

RESERVOIR SOLUTIONS

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Ryder Scott Calgary Conference

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Ryder Scott Canada Reserves Conference

May 10



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Best practices in petroleum geoscience: A combination of MAN and MACHINE



— **Steve Phillips**, managing senior vice president and head of G&G

Will the future be dominated by computerized machines or will humanity prevail? Plenty of sci-fi books and films have contemplated this question, including “The Terminator,” arguably the most well-known movie. In the realm of petroleum geology, not the subject of a blockbuster movie yet, the struggle between minds and machines is ongoing.

Petroleum reservoirs in the real world are always more complex than available data can fully resolve. That source of uncertainty is compounded by measurement error and noise in the information we do manage to collect.

Our efforts to use available data to characterize oil- and

gas-bearing formations are also influenced by the tools at hand. In the past, a petroleum geologist was primarily a mapmaker, using two-dimensional surfaces (paper) to describe 3D phenomena (rocks). Today, computer applications are almost always used to some degree.

In petroleum exploration and development, nearly every new well generates another data point requiring some adjustment to the pre-drill map or model. Despite great improvements in our data acquisition and interpretation techniques, the subsurface remains an uncertain domain with plenty of surprises. Although information about the real world is typically imperfect or incomplete, data can be put to good use if combined with knowledge and skill.

During the last 20 years or so, the processes and tools for reservoir description have evolved dramatically. What once required considerable hand-eye coordination, and a measure of

well and what machines do well.

A human mapper begins with a concept in mind, such as, “This is a north-plunging anticlinal structure,” or “This is a distributary channel sand.” The geologist then attempts to contour the surface or property by interpolating and extrapolating between and beyond available data points.

In addition to a concept, many “rules” control where a mapper’s pencil should go. For instance, geologists should

maintain proper isochore separation between the structure maps of two adjacent formations. If a geologist is true to those rules, the end result should satisfy the geological “eye” of the creator. And yes, no two geologists will produce exactly the same map from the same data.

Some computer-mapping algorithms do a good job of replicating what a human with a pencil might do. However, tweaks to these applications can produce wildly different contour patterns from the same data depending on the mathematical method and other imposed parameters, such as trends. This variability in output can lead to mistrust in

computerized geology.

Computers do not “think” about reservoirs. However, they do something for which the human mind is not well equipped. Computer mapping and modeling algorithms can operate on the basis of a data relationship model, also known as a variogram, as shown on this page.

Imagine that you are making a topographic map of a rugged mountain slope. After gathering numerous elevation data points, you consider each possible pair of points and record the

