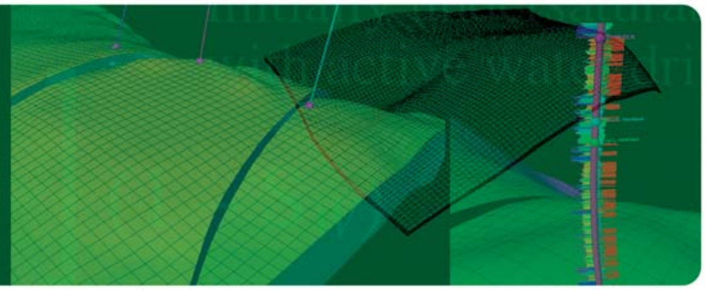
RESERVOIR SOLUTIONS



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RS experts to present topics, workshop at SPE-ATCE

Ryder Scott professionals are making presentations on reserves issues for the remainder of 2006 at various conferences, including at the Society of Petroleum Engineers annual conference to be held Sept. 24 to 27 at San Antonio's Henry B. Gonzalez Convention Center.

Hodgin

Harrell

Analog selection outlined

John Hodgin, president, will present, "The Selection, Application, and Misapplication of Reservoir Analogs for the Estimation of Petroleum Reserves," on Tuesday, Sept. 26 at 2 p.m. in Room 217B. Chairman Emeritus **Ron Harrell** co-wrote the SPE paper, No. 102505.

In researching previous literature on analogs, Hodgin and Harrell discovered that no similar papers are available through SPE or other sources. They also cited a 2002 "global" survey that indicated a lack of documented standards for analog-selection criteria within oil and gas companies.

Hodgin referred to the survey by **S. Qing Sun** and **J.C. Wan** and said, "While analogs were deemed to provide critical insight, no one within the surveyed companies had codified analog best practices."

Tables in the paper help systematize analog criteria. For instance, one table provides a useful comparison of SPE and U.S. Securities and Exchange Commission guidelines for the use of analogs based on such criteria as proximity, geological, petrophysical and engineering parameters.

Over the past few years, proximity as a criterion for an analog has been highly discussed and debated by industry. SEC guidance on proved reserves limits analogs to proved reservoirs in the same geological formation and in the immediate area.

While the SPE definition is similar in that regard, additional criteria involving geological setting and depositional history must be analyzed to validate the analog. Hodgin and Harrell suggest that the physically closer the analog is to the subject reservoir, the better but that SPE and SEC guidelines are not governed by absolute distances alone.

The SEC effectively limits reliance on analogs to those in the same field in cases where the company is trying to support a case for economic producibility without a conclusive formation test. The agency made an exception in 2004 when it stated that it would not object to the reporting of proved reserves without a conclusive flow test in the deepwater Gulf of Mexico if the company confirmed economic producibility through open-hole well logs, core data, 3D seismic information and pressure and fluid data obtained

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Lobby bridge at convention center

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through high-quality wireline testing.

In their paper, Hodgin and Harrell state that "this is the only known instance where the SEC technical staff has concluded that a combination of specified, high-quality reservoir information can be considered as a de facto analog for a formation test. The SEC has steadfastly refused to allow this same procedure to be acceptable outside the Gulf of Mexico even though similar conditions exist throughout the producing regions of the world."

The authors also address SPE and SEC requirements for similarity. The SEC standard is that the subject reservoir must demonstrate equal or more favorable characteristics in every area of comparability to the analog. "The SEC staff has not allowed any latitude," said Hodgin.

SPE allows reserves to be classified as proved when parameters for the analogous and subject field are the same or similar to each other. Those guidelines prompt questions such as how close is close? "An evaluator using SPE guidance must exercise some level of reasonable judgement," the authors state.

Hodgin and Harrell also delineate the screening criteria necessary to deem an analog suitable for use in reserves classification and quantification for potential compliance with both SPE and SEC guidelines. Other topics include the application of analogs to support proved undeveloped reserves according to the SEC one-offset rule and building a case for reasonable certainty.

