RYDER SCOTT

2019 QUARTER 1

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RYDER SCOTT COMPANY LP
TEXAS

RESERVOIR SOLUTIONS

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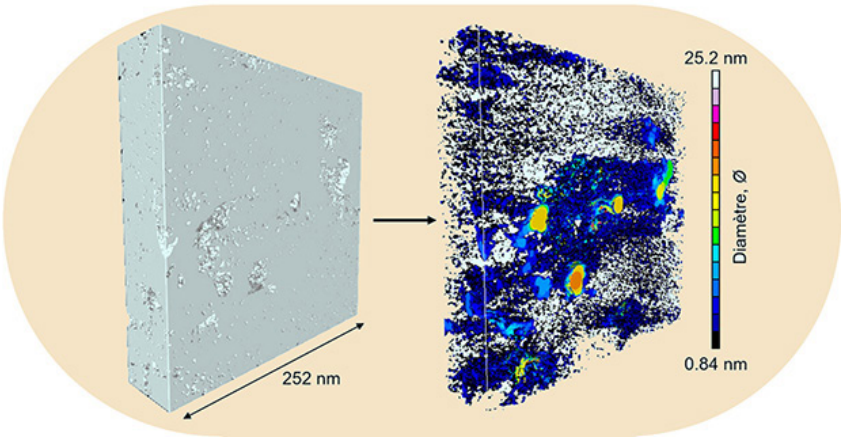
3D imaging of kerogen to improve production forecasts, MIT researchers say

"More accurate predictions of how much oil or gas can be recovered from any given formation" can be achieved through electron tomography of kerogen, said researchers at the Massachusetts Institute of Technology last October. They have used the imaging technique to generate 3D images of the nanostructure of pores in an organic component of oil and gas source rocks with 50 times more detail than previously achieved.

The 3D images have a resolution of less than 1 nanometer or one-billionth of a meter. Previous attempts to study kerogen structure had never imaged the material below 50-nanometers resolution, the researchers said.

The technical paper is posted on the website of the National Academy of Sciences at https://www.pnas.org/content/pnas/early-/2018/11/14/1808402115.full.pdf



Using electron tomography, Pellenq et al probed a kerogen sample to study its internal structure. At left, the sample as seen from the outside, and at right, the detailed 3D image of its internal pore structure. Image credit: MIT News Office.

The industry has long known that thermal maturity of kerogen is a key to its productivity and that pore structure and its interactions with fluids govern the mechanisms involved in hydrocarbon production from shale.

"Our 3D reconstructions confirm the formation of nanopores and reveal increasingly tortuous and connected pore networks in the process of thermal maturation," the study stated. "Relatively immature kerogen tends to have much larger pores but almost no connections among those pores, making it much harder to extract the fuel. Mature kerogen, by contrast, tends to have much tinier pores, but these are well-connected in a network that allows the gas or oil to flow easily, making much more of it recoverable."

In electron tomography, a small sample of the material is rotated within the microscope as a beam of electrons probes the structure to provide cross-sections at one

Please see 3D imaging on page 12

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Oil prices drop to $46 in December, analysts rejigger price decks

Starting in November, the only industry news was oil price. And news it was, as many were caught by surprise. On Nov. 5, the United States reimposed economic sanctions on Iran but gave eight of Iran's biggest oil and gas customers — China, South Korea, Taiwan, India, Greece, Turkey, Japan and Italy — waivers.

"It was only at the start of October that analysts were wondering if oil would soon cost $100 a barrel. Then a trap door opened and oil prices have been in a rapid descent since, losing nearly a third of their value in about eight weeks," the *Wall Street Journal* reported Nov. 27.

Market sentiment is difficult to predict and "turns on a dime." With the "lower for longer" price downturn still fresh on the minds of Big Oil, reality set in for international oil companies (IOCs) ready to test their new financial discipline.

> *"Then a trap door opened and oil prices have been in a rapid descent..." – WSJ*

On Nov. 6 — a day after the sanction waivers were effective — the U.S. Energy Information Agency (EIA) released its monthly outlook stating that in 2019, West Texas Intermediate (WTI) would average $65 a barrel, which is close to last year's average of $65.56. Please see "Average annual oil price for SEC reporting soars 28 percent," on next page.

By Nov. 26, three weeks after the waivers, WTI price was $51 and some change, down 30 percent over the recent high. Three days later oil crashed below $50 a barrel for the first time in more than a year as Russia did not commit to supply cuts, and U.S. crude stockpiles rose 3.58 million barrels in the longest run of gains since November 2015, reported *Bloomberg*.

Adding to the volatility and market uncertainty was a U.S.-China trade war that caused stock markets worldwide to plunge in December. The basics of this latest oil price crash are similar to those discussed in a *Forbes* magazine article, "The Next Oil Price Collapse," published in December 2017.

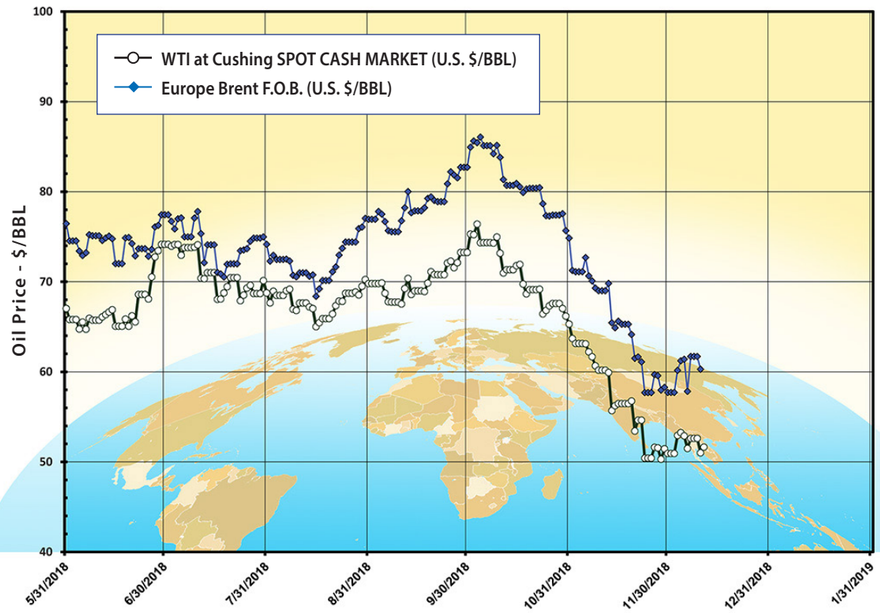
"The price collapse could occur in response to a bearish U.S. stock market, especially presaging a recession; cheating by Iraq or Russia; or U.S. oil shale production appearing so robust as to threaten OPEC's long-term market share," reported **Michael Lynch**, an energy analyst and contributor to *Forbes*.

On Nov. 30, U.S. oil production, boosted by prolific Permian Basin output, reached an all-time high at 11.7-million barrels a week, adding to the worldwide supply glut, the EIA reported.

Oil prices spiked, with WTI holding at more than $53 a barrel, on Dec. 7 after Iran agreed to an OPEC oil production cut of 800,000 B/D, and Russia and non-OPEC producers agreed to curtail 400,000 BOPD — a 1.2 million BOPD overall cutback.

On Dec. 17, oil dipped below $50 a barrel, which analysts attributed to an oversupply in the U.S. market. The dip became a valley on Dec. 20 as stock markets plunged further and WTI oil prices plummeted more than 4 percent to $46.21 a barrel, the lowest level since August 2017. The Dow Jones Industrial average dropped to a 14-month low entering a bear market.

Recent Price History of Oil Benchmarks



Oil prices started their precipitous fall in early October which continued through December.

Delaware Basin tops USGS list of oil and gas resource plays

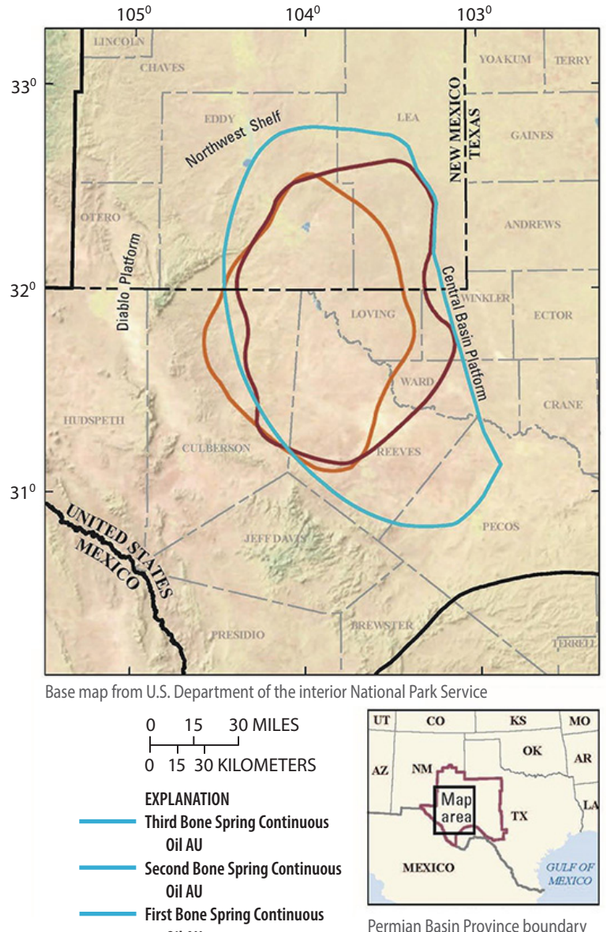
The Delaware Basin in Texas and New Mexico has the most oil and gas resources ever estimated by the U.S. Geological Survey, the USGS announced in December. The Wolfcamp shale and overlying Bone Spring formation in the Delaware Basin portion of Texas and the New Mexico Permian Basin province contain 46.3-billion barrels of oil, 281 Tcf of gas and 20-billion barrels of gas liquids, according to the assessment.

This estimate is for undiscovered, technically recoverable, "continuous" unconventional hydrocarbon resources.

Undiscovered resources are those that are estimated to exist based on geologic knowledge and already established production, while technically recoverable resources are those that can be produced using currently available technology and industry practices. Whether or not it is profitable to produce these resources has not been evaluated.

The Wolfcamp shale in the Midland Basin portion of the Permian Basin province was assessed separately in 2016, and at that time, it was the largest assessment of continuous oil conducted by the USGS. The Delaware Basin assessment of the Wolfcamp shale and Bone Spring formation is more than two times larger than that of the Midland Basin.

"The results …demonstrate the impact that improved technologies, such as hydraulic fracturing and directional drilling, have had on increasing the estimates of …resources," said **Walter Guidroz**, program coordinator of the USGS Energy Resources Program.



Base map from U.S. Department of the interior National Park Service

Permian Basin Province boundary is shown in plum.

Assessment units for the Wolfcamp Shale and Bone Spring Formation of the Delaware Basin.

Average annual oil price for SEC reporting soars 28 percent

The annual average prices for reporting year-end 2018 petroleum reserves to the U.S. Securities and Exchange Commission showed an increase in the WTI Cushing crude oil benchmark to $65.56 per barrel, an increase of 28 percent over last year.

The Henry Hub gas benchmark had a more modest increase of 4 percent to $3.101 per MMBTU. The Brent crude oil benchmark settled in at $71.54 per barrel, a 31 percent increase.

Other benchmarks and information on using differentials are posted at www.ryderscott.com/wp-content/uploads/FDOM_Benchmark_Prices.pdf

The prices are based on the unweighted, arithmetic average of the first-day-of-the-month price for each month in the calendar year. E-mail inquiries to fred_ziehe@ryderscott.com.

Multivariate analysis takes its rightful place in evaluator tool belt

Faced with a myriad of geological and drilling-and-completion (D&C) variables, the reserves evaluation sector has turned to multivariate analytics (MVA) to measure the effect of parameters on well performance. Multiple linear regression, one of many MVA tools, helps evaluators identify which completion variables have the highest impact on production and estimated ultimate recoveries (EURs) in unconventional plays.

When needed, statistical analysis helps bolster an evaluator's professional judgement. For Ryder Scott, the goal is to determine a best-fit production decline curve after statistically analyzing the play. The end game is an optimized field development plan to maximize the value of a producing asset.

"Really, any of you could be concentrating on any one particular variable to optimize your design, but if you only look at one variable, then you might be missing the bigger picture," said **Joshua J. A. Firestone**, an economist at Ryder Scott.

Firestone's remarks were part of his presentation at the Ryder Scott reserves conference in Houston four months ago.

Continuing, he said, "We have all these completion designs and they're changing rapidly. We're trying to absorb this information to improve our insights and make better decisions."

Joshua J. A. Firestone

Not all it seems

The goal of MVA is to understand the relationships of inputs to outcomes to better identify inputs with the most impact on a particular outcome.

Firestone showed a slide with three operators — A, B and C — to introduce an example of variables in D&C technology and geology that determine EURs. See the slide below.

"Initially, we would think the operator with the best geology would have the most success, but, of course, the other operators have their own ideas about how to create completion designs to extract the most value," he said.

On a lateral-foot basis, Operator A may be in the core geologic zone, but isn't doing any better than Operator C, which has relatively poor geology and acreage position.

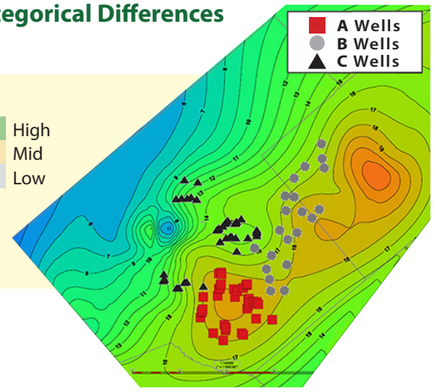
"We are not sure what is going on here, and that is where multivariate analysis can help provide insights," said Firestone.

Determination of Categorical Differences

- Completion designs are changing rapidly

	A ■	B ●	C ▲
Geology	Best	Good	OK
Lateral Length	5,000	7,500	9,500
Proppant LBS/FT	2,000	1,500	2,500
Stage Length	300	280	200
Well Spacing	262	625	525
Reserves BBL/LatFT	61	72	60

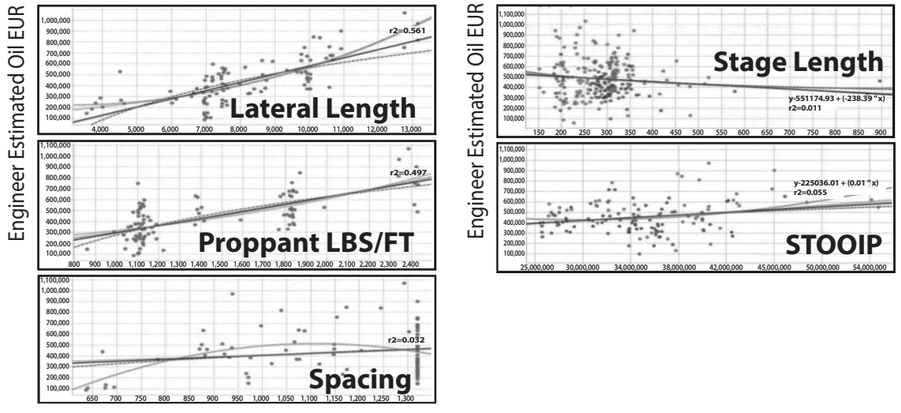
High / Mid / Low



- Considering all factors, can an operator create a better development plan to maximize value of future wells?

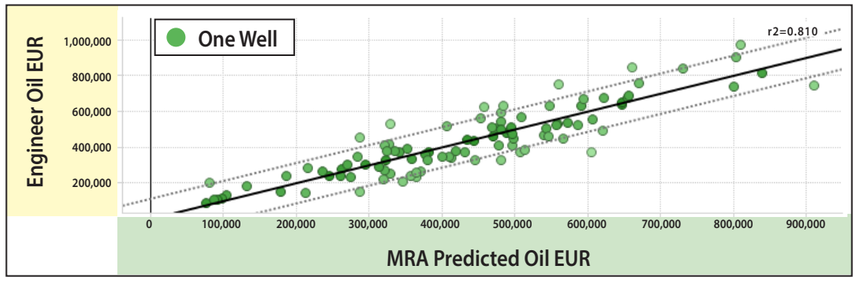
Multivariate regression analysis (MRA)

Firestone showed bi-variate relationships between D&C parameters and the engineer's EUR on separate charts as shown below.



He then "visualized" the combining of these variables in a multivariate relationship, where predicted oil EUR is plotted against engineering forecasts of oil EUR. See chart as follows:

Combined Multivariate Relationship



"MRA allows us to better understand aspects of these fields," said Firestone. "For instance, if the operator sees that the lease is not in the core geologic zone, then the company can explore alternative ways to complete the wells."

"What are the impacts of each of the individual variables? If I drill longer laterals, or include more proppant, how is that going to impact my reserves value? The solution is to combine those sensitivities or individual variables to analyze the completion design as a whole," said Firestone.

Regression basics

A simple linear regression equation is based on the slope-intercept formula, y = mx+b, where x is the independent variable (IV) and is assumed to be causing a change in y, which is the dependent variable (DV). The slope is equal to the change in y divided by the change in x. The slope, designated as m, measures the rate of observed change in variable y as a function of changes in variable x.