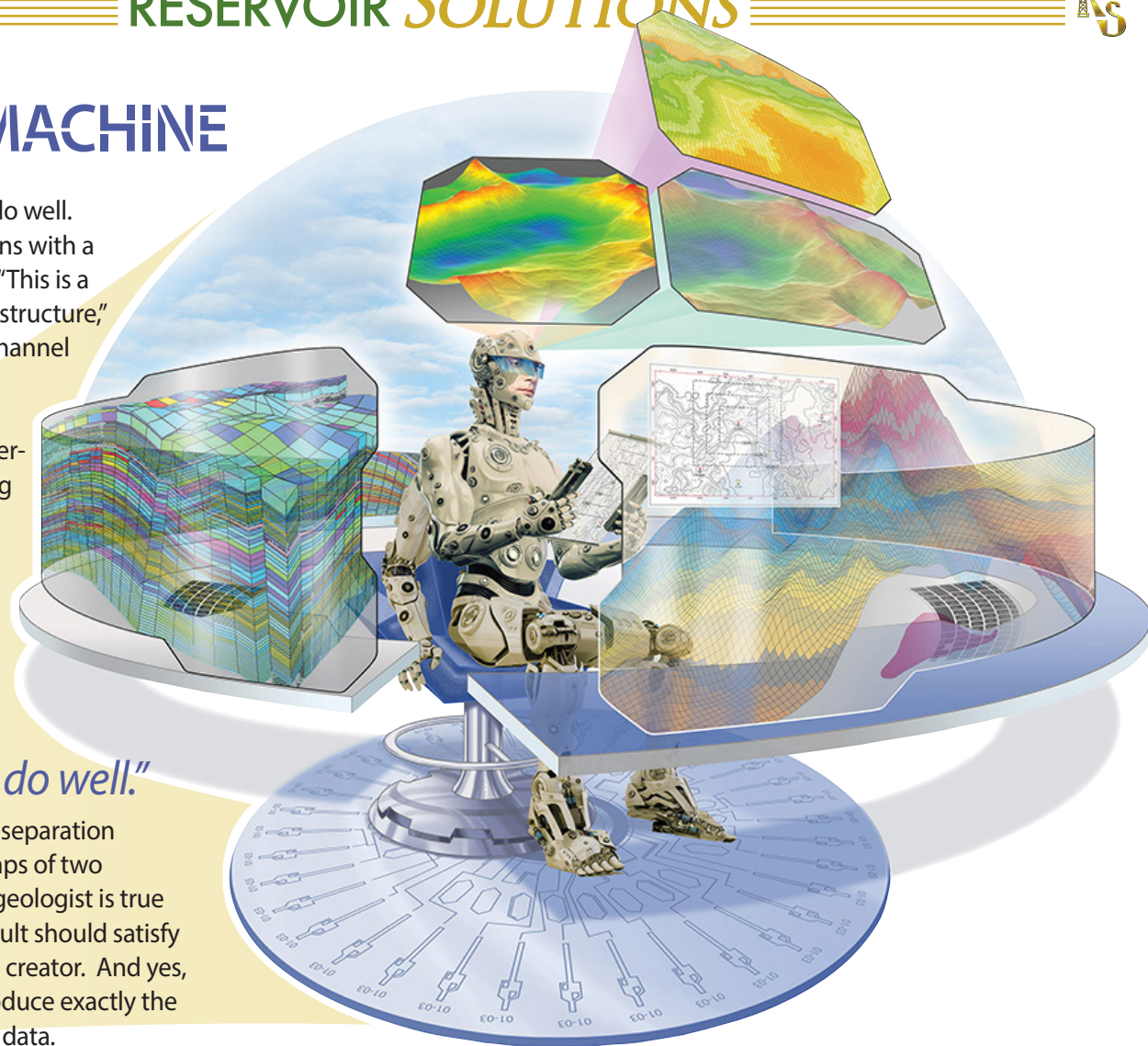
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“The first step is to understand what minds do well and what machines do well.”

drawing skill, is now overwhelmingly performed with computer applications. From the perspective of reserves evaluators, we should ask ourselves, are we getting better reservoir descriptions and forecasts as a result?

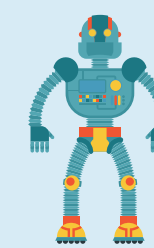
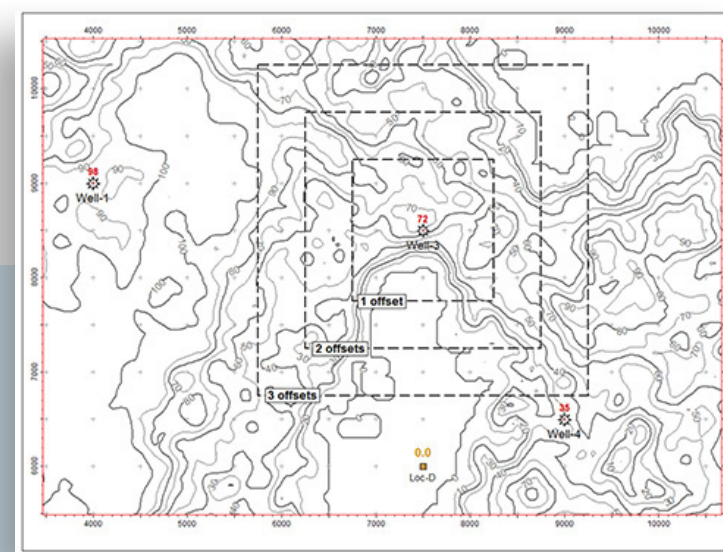
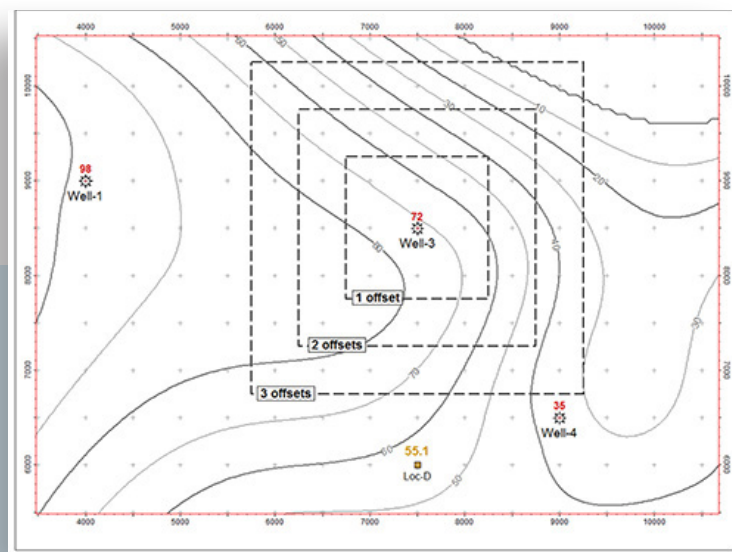
Geoscientists at Ryder Scott today approach that question as they strive to maintain standards established by our firm’s predecessors while also evolving, along with our clients, through the application of new, reliable technologies. The goal is to create a work product that honors long-standing, hands-on petroleum geology techniques while benefitting from more computerized approaches.

