RESERVOIR SOLUTIONS

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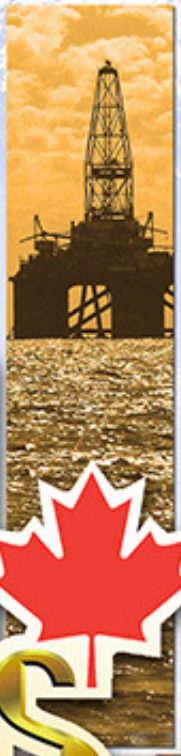
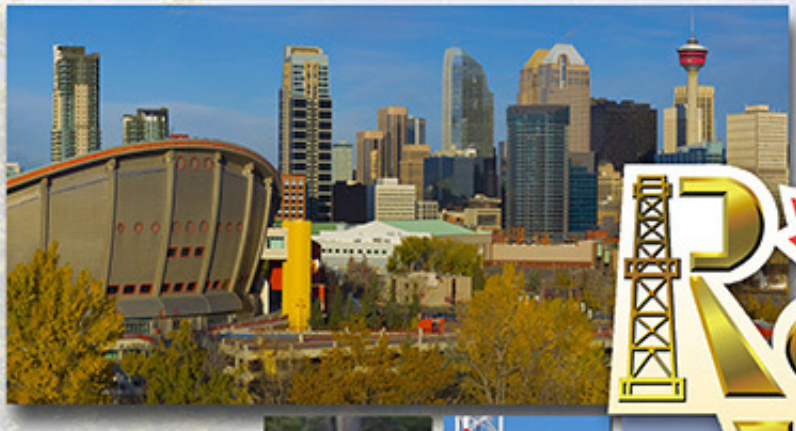
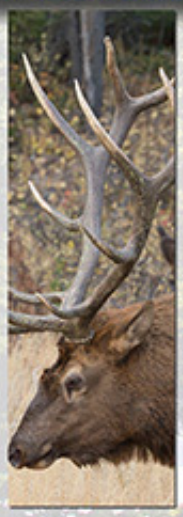
Ryder Scott Canada Reserves Conference

May 16







Oil and gas experts to meet at May conference on petroleum reserves

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Oil and gas experts to meet at May conference on petroleum reserves

North American experts will share their knowledge of petroleum reserves and related topics at the Ryder Scott Canada Reserves Conference, Tuesday, May 16. Organizers anticipate that up to 150 oil and gas executives, managers and technical professionals will attend the full-day event at the Marriott Downtown Hotel in Calgary.

Scheduled speakers include authorities in the E&P industry, academia, government and consulting.

Type wells

John Lee, a professor at Texas A&M University, will present "Type Well Analysis — Complexities and Analytic Techniques." His presentation will examine the reliability of type well production profiles. Lee was an engineering fellow at the U.S. Securities and Exchange Commission eight years ago, advising the regulator on "modernization" of its reserves reporting rules.

"Large financial transactions involving oil and gas assets are based, in part, on type curves," said Lee. "However, do we know the track record of those forecasts compared to actual performance observed later?"

His presentation will address biases in the conventional practice of type well construction that leads to overly optimistic estimates. Lee, a member of the National Academy of Engineering, will also offer methods of type well construction with higher confidence levels.

Also, **Vitaliy Charkovskyy**, a senior petroleum engineer at Ryder Scott Canada, will make a presentation on "A Type Well Prepared Example Walkthrough," following Lee.

Monograph 4

Jim Erdle, vice president USA & Latin America at the Computer Modeling Group Ltd., will present an overview of SPEE Monograph 4, "Estimating Ultimate Recovery of Developed Wells in Low-Permeability Reservoirs." He was a member of the Society of Petroleum Evaluation Engineers Monograph 4 committee.

Lee is one of ten authors who put together Monograph 4. "It recommends that for proper estimates of developed reserves, it is critical to use both rate and pressure data. However, Monograph 4 stops short of addressing the assignment of developed reserves," he said.

The monograph presents methods for analyzing well performance of tight reservoirs and estimating recoverable volumes from oil and gas shale plays. Evaluation methods discussed include traditional decline-curve analysis, recent alternative DCA methods, rate-time analysis and numerical reservoir simulation.

