

“Serious unknowns” in forecasts of production from shale plays, SPE considering “summit,” says Lee

Serious unknowns in forecasting production from shale plays has prompted a Society of Petroleum Engineers exploratory committee to consider organizing a multi-day, multi-organizational summit to study the issues, said **John Lee**, professor of petroleum engineering at the University of Houston.

Lee, a committee member, made his remarks at the latest annual Ryder Scott reserves conference where he presented, “Are our proved reserves reasonably certain?” He said that to forecast production from unconventional reservoirs, industry uses empirical models for production declines developed almost a century ago and reservoir modeling techniques first developed in the mid-20th century.

Lee, a member of the U.S. National Academy of Engineering, argued that those methods have limitations in evaluating unconvensionals. The predominant industry approach is to consider that horizontal wells with multistage hydraulic fracturing have two

dominant flow regimes in unconventional reservoirs —transient, most likely linear flow up to fracture interference, and boundary-dominated flow after fracture interference.

He encouraged the industry to consider a four flow-regime model “closer to the truth”:

- ◆ Transient linear flow to fracture interference
- ◆ Boundary-influenced flow after fracture interference
- ◆ Transient linear flow from unstimulated matrix into stimulated reservoir volume (SRV)
- ◆ Boundary-dominated flow if and when a well drains to its limits

“We have limited experience observing long-term declines in unconventional reservoirs,” he said. “I’ve not seen a well in boundary-dominated flow drain to its limits yet, but I expect to,” remarked Lee.

He said industry has no models that totally, uniquely account for the physical processes of flow regimes. It’s generally accepted that wells producing from unconventional reservoirs have long-duration transient flow. However, the industry faces unknowns, said Lee, including how to physically model contributions from hydraulic fractures and reopened natural fractures.

“A serious unknown is in how to model physical mechanisms that control multiphase-flow characteristics, for instance, in wells experiencing condensate formation in the reservoir and other wells in which gas comes out of solution from volatile oils,” said Lee.

Besides the four flow regimes, Lee cited a fifth that occurs during fracture-fluid cleanup early in field life. He cautioned against using data showing an early decline in



Lee

bottomhole pressure (BHP) caused by fracture fluid cleanup and by choking back wells. “That will cause errors because the data does not reflect long-term trends,” said Lee.

While production data recorded during changing BHPs are correctable, data from well cleanup is not easily corrected, he said. Early data is best discarded except in rigorous multiphase modeling.

Lee’s solution is for the industry to deal with various unknowns using simple models more effectively for routine forecasting. That includes using the two-segment Arps model to analyze the performance of hundreds of wells when results are quickly needed. Lee discussed b factors used in the Arps model for each of the four flow regimes. The hyperbolic b exponent in the Arps equation generates the curved portion of the production decline before a well begins a long-

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Reserves reconciliation process needs improvement



MacDonald

The highlights of a Society of Petroleum Evaluation Engineers paper, “Standardized Order and Calculation Method to Reconcile Reserves,” were presented at the latest Ryder Scott Canada reserves conference in Calgary. The paper’s author is **Gary J. Gonzenbach**, a partner at TRC Consultants LC.

John MacDonald, P.Eng. and technical specialist at Ryder Scott Canada, made

the presentation. He said that Gonzenbach in his paper introduces problems in reserves reconciliations—namely, that they are time consuming, vague and predominately manual while the results tend to be inconsistent and difficult to reproduce—that is, unless oil and gas companies can agree on standardized calculation methods.