The first step is to understand what minds do



Does map support reserves category?

Smooth map provides high comfort factor but may not reflect data relationships.



Does map support reserves category?

Map based on computer-generated variogram is more difficult to endorse, but may be a more realistic representation of the data.

Ryder Scott Canada Reserves Conference

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

North American experts will share their insights on petroleum reserves at the Ryder Scott Canada Reserves Conference, Tuesday, May 10. Organizers anticipate that up to 150 oil and gas executives, managers and technical professionals will attend the full-day event at the Hyatt Regency hotel in downtown Calgary.

Slated speakers include authorities in the E&P industry, government, banking and research. **Phillip Chan**, a former chief petroleum officer at the Alberta Securities Commission, plans to share his perspective on reserves-reporting practices and compliance with National Instrument 51-101. Public issuers in Canada are required to disclose their reserves in accordance with the instrument.

NI 51-101 and companion, the Canadian Oil and Gas Evaluation Handbook, are part and parcel of a regulatory reporting system universally considered to be most closely aligned with business cases. In the Canadian market, producers are required to report proved and proved-plus-probable reserves or the 2P case as well as the proved case (1P). Statistically, 2P estimates have at least a 50-percent probability that they will equal or exceed actual hydrocarbon quantities recovered under economic limits using current technology.

Please see Reserves Conference on page 6



Other details:

When: Tuesday, May 10, 7 a.m. to 7 p.m.

Where: Hyatt Regency Calgary, 700 Centre Street SE, Calgary, Alberta, Canada, T2G 5P6

Attendees: Conference agenda is targeted to an audience with at least a “big picture view” of petroleum reserves. For a wider appeal, presentations on other oil-and-gas-related subjects are scheduled. Attendees will receive presentations on USB drives. APEGA-licensed geologists and engineers will earn up to eight Continuing Professional Development hours. Attendees will network at breaks and at the evening cocktail reception.

No cost for the event. Complimentary food and beverage will be catered by the Hyatt. For more information, please send an email to ConferencesCalgary@ryderscott.com.

Schedule of Events

“Evaluation Challenges in a Changing North America”

Time	Speaker	Affiliation	Topic
7 a.m. – 8 a.m.			Conference Check In and Light Breakfast
8 a.m. – 8:30 a.m.	Larry Connor <i>Dir. of Canadian Ops.</i>	Ryder Scott	Welcome and Introduction
8:30 a.m. – 9:15 a.m.	John Lee <i>Professor</i>	Texas A&M University	Use of Reliable Technology in Reserves Estimation and Reporting
9:15 a.m. – 10 a.m.	Dinara Millington <i>VP Research</i>	Canadian Energy Research Institute	Low Crude Price Impacts on the Canadian Economy
10 a.m. – 10:30 a.m.			Break
10:30 a.m. – 11:15 a.m.	Ray Dupuis <i>President & CEO</i>	Gen2Rev Inc.	Maximum Likelihood Estimates
11:15 a.m. – 12:15 p.m.	Cheryl Sandercock <i>Managing Director</i>	Scotia Waterous Inc.	Canadian M&A Market Perspectives
12:15 p.m. – 1:15 p.m.			Buffet Luncheon
1:15 p.m. – 2 p.m.	Craig Burns <i>Manager Petroleum Dept.</i>	Alberta Securities Commission	Regulatory Update
2 p.m. – 2:45 p.m.	David Pursell <i>Head of Macro Research</i>	Tudor, Pickering, Holt & Co.	Crude Oil - Why Lower for Longer Won't Happen
2:45 p.m. – 3:30 p.m.			Break
3:30 p.m. – 4:15 p.m.	Philip Chan <i>President and CEO</i>	Page Compliance Ltd.	Conveying Potential of Assets through ROTR Disclosure
4:15 p.m. – 5 p.m.	Ian McDonald <i>Vice President Reserves</i>	Nexen Energy ULC	Updating SPE-PRMS Reserves Definitions - Current Considerations
5 p.m. – 7 p.m.			Cocktail Reception

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Craig Burns, manager of the ASC petroleum department, plans to update the audience on the changing requirements of NI 51-101.