New DCA technique tested in Montney shale

He Zhang, petroleum engineer at Ryder Scott, will present his study on the use of extended exponential decline curve analysis (EEDCA) to estimate reserves in the Montney shale play in Canada. This DCA method, which was introduced by Zhang et. al (SPE 175016) in 2015, provides results similar to other decline-curve techniques, but is simpler and requires less effort, he says.

EEDCA is able to match early and late time well performance without any requirement to switch decline models for shale producers. Theoretically, it can arrive at the final decline —βe or Dmin — sooner than the modified hyperbolic method, which is in wide use as the preferred, reliable industry method.

His presentation at the reserves conference will further discuss the transient b-factor effect and how to calculate the value of Dmin, for the Montney shale. In the original Arps paper, the b-factor of the hyperbolic equation was assumed to be a constant and limited to values less than or equal to 1.0. "However, many literature papers and field observations have shown that the b-factor changes with time in shale wells and, in many cases, can be well above 1.0, especially during the transient flow period," said He.

As a result, evaluators have modified the original DCA to incorporate a b-factor larger than 1.0 and a minimum exponential decline rate (Dmin) at the late-time life in shale production predictions. Lee; **Dean Rietz**, president at Ryder Scott; and others co-wrote the SPE paper.

A full article on EEDCA, including the equation, was published in the October 2015 *Reservoir Solutions* newsletter at https://www.ryderscott.com/wp-content/uploads/2015NL_Oct.pdf#.

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Ryder Scott Canada Reserves Conference

Ryder Scott Reserves Conference – Cont. from page 3

SPE-PRMS revisions to be final in 2017

John Etherington, managing director at PRA International Ltd., will discuss the status and plans for the update project on the 2017 SPE Petroleum Resources Management System.

In the previous issue, *Reservoir Solutions* newsletter reported that the SPE Oil & Gas Reserves Committee dropped its concept of uneconomic and economic proved reserves and redrafted its proposed guidelines so that all reserves categories are required to be economic.

The SPE-PRMS is considered to be the best set of technical and commercial guidelines in the industry for estimating reserves worldwide.

Carbon tax effect on value of reserves

A carbon tax to curb emissions has gone live in Alberta. The levy in Alberta is $20 a tonne this year and $30 a tonne in 2018, and while much of it is paid by consumers, the tax is chipping away at petroleum reserves just a tad this year because of the "buried cost impact" that shows up primarily in vehicle fuel charges, municipal taxes and higher costs from vendors passing on the tax.

The public will be taxed at the gas pump and in home heating bills.

Industry won't have to contend with the levy directly until 2023 when it will go into effect on oilfield operations in Alberta, and apply to fuel use, flaring and venting.

Also, the carbon tax is reducing both reserves volumes and net present values this year, because in forecasts for year 2023 and thereafter, the levy will raise the economic limits used to estimate reserves.

John MacDonald, vice president at Ryder Scott Canada, will explore those issues and present, "Carbon Tax in the Evaluation of Alberta Reserves." He also will include the history of carbon tax in British Colombia oil fields as a model.

Open, honest dialogue

"Conference agenda is designed to inform and to elicit straightforward dialogue among all participants, including the audience," said **Larry Connor**, Ryder Scott director of Canadian operations and conference director. "Also, during regular breaks and at the post-conference reception, networking opportunities will provide occasions for evaluators to mingle and discuss common reserves issues."

Attendees also have a chance to seek clarifications on reserves disclosure issues with regulatory officials in attendance and who are available, understanding that the opinions of those officials do not necessarily reflect the opinion of the regulatory bodies.

Ryder Scott Canada underwrites the conference. For more information, please send an email to ConferencesCalgary@ryderscott.com.

Calgary-based Ryder Scott Canada conducts a full range of geological and reservoir engineering studies to estimate petroleum reserves and field economics for clients worldwide, including juniors, royalty trusts, independents and major integrated oil and gas companies.

Editor's Note: Monograph 4 can be purchased at https://secure.spee.org/store. The SPE paper on EEDCA is available for purchase at www.onepetro.com.

RS Houston conference Sept. 21

The Ryder Scott reserves conference in Houston is set for Thursday, Sept. 21 at the Hyatt Regency Hotel in downtown. A full house of almost 400 is anticipated. Attending licensed petroleum engineers will receive six to eight hours of CEUs (Continuing Education Units). Email requests, questions or comments to **RSCConfHouston@ryderscott.com**.

Other details:

When: Tuesday, May 16, 7 a.m. to 7 p.m.