Reserves reconciliations, which measure both

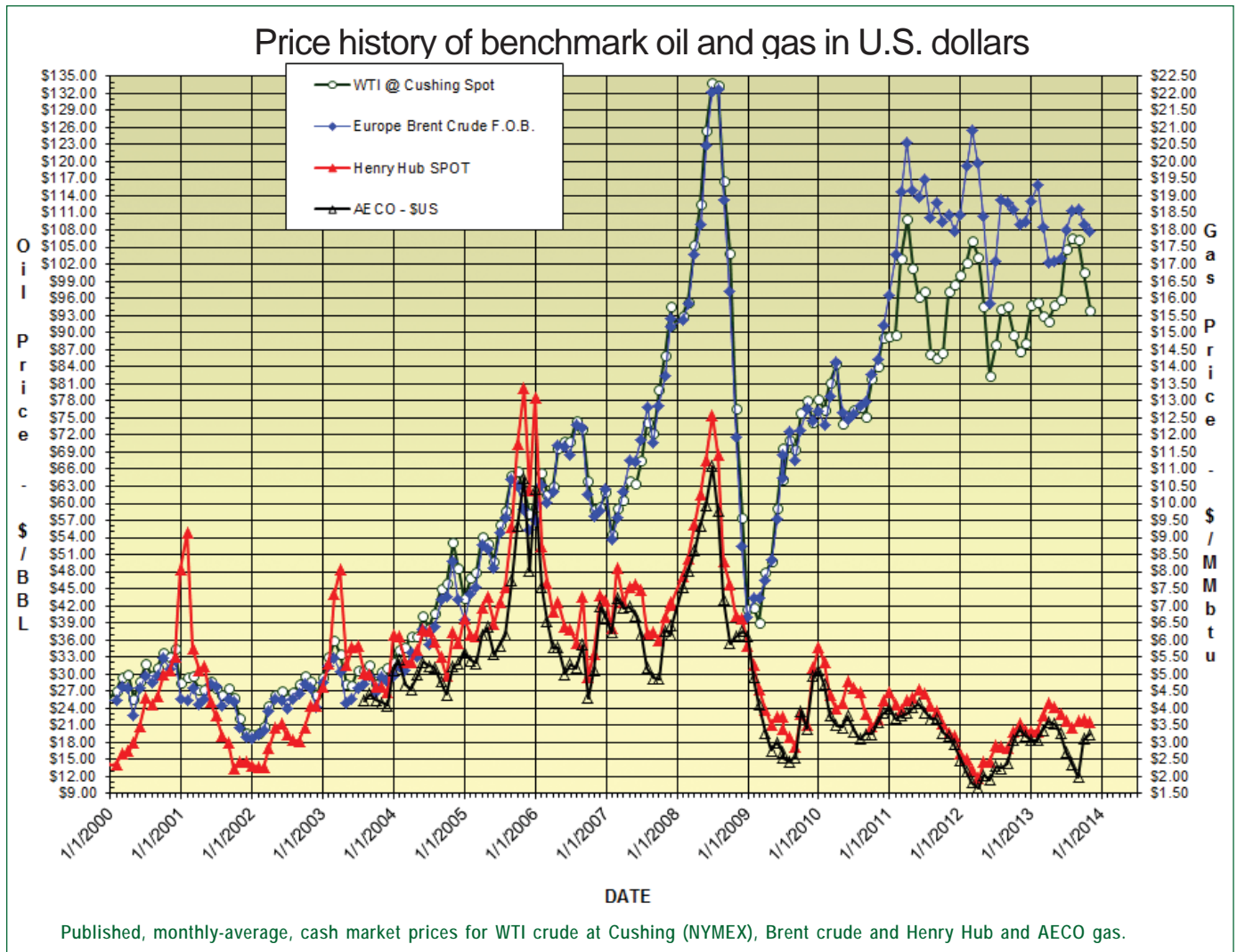
value and reserves changes, are used for disclosures to regulators, corporate dashboards, tracking reserves from possible to probable to proved and tracking replenishment of resources. Change factors in reconciliations include acquisitions, divestitures, economic factors and technical revisions.

“The CSA (Canadian Securities Administrators) and SEC (U.S Securities and Exchange Commission) do not explain how to calculate technical revisions, so the methods vary,” said MacDonald.