Industry and various regulatory regimes worldwide use the Society of Petroleum Engineers Petroleum Resources Management System as the best set of technical and commercial guidelines for estimating reserves. Changes to that system and their effect will be addressed by **Ian McDonald**, vice president reserves at Nexen Energy ULC.

Cheryl Sandercock, managing director at Scotia Waterous Inc., will discuss the state of the markets and what to expect. Equity values of North American oil and gas companies have plummeted, with some at levels not seen since before the shale revolution.

Dinara Millington, vice president research at the Canadian Energy Research Institute, plans to present the latest research on low crude prices and their impact on a reshaped Canadian economy. "Business sentiment has deteriorated as the negative effects of the commodity price shock continue to unfold and spread beyond the resource sector," stated the Bank of Canada, the country's central bank, in its latest quarterly business outlook survey.

John Lee, professor at Texas A&M University, will make a presentation on the use of reliable technology in unconventional reservoirs. He was an academic engineering fellow for three years with the U.S. Securities and Exchange Commission during the agency's rules-change process that led to a "modernized" reserves reporting system in 2010.

Ray Dupuis, president & CEO at Gen2Rev Inc., also plans to present.

"The meeting will provide an impromptu place for evaluators to meet their counterparts from other companies face to face to discuss common reserves issues," said **Larry Connor**, director of the conference and a board member at Ryder Scott. "It's a chance for an evaluator to meet a regulatory official to seek clarifications on an issue without raising a red flag. The conference is designed to elicit honest dialogue from all participants."

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

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

RS president is new SPE distinguished lecturer

Dean Rietz, president at Ryder Scott, is a new 2016-17 SPE Distinguished Lecturer.

"That is quite an honor," said **Don Roesle**, CEO at Ryder Scott. "Dean has sacrificed his personal time for the greater good of the industry by teaching reservoir simulation to a variety of audiences. He will be a highly beneficial addition to the lecture tour."

Rietz has been with the firm for 20 years as a petroleum engineer specializing in numerical reservoir modeling.

A 36-member SPE committee, with representatives from each region, selected Rietz through a process the society describes as "rigorous and long." He presented to the committee, which also considered his teaching activities as an adjunct professor of petroleum engineering at the University of Houston and as an instructor for SPE short courses on simulation.

For interested SPE sections, information on the 2016-17 distinguished lecturers will be available at <http://www.spe.org/dl/>. Rietz plans to deliver his presentation, "Incorporating Numerical Simulation into Your Reserves Estimation Process," to several sections worldwide.

Rietz, who managed the Ryder Scott simulation staff, has conducted reservoir simulation studies of oil and gas fields throughout the world. He has been involved with all facets of simulation.

In 2001, he and a Ryder Scott colleague wrote an SPE paper that broke ground on the application of reservoir simulation to reserves evaluations. They did it to begin a dialog on the topic, which had not been thoroughly discussed and documented then.

The seminal paper, the first of four published by SPE and written by Rietz and co-authors, was "The Adaptation of Reservoir Simulation Models for Use in Reserves Certification under Regulatory Guidelines or Reserves

Definitions," (SPE 71430).

Simulation is widely regarded as the most technically sophisticated, advanced reservoir engineering sub-discipline in the industry. However powerful, the technique is also poorly understood and suffers from misuse by those with insufficient hands-on knowledge. Rietz has bridged that shortfall through his presentations, which are designed to clear up misconceptions, establish the basics and delve



Dean Rietz, on right, with University of Houston graduate **Arjun Ravikumar** at a December 4 reception hosted by the UH Cullen College of Engineering. The event was held to celebrate the then newly approved department of petroleum engineering for undergraduates. Rietz is an adjunct professor of petroleum engineering at UH.

into advanced issues.

Ron Harrell, chairman emeritus at Ryder Scott and a former distinguished lecturer, nominated Rietz, who has BS and MS degrees in petroleum engineering from the University of Oklahoma and University of Houston, respectively. He is also a registered professional engineer in Texas.

RS posts historical petroleum production and consumption

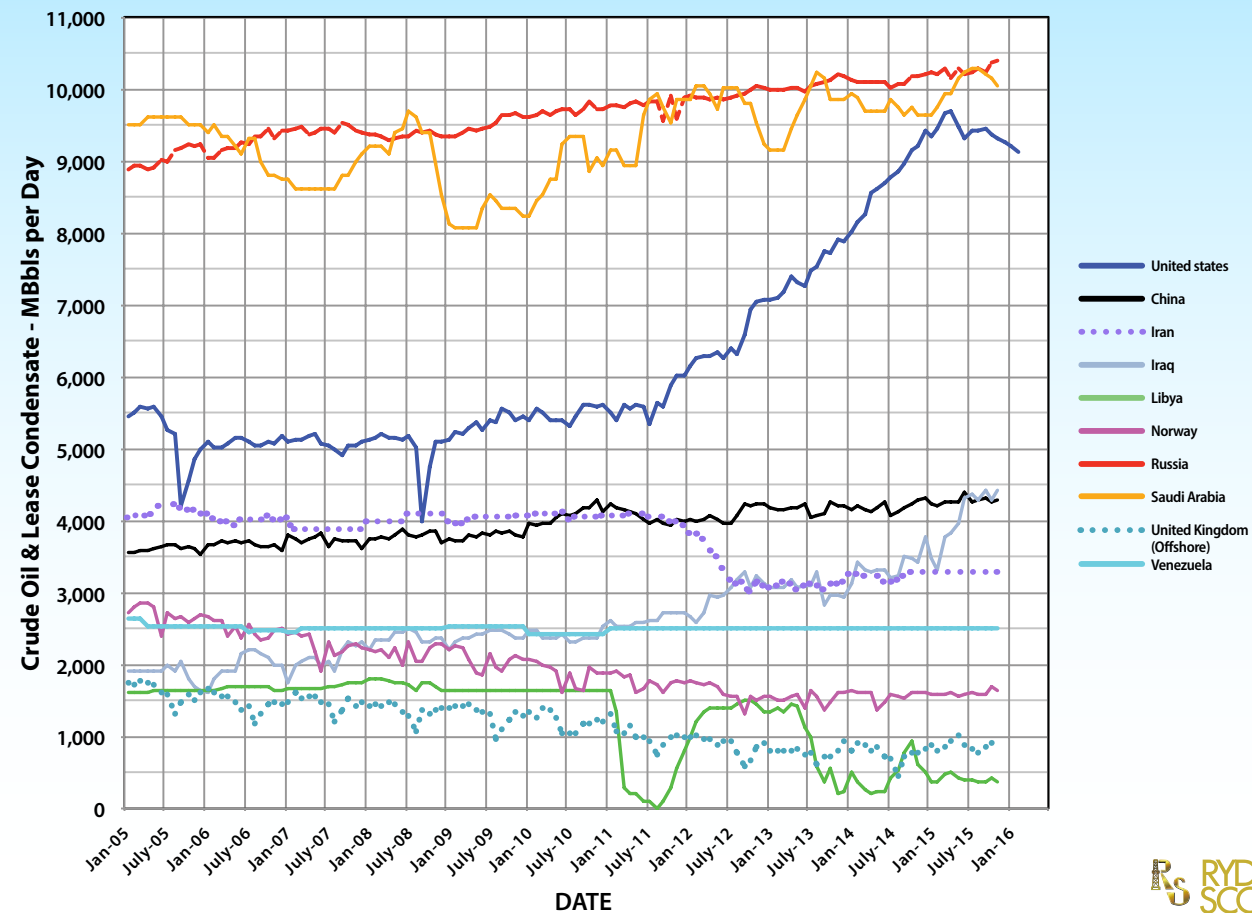
Ryder Scott now posts historical petroleum-production and -consumption charts monthly through links on the firm's homepage at www.ryderscott.com. The three charts track history since 2000 and are accessed from the same section as monthly historical charts for year-end SEC pricing and oil and gas benchmark pricing.

The charts show crude oil and lease condensate production by country, petroleum produced and consumed by country/region and world petroleum produced and consumed. Ryder Scott decided to post those charts because of the special interest in supply and demand during the current low-price environment.

The March chart on production shows a continued drop in U.S. output. U.S. Energy Information Administration forecasts call for oil production to drop next year by 480,000 B/D to 8.19 million barrels—more than double the previous month's predicted decline of 230,000 B/D.

Crude Oil & Lease Condensate Production by Country

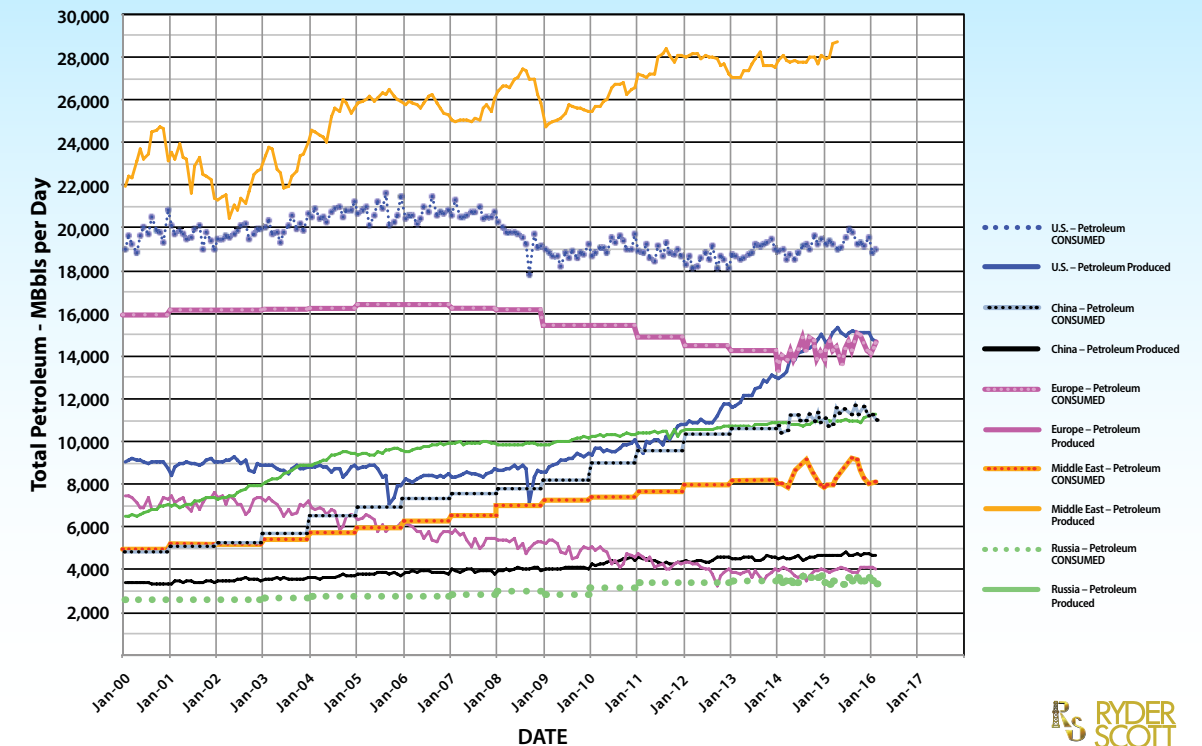
EIA Tables 1, 11.1a & 11.1b http://www.eia.gov/forecasts/steo/report/us_oil.cfm <http://www.eia.gov/totalenergy/data/monthly/p>



Petroleum Produced & Consumed by Country/Region

(Includes crude oil, lease cond, NGLs, & Other Liquids (biodiesel, ethanol, liquids from coal, gas, & oil shales etc))

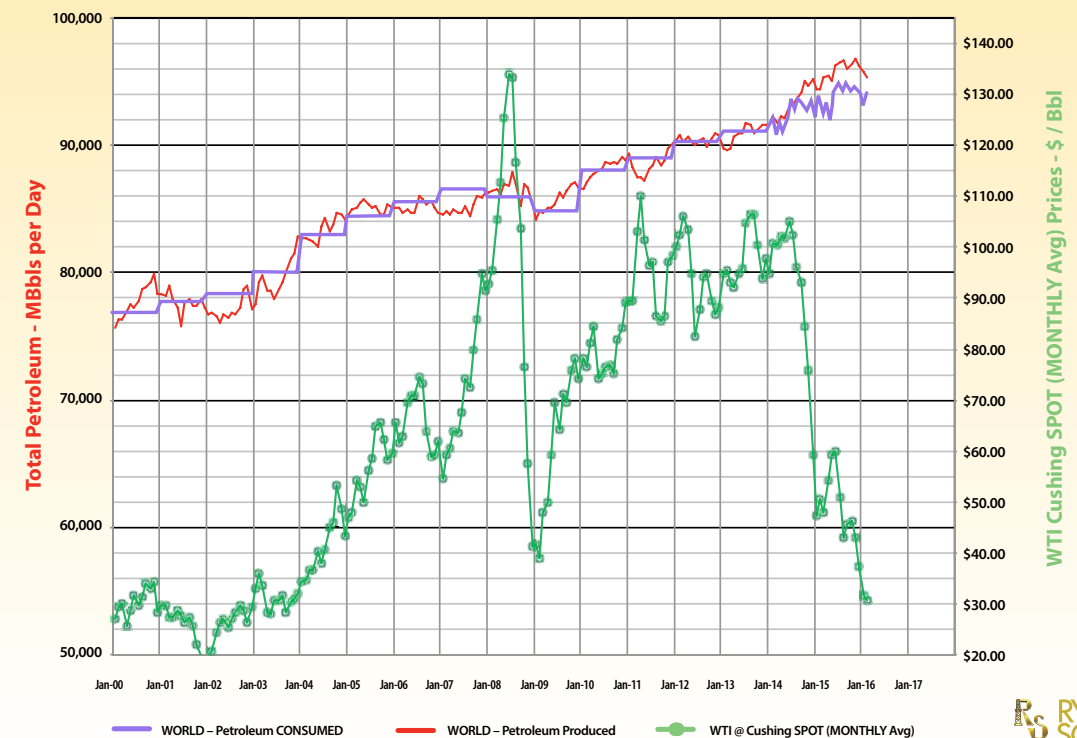
EIA Tables 3a, 3b & 3d http://www.eia.gov/forecasts/steo/report/us_oil.cfm