Where: Marriott Downtown Hotel in Calgary, 110 9th Ave. SE, Calgary, AB T2G 5A6

Attendees/Agenda: Conference agenda is targeted to an audience with at least a "big picture view" of petroleum reserves. For a wider appeal, presentations on other oil-and-gas-related subjects are scheduled.

CPD hours: APEGA-licensed geologists and engineers will earn up to eight Continuing Professional Development hours.

Essential Extras: Attendees will receive notepads, pens and "approved" presentations on USB drives.

Costs: No cost for the event. Complimentary food and beverage will be catered by the Marriott. For more information: Please send an email to **ConferencesCalgary@ryderscott.com**.

Schedule of Events

"Evaluation Challenges in a Changing North America"

Time	Speaker	Affiliation	Topic
7 a.m. – 8 a.m.			Conference Check In and Light Breakfast
8 a.m. – 8:30 a.m.	Dave Haugen *Senior Vice President*	Ryder Scott Canada	Welcome and Introduction
8:30 a.m. – 9:30 a.m.	John Lee *Professor*	Texas A&M University	*Type Well Analysis - Complexities and Analytic Techniques*
9:30 a.m. – 10 a.m.	Vitaliy Charkovskyy *Senior Petroleum Engineer*	Ryder Scott Canada	*Type Well Prepared Example Walkthrough*
10 a.m. – 10:30 a.m.			Break
10:30 a.m. – 11:15 a.m.	Craig Burns *Manager, Petroleum*	Alberta Securities Commission	*Disclosure of Abandonment and Reclamation Costs in National Instrument 51-101 Standards of Disclosure for Oil and Gas Activities and Other Topics of Current Interest*
11:15 a.m. – 12:00 p.m.	Doug Wright *VP Engineering & Corp. Dev.*	Strategic Oil & Gas Ltd.	*COGEH 2017 Update*
12:00 p.m. – 1:00 p.m.			Buffet Luncheon
1:00 p.m. – 1:45 p.m.	He Zhang *Petroleum Engineer*	Ryder Scott Co. LP	*Application of Extended Exponential Decline Curve Analysis to the Montney Reservoir*
1:45 p.m. – 2:30 p.m.	Jim Erdle *VP USA & Latin America*	Computer Modeling Group Ltd.	*An Overview – Estimating Developed Reserves in Unconventional Reservoirs*
2:30 p.m. – 3:00 p.m.			Break
3:00 p.m. – 3:45 p.m.	John Etherington *Managing Director*	PRA International Ltd.	*SPE-PRMS Update Project - Status and Plans*
3:45 p.m. – 4:30 p.m.	John MacDonald *Vice President*	Ryder Scott Canada	*Carbon Tax in the Evaluation of Alberta Reserves*
	Dave Haugen *Senior Vice President*	Ryder Scott Canada	Concluding Statements
4:30 p.m. – 7:00 p.m.			*Cocktail Reception*

DCA rules of thumb for conventional reservoirs are difficult to unlearn

— Scott Wilson, senior vice president and co-author of SPEE Monograph 4

When I was asked to write Chapter 5 on decline-curve analysis (DCA) for the recent SPEE Monograph 4 on unconventional wells, I thought, "How is that any different than conventional well decline-curve analysis? There is nothing interesting there."

I had been forecasting unconventional wells for years, and they seemed no different than tight reservoirs, hydraulically fractured reservoirs, horizontal wells or combinations of those. Perhaps I was missing something.

Had my application of DCA just evolved with the reservoirs that industry was developing? Did I fail to notice the transition from conventional to unconventional?

Many books describe the equations needed for DCA, i.e., "Oil and Gas Property Evaluation," by John Wright, 2013. However, specifically focusing on the application of DCA as used by a practitioner with real wells, real data and real software was an attractive opportunity. I accepted the challenge.

Three years later, what I'd learned is that there are many rules of thumb used in conventional wells that are difficult to unlearn. These guidelines find their way into literature, academia, and sometimes, even into practice. Although they originally had meaning and value when first determined, their usefulness often fades as technology and workflows evolve.

For example, who will notice if the equation for determining cumulative production is mathematically unbounded for b values larger than about 0.7 at infinite time? No professional engineer would care, since our forecasts are constrained by realistic time horizons.