Pressure data and reserves

John McLaughlin, a petroleum engineer at Ryder Scott, will present, "Uses and Misuses of Pressure Data for Reserves Determination," on Monday, Sept. 25 at 2:50 p.m. in Room 205. The paper, No. 103221, cowritten by **Brad Gouge**, also a petroleum engineer at Ryder Scott, presents applications of pressure data analysis for estimation of reserves under the definitions of the SEC and SPE/World Petroleum Congress.

The authors comment that pore pressure gradient (PPG) data can be a powerful tool to determine fluid contacts and reservoir continuity. However, PPG data alone is not enough to define water/hydrocarbon contacts for SEC proved reserves. With corroborating data, PPG data may be valid for SPE/WPC proved categorizations. Other conclusions are as follows:

- PPG data may be used to define the SEC and SPE/WPC proven gas/oil contacts (GOCs) if the products have nearly equivalent values per reservoir unit volume, data quality is reasonable and supporting information is available. If gas has little value with no current market, evaluators use the logged high-known oil (HKO) as the SEC and SPE/WPC proven GOC.
- Evaluators use post-production PPG data with sufficient supporting engineering and geologic data to prove reservoir connectivity. This data may help expand proved portions of the reservoir beyond the one-offset spacing required for the SEC and SPE/WPC proved undeveloped classifications.
- Transient pressure data helps in the estimation of the average reservoir pressure and in the determination of reservoir characteristics that affect well performance. Transient data does not explicitly prove a drainage area for SEC or SPE/WPC purposes.
- If the reservoir initially has a gradient greater than 0.6 psi/ft pressure, use the material balance

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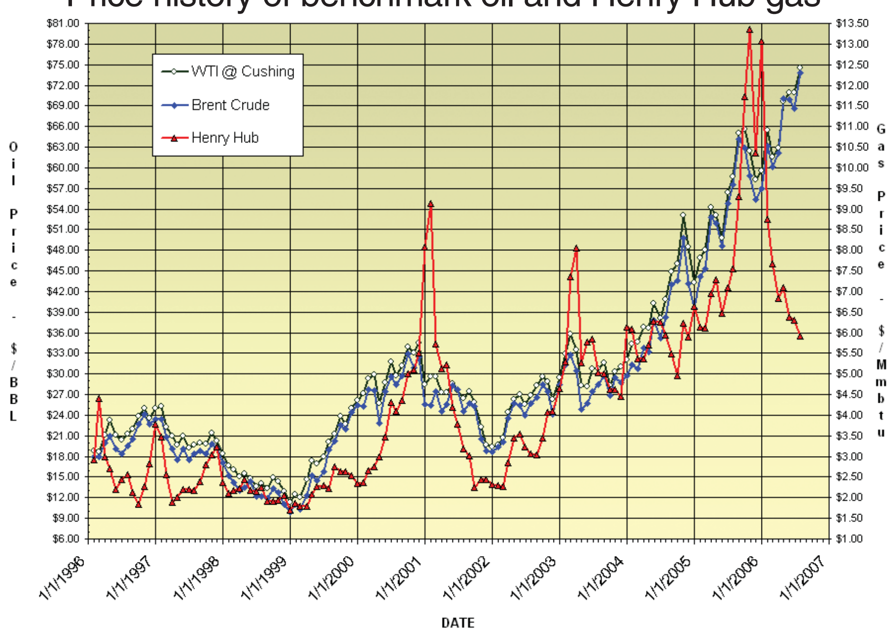
Price history of benchmark oil and Henry Hub gas



The historical price chart shows published, monthly-average, cash market prices for WTI crude at Cushing (NYMEX), Brent crude and Henry Hub gas.

Publisher's Statement

Reservoir Solutions newsletter is published quarterly by Ryder Scott Company 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 115 employees, including 72 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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McLaughlin

Gouge

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equation set for overpressured reservoirs.

