector response functions to determine minimum passes and maximum speed for desired statistical accuracy. The formation evaluation objectives dictated a logging program as outlined below:

- Single logging pass in pulse neutron (PNC) mode
  - Processed data
    - identifies gas using overlay technique
    - determine porosity
- 3 logging passes in Carbon Oxygen (CO) mode (30m/hour or 0.5/min)

Data Analysis

The CO and PNC raw data (i.e. field log) does not reveal anything informative. Through the use of rescaling and normalization of curve data, we are able to generate a simple plot that can be easily interpreted for the presence of gas. This plot technique is know as a RPM Interpretive Plot. This plot is most effective in sandstone reservoirs and sand shale sequences. It is not appropriate in carbonates or highly variable lithologies, since lithological effects are larger than any effects resulting from changes in the saturating fluid.

The RIN curve from the RPM is used as the primary gas indicator. In combination with the ISS (Inelastic short space counts) response it is used to discriminate between a tight and gas bearing zone. It is presented as a Differential RIN curve which is the ratio of inelastic counts (extra-long verses short spaced detectors) compared to a 40 meter running average. It is used on the interpretive plot for easy gas zone identification. In gas bearing zones the Differential RIN will respond negatively. It is shaded red to highlight these prospective zones. Note that the RIN curve will also respond in coals and sometimes in tight zones. There are auxiliary curves which are used to assist in the interpretation in these cases.

The Sigma and Ratio curve overlay is also an important component of the RPM Interpretive Plot. Sigma is the neutron capture cross section of the formation. Sigma responds mostly to the matrix, fluid type, and salinity. In shale zones and wet reservoirs with high salinity, sigma will read high. In clean hydrocarbon zones, or fresh water reservoirs, sigma will read low. It is difficult to distinguish between fresh water and oil using the Sigma curve.

The RATO curve is the ratio between the count rate curves for the short and long spaced detectors. This curve is similar to a neutron ratio and responds in the same way to porosity as a neutron porosity device or CNL tool. This curve will read low in a gas bearing zone and high in a clean wet sandstone reservoir.

Rescaled RATO and Sigma curves are overlaid and plotted on a reversed scale. Because Ratio and Sigma both tend to read low in a potential reservoir, this plot assists in identifying potential reservoirs. Also, when the Sigma is low and the ratio is higher, a green shaded crossover occurs, and is indicative of a move from saline fluid or gas towards fresher fluid or oil.

Interpretation Results – Well A

The CO analysis is displayed for well A (Figure 3). The Lower Basal formation is the existing oil producing zone. The CO identified current water saturations in the order of 60%. This zone was producing, on pump, 72m^3 water per month, 23m^3 of oil per month, and some associated minor gas.

The evaluation reveals that the upper zone of interest – the Lower Belly River formation – typically regarded as wet, non hydrocarbon producing shows similar (slightly lower) oil saturations, particularly in the upper zone. The operator adopted the strategy that when the lower zone watered out and was abandoned, the upper zone would be perforated to reduce risk of too much incremental water production associated with the oil in place in the Lower Belly River.

Interpretation Results – Well B

In the second well the PNC data is considered (Figure 4).

A particularly useful gas indicator in formations like the Belly River is the RIN curve (when used in conjunction with other RPM data). This curve is the ratio of the inelastic counts (0 to 100 microseconds) from the long spaced detectors compared to the short space detector. From empirical evidence, using an overlay technique, this measurement has been found to be sensitive to gas. The RIN value typically declines when it detects gas in the formation. It is a qualitative measurement subject to interpretation. It is not possible to make quantitative interpretations from the size of the RIN response when using this overlay technique.

The RIN overlay (ratio of inelastic counts between detectors) data reveals a zone with bypassed gas. In a clean sand zone, at 960 – 963 m, RIN overlay declines, Sigma read low and slight