WORLD Petroleum Produced & Consumed

(Includes crude oil, lease cond, NGLs, & Other Liquids (biodiesel, ethanol, liquids from coal, gas, & oil shales etc))

EIA Tables 3a, 3b & 3d http://www.eia.gov/forecasts/steo/report/us_oil.cfm



Engineer joins simulation group

Amara Okafor joined the reservoir simulation group at the Ryder Scott Houston office as a senior petroleum engineer. She has 10 years of reservoir modeling experience. Previously, she worked as an appraisal and reservoir modeling engineer, specifically in Gulf of Mexico exploration at Marathon Oil Co.

Okafor conducted numerous integrated full-field simulation studies for resources estimation, property appraisals, acquisitions and

divestitures, field development planning and probabilistic analyses while at Marathon. She provided engineering support in identifying and ranking potential opportunities for the GOM exploration and appraisal team.

Okafor also worked within a multidisciplinary integrated modeling team at Marathon, building and managing simulation models for history matching and forecasting of both operated-and non-operated assets. She performed pressure-transient analysis to estimate reservoir parameters for various simulation studies.

She started her career at Schlumberger as a reservoir engineer, conducting horizontal well reservoir modeling for history matching and

Amara Okafor

forecasting of naturally fractured shale reservoirs in the Marcellus, Woodford and Barnett shale plays. Okafor performed numerous gas storage reservoir studies, and estimated technically recoverable reserves through reservoir modeling.

Okafor has a BS degree in petroleum engineering from the Federal University of Technology in Owerri, Nigeria, and an MS degree in petroleum engineering from Texas A&M University. She is a member of the Society of Petroleum Engineers.



MAN and MACHINE – Cont. from page 11

differences in elevation, horizontal separation and compass bearing between them. In the end, you have a model of elevation variability with respect to distance and direction among your data points.

A human mapper could certainly interpolate and extrapolate among these points and make a credible map of the mountain side. Alternatively, a computer generates a surface grid by respecting this variability model, thereby producing a map that is potentially more characteristic of the real world.

What does this all mean to a petroleum geologist involved in reserves estimation? Aim for a future in which minds and machines are complementary.