Finally, the y-intercept is b, i.e., the value of y when x = 0. This well-understood function applies to the relationship between only one IV and DV. In multiple linear regression, the equation changes slightly, but the underlying mechanics of the formula remain the same. The new equation for the predicted value is $y = m_1x1 + m_2x2 + \ldots + m_ixi + b$.

"One of linear regression's important assumptions is in the name, linearity, thus implying a constant rate of change in the DV when the IV changes," said Firestone. "For example, consider the impacts of drilling an incremental lateral foot and the expected change in reserves or production."

A linear-relationship implies that an incremental foot drilled at the heel of the well will yield the same expected reserves or production as an incremental foot drilled at the toe. "This may not be the case, but since it is an assumption of the methodology, it is important to keep in mind," Firestone remarked.

"Other relationships, such as a logarithmic fit, imply a diminishing return in reserves or production for each additional foot drilled," said Firestone.

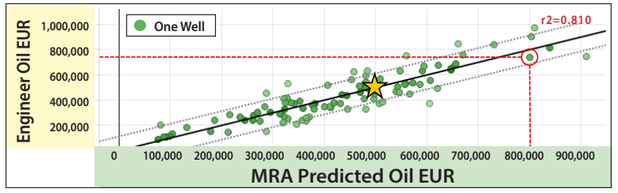
If an engineer determines a logarithmic or other form of fit better describes the underlying aspects of the geology or completion, the variable can be "transformed" by taking the natural log of the variable before including it in the linear regression equation to better capture the curvilinear relationship between variables.

A summary of regression basics, including method of least squares, is at http://faculty.cas.usf.edu/mbrannick/regression/regbas.html. Least squares is the most common technique for fitting a linear regression line.

Industry applications of regression analysis

Firestone showed a chart of regression analysis with engineering-estimated EUR as the DV on the Y axis and MRA-predicted EUR of 800,000 barrels on the X axis.

Please see as follows:



Variable List	MRA Weights		Well Values		MRA Equation
• Intercept	- 200,000			=	- 200,000
• Lateral Length	56	x	7,000	=	392,000
• Proppant LBS/FT	120	x	1,200	=	144,000
• Well Spacing	300	x	500	=	150,000
• Stage Length	- 400	x	350	=	- 140,000
• STOOIP (MMBLS)	8,000	x	19	=	152,000
				Σ	498,000

Examination of the errors — also called residuals or deviations from the best-fit line to the observed values — enables the evaluator to investigate the validity of assuming a linear relationship. In Firestone's example, the difference between engineering and statistical estimates is the residual.

The goal of the equation is to minimize those residuals. "We are trying to explain as much of the variation as reasonably possible," said Firestone.

Please see Multivariate Analysis on page 6

Multivariate Analysis – Cont. from page 5

Calculating an R^2 value shows the amount of variation in the DV explained by the IVs. "In this case, it's 0.81, meaning 81 percent of the variation in the reserves of these wells has been explained by our variable list," said Firestone.

MRA predictions for each of the IVs — lateral length, proppant LBS/FT, well spacing, stage length and STOOIP (MMBLs) — are combined to generate an equation, which is a series of weightings. Also included in the weightings is the intercept — the y value of the point where the regression line intersects the y-axis. Firestone multiplied the weightings by each individual well value and summed the results.

The MRA generated an example well with an EUR of 498,000 barrels of oil, indicated with a star on the regression line in the chart as shown on the prior page.

"The MRA indicates this is what the well will produce," said Firestone. "We will check that number against the engineer's estimate and gauge how well the equation worked," he said.

Changing completions and estimates over time

The importance of individual variables may change depending on the maturity of the well and geological characteristics. Early-time completion variables have more impact during early production – the same period of time which dictates much of the net present value (NPV).

Conversely, EURs are more dependent on geologic and well-spacing variables. Firestone mentioned that the types of IVs a company may want to investigate most closely depend on whether the company is looking at the economics or reserves of a well. Certain variables have differing degrees of impact depending on which of those analyses is done.

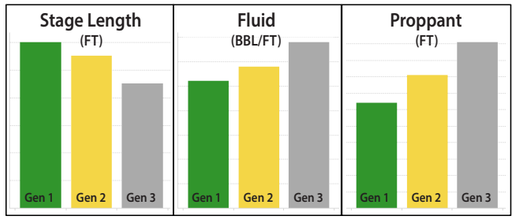
The greater the number of changing parameters for a completion design, the greater the complexity of forecasting production profiles. As an example, Firestone said a client changed stage length, fluid quantity and proppant weights over three generations of wells and indicated that those changes caused IP rates to almost double during the period.

"Our first question as reserve evaluators should be, 'Are these variables actually causing a change in reserves,'" he said. "So, in the MRA, we entered only those three variables and generated a plot with an R^2 value of 0.32 — not a great fit, but it's okay. We're explaining 32 percent of the variation."

When Firestone factored in additional variables, such as the longer drilled laterals and changes in spacing and location over the period of study, he said he got a much better fit, moving from an R^2 value of 0.32 to 0.65. Please see the chart on key variable impact.

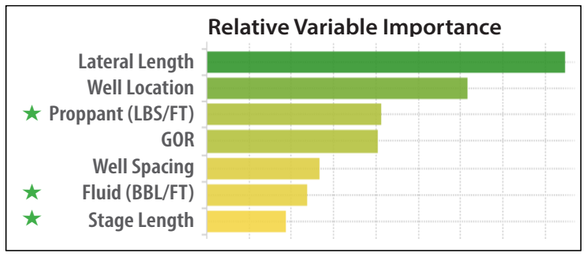
Key Variable Impact

- With completion designs changing, how should reserves volumes be estimated?
- Are these variables actually causing a change in reserves?
- Are there additional variables that should be considered?



R^2 increases from 0.32 to 0.65

For simplicity, Firestone included a relative variable importance table in the slide below to highlight the variables the client initially said were causing the change in reserves.



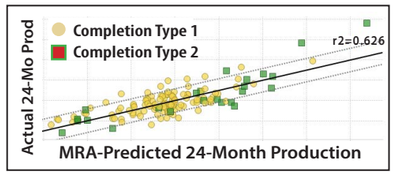
"Lateral length, well location, GOR and well spacing are highly impactful, yet somehow they were just overlooked as being significant because the client was not looking at all of the variables together," he said. "Since we have better identified the key variables, the odds that we are overestimating the impact of an individual variable has been diminished."

Firestone also introduced a case for determining categorical differences. "We have two different completion types. We want to analyze the differences, taking into account all the other relevant differences in the completions or geology."

Please see the following chart of Completion Type 1 vs.

Determination of Categorical Differences

- Is there a difference in completion type performance?
  - Completion Type 2 wells produce 35,000 additional bbls in the first two years of production



Variable List
- Effective Lateral Length
- Proppant LBS/FT
- Stage Length
- Well Spacing
- Fluid Properties
- Completion Type

Completion Type 2 with an R^2 value of 0.626 for the comparison.

"We see the green wells look a little bit better, but it's still inconclusive," said Firestone. He conducted an MRA and found that Completion Type 2 wells were actually producing, on average, an additional 35,000 barrels of oil in the first two years after normalizing lateral length, proppant, stage length and even geology.

Firestone said other categorical differences can be determined by applying this type of analysis to better understand whether reservoirs act similarly to completions when limited geology is available or whether operators in overlapping areas achieve similar results.

Benchmarking operators in overlapping acreage can be done through MRA. "It will show relative performances taking into account relevant differences between the completion designs of the two operators," said Firestone.

He remarked, "Such benchmarking really cannot always be adequately accomplished without multivariate analysis. If an engineer looks at the company's wells versus competitors, he or she could come to a quick conclusion that because there is a difference in the proppant pounds per foot and fluid barrels per foot, that could be the cause of the difference in observed production."

If the engineer places all variables thought to be relevant into a multivariate analysis, and the equation delivers a statistically significant categorical variable showing a difference between his company and competitors, then a more reliable conclusion replaces the quick one.

"Certainly the proppant and fluid may be part of the story, but there has to be something else the engineer had not previously considered," said Firestone.

He recommended that analysts perform a sensitivity test of the MRA equation to calculate the impact of each individual variable. He showed passing and failing results of a sensitivity test in a chart of D&C parameters and in-place hydrocarbon volumes. Please see the following chart.

Estimating Variable Impact

Passing Results

Variable List	Sensitivity
• Intercept	
• Lateral Length	7.9 %
• Proppant LBS/FT	2.9 %
• Well Spacing	3.0 %
• Stage Length	-2.8 %
• STOOIP (MMBLS)	

Screen for outsized individual variable impacts

Failing Results

Variable List	Sensitivity
• Intercept	
• Lateral Length	19.4 %
• Proppant LBS/FT	6.5 %
• Well Spacing	1.4 %
• Stage Length	-2.2 %
• Fluid BBLS/FT	2.2 %
• Well Location	

Sensitivity testing the equation evaluates the impact of each individual variable

Sensitivity testing seeks to measure the extent of a single IV's impact.

"This helps sanity check an equation," Firestone said.

He looked at how a 10-percent change in a particular variable affected the reserves estimate. The 10-percent increase in the lateral length of a 'median type well' caused a 7.9-percent change in reserves, as can be seen in the passing results on the left side of the chart above.

"This could be a little low, but it is certainly not unreasonable – there may be some kind of diminishing effectiveness of extracting the reserves as this well becomes longer," said Firestone.

The equation for the right side of the chart, however, has an unreasonable sensitivity to lateral length. Increasing a well's lateral by only 10 percent when holding all other factors constant, should not yield a change in reserves greater than 10 percent.

"If this was the case, we would drill the well for miles and miles," he said.

Really independent?

IVs are not always truly independent because, in the real world, there are dependencies between them. The contributions of lateral lengths, pounds of proppant, number of stages, etc. are related and not mutually exclusive. Sensitivity testing helps decipher the degree of IVs impact.

"Multivariate analysis aids in our understanding of which D&C parameters contribute the most to increases in reserves," said Firestone. "However MVA is just a tool.

Please see Editor's Note on page 8

Editor's Note – Cont. from page 7

Engineering and geology judgement still apply."

*Editor's Note: Six years ago, **Adam Farris**, in Analytics magazine, wrote that "the idea of a 'data scientist' was new, and should be considered alongside the petrophysical, geophysical and engineering scientists."*

He asked, "How does the industry bridge the vocabulary and cultural gap between data scientists and technical petroleum professionals? Ideas, applications and solutions generated outside the oil and gas industry rarely find their way inside. Other industries seem to have bridged this gap, but in talking to experts in the broader technology industry, the oil industry is seen as a no man's land…."

With no slight to the assertions of Farris, six years is a lifetime in the fast moving world of business and technical metrics. The upstream industry has been driven by data analysis and strong collaboration with geologists, petrophysicists, geophysicists, operations, etc., for decades. The sector is no stranger to predictive, interactive multivariate statistical models that predict geologic sweet spots and compare completion practices

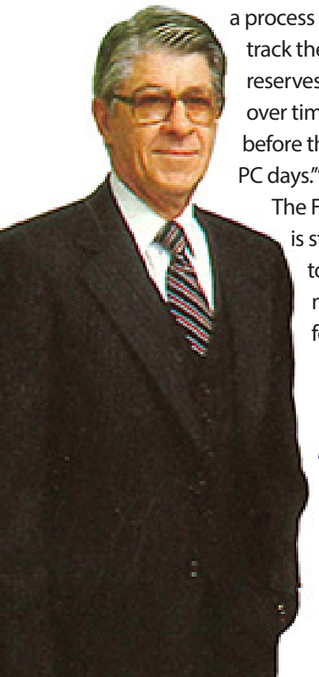
Early leader at Ryder Scott, creator of "Fickert sheet" dies

— *Katherine Wauters, contributing writer*

William "Bill" Eugene Fickert, who began working at Ryder Scott in Wichita Falls in 1958, died Nov. 20. He was 94. One of his contributions to the firm was the "*Fickert sheet*," created to establish and maintain historical records from previous studies.

Fred Ziehe, advising senior vice president who joined Ryder Scott in 1976, said, as a new employee, he began using the sheet.

"I reviewed work from other consulting firms," Ziehe said, "And none of them had a process in place to track their historical reserves estimates over time. This was before the 'modern PC days.'"



William "Bill" Eugene Fickert

The Fickert sheet is still in use today in a modified PC format using modern technology.

"Every day with Bill was a teaching moment," said **Nina Roberts**, a technical analyst who joined Ryder Scott in 1981. "You had better 'buckle up' and be ready when you entered his office. He was an expert extraordinaire at organization and expected the same from me and everyone."

Fickert's management style was different from most. Roberts said, "He taught me the finesse of directing people without making them feel less than equal. He was the ultimate team player."

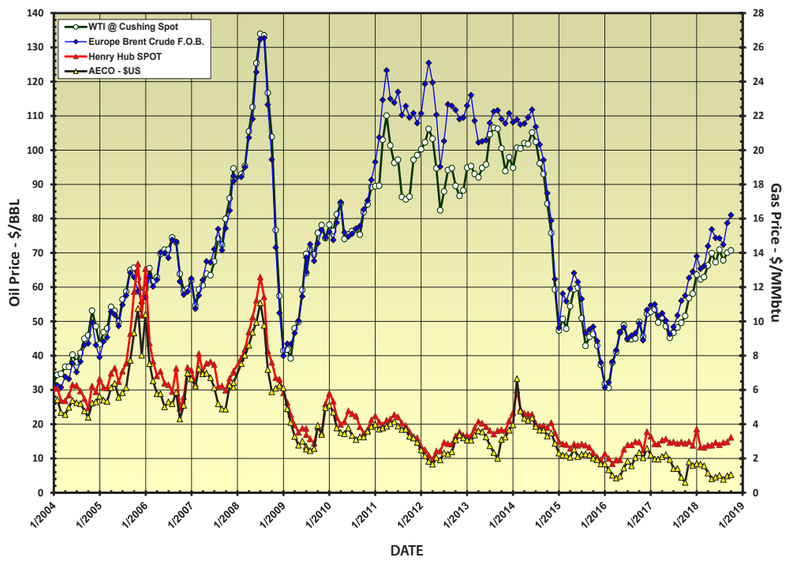
In the mid-1970s, Ryder Scott wasn't organized into groups, so younger engineers were exposed to and learned from senior engineers with varying backgrounds.

"Bill took me under his wing," Ziehe said. "I sure learned the importance of having a process to generate repeatable results and to explain the reasoning I used to estimate reserves."

Organized, methodical, detail-oriented, a fast eater and walker, friend and mentor

Please see Early Leader on page 10

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.

Reservoir simulation: A tool for making informed decisions on well spacing in unconventional plays

Miles Palke

The results of dynamic modeling as applied to well-spacing optimization in various unconventional plays were presented by **Miles Palke**, head of the reservoir simulation group at Ryder Scott. He recently made his remarks at the SPE Hydrocarbon Economics and Evaluation Symposium in Houston.

JPT magazine published an article in late November, "How Close is Too Close? Well Spacing Decisions Come with Risks," featuring Palke and others.

"There is no formula for properly spacing wells in unconventional plays. When a reservoir consultant recently described conversations with clients about how many wells they could drill per acre, it sounded like a doctor advising a patient considering back surgery," the article stated.

"I am not trying to tell producers what their spacing should be," Palke told the magazine, adding that the modeling and production history matching that Ryder Scott offers is part of "a process to help clients make informed decisions."

The question on spacing of wells has always been, "Where is the point of diminishing returns as well spacing gets tighter?"

Conventional vs. Unconventional Reservoirs

Conventional Reservoirs

- Matching static pressures dominated by reservoir parameters.
- History matches focus purely on reservoir parameters.
- Well productivity (completion, skin, PI) more directly considered in predictions than during history matching.
- Many uncertain parameters to adjust.
- Difficulty achieving a history match.
- Frequently full-field simulation models with many wells.

Unconventional Reservoirs

- Matching flowing pressures dominated by a combination of reservoir and wellbore parameters.
- History match about result of completion as much as purely reservoir parameters.
- Well productivity (completion, skin, PI) directly considered during entire process, not just for predictions.
- Many more uncertain parameters to adjust.
- Nature of data makes history matching more difficult.
- Frequently models of single wells or small groups of wells.

Most reservoir simulation models constructed in the industry use the familiar black oil formulation, but Ryder Scott uses compositional or chemical tools as needed, said Palke, who added that he uses an equation of state (EOS) PVT (pressure volume temperature) model to develop detailed EOS-based fluid characterizations for inclusion even in black oil models.

History matching is frequently the only information available to help identify the value of parameters that determine the outcome of the sensitivity analysis, Palke told the audience. The history-matching process narrows down the value of key parameters that determine optimal spacing.

"The best well spacing may depend on fracture half-length, or other parameters whose effective values are estimated through history matching."

Fracture half-length is the distance from the wellbore to the outer tip of a fracture propagated from the well by hydraulic fracturing.

He has also used rate-transient analysis to "precondition" simulation models to make history matching more efficient, but has experienced mixed results. "Translating (RTA) results into the simulation grid sometimes has a limited benefit because of inconsistency in modeling approaches," said Palke.

Relative permeability is a large driver of reservoir performance, especially regarding fractional flow of different fluids, however the use of relative permeability and PVT data remain an area of interest for research on unconventional reservoirs.

Although he cautioned about generalizing from the information he provided on individual unconventional plays, Palke

Please see Reservoir Simulation on page 10

Reservoir Simulation – Cont. from page 9

summarized the following "take-aways" from his reservoir simulation work.

