Software Responding To CBG, Tight Gas

By Yogi Schulz

CALGARY, ALBERTA–Record wellhead prices, continuing high demand and declining reserve additions per conventional natural gas well are increasing interest in unconventional gas reserves, including coalbed gas, tight sands and shales, basin-centered accumulations, and over the longer term, even methane hydrates. As advancements in technology continue to improve the industry's ability to delineate and develop unconventional gas reservoirs, resources that are considered unconventional today may well become the conventional exploration and production plays of tomorrow.

The size of the unconventional gas resource base is substantial. For example, according to GRI, coalbed gas represents 12 percent of the total U.S. energy resource potential, with CBG now accounting for more than 10 percent of total annual U.S. natural gas production.

Although estimates vary, the tight gas resource potential is even larger. There are today more than 40,000 producing wells in tight gas sands in the United States, with average daily production of 170 Mcf per well. However, because permeabilities in the microDarcy range make it difficult to economically recover tight gas, only a small percentage of these reservoirs have been economically viable using conventional drilling and completion technology. Typically located onshore, the size, location and quality of tight gas reservoirs vary considerably.

Successful production strategies for unconventional gas rely more heavily on comprehensive reservoir models than do conventional gas production strategies, making reservoir simulation key in unconventional gas development to delineate crucial recovery factors such as lithology and fault and fracture geometries.

Key Geological Difference

The key geological difference between conventional gas and unconventional gas is how the gas is trapped within the formation. Conventional gas is located under pressure in the pore spaces of a high-permeability formation. The gas begins to flow once the well bore penetrates the gas-laden formation.

FIGURE 1

Cumulative Production versus Remaining Gas (Coalbed Gas Field)

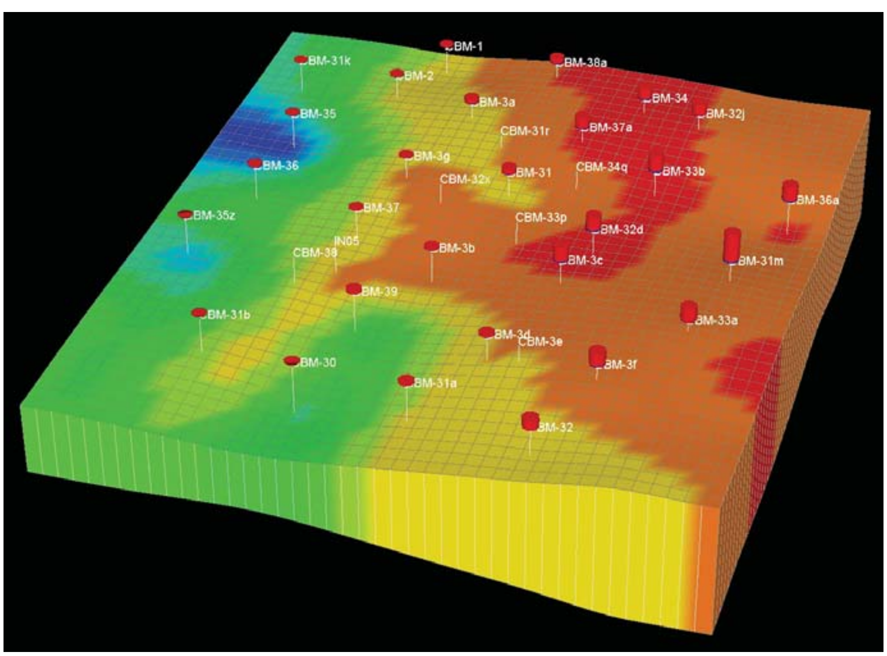

Image courtesy of Computer Modelling Group Ltd.

As Simon Testa, president of TICORA Geosciences Inc. in Arvada, Co., explains, "Unconventional gas reservoirs are sorption reservoirs where gas is stored by adsorption to the matrix. Before it can be produced, unconventional gas must be released from the reservoir matrix."

The gas is released in response to a drop in pressure across the reservoir. If the reservoir is saturated with water, as is the case typically in coal seams, water will be extracted to draw pressure down to the point where gas will flow for production, he adds. If the reservoir is gas saturated, little or no water will be produced, and conventional gas will be produced first, followed by the unconventional gas.

As a result of this geological difference, unconventional gas reservoirs exhibit peculiarities that dictate a different approach to their development than conventional gas plays. For starters, unconventional gas reserves are almost always far greater per pool than conventional gas, because the gas is stored in a form that has a density much like a liquid rather than a gas under pressure, according to Peter Sammon, senior staff scientist at Computer Modelling Group Ltd. in Calgary.

"The volume of unconventional gas per volume of reservoir can be orders of magnitude greater than in conventional reservoirs," he states. "However, a lower percentage of the in-place gas in an unconventional reservoir is typically recovered."

Figure 1 shows cumulative production volumes (red barrels above the well bores) and remaining unconventional gas available for desorption (indicated by the red through blue shading) in a coalbed gas field.

Many unconventional gas wells produce at rates similar to average conventional gas wells, although they rarely produce at rates equaling the best conventional gas wells. Unconventional gas plays also tend to exhibit higher production costs because of the higher numbers of wells required, even though a lower percentage of in-place gas is ultimately recoverable than in a conventional reservoir.

Despite these challenges, many exploration and production companies–especially independents–are seriously pursuing unconventional gas plays, ranging from the Barnett Shale in the Fort Worth Basin to coalbed gas in Wyoming's Powder River Basin. The motivations include reduced opportunities for conventional gas, strong gas prices that are expected to continue, and the existence of various commercially successful unconventional gas projects.

Unconventional gas production continues to increase in North America each year. In fact, the Barnett Shale now ranks as the largest producing gas field in Texas. And while commercial coalbed gas production is only beginning in Canada, CBG production continues to climb each year in the lower-48–thanks largely to field development activity in the Powder River and San Juan basins. In Canada, leading projects include the Beiseker and Gayford developments in Alberta.

Complex Characteristics

The more complex characteristics of unconventional gas plays demand more sophisticated production strategies that cannot be worked out through simple analytical techniques using a spreadsheet. Much of the added complexity arises from the fact that unconventional gas typically exists in the reservoir in three forms:

- Adsorbed gas in the matrix;
- Free gas in the matrix; and
- Free gas in reservoir fractures.

For a reservoir simulator to produce a reasonably accurate production forecast, it must treat these three forms separately, because they behave differently.

The reservoir characteristics that reservoir models must take into account include low permeability, multiple narrow gas zones, increasing areal extent of projects, formation pressure effects of a number of potential injectants, and the interaction of the injectants such as carbon dioxide (Figure 2) with the gas and the formation. Modeling the shrinking and swelling that occurs in presence of different gases–especially CO_2–is no easy task for reservoir simulation.

The project characteristics that reservoir models must manage include smaller grid cells in the model to improve precision, larger volumes in the geomodel, and more actual and proposed wells, often with multiple completions in different productive zones.

The business drivers that reservoir models must respond to include a desire to minimize drilling, completion and operating costs, as well as the need to maximize the recovery factor without damaging the reservoir, reduce the surface impact of project operations, and minimize the cost and cycle time for the reservoir evaluation itself.

Together, these factors are creating a prominent role for reservoir simulation in unconventional gas plays, from CBG to tight sands. Hardware and software advancements in reservoir simulation are helping operating companies achieve the objectives of maximizing unconventional gas production and reserves recovery while minimizing field development and production costs.

These factors are also converging to create reservoir models with an increasing numbers of data points that demand more computing power. The major suppliers of reservoir simulation software for unconventional gas are responding to the demands of their customers with a stream of software improvements.

However, even though the size and complexity of reservoir models is growing, no one wants an increase in elapsed time to process a simulation scenario. In fact, the opposite is true. Given the time value of money, every exploration and production company is seeking to reduce cycle times. This situation is causing reservoir simulation software to move from high-end personal computers to Linux PC clusters, faster UNIX servers, parallel processing and grid computing technologies.

Software Advances

E&P companies continue to push their software suppliers for various functionality improvements. Software suppliers have responded with advances in ease of use, improvements in precision and accuracy, and decision support capabilities. Table 1 contains criteria to consider when selecting acquiring reservoir simulation software.

Technical advances include, for example, better user interfaces for data loading, model building and display of simulation results in a visualization environment. In terms of improvements in precision and accuracy, software vendors are introducing improved mathematical formulas for describing the interaction of the gas with the coal formation, and the response of the formation to reduced pressure or an injectant.

Examples of decision support capabilities include the ability to study and model completion alternatives to help answer a litany of questions, such as determining which zones should be completed, deciding whether vertical wells need to be hydraulically fractured, or figuring out whether horizontal drilling could improve production.

Jim Flynn, manager of simulation busi-

FIGURE 2

CO_2 Penetration into an Unconventional Gas Reservoir

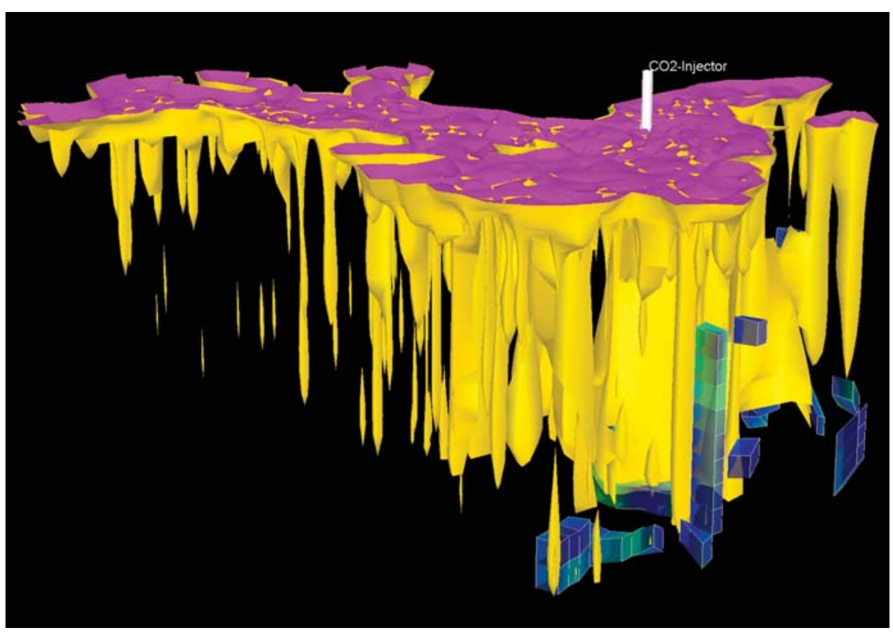

Image courtesy of Computer Modelling Group Ltd.

ness development at Schlumberger Information Solutions in Houston, says, "The ability to integrate completion analysis with reservoir simulation within a single workflow reduces cycle times, simplifies and streamlines decision making, and enables a more complete view of the reservoir. The result is that oil and gas professionals have a better understanding of the variables that ultimately control hydrocarbon production and recovery rates in unconventional reservoirs."

As operating companies develop more and more unconventional gas reservoirs, the demands on simulation software will only grow, suggests Scott Reeves, executive vice president of Advanced Resources International in Houston. A case in point is coalbed gas projects now evolving into enhanced recovery projects, where an injectant–typically carbon dioxide or nitrogen–is injected into the formation, where it is preferentially adsorbed to the coal to release the gas content from the formation.

"Accurately modeling the injection of CO_2 or N_2 into any reservoir requires additional capabilities in the simulation software," Reeves relates. "It becomes even more challenging in unconventional gas reservoirs because of the complex nature of those plays to being with."

Software suppliers are responding by developing enhancements to support a wider range of coal qualities, such as high-ranked coals, deeper coals and lower-permeability coals, as well as expanded simulation capabilities to model different drilling and completion options. Figure 3 displays a sample 3-D screen view of results from Schlumberger Information Solutions' ECLIPSE® reservoir simulator using different drilling and completion strategies in a coalbed gas field.

Catch-22 Dilemma

On the one hand, unconventional gas plays require more sophisticated (i.e., more expensive) reservoir simulation to properly address all of the factors involved in field development and production. On the other hand, however, the higher operating costs for unconventional gas production makes it difficult for plays to support highly detailed reservoir studies. What is the producer to do?

Fortunately, continuing reductions in the cost-versus-performance of computing hardware is helping eliminate this Catch-22 dilemma by steadily driving down the cost for computationally intensive reservoir simulation and visualization. Even as new types of computing architectures such as Linux clusters reduce the cost and time required to process vast amounts of reservoir simulation data, hardware and software advances are bringing high-end 3-D visualization capabilities all the way down to the desktop level to support collaborative workflows all along the value chain.

Rocky Mottahedeh, president of United Oil & Gas Consulting Ltd. in Calgary, says operators are using 3-D visualization technology in unconventional gas plays primarily to plan field development, select the most favorable drilling targets, and help guide wells to the selected zones.

"Companies continue to seek to optimize performance by reducing cost and improving recovery rates," he remarks. "These goals demand optimizing the number and types of wells drilled, and minimizing the risk if having wells miss their reservoir targets."

TABLE 1

Reservoir Simulation Software Selection Criteria

Software Selection Category	Software Selection Criteria
Supported functionality	Three-phase, multicomponent fluids Triple porosity Multiple grid block shapes Rock fluid interaction Sophisticated component properties Suspended component properties Geomechanic effects
Ease of use	Model setup Post-process output management Overall operation of the software
Supported input formats	Geomodel interchange format
Supported output formats	Mapping Visualization
Supported integration points	Completion analysis tools
Acceptable elapsed time to process a modeling scenario	Hours Days Smart calculation to reduce elapsed time to completion
Maximum size of reservoir model supported	Maximum number of grid blocks Maximum number of data points Maximum number of time steps Maximum number of wells Maximum number of well completions
Available for the desired operating system	Windows UNIX Linux
Makes use of desired computing technologies	Server clusters Parallel processing Grid computing
Acceptable precision and accuracy	Calculation accuracy History match
Acceptable decision support capabilities	Propose well locations Model effect of directional wells Model effect of fracturing
Acquisition cost	Software license cost Initial training cost Computing environment cost
Operating cost	Staff cost Computing cost Software maintenance cost

FIGURE 3

Multilateral versus Vertical CBG Completions (Simulated results after 10 years of production)

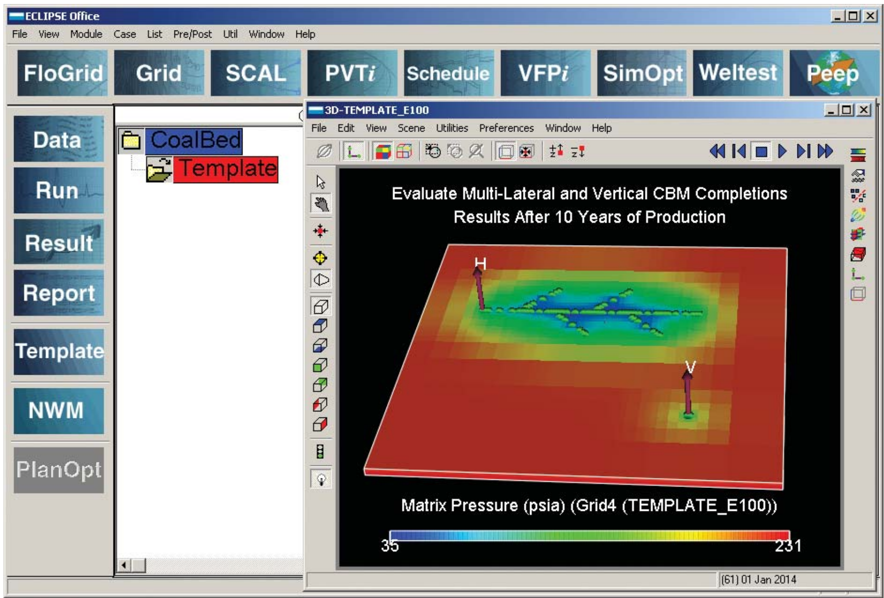

Image courtesy of Schlumberger Information Solutions

Figure 4 shows a 3-D geomodel of Southern Alberta coalbeds generated by United Oil & Gas Consulting's SMART 4D® geomodeling software, depicting the distribution of coalbed facies in the Belly River Formation. Vertical distance represented in the model is about 1,500 feet, with a series of coalbeds varying from a few feet to more than 50 feet in thickness. The Belly River coals are encountered at a depth of ±3,000 feet. The lower map shows a total coal thickness map with a maximum of 150 feet.

Reservoir simulation has advanced rapidly for unconventional gas over the past few years in response largely to the industry's increasing focus on coalbed gas and tight gas. But each type of unconventional gas play is a different game, and successfully developing these reservoirs requires a fundamental understanding of the various factors that govern their ability to produce gas at economic rates, according to Ken M. Dedeluk, president and chief executive officer of Computer Modelling Group Ltd. in Calgary.

"My vision of the future of unconventional gas production includes the notion that only the most technologically savvy companies will successfully exploit unconventional gas reservoirs," he asserts. "Understanding the physics of the reservoir is the key, because unconventional gas plays are far more technically challenging than conventional plays."

For the operator that translates into undertaking more simulation design and field engineering work than in conventional gas plays, he adds. "In the future, reservoir simulation will increasingly become an integral part of day-to-day production operations in unconventional gas plays, guiding the production optimization decisions, just as process control does today," Dedeluk concludes. ❐

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FIGURE 4

3-D Model of Distribution of Coalbed Facies (Belly River Formation, Southern Alberta)

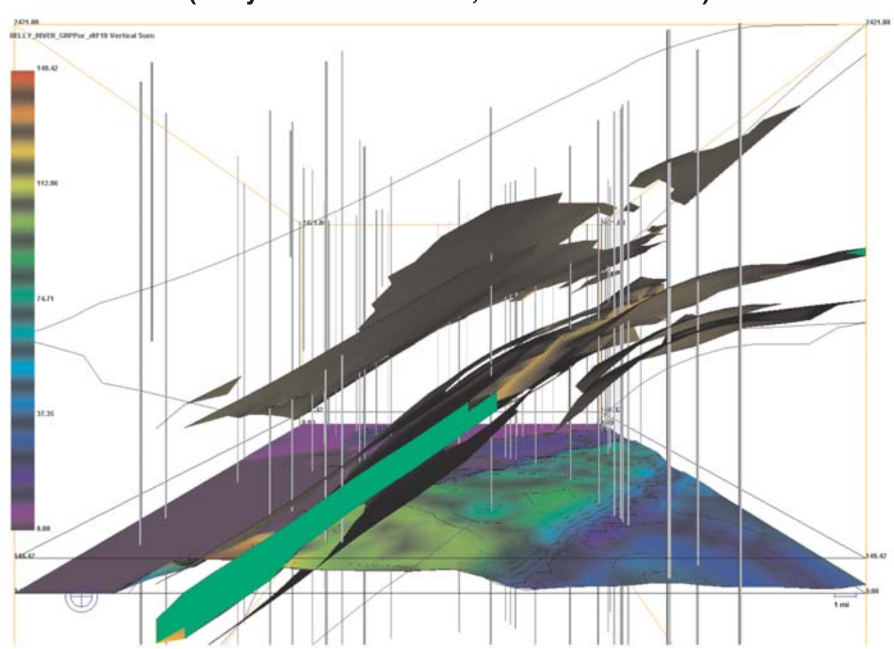

Image courtesy of United Oil & Gas Consulting Ltd.