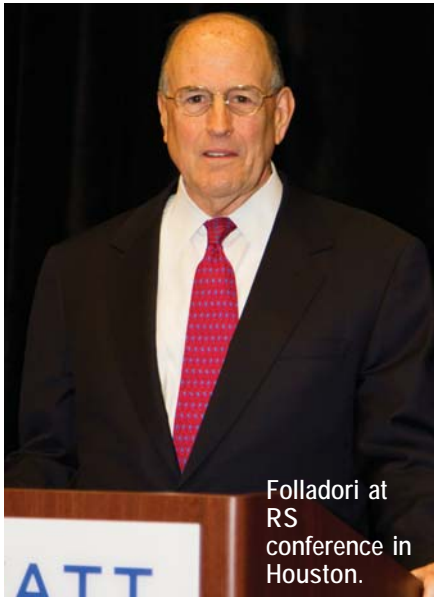
The most common method is to first, identify change factors in the reconciliation. Then each factor is evaluated using incremental change accounting. However, this method can bias the results toward one factor or another based on the order of calculation. The alternative is to use “isolation sensitivities,” which circumvent the calculation-order bias.

Both methods result in leftover volumes from interrelated changes. Those volumes tend to be pushed to technical revisions thereby distorting the reconciliation view, MacDonald related. “The Gonzenbach paper is ultimately a plea for industry to

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How revision to SEC rule plays out in YE 2013 reporting to be “interesting,” says Folladori at RS conferences



Folladori at RS conference in Houston.

The latest interpretations and comment letters on oil and gas reserves disclosures from the staff of the U.S. Securities and Exchange Commission were analyzed at Ryder Scott reserves conferences in Calgary and Houston by **Marc Folladori**, a partner at the Mayer Brown law firm in Houston. He said that year-end 2013 filers are very likely taking into account a recent SEC staff interpretation that allows a company to report proved

developed reserves from an improved recovery project before a production response.

The May 16 Compliance Disclosure Interpretation, CDI 106.01, stated that if a registrant has spent all funds required to install and implement an improved-recovery technique but has not yet achieved a production response, then the registrant may still classify the reserves as proved developed, if they otherwise meet all criteria for proved reserves in Regulation S-X Rule 4-10(a)(22) and developed reserves in Rule 4-10(a)(6). The revised definition of developed reserves applies to all categories, including proved, probable and possible.

“It will be interesting to see how this plays out at year-end 2013,” said Folladori.

He presented issues involving the five-year rule for proved undeveloped reserves, reliable technology rule and various non-reserves topics, such as hydraulic-fracturing liabilities, finances and accounting and the U.S. Dodd-Frank resource extractions disclosure rule, which was vacated by a federal court last July. The rule had required companies to disclose payments made to foreign governments in connection

with commercial development of oil, gas or minerals.

Folladori also said that the SEC has issued “many” comment letters on the disclosure of third-party reserves engineering information.

He summarized SEC comments as follows:

- ◆ Clarify whether the report was a “review” or “audit.”
- ◆ Address deficiencies in disclosures that are required to be in reports.
- ◆ Address incorrect principles/standards followed.
- ◆ Provide “supplemental information” in spreadsheet format, such as summary income forecasts for proved reserves and individual income forecasts and exhibits, such as maps, volumetric calculations, decline parameters, etc.
- ◆ Address inconsistencies between company’s estimates and those in third-party report.
- ◆ Use specific language to explain the actual reserves methodology that was applied instead of using general “boilerplate” language to explain all methodologies that could be applied.

Folladori’s presentations and all presentations from both conferences are posted at ryderscott.com/Presentations/index.php.

Tertiary recovery scheme for heavy oil field studied



Charkovskyy

Vitaliy Charkovskyy, reserves evaluator at Ryder Scott Canada, showed how to predict the performance of a specific heavy-oil field under a chemical-enhanced recovery scheme through the use of reservoir simulation. He demonstrated the process at the Ryder Scott Canada reserves conference.