> *"Operators turn to consultants such as Ryder Scott for history-matched reservoir models..."*
>
> – *JPT* Magazine

General observations

- Optimization of spacing has a strong relationship to fracture half-length.
- Half-length is usually varied in the history matching exercise, but . . .
- History matches are non-unique, and depend on other input parameters.
- Allow other sources of information to influence the history matching:
  - Micro-seismic
  - Presence or absence of frac hits
  - Fracture analysis
  - RTA
- Consider conducting sensitivity studies to cover uncertainty in other unmatched parameters, such as petrophysical values.
- Fracture half-length contributes to the optimal well spacing.
  - Other parameters, such as permeability and layering, can make a significant difference.
- Fracture half-length can be history matched, but is usually highly dependent on fracture height.
- In these cases, the challenge is in matching the pressure history along with each phase rate.
- Equivalent matches were achieved for varying fracture half-lengths, making the selection of the optimal well spacing subject to a residual uncertanty.
- Information from outside the simulation study must be considered in the decision-making.

"Operators turn to consultants such as Ryder Scott for history-matched reservoir models because they want results that line up with the output from actual wells," the *JPT* article stated. "But that leaves a lot of room for judgment calls."

Palke told the magazine, "Using the same wells for an equivalent history match, you can arrive at a range of options from 80 acres to 120 acres per well. If you have a big land position, that (difference) is a lot of wells. You would want to do a lot of work to decide which of those is the best decision."

Early Leader – Cont. from page 8

are just a few of the words employees used to describe Fickert. He was the embodiment of order in all aspects of his life.

Ziehe said, "I remember a time when Bill invited me to go deer hunting in Fredericksburg. He gave me a multi-page map, beginning with a Texas state map and star marking the town."

In true engineering fashion, the maps became increasingly detailed, each page showing another level, from Fredericksburg to the highway exit, then turns off small roads to dirt roads.

"The last map showed the farm property and house location, and most importantly, the deer blinds," said Ziehe.

Fickert served in the U.S. Air Force in the Pacific Theater during World War II. His next stop was the University of Texas. With petroleum engineering degree in hand, he began a nearly 30-year career at Ryder Scott, which owes its reputation, in part, to Fickert and others who shaped the firm's early history.

He was made a partner in January 1962 and retired in 1986 as a senior vice president. Fickert taught short courses and seminars, including "Economics of Waterflooding the Garyburg Dolomite in South Cowden Field," and "Waterflood Case History Caprock Queen Field."

He was an elder and committee chairman at Christ Presbyterian Church in Midland, TX, and taught Sunday school to junior-high students. Since 1971, Fickert had been a member of Memorial Drive Presbyterian Church in Houston, where he was also an elder and volunteer.

He is survived by a sister, **Joan Finkboner** of Illinois; daughter, **Karen Ann** and son-in-law **Scott McCoy** of Austin; son, **Gary Lee Fickert** of Houston and three grandchildren: **Shawn Thomas McCoy**, **Kristin Nicole Fickert** and **John Austin Fickert**.

In addition to his family, Fickert leaves behind his "Ryder Scott family," including those he helped mold several decades ago.

Liabilities soar for wellsite cleanup costs in Canada

In November, the *Globe and Mail* newspaper in Ontario published articles on abandoned wells and mounting liabilities for cleanup in British Columbia, Alberta and Saskatchewan. The Alberta Energy Regulator, the same month, estimated the costs of cleaning up the province's oilpatch could be as high as $260 billion up, from the previous $58-billion liability to taxpayers from orphaned and abandoned wells.

The Globe reported that "20 percent of all oil and gas wells in the three provinces are inactive, and that there are 54,147 more idle wells there than in 2005. Such wells no longer produce oil and gas, but have not been plugged." The newspaper also counted another 84,569 abandoned wells, some idle for decades.

Reclaiming the well sites and surface facilities and restoring the land to its original state are the responsibility of producers.

"Those wells have been filled with cement and capped because there is no profit left in them, but companies have not yet reclaimed the sites and restored the surrounding land to its original state," the *Globe* stated.

Canada's *National Observer* newspaper also reported in late November at a press conference, the Alberta Energy Minister **Margaret McCuaig-Boyd** threatened to crack down on the oil industry. She said, "Canadians shouldn't be on the hook for actions of irresponsible operators."

In November, the Alberta Liberal Party called for the province to create a bond program that requires companies to put up cash for cleanup costs to protect the government.

"Many U.S. states require companies to seek continuing approvals and post security bonds to keep wells inactive," the *National Observer* stated. "In some cases, they have to show evidence that the wells could be returned to production, if commodity prices improve."

Companies in Alberta have only submitted about $1.6 billion in security deposits to cover the costs. At the same time, unowned orphan wells – some abandoned, others to be abandoned – increased from fewer than 800 to more than 2,000. After Sequoia Resources Ltd. went bankrupt last year, the costs to decommission and clean up 4,000 wells, pipelines and other facilities fell in the lap of the province.

The *Globe* investigation also reported brisk trade in distressed wells and other facilities between major companies offloading those properties to smaller buyers with no ability to pay for abandonment and reclamation costs (ARC). "The deals were approved, even in cases where purchasers didn't meet the Alberta regulator's test for financial fitness," the publication stated.

Recent news has ramifications for the reserves sector. A year ago, *Reservoir Solutions* newsletter reported that the Society of Petroleum Evaluation Engineers chapter in Calgary was poised to challenge the Alberta Securities Commission interpretations of a 2015 regulation that requires a reporting issuer (RI) to cashflow oil and gas production net of ARC for wells, surface facilities and pipelines up to the sales point.

As it played out, SPEE lost whatever bluster it had, and its language in the 2018 Canadian Oil & Gas Evaluation Handbook (COGEH) fell in line with the ASC. COGEH clarified that abandonment-and-decommissioning costs should address producing wells, suspended wells, service wells, gathering systems, facilities and surface land development.

If ADR costs are excluded, COGEH recommends that the RI disclose those omissions to reconcile unaudited (supplemental) information in the 10-K with the audited financial statement. On the accounting side, all ADR costs are reported annually as asset retirement obligations.

In light of the November news on abandoned wells, reporting ARCs may become an even bigger issue in the reserves evaluation sector.

Canada's National Instrument 51-101 governs public issuers in Canada and refers to COGEH as "the standard of practice for evaluation and classification."

Historically, reporting issuers in Alberta have been more selective in their disclosures. "The cost of abandoning an exploration well, which is unrelated to reserves cash flows, should not be included," said one RI.

Just how the Canadian industry treats ARCs in reserves disclosures will be for all to see in year-end 10-Ks released in March.

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3D imaging – Cont. from page 1

angle after another. These are then combined to produce a full 3D reconstruction of the pore structure.

Sampling mature kerogen can be cost-effective. "Analysis can be done on rotary sidewall cores taken when drilling is stopped to acquire logs," said **George Dames**, advising senior vice president geoscience/geologist at Ryder Scott. "Geochemistry and TOC (total organic carbon) analysis is frequently done on cuttings."

Drill cuttings from a siliceous Marcellus formation in Pennsylvania provided the first kerogen sample tested by researchers. The less expensive cuttings process involves removing pieces of broken rock from the well via drilling fluids and raising them to the surface for study.

The paper was written by **Roland Pellenq**, MIT senior research scientist, as well as others at MIT, Shell Technology Center in Houston, and French National Center for Scientific Research and Aix-Marseille University in France.

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 multidisciplinary studies incorporate geophysics, petrophysics, geology, petroleum engineering, reservoir simulation and economics. With 115 employees, including 80 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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RYDER SCOTT COMPANY LP
TEXAS

RESERVOIR SOLUTIONS

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The Ryder Scott Mexico Reserves Conference in Cancún will be a two-day event, May 16 and 17, with the first day devoted to presentations by Ryder Scott staff. Guest speakers will present the second day. Ryder Scott will host the conference at the beautiful Grand Fiesta Americana Coral Beach Resort.

The cost of the conference is $350 USD and includes the following:

- **Attendance to both days of the conference**
- **Two nights at the Grand Fiesta Americana Coral Beach Resort**
- **Breakfast, lunch and happy hours**

Discounted hotel rates are also available for extended stays. For questions or information on how to register, please email organizers at RSCConfMexico@ryderscott.com.

Please see Mexico Reserves Conference on page 5

TABLE OF CONTENTS:

WSJ, Forbes send mixed signals on production forecasts

Early this year *the Wall Street Journal* asserted that oil and gas companies, in large part, are overestimating their reserves and production from unconventional plays.

"Two-thirds of projections made by the fracking companies between 2014 and 2017 in America's four hottest drilling regions appear to have been overly optimistic, according to the analysis of some 16,000 wells operated by 29 of the biggest producers in oil basins in Texas and North Dakota," stated the *WSJ* article.

That translates to 10 percent less oil and gas than forecast — an underperformance of 1-billion BOEs.

Forbes countered with an editorial stating that modeling entities around the world, including big banks, systematically underestimate production growth for shale oil and gas.

The *WSJ* aggregated and analyzed financial information at company levels in the U.S. while *Forbes* took a 30,000-ft view of industry, looking at forecasts from the U.S. Energy Information Administration and others. Different sets of metrics yielded different answers.

Spending outpaces revenues

The *WSJ* used interviews and industry sources to identify the culprits -- quicker-than-assumed production-decline rates, over-concentrations of well densities and forecasting based on insufficient sample sizes of wells.

"Academic research has suggested that data from at least 60 wells, producing for six months or more, would be needed for accurate forecasts," *WSJ* stated. "Yet some companies and analysts have made predictions based on fewer than 10 wells."

The *WSJ* also said that the 29 tracked companies spent $112 billion more in cash than generated from operations in the last 10 years, according to a financial information source.

"The Journal's findings suggest current production levels may be hard to sustain without greater spending because operators will have to drill more wells to meet growth targets," stated the *WSJ*.

The publication also stated that producers began using the term EURs (estimated ultimate recoveries) when prices dropped this decade to de-emphasize reserves, which are commercially recoverable under current economic conditions.

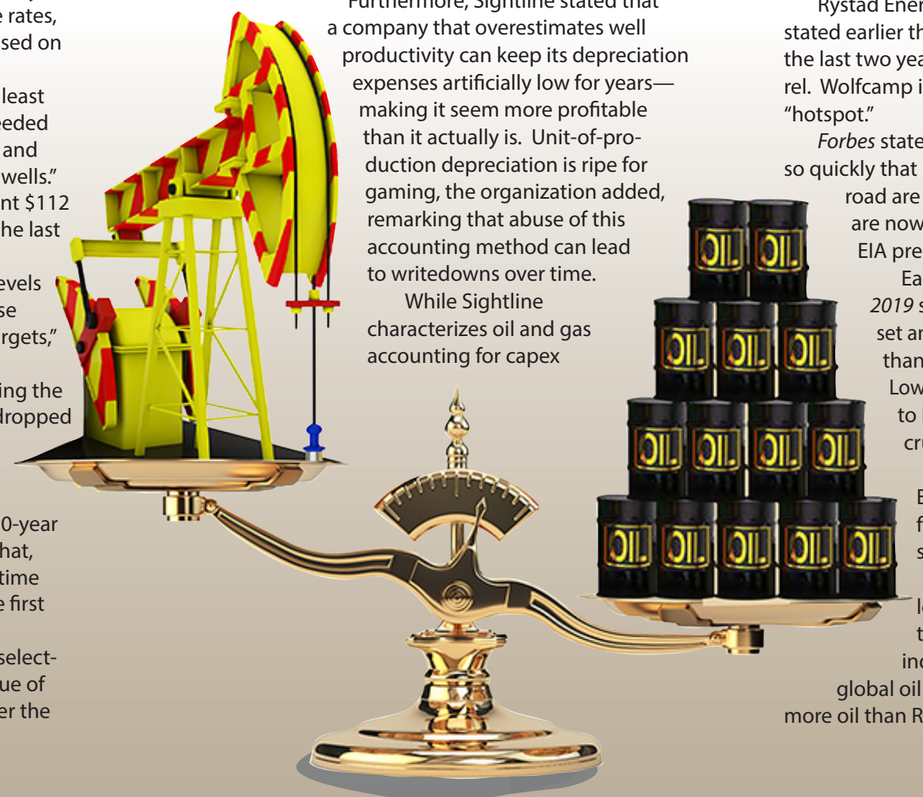
The *Journal* found that some producers factored in 50-year field lives into the EUR calculations to pad them out — that, despite economic realities that 80 percent of a well's lifetime production from unconventional reservoirs occurs in the first two years, by some accounts.

The *WSJ* also noted that the enterprise value (EV) of selected U.S. oil companies in 2017 averaged 2.8 times the value of proved reserves compared to 1.7 times in 2007. The wider the value gap, the weaker the financial fundamentals. The formula for EV is market capitalization plus total debt less cash and cash equivalents.

Fracking depreciation dodge

To question the financial health of the industry, Sightline Institute, a nonprofit think tank, pointed to what it depicted as a less-than-transparent oil and gas accounting system. Two months ago, Sightline posted a blog, "The Fracking Depreciation Dodge," which stated that oil and gas companies in the shale "use a variety of accounting tricks to distract investors from the fundamental weakness of their business models."

Specifically, the institute examined accounting concepts involving capital expenditures and depreciation. "Capex doesn't really count as spending at all. It is considered an investment rather than an expense. After a company makes a capital expenditure, its accounts show a decrease in cash, but an offsetting increase in the value of its capital assets," the blog stated. "Massive capital outlays will affect cash balances. But they will have no immediate effect on a company's tally of profits and losses."



Furthermore, Sightline stated that a company that overestimates well productivity can keep its depreciation expenses artificially low for years—making it seem more profitable than it actually is. Unit-of-production depreciation is ripe for gaming, the organization added, remarking that abuse of this accounting method can lead to writedowns over time.

While Sightline characterizes oil and gas accounting for capex and DD&A as "tricks," by some accounts, it fails to acknowledge that most investors are savvier than that.

For a primer on oil and gas accounting fundamentals, including depreciation, please see "Basic Petroleum Accounting for Petroleum Engineers," SPE technical paper No. 162907-MS, 2012, by **Dan Olds**, managing senior vice president at Ryder Scott. It is available for purchase at www.onepetro.org/.

No cause for panic

Forbes pointed to surging U.S. oil production growth as evidence that shale economics are not eroding. The editorial cited gained efficiencies, lower break-even points (BEPs) and better technology as mitigating factors.

"In the wake of the price collapse of 2014-2017, oil and gas companies have been forced to cut their breakeven costs to stay afloat," *Forbes* stated. "There were over 100 E&Ps that went belly-up during the period. Now, our shale producers have breakevens of just $50 to $55 per barrel, down from over $80 a few years back."

A BEP does not account for sunk costs, such as acreage and overhead, making it a "more forgiving" hurdle rate than life-cycle economics. Still, signs are that cost recovery is strengthening.

Rystad Energy, the primary source for the *WSJ* article, stated earlier this year that the average well completed over the last two years in Wolfcamp A is profitable at $45 a barrel. Wolfcamp in the Delaware Permian Basin is a so-called "hotspot."

Forbes stated that "the Shale Revolution has been rising so quickly that EIA predictions for 5, 10, or 15 years down the road are being surpassed in a single year's time. …We are now producing 80 percent more crude oil than the EIA predicted we would be back in 2012."

Earlier this year, the EIA *Annual Energy Outlook 2019* stated, "U.S. crude oil production continues to set annual records through 2027 and remains greater than 14-million barrels per day through 2040. Lower 48 onshore tight oil development continues to be the main source of growth in total U.S. crude oil production."

In March, the Paris-based International Energy Agency (IEA) issued its annual oil market forecast, which focuses on international energy supply and demand.

The IEA report stated, "The United States will lead oil-supply growth over the next six years, thanks to the incredible strength of its shale industry, triggering a rapid transformation of global oil markets. By 2024, the United States will export more oil than Russia and will close in on Saudi Arabia – a pivotal milestone that will bring greater diversity of supply in markets."

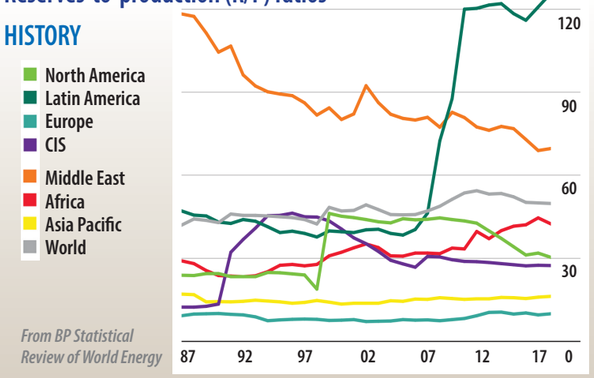
The *Forbes* editorial added that shale may be the safest long-term investment of all, because significant-scale replacements simply do not exist. At press time, the article was posted at https://www.forbes.com/sites/judeclemente/2019/01/13/u-s-shale-oil-and-natural-gas-underestimated-its-whole-life/#693cf144b596.

For a related article, please see "Permian Basin: Is the sky really falling?" at https://www.ryderscott.com/wp-content/uploads/2018NL_October.pdf?r=false. It covers the industry debate on how to best forecast oil and gas production from tight formations — an issue that has intensified, as evaluators pore over a growing cache of historical well data.

IOCs highgrade portfolios, petroleum reserves drop

S&P Global *Platts* news service recently reported that some IOCs (international oil companies) are high-grading their oil and gas property portfolios while moving away from a strategy of stockpiling reserves to replace annual production.