- Reservoir abandonment pressures for p/z analyses should be based on ultimate average reservoir pressure. Using the minimum bottomhole pressure determined by facilities constraints and the VLP curves for the well is too low and incorrect.
- Insufficient buildup/shut-in times may make shut-in bottomhole pressures a poor substitute for average reservoir pressures. Using basic well-test equations to compare investigative radius achieved in a shut-in to the well drainage area is a quality control measure that may help identify whether this is an issue.
- Rate-transient material balance is a powerful new tool. The evaluator must carefully review data quality as poor quality introduces too much uncertainty for results to be useful in determining SEC or SPE/WPC proved volumes.

Other ATCE activities

Wagner

Hodgin and **Bob Wagner**, a consultant and former senior vice president at Ryder Scott, will conduct a petroleum reserves short course on Saturday and Sunday, Sept. 23 to 24 at the ATCE. They will focus on the estimation of petroleum reserves under SEC and SPE/WPC reserves definitions and discuss recent developments and interpretations.

The course covers proved, probable and possible reserves classifications and reservoir engineering and geoscience methods and their use in case examples. Hodgin and Wagner will also discuss typical errors in estimating reserves and how to avoid them. In addition, the course covers supplemental estimation techniques, such as reservoir simulation and probabilistic methods, and how to apply them.

SPE will award 1.6 continuing education units for this two-day course.

Ryder Scott will also exhibit at booth space 2928. Company staff will distribute literature, software and other items and will be available for discussions.

Harrell presentation Nov. 16

Chairman Emeritus **Ron Harrell** is scheduled to brief the SPE Gulf Coast Section reservoir study group Nov. 16 on the unified 2007 reserves and resources definitions. The luncheon presentation is scheduled for 11:30 a.m., Thursday, Nov. 16, at the Courtyard on St. James in Houston. For further information or to register, go to www.spegcs.org.

Acuña chairs IQPC conference

Herman G. Acuña, senior vice president at Ryder Scott, was scheduled to chair the "Reserves Valuation, Management and Accounting" conference on September 12 to13 in Dubai, UAE. The conference, hosted by the International Quality & Productivity Center, focuses on strategies in accurately estimating, classifying and reporting reserves.

Acuña

Howard Lam and **Jane Tink**, former vice presidents at Ryder Scott Canada, were promoted to senior vice presidents. **Rick Marsall** and **Harris Ghozali**, at the Denver and Houston offices, respectfully, were promoted to vice presidents.

Lam

Tink

Ghozali

Marshall

Five petroleum engineers, geologist join Ryder Scott

Six professionals recently joined Ryder Scott in the Houston, Calgary and Denver offices.

Baishev

Timur B. Baishev, petroleum engineer, joined Ryder Scott Canada in Calgary. Baishev has more than 25 years experience in research and development in the oil industry. He worked with Ryder Scott throughout the 1990s until 2002 as head of the E&P department at United Consultants FDP in Moscow and as vice president and chief at the Moscow office of Russian Petroleum Consultants Corp.

Baishev has extensive experience using various engineering techniques, including analysis of decline curves, volumetrics, well-test data, material-balance information, pressure-transient data and PVT data. He also worked at Sonatrach Oil State Co. during 1988 to 1992 where he performed reservoir and production engineering analysis and geological modeling. Baishev has BS, MS and PhD degrees in petroleum engineering from the Moscow Institute of Oil and Gas.

Ballesteros

Mario A. Ballesteros, petroleum engineer, joined the Ryder Scott International Group in Houston. He has more than ten years of reservoir engineering experience, including a background in reserves estimation and analysis of secondary- and tertiary-recovery projects as an engineer and supervisor.

Ballesteros worked at Chevron Corp. during 1995 to 2006 in Colombia, Angola and the mid-continent U.S. He evaluated primary-recovery, waterflood and CO2 projects. Ballesteros has a BS degree in mechanical engineering and MS degree in petroleum engineering, both from the University of Tulsa.

Cocco

Martín J. Cocco, petroleum engineer, also joined the International Group of Ryder Scott in Houston. Before that, he worked at Chevron North America as a reservoir engineering consultant and at Chevron Overseas Petroleum in Argentina as a reservoir engineer in the asset development department. At Chevron, he calculated and booked reserves and analyzed field performance and drilling programs to support major reserves changes. He has a BS degree in chemical engineering from the University of Buenos Aires and MS degree in petroleum engineering from Stanford University.