The objective was to assess the feasibility of implementing chemical flooding in a previously waterflooded heavy oil reservoir in Kazakhstan. The study concluded that the operator should evaluate a line-drive drilling pattern with vertical polymer injectors and infill wells to reduce spacing to 20 acres while increasing injectivity.

Charkovskyy stepped through the reservoir simulation process starting with the static geological model. He discussed laboratory data, choice of modeling software, PVT modeling and core-flood simulations, history matching of the primary and waterflood field performance and forecasting field performance under polymer injection.

The study showed that alkali-polymer—which was eliminated from consideration because it caused precipitation of solids in formation water—did not produce significantly more oil than polymer alone. Charkovskyy said that the model’s history match could be improved with reservoir pressures and gas-production histories. Very little pressure data

was available, he said.

His presentation included detailed charts and graphs. His slides and all presentations from the conference are posted at ryderscott.com/Presentations/index.php.

Successful pilot responses support proved EOR reserves

The U.S. Securities and Exchange Commission may be open to industry's use of a combination of favorable pilot-project responses to help support proved EOR (enhanced oil recovery) reserves bookings, said **Marylena Garcia**, senior reservoir engineer at Ryder Scott.

"This is an opinion. Document your work and conclusions to present a compelling case," she remarked at the Ryder Scott reserves conference.

To support proved EOR reserves through a pilot project, the SEC requires a favorable production response in the target or analog field (commercial analogy). Likewise, under the Society of Petroleum Engineers Petroleum Resources Management System, a favorable production test in a pilot project is strong evidence for proved

EOR reserves. However, the SPE-PRMS has broadened and expanded its set of responses to include changes in bottomhole pressures and in gas-oil ratios.

To support proved EOR reserves disclosed in SEC filings, the issuer documents favorable production responses and uses supporting data from the following cases:

- ◆ Installed EOR program in subject or analogous reservoir supports engineering analysis.
- ◆ Reliable technology (as defined by the SEC) is successfully used and documented.
- ◆ EOR project development has been approved by all parties.

The SPE-PRMS makes no mention of booking reserves of any kind based on reliable technology.

Garcia presented slides on EOR reserves detailing injection- and

production-well patterns, favorable pilot production responses, production baselines and EOR wedges, analogs, reliable technology, recovery factors, simulation and history matching and conclusions/recommendations.

Her presentation and others from the conference are posted at ryderscott.com/Presentations/index.php.



Garcia at RS conference in Houston.

Critical parameters to review to establish an EOR analogy

Geoscience	Engineering	Operational
Structural Configuration	Pressure and Temperature	Well Spacing
Lithology and Stratigraphy	Fluid Properties	Artificial Lift Methods
Principal Heterogeneities	Recovery Mechanism	Pattern Type and Spacing
Reservoir Continuity	Fluid Mobility	Injector to Producer Ratio
Average Net Thickness	Fluid Distribution	Annual Injection Volumes
Water Saturation	Reservoir Maturity	Fluid Handling Capacity
Permeability	Well Productivity	Stimulation Design
Porosity	EOR Specifications	Areal Proximity
Areal Proximity	Areal Proximity	

Petroleum engineer joins Ryder Scott Houston office



Everitt

Brian Everitt joined Ryder Scott in Houston as a petroleum engineer. He was a business development reservoir engineer at J-W Midstream Co. where he analyzed reservoir potential to support exploration in new areas.

He also performed volumetric production forecasts and provided economic analysis for projects under evaluation. Before that, Everitt was a lead reservoir engineer at Western Production Co. for reserves management.

He also provided reservoir engineering support and economic evaluation for acquisitions at Constellation Energy Partners LLC. Before that, Everitt was a petroleum engineer at Snowmass Energy Partners from 2008 to 2011. He conducted reserve forecasting and new deal screening and evaluation.