Reserves-to-production (R/P) ratios



From BP Statistical Review of World Energy

"Where a company's production-to-reserve (sic) ratio, or reserves life, was once a proxy for business sustainability, many now see exposure to stranded assets in reserves either too expensive or polluting to extract," stated *Platts*. The ratio of reserves divided by production is used as a metric to check whether a producer is maintaining a sufficient inventory of assets.

"Shell …has only replaced its annual production with new reserves twice since 2011 …," *Platts* reported. "The Anglo-Dutch supermajor is now able to maintain just 8.4 years

Please see Reserves Life Ratio on page 8

JVs get nod over debt, equity

Results of the spring borrowing-base redeterminations survey of Haynes and Boone LLP yielded the following expectations for reserves-based lending:

- Most respondents — comprising producers, oilfield service companies, energy lenders, private equity firms and others — expect spring borrowing bases to remain the same or slightly decline.
- Producers have hedged 40 to 60 percent of their production, making it less likely that borrowing bases will dramatically change.
- Sourcing capital through joint-venture transactions is gaining favor, as equity and debt go by the wayside.
- 2019 will be a difficult year to monetize assets.

For the full survey results, which include charts and graphs, please go to http://www.haynesboone.com/-/media/files/energy_bankruptcy_reports/borrowing_base_redetermina-tions_survey.ashx?la=en&hash=855F00BF4B92E6EA14A5C8B-30B2268A4EA0C43E7.

Planned sources of capital for 2019

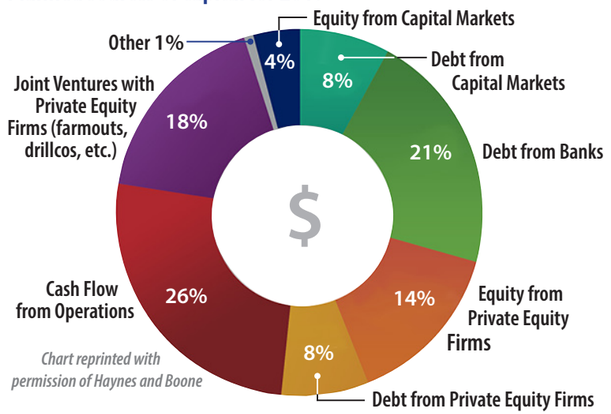
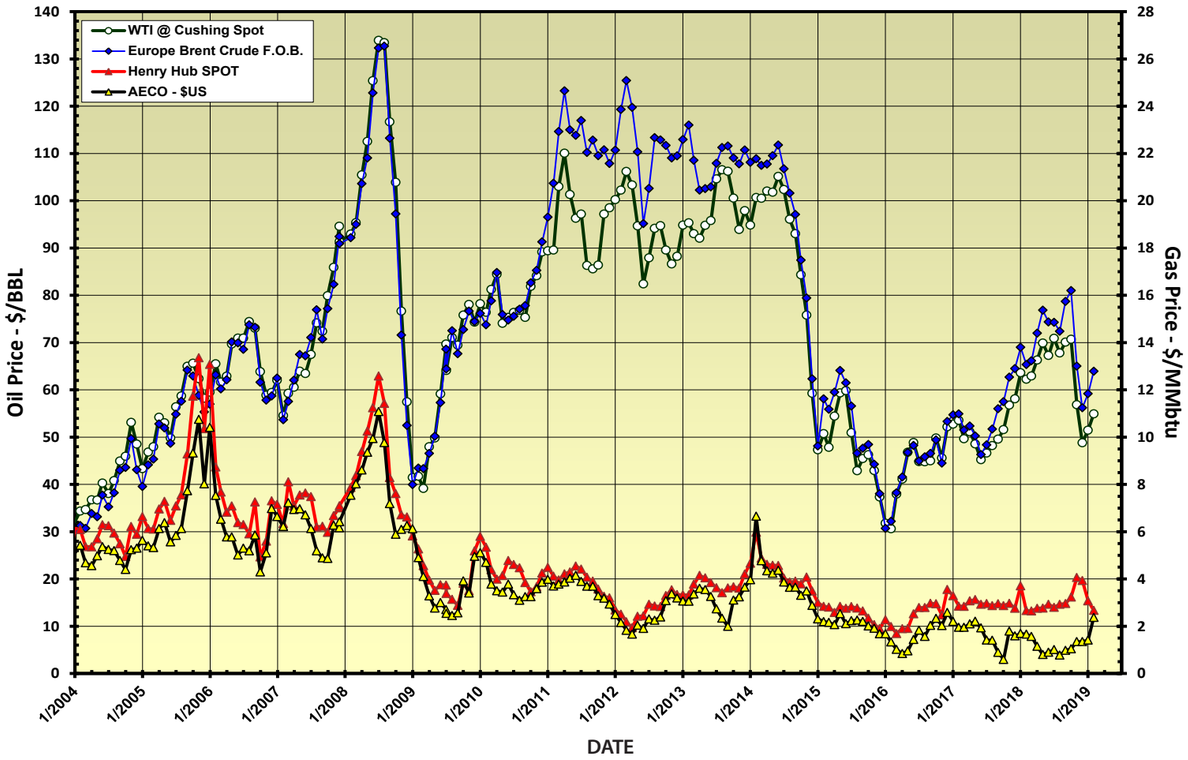


Chart reprinted with permission of Haynes and Boone

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.

Ryder Scott Mexico Reserves Conference – Cont. from page 1

2019 Mexico Conference - Schedule of Events

"Evaluation Challenges in a Changing World"

DAY 1 - Thursday, May 16, 2019

Time	Speaker	Affiliation	Topic
11:00 a.m. – 12:00 p.m.			Registration
12:00 p.m. – 12:15 p.m.	Guale Ramirez *Executive Vice President*	Ryder Scott Co. LP	Welcome and Open Conference
12:15 p.m. – 1:30 p.m.	Dan Olds / Guale Ramirez *Mng. Sr. VP - Member PRMS Cmte / Exec. VP*	Ryder Scott Co. LP	*The NEW (approved June 2018) SPE-PRMS Reserves Definitions*
1:30 p.m. – 2:30 p.m.			Lunch
2:30 p.m. – 3:30 p.m.	Dan Olds / Guale Ramirez *Mng. Sr. VP - Member PRMS Cmte / Exec. VP*	Ryder Scott Co. LP	*The NEW (approved June 2018) SPE-PRMS Reserves Definitions*
3:30 p.m. – 4:15 p.m.	Herman Acuña *Managing Senior VP*	Ryder Scott Co. LP	*Maturation of Resources from Exploration to Delineation and Development*
4:15 p.m. – 4:45 p.m.			Coffee & Networking
4:45 p.m. – 5:30 p.m.	Steve Phillips *Mng. Senior VP - Head of Geoscience*	Ryder Scott Co. LP	*Building a Geostatic Model for the Purpose of 1P, 2P & 3P Reserves Estimation*
5:30 p.m. – 6:15 p.m.	Miles Palke *Mng. Senior VP - Head of Simulation*	Ryder Scott Co. LP	*Building a Dynamic Simulation Model for the Purpose of 1P, 2P & 3P Reserves Estimation*
6:15 p.m. – 8:15 p.m.			Drinks and Heavy Hors d'oeuvres

DAY 2 - Friday, May 17, 2019

Time	Speaker	Affiliation	Topic
7:30 a.m. – 8:00 a.m.			Breakfast
8:00 a.m. – 8:15 a.m.	Guale Ramirez *Executive Vice President*	Ryder Scott Co. LP	Welcome to Second Day of Conference
8:15 a.m. – 9:00 a.m.	Hector Moyano / Juan M. Gavilan *Manager / Leader Reservoir Development*	Pan American Energy LLC / Hokchi Energy - Mexico	*Building a Model for the Certification of Reserves of the Hokchi Field, an Offshore Field in the Gulf of Mexico*
9:00 a.m. – 9:45 a.m.	Gildardo Guerrero Cruz *Mexico Operations Consultant*	Consultant	*Potential for Reserves Growth in the Onshore Southern Region*
9:45 a.m. – 10:15 a.m.			Coffee & Networking
10:15 a.m. – 11:00 a.m.	Carlos Morales *CEO*	Petrobal	*Navigating a Different Boat - The Private Perspective*
11:00 a.m. – 11:45 a.m.	Stefano Volterrani *Vice President*	GX Technology	*Extracting the Maximum Information from your Seismic Data*
11:45 a.m. – 12:30 p.m.	Adan Oviedo *Consultant*	Consultant (Former Subdirector for Exploration at Pemex E&P)	*Exploration Prospectives in the SE basins, where Mexico produces 95% of its reserves*
12:30 p.m. – 1:45 p.m.			Lunch
1:45 p.m. – 2:30 p.m.	Herman Acuña *Managing Senior VP*	Ryder Scott Co. LP	*Evaluating Reserves and Resources for Unconventional Plays*
2:30 p.m. – 3:15 p.m.	Sandeep Khurana *Vice President*	Granherne	*One Gulf Reaching 50 Billion BOE and Growing*
3:15 p.m. – 3:45 p.m.			Coffee & Networking
3:45 p.m. – 4:30 p.m.	Enzo Aconcha *Senior Geologist*	Ryder Scott Co. LP	*Case Study of a Tertiary Field in the Southern Region - A Joint Project with GX Technology*
4:30 p.m. – 5:15 p.m.	Gelacio Martin / Salvador Macias *Directors*	Comisión Nacional de Hidrocarburos (CNH) - Mexico	*CNH: Reserves Books*
5:15 p.m. – 5:30 p.m.	Guale Ramirez *Executive Vice President*	Ryder Scott Co. LP	Thanks - *Conference Closing*
5:30 p.m. – 7:00 p.m.			Drinks and Hors d'oeuvres

Petroleum engineers: Unsung but advancing the quality of life

Scott Wilson

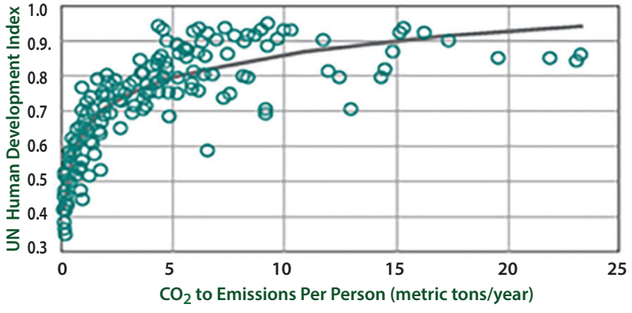
Scott Wilson, senior vice president at Ryder Scott, penned an editorial, "Why We Matter," in the March *JPT* magazine published by the Society of Petroleum Engineers. It is an ode to every petroleum engineer who helps satisfy the world's energy demands through development of hydrocarbon resources.

"When worldwide oil and gas consumption reached record levels yet again in 2017, SPE members were there when it counted, helping to generate more light and power for billions of people across the world," he wrote.

Wilson, a petroleum engineer, looks back to a time when society was lifted out of poverty by cheap energy. "For more than five generations, the oil and gas industry has helped raise living standards; protected environments by replacing firewood with natural gas and propane; and provided food to hungry people by increasing farming productivity, transportation, refrigeration, and packaging," he wrote. "Before hydrocarbons, the great whales were almost hunted to extinction to provide oil for lamps."

The first part of Wilson's theme is that petroleum engineers matter despite being rebuffed by Western societies with ideas about energy that don't always square with science and current economics — two pillars of the reserves evaluation sector.

The second part focuses on a review confirming that higher CO_2 emissions correlate with a greater quality of life for third world countries, emerging economies and beyond that until the population becomes highly industrialized and enriched.



The relationship between CO_2 emissions per person and quality of life as expressed in the United Nations Human Development Index.

At that point, as the population emits more CO_2, incremental benefits diminish. Please see chart from the United Nations Human Development Index study showing the leveling out of quality of life.

Wilson questions whether those upscale populations have forgotten what life was like without fossil fuels. As an example of an underappreciation of the industry, Wilson referred to a 2018 proposal in Colorado that "ostensibly in the name of safety, would have pushed the oil and gas industry out of the state by cutting off access to future drilling locations."

Please see the proposition, which was defeated, at https://dcgop.org/proposition112/.

Before the referendum, Wilson decided to canvass his neighborhood in the Denver suburbs to make the case for fossil fuels, asking each neighbor how he or she felt about effectively banning the oil and gas industry. Through his man-on-the-street interviews, he discovered what public relations practitioners have confirmed for some time now, and that is emotional appeals are more persuasive than logical ones and ultimately, drive decision-making.

"I quickly realized some were motivated by fear and beliefs not rooted in reality. To them, this sinister new trend known as 'fracking' was responsible for sinkholes, pipeline leaks, all earthquakes and inclement weather," he wrote.

"While each person … was polite and talked with me until I had 'worn out my welcome,' this vocal minority seemed uninterested in information that might challenge their beliefs."

Wilson observed paradoxes in Western cultures enriched by oil and gas that shun the industry at every turn. Among his examples are the yellow-vest protests in France and oil antagonism in Norway and the U.K.

Wilson sees parallels in the overreaction to the Fukushima Daiichi nuclear disaster caused by a tsunami. "After the disaster, Germany announced it would close all its zero-emission nuclear plants by 2022, even though only one of 17 active plants was near an ocean," he wrote.

Wilson wraps up the editorial with his failed attempt to switch to solar power as an alternative, cheaper energy source. "It was only after I installed a solar hot water system that I realized the cost to run the two electric circulating pumps was more than the cost of gas to heat an equivalent amount of hot water," he wrote.

Wilson concluded, "We provide a product that makes lives better for billions of people, and will continue to do so for decades to come." The 1,700-word article, at press time, was published at https://www.spe.org/en/jpt/jpt-article-detail/?art=5158.

Two petroleum engineers join Ryder Scott

Edward M. Polishuk

Edward M. Polishuk joined the Ryder Scott Denver office as a senior petroleum geoscientist after working there as a contractor. He has deep, hands-on knowledge of Rocky Mountain assets and evaluates oil and gas reserves. He also analyzes A&D opportunities.

Polishuk is an expert in the DJ Basin, and designed a robust spacing-stacking-completion design for the play. He has additional experience in the Permian, Eagle Ford, Delaware, Scoop/Stack, Marcellus/Utica, Bakken, Powder River, Piceance, San Juan and Uinta basins and plays.

Before joining Ryder Scott, he had been an oil and gas consultant since 2016 at GMG Energy in Denver. Polishuk evaluated prospects and conducted investigations for private investment companies. The work involved data room analysis and evaluations of acquisition candidates and joint ventures.

Before that, Polishuk was a development manager/senior engineer at Bonanza Creek Energy Inc. starting in 2012. He generated type curves, EUR projections, PUD capturing and spacing and PDP forecasting, and was involved in subsurface modeling and spacing studies.

He assigned reserves and resources to more than 3000 locations for four target horizons. Polishuk also was involved in asset and project management as well as engineering and geoscience work.

During 2006 to 2012, he worked at Encana Oil & Gas USA Inc. where he started as a lead reservoir engineer evaluating DJ, Paradox and west Texas basins. Polishuk forecast production, and quantified and analyzed oil and gas assets. He also conducted portfolio analysis, analyzed economics, managed AFEs, conducted economic modeling, evaluated potential acquisitions, optimized well performance and spacing and performed subsurface modeling.

After that, he was group lead, strategic planning for the South Rockies Business Unit for two years. Polishuk evaluated reserves, managed business development and analyzed JV and A&D opportunities. He conducted divestiture modeling for property sales packages up to $2.5 billion in value. He was the lead economic modeler and coordinator for $10 billion in funding deals for midstream JVs in the Piceance and DJ basins.

At his most recent position at Encana, he was senior reservoir engineer in charge of reserves, A&D and all engineering functions for the maturation of a new deep-exploration resource play in the Piceance Basin — from conceptualization to commercial exploitation. Polishuk was also in charge of asset management for a Niobrara/Mancos deep exploration program.

Before he worked at Encana, Polishuk was a senior reserve and economic analyst in 2002 for Williams Cos. Inc. Polishuk audited and analyzed economic projections, prepared budget forecasts and designed and tracked finances and performance measures.

In 2005, he became a reservoir engineer for Williams. Polishuk forecast production and evaluated reserves of the Piceance Highlands asset. He also monitored well performance and assisted with well bore and completion designs.

In 2000, he was an engineering advisor for two years at Ogre Partners Ltd. where he became an advanced user of the economic and reserve analysis software.

Polishuk was an asset team leader at Statoil Energy Inc. during 1995 to 1999. He conducted project management and implemented 40-to-80 well annual drilling programs in the Appalachian Basin. He was involved in full-cycle prospect generation, budgeting, economics, and completion design.

Polishuk was also involved in reserves management, reservoir characterization, production forecasting and enhancement of gas assets with a focus on tight gas sands and fractured Devonian shale reservoirs. He also worked in A&D and field operations for Statoil.

Polishuk has a BS degree in geology from Virginia Polytechnic Institute and State University. He is a member of SPE.

Beau Utley

Beau Utley has rejoined Ryder Scott as a petroleum engineer after a year's absence during which he led technical evaluations and analyzed transactions at a private investment firm in Houston. He originally joined Ryder Scott in 2015.

Before that, Utley worked at Encino Energy LLC as a reservoir engineer where he evaluated reserves for borrowing base redeterminations and reporting to the U.S. SEC.

He also worked at EnerVest Ltd. beginning in 2012 as a reservoir engineer responsible for assets in Oklahoma, Texas, Arkansas and Kansas. Utley prepared reserves and cashflow forecasts for PDP wells and estimated upside value. He was involved in the technical evaluation of more than $350 million in acquisitions. He also estimated reserves for filing with the U.S. SEC and for internal reporting.

Before that, Utley was a petroleum engineer at Constellation Energy Partners LLC where he provided reservoir engineering analysis and economic evaluation for all properties and potential acquisitions. That included estimating reserves under rules of the U.S. SEC and guidelines of the SPE-PRMS.

He also was a production engineer at Samson Resources Co. where he performed production surveillance and project management for more than 300 oil and gas wells in northwest Oklahoma and southern Kansas. Utley also analyzed and recommended artificial lift designs and designed and implemented well stimulation treatments and recompletions.

He has a BS degree in petroleum engineering from the University of Oklahoma and an MBA degree from the University of Houston. Utley is a member of SPE.

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Reserves Life Ratio – Cont. from page 3

of current production with its proved reserves, the lowest reserves life ratio of its oil major peers."

Also, Shell claims the U.S. Securities and Exchange Commission is penalizing the company by not allowing it to book reserves committed to its LNG terminals unless a third-party sales contract is in place, reported *Platts*. The supermajor is integrated and markets a lot of its own gas — a practice that it contends keeps some reserves off the books.

Platts also cited other IOCs that "take a more traditional view of growing their reserves," among them ExxonMobil Corp., which had 14 years of production in early 2018, and ENI SpA, which considers reserves to be a "marker of business sustainability."

For the full article, please see, "Oil majors wrestle with reserves as industry health measure" at https://blogs.platts.com/2019/02/28/oil-majors-reserves-health-measure/.

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 multidisciplinary studies incorporate geophysics, petrophysics, geology, petroleum engineering, reservoir simulation and economics. With 115 employees, including 80 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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2019 QUARTER 3

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RYDER SCOTT COMPANY LP
TEXAS

RESERVOIR SOLUTIONS

Published quarterly by Ryder Scott Co. LP July – Sept. 2019 / Vol. 22, No. 3

Rietz elected as new CEO, Roesle steps down

The new chairman and chief executive officer at Ryder Scott is **Dean Rietz**. Stepping down from those positions after 14 years at the helm, was **Don Roesle**.

Rietz is the seventh top executive in the 82-year history of Ryder Scott. He was elected to the board of directors in 2005, and served as executive vice president in 2012 and president in 2015. He joined Ryder Scott in 1995, and established the reservoir simulation group three years later. The formation of this group underscored Ryder Scott's commitment to advancement of its reservoir modeling capabilities.

Considered an expert, Rietz has been involved with all facets of simulation, including initial model design and conceptualization, model construction, history matching, calibration and final project documentation. In 2001, he and a colleague wrote a seminal SPE paper on reserves evaluations and the application of simulation, "The Adaptation of Reservoir Simulation Models for Use in Reserves Certification under Regulatory Guidelines or Reserves Definitions," (SPE 71430).

The published work broke ground and was the first of four SPE papers written on that subject by Rietz and Ryder Scott co-authors.

Rietz has more than 35 years of industry experience. Before joining Ryder Scott in 1995, he taught in-house material-balance schools to engineers at Chevron Corp. and the Eclipse user course while at Intera Petroleum Production Division.

Rietz began his career at Chevron USA Inc. in 1984 as a project engineer and started conducting modeling studies at Chevron E&P Services in 1988.

He is a registered professional engineer in Texas. Rietz received a BS degree in petroleum engineering from the University of Oklahoma and MS degrees in petroleum engineering and hospitality management from the University of Houston.

Rietz is an adjunct professor at UH where he teaches an applied reservoir simulation graduate course. He is also a member of SPE, SPEE and an instructor for the SPE short course, "Reservoir Simulation for Practical Decision Making."

Rietz was also a 2016-2017 SPE Distinguished Lecturer and chairman of the UH Petroleum Engineering Advisory Board.

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Roesle guided RS through decades of industry change

Don Roesle, former CEO at Ryder Scott, sees another market trend since he joined the firm 44 years ago. "Who would have ever thought of the possibility that Saudi Aramco would launch an IPO in public financial markets because they were concerned about cashflow from oil production in a low-price environment," he recently said. "Or that some of the other mega producers in the Middle East would be considering transparency in their reserves process in case they have to go to public markets?"

With more than four decades of experience in the international oil and gas industry, Roesle knows that change is the only constant.

Under his leadership in operations in the 1990s, Roesle helped guide Ryder Scott during major changes, including its transition from the premier U.S. and Gulf of Mexico evaluation consultant to its rapid growth in the international arena. He directed multidisciplinary project teams in major reservoir and field-development studies worldwide during that time.

Roesle joined Ryder Scott in 1975 and became vice president in 1979, senior vice president in 1995, executive vice president in 1997, president and chief operating officer in 2000, CEO/COO in 2005 and CEO/chairman in 2006.

In 1999, he and other board members changed the firm's 62-year-old trade name, Ryder Scott Company Petroleum Engineers, to Ryder Scott Petroleum Consultants. The new moniker reflected Ryder Scott's transformation from an engineering concern to a multidisciplinary reservoir evaluation firm.

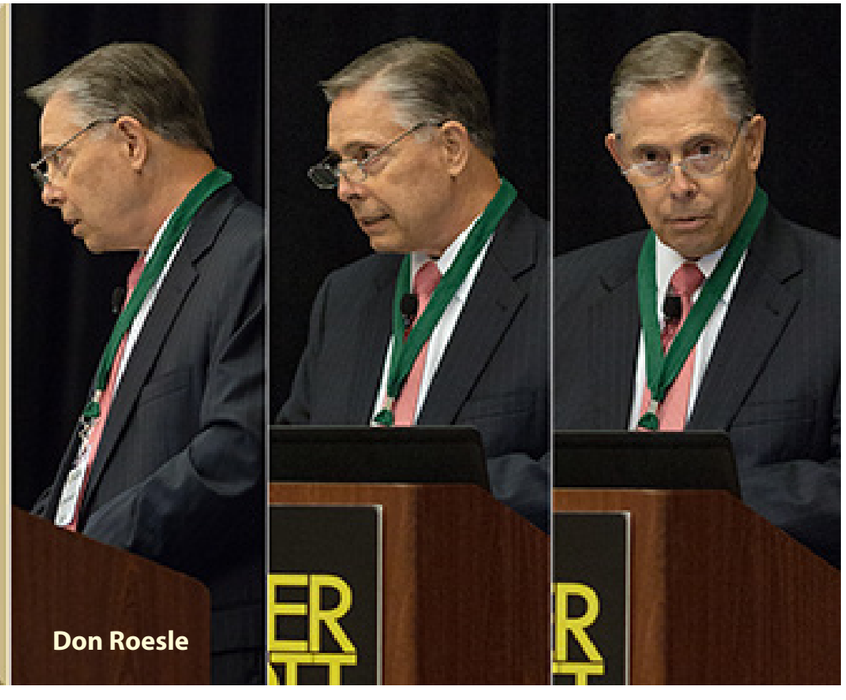
Then came the post-Enron era characterized by increased regulatory scrutiny as Sarbanes Oxley became a primary driver for change. Following a major reserves revision by the U.S. Securities and Exchange Commission, Royal Dutch Shell engaged Ryder Scott to conduct a fast-track review of the reserves classifications of selected fields in 2004.

As Roesle would say later, "Company management, investors and regulators are all asking questions about reserves assets, compliance, corporate governance, independence and transparency. They are asking that critical question, is the company SEC and SOX compliant? And they are turning to evaluators for those answers?"

On Roesle's watch, Ryder Scott grew its position as the No. 1 consultant of record as measured by number of clients filing reserves information with the SEC.

However, more SEC clients meant more challenges in dealing with outdated reserves reporting regulations. Always upfront and honest, Roesle told a group of reserves evaluators,

"Who would have ever thought of the possibility that Saudi Aramco would launch an IPO in public financial markets because they were concerned about cashflow from oil production in a low-price environment?"


Don Roesle

"The SEC, your chief regulator, has made our jobs a little more difficult on a daily basis, as we try to interpret exactly the intent of their guidelines."

His remarks were part of a presentation at the 2008 Ryder Scott reserves conference. Roesle pointed to signs that the SEC was preparing for "possible changes," and by the end of the year, the SEC adopted more modern reporting rules.

He managed one of Ryder Scott's largest projects – the Elk Hills field study in 1998. The firm deployed 51 of its engineers and geoscientists, grouped them into reservoir asset teams and assigned each team to a specific Elk Hills reservoir.

"Very few reservoir engineering firms at that time even had that many professionals to do the work," he said. The firm spent more than 40,000 hours analyzing the field data and produced a three-volume report a foot thick.

Under his leadership in the 2010s, Ryder Scott acquired more clients producing from emerging shale plays and, buoyed by high prices, the firm reached record sales revenues.

Roesle began his career at Tenneco Oil Co. as a drilling and reservoir engineer. But it was his tenure at Ryder Scott that will be remembered. His office was always open to anyone at the firm.

Brenda Mayes, vice president of administration, described Roesle as "detail oriented, works with excellence, but works with compassion for Ryder Scott, its employees and families."

At meetings, Roesle made his points but also listened to all sides without interrupting -- treating adverse viewpoints not as threats, but as valuable feedback -- he would then make a decision as leader or in concert with the board of directors or executive committee.

With an Xs and Os coaching style, Roesle has been a mentor for those who are now senior experts at Ryder Scott.

"In the course of someone's career, you may have the opportunity to work with somebody like Don only about once or twice in a career," said **Larry Connor**, advising senior vice president. "Don made a difference in my career and the careers of others."

Roesle also mentored **Miles Palke**, who is head of reservoir simulation. "Nobody else in the company has been a better mentor to me and to other engineers in Ryder Scott's history," said Palke. "Over time, I've learned so much on reserves and reservoir engineering."

Roesle has given numerous presentations and seminars to both the financial community and industry colleagues. He is a registered professional engineer in Texas and a member of SPE and the Society of Petroleum Evaluation Engineers.

Roesle is a past member of the Industry Advisory Committee to the Department of Petroleum and Geosystems Engineering at the University of Texas and currently serves on the UT Engineering Advisory Board of the College of Engineering.

Roesle has BS and MS degrees in petroleum engineering from UT.

Student interview elicits insights into profession

Last year, **Caleb Hoopes**, an 11th-grader at Blue Valley High School in Overland Park, KS, contacted Ryder Scott to find out more about petroleum engineering as a profession. He never expected that CEO **Don Roesle** would reply and offer some guidance.

Hoopes said, "I took a tour of the University of Kansas and the petroleum engineering building and I loved it. Ever since then I have been doing research and I think that petroleum engineering is for me."

Roesle agreed to answer several questions from Hoopes, including, "If you had it to do over, related to your career or education, would you do anything differently?"

Roesle responded, "I can say in all honesty that I would not change a thing I have done. I obtained a first-class education that prepared me very well for the energy industry and I have been very fortunate in the opportunities that have been presented to me."

He added, "The one exception to my comments is that I wish I had taken more geology courses while in college. Many engineers come into the industry with an incomplete understanding of the geosciences, which can be a hindrance to their full understanding of the reservoirs under evaluation."

Asked about what an average day looks like, Roesle said, "If you decide on the petroleum engineering field, you are picking a very demanding career, particularly in the consulting business. Every project comes with a deadline that clients expect you to meet. Each project is different but yet with many common requirements."

He added, "Our days are generally filled with almost constant time on a computer manipulating unbelievable amounts of data to determine the best and most reasonable answer to analyzing oil and gas reservoir performance to determine the quantities of recoverable reserves and their economic value."

The CEO continued to share his perspective with Hoopes, who used the feedback in a classroom project.

Roesle said, "Petroleum engineering is not a high-profile career like medicine or the legal field, but it can be a very rewarding career path. It's very technical in nature but can lead to many opportunities in the business world through finance and management. Many heads of energy companies are engineers by training, not business majors, but their career paths take them into management. Petroleum engineering is a worldwide profession that presents the opportunity for travel and involvement with people from all

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15th Annual Ryder Scott Reserves Conference

Houston conference, panel discussion feature a return to conventional reservoirs

The Ryder Scott reserves conference in Houston on Sept. 12 will feature presentations that reflect a growing change in sentiment among U.S.-based producers. In the Barnett shale play 30 years ago, producers began climbing the learning curve, increasing efficiencies and improving drilling-and-completions technology. They applied that know-how to other emerging plays, and now the United States is poised to pump a record 13.4 million BOPD by year-end, with the Permian Basin leading the way.

At the same time, the U.S. shale industry is starting to show some cracks, as critics in the industry and news media point to less than stellar returns, rising debt and production forecasts that do not meet expectations. Last year, the *Wall Street Journal* stated, "Two-thirds of projections made by the fracking companies between 2014 and 2017 in America's four hottest drilling regions appear to have been overly optimistic," based on 16,000 wells operated by 29 of the biggest producers in oil basins in Texas and North Dakota.

Industry critics of the Permian say that higher-than-expected GORs and lower oil production rates develop as reservoir pressures drop below bubble point, signifying "bubble point death." Others have published that after five years of production, horizontal wells in the Wolfcamp deep basin have declined annually at about 14 percent rather than the expected 5-to-7-percent terminal declines seen in older vertical wells there.

Tighter spacing and well-to-well interference have steepened the declines. Formations have not been as liquid rich as once expected.

While the issue is not yet settled, some oil and gas companies have shifted their focus. **Ali Porbandarwala**, senior vice president at Ryder Scott, has noticed clients cultivating a growing "balance of property portfolios with a good mix of conventional and unconventional opportunities, generating varied time horizons and cash flows."

He added that costs to acquire unconventional acreage in core areas have run too high for many producers to make healthy returns. Porbandarwala said, "Capital markets are now more reluctant to finance unconventional oil and gas projects when a company's operating free cash flow is limited. The honeymoon period may be over. There is a growing number of conventional opportunities in the world with more attractive returns."

Counter to that, some within the financial community are unwilling to shift their attention from unconventionals. Generally, experienced, successful producers in "statistical" plays are focused, specialized enterprises with lower risks than more diverse E&P companies, some investors say.

Porbandarwala is organizing the Ryder Scott conference. On tap are presentations and discussions on those issues.

Perennial speaker **John Lee**, a professor at Texas A&M University, will present, "Are Our Estimates of Recovery from Unconventional Resources as Bad as Critics Say?" A panel discussion led by **Ron Harrell**, chairman emeritus at Ryder Scott, will focus on the potential shift of capital back to conventional assets.

Please see the following agenda and schedule.

Details at a Glance

Date: Thursday, Sept. 12, 2019
Time: Check-in starting at 7 a.m.; conclusion of ethics presentation at 5:10 p.m.
Where: Hyatt Regency Hotel, Imperial Ballroom, 1200 Louisiana St., Houston, Texas 77002
Ethics Hour: Starts at 4:10 p.m.
Cocktail Reception: 5:10 p.m. to 7 p.m.
Email requests, questions or comments to RSCConfHouston@ryderscott.com.

Schedule of Events

"Evaluation Challenges in a Changing World"

Time	Speaker	Affiliation	Topic
7:00 a.m. – 8:00 a.m.			*Conference Check In and Light Breakfast*
8:00 a.m. – 8:20 a.m.	Dean Rietz & Guale Ramirez *CEO & President, respectively*	Ryder Scott Co. LP	Welcome and Introduction
8:20 a.m. – 9:05 a.m.	Vicki Hollub *Chief Executive Officer*	Occidental Corp.	*TBA*
9:05 a.m. – 9:50 a.m.	John Lee *Professor*	Texas A&M University	*Are Our Estimates of Recovery from Unconventional Resources as Bad as Critics Say?*
9:50 a.m. – 10:20 a.m.			Break
10:20 a.m. – 10:55 a.m.	Miles Palke *Managing Senior VP - Simulation*	Ryder Scott Co. LP	*Latest Themes in SEC Comment Letters*
10:55 a.m. – 11:30 a.m.	Adam Cagle *Senior PE - Data Science Coordinator*	Ryder Scott Co. LP	*Talking Shop: Data Science at Ryder Scott*
11:30 a.m. – 12:30 p.m.			Buffet Luncheon
12:30 p.m. – 1:15 p.m.	Michael E. Clark *Reserves Consultant, Global Reserves*	Chevron Services Co.	*Booking Proved Reserves Beyond Original Facility Design Life - Gulf of Mexico*
1:15 p.m. – 2:00 p.m.	Ron Gajdica *Managing Director and Global Head of Engineering*	EIG Global Energy Partners	*Practical Use of Reserves Reports: Compliance, Lending and Transactions*
2:00 p.m. – 2:15 p.m.			Break
2:15 p.m. – 3:00 p.m.	Steve Phillips *Managing Senior VP - Geoscience*	Ryder Scott Co. LP	*Mind the Gap - Leaping from Prospective to Contingent Resources - A Case Study*
3:00 p.m. – 4:00 p.m.	Panel Discussion - led by Ron Harrell *Ryder Scott Chairman Emeritus*	Ryder Scott Co. LP	*Ron Gajdica w/ EIG,, Eric Hambly w/ Murphy Oil Corp., Tom Harris w/ Blackrock Inc., John Howie w/ Tellurian Inc.*
4:00 p.m. – 4:10 p.m.			Break
4:10 p.m. – 5:10 p.m.	Dee Raibourn *Senior Enforcement Attorney*	U.S. SEC	*Financial Fraud and its Enforcement at the SEC*
5:10 p.m. – 7:00 p.m.			*Reception including Wine and Beer*

From left, Ryder Scott petroleum engineers Mark Nieberding, senior petroleum engineer; Guale Ramirez, president; Herman Acuna, executive vice president; and Miles Palke, managing senior vice president, at the 2018 reserves conference in Houston.

New board members, other promotions at Ryder Scott

Besides the board election of Dean Rietz to CEO, Ryder Scott made other major management changes and promotions. Former executive vice president **Guale Ramirez**, a petroleum engineer since 1976, is the new president. He joined Ryder Scott as a petroleum engineer in 1981.

Before that, Ramirez worked as a petroleum engineer at Natomas North America and Sun Production Co., where he began his career. He has a BS degree in mechanical engineering from Texas A&M University.

Ramirez is a registered professional engineer in Texas and member of SPE, SPEE and the Society of Petrophysicists and Well Log Analysts.

Miles Palke

New board members

Newly elected board members are managing senior vice presidents, **Miles Palke** and **Tosin Famurewa**.

Palke, leader of the reservoir simulation group, has more than 20 years of reservoir engineering experience with a heavy emphasis on simulation. Areas of expertise include sector and full-field modeling, fluid characterization, compositional simulation, coalbed-methane recovery, gas storage operations, nodal analysis, well test analysis and material balance analysis.

He has MS and BS degrees in petroleum engineering from Stanford University and Texas A&M University, respectively, and is a member of SPE.

Tosin Famurewa

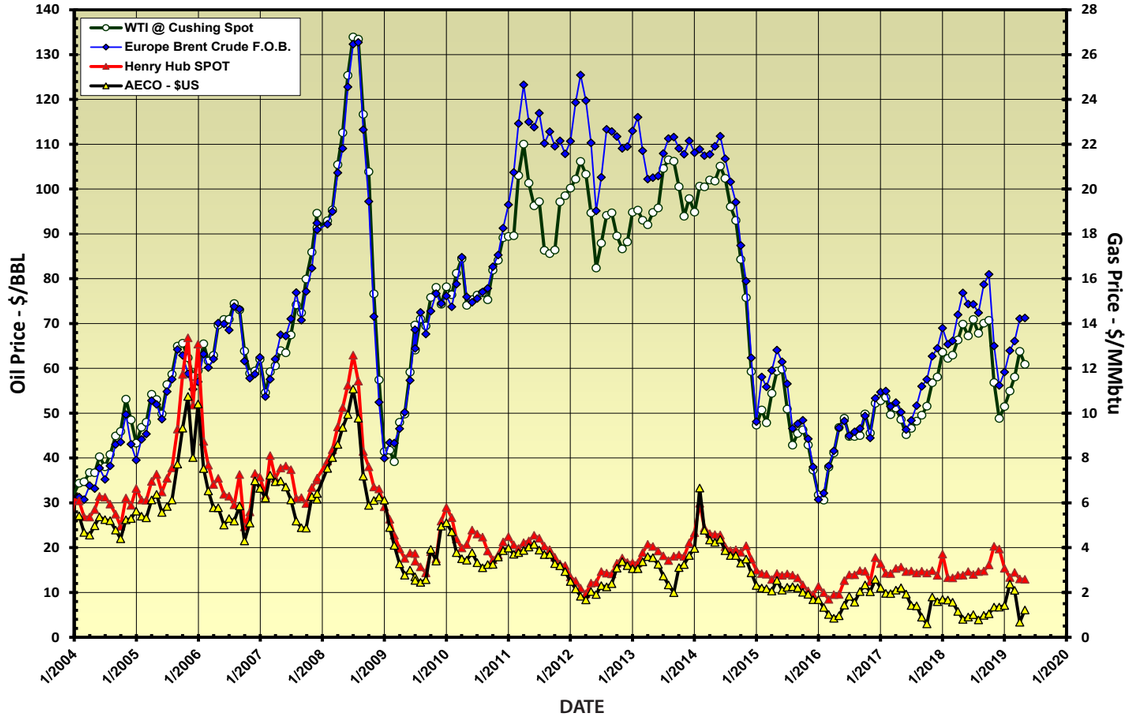
Famurewa began his career at Texaco Inc. and Chevron Corp. For more than 20 years, he has conducted reserves evaluations and analyzed waterflood and steamflood EOR projects worldwide.

At Ryder Scott, Famurewa, group leader, manages evaluation projects. He estimates reserves, forecasts production and analyzes field economics to generate discounted net present values.

He has an MS degree in petroleum engineering from the University of Southern California and BS degrees in chemical engineering and material science, respectively, from the University of California at Berkeley.

Famurewa is a member of SPE.

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.

Other promotions

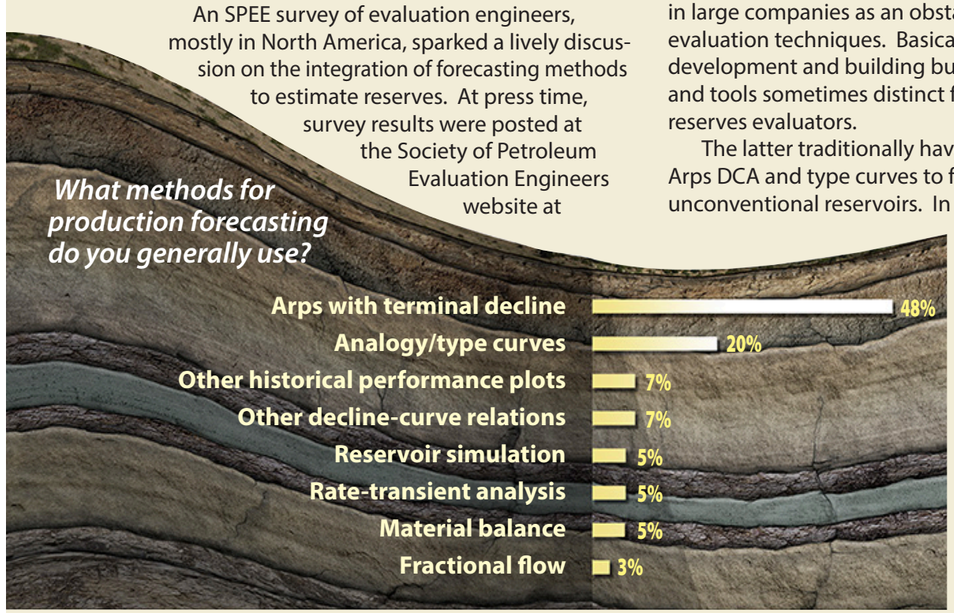
Herman Acuna and **Larry Connor** are new executive vice presidents. The board promoted **Ryan Wilson** to managing senior vice president and group leader. **Philip Jankowski** is a new senior vice president.

Victor Abu, **Deji Adeyeye**, **Vitaliy Charkovskyy**, **Amara Okafor**, **Lehi Woodrome** and **He Zhang** became vice presidents.

The board promoted **Cindy Ton** to senior engineering technician and **Jacqueline Nemry**, **Nathan Spann** and **Mark Stell** to engineering technicians.

SPE TIG debates industry practices for production forecasting in N. America

An SPEE survey of evaluation engineers, mostly in North America, sparked a lively discussion on the integration of forecasting methods to estimate reserves. At press time, survey results were posted at the Society of Petroleum Evaluation Engineers website at https://secure.spee.org/sites/spee.org/files/spee_software_symposium_user_survey_results_for_distr_20181017-002_1.pdf



Source: SPEE 2018 Petroleum Evaluation Software Symposium

Although most of the questions focused on the use of economic software, the question and results (above) are what set online discussions abuzz in a reservoir engineering technical interest group (TIG) of the Society of Petroleum Engineers (SPE).

TIG participants questioned why almost half of the 312 respondents indicated they generally use decline-curve analysis (DCA), an empirical method for production forecasting, instead of analytical tools. Only 5 percent or less of survey takers used either reservoir simulation, rate-transient analyses or fractional-flow methods.

To varying degrees, those reservoir engineering tools address the physics of fluid storage and flow.

Survey respondents comprised a balanced "sounding board," with 47 percent working at E&P companies while 39 percent were consultants. Results were regionally biased in that, all but 11 respondents were based in North America.

TIG participants pointed to "departmentalization" of staffs in large companies as an obstacle to integration of various evaluation techniques. Basically, those dedicated to field development and building business cases use processes and tools sometimes distinct from those used by corporate reserves evaluators.

The latter traditionally have relied mostly on modified Arps DCA and type curves to forecast production from unconventional reservoirs. In projects with some level of maturity, those methods enable corporate reserves evaluators to quickly handle large numbers of wells, especially with the rising use of autoforecasting routines.

The survey did not elicit comments on more recent DCA methods by name or on probabilistic modeling. Stochastic methods, used since the 1960s when it got its start primarily in exploration and drilling, have ascended in the world of reserves evaluations, ushered in by multivariate regression analysis, machine learning and other statistical approaches.

One commenter advocated for a more holistic, integrated approach to estimate reserves, suggesting that results from simulation and other methods be shared regularly with the reserves-evaluation side.

Another TIG member said the use of DCA in corporate reserves reporting satisfies U.S. and Canada regulators who want public issuers to use consistent, repeatable computational methods. In that way, investors are able to use a common yardstick to compare public issuers and their estimated reserves and net present values under standardized measures.

Reservoir simulation that meets the criteria of a "reliable technology" under SEC definitions can be used, in most cases, with other methods, to estimate and file reserves.

For information on SPE TIGs, contact the society. The website is www.spe.org.

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corners of the world."

Hoopes said he was grateful to have the opportunity to learn more about the industry from Roesle. "The interview piqued my interest even more and I am very excited for what the future holds," he remarked.

Roesle concluded his remarks, saying, "I hope my comments have been somewhat helpful to you, Caleb, in understanding what my profession is like. Keep in mind that everyone's experience is different. If you have any thoughts, comments or other questions, don't hesitate to contact me either by email or phone. Whatever path you decide on I wish you the very best."

Publisher's Statement

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RESERVOIR SOLUTIONS

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Reservoir Solutions add-ins grow to 12

Ryder Scott has posted two new Reservoir Solutions Excel add-ins to the webpage at https://www.ryderscott.com/reservoir-solutions/. They are the Lognormal Probability Tool and the Exponential Calculator.

More than 20 years ago, Ryder Scott released its first Reservoir Solutions freeware program and by 2006, the number of petroleum engineering and geoscience applications had grown to 10. Today, the Excel add-ins are used by thousands in the industry the world over.

Bob Royce, petroleum engineer, said, "Right now, I am using the Log Wizard software to do a Simandoux shaley sand analysis. It works well and gives me the answers I need very quickly. I have also used the volumetrics and P/Z add-ins."

To request a password to enable the Reservoir Solutions downloads, please go to https://www.ryderscott.com/reservoir-solutions/rs-freeware-password-request-form/.

The latest version of the software family is compatible with the following versions of Excel: 2007, 2010, 2013, 2016 and 2019. In addition, Ryder Scott developed a fix for Office 365 users, who earlier this year reported that the engineering menu did not load or appear on the add-ins tab of the Excel ribbon after installation.

Please go to https://www.ryderscott.com/reservoir-solutions/ for further information on how to solve the loading problem.

Starting with the two new programs, the following summaries describe the capabilities and functions of each add-in.

Ryder Scott designed the **Lognormal Probability Tool** to assist the experienced petroleum professional in developing assessments of undeveloped reserves and resources quantities in resource plays. The tool is based on the methodology outlined in Monograph 3, "Guidelines for the Practical Evaluation of Undeveloped Reserves in Resource Plays (2010)," published by the Society of Petroleum Evaluation Engineers. The template displays a probit plot with up to three lognormal distributions, each containing as many as 4,000 data points. The **Lognormal Probability Tool** features utilities for sorting data series. It also offers options to select the data interval over which the linear regression will be conducted. The logarithmic scale has a range of adjustments. With the preparation of the probit plot itself, the program will also determine and display the results of the analysis to include P10, P50 and

Please see Reservoir Solutions on page 2

Data Analytics

Ryder Scott has posted Well Collator -- a fully automated, web-based application that takes surface and bottom-hole coordinates for a group of wells in a CSV file. Then the tool makes use of a pad-branch-stem hierarchy that enables the user to estimate spacing in a cluster (pad) of wells. The free application is at https://www.ryderscott.com/software/well-collator/.

Adam Cagle, data science coordinator, said Ryder Scott plans to introduce a spacing-vs.-time calculation. "The enhancement will show how the well's spacing has changed over time and return this information as a time-series variable," he said.

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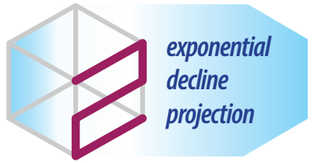
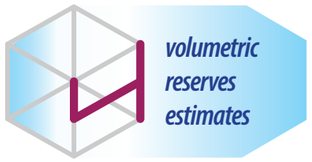
P90 distributions; lognormal series mean; arithmetic mean; and Swanson's mean. Also provided are Monograph 3 metrics P10/P90 and $\hat{p}$. Finally, the tabulation will display the count of data points included in the linear regression and indicate the conformance of the analysis to the criterion presented in Monograph 3, namely, whether the analyzed sample size meets the minimum recommended size.



Using **Exponential Calculator**, evaluators can enter any three valid exponential decline projection variables into the template and click "Calculate." The simple-to-use utility then calculates and displays the remaining two variables. For example, if the user enters initial and final rates for an exponential decline as well as an annual decline rate, **Exponential Calculator** will display remaining reserves and life of the projection. Of critical importance, the evaluator must enter parameters from a valid projection. Entering variables that are not physically or mathematically possible will generate invalid results.

TruVert 2-D provides a sophisticated calculation procedure to determine true vertical thickness (TVT) and net pay in deviated wellbores that penetrate dipping reservoirs. While the computation procedures are relatively simple, manual TVT calculations can be time consuming and often confusing. With **TruVert 2-D**, the user enters measured-depth log data, either measured or subsea contact depths and standard directional survey data for rapid, accurate calculation results.

TruVert 2-D enables the advanced user to emulate heterogeneous reservoir stratigraphy, providing net pay calculations by phase. As a bonus, **TruVert 2-D** incorporates Excel's versatile graphics-handling capabilities to provide the energy professional with printer-friendly, hard-copy output of individual reservoir geometry.



RyVOL facilitates the preparation of volumetric reserves estimates for oil and gas wells and reservoirs. The menu-driven program provides templates for either oil or gas reservoirs and allows the user to determine such fluid and reservoir properties as gas deviation factors, pseudocritical temperatures and pressures, oil- and gas-formation volume factors and calculated solution gas-oil ratios.

Volumetric in-place and recoverable reserves are based on user input for reservoir volumes and recovery factors. Secondary product recovery is calculated either as a percentage of product in-place or as a ratio relative to primary product. **RyVOL** works with the **Reservoir Solutions Modules 1.0**.

Reservoir Solutions Modules 1.0 gives reservoir engineers the capabilities to solve common problems requiring the calculation of oil and fluid properties, such as pseudocritical properties, compressibilities and formation-volume factors. Included in the program are functions for calculating Tc (pseudocritical temperature), Pc (pseudocritical pressure), Z factor (real gas deviation), shut-in bottomhole pressure, Cg (gas isothermal compressibility), Cw (water isothermal compressibility), Co (oil isothermal compressibility), Bo (oil formation volume factor) and Bg (gas formation volume factor).

Reservoir Gas Analysis Software (ResGAS) computes critical pressures and temperatures and specific gravities and heating values of a gas stream. The application works with the **Reservoir Solutions Modules** program.

The computation of gas properties includes corrections for contaminants and adjustments for condensate content. **ResGAS** also calculates wet gas in place and recoverable wet-, dry- and sales-gas volumes as well as recoverable condensate volumes.

ResGAS computes the estimated recovery of propane, butane and sulfur and approximates the BTU content of separator and gas sales. A user must enter separator-gas component percentages derived from laboratory analysis and other data input, including well and reservoir parameters and recovery factors.

QuickLook economics evaluation software gives the user a simple, fast tool to compute screening economics for prospects, evaluate workovers and recompletions and run preliminary lending economics. The user can run complete reserves and cash flow projections for individual wells or properties.

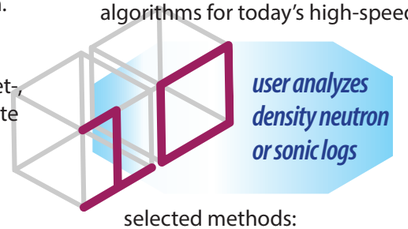
QuickLook computes up to four distinct product streams, two oil and two gas, and secondary product streams based on gas-oil ratios or condensate yields. The program provides options for exponential, hyperbolic, harmonic and manual product projections. A user can also subtract or add together streams.

QuickLook also has multiple expense, tax and investment-parameter options as well as a provision for abandonment costs.

The **Material Balance application** automatically calculates original gas in place (OGIP), estimated ultimate recovery (EUR), BHP/Z vs. cumulative gas production and Tc and Pc properties from gas gravity while adjusting for contaminants. Using the popular Cullender-Smith (1956) method as modified by Ryder Scott, the utility software also predicts shut-in bottomhole pressures from tubing pressures in gas wells.