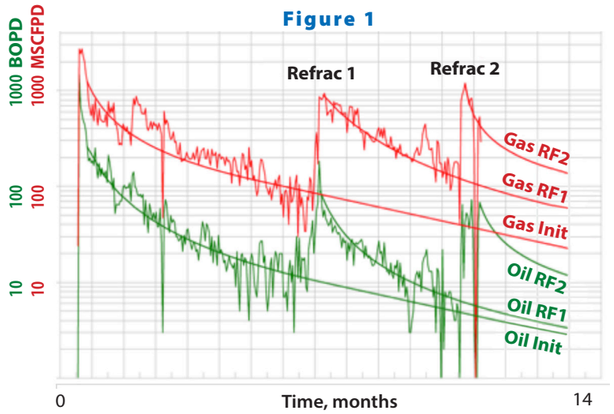
What about the common precept that the b factor can't be greater than 1? The runaway cumulative volume problem linked to the use of high b factors is only material if one forgets to use a trailing dmin segment on every hyperbolic. That has been a policy of professional forecasters at least since Long and Davis documented the trailing dmin in their 1987 SPE paper (No. 16237).

Many good ideas have surfaced in recent years to replace the functional forms that Arps summarized in 1944 and that were invented by others decades earlier. However, an article in *Bloomberg News* three years ago sums it up nicely, "As far as Arps being old, the wheel was invented a long time ago too, but it still comes in handy."

By using multi-segment forecasts, Arps DCA can be used to capture a wide range of reservoir behaviors, i.e., b=2 is exactly the same as theoretical linear flow into a fracture face. At the same time, exponential curves accurately depict late-life flows since they honor typical late-life behavior in many types of reservoirs.

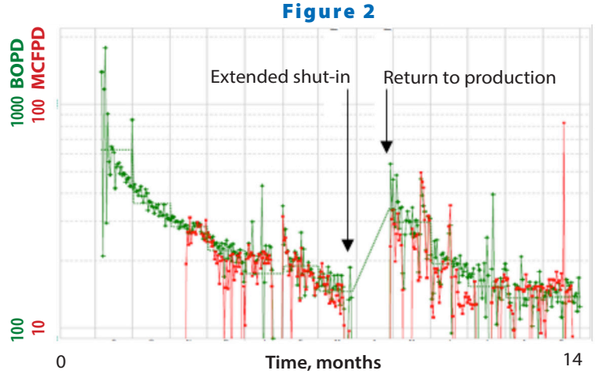
Unfortunately, those theoretical models typically require constant flowing bottomhole pressure, single-phase flow and a long list of simplifying assumptions. Multiple studies of b-factor trends imply that b will decrease over time as the well transitions from one flow regime to another. Frac flowbacks, constrained early production and reservoir supercharge are just three of the hundreds of well-life-changing events for an unconventional well and that popularized the use of flexible multi-segment Arps curves.

Figure 1



In the giant Wattenberg field, common practice is to refrac vertical wells since fracture conductivity declines and stress orientation changes. In Figure 1, three independent Arps curves are used to model three distinct periods of this well's life. The distance between the gas and oil lines becomes wider over time, indicating that even though oil production rates re-start after a re-frac, the reservoir pressure falls and remaining fluids get gassier.

Figure 2



Tight perm behavior is easily seen in rate responses after extended shut-ins. Consider the following example from the Bakken shale play (Figure 2).

In this case, the well might have been flowing naturally and then started to loadup and fail two months before it went down for artificial-lift installation. Note that the gas sales were not reported for the first few months, probably because the producer did not have a gas hookup until the third month.

Figure 3

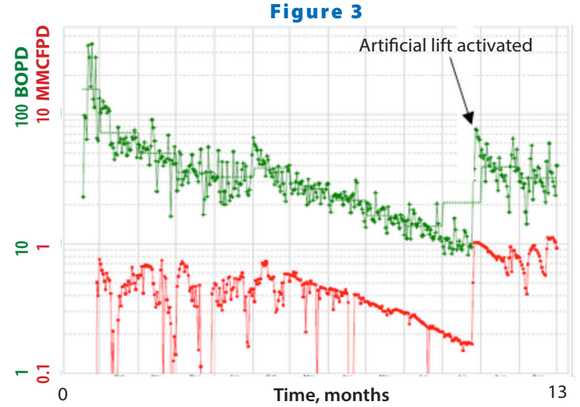


Figure 3 shows a significant production spike caused by implementation of artificial lift.