Everitt also was a production engineer at RJD Management Co. Inc. for two years where he analyzed and optimized production and supervised workovers. He also conducted subsurface mapping.

Everitt began his career at XTO Energy Inc. as a field engineer in 2005. He has evaluated numerous conventional and unconventional plays and reservoirs across the United States.

Everitt has a BS degree in petroleum engineering from Texas Tech University. He is a member of SPE.

Stronger gas prices to result in YE reserves increases

Gas producers filing 10-Ks with the U.S. Securities and Exchange Commission this year may show reserves increases because year-to-year average benchmarks increased as much as 33 percent. The SEC requires companies that report annually to calculate and disclose oil and gas reserves using 12-month average prices.

The YE 2013 Henry Hub gas cash-market price is \$3.67 per MMBtu, up from \$2.76 last year. The Colorado Interstate benchmark gas price is \$3.53 per MMBtu vs. \$2.57 last year. The AECO Canadian gas price is \$3.01 per MMBtu compared to \$2.33 last year. All fell short of the \$4 mark often cited as an industry gauge for healthy returns.

Already strong oil benchmarks showed little movement from YE 2102 to YE 2013. They are as follows:

- ◆ WTI Cushing, OK, from \$94.71 per barrel to \$96.78.
- ◆ Plains Marketing LP posted price for WTI (Midland, TX) from \$91.21 per barrel to \$93.42.
- ◆ St. James, LA, Sweet (LLS) spot price from \$111.03 per barrel to \$106.73.



- ◆ Europe Brent spot price FOB from \$111.21 per barrel to \$108.11.

Monthly benchmark prices and yearly averages used for SEC reporting are accessible through a link—O&G Benchmark Prices to Estimate Petroleum Reserves—on the Ryder Scott home page at www.ryderscott.com.

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SPE papers on reservoir simulation broke ground

Ryder Scott has used reservoir simulation since the 1970s but it was not until 2001 that two of the firm's petroleum engineers wrote a seminal paper on reserves evaluations and the application of simulation. They did it to begin a dialog on the topic, which had not been thoroughly discussed and documented then.

Co-author **Dean Rietz**, executive vice president, said at that time, "Knowledge of this topic resides with an undoubtedly highly specialized, small group — engineers who estimate reserves and conduct simulation. Considering our intimate knowledge of reservoir modeling coupled with our long-established skills in reserves evaluation, it was natural that Ryder Scott initiate dialogue on the subject."

The Society of Petroleum Engineers paper, "The Adaptation of Reservoir Simulation Models for Use in Reserves Certification under Regulatory Guidelines or Reserves Definitions," (SPE 71430) had a long title and was long overdue. The society selected it for presentation at the SPE 2001 annual conference, and the following year, published the paper in abridged form in flagship magazine, *Journal of Petroleum Technology*.

The published work was the first of four written by Rietz and Ryder Scott co-authors, including **Miles Palke**, senior vice president. At the latest Ryder Scott Canada reserves conference, Palke presented "Reservoir

Simulation in Reserves Analysis" to recap some key issues in those papers.

He said that the papers are still the only SPE ones *Please see Palke on Page 8*



Dean Rietz (left), executive vice president, and Miles Palke, senior vice president, at the SPE Mexican Petroleum Congress last June. They wrote a seminal paper on reserves and the application of reservoir simulation in 2001.



Speakers at the Ninth Annual Ryder Scott Reserves Conference in Houston were (from left) Vinicio Suro-Perez, a petroleum engineer at Pemex; John Lee, professor of petroleum engineering at the University of Houston; Marylena Garcia, senior reservoir engineer at Ryder Scott; Tisha Conoly Schuller, president and CEO at Colorado Oil & Gas Assoc.; Joe Stowers, petroleum engineer at Ryder Scott; Jennifer Fitzgerald, senior vice president – group coordinator at Ryder Scott; Thomas Holley, professor and director at UH; Marc Folladori, a partner at Mayer Brown LLP; and Don Roesle, CEO at Ryder Scott.