With the **Flowing Pressure Analysis** program, a user can evaluate the performance of producing gas or gas-injection wells. The program enables the user to calculate flowing bottomhole pressures (FBHP) for gas wells. The application also automatically computes associated backpressure equation parameters and displays a traditional log-log backpressure curve at the user's option.

For producing wells, absolute open flow (AOF) potential is also calculated. Static bottomhole pressure (SIBHP) can be determined from shut-in tubing pressure (SITP). The application integrates techniques derived from Cullender-Smith and Turner, Hubbard and Dukler (1969). Ryder Scott modified those algorithms for today's high-speed computers.

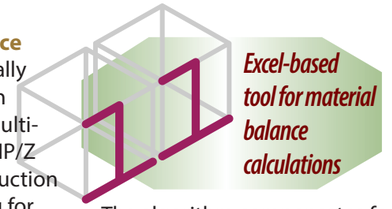


With **LogWizard**, a user analyzes density neutron or sonic logs using either of two templates and calculates the following petrophysical values based on user selected methods:

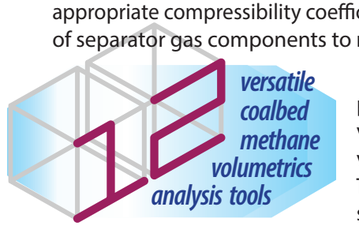
- Shale content—Applicable to consolidated and unconsolidated formations
- Total porosity—Uses arithmetic-average or sum-of-squares method
- Effective porosity—Uses arithmetic-average or sum-of-squares method
- Formation water saturation—Solves using Archie or modified Simandoux algorithms

For sonic logs, the program template uses interval transit time to calculate uncorrected sonic and effective porosities. For water-saturation and shale-content computations, **LogWizard** includes visual basic functions that can be exported or linked to other Excel applications.

Based on user-selected criteria, **LogWizard** calculates gross reservoir sand thickness and net pay thickness as well as average porosities and water saturations for pay sections. The program incorporates an Rw calculator to assist users in computing formation water resistivity from log data. The template also contains areas for entering core data or notes.



RamBal is an easy-to-use, Excel-based tool for material balance calculations to help predict future performance of abnormally pressured, unconventional gas fields. The algorithm compensates for reservoir rock and water compressibility in determining both OGIP and recoverable reserves and accounts for finite downdip free water expansion. The program requires only commonly available reservoir pressures, temperature data and gas properties and includes "calculators" and tips to help experienced petroleum professionals assess appropriate compressibility coefficients as well as the conversion of separator gas components to reservoir (wet gas) conditions.



The **rscCBM** program provides the user with versatile coalbed methane volumetrics analysis tools. The program incorporates standard Langmuir parameters obtained from laboratory analysis of coalbed core samples and has a feature-rich set of calculation procedures to provide useful, reliable results.

The volumetrics program presents a graphical representation of results for each zone, seam or well, which can be printed. Data validation and enhanced navigation are used extensively. In each case where calculated results are anticipated in the program, the user may optionally override such calculations. Those changes will be evident to the user by a change in background color. That is especially important when no lab data is available and calculations are entered manually rather than basing them on Langmuir parameters.

The templates in **rscCBM** are large by design and use "frozen panes" to facilitate data entry and visualization of graphical results. That could create difficulties for users with low-resolution graphics displays. To compensate, the program automatically detects the user's display settings to set or eliminate frozen panes.

Reservoir Solutions user manuals are included in the Excel files accessible from the engineering menu. All posted freeware programs produce presentation-quality, on-screen views and printer-friendly, hard-copy output.

Ryder Scott also distributes USB drives with the freeware from its booth at the SPE-ATCE and NAPE events.

Editor's Note: *Ryder Scott does not guarantee or warrant the accuracy or reliability of the Reservoir Solutions software and disclaims its fitness for any particular purpose.*

Acuña adds resources classification for some companies to consider

-- **Herman Acuña**, executive vice president

Herman Acuña

In this article, we explore the difficulties that some E&P companies face when maturing volumes from exploration to development – especially those companies trying to expedite declarations of commerciality to satisfy the demands of management, board members and stakeholders.

We all have seen the headlines proclaiming large discovery volumes, sometimes expressed as "reserves." In some cases, those announcements fall short of the stricter, higher classification standards of the SPE-PRMS (Society of Petroleum Engineers Petroleum Resources Management System).

The root of this over-optimism starts with maturation procedures that encourage exploration departments to regularly hand over opportunities to those in field development soon after the discoveries. In some cases, those exploration units limit delineation to maintain lower finding costs. That, in turn, keeps other key performance indicators (KPIs) for exploration at optimum levels.

However, curtailing delineation causes problems with the maturation of an opportunity, in part, because generally, a development department operates differently from an exploration unit.

E&P companies approve development budgets based on internal costs to evaluate their portfolios of opportunities. The premature handover of a discovery, not yet matured or in the portfolio, may result in a stopping point in the workflow.

Typically, companies do not design development budgets for further delineation and maturation. Furthermore, those in field development apply the rigor of the SPE-PRMS definitions to volumes handed over by exploration. That generally results in significant downward revisions to resources and reserves categorizations and classifications. Please see Fig. 1 on this page.

To keep those project opportunities from falling into "no-man's land," I recommend that instead of the traditional exploration-to-development handover, companies create opportunity maturation teams (OMTs) to do the following:

- **Focus on advancing the opportunity without the KPIs for exploration and/or development.**
- **Incorporate expertise from both exploration and development teams.**
- **Facilitate continuity of analysis.**
- **Designate an opportunity maturation budget.**
- **Achieve a unified handover to development and clearly define the "sponsor" responsible for the progression.**

Please see that approach schematically in Fig. 2 on the right.

Once "discovered," some exploration departments with large discoveries reclassify prospective resources to 1C, 2C and 3C contingent resources based on analyses that more closely resemble exploration practices, not those of development. Hydrocarbon volumes can be classified incorrectly, particularly when considering the SPE-PRMS requirement that without additional technical data, there should be no change in distribution of technically recoverable volumes when projects are reclassified from contingent resources to reserves.

Accordingly, volumes that qualify as 1C, 2C or 3C also progress to 1P, 2P or 3P. The SPE-PRMS provides a tool to track the progression of those opportunities during the maturation process. However, in my opinion, the PRMS is missing a classification for large discovered volumes not qualified to be classified as contingent resources.

To assist E&P companies, I have proposed an additional classification defined as "scope for recovery" to bridge this gap. This classification allows for the recognition of large discoveries without having to declare them contingent resources. It provides flexibility for wider ranges of technical uncertainty.

The proposed OMTs can also organically operate within the organization with budgets separate from exploration and development. The following graph, Fig. 3, shows a modified SPE-PRMS framework as discussed in this article.

Editor's Note: *This editorial expresses the views of Herman Acuña, executive vice president, and are not necessarily those of Ryder Scott or its professionals. We have published his commentary to stimulate further open discussion in our industry.*

This editorial is based on a presentation from Acuña at the Ryder Scott Mexico Conference in Cancun, Mexico, in mid-May. The conference was the first one held by Ryder Scott outside of the U.S. and Canada. Attendees hailed from nine countries: Argentina, Brazil, Colombia, Ecuador, Italy, Mexico, Nigeria, Paraguay and the U.S. Over two days, 15 speakers made presentations. The audience enjoyed live simultaneous translations from English to Spanish and vice versa. Ryder Scott plans to hold a conference in Canada next year and further plans call for a conference outside North America in 2021.

Fig. 1

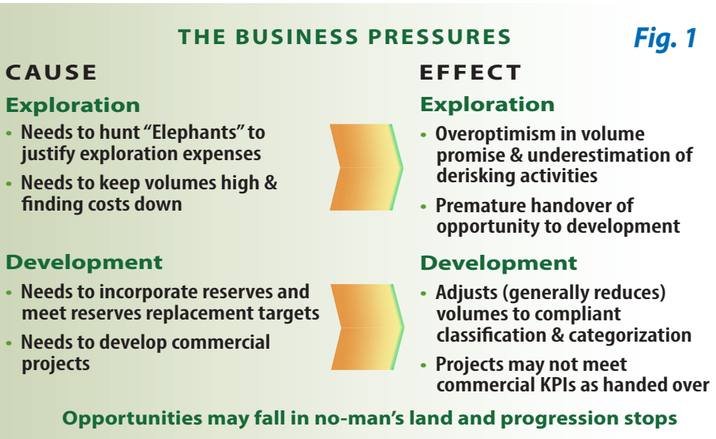


Fig. 2

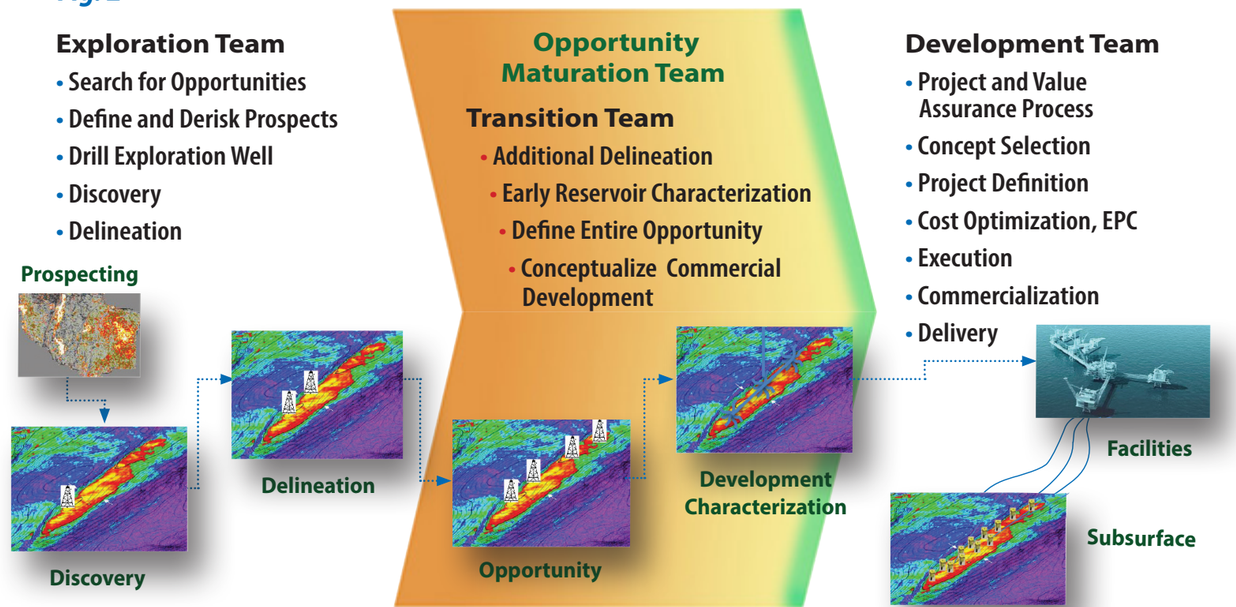
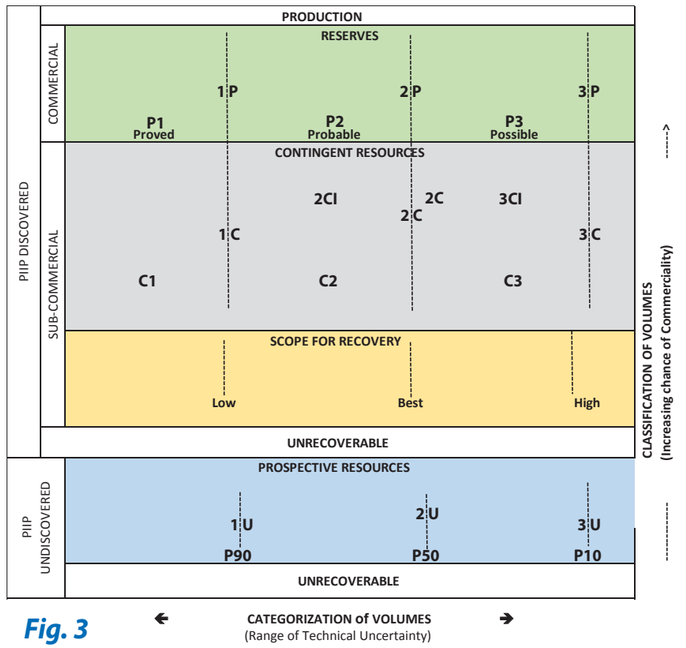


Fig. 3



SPE-PRMS offers flexibility to industry

-- **Dan Olds**, managing senior vice president and incoming SPE-OGRC chairman

The SPE-PRMS preamble notes that the guidelines "allow flexibility for entities, governments and regulators to tailor applications for their particular needs." Perhaps the most common example is where oil and gas companies customize the PRMS matrix.

They often add new subclasses for detail and closer alignment with internal decision-making processes. Additional detail can be useful in transitioning from potential to contingent resources.

In theory, the transition should be straightforward. In practice, it may take several wells over an extended period to determine the extent of the discovery. During that time, each new well can cause large swings in resources estimates.

The introduction of an intermediate class between prospective and contingent resources is an example of a customization that provides clarity during the process of maturing a discovery to contingent resources.

Up, up and away: Helium prices soar, interest in Saskatchewan heightens

Marlon McDougall is restless these days. The president of North American Helium (NAH) Inc. is ready to hook up the first of 10 wells to surface facilities and a gas plant to produce Helium, which, at $300 per Mcf, is 100 times more valuable than natural gas.

"We expect to have a single-well purifier in place the second quarter of 2020 and a larger-scale plant on stream by the third quarter of 2021," he said. "As we build and commission plants, we would expect each plant to have a production profile of between 50 to 100 MMcf per year of helium."

NAH has completed 10 of the 13 wells it drilled at a cost of $1.2 million per well. The wells in southwestern Saskatchewan penetrate conventional reservoirs with stratigraphic intervals in the western Williston basin from 6,900 to 7,900 ft deep.

"The reservoirs have significant porosity and permeability, so well density for pool development is very efficient," said McDougall.

Rather than expanding a known discovery, NAH drilled into an untapped reservoir in Saskatchewan and discovered helium in that area for the first time since the 1960s, the *Northern Miner* newsletter reported in August of last year.

Geologists learned about the potential for helium in southwestern Saskatchewan while searching for oil and gas in the late 1950s and 1960s. "The discovery of the helium resulted in steady production in Saskatchewan from 1963 to 1977," stated *Professional Edge* magazine, published by the Association of Professional Engineers and Geoscientists of Saskatchewan (APEGS). "However, when the price of helium dropped, well producers quietly shut the doors and walked away. Now, with the price of helium rising, these old wells have been rediscovered."

Please see article at https://www.apegs.ca/e-edge/Archive/Edge167/helium.html.

G&G

A 2016 report from the Saskatchewan Geological Survey concluded that the most viable model for exploration targets seems to be closed structures created by Cambrian to Cretaceous sediments. Please see report at https://pubsaskdev.blob.core.windows.net/pubsask-prod/94157/94157-Open_File_Report_2016-1_Yurkowski.pdf.

"At this early stage of exploration and development of helium resources in Saskatchewan, the most obvious and easiest targets to suggest for exploration are structural traps characterized by sedimentary rocks …draped over Precambrian monadnocks," stated **Melinda M. Yurkowski**, SGS petroleum geologist, in the report.

Monadnocks are isolated, underground hills of bedrock. Gas-trapping Paleozoic sedimentary rocks are an effective seal that entraps the small, lighter-than-air helium molecules.

"Monadnocks are easily identified in seismic surveys," the report stated. NAH is acquiring seismic data over its four major prospect areas and has correlated logs with seismic data where possible, considering the few Cambrian penetrations in the basin.

"It has taken a significant investment to shoot new seismic, interpret it and drill wells to test our theories," said McDougall.

The Upper Cambrian Deadwood conventional formation has the highest concentration of helium, according to the SGS study. Helium discoveries in the 1950s, including Battle Creek in 1952, also helped delineate this target basal sand in the formation.

Naturally occurring, radioactive uranium and thorium have disintegrated over half a billion years to form Helium in southwestern Saskatchewan and elsewhere in the earth's crust. During the early evolution of earth, heavier air displaced primordial helium from the sun and the gas dispersed into space.

For NAH, helium will represent about 0.5 to 0.9 percent of the gas stream while nitrogen will serve as the "carrier gas" at 98 percent of the stream. Trace-gas components comprise the remaining 1 to 2 percent.

"Because nitrogen is inert and makes up 78 percent of the atmosphere, all carrier gas will be vented," said McDougall. "Significant capital investment would be required to commercialize other gas streams. However, we continue to explore opportunities to use the carrier gas (N2) for agricultural applications."

Under a reasonably escalated sales price scenario, NAH expects that the wells will pay out within one to two years.

Please see Up, Up and Away on page 8

Well 6-30-3-27W3M drilled in southwestern Saskatchewan by North American Helium looks like any other gas well, except it is poised to produce helium. The gas can be up to 100 times more valuable than methane, but only makes up about 1- to 2-percent of the produced gas stream.

