InSite

CWLS Magazine
Dec 2005 Issue 4 Volume 24

CANADIAN WELL LOGGING SOCIETY
1955 – 2005

Inside this issue…

11 Underbalanced Foam Drilling

21 Composite Colour Display of Spectral Gamma-Ray Logs

InSite

CWLS Magazine December 2005

Issue 4 Volume 24

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Cover Photos: *A cool and wet night on Precision 296. Photo courtesy Lazar Rajcic.*

Vibroseis units shooting a 3-D seismic survey in NEBC, March 2205. Photo courtesy Robert Bercha

If you have a photo that the CWLS can use on its 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:

Front row from left to right: Carley Gyori, Richard Bishop, John Nieto, Ken Faurschou, Dion Lobreau
Back row from left to right: Jeff Levack, Ben Urlwin, Gary Drebit, Robert Bercha

President's Message

Well, the CWLS' 50th year is almost at a close and it's been an excellent year! It's worth listing some of the year's highlights!

We have over 500 members and have had record attendances at our lunches, (see article by Treasurer, Gary Drebit, in this edition) plus an outstanding unconventional reservoirs joint-SPWLA topical conference at Kananaskis (a first for the SPWLA outside the USA!) and also a successful 50th anniversary lunch in October! We've seen even more value in joining the CWLS with our new website, offering newly designed Rw catalog, special core analysis database, on-line member services and new "community of practice" site, which I think will be the way we communicate work-related questions in the coming years.

We're all proud of the "InSite", it's truly a high quality magazine, stewarded by our editors Robert Bercha and Ben Urlwin.

The committee is gearing up for the elections at the end of December. Our Past President Jeff Levack has done well soliciting candidates for the CWLS executive. This task is becoming more tricky each year as people are busier, drilling more wells and with less time to devote to volunteer work!

John Nieto, CWLS President thanking Jim Klein, SPWLA President for an excellent talk

John Nieto,CWLS President , Jim Klein, SPWLA President, Ken Faurschou CWLS V-P

PLEASE, come forward next year and support your Society. Without the Executive volunteers, **THERE WILL BE NO CWLS!**

Dion Lobreau, our membership chair has been instrumental in getting the CWLS into the next millennium, with a fully web-based joining form and payment method. He will be giving the membership short demonstrations just before the upcoming lunches in December and January.

I'd also like to take this opportunity to thank the Ladies at the APEGGA (CWLS) office, Britt, Pelly and Susan for their outstanding assistance throughout the year, without them our task would be so much harder!

We're looking forward to the AGM on February 8th, this promises to be a good 'show', Ken Faurschou, our V-P having secured a controversial speaker, Dr. Patrick Moore, who used to be with Greenpeace! As always, we appreciate the support of our sponsors, and Ken will be calling to seek your help with the 2006 AGM. Thanks to you all!

So, what of the 50th Lunch? We were fortunate to have SP-WLA President Jim Klein visit us in Calgary to present his 'distinguished lecturer talk' on Petrophysical evaluation in Horizontal wells. We had more than 250 members attend the lunch and they were rewarded with a surprise 'birthday gift'

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Editor's Note

Welcome to the final InSite publication for 2005! After what has been an amazingly busy season for 2005 (with over 80% of the available drilling fleet in constant work) we are now heading into what is likely going to be a record breaking 2005/2006 winter drilling season, with personnel and services once again strained to their very limits. With the onset of the cold weather, Canada's drilling activity peaked to a record 700 plus operating rigs (out of a fleet of 762 available rigs), a level never before seen in our industry, and one that will undoubtedly be sustained through an ever increasing energy demand both within North America, and across the globe. November saw the Canadian oil and gas industry surpass the 20,000 drilled wells mark, giving the industry an almost guaranteed chance of blowing the 2004 calendar year record of 22,720 drilled well level out of the water. This is in conjunction with a possible 30,000 wells being licensed through 2005, another record benchmark.

Areas within relatively easier facilities reach are red hot with activity. However, we are also seeing a very localized drop in activity in areas that are not so close to market, such as the Northwest Territories. With huge uncertainties still hanging over the Mackenzie Valley pipeline, many operators, including Apache Canada and Paramount Resources Ltd., are putting on hold their drilling programs for this remote exploration until further progress is made with approvals and construction of the pipeline. Even with these localized low spots of activity, the oil and gas industry in Canada is operating at an unprecedented speed, with record after record being tumbled as we come to the close of 2005. This has helped fuel Alberta's economy and prosperity, with the province's surplus surging into the multiple of billions of dollars. This economic boon has been particularly noticeable in the oil and gas capital of Calgary, where property prices continue to soar, and with no obvious end to the high energy demands, are likely to continue to climb as we proceed to the end of the first decade of the second millennium.

As we proceed to the end of this first decade, the Kyoto Protocol is going to be dragged more and more into the limelight of Canada's political, and media, landscape. Nearly eight years after the Federal Government committed Canada to this protocol, and coming up one year since it became international law, Canada's Federal Government is yet to propose, let alone implement, any policies to attempt to meet our 2012 Kyoto emissions target. In fact, not only are we not on target to meet the Kyoto criteria, the latest statistics show that Canada's emissions have in fact climbed to levels nearly 24% higher than those of 1990, leaving a 30% emission target deficit to be dealt with over the remaining six or so years until the end of the original Kyoto agreement. This is contrary to PM Paul Martin's assurances that Canada will meet its Kyoto obligations. An up and coming Federal election has now forced our political leaders into addressing this issue. With no significant effort yet to be seen from our Federal leaders to address our Kyoto obligations, comments the likes of which Martin released on the weekend ("Canada will aggressively push forwards to honour its Kyoto commitments") seem to be coming a little too late to be able to be considered serious. It will definitely be an interesting Q1 of 2006 as the Federal election takes place, and an interesting last half of the first decade into the second millennium as Canada moves ahead with the other Kyoto-obligated countries to the accords' ultimate end.

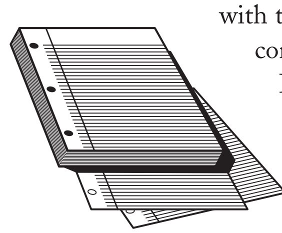
In this InSite publication, we have a variety of papers for your perusal. The first is a discussion on under-balanced drilling within coal horizons for CBM. Our second paper addresses the utility, and the subsequent display of spectral GR logs. Our final article is the next in a series presentation of Myth Interpretation of wireline logs (which all are invited to write responses to). Finally, Tech Corner has a look at surface geochemical exploration for oil and gas.

From the entire Executive Board at the CWLS, have a great holiday season, and we look forward to seeing you all again in 2006!

Robert Bercha
Ben Urlwin
CWLS Publications Co-Chairs

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 Ben Urlwin (ben@waveformenergy.com) at (403) 538-2185 or Robert Bercha (robert_bercha@anadarko.com) at (403) 231-0249.



As the Winch Turns: The Bored Derrickhand

The rig was situated on top of a hill with the lease nestled into the side of a mountain in a beautiful part of Alberta giving the rig a fabulous view of the valley below. It had been on location for six months and for all anyone knew it could be another six months before the well would reach total depth and be completed. A 4000+ meter directional well in a tough drilling area of the foothills where hole problems and slow drilling were common. The proximity to a small town, major highway, a number of campgrounds and the critical sour rating required this operation to have several services onsite with full night crews for 24 hour coverage.

Life as a rig hand on a big triple like this involved a lot of scrubbing, cleaning and long bit trips. The drilling was slow, sometimes less than one meter/hour and because of the top drive with the stands of pipe already made up, sometimes there were days between connections. The derrickhand had even less to do since there was a mud engineer onsite 24 hours per day to do the daily mud checks.

For some reason if someone from the day shift has a nap on their couch, it is just that, a nap. On the other hand if someone from the night shift even lies on the couch, then they were sleeping on the job. So, most of the service hands would join the rest of the rig crew in the doghouse for coffee and companionship through the wee hours of the morning. Usually this was when there wasn't anything good on satellite or if you have seen the same movie fifteen times in the past month and watching it again would be like consuming a drowsy form of cough syrup then trying to stay awake.

This one night in February, sometime between 2 am and 4 am is when it happened. The night sky was clear and full of brightly shining stars as the half moon was casting a little light on to the snowy lease. The air was still and crisp, a reasonable -25 degrees Celsius for that time of year. It was one of those nights you felt lucky to be working in such a place. Most of the rig crew and some of the service hands were in the doghouse for a safety meeting. Out of darkness we saw the grey outline of a figure lurking behind the draw works while slowly moving towards us. As we crowded around the doghouse window to the rig floor we peered through the foggy glass to get a glimpse of the moving shadow. To our shock and amazement it was the bored derrickhand coming to join us for the safety meeting ironically enough in nothing but his hard hat, safety glasses, and steel-toed boots. Laughter poured out of the doghouse as we were all bored too, just not that bored.

Something like that will probably never occur again with today's safety regulations and awareness combined with the increased professionalism of field staff. I'm sure by now that derrickhand has moved on to something better like a driller in charge of his crew or maybe even a rig manager.

Mike Eddy

President's Message … *continued from page 3*

from the 50th Executive – a 50th anniversary CWLS watch, ladies' and men's versions! I'm told by several of the members that their watches are still ticking after 2 months – an added bonus!

Jeff Levack and I have represented the CWLS in a CAPP initiative to work with the AEUB to design a digital format, acceptable to all, which will eventually lead to no-paper! This initiative has huge ramifications for the way we work – so stay tuned into 2006!

Finally, we need new members to stay a healthy society, we've had many more student members this year, thanks in part to a push at the Geoscience mixer – thanks to Carley Gyori our secretary and Louis Chabot our student liaison for putting on our 'best face' at this mixer! Students, don't forget your $10 gets you full membership website benefits plus FREE monthly lunches at the Palliser! Also, our scholarships need to be given to worthy students – please contact our Chair of committees, Richard Bishop – he'll guide you through the process!

I wish you all a merry Christmas and a happy, healthy New Year!

John Nieto, CWLS President.
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Message from the Treasurer

Where Does the Money Go?

Where does all the Money go? That is one of the questions I asked myself and the reason that I ran for Treasurer of the CWLS. In a previous life, I thought I was going to become an accountant. After finishing school, I decided that was not what I wanted to do. I now work in the petroleum industry trying to determine what the numbers mean, go figure. In this article, I want to address two topics that are usually commented on: Technical Lunch Fees and the InSite Magazine. Our webpage could also be commented on but I will leave that to other members of the executive.

First off, I want to say that everyone in the CWLS executive put the members first. "What is the benefit to our members?" is often heard at any of our monthly meetings. We feel that the technical Lunches are of a high caliber.

Technical Lunch

Figure 1, has technical lunches plotted from March 2004 to September 2005. February is the Fall AGM and therefore is not plotted. As well, there are no technical Lunches scheduled during the July/August break. The three lines plotted are Total Attendance (member and non-member) in Yellow, Member Attendance in Blue, and non-member attendance in purple. You will notice that the average member attendance is approximately 100 people but the non-member attendance varies depending on the talk that is presented. As an example, In September 2005 the technical talk was "Geological controls on CBM production in the Horseshoe Canyon Formation, Alberta Plains" by Olwen Wirth of MGV Energy Inc. That talk had the highest attendance. Member attendance did not change that much from previous talks but non-member attendance drove the total, as non-members represented 41% of the total attendance.

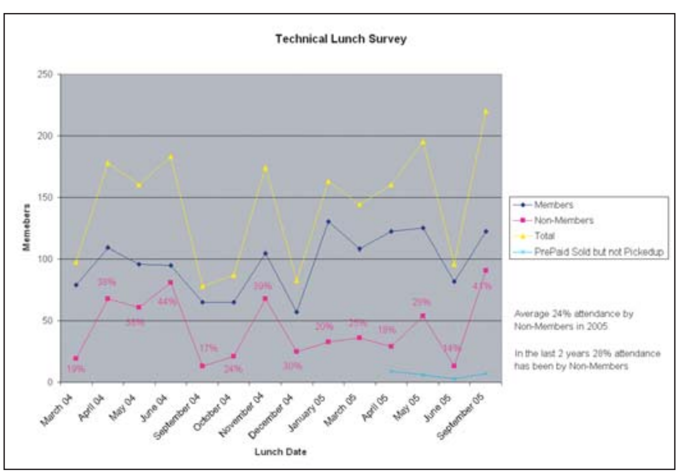

Figure 1: Technical lunch data for March, 2004 – February, 2005.