MLE of in-place gas from material balance study considerably lower than COGEH-case P50s and P10s

Ray Dupuis, a reservoir engineering specialist at Niko Resources Ltd., presented the “Application of Maximum Likelihood to the Gas Material Balance” at the Ryder Scott Canada reserves conference. He noted that COGEH (Canadian Oil and Gas Evaluation Handbook) Vol. 2 states that deterministic methods do not provide a mathematically derived quantitative measure of probability.

“That statement is only partly true,” Dupuis said. “Statistical analysis of data fitting a deterministic model can quantify probability. The principal goal of my presentation is to show that.”

Dupuis demonstrated the maximum-likelihood estimation (MLE) method with a series of slides. The MLE approach maximizes the likelihood (probability) that measured data fit a model, say for example, the equation of a straight line. He showed how to conduct an MLE to obtain statistically efficient parameter estimates for a gas

material-balance model.

His 17-slide presentation featured mathematical formulas and charts, including p/z vs. G_p graphs with superimposed probability plots. In his material-balance example, Dupuis showed differences between qualitative P90, P50 and P10 values of gas initially in place (G) published in the COGEH and those quantified from a distribution generated using probabilistic analysis.

“The differences are large enough to be of concern and are more pronounced at the P50 and P10 levels for this particular case,” said Dupuis. For the analyzed material balance data, estimates of G using the MLE method were 1.6 percent lower than the COGEH P90 volume and more than 14 percent lower than the COGEH P10 level.

His and all presentations from the conference are posted at ryderscott.com/Presentations/index.php.

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tailed, possibly exponential decline.

Lee also discussed more complex approaches, including the use of rate-transient analysis (RTA). He remarked that reservoir simulation is a good choice in problematic situations involving, for instance, variable-length, unevenly spaced, complex fractures as well as pressure-dependent rock and fluid properties and multiphase flow.

Lee also outlined logical workflows for forecasting and said that a “complete” model might consider the physical processes occurring in the four flow regimes.

He said that members of the exploratory committee of the SPE reservoir description and dynamics committee included Oliver Houze, CEO of Kappa Engineering, and Tom Blasingame, professor at Texas A&M University. Lee was an engineering fellow at the U.S. Securities and Exchange Commission during its rules modernization process six years ago.

His and all presentations from the Ryder Scott reserves conference are posted at ryderscott.com/Presentations.

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agree to a standardized reconciliation process,” he said.

The paper contends that the processes to produce reconciliation reports can be automated resulting in as much as a 20-to-1 savings in time and money. The presentation on Gonzenbach’s paper and all presentations from the conference are posted at ryderscott.com/Presentations/index.php.

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solely devoted to the application of reservoir simulation to estimate reserves. “There is very little literature on the subject,” Palke remarked.

The other three papers are as follows:

◆ “Reservoir Simulation and Reserves Classifications-Guidelines for Reviewing Model History Matches To Help Bridge the Gap between Evaluators and Simulation Specialists” (SPE 96410)

◆ “Case Studies Illustrating the Use of Reservoir Simulation Results in the Reserves Estimation Process” (SPE 110066)

◆ “A Novel Simulation Model Review Process” (SPE 159274)

Palke’s presentation focused on reservoir simulation and proved reserves, history matching for immature and mature reservoirs and reviewing models. It and all presentations from the conference are posted at ryderscott.com/Presentations/index.php.

The SPE papers are available for purchase at onepetro.com.

Visit us at NAPE Booth No. 2309, Feb. 4 - 7 in Houston

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 studies a year. Ryder Scott multidisciplinary 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.



Vinicio Suro-Perez, a petroleum engineer at Pemex, showed detailed slides on the geology of the Chicontepec field in Mexico at the Ryder Scott reserves conference. His and all conference presentations are posted at ryderscott.com/Presentations/index.php.

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