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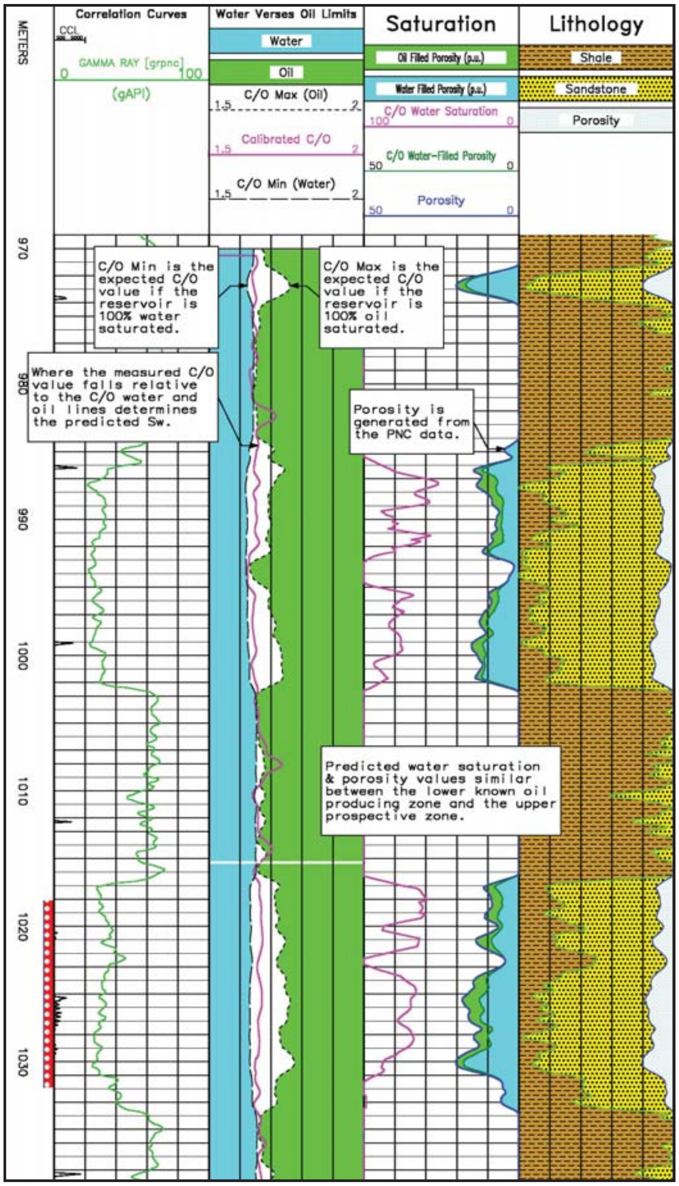

Figure 3

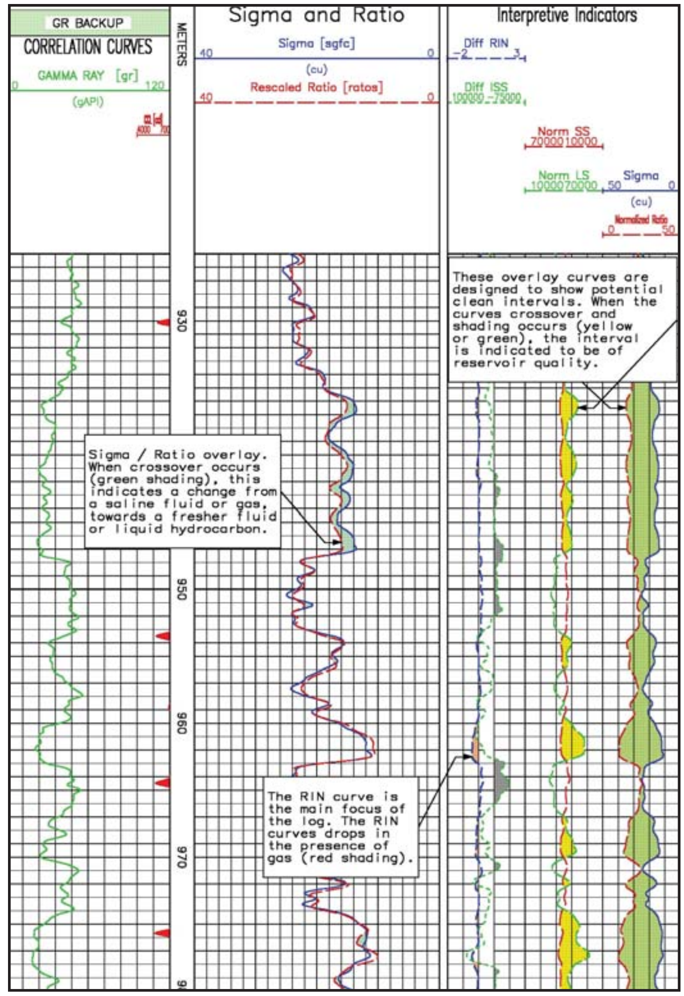

Figure 4

cross over occurs between Sigma and RATO (total count long and short)

The interval from 960 – 963 m was perforated. A strong pressure response was seen and a significant economic volume of gas is now being produce from this zone.

Conclusions

Evaluation of older wells in through tubing applications can benefit from the use of technologies with multifunction formation evaluation capabilities, such as the RPM-C logging instrument. The instrument operates in different modes to provide several different measurements which can aid in both oil and gas detection. In gas applications it can be run in PNC mode to accurately identify gas zones using RIN, Sigma, Ratio and Long and Short Spaced counts from its three NAI detectors. In formations such as the Basal Belly River or formations with water of unknown salinity where there is an active water flood the tool can also be employed to locate bypassed oil by running the RPM instrument in its Carbon Oxygen (CO) mode. The tool design is modular with no section longer than 3 m (10 feet), for ease of handling and transport. It can be combined with standard and advanced PLT instruments for simultaneous measurements where warranted.

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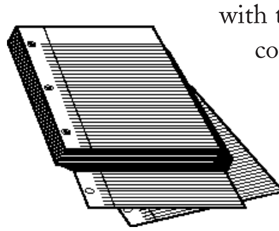


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Flare 03 on a Husky well on November 12, 2003.
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