Up, Up and Away – Cont. from page 7

Demand and prices

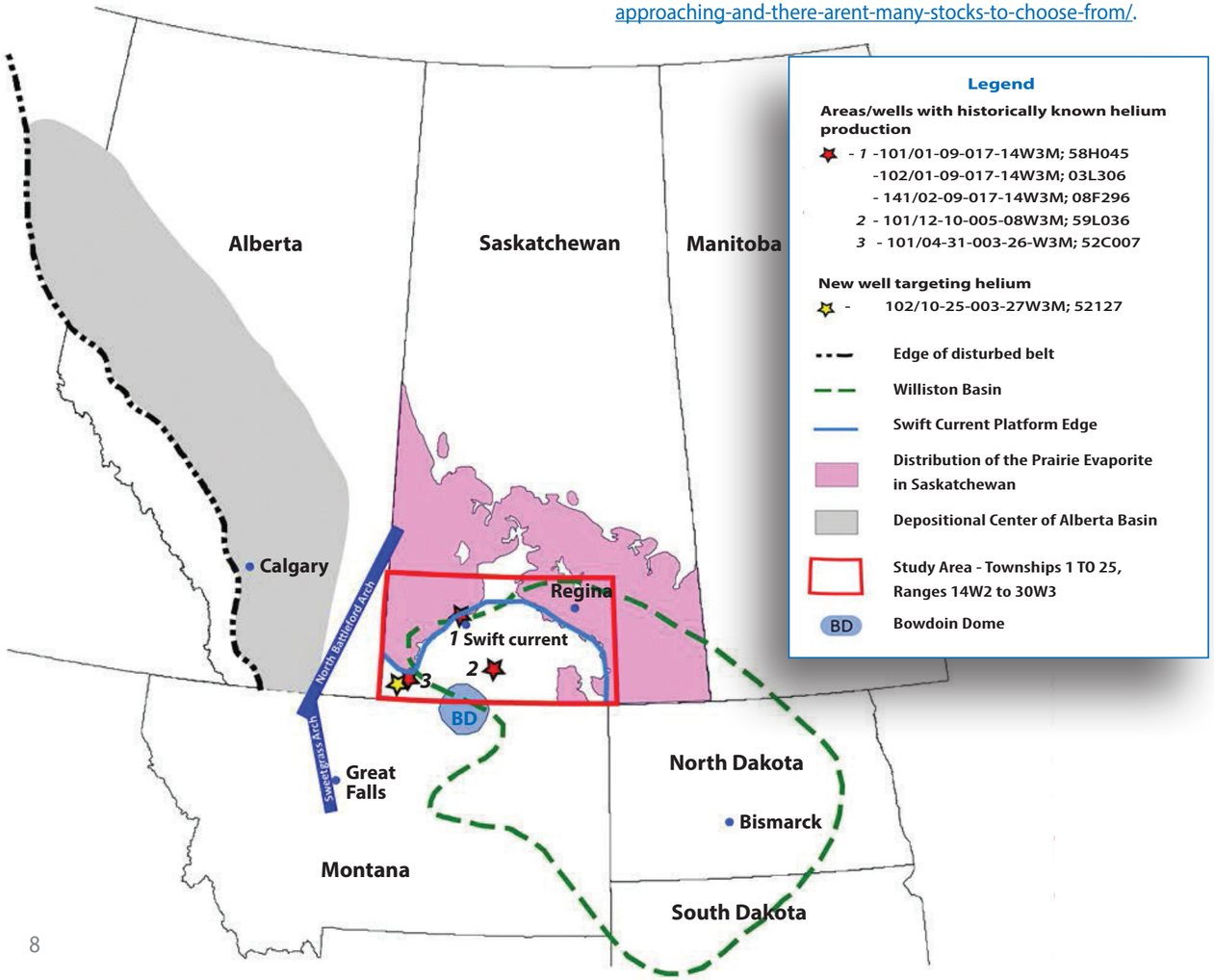
"The search for new sources of helium is of paramount importance as a combination of declining production and increasing demand have made helium prices soar. This follows a century in which the United States had a near monopoly on helium reserves and U.S. production met global demand," states an introduction in the "History of Helium Exploration, Part 2," published by the American Association of Petroleum Geologists this year.

The U.S. government sold off its strategic stockpile of helium in the mid-1990s, which accelerated the shortfall. At the latest auction of the U.S. Bureau of Land Management (BLM) more than a year ago, shortages boosted spot market prices to multiples of 2 to 4 times the average price to $280 per Mcf of raw, unprocessed helium. Ten years ago, the price was $50 per Mcf.

Helium is transported as gas or liquid to distributors worldwide, and like oil, prices rise and fall in a world market.

"We have participated in BLM auctions and have bought and sold helium into the market," said McDougall. "Because it is trucked, you can sell to the full spectrum of companies -- end users, distributors, large industrial gas companies and others." While prices are confidential and for the most part, not shared within the industry, NAH believes it is reasonable to expect "term" Helium deals to be above $300 per Mcf in the future.

While the prices are high, the market is diverse. An August special report from *Stockhead*, which publishes news on emerging markets in the Alberta Stock Exchange, cited business sectors that depend on helium -- space exploration, rocketry, high-level science, medical industry for MRI machines, fiber optics, electronics, telecommunications, superconductivity, underwater breathing, welding and nuclear power stations. Please see *Stockhead* article at https://stockhead.com.au/energy/a-helium-boom-is-fast-approaching-and-there-arent-many-stocks-to-choose-from/.



Map showing the SGS study area, Williston basin, center of the Alberta basin (Wright et al., 1994) and well locations published in 2016. See legend. Two years later, NAH, the most active driller in the area, had six wells completed, with one planned and one abandoned. Royal Helium Corp., Weil Group Resources LLC, Canadian Helium Inc. and the City of Medicine Hat were also drilling.

Credit: *Yurkowski, M.M. (2016): Helium in southwestern Saskatchewan: accumulation and geological setting; Saskatchewan Ministry of the Economy, Saskatchewan Geological Survey, Open File Report 2016-1, 20p. and Microsoft Excel file.*

Because of its low boiling point, liquid helium is used in industrial cryogenic systems when extremely low temperatures below the boiling point of nitrogen are needed.

On the supply side, Canada has the fifth- or sixth-largest helium resource in the world, behind the U.S., Qatar, Algeria, Russia and possibly Tanzania, states APEGS.

The role of Ryder Scott Canada

Building capital-intensive gas separating facilities and plants to refine the raw gas stream into purified helium involves significant outlays, and is an economic barrier.

McDougall said that NAH is pursuing financing based on reserves and resources quantities supported by independent reports from Ryder Scott Canada. "Those reports, also used for marketing, have allowed us to demonstrate that there is a significant helium business to be developed in Saskatchewan," he remarked.

A Ryder Scott Canada volumetric study for the private Calgary-based explorer is helping to support an early-stage, in-progress material balance study by the NAH technical staff, said McDougall.

Mike Lam, vice president - technical specialist at Ryder Scott Canada, analyzed the geology of the NAH properties, understanding that helium is very similar to conventional gas in that the evaluator is looking for structural/stratigraphic entrapment with a good top seal.

"A big difference between conventional hydrocarbon and helium is the source. Most helium is thought to form from radioactive decay of uranium and thorium in granitoid rocks. It's no surprise then that many helium reservoirs we have observed start in reservoirs that drape over identified basement highs," he said. "That doesn't mean there aren't accumulations in younger rock, but it's certainly understandable to start near the source."

Ryder Scott Canada has prepared reports for other helium producers in Canada and elsewhere. The firm estimates reserves and resources under COGEH guidelines and NI 51-101 regulations for clients in and outside of Canada. For more information, please contact Dave Haugen, manager of the Calgary office, at dave_haugen@ryderscott.com.

Spy in the sky finds less Permian efficiency than reported

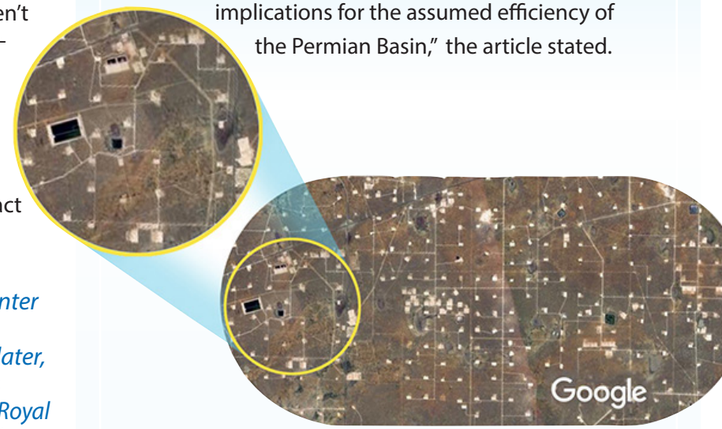
Kayrros Inc., a consulting firm with the tag line, "Disruptive Analytics for Energy Markets," claims that satellite observations show that operators underreported fracing by more than 20 percent in the Permian Basin. The article is at https://www.kayrros.com/media.

The significance of this is "it took many more wells to account for production in 2018 than were reported (to state commissions or FracFocus, a public repository). Assuming a cost of $5 million per horizontal completion, 2018 operator capex is also underestimated by as much as $4.1 billion," stated the article.

"Further, the sand and water intensity of Permian tight oil production in 2018 was 23 percent greater than previously recorded with sand demand being underestimated by 9.2 billion pounds and water by 12.5 billion gallons."

Kayrros also said that the backlog of drilled uncompleted (DUC) wells is considerably smaller than thought.

"The findings have significant implications for the assumed efficiency of the Permian Basin," the article stated.



This image, attributed properly, shows wells in the Permian Basin, but is not a Kayrros image.

Russian alliance partner translates SPE-PRMS

Dmitri Zabrodin, center, stands with his students showing training certificates after completing the three-day SPE-PRMS training session in Almaty in March. Classroom participants were geologists and petroleum engineers from oil and gas producers in Kazakhstan.

Long-time Ryder Scott alliance partner, **Dmitri Zabrodin**, vice president at FDP Engineering LLP, has finished translating the 2018 SPE-PRMS into Russian. It is available at https://www.spe.org/industry/docs/PRMgmtSystem_V1.01_RUS-FINAL.pdf

He donated more than 150 hours of his own time to SPE to translate the 67-page document.

The PRMS (Petroleum Reserves Management System) comprises guidelines for evaluating hydrocarbon reserves and resources. It has become the de-facto international standard for classifying recoverable petroleum quantities.

Moscow-based FDP and Ryder Scott work together on resources and reserves studies across the FSU.

Latest project part of ongoing efforts

The project not only required the language skills of a translator, but a deep knowledge of reservoir engineering, production forecasting, economics and the PRMS itself.

Zabrodin delivered the translation to SPE by the target date in September. Ryder Scott and FDP professionals assisted Zabrodin in drafting the translated text, which was peer-reviewed by both Russian and international SPE-designated experts.

One of the first attempts to map the Russian system to the PRMS was done by Zabrodin and **John Hodgin**, then president at Ryder Scott. They presented their work at the International Geoscience Conference in Tyumen, Russia, in late 2007. On that project, they reviewed the 2005 SPE mapping work and, at that time, the new 2007 SPE-PRMS to remap those guidelines to what was then newly drafted Russian RF-2005 reserves standards.

As a speaker and instructor in the FSU, Zabrodin has helped bridge differences between the PRMS and the Russian classification and categorical standards for reserves and resources.

At the Russian O&G Summit E&P in 2015, Zabrodin delivered a presentation that compared the recently enforced RF-2013 classification system in Russia to the 2007 SPE-PRMS. Please see the July-September 2015 *Reservoir Solutions* article, "New Russian reserves classification system introduces economic limits," on Page 8 at https://secureservercdn.net/184.168.47.225/803.9a5.myftpupload.com/wp-content/uploads/July-2015-Newsletter.pdf.

In 2016, Zabrodin presented a three-day training course on the application of the SPE-PRMS definitions and classifications to reserves evaluations. He designed the course agenda for various specialists in major oil and gas producing companies in the Republic of Kazakhstan.

After that, Zabrodin regularly presented the three-day course to several producing companies and scientific organizations in Kazakhstan. In addition, he conducted an online SPE-PRMS class to reach other audiences in the country. This year, he presented the SPE-PRMS class in Almaty and Atyrau.

Through his continuing training sessions, Zabrodin has been instrumental in helping to guide Kazakh management and

Please see Russian Partner Alliance on page 12

U.K. shale gas reserves are 80 percent smaller than estimated, study claims

U.K. shale gas reserves are at least 80 percent smaller than thought, concluded a University of Nottingham report last August. The study is at: https://www.nature.com/articles/%20s41467-019-11653-4.

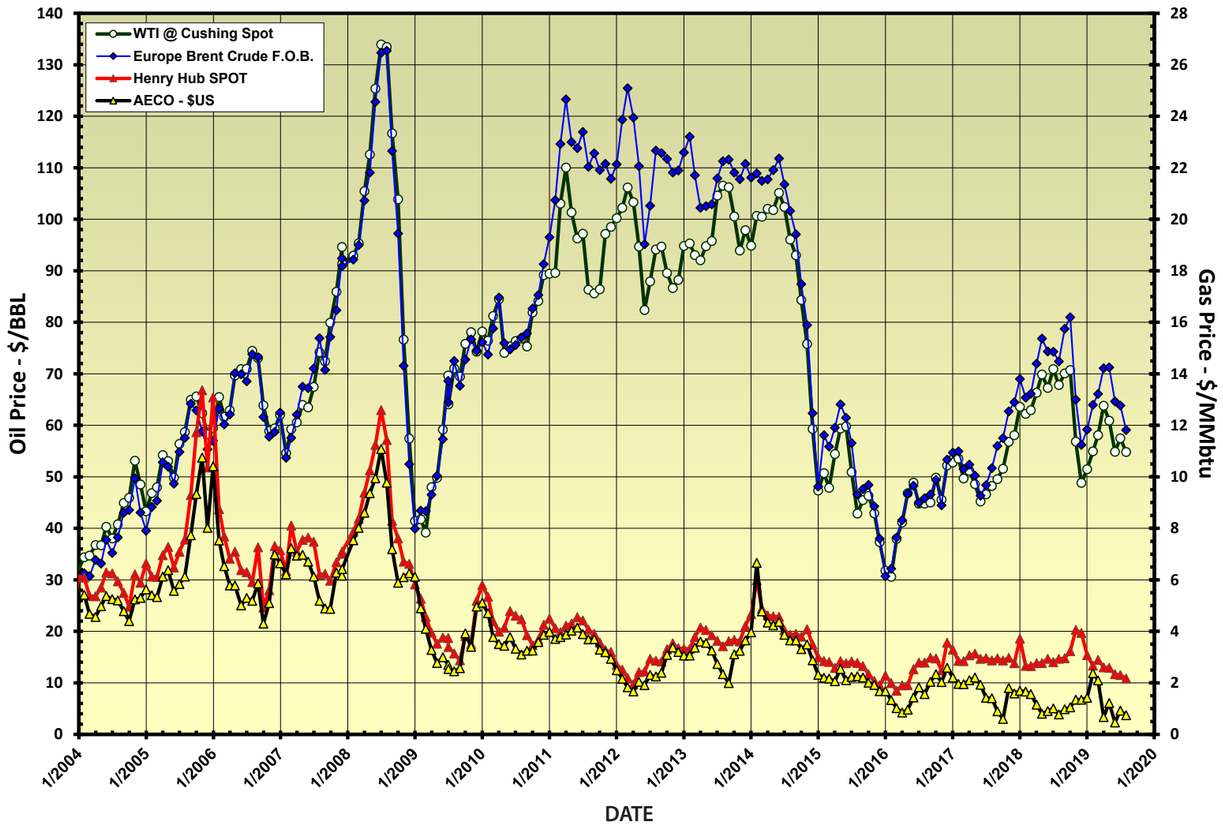
Web-based media outlet *The Conversation* detangled some of the convoluted, scientific language in the report at http://theconversation.com/how-we-discovered-uk-shale-gas-reserves-are-at-least-80-smaller-than-thought-122076.

In 2013, scientists conducting a U.K. government study estimated the in-place gas volumes in the Bowland shale with models developed for shales in the U.S. They did not take into account key differences between shale gas in the two countries.

The Conversation reported, "Initial estimates of this gas-holding capacity may have been inflated as they overlooked the effect of moisture, which is known to reduce the amount of gas held within the shale."

The scientists estimated that the Bowland shale play contained 1,300 Tcf of gas and could provide the U.K. with up to 50 years of gas at current demand. Revised estimates, assuming a "fairly optimistic" 10-percent recovery factor, yielded 200 Tcf of gas or a 10-year supply.

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.

Ryder Scott Co. LP
1100 Louisiana, Suite 4600
Houston, Texas 77002-5294
Phone: 713-651-9191; Fax: 713-651-0849
Denver, Colorado; Phone: 303-623-9147
Calgary, AB, Canada; Phone: 403-262-2799
E-mail: info@ryderscott.com
Web site: www.ryderscott.com

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reserves-evaluation professionals in their transition from the obsolete Soviet reserves booking system to the modern, universally accepted SPE-PRMS.

Earlier this year, the chairman of the SPE Oil and Gas Reserves Committee (OGRC) asked Zabrodin to "lead the effort to translate the 2018 PRMS into Russian" after considering recommendations of support. SPE said it selected Zabrodin because of his expertise.

"He has been granted the freedom to manage the translation that he deems most effective," the OGRC said then.

The committee is the most influential decision-making body for establishing and revising petroleum reserves definitions used by the industry worldwide. The 2018 SPE-PRMS was jointly approved by the boards of SPE, Society of Petroleum Evaluation Engineers, World Petroleum Congress, American Association of Petroleum Geologists, Society of Petrophysicists and Well Log Analysts and European Association of Geoscientists & Engineers.

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