Water production is not shown on either of these plots which makes it difficult to determine if the extended shut-in was accompanied by an offset frac that supplied water and incremental production to the parent well. Figure 4 shows classic reservoir behaviors that may be missed if only a single phase is used for forecasting.

Please see DCA rules on Page 10

Figure 4

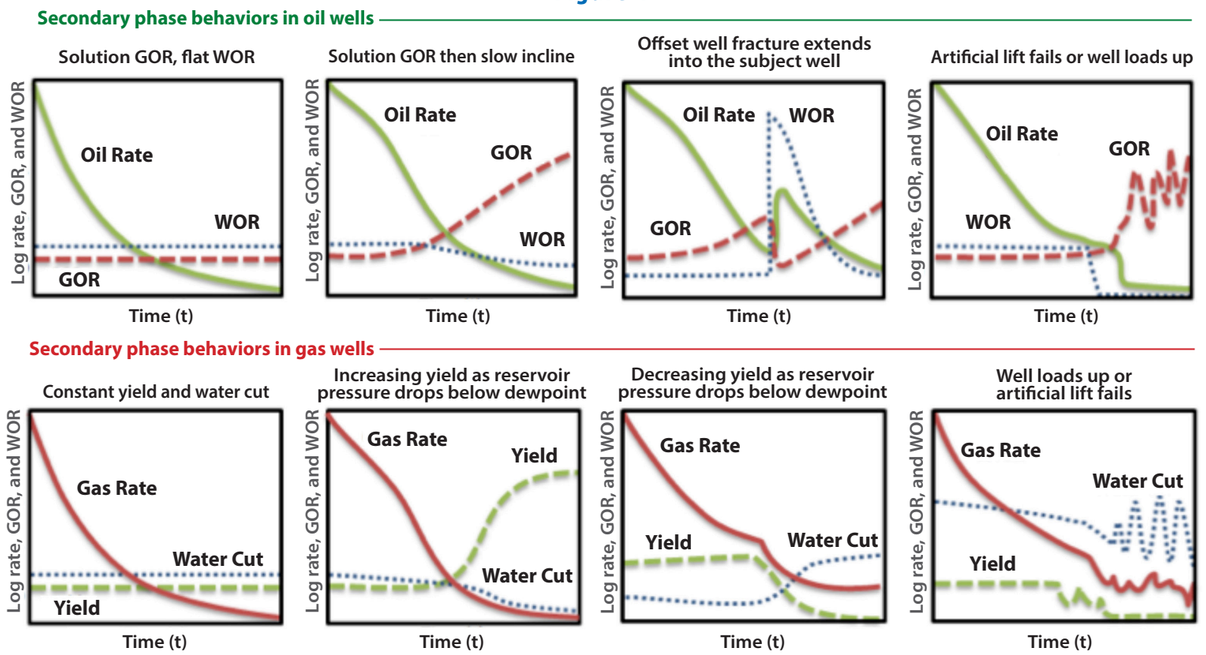


Figure 4. *Examples of production behaviors in unconventional oil reservoirs (top) and gas reservoirs (bottom). Each plot shows a different situation and possible trends resulting from that condition.*

Ryder Scott is 80 years old

Ryder Scott is celebrating its 80th anniversary this year. Ryder Scott Company Petroleum Engineers began operations in Bradford, PA, in 1937. Formerly an oil producer in the early to mid-1930s, Ryder Scott became the first engineering firm and research laboratory in the world devoted to solving waterflood problems.

Harry M. Ryder and **David Scott Jr.** formed the partnership after being asked for technical assistance by producers that had noticed the success of Ryder Scott-engineered waterfloods in the Bradford field. The firm originated several techniques. **Donald T. May**, the first employee, pioneered chip-coring analysis to provide accurate petrophysical data from a single plug of sand. Ryder, an electrical engineer, developed selective shooting of nitroglycerin for open-hole completions. Ryder Scott also used a modified five-spot well pattern.

The firm continued to implement the best techniques under total engineering control to slow the production decline in the Bradford area during the 1940s. That included selective plugging in zones of water inflow and improvements in core acquisition, logging, completion practices, injection waters and pressures, well spacing and oilfield equipment.