Janicki

With 15 years of experience evaluating properties in western Canada, **Ed Janicki**, petroleum geologist, has joined Ryder Scott Canada. Before that, he worked at Teknica Petroleum Services Ltd. in Libya as a reservoir geologist. Janicki was also an exploration geologist during 1997 to 1999 at Veba Oil & Gas Gmbh in Libya. In that country, he has analyzed plays with block faulting, fracturing and debris-flow sediments; provided reservoir geology input for workovers, and performed mapping.

Also, Janicki worked at the Northwest Territories Geoscience Office during 2000 to 2005 as a project geologist. During the 1990s, he worked at Dax Geological Consultants, McLeay Geological Consultants Ltd. and Zeeland Eco Ltd.—all consulting firms in Canada.

He was a senior geologist at Bow Valley Industries Ltd. during 1988 to 1991. Also, Janicki was an exploration and development geologist during 1980 to 1986 at Hudson's Bay Oil & Gas Ltd. and later at acquiring company Dome Petroleum Ltd. He began his career at the Department of Indian and Northern Affairs in Quebec in 1978. Janicki has a BS degree in geology from Carleton University.

Richard J. Marshall, joined the Denver office as a petroleum engineer and was promoted to vice president. Please see photo on Page 3. Previously, Marshall was a consultant for six years and provided property evaluation, litigation support and general petroleum and geological consulting. During 1981 to 1999, Marshall worked at Ryder Scott.

He began his career at Texaco Inc. in 1976 as a production engineer and then worked for Phillips Petroleum Co. as a reservoir engineer and Petro-Lewis Corp. in technical management before joining Ryder Scott. Marshall has a BS degree in geology from the University of Missouri and a MS degree in geological engineering from the University of Missouri at Rolla.

Stinson

Jim F. Stinson joined the Houston office as a petroleum engineer. He has more than 30 years experience in oil and gas consulting at EBS & Associates Inc.; Keplinger & Associates Inc. and Miller, Banta, Poyner & Stinson Inc. He has reservoir evaluation experience in every major U.S. producing basin, including in the gulf coast salt dome, onshore and offshore, and

Please see Staff Added on next page

Geo modeling of thin bed CBM reservoirs detailed

Phillips

Steve Phillips, vice president and geologist at Ryder Scott, said that even though volumetric analysis of original and remaining gas content is a routine step in estimating coalbed-methane reserves, measuring the thickness and quality of thin coal seams is frequently problematic, because of the limitations of the wireline-log resolution.

Phillips made his remarks at the Ryder Scott reserves conference last May. He said that Ryder Scott confronted this issue during a recent assignment to create a 3D geologic model of a Black Warrior basin CBM field.

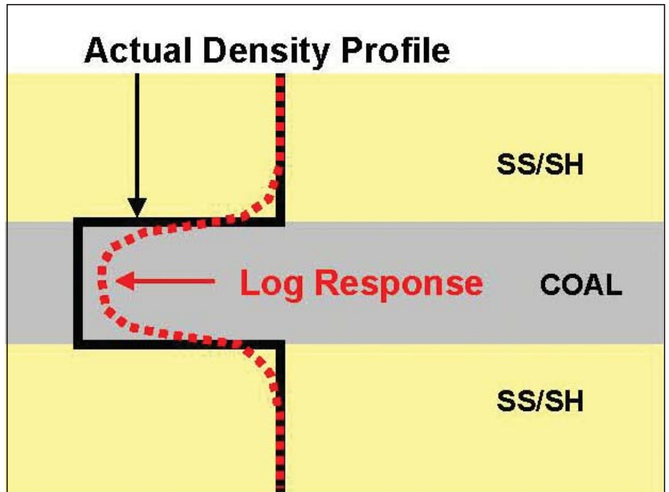

Figure 1

The bulk density log is the key to identifying coal thickness and quality, said Phillips. Logs run in the study-area wells are recorded on a 1/10th-ft sample interval and have a vertical resolution of about eighteen inches.