As you can see, non-member attendance drives our Technical Lunch crowd, so the challenge is; how do we convert these non-members to members? Again, that would be another article for later.

So let's concentrate on the money. We are lucky enough to have our lunches at the Fairmount Palliser Hotel. Each lunch booked costs $22.00/seat; plus 15% gratuity, plus 7% GST for a total of $26.84 per person. The Palliser also charges us for the screen and audio system, approximately $120.00. Plus there is a matter of the cocktail bar. We have discussed eliminating the cocktail bar but the cost saving are negligible in comparison to upsetting tradition. The bar costs us $200.00 minus a portion of some of the liquor sold. Therefore, on average, we usually pay the Palliser an additional $100.00. Finally, there is the award! Sometimes this award is affectionately known as the "Squatting Dog". But at a cost of $220.00, we should give this piece of art the respect it deserves.

So as an example, if we averaged 100 members and 30 non-members, at a technical lunch, our cost would be $3929.20.

Before April, we charged $25.00/ticket for members and $30.00/ticket for non-members and we allowed people to reserve seats (sometimes they did not show up). On the average we usually had 8 open seats that we could not sell at the door. Each empty seat you see at the Technical lunch costs our Society $26.84. As I mentioned before, the average attendance of a talk, by members, is 100 people. Therefore, if we assume 130 people show up our revenue would be 100 members multiple by $25.00 is $2500.00. Plus 30 non-members are $30.00/ticket would be $900.00 minus the usual 8 people that did not show up and we have a loss of $529.20. Of course a more successful talk with greater attendance would have a greater loss. Something had to be done, so in April the CWLS

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Where Does the Money Go? … *continued from page 7*

raised the ticket prices to $30.00/member and $35.00/non-member. We also removed the ability to reserve seating with option to pay at the door and therefore eliminated the constant $215.00 loss (on average – rounded).

Even at $30.00/ticket (for members) our revenue for a technical lunch is a breakeven event. Again, 100 members at $30.00/ticket is $3000.00 and 30 non-members at $35.00 is $1050.00. Our revenue for that technical lunch would be a profit of $120.80. There is very fine line between profit and loss. As you can see, sometimes our Lunches are attended by less than 100 people in total.

But with all that said, if we are providing our members something that is technically enjoyable and allows "like minded people" the opportunity to discuss the topic presented that is the goal of the technical lunch.

The InSite Magazine

Again, we feel that the InSite magazine is a good method of bringing value to our membership. I estimate our membership to be 440 members with 34 corporate members. Each member receives an electronic format via e-mail and a printed version via regular mail. Plus we also send a dozen or so magazines to Universities to promote our Society. It is also available for free download from the CWLS web site at www.cwls.org. "The Magazine is dedicated to providing a forum to its members for the sharing of information and published papers that provide current and comprehensive analysis of issues and problems that affect the search for oil and gas." YTD the magazine has cost us $13,691.72 to print.

However, our Publication Chair and co-Publication Chair continue to sell advertisements in this Magazine to help support itself. We hope to breakeven on this, as we see the members benefiting from a good publication that represents them. All articles are created by volunteer writers and only the printing/mailing is an expense. It reaches the decision-makers and key target audience so it makes sense to advertise. CWLS InSite rates can be seen on Figure 2. YTD collections for advertising is $12,327.00 minus YTD mailing out costs of $3,066.00 gives the operating cost at a loss of $4,430.72.

As you can see, most of the revenue we collect from Corporate Sponsorships helps us keep our Society active. Platinum Corporate Sponsorship is $1000.00 and we have 4 companies that do that. Gold Sponsorship is $500.00 and we have 11 companies, 4 companies at silver sponsorship with $250.00 and 15 companies that help us with a bronze sponsorship of $160.00. With this additional $12,900.00 we offset our cost for technical lunches and the InSite Magazine.

Final thought

I want to mention that past executive members have done a great job of saving money and that helps us defer the cost of some of our other projects. In July of 2005 I converted one of our GICs to a Corporate AAA bond. The GIC was collecting 2.5% interest and was due at that time. Instead of reinvesting it in the same vehicle, the executives voted to re-invest our $110,000.00 at 6.7% interest in that bond. The amount is significant and will ensure that our Society will be around for another 50 years.

Gary Drebit, CWLS Treasurer

Ad Size *(per issue)*

	1 Issue	2 Issues	3 Issues	4 Issues
Full page – 7.5" x 9.75"	$475	$450	$425	$400
1/2 page – 7.5" x 4.25"	$300	$285	$265	$250
1/4 page – 3.5" x 4.25"	$200	$190	$18	$170
1/8 page – 7.5" x 1.5"	$125	$120	$115	$110
Business Card – 3.5" x 2"				
(Non-member)	$75	$72.50	$70	$68.50
(Member)	$40	$35	$30	$25

Figure 2 – CWLS InSite advertising rates

New Members

Vlad Iglesias, Tucker Wireline
James Mott, Primordial Energy Ltd.
Granger Low, Proven Reserves Exploitation Ltd.
Chris Colbourne, Ryder Scott Petro. Consultants
Hesham Moubarak
Richard Xu, Crewes Project, U of C
James K. Robertson, BC Oil and Gas Commission
Jordan Davidson, Hotwell Canada Ltd
David Fowler, University of Calgary
Jarred Atkinson, University of Calgary
Tyrus Bender, University of Calgary
Dan Hermary, University of Calgary
Dennis Melrose
Jean-Francois Gagnon
Alessandro Deminico
John McMullen, Medora Resources
Dean Williams, Devon Canada
Anne Lamont, Anadarko Canada
Tom Buxton, Schlumberger Canada Ltd.
Maggie Malapad, Schlumberger of Canada
Lynette Wopnford, Nexen Inc.
Basim Faraj, Talisman Energy
Rob Duthie, Baker Atlas
Les Crowder, Kuwait Gulf Oil Company
Chris Ayadiuno, Encana
Brad Golinowski, Athena Resources
Kirk Stewart, RECON Petrotechnologies
Douglas Schmitt, U of Alberta,
  Inst. for Geophysical Research
Lino Ramirez, University of Alberta
Wallace James, Hunt, Wallace & Associates LLC
Vikram Sen, University of Calgary
  – Chem & Petroleum Eng
Zacharia Odio, Prospectors Corp.
Bahaa Beshry
Paul Nielsen, Anadarko Canada Corporation
Kelly Skuce, Burlington Resources
Dean Rokosh, EUB/Alberta Geological Survey

Dion R. Lobreau
CWLS Membership Chairman

An ancient meteorite crater at the head of a wadi in Yemen. The crater is estimated to over 300,000 years old. Photo courtesy of Ben Urlwin

Underbalanced Foam Drilling – Production Optimization and Risk Mitigation for CBM Projects

Lee Campbell, Weatherford International
Brant Bennion, Hycal Research Laboratories

Abstract

The recent trend to drill long horizontal sections through coal seams, as opposed to vertical wells, has forced more attention on ways to minimize the skin damage to these reservoirs. Historically underbalanced CBM wells have been drilled vertically with air and then cavitated. This technique minimizes skin damage while increasing productivity. This paper proposes that drilling underbalanced horizontal wells through coal seams with foam as the drilling fluid will increase the productivity of the well while reducing the operational risks associated with this type of drilling.

A Canadian study was undertaken recently to evaluate techniques that could be applied to improve the productivity of coal bed methane (CBM) reservoirs. Since the emergence of CBM drilling in Canada, the majority (300-500) of wells have been drilled vertically with conventional overbalanced fluids, and out of these only one has been drilled horizontally.

A series of core flood tests were conducted to evaluate formation damage and the effects of overbalanced drilling operations in coal bed methane applications in Alberta. The objective of the tests was to quantify the skin damage to the cleat system of a coal reservoir with a variety of water based drilling fluids including a foam base fluid. The results showed that all of the tested drilling fluids would significantly damage coal reservoirs if they entered the cleat system. To minimize this apparent skin damage it was proposed to maintain a bottom hole pressure (BHP) less than the near wellbore reservoir pressure at all times (i.e. drill in an under-balanced state). It was proposed that a correctly engineered foam system could be used to mitigate some of the risks associated with drilling CBM wells.

The results indicated that a horizontal well drilled with foam that intersects the direction of maximum permeability while maintaining an optimized underbalanced state would have the potential to significantly improve the overall productivity of a CBM well.

Introduction

In recent years more and more coal bed methane (CBM) wells have been drilled horizontally. This technique is gaining recognition within the industry because if applied correctly, horizontal drilling through CBM reservoirs can have several distinct advantages over vertical wells. One of the key features of CBM reservoirs is that they are naturally fractured with the presence of a cleat system. Face cleats are analogous to vertical fractures and propagate continuously through out the seam. Butt cleats are discontinuous fractures that terminate at the face cleats. This is the macropore system that contributes to the permeability of the reservoir.

The result of this ordered fracturing within the coal seam leads to an inherent anisotropic permeability that is associated with CBM reservoirs. It has been shown that a properly drilled and completed horizontal well that intersects the large permeability axis (i.e. perpendicular to the face direction) will result in better production than a fractured vertical well (Deimbacher, SPE 21280). In addition to this, is the increased cross sectional area exposed, allowing reservoirs to be de-watered more quickly, increasing the NPV of the gas reserves. It was shown in King and Ertekin (SPE 13091) that the length of the wellbore had a greater influence on both the initial and long-term production rates than the number of wellbores drilled. Due to this, fewer wells are required to be drilled to achieve the expected production, which can lead to reduced development costs and a reduced environmental impact.

However one factor that needs to be addressed when considering drilling horizontal sections through a coal seam is formation damage. Formation damage becomes more of an issue as more of the coal seam is exposed and for a longer time. One technology that has recently been looked at to improve the efficiency of CBM wells is underbalanced drilling. Underbalanced drilling can help mitigate formation damage due to prevention of fluids invading the coal matrix.

There are two main mechanisms of formation damage in coal seams. The first is thought to be due to chemical adsorption of the drilling fluid chemicals to the coal surface. This causes sorption induced swelling of the coal matrix and reduces the coal seam permeability (Puri et al SPE 21813). The other mechanism of damage is due to invasion of fines, which cause plugging of the cleat system.

The use of foam as an underbalanced drilling fluid has increased significantly in the last few years. There are numerous reasons that foam is becoming the underbalanced fluid of choice within the industry. Foams give improved flow profiles as compared to 2-phase systems as they produce a much more

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Underbalanced Foam Drilling *… continued from page 11*

homogenous flow regime in the annulus. This minimizes slug flow and allows greater control of pressure transients on surface. In addition, the inherent high viscosity associated with foam provides superior hole cleaning to both 2-phase and single-phase flow. With the advent of recyclable foams the environmental management of the fluid is reduced as the system can be run in a closed loop environment.

Experimental Results of CBM Formation Damage Paper

Since no coal samples were available from the wells in the area of interest, samples of coal removed from an analog McRae coal seam that was surface mined on the eastern flank of Grass Mountain in Alberta were used for this study. These heavily fractured/cleated samples were cast in epoxy to maintain and preserve cleat integrity, 3.81 cm plugs were then drilled out of the extensively cleated areas of the coal for testing purposes (see Figures 1 and 2). Permeability to air of the 'dried' cleated coal samples, under nominal overburden pressure varied from 0.2 to 110 mD and porosity from 1.8 to 9.7% (Table 1). A suite of fairly similar mid permeability range samples was selected for testing purposes. The tests were conducted using a 3% KCl solution to simulate inert formation brine and measure the reduction in cleated coal brine permeability caused by overbalanced drilling fluid contact. Since the coal must be dewatered prior to commencement of gas production, maintaining high permeability to water is essential to ultimately maximize productivity to gas and hence the selection of the brine as the primary initial producing phase used in this test as the permeability measurement fluid. Seven different overbalanced drilling fluids and one simulated underbalanced fluid base system (tested in an overbalanced mode to simulate formation damage that would occur if the underbalance pressure condition were to be lost) were blended and supplied for testing.

Figure 1 – Coal Seam Sample Cast in Resin for Drilling

Figure 2 – Illustration of Drilled Intact Coal Plug with Fractures and Cleats Preserved for Mounting for Formation Damage Testing

Routine Core Analysis

Sample No.	Air Permeability (mD)	Porosity (fraction)
SP1	0.24	0.018
SP2	6.62	0.028
SP3	14.33	0.023
SP4	14.79	0.028
SP5	47.19	0.050
SP6	110.96	0.036
SP7	13.76	0.036
SP8	20.71	0.038
SP9	101.66	0.097
SP10	5.31	0.021

Table 1 – Routine Analysis of McRae Coal Seam Samples Used In the Formation Damage Studies

The core samples to be tested were mounted using the equipment illustrated in Figure 3 using high capacity flow heads to conduct whole drilling fluid across the face of the core sample. Core samples were maintained at the specified reservoir temperature of 20°C and a net overburden pressure of 8900 kPa was applied to each sample to simulate the net effective overburden stress in the reservoir.

Continued on page 13…

Underbalanced Foam Drilling... *continued from page 12*

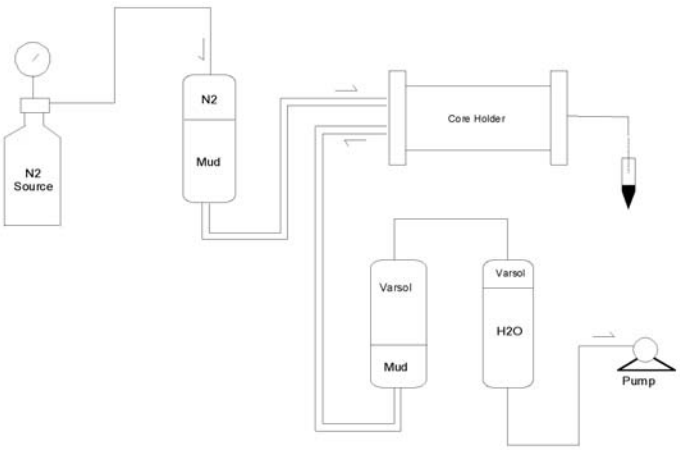

Figure 3 – Coal Seam Drilling Mud Formation Damage Test Apparatus Schematic

All of the 'synthetic' mud samples had representative volumes of coal microfines (< 38 microns) added. This simulated suspended solids concentrations which occur downstream of solids control equipment at the drilling rig and thus simulated bit generated solids naturally present in the field drilling fluids (the field mud already contained drill solids and hence no additional solids were added to this fluid system). The following procedure was then used for each sample:

1. Displace brine (3% KCL) through the core (Forward Direction 1) at the specified reservoir conditions to determine the initial effective permeability to gas at immobile water saturation. This displacement is conducted at low rate to minimize the potential for fines migration.
2. Displace supplied whole drilling fluid (rock microfines in suspension) across the simulated formation face (Reverse Direction 2) at representative field overbalance conditions. Track dynamic fluid loss and measure formation of the mud filter cake occurring at the formation face as drilling fluid filtrate leaks off into the simulated near wellbore region.
3. Displace brine in the original flow direction (Direction 1) at incrementally increasing draw down pressures and measure stabilized permeability to brine at each pressure. The threshold pressure regain technique is used to determine the minimum pressure range at which the rock begins to flow. By comparing pre- and post-leakoff permeability values, the relationship between drawdown cleanup pressure and permeability impairment is defined relative to the specific test mud attributes, overbalance conditions, and reservoir rock quality utilized.

Major salient results of the experimental lab program are summarized in Table 2.

The test results in Table 2 indicate that damage was significant with all of the overbalanced mud systems tested. A portion of the damage is likely due to mechanical damage associated with the 3% by mass drill solids (coal fines pulverized to less than 40 microns), which were added to each mud system prior to testing to simulate drill solids present in a normal circulating drilling fluid. Chemical adsorption may be the other dominant contributing damage mechanism. The Kelzan plus Drispac system had the best combination of fluid loss and damage of the systems evaluated. The base foam system was tested in a bro-

Sample Number	Fluid Tested	Routine Dry Air Perm (mD)	Porosity Fraction	Overbalance Pressure (kPa)	Fluid Loss in 240 min (cc)	Initial Brine Perm. (mD)	Final Brine Perm. (mD)	Reduction by Mud Contact (%)
9	Pure Drispac	20.71	0.038	5000	37.1	3.32	0.739	-77.7
7	Kelzan + Drispac	13.76	0.036	5000	3.9	1.38	0.332	-76.0
3	Kelzan XCD pH = 12	14.22	0.023	5000	4.6	0.86	0.112	-87.0
4	Kelzan XCD pH = 7	14.78	0.028	5000	1.8	1.42	0.295	-79.2
5	Base Foaming Solution	47.19	0.050	1000	127.8	1.17	0.269	-77.0
7A	Kelzan XCD Field Mud	29	0.025	5000	20.6	5.14	1.39	-72.9
5A	Kelzan XCD + Fiber Bridging Agent	55	0.027	5000	5.3	8.94	1.23	-86.3
3A	Barite/Bentonite Based Mud	21.5	0.020	5000	156.2	2.22	0.556	-74.9

Table 2 – Summary of Coal Bed Methane Overbalanced Drilling Fluid Formation Damage Test Results

Continued on page 14...

Underbalanced Foam Drilling *… continued from page 13*

ken fashion, simulating a loss of the underbalanced condition and the displacement of solids laden base foaming solution slightly overbalanced into the formation. This indicates a loss of the underbalanced condition during an under-balanced drilling (UBD) operation will cause damage comparable to that experienced with conventional overbalanced fluids, and highlights the importance of proper design to ensure that the UB condition is maintained on a constant basis throughout the drilling and completion operation in the coal seams.

Underbalanced Drilling Techniques

The results from the core flood tests described above indicate that to minimize formation damage to the coal matrix, fluid and solids invasion has to be prevented as much as possible. One technique available to achieve this is underbalanced drilling (UBD). Underbalanced drilling is characterized by a circulating downhole pressure along the wellbore less than the reservoir/formation pressure in the zone adjacent to the wellbore (near wellbore pressure) resulting in reservoir fluid controlled inflow while drilling. An underbalanced horizontal well schematic is shown in fig. 4.

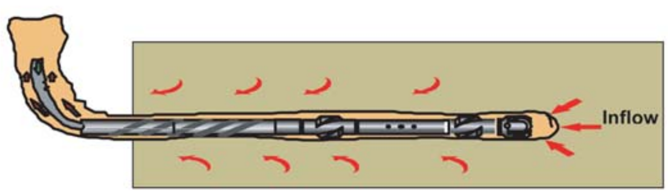

Figure 4

Foam Drilling

Foams consist of a continuous liquid phase, forming a cellular structure that surrounds and entraps a gas (fig 5). Water alone will not form foam, as any bubbles that are created coalesce as soon as they touch one another. A surfactant, or foaming agent, in the liquid phase, stabilizes the films that form the bubble walls, which allow the foam structure to persist. Foams can have extremely high viscosities; in all instances their viscosities are greater than that of both the liquid and the gas that they contain. At the same time, their densities are usually less than one-half that of water. With this combination of high viscosity and low density, foamed drilling fluids can provide several benefits to drilling operations.

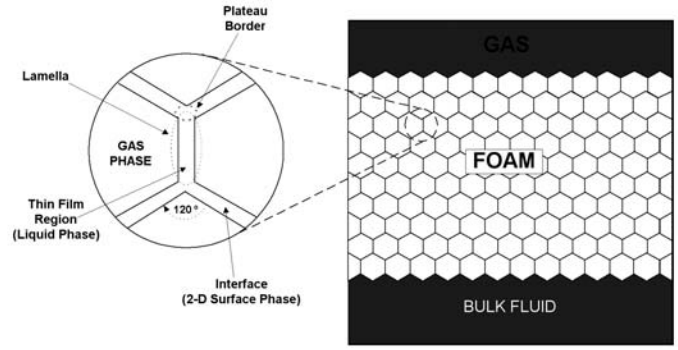

Figure 5 – Anatomy of Foam

Air is most commonly used as the gaseous phase in foam drilling with water as the liquid phase. It is possible however to make foam with other gases such as nitrogen, carbon dioxide and natural gas. Because the liquid phase is continuous, foam formed with air will not normally permit combustion of produced hydrocarbons or in the case of CBM drilling the coal itself. Air foams are frequently used in fire-fighting to extinguish burning hydrocarbons.

Foams typically contain a high percentage of gas (55% – 96%). This number is referred to as the foam quality. A foam quality greater than 96% causes the fluid to behave as a mist. When the foam quality is less than 55% the fluid acts as a 2-phase fluid. Because of this high percentage of gas, foams can be formulated to have a wide range of fluid densities from as low as 50 kg/m3 to 780 kg/m3 equivalent circulating density.

In addition to formation damage issues discussed above there are a number of drilling related problems that are encountered while drilling CBM wells. Like conventional wells the correct fluid selection can alleviate all or most of these problems while still providing a cost effective operation. Some of the problems experienced while drilling CBM reservoirs are listed below, and will be discussed presently.

- Poor Hole Cleaning
- Wellbore Stability
- Lost Circulation
- Differential Sticking
- Water Inflows

In comparison with conventional overbalanced fluids and air/mist drilling the use of foam as the drilling fluid can mitigate these issues.

Continued on page 15…

Underbalanced Foam Drilling *... continued from page 14*

Hole Cleaning

One of the main problems when drilling coal seams either over or underbalanced is hole cleaning. The unique fluid chemistry associated with foam systems create the ability to transport up to ten times the amount of cuttings of a single phase fluid. This is because of the high viscosity that is an inherent property of foam allowing efficient cuttings transport, at annular velocities that are much lower than those required for dry air or mist drilling. Annular velocities as low as 30 m/min have been proven sufficient to adequately clean the wellbore on many foam drilling operations. This low velocity flow regime is beneficial when drilling through unconsolidated formations as it minimizes erosion. In addition to the dynamic cuttings transport, foam has the ability to suspend cuttings when circulation ceases. This is particularly important for horizontal drilling applications as it prevents cuttings falling to the low side of the hole and then being degraded by the action of the drill pipe and bottom hole assembly (BHA). Due to the friable nature of coal, large "chunks" can enter the wellbore as the formation is drilled. Removal of these "chunks" is essential as they can lead to instances of stuck pipe due to "packing off". Another reason that they should be removed as quickly as possible is to prevent solids degradation through re-grinding. Once the particle size is reduced it becomes difficult to remove at surface with the solids control equipment. In addition to affecting fluid properties these ultra-fine solids have the potential to cause severe formation damage if they enter the cleat system of the coal.

ROP

Bottomhole pressures with foam tend to be higher than those in dry gas or mist drilling. This may reduce penetration rates below those for dry gas. However, penetration rates with foam are often still considerably higher than can be achieved in mud drilling. The rate of penetration (ROP) is significantly increased with decreasing mud weight. When the bottom of the hole is fractured by the action of the bit, the hydrostatic pressure of the fluid column acts to keep the cuttings in their original position; this is known as the "chip hold down effect". The result of this is that bit action is largely used to regrind the cutting rather than for making new hole. The converse of this is true for underbalanced drilling. Since the hydrostatic pressure exerted by the fluid column is less than the formation pressure, the cuttings have a tendency to explode away from the bottom of the hole and enter the fluid stream allowing the bit to act only on new formation. However it is strongly recommended when drilling the reservoir section of any well that the ROP is controlled so that the cuttings concentration in the annulus be maintained at less than 4%. If this cutting concentration is exceeded, there is the risk that the bottom hole circulating pressure (BHCP) will increase, causing an overbalanced condition, which as demonstrated by the experimental data will cause serious formation damage.

Wellbore Stability

The higher annular pressures with foam can potentially reduce mechanical wellbore instability experienced when drilling with a dry gas or mist. At the same time, the low annular velocities, typical of foam drilling, greatly reduce the possibility of erosion of the borehole wall.

Lost Circulation

Typically CBM reservoirs are low pressure reservoirs that are highly fractured. This situation can lead to instances of severe lost circulation when using conventional overbalanced drilling techniques. This lost circulation can lead to a dramatic reduction in productivity due to solids contained in the drilling fluid causing plugging of the cleat system. Additions of lost circulation material to the drilling fluid to treat this problem will only compound formation damage effects. Even when water is used as the drilling fluid this can lead to instances of formation damage. This is due to the solids invasion, where large amounts of small particles of rock or coal enter the cleat system and cause plugging of the macro pore system. The low density of foam allows underbalanced conditions to be established in almost all circumstances preventing the migration of solids into the coal matrix. The additional costs associated with lost fluid and substantial rig time spent curing the lost circulation problem rapidly increases the cost of drilling a well.

Water Flows

A significant benefit of using foam as an underbalanced drilling fluid, and one of the main reasons for its suitability for CBM applications, is its ability to lift large quantities of produced liquids. When water inflow is too large to be efficiently lifted with mist, it is often possible to continue drilling underbalanced by switching to foam. Water inflows can be an issue when drilling CBM wells underbalanced due to the large amounts of water in place in the coal matrix. Modeling has shown that for a typical CBM well in Alberta, the under-balanced condition can be maintained when using foam with water influxes of up to 5 m3 per hour. This can be achieved by adjusting the foam properties and gas injection rates to maintain a stable BHP, and therefore maintain the under-balanced conditions.

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Underbalanced Foam Drilling *... continued from page 15*

Differential Sticking

Differential sticking occurs when a permeable formation is drilled with a highly overbalanced mud system. The differential pressure generates a side force that pushes the drill string and BHA into the filter cake. Stuck pipe can dramatically increase the drilling costs through additional rig time, fishing operations and possibly leaving expensive tools downhole. When drilling underbalanced, differential sticking is eliminated for two reasons; there is no build up of filter cake as there is no fluid invasion to the wellbore, and; there is no side force developed because there is no overbalanced differential pressure.

Conclusions

The results of the core flood tests indicate the use of a wide variety of high technology overbalanced 'drilling' fluids designed to minimize formation damage in conventional reservoir situations are ineffective in the McRae coal seams.

Significant formation damage to the cleat/fracture system of the coal by whole mud losses and polymer/chemical adsorption occurred.

The data strongly suggests that the use of underbalanced drilling would be beneficial to reduce the impact of these overbalanced drilling related damage mechanisms. The consistent maintenance of the underbalance pressure condition during the entire underbalanced drilling operation is crucial in ensuring the success of UBD as a formation damage reduction technique in the McRae coal.

A review of the literature demonstrates that in the correct application, drilling coal seams horizontally can increase the productivity and reduce the number of wells required to develop the field.

The use of foam as the drilling fluid for the underbalanced portion of the well will give a more stable flow profile and can mitigate some of the operational risks associated with CBM wells.

The use of underbalanced horizontal drilling techniques should be undertaken only after an exhaustive cost analysis of the project has been performed. The additional cost of the UBD equipment and time to drill the horizontal well has to be weighed against the reduced number of wells required to develop the field and possible increase in productivity.

Representing the CWLS at the Student mixer were: (from left to right) Mr. John Nieto – CWLS President, Mr. Louis Chabot – Student Liaison and Ms. Carley Gyori – Secretary. Mr. Reigh McPherson was also present but not in the picture.

Canadian Well Logging Society members were present at the 2005 APEGGA Geoscience Student Mixer which took place on Tuesday evening September 27th at The Metropolitan Centre. During this outreach event many professional societies including the CWLS were present along with industry professionals. This event facilitated an exchange and discussion on various subjects of interest with geology and geophysics students from the University of Calgary (~30 students) and the University of Alberta (30+ students). This evening was very well attended with many new students joining the CWLS society. All the CWLS information and literature that we brought with us was given out. We are looking forward to another fun mixer next year.

Louis Chabot
CWLS Student Liaison Volunteer

Myth-Interpretation

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This series on interpretation myths is intended to provoke discussion, rebuttal, dialog, or alternate 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 #2: Dipmeters Measure True Formation Dip

Dipmeter tools, of course, don't measure dip directly – they measure a number of conductivity curves that are correlated by computer algorithms to determine a formation dip at a particular depth. The log headings say "True Dip", but is that really true? The "True" in True Dip actually means the dip direction is relative to true North, but it says nothing about the accuracy of the dip angle or dip direction.

There are half a dozen different ways to correlate the curves and as many ways to average the results for presentation on the log, not to mention the permutations of parameters that can affect the answers. These techniques were outlined in a review paper by the author in "Dipmeter Tools and Presentations", in Canadian Well Logging Society Journal, Dec 1992.

Certain parameters will exclude high angle dips, so you won't see fracture or fault planes. Other parameters effectively smooth the results so that you cannot see bedding inside a sand body. If you are mining this sand body with a multi-million dollar shovel, or chasing the sand body along its axis with million dollar wells, this lack of detail could be kind of crucial to your bottom line (or your insurance company).

A bad choice of parameters or computation method can lead to very misleading results. Doublets, even quadruplets, of identical dips are a function of parameter choice and do not represent two (or four) individual dipping beds. On the other hand, the program may find many possible dips within a correlation interval – clustering and pooling will choose one dip angle from as many as 25 or 30 possible candidates. Which one is the real dip?

Much of the problem can be eliminated by comparing calculated dips with formation micro-resistivity image logs. It is amazing how often the computation method or parameters can be shown to be giving inappropriate results after this comparison is made. Fortunately, many dipmeters can be reprocessed with more appropriate parameters, but there are literally tens of thousands in well files that will never see this benefit because the digital data has been lost. So geologists will continue to infer the wrong geological setting from such logs.

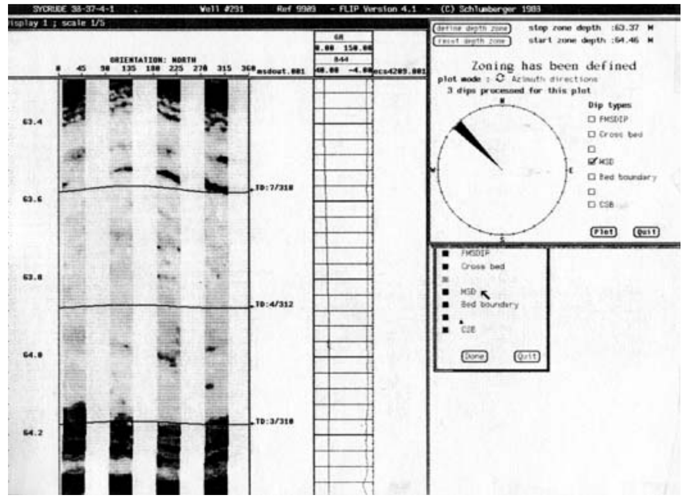

Figure 1: MSD dips picked from formation microscanner. Maximum dip is 7 degrees.

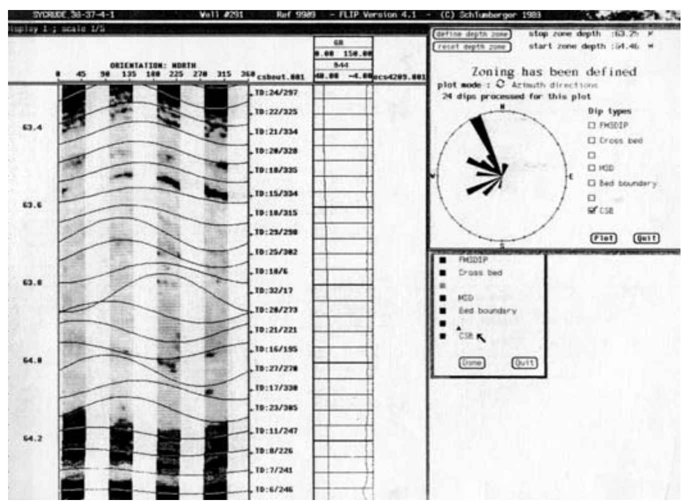

Figure 2: CSB dips picked from formation microscanner. Maximum dip is 25 degrees.

The example below is from a forensic analysis project from more than 15 years ago. The problem here was that the client liked the highly smoothed dipmeter presentation he was used to. The fact that the current dipmeters were "noisy" was a bone of contention. These illustrations show the range of possible solutions. Judge for yourself which set of dip results you think reflect the "True Dip".

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Myth-Interpretation … *continued from page 18*

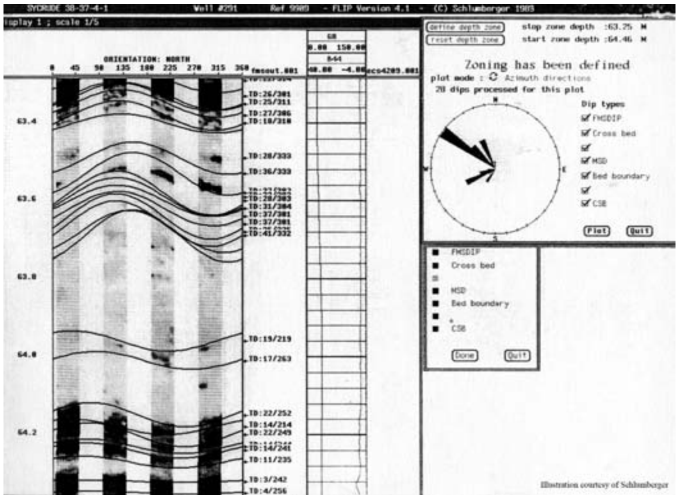

Figure 3: FMS dips picked from formation microscanner. Maximum dip is 37 degrees.

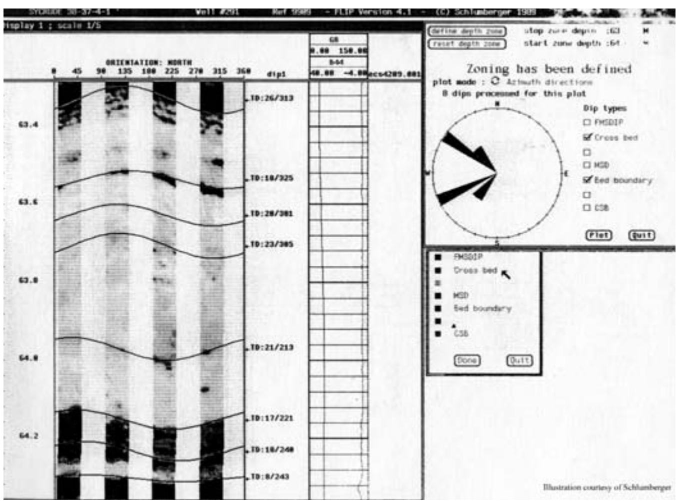

Figure 4: Hand picked dips picked from formation microscanner. Maximum dip is 28 degrees.

Dips can be computed automatically on a microscanner log by the same methods as used for the stratigraphic high resolution dipmeter. MSD, CSB, FMS, and handpicked dips over the same interval are demonstrated in Figures 1 through 4. Each plot has entirely different dip results, emphasizing the need to understand the different dip calculation methods. In particular, the MSD dips in a strongly cross bedded formation suffer badly from the averaging calculation. Compare Figure 1 (MSD) with Figure 2 (CSB). It is clear that MSD dips do not follow the bed boundaries very well and underestimate dip angle at the sand top and base by 7 to 10 degrees.

The FMS dips (Figure 3) use a different form of correlation, so they honour the bed boundaries even better than CSB dips. Computed dips are even steeper than CSB and much steeper than the MSD, indicating the relative degree of averaging being done by the program. The hand picked data in Figure 4 is probably the best result, but it is labor intensive. It takes about half a day to compute all FMS dips over a 300 foot interval, delete all unwanted dips manually, and pick additional dips not found in the original computation.

You might want to try a similar study on one of your sandstone plays.

You should appreciate these differences when using conventional dipmeter logs. Any form of best fit or averaged dip will probably underestimate dip angle unless some very dominant bed boundary exists that will swamp all others. The assumption made by the programmers is that major bed boundaries do this, but as you can see from the illustrations, this is not always true. If you can afford it, run FMS or televiewer images to help interpret dipmeter arrow plots. Since the vast majority of existing dipmeters cannot be augmented by FMS, BEWARE of averaged results.

Remember, it's "True North – Strong and Free", not "True Dip – Smoothed and Averaged".

Composite Colour Display of Spectral Gamma-Ray Logs

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Overview

Spectral gamma-ray tools provide a family of curves that must be simultaneously interpreted. This makes objective interpretation difficult. Instead, potassium, thorium and uranium concentration logs can be displayed as a superimposed variable density series using monochrome red, green and blue curves, respectively. The result is a data-rich, attractive full-colour image that provides many clues to aid lithologic interpretation and log correlation. In particular, ratios are represented by obvious colour variations, and total count by image brightness.

Introduction

The human visual system can discriminate between millions of colours; Drury (2004) has some excellent background on the subject. In contrast, spatial resolving power is limited by the finite physical parameters of the eye. It is straightforward to calculate that the eye is capable of resolving about 10 lines per millimetre (for a full contrast image at normal reading distances). This means that in a typical 1 cm-wide log plot, the average person can discriminate between 100 values. This should be regarded as a best case; I think it is fair to say that most people would be unable to spot differences anywhere near that small when they are more than a few centimeters apart.

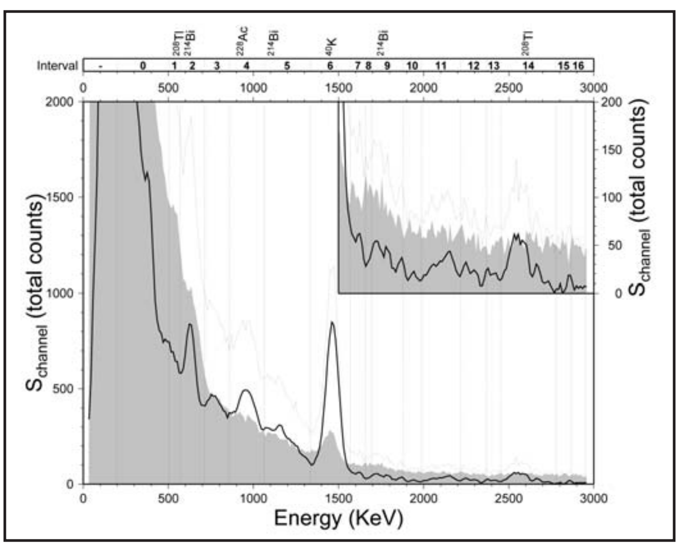

Figure 1. An example of a gamma-ray spectrum from Dean (2004). Each data point on a spectral gamma-ray log is calculated from a spectral histogram like this one from 509.36 m in ODP Leg 195. The thin black line shows the result of removing a background spectrum (grey area) from the raw data (heavy black line), then applying a three-point mean boxcar filter. Peaks in the spectrum identify the radioelements indicated at the top; the zones are after Blum et al. (1997). The inset shows an expanded scale for energies above 1500 keV.

Color has been widely applied in all aspects of geoscience, especially since the widespread use of computers came about. Most applications of colour, however, map a given attribute directly to an arbitrary and one-dimensional sequence of colours. The technique is known as false colour. There is no significance to any colour (that is, one could just as easily pick one colour 'map' as another), and only one attribute can be represented at a time.

More information can be conveyed by combining colors into a three-colour composite display. This approach is especially useful for spectral data, since it is analogous to the way our eyes and brain detect and process the colours around us, with highly sensitive detectors for red, green and blue light. The technique simply maps a low-frequency attribute to red, a medium-frequency attribute to green, and a high-frequency attribute to blue. The three colour layers are then combined to produce a single image.

Composite colour-layer maps are often used in satellite image analysis, especially for spectral data, and the approach was introduced to earth scientists by Grossling (1969). Aerially-surveyed spectral gamma-ray data are sometimes displayed as composite red-green-blue images (Broome et al., 1987). More recently, the same approach has been applied to seismic reflection sections (Theophanis & Queen, 2000). In this paper, I apply the technique to the display of spectral gamma-ray logs, and find the results to be useful for log correlation and lithologic interpretation.

The spectral gamma-ray logging tool uses a photomultiplier to detect interactions between gamma-ray photons and a sodium iodide crystal. The device measures the energy of each photon, and over time, gamma rays of various energies are recorded. Since gamma rays released from radioisotope decay have characteristic energies, radioisotope concentrations can be estimated from the energy spectra collected by the tool; an example spectrum is shown in Figure 1. Of most interest are the bands of the spectrum that correspond to the decay of potassium-40, thallium-208 and bismuth-214 nuclei. Thallium-208 and bismuth-214 are of interest because they are components of the decay series of thorium-232 and uranium-238 respectively. Gamma rays from the decay of potassium-40 are the biggest contributor to the count in the lowest energy band, those from bismuth-214 fall into the highest.

Continued on page 22…

Composite Colour Display … *continued from page 21*

The chief advantage of the technique is that three attributes, in this case radioelement concentrations, are displayed simultaneously in a single attractive, data-rich, and intuitive display. The display complements existing lithologic interpretations and makes a particularly enlightening fill for the gamma-ray log.

Method

To be consistent with the electromagnetic spectrum, the lowest energy emissions are mapped to the low-energy end of the visible spectrum. In effect, we shift the spectral gamma-ray logs into the visible part of the spectrum. Since the gamma-ray emissions from decay of potassium-40 nuclei have the lowest energy, the potassium log is represented by shades of red, thorium by green, and uranium by blue (Figure 2).

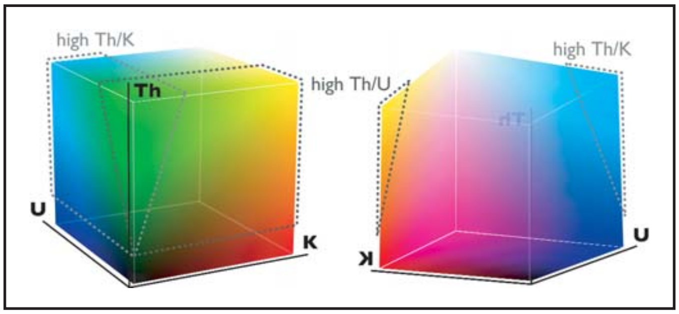

Figure 2. Spectral gamma-ray components mapped on to red-green-blue colour space. Two views of the same cube show how the primary colours combine additively to make almost every hue in the rainbow. I have highlighted regions approximately representing high Th/K and high Th/U values.

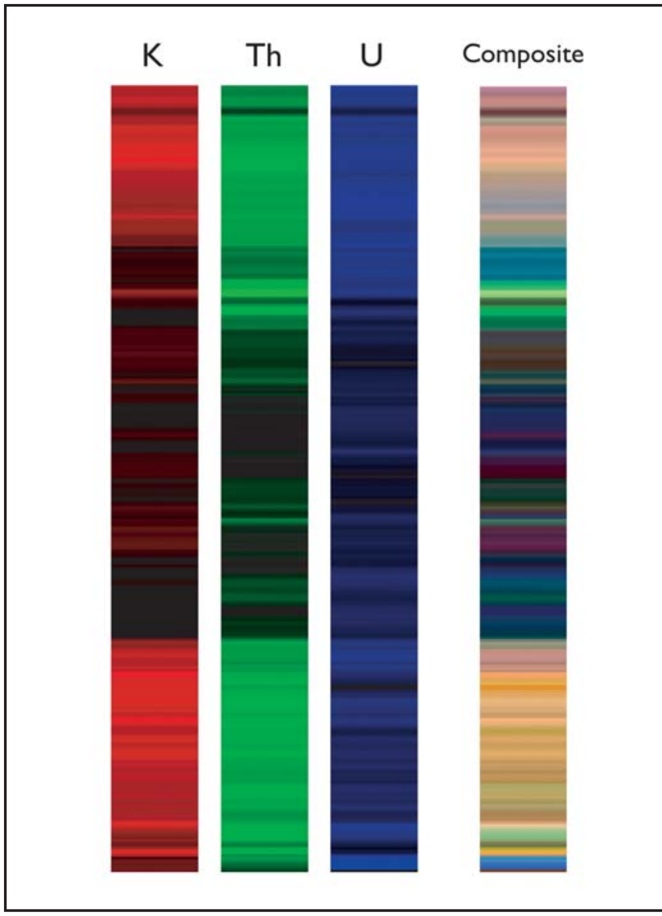

Figure 3. The logs are displayed as monochrome variable density plots. Potassium concentration is displayed in red, thorium in green, and uranium in blue. The colours of each sample are additively combined to give a full-colour image.

The logs are represented by monochrome variable density displays. Thus, low relative amplitudes translate to low colour values and are displayed as dark colours. Conversely, high amplitudes are displayed as bright, saturated colours. Colours are combined additively, as coloured light combines. Figure 3 shows how the log values combine to make the composite image.

The method consists of two steps: quality control, and constructing the composite log images. I am not aware of any software to make these displays directly from log data. Consequently, making the final image required some additional steps: processing the LAS files to a particular format, importing the logs as images into an image processing software tool, making the composite images, exporting the images as TIFFs, and attaching the images to the correct depths. I used Landmark's PowerView® software for the image processing and imported the resulting TIFF files to an OpenWorks® database, where they were depth-registered. I displayed the images in the StratWorks® log interpretation tool, as shown in Figure 4.

Quality control is a simple case of checking that the logs are quantitatively comparable from well to well. If the logs are not consistent, then you will not be able to compare colours from well to well. In this case, you should consider calibration or other processing to correct this defect. If this is not an option, you could normalize the logs before proceeding, remembering that this will mean that colours vary from well to well.

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Composite Colour Display *… continued from page 22*

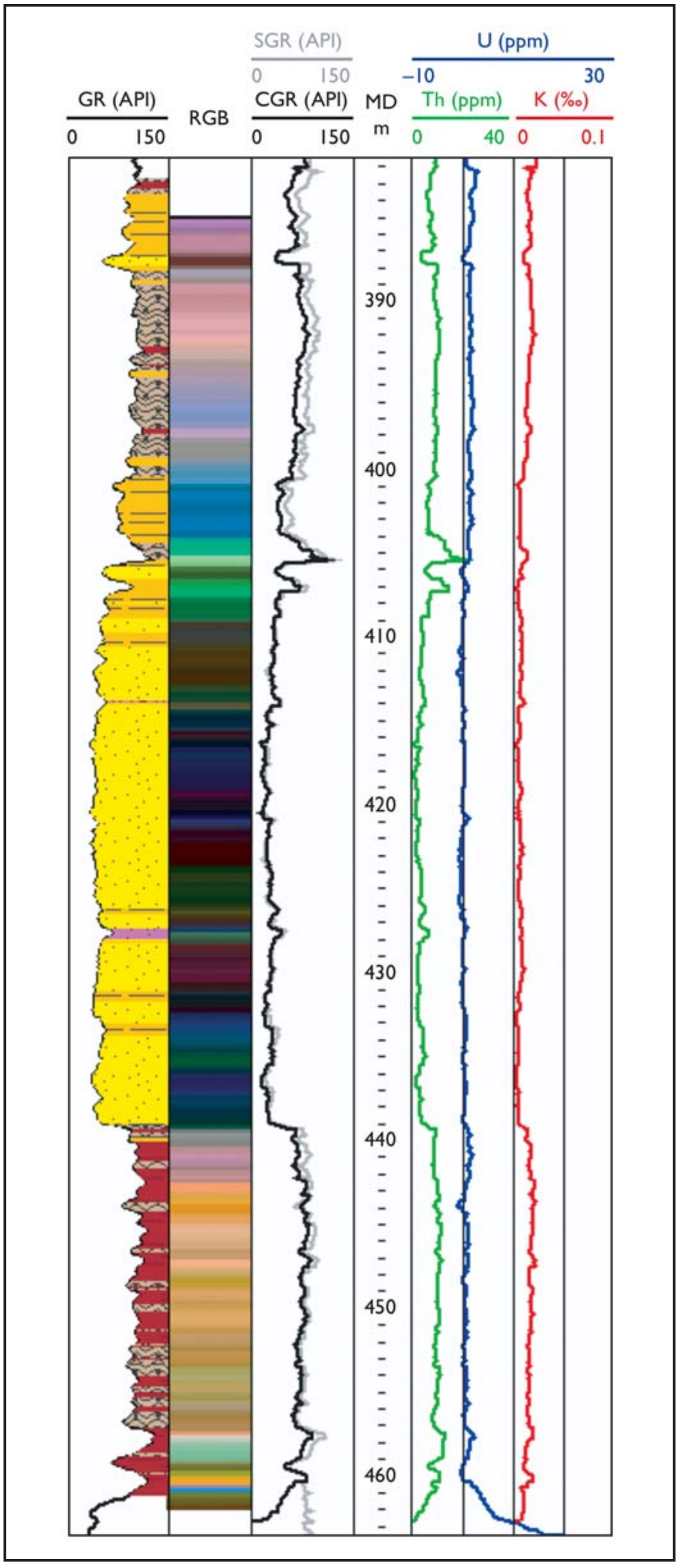

Figure 4. The composite display clearly shows lithologic differences and similarities and makes an interesting complement to the lithology interpretation (from core and logs). Subtle variations are much more obvious than they are in the wiggle traces.

Discussion

With more and more information being collected and displayed on well displays, data density is a real issue. Wiggle traces require lots of space if small changes in amplitude are to be seen. But the wider the trace, the harder it is to get the geological big picture, and the less room there is for other data. The data density of the wiggle-trace plot for potassium, thorium and uranium in Figure 4 is about 8 data points per square centimetre. In contrast, since the variable density plot requires only a narrow track, and since the composite spectral-gamma-ray log represents three logs, its data density is 40 cm^{-2}.

Mineralogical interpretation is aided by spectral gamma-ray data. Adams & Weaver (1958) pointed out the association between high uranium concentrations and organic matter, so black shales would be blue in the composite display. The potassium log has a similarly almost diagnostic response to glauconite and other micas; such a response would be a bright reddish colour in the composite display. Yellowish colours would indicate higher thorium concentrations, in addition to the potassium, and would therefore more likely indicate the presence of clays.

It may also be possible to recognize certain geological conditions from the composite spectral gamma-ray colour. For example, Ehrenberg & Svånå (2001) noted that high Th/U and low Th/K ratios mark major flooding surfaces in the Palaeozoic Finnmark carbonate platform. Such flooding surfaces would be green or yellow in the composite display. Similarly, they noted that minor flooding surfaces are distinguished by high concentrations of uranium, perhaps associated with organic matter; these would be bright blue in the composite display.

Conclusions

Whilst wiggle-trace logs lend themselves well to the recognition of relative changes in amplitude at small scales, there is a lot of white space in the log display. This makes them rather inefficient communication tools. Furthermore, simultaneously comparing or correlating multiple logs requires a great deal of experience and time.

Composite colour displays of spectral-gamma-ray logs are attractive, data-dense, and intuitively interpreted. With careful calibration of the logs, colours are directly related to lithology and radiochemistry. Subtle lithologic variations are easy to see, even for the novice. My hope is that these displays become standard additions to log display and interpretation software suites.

Continued on page 24…

Composite Colour Display ... *continued from page 23*

Acknowledgements

Thanks to Ryan Lemiski and Denis Druesne for the discussions that led to this work. Thanks also to ConocoPhillips Canada Limited for their permission to use the log example, and to Simon Dean of the National Oceanography Centre, Southampton, UK, for the gamma-ray spectrum example.

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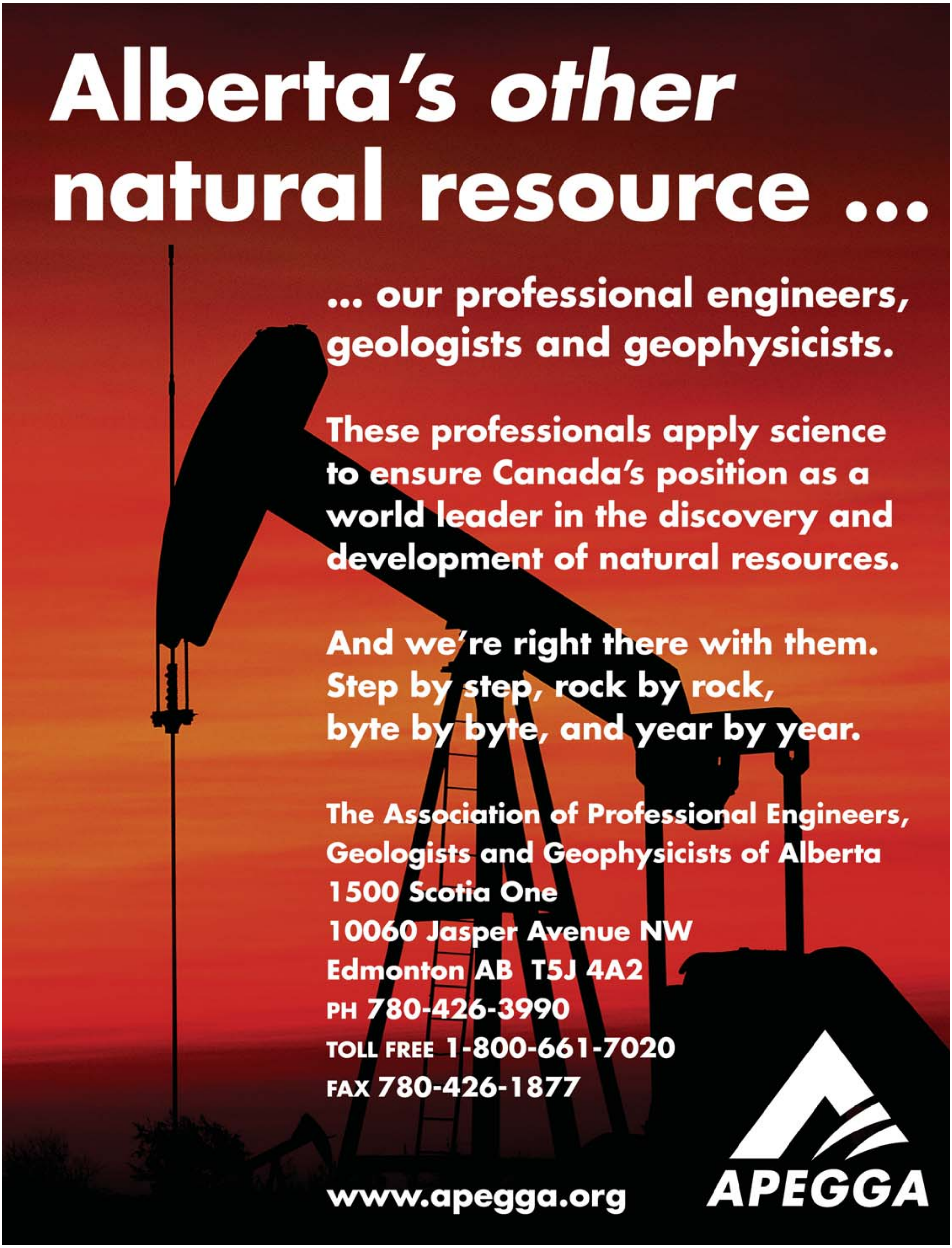

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Tech Corner: Surface geochemical exploration for oil and gas: New life for an old technology

Dietmar "Deet" Schumacher
Geo-Microbial Technologies, Ochelata, Oklahoma, U.S.

Surface geochemical exploration for petroleum is the search for chemically identifiable surface or near-surface occurrences of hydrocarbons, or hydrocarbon-induced changes, as clues to the location of oil and gas accumulations. It extends through a range of observations from clearly visible oil and gas seepage (macroseepage) at one extreme to identification of minute traces of hydrocarbons (microseepage) or hydrocarbon-induced changes at the other.

Surface geochemical methods have been used since the 1930s, but the past decade has seen a renewed interest in geochemical exploration. This, together with developments in analytical and interpretive methods, has produced a new body of data and insights about geochemical exploration. Many of these developments are summarized in "Hydrocarbon Migration and Its Near-Surface Expression" (AAPG Memoir 66). Geochemical surveys and research studies document that hydrocarbon microseepage from oil and gas accumulations (1) is common and widespread, (2) is predominantly vertical (with obvious exceptions in some geologic settings), and (3) is dynamic (responds quickly to changes in reservoir conditions).

The principal objective of a geochemical exploration survey is to establish the presence and distribution of hydrocarbons in the area and, more importantly, to determine the probable hydrocarbon charge to specific exploration leads and prospects. For reconnaissance surveys, seeps and microseeps provide direct evidence that thermogenic hydrocarbons have been generated; that is, they document the presence of a working petroleum system and identify the portions of the basin that are most prospective. Additionally, the composition of these seeps can indicate whether a basin or play is oil-prone or gas-prone. If the objective is to evaluate individual exploration leads and prospects, the results of geochemical surveys can lead to better risk assessment by identifying those associated with strong hydrocarbon anomalies, thereby highgrading prospects on the basis of their probable hydrocarbon charge. For development projects, detailed microseepage surveys can (1) help evaluate infill or stepout drilling locations, (2) delineate productive limits of undeveloped fields, (3) identify bypassed pay or undrained reservoir compartments, and (4) monitor hydrocarbon drainage

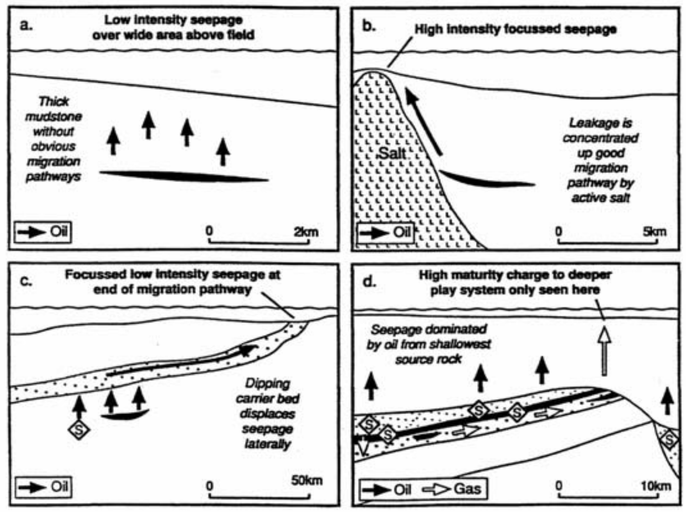

Figure 1 – Spectrum of contrasting seepage styles and migration pathways from the Gulf of Mexico and the North Sea (modified from "Understanding geology as the key to using seepage in exploration: the spectrum of seepage style" by Thrasher et al., AAPG Memoir 66, 1996).

through use of repeat geochemical surveys. Hydrocarbon microseepage surveys have potential to add value to 2-D and 3-D seismic data by identifying those features or reservoir compartments that are hydrocarbon-charged.

The underlying assumption of all near-surface geochemical exploration techniques is that hydrocarbons are generated and/or trapped at depth and leak in varying but detectable quantities to the surface. This has long been an established fact, and the close association of surface geochemical anomalies with faults, productive fairways, and specific leads and prospects is well known. It is further assumed, or at least implied, that the anomaly at the surface can be reliably related to a petroleum accumulation at depth. The success with which this can be done is greatest in areas of relatively simple geology but becomes increasingly difficult as the geology becomes more complex. The geochemical anomaly at the surface represents the end of a petroleum migration pathway, a pathway that can range from short-distance vertical migration to long-distance lateral migration. An example of these contrasting seepage styles and migration pathways is illustrated in Figure 1.

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Seepage activity

Seepage activity refers to the relative rate of hydrocarbon seepage. Active seepage refers to areas where subsurface hydrocarbons seep in large concentrations into shallow sediments and the overlying water column. Active seeps often display acoustic anomalies on conventional and high-resolution seismic profiles. Such seepage occurs in basins now actively generating hydrocarbons and/or that contain excellent migration pathways. Active seeps are easily detected by most geochemical sampling methods. Examples of active seeps are found in the Gulf of Mexico, offshore California, parts of the North Sea, the southern Caspian Sea, offshore West Africa, and offshore Indonesia.

Areas where subsurface hydrocarbons are not actively seeping are said to be characterized by passive seepage. Such seeps usually contain low molecular-weight light hydrocarbons and volatile higher molecular weight hydrocarbons above background concentrations. Acoustic anomalies may be present, but water column anomalies are rare. Anomalous levels of hydrocarbon seepage may be detectable only near major leak points or at greater than normal sampling depths. Passive seepage occurs in basins where hydrocarbon generation is relict or migration is sporadic or inhibited by a major migration barrier. Areas with passive seepage include many intracratonic basins, offshore Alaska, the northwest shelf of Australia, central Sumatra, and parts of the North Sea. As indicated above, there is a seepage continuum from the lowest detectable levels at one extreme to visible oil and gas seeps at the other. Macroseepage refers to the visible oil and gas seeps. Microseepage is defined as elevated concentrations of analytically detectable volatile or semivolatile hydrocarbons, or hydrocarbon- induced changes, in soils and sediments. The existence of microseepage is supported by a large body of empirical evidence including (1) increased concentration of light hydrocarbons and hydrocarbon-oxidizing microbes in soils and sediments above petroleum reservoirs, (2) an increase in key light hydrocarbon ratios in soil gas over oil and gas reservoirs, (3) sharp lateral changes in these concentrations and ratios at the edges of the surface projections of these reservoirs, (4) similarity with stable carbon isotropic ratios for methane and other light hydrocarbons in soil gases to those found in underlying reservoirs, and (5) the disappearance and reappearance of soil gas and microbial anomalies in response to reservoir depletion and repressuring.

Microseepage rates and surface hydrocarbon concentrations can vary significantly with time. Surface hydrocarbon seeps and soil geochemical anomalies appear and disappear in relatively

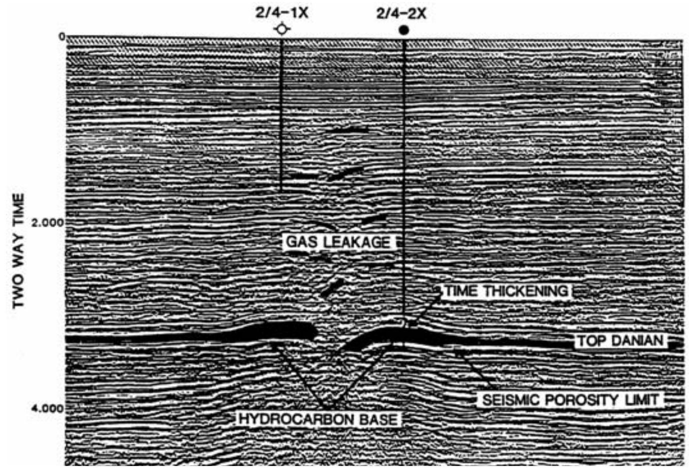

Figure 2 – Seismic cross-section of Ekofisk Field, North Sea, illustrating a well-developed gas chimney caused by low-velocity conditions due to gascharged sediments (from "Ekofisk: First of the giant oil fields in western Europe" by Van den Bark and Thomas, AAPG Memoir 30, 1990). Hovland and Sommerville (1985) estimated gas-seepage at 1000 liters per hour. Extrapolating this estimate to the total area of gas seepage, approximately 100 000 m2 containing 140 seeps, gives a net flux of 890 liters per square meter per year.

short times – weeks to months to years. Results from studies of natural seeps and underground storage reservoirs, as well as repeat surveys of fields, indicate that the rate of hydrocarbon migration and microseepage varies from less than 1 m per day to tens of meters per day. Empirical observations and computer simulations suggest that the mechanism for microseepage is a buoyancy driven, continuous-phase gas flow through water-wet pores and fractures.

Nearly all surface exploration methods rely on the assumption that hydrocarbons migrate in a predominantly vertical direction from source rocks and reservoirs to the surface. Evidence for vertical leakage of hydrocarbons is commonly seen on conventional seismic and high-resolution seismic sections. Figure 2 illustrates an example of such a gas-leakage chimney over Ekofisk Field in the North Sea. There are numerous published articles showing apical (or direct) geochemical anomalies over oil and gas fields, as well as over petroleum storage reservoirs. A recent review of more than 850 wildcat wells – all drilled after completion of surface geochemical surveys – finds that 79% of wells drilled in positive geochemical anomalies resulted in commercial oil or gas discoveries; in contrast, 87% of wells drilled in the absence of an associated geochemical anomaly resulted in dry holes. Data such as these represent powerful, if empirical, evidence for vertical migration and microseepage of hydrocarbons.

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The surface geochemical expression of petroleum seepage can take many forms, including (1) anomalous hydrocarbon concentrations in sediment, soil, water, and even atmosphere; (2) microbiological anomalies and the formation of "paraffin dirt"; (3) anomalous non-hydrocarbon gases such as helium and radon; (4) mineralogical changes such as the formation of calcite, pyrite, uranium, elemental sulfur, and certain magnetic iron oxides and sulfides; (5) clay mineral alterations; (6) radiation anomalies; (7) geothermal and hydrologic anomalies; (8) bleaching of redbeds; (9) geobotanical anomalies; and (10) altered acoustical, electrical, and magnetic properties of soils and sediments. Figure 3 represents a generalized model of hydrocarbon microseepage and their varied geochemical and geophysical effects on soils and sediments.

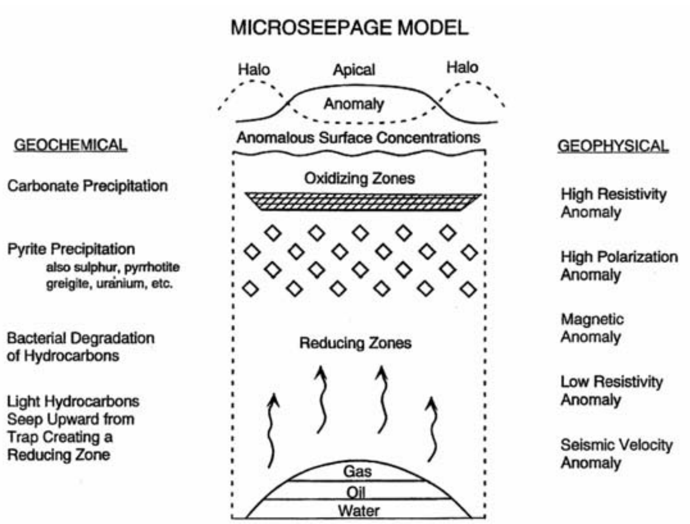

Figure 3 – Generalized model of hydrocarbon microseepage and hydrocarbon- induced effects on soils and sediments (from "Hydrocarbon-induced alteration of soils and sediments" by Schumacher, AAPG Memoir 66).

Survey design and interpretation

The importance of proper survey design and sampling density for target recognition cannot be overstated. Hydrocarbon microseepage data are inherently noisy and require adequate sample density to distinguish between anomalous and background responses. The major causes of ambiguity and interpretation failures involving surface geochemical studies are probably undersampling and/or selection of an improper survey method. To optimize the recognition of an anomaly, the sampling pattern and sample number must take into consideration the objectives of the survey, the expected size and shape of the anomaly (or geologic target), the expected natural variation in surface measurements, and the probable signal- to-noise ratio. Defining background values adequately is an essential part of anomaly recognition and delineation. For prospect evaluation, as many as 70% of the samples collected should be obtained outside the area of immediate interest. For properly designed surveys, and under ideal geologic conditions, the areal extent of surface geochemical anomalies can closely approximate the productive limits of the reservoir at depth.

How does one select a method (or methods) for a surface geochemical exploration program? The choice of method(s) depends on the kinds of questions you hope the survey results will answer. In other words, what are the objectives of the survey? Is it to demonstrate the presence of an active petroleum system in a frontier area, or to high-grade previously defined exploration leads and prospects, or to determine the type of petroleum (i.e., oil versus gas) likely to be encountered? What other data are presently available in the area of interest (satellite imagery, aeromagnetics, gravity, seismic, etc.)? What geochemical methods have previously been used successfully in the area of interest, or in a geologic analog? What limitations are imposed by the survey area (onshore or offshore, deep water or shallow, jungle or desert, mature basin or remote area, budget and personnel constraints, etc.)? It is beyond the scope of this article to discuss the advantages and limitations of specific methods or sampling procedures, but such information is readily available in published literature. As a generalization, direct hydrocarbon methods are preferred over indirect methods because they can provide evidence of the very hydrocarbons we hope to find in our traps and reservoirs. Additionally, chemical and isotopic analysis of these hydrocarbons, especially the high molecular weight hydrocarbons, can provide insight into the nature and maturity of the source rocks that generated these hydrocarbons. If surface conditions or budgetary constraints preclude the use of direct hydrocarbon detection methods, the next best choice is one of those indirect methods most closely linked to hydrocarbons and hydrocarbon accumulations. Whenever possible, it is recommended to use more than one geochemical survey method, for example, combining a direct method with an indirect method. The use of multiple methods can reduce interpretation uncertainty because seepage- related anomalies will tend to be reinforced while random highs and lows tend to cancel each other out.

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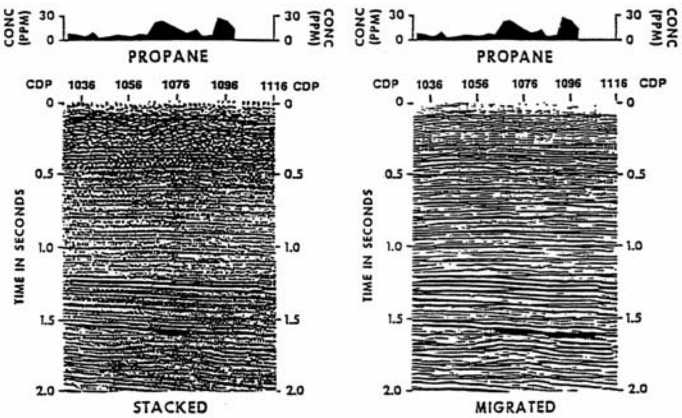

Figure 4 – Geochemical expression of a stratigraphic trap at about 5600 ft (1.5 s)in the Cretaceous Escondido Sandstone, La Salle County, Texas (from "Exploration enhancement by integrating near-surface geochemical and seismic methods" by Rice, Oil and Gas Journal, 1989). A soil gas hydrocarbon survey was conducted to look for evidence of hydrocarbon microseepage from a seismically defined trap at CDP 1070 (left). Propane soil gas anomalies were detected at CDPs 1070 and 1096. A wildcat drilled at CDP 1070 resulted in a new field discovery. The geochemical lead at CDP 1096 was reevaluated seismically and, after additional processing, a revised interpretation (right) predicted porosity development coincident with the surface geochemical anomaly. A productive well was subsequently drilled.

The presence of hydrocarbon macroseeps or microseeps in the area of a geochemical survey is direct evidence that petroleum has been generated. Hydrocarbon seepage at the surface represents the end of a petroleum migration pathway. These hydrocarbons may represent hydrocarbon leakage from an accumulation, or merely leakage along a carrier bed or other migration pathway. Anomalies defined by multiple samples from one or more survey lines may indicate the location of discrete structural or stratigraphic targets within the survey area. If the basin or play is characterized by predominantly vertical migration, then the correlation of a strong geochemical anomaly at the surface with a possible trap at depth suggests that the trap is charged with hydrocarbons; conversely, if the trap is not associated with a positive geochemical anomaly, the assumption is that the trap is not charged with hydrocarbons. Because relationships between surface geochemical anomalies and subsurface accumulations can be complex, proper interpretation requires integration of surface geochemical data with geologic, geophysical, and hydrologic data (Figure 4).

Summary

The past decade has seen a renewed interest in surface geochemical exploration which, together with developments in analytical and interpretive methods, have produced a new body of data and insights that establish the validity of many of these exploration methods. Surface exploration methods cannot replace conventional exploration methods, but they can be a powerful complement to them. Geochemical and other surface methods have found their greatest utility when used in conjunction with available geologic and geophysical information. The need for such an integrated approach cannot be overemphasized. Seismic data, especially 3-D data, are unsurpassed for mapping trap and reservoir geometry; however, only surface geochemical methods can consistently and reliably map hydrocarbon leakage associated with those traps. Properly acquired and interpreted, the combination of surface geochemical data and subsurface exploration data has the potential to reduce exploration and development risks and costs by improving success rates and shortening development time.

Suggestions for further reading

Hydrocarbon Migration and Its Near- Surface Expression by Schumacher and Abrams (AAPG, 1996). Soil Gas and Related Methods for Natural Resource Exploration by Klusman (Wiley, 1993). Surface Exploration Case Histories by Schumacher and LeSchack (AAPG-SEG Special Publication, in preparation).

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2006 JOINT CONVENTION

WHAT'S NEXT?
Where is our industry heading?

May 15 – 18, 2006
Calgary, Alberta, Canada

Schedule of Activities – WHAT'S NEW?

As the industry changes so must the convention format to fit the needs of our delegates. The technical presentations and exhibition will again be housed in the Round Up Centre, Stampede Park. However, the convention has been reduced from a full week of activities to 4 days! This allows our exhibitors, sponsors and delegates to fit more in during a shorter time period – which we all need during these busy times in industry.

It is hoped that our exhibitors, the technical programme and the social events will showcase our theme WHAT'S NEXT? Where is our industry heading? and light the way forward.

Time	Monday, May 15	Tuesday, May 16	Wednesday, May 17	Thursday, May 18
7:30	Onsite Registration (Monday–Tuesday)			
8:00	Exhibition Hall Opens (Monday–Tuesday)			
8:30 – 11:00	Oral Sessions, Palomino Rooms, Hall D Lecture Rooms, Archie Boyce Theatre (Monday–Wednesday)			Core Conference, AEUB Core Research Centre
11:30 – 1:00	Keynote Luncheon, Jay Ingram	Lunch Break	Lunch Break	BBQ Lunch
1:15 – 3:45	Oral Sessions, Palomino Rooms, Hall D Lecture Rooms, Archie Boyce Theatre (Monday–Tuesday)		CSEG Special Sessions / Core Conference, AEUB Core Research Centre	Core Conference, AEUB Core Research Centre
4:00 – 5:30	Ice Breaker, Exhibition Hall	CSPG LTMR / Mini Breaker	Student/Industry/Faculty Reception	Core Meltdown, AEUB Core Research Centre, 4:00 - 7:00
6:00		*Exhibition Hall Closed*		
6:30 – 7:00				
7:30	*Exhibition Hall Closed*			

For a complete list of Technical Sessions, please refer to www.geoconvention.org/submitPaper2006.cfm

Overwhelming response to Abstracts!

The 2006 Joint Convention Abstract Submission opened on November 1, 2005 and we have had an overwhelming response!

The deadline to submit abstracts for oral, poster and core presentations is JANUARY 31, 2006. Late submission will NOT be accepted – and at this rate we may fill up before the deadline!

This is going to be the best one stop exhibition in 2006!

As predicted, the 2006 Exhibition is also showing high demand of interest from companies wishing to profile their products and services. With the CSPG, CSEG and CWLS partnering once again, exhibiting at WHAT'S NEXT? Where is our industry heading? is the best one-stop opportunity to meet key geoscientists.

Invest in this year's joint convention!

Sponsorship is critical to the success of any conference. In order to facilitate a meaningful exchange of ideas and information the CSPG, CSEG, and CWLS require the support of our sponsors for the upcoming Conference. Without the support of our industry companies, we would not be able to fulfill the mandates to promote the Earth Sciences, especially as they relate to the exploration and exploitation of petroleum and natural gas.

Sponsorship opportunities include the Keynote Luncheon, Delegate Bags, Technical Halls, Student Sessions, Speakers' Breakfast, Ice Breaker, Special Events and more!

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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.

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COMPANY
ADDRESS:...

....

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ADDRESS:...

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E-MAIL____ OFFICE____ HOME____

BUSINESS
PHONE:...

RESIDENCE
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PROFESSIONAL
DISCIPLINE:..

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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

Canadian Well Logging History – CWLS Founding Meeting

The founding meeting of the CWLS was held on August 4, 1955 at 8:00 PM at the 400 Club in Calgary. A total of 20 people from 15 different companies attended this first meeting. A few of the companies that were represented included: Hudson Bay Oil and Gas, McCullough Tool Company, Perforating Guns of Canada, Lane-Wells Canadian Company, Canadian Gulf Oil Company and Royalite Oil Company.

Mr. A. A. Brown (See Photo) called the meeting to order and so began deliberations as to the future of the CWLS. After several hours of lively discussion a number of key recommendations were suggested or voted on and agreed to. These included:

A. A. Brown, CWLS founder and its first president. (photo source unknown)

1. That a group interested in the geological and engineering aspects of oil well investigation be formed
2. That a technical paper be presented at each meeting
3. That membership should not be limited at present
4. That the group remain independent of other organizations such as API or ASPG
5. Canadian problems will be the main focus of the group
6. A committee consisting of a chairman, secretary, treasurer and a member at large should be elected. (This committee would remain in office until January 1, 1956)

Upon completion of elections the following were elected to the executive: A.A. Brown, president, E.J. Burge, treasurer, B. McVicar, secretary and A.G.T. Weaver, member at large.

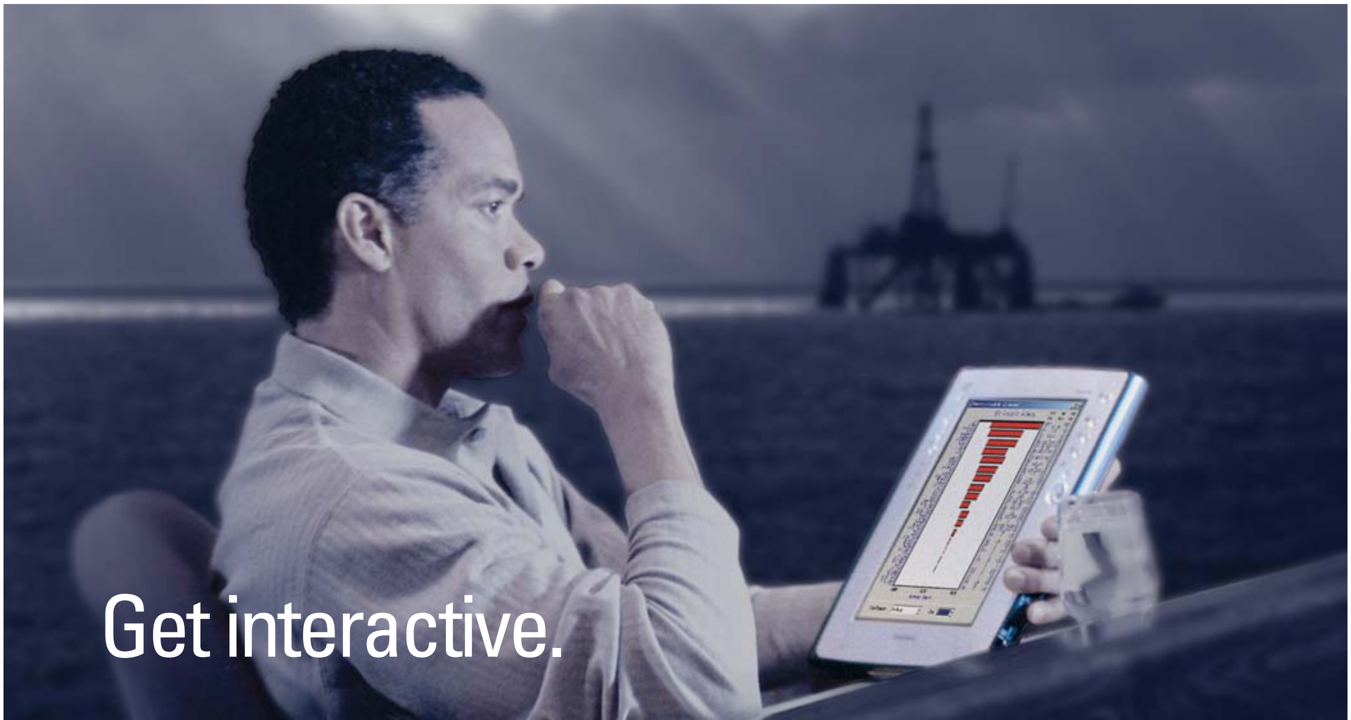
Determination of a name for the group was then embarked on. A number of suggestions were put forward, including: Alberta Well Logging Society, Canadian Society of Well Log Interpreters, and Alberta Society of Petrophysicists. Upon further discussion two of the above names were amended to The Canadian Well Logging Society and The Canadian Society for Well Log Interpretation. A vote was carried out and the second name won out. As of August 4, 1955 the society became know as The Canadian Society for Well Log Interpretation.

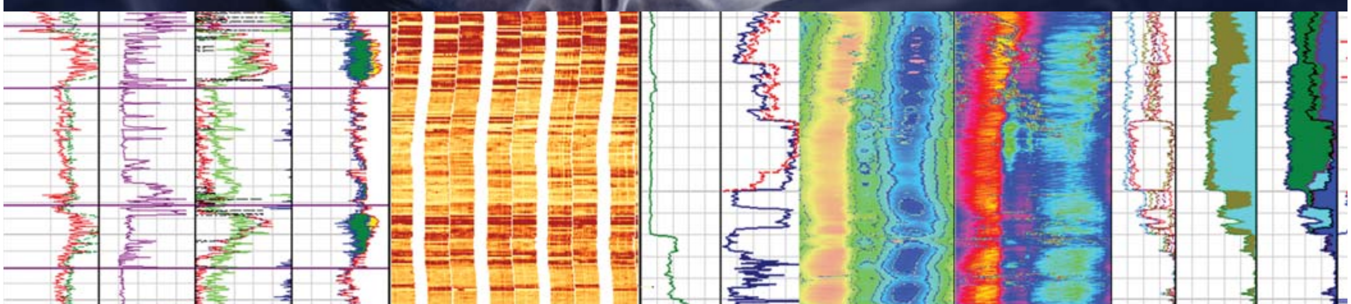
Robert Bercha

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.





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Fairmont Palliser Hotel, Calgary, AB

February 8, 2006
CWLS ANNUAL GENERAL MEETING
Fairmont Palliser Hotel, Calgary, AB

March 5 – 8, 2006
SPWLA ABU DHABI TOPICAL CONFERENCE
Permeability in Carbonates
Beach Rotana Hotel, Abu Dhabi
http://www.spwla.org/

April 2 – 6, 2006
SPRING TOPICAL CONFERENCE
Net Pay Determination
Westward Look Resort, Tucson, Arizona
http://www.spwla.org/

May 15 – 18, 2006
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Discounts on business card advertisement for members.

A high resolution .pdf of the latest InSite is posted on the CWLS website at www.cwls.org. For this and other information about the CWLS visit the website on a regular basis.

Rigging down an FMI tool on Trailblazer #6.
Photo courtesy Lazar Rajcic.

Life at the equator. A cook prepares the weekly Sunday BBQ on the deck of a jack-up rig, offshore Ecuador.
Photo courtesy of Ben Urlwin.

Precision Rig 296. Photo courtesy Lazar Rajcic