With the Bradford area's inevitable decline in the 1950s, Ryder Scott moved to Wichita Falls, TX, to design successful secondary recovery projects. **John Buckwalter** became president in 1956, managing the Wichita Falls office and laboratories. Under Buckwalter's leadership, Ryder Scott expanded geographically to a wider physical presence than at any time in its history.

The firm had offices in Houston, Midland, Shreveport (Louisiana), Buenos Aires and an outpost organization in Caracas, Venezuela. Ryder Scott also had oilfield projects on six continents. A detailed history, "Buckwalter: 'Parachuter' with bold vision in 'Mad Men' age," was published in the March 2012 *Reservoir Solutions* newsletter at https://www.ryderscott.com/wp-content/uploads/news-2005-mar.pdf?r=false

In the late 1960s, **Ray Cruce** guided the evolution of Ryder Scott as it intensified its business and technical focus on independent petroleum reserves estimations. In 1967, the firm moved from Wichita Falls, TX, to Houston after acquiring Robert W. Harrison & Co. known for its reserves evaluations.

The "marriage" of Ryder Scott and Harrison formed the basis for the new firm that grew rapidly and became known for its advanced skills.

Cruce's background was primarily in reserves estimations. He sensed greater opportunities for that type of work, so he began contacting financial institutions after becoming chairman of the board and president in 1972. New York investment bankers and commercial lenders, keen on reducing risks in reserves-based lending, listened to Cruce. They became convinced that third-party certification was the best method of establishing a reasonable value for petroleum properties used as collateral.

Reservoir evaluations became the mainstay of the firm as bankers recommended to their clients that they obtain reports from reputable consultants as prerequisites for loans. Ryder Scott's name became a standard on most bankers' lists of qualified evaluators.

While Cruce had built Ryder Scott's business through face-to-face meetings over several decades, the next CEO **Ron Harrell** continued that approach while supplementing it with modern public relations methods. With Harrell at the helm as president in 1998 and CEO in 2000, Ryder Scott reached wider audiences as its global business grew.

He made 5 to 10 appearances every month, delivering presentations on oil and gas appraisals, reserves definitions and estimates and other topics. Harrell was also a leader in the Society of Petroleum Engineers, serving on the society's Oil and Gas Reserves Committee that drafted revised reserves definitions in 1997. He had a direct influence on how those standards were drafted.

Harrell also chaired the 1999-2000 SPE reserves committee.

Today, under the leadership of CEO **Don Roesle**, Ryder Scott bears little resemblance to the core-analysis laboratory of the 1930s. However, the firm still retains the principles of its founders — that oil and gas projects be evaluated and engineered to the highest professional and ethical standards.

A more complete history was published in the March-May 2012 *Reservoir Solutions* newsletter at https://www.ryderscott.com/wp-content/uploads/312nsltr.pdf. Previous articles on Ryder Scott's history are also published in prior newsletters.

Photo above – *Wichita Falls office in 1950s.*

Photo right – *Donald T. May, back row, second from left, and former president John F. Buckwalter, row above front row, second from right, appear in photo of undetermined vintage.*

Photo right – *Corporate offices today - Houston, Texas*

1937 – Incorporated in 1937 in Bradford, PA. Formerly an oil producer.

1940s – First lab in world devoted to waterfloods. Moved to Wichita Falls, TX.

1950s – Maintained five offices. Projects on six continents.

1960s – Spun-off businesses, acquired consulting firm, moved to Houston.

1970s – Conducted 700th waterflood study. Big growth in reserves studies.

1980s – Opened Denver office.

1990s – Opened Calgary office. Study of Elk Hills Naval Petroleum Reserves.

2000s – Age of SOX; Major reserves studies for compliance with U.S. SEC.

2010s – Business shaped by emergence of shale plays, industry slump.

DCA rules – Cont. from page 9

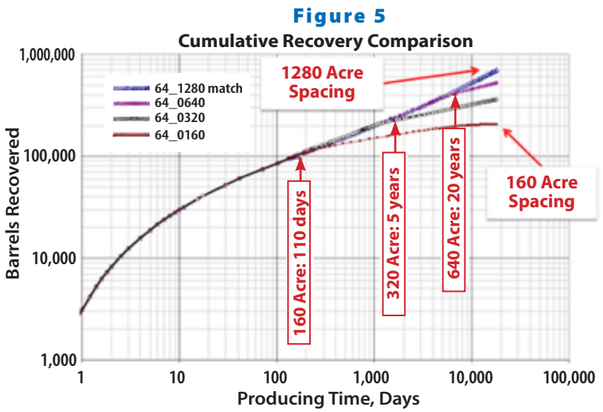


Figure 5. *In this simulation, wells start interfering at 110 days when spaced at 160 acres per well, while four wells per 1280 acres (640-acre spacing) do not show interference until 20 years after initial production.*

All methods have their strong and weak points, so the monograph chapter concludes by describing how classic DCA can be coupled with reservoir simulation to recognize infill well interference once it begins. While DCA can accurately match historical patterns evident in each well, anticipating future events that will change the previous trend is the purview of seasoned forecasters using alternate methods. Figure 5 shows how reservoir simulation studies can predict when well interference will be evident for several spacing scenarios.

Far from recommending that only trusted standard tools be used on new wells, Chapter 5 describes how conventional DCA can be used on unconventional wells, but highlights some of the issues that can make DCA difficult for any well. As always, a combination of tools and methods will provide a more nuanced view of a well's personality. Each of the remaining chapters in the monograph highlight the wide variety of tools that forecasters have at their disposal to forecast existing wells in unconventional reservoirs.

Article Note: Thanks to Stuart Filler, a senior vice president at Ryder Scott and past president of SPEE, for asking me to write Chapter 5 of the monologue and for assisting with this article. Monograph 4 can be ordered online at https://secure.spee.org/store.

History of Azerbaijan oil chronicled further in second book

Volume 2 of "The Concise History of Azerbaijan Oil," is a recent book release that chronicles various milestones of the Baku oil industry — from the world's first mechanical oil well in 1846 to the region's current status as a main source for Caspian oil. Along the way, companies in Baku produced half the world's oil by 1899, making it the No. 1 producing country, and surpassing the 40-million-BOPD output of the United States. In 1949, Baku oilmen discovered the then largest offshore oil field worldwide, Oil Rocks.

Those superlatives and other events are painstakingly documented and transcribed from Russian to English by author **Mir-Yusif Mir-Babayev**, both in Volume 2 and in the first volume, published in 2008.

Mir-Yusif Mir-Babayev

In those pages, he details the history of the Baku oil industry through thousands of hours of research and hundreds of references, making the volumes essential reference books for any oil scholar's library.

Nothing less should be expected from Mir-Babayev, a professor at Azerbaijan Technical University, who helped bring to light the drilling of the 1846 Bibi-Heybat well through his Volume 1 history. The September 2012 *Reservoir Solutions* newsletter published a four-page feature article on Volume 1, "166-year-old oil well largely unknown to West until 2002," which is posted at https://www.ryderscott.com/wp-content/uploads/news-2012-sep.pdf.

As the story goes, records of the drilling of the 1846 Bibi-Heybat well were published in 1904 and collected by the Caucasian Archeographic Commission. However the archived material went unnoticed for 65 years until an Azerbaijani historian found the records and published a Russian-language text that included the account. Mir-Babayev published the first English-language account in 2002 thus introducing the history to a wider audience.

The newsletter stated, "The history of the modern oil industry usually begins with the drilling of the now iconic Drake well in Titusville, Pennsylvania, in 1859. … that's a Western perspective, however. Not everyone was skimming oil before 1859."

Temple of the Zoroastrian fire worshippers at Surkhani near Baku.