In other words, the detector on the logging tool must be about 1.5 ft or more above or below the boundary between coal and adjacent rock before it can yield a reliable density reading of the seam, he said.

Therefore, the minimum density observed in seams thinner than about three ft will be some value between the true density of the coal and that of the surrounding rock. This problem is also known as "shouldering" and is illustrated in Figure 1.

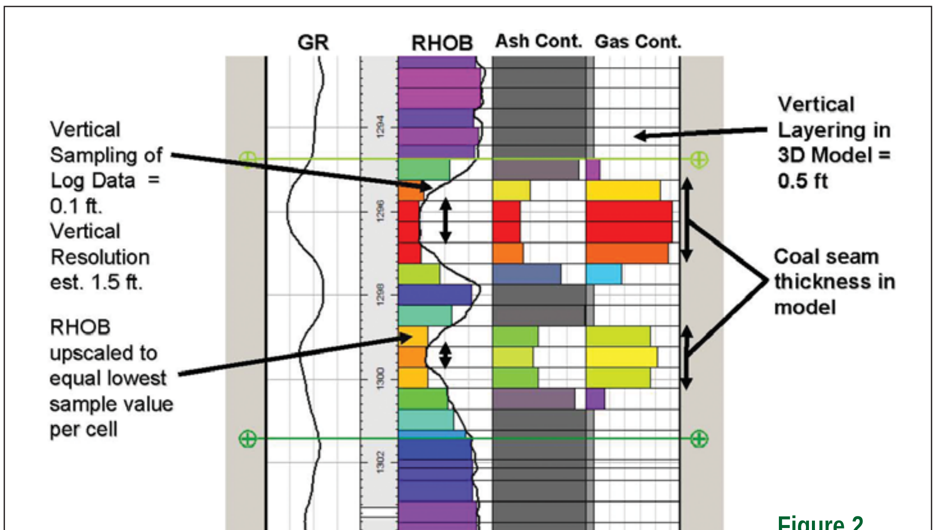

Figure 2

A 3D geologic model attempts to simulate a reservoir by approximating the actual geologic conditions with a finite number of box-like cells. Those cells represent the physical bulk volume of the reservoir.

"Think of a room filled with pizza boxes. These boxes occupy space and can be filled with a variety of values that represent reservoir properties. Think of pizza and toppings in each box," said Phillips.

He designed the geologic model to compensate for the shouldering effect to give thin coal seams their most realistic gas content. Phillips set the cell height to six inches, providing each cell with five density samples from the wireline log for upscaling into a single value. He used density logs previously normalized by Ryder Scott contract petrophysicist **Rick Richardson**.

Commonly, upscaling involves a simple averaging of the finely sampled input values into cells penetrated by a well. However, in this case, Phillips chose the minimum density value as the single density number representing each cell.

"By choosing the minimum value, cells at the upper and lower coal-seam boundaries are not severely penalized for shouldering effects," said Phillips. "And for thicker coal seams, where the log reading is reliable, the result is the same as averaging the individual log readings."

See example in Figure 2. For more information on geological modeling, Phillips can be contacted at steve_phillips@ryderscott.com.

A full recap of the reserves conference was published in the June 2006 *Reservoir Solutions*.

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in the Midland, San Juan and Appalachian basins. Experience in international areas includes offshore New Zealand, North Sea, South America and offshore China. Stinson received a BS degree in petroleum engineering from Mississippi State University.

Lure of vast gas resources spurs interest in hydrates

Wilson both cautious and optimistic on hydrates

In the early 1990s, **Scott Wilson**, like most petroleum engineers, had scorned gas hydrates as either a nuisance that intermittently freezes off chokes or a severe hindrance that plugs off entire pipelines.

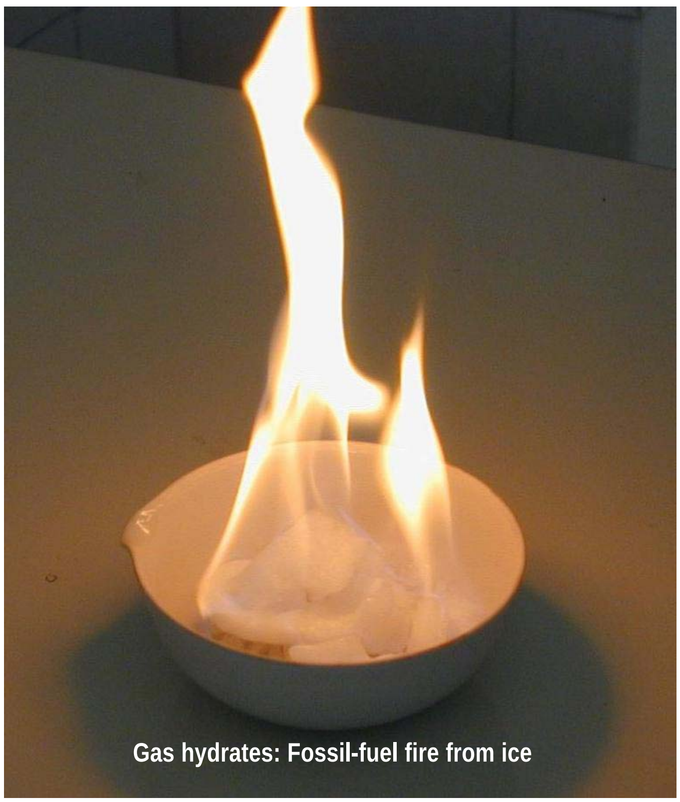
At that time, the industry did not see these clusters of frozen water molecules, each holding a methane molecule, to be a potential energy source. Wilson first heard of exploiting natural gas hydrates about 15 years ago as an industry advisor to the University of Alaska Fairbanks.

Now a vice president in the Ryder Scott Denver office, Wilson is considered an expert in hydrate modeling and serves on the joint National Energy Technology Laboratory—U.S. Geological Survey methane hydrate simulator team. With natural gas prices soaring, government and industry have begun to investigate the feasibility of commercially producing gas hydrates.

Experts have said that more hydrocarbons are contained in hydrate deposits than the combined oil, gas and coal reserves worldwide. USGS studies predict that 500-to-120,000 Tcf of natural gas are locked up in gas hydrates worldwide.

"That's a 18-digit number, believe it or not. The upper limit is 120 quadrillion standard cubic feet," said Wilson. "But with a zero recovery factor, a huge number times zero is still zero and there is a lot of gold in the ocean too."

In debates between proponents and naysayers, Wilson has yet to take sides. "Only long-term test wells can prove up a play, but I still remain hopeful that hydrates will be commercially exploited one day," he said.


Gas hydrates: Fossil-fuel fire from ice

"That's a 18-digit number, believe it or not. The upper limit is 120 quadrillion standard cubic feet. But with a zero recovery factor, a huge number times zero is still zero and there is a lot of gold in the ocean too." — Wilson

U.S. government funding has focused on further defining the resource, evaluating the climate change and environmental impacts and most recently on investigating production methods and potential. The government of Japan spends millions of dollars each year trying to better define the potential of gas hydrate since significant volumes exist in the sediments just offshore.

However, drilling and testing deepwater wells is prohibitively expensive. The more feasible opportunities for testing are in the U.S. and Canada Arctic region.

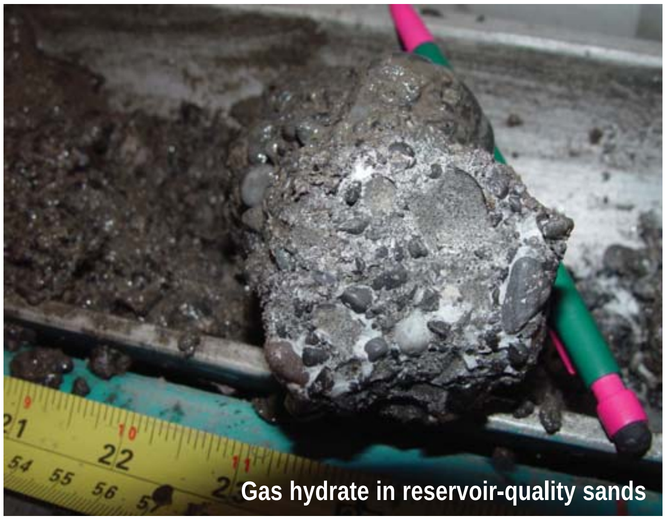
Meanwhile, industry has focused on flow assurance with a few numerical studies showing disappointing results at prices prevalent in the late 1990s. At that time, Henry Hub benchmark gas prices were around $2 per MMBTU. Since then, the economics have changed dramatically, with Henry Hub prices fluctuating between $7 and $13 per MMBTU over the past year.

Four short years long on progress

Four years ago, Wilson helped predict the performance of a hypothetical gas hydrate test well on the North Slope of Alaska in a joint project between the DOE and BP Exploration Alaska Inc. He helped quantify technical risk and conducted numerical modeling work.

"There are a variety of numerical prediction methods that have grown from compositional/thermal simulators, academia and government-funded research," said Wilson. "These models have done well in predicting behaviors on the scale of a pipeline plug, but when it comes to predicting the dissociation around a horizontal gas hydrate producer in a 30-ft thick zone spaced at 40 acres, that's a big extrapolation."

The lack of macroscopic data has been the greatest challenge to improving predictions even today. Although gas hydrate remains frozen in huge quantities below the permafrost in petroleum basins in Siberia, Northwest Territories and Alaska, no one has attempted to produce the gas intentionally. The Messoyakha field in North Central Siberia is reputed



Gas hydrate in reservoir-quality sands

to have produced gas from hydrates as well as conventional gas, but indisputable evidence of commercial production still does not exist.

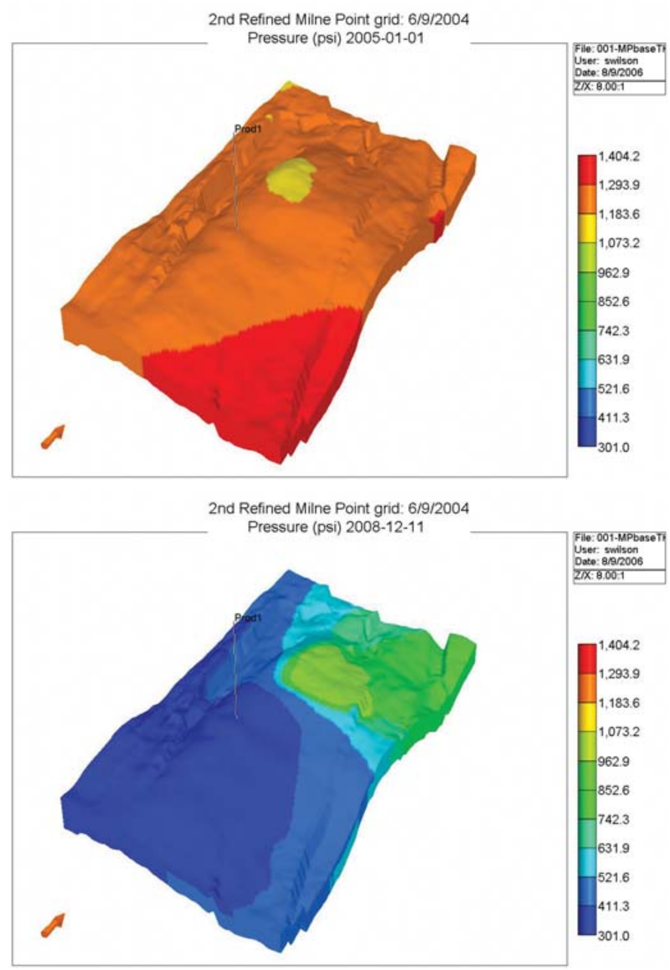
In 2002, encouraging well test results indicated potential producibility at the Mallik project on the Mackenzie Delta in Canada. The partners cored thick, high-saturation sections of gas hydrate and conducted several wireline formation tests (MDT tests) that showed permeability of the gas-hydrate-bearing section to be higher than expected.