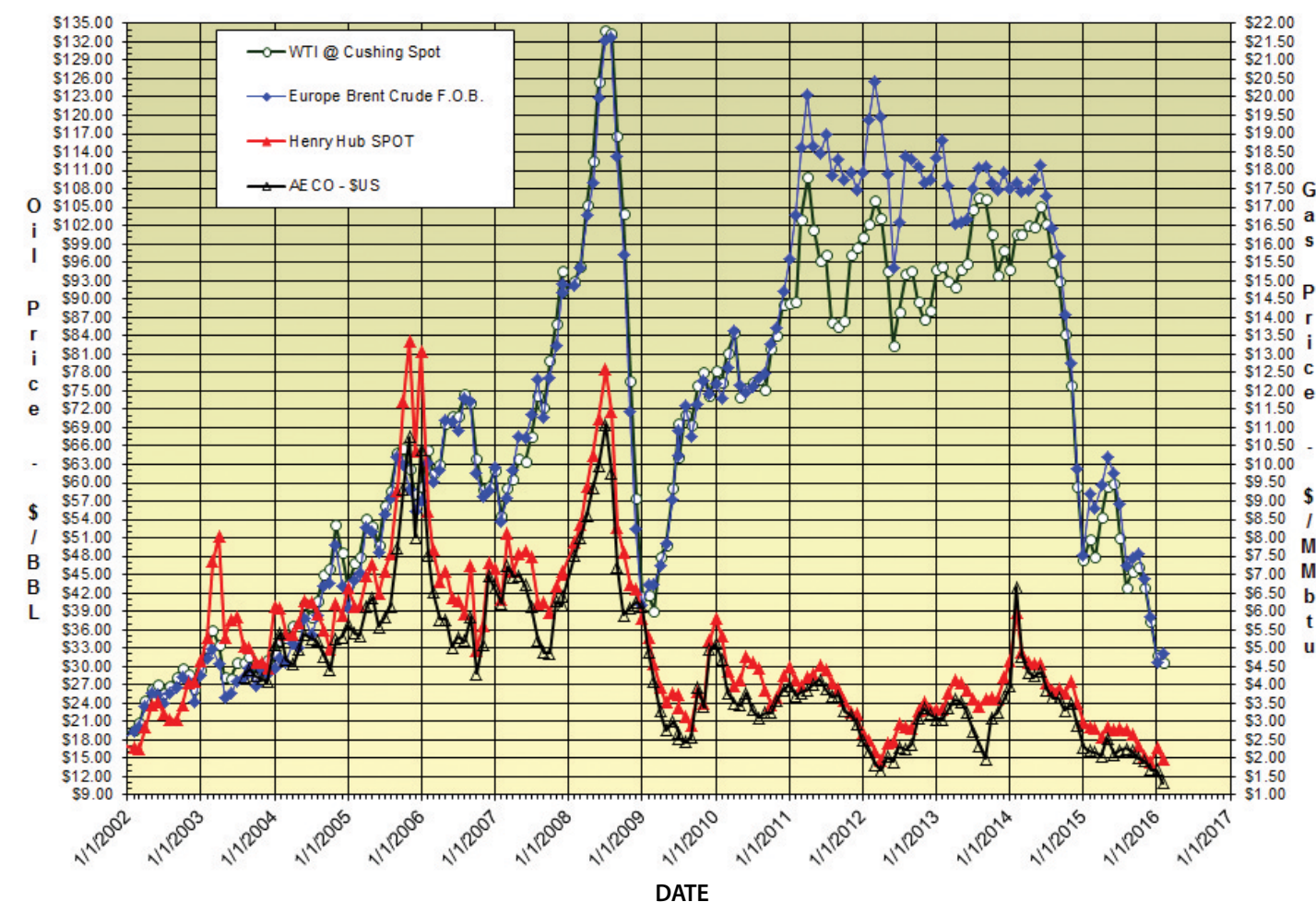
In doing that, the following guidelines apply:

- A final map or 3D model should respect the long-standing principles of petroleum geology.

- The work should be easily verified with supporting documentation.
- Input data should be carefully reviewed for correctness and completeness.
- Geologists should evaluate, understand and capably apply new technologies to reliably characterize petroleum reservoirs.
- Treat cyborgs from the future with caution, knowing that they might be great mapmakers.

Editor's Note: Phillips presentation, "Mapping Petroleum Reservoirs: Who's in Charge, Minds or Machines," is posted at www.ryderscott.com/presentations. It was delivered at the latest Ryder Scott reserves conference by **Brett Gray**, senior petroleum geologist, who is not a cyborg.

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



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

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In the News

Waiting out the price decline with high-interest loans

Reuters reported in mid-March that private equity firms have emerged as lenders of last resort for some U.S. energy companies. Interest on some loans is increasing to more than 12 percent.

"Tens of billions (of dollars) worth of loans are expected to be downsized or redetermined across the energy sector this spring as banks pare their exposure to the battered industry," a *Reuters* calculation showed. "Desperate to hang on to their sources of financing, energy companies are likely to accept stringent deal terms they may not have accepted in normal times. Indeed,

some are also restructuring their debt with bondholders."

U.S. banks have been increasing the amount of money they set aside to cover energy-related losses and some have been looking to sell blocks of distressed energy loans to private equity firms to remove the risks from their balance sheets, the wire service reported. Some banks are selling their energy revolver loans to private equity firms at deep discounts.

If a company defaults on the loan and files for bankruptcy, then the private equity firm may become a secured creditor and claim the assets in a loan-to-own strategy.

Publisher's Statement

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

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