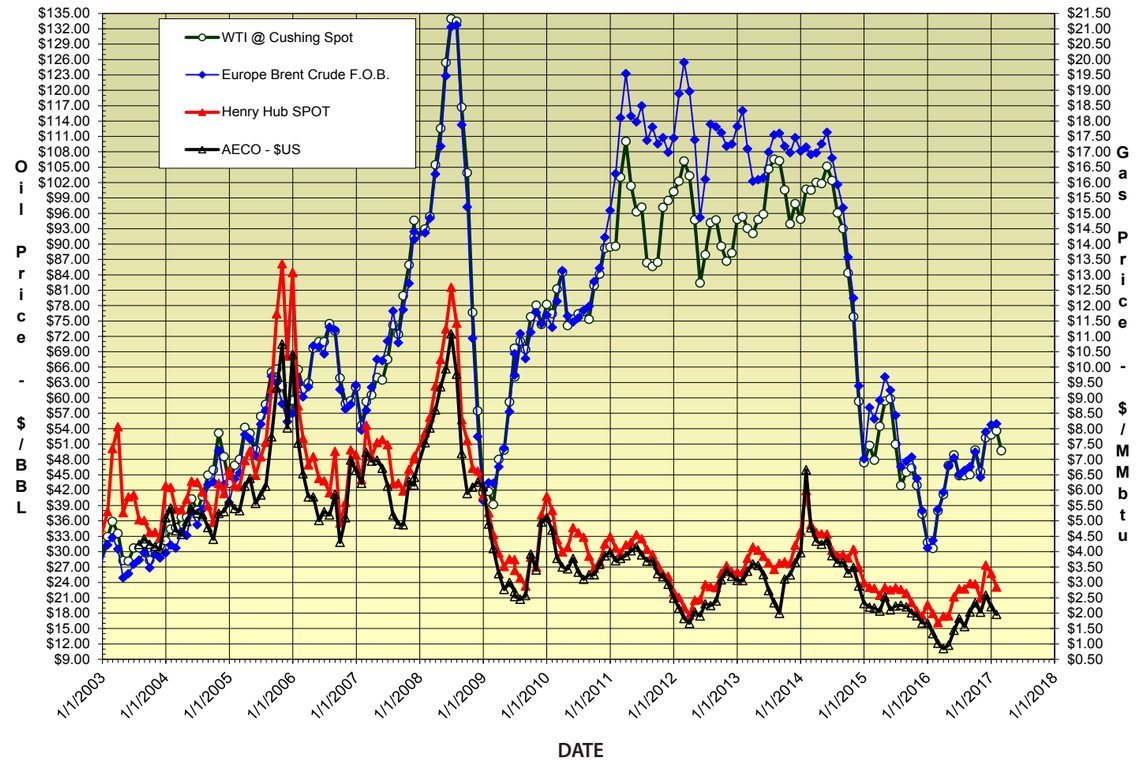
Volume 2 comprises eight essays with the first addressing the history of drilling oil and gas wells in Baku. Oil processing, transportation, research and development, marketing, current events and historical timelines and photos also are presented in this 370-page text.

While the accounts in the book are compelling, a lack of contents and index pages makes quick lookups difficult, requiring a reader to skim through the pages to find specific items. The English translation is clear, albeit not perfect, with some of that owing to the fact that the Russian language is wordier than English. Ultimately, the satisfying read compensates for any shortcomings.

The academic essay approach to organizing the material maintains the focus, and supports the thesis that Azerbaijan has a distinctive place in the history of exploration, production, refining and transportation.

Please see History of Azerbaijan on Page 12

Price history of benchmark oil and gas in U.S. dollars



Published, monthly-average, cash market prices for WTI crude at Cushing (NYMEX), Brent crude and Henry Hub and AECO gas.

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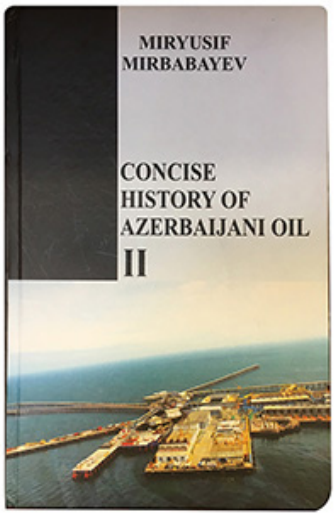
History of Azerbaijan – Cont. from page 11

Mir-Babayev chose to generalize on some subjects that were featured in Volume 1. For instance, he wrote about the innovations and business acumen of the Nobel brothers from Sweden in three detailed essays in Volume 1. However, in Volume 2, the Nobels receive far less attention, and understandably so to avoid duplication.

The result is that both "companion" volumes are needed to flesh out Baku's oil history.

Editor's Note: Volumes 1 and 2 are available for purchase from Mir-Babayev through requests made over his emails at mirbabayevmiryusif@yahoo.com and mirbm0@bp.com.



Publisher's Statement

Reservoir Solutions newsletter is published quarterly by Ryder Scott Co. LP. Established in 1937, the reservoir evaluation consulting firm performs hundreds of oil and gas reserves studies a year. Ryder Scott multi-disciplinary studies incorporate geophysics, petrophysics, geology, petroleum engineering, reservoir simulation and economics. With 130 employees, including 90 engineers and geoscientists, Ryder Scott has the capability to complete the largest, most complex reservoir-evaluation projects in a timely manner.

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