Each of the tests recovered water and gas with better results than from many tight-gas wells before stimulation. Unfortunately, the partners did not attempt a long-term test in the Mallik well because of weather-window and budget constraints.

In 2003, Wilson was involved in creating the first field-scale gas hydrate reservoir simulation that used actual characteristics of a reservoir at the North Slope's Milne Point. He used geologic description work done at USGS, thermal/compositional fluid and rock descriptions from a University of Alaska master's thesis and the CMG STARS simulator to model a realistic depletion scenario.

Wilson

Wilson had to make a few modifications to get the model of the reservoir to run cleanly. For example, all reaction temperatures had to be shifted up since the model stops at 0 degrees Celsius and some of the most "interesting" behaviors happen at the freezing point of water.



Wilson created this dynamic model of a gas hydrate reservoir at Milne Point on the North Slope of Alaska. It shows reduced pressure over time as free gas adjacent to the hydrates is extracted through a hypothetical pilot well. The pressure reduction causes the gas hydrate to start to disassociate.

"In the end, the results were reasonable and reflected a base on which sensitivities could be run," he said.

Wilson presented his results at the AAPG Hedberg conference in Vancouver in 2004. Since then, the interest in potential gas hydrate production has grown steadily. At the request of U.S. Secretary of Energy Samuel Bodman, Wilson serves on the DOE Methane Hydrate Advisory Committee and has recently advised the U.S. Minerals Management Service on a 2006 study of U.S. gulf coast gas hydrate potential.

BP continues the collaborative research project in Alaska with the DOE and has recognized the innovative work. Most recently, Wilson provided expert commentary in the April 2006, *Popular Mechanics* magazine, in an article, "Fire in Ice," posted at www.popularmechanics.com/science/earth/2558946.html.

The article outlines two main extraction methods that have been successfully tested at the Mallik site.

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Hydrates—Cont. from Page 7

The first, depressurization, involves drilling a hole into the hydrate layer to draw down the pressure, causing hydrates to dissociate and gas to flow up the pipe. Thermal injection, the second technique, destabilizes hydrates by pumping hot water into the deposit. Because depressurization requires less energy, Wilson calls it the "lowest-hanging fruit."

The article states that a third method appears promising, too, but has so far only been tested in a lab. Injecting carbon dioxide into a hydrate formation displaces methane and has the added benefit of locking away an abundant greenhouse gas.

"Gas hydrates today are an opportunity for some young person to become richer than Bill Gates." — Deffeyes

In the book, "Beyond Oil: The View from Hubbert's Peak," author **Kenneth Deffeyes** states, "Gas hydrates today are an opportunity for some young person to become richer than Bill Gates. The methane hydrates already identified are larger than all the world's oil, gas, and coal combined. …It won't be easy; the major oil companies have known about the gas hydrates since 1970 and so far haven't announced a promising extraction methodology."

Wilson sees a parallel between the evolution of hydrate extraction and the exploitation of other earlier so-called unconventional resources that now are considered mainstream. "How many operators were drilling for unconventional gas over permafrost or willing to complete a low-rate gas well in the deep water? This feels just like the coalbed methane activity in 1984 when Arco's Denver-based special projects group was trying to bring San Juan basin coal gas to market. Back then, CBM was just a science project too. Today, that science project provides more than 10 percent of the U.S. natural gas supply."

An international consortium, including the USGS, Department of Energy, Canada, Japan, India, Germany and the energy industry conducted test drilling at Mallik in the Mackenzie Delta of the Canadian Arctic. This location was chosen because it has one of the highest concentrations of known gas hydrates in the world. Although the Mallik 2002 program began with a handful of researchers, the realization of the program over the course of its four-year life required the dedicated efforts of more than 200 scientists from 50 research institutes, consultancies and companies. Photo and copy courtesy of USGS.

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