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Project Targets The New Albany Shale

By Iraj A. Salehi

DES PLAINES, IL.–While the New Albany Shale spans Illinois, Indiana and Kentucky, to date, gas has been produced primarily in western Indiana and southwestern Kentucky (Figure 1). A November 2006 presentation by Texas' Bureau of Economic Geology for the Petroleum Technology Transfer Council estimates the New Albany Shale holds between 90 trillion and 160 trillion cubic feet of natural gas, of which 1.9 Tcf-19.2 Tcf is considered technically recoverable.

While production from this rich resource has met with many technical challenges resulting from its low permeability and low reservoir pressure, as well as high drilling and completion costs, this resource has become a prime research and development target, thanks to advanced technologies, cost savings realized from horizontal drilling, and the proximity of production to points of use.

FIGURE 1

Location of New Albany Shale Outcrops and Cores

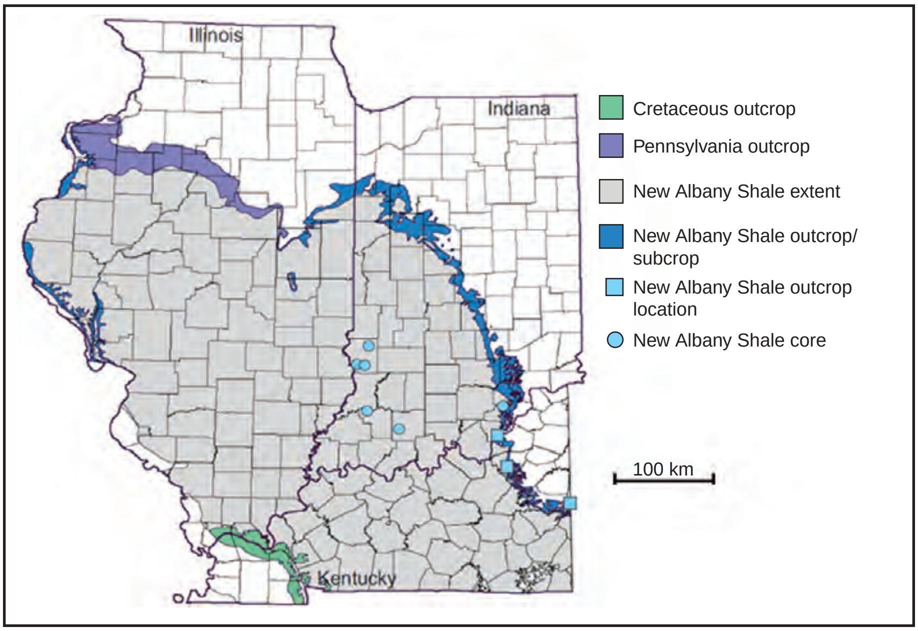


FIGURE 2

New Albany Shale Project Structure and Information Flow

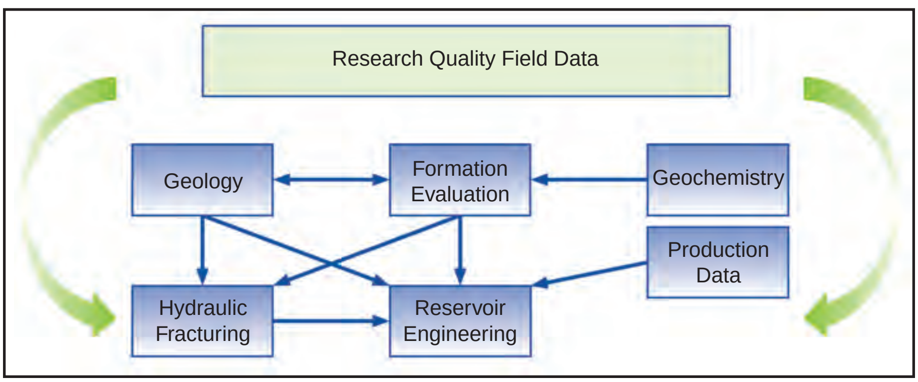
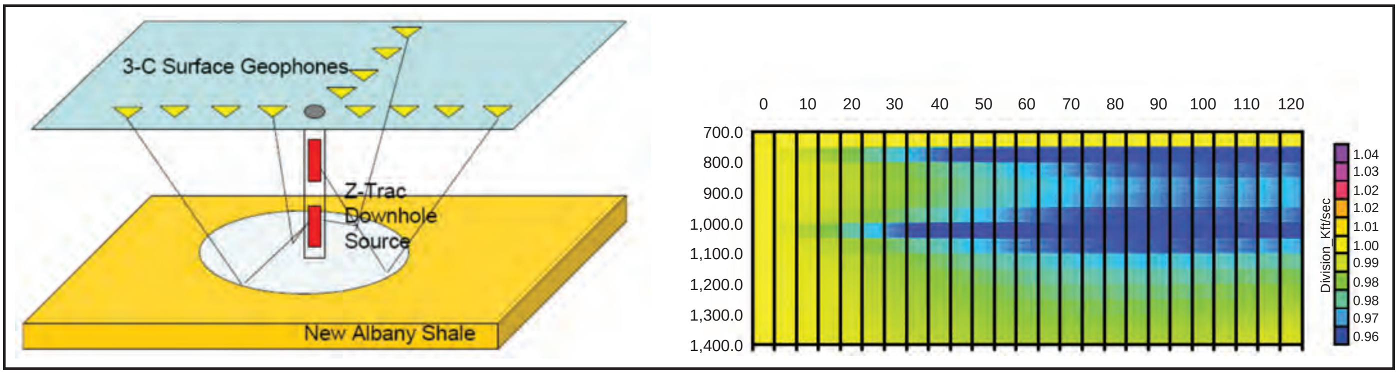


TABLE 1

Project Participants
Producing Companies
Atlas America
Aurora Oil and Gas Corp.
Breitburn Energy
CNX Gas Corp.
Diversified Operating Corp.
NGAS Resources
Noble Energy
Rex Energy
Trendwell Energy Corp.
Research Organizations
Gas Technology Institute
Texas A&M University
Bureau of Economic Geology (University of Texas)
West Virginia University
Amherst College
University of Massachusetts
University of Arizona
Pinnacle Technologies
ResTech Inc.

FIGURE 3

Reverse Vertical Seismic Profile Schematic (left) And Velocity Variation (right) from RVSP



In August 2008, the Gas Technology Institute began a field-based research project aimed at developing techniques and methods to increase the success ratio and productivity of New Albany Shale wells to a level at which otherwise non-commercial wells would become viable. These efforts are being funded by the Research Partnership to Secure Energy for America, and are supported by several producing companies engaged in developing the shale.

The New Albany Shale project is a field-based cooperative project with 18 participants: nine producing companies and nine research organizations (Table 1). Producer involvement and cost sharing combine scientific and technical analyses with field data acquisition, testing, and field validation. A comprehensive integrated project plan for geologic, geochemical, reservoir engineering, and production stimulation studies as well as a detailed field data acquisition and testing plan addressing all major issues are being implemented.

The project is focused on characterizing the New Albany Shale, especially natural fractures and their interaction with hydraulic fracture stimulation. The primary objectives are to develop techniques and methods for identifying and characterizing natural fractures, and developing effective fracture techniques. In addition to these efforts, formation evaluation and reservoir engineering serve as the key sources of information for determining the producible gas, and have been considered in great detail.

Figure 2 depicts the flow of information and data among various project elements.

A key factor in the success of the project is high-quality data acquired from participating-company wells. The producing companies allow the project to run special logs, cut cores, and perform special tests to calibrate and verify analytic results. Background geologic and reservoir data provided by producers are equally important in ascertaining the relevance of the research to the New Albany Shale resource.

To date, the project has evaluated sets of logs and cores, one microseismic fracture image, one reverse vertical seismic profile, and one field-scale reservoir simulation. The following data have been acquired:

- 360 feet of cores and a complete suite of logs for geological, geochemical, formation evaluation, reservoir engineering, and rock mechanic studies;
- 45 water samples to study methanogenic bacterial population;
- 30 core samples and 30 gas samples for geochemical analysis;
- Production data from more than 250 wells;
- Several cores from public repositories;
- One geologic field trip;
- One microseismic fracture imaging survey (another was scheduled for April 2010); and
- One reverse vertical seismic profile.

Figure 3 provides a schematic of the reverse vertical seismic profile technique and the velocity variation deduced from the profile.

Geologic Studies

The focus of the geologic studies has been on characterizing natural fractures. Specific attention has been paid to determining the response of sealed natural fractures to hydraulic fracturing.

Over the course of a year, published fracture characterization data were studied and augmented with fracture description in cores and outcrops for 12 cores from southern Indiana, 360 feet of core from the project's cooperative wells in western Kentucky, and four outcrop locations.

Among the major findings from these studies, it was learned that natural fractures are common in the New Albany Shale, but they vary in character and in their effect on gas production.

In many cores, there is more than one opening-mode fracture set. Based on aspect ratio, mineral fill, orientation, and whether the fracture has been shortened during sediment compaction, the fracture sets have different origins.

The majority of fractures observed in cores from the Clegg Creek Member (the usual gas target) are similar to the demonstrably weak planes present in the Barnett Shale in the Fort Worth Basin, where calcite mineral fill is only weakly attached to the fracture walls. These fractures are undeformed, straight-sided, have high height-to-width aspect ratios, and commonly are arranged in "en echelon" arrays.

Fractures in the lowest part of the Blocher Member are partly open, and have low height-to-width aspect ratios and irregular fracture walls. They are sealed with dolomite, and have residual bitumen and large open vugs. The most common sealing cement is calcite, but some samples are sealed by both calcite and quartz. It is believed that quartz cements result in stronger fracture planes because of bonding between wall rock and cement.

Samples from cores from Sullivan County, In., were studied to determine subcritical index, fracture toughness, and Young's modulus. The highest subcritical indexes were measured in the samples from the two horizons where the apparent fracture intensity was lower. A higher subcritical index generally indicates a more clustered fracture pattern.

In a highly clustered pattern, the chances of sampling fractures decrease. Therefore, it is possible that the lower horizon in the Solsman well and the core from the Osburn Trust well are fractured, but the clustering indicated the fractures were not sampled.

The structural grain of the two areas–southern Indiana and western Kentucky–is fundamentally different. Southern Indiana is dominated by the Wabash Valley normal fault system, which is active and trends north-south. Western Kentucky is dominated by the east-west trending Rough Creek Graben. The major and minor faults, and opening-mode fractures, reflect this difference in part, while preliminary core data suggest that some opening-mode fractures in western Kentucky may not be parallel with the larger faults.

In situ stress must be determined on a site-specific basis. The World Stress Map database suggests a swing in the maximum horizontal stress direction from east-northeast in southern Indiana to east-west in western Kentucky. The large difference in underlying local structure may have a significant perturbation effect on the far-field stress orientation.

Geochemical Studies

Planned geochemical analysis is aimed at characterizing the biogenic and thermogenic nature of New Albany gas, as well as reserve repletion through continuous bacterial generation of methane.

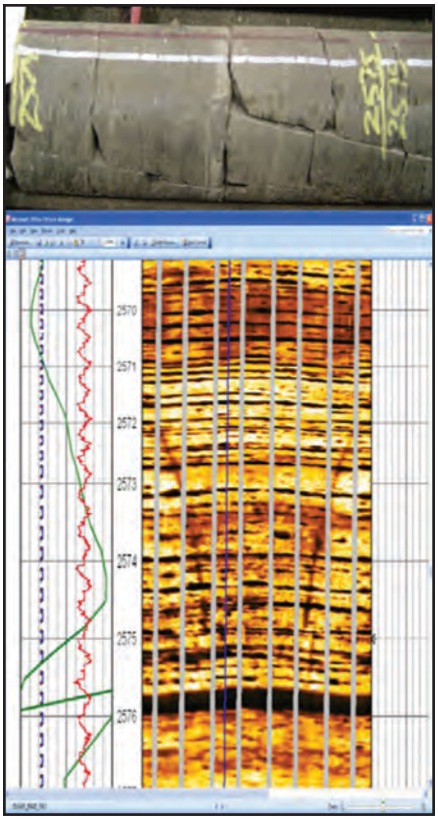
To date, 30 core samples, 45 water samples and 30 gas samples have been collected and partially analyzed. The data have been augmented with data from GRI's Antrim Shale studies.

The New Albany study has revealed that T-RFLP profiles–essentially DNA "fingerprints"–of the archea in samples collected from the New Albany Shale and Illinois basin coalbeds demonstrate that the methanogenic communities in these sources are strikingly similar.

The isotopic composition of water and gas produced by the Antrim-well samples has shifted significantly over the past 15 years. With respect to hydrogen isotopes, the water is 10 percent lighter on average and the methane is 8.5 percent lighter. These findings provide compelling evidence that methane generation has occurred over the past 15 years at a significant rate. The same process may be taking place in the New Albany Shale.

FIGURE 4

Bore-Hole Image Log and Core From NGAS Well 2485 Pilot Hole



Biodegradation indexes determined for 13 New Albany Shale core samples demonstrate that degradation is variable over short vertical distances, and suggest the aromatic hydrocarbon fraction is degraded first. This is similar to observations in coal, but dissimilar to what has been observed during oil degradation.

Hydrocarbons extracted from New Albany Shale core materials show evidence of increasing biodegradation (e.g., depletion of alkanes) toward the Illinois Basin margin.

Formation Evaluation

Log analysis work includes developing advanced methodology–through correlation with core data–for calculating shale porosity, water and bitumen saturations, free gas saturation, and adsorbed gas. A review of all available core and log data provided by operating partners has been completed, along with a review of previous GTI studies, including the 1999 Producibility Consortium and the GIS Compilation of Gas Potential of the New Albany Shale in the Illinois Basin.

This work has identified a discrepancy between total gas from canister measurements, and the compilation of isotherm-adsorbed gas and core-measured free gas. The source of the discrepancy is known to be the presence of heavy components in the gas.

Using rotary sidewall and whole-core data from two wells, major differences in core-measured matrix permeability have been noted. It is unclear whether the differences are related to core handling and protocols, or reflect actual reservoir character.

High oil saturations and subnormal pressure are noted in most of the wells for which data are available.

A basic log analysis model for determining porosity, saturation, shale lithology, total organic carbon, and gas-in-place has been developed using available core and log data.

Initial work has been completed using limited sonic data to compute Young's modulus and Poisson's ratio, and to calculate isotropic uncalibrated stress profiles.

Figure 4 is a bore-hole image log and a core from NGAS Resources' well 2485 pilot hole.

Reservoir Engineering

Because regularly spaced production data from the New Albany Shale are scarce, the New Albany project has adopted a two-pronged approach for reservoir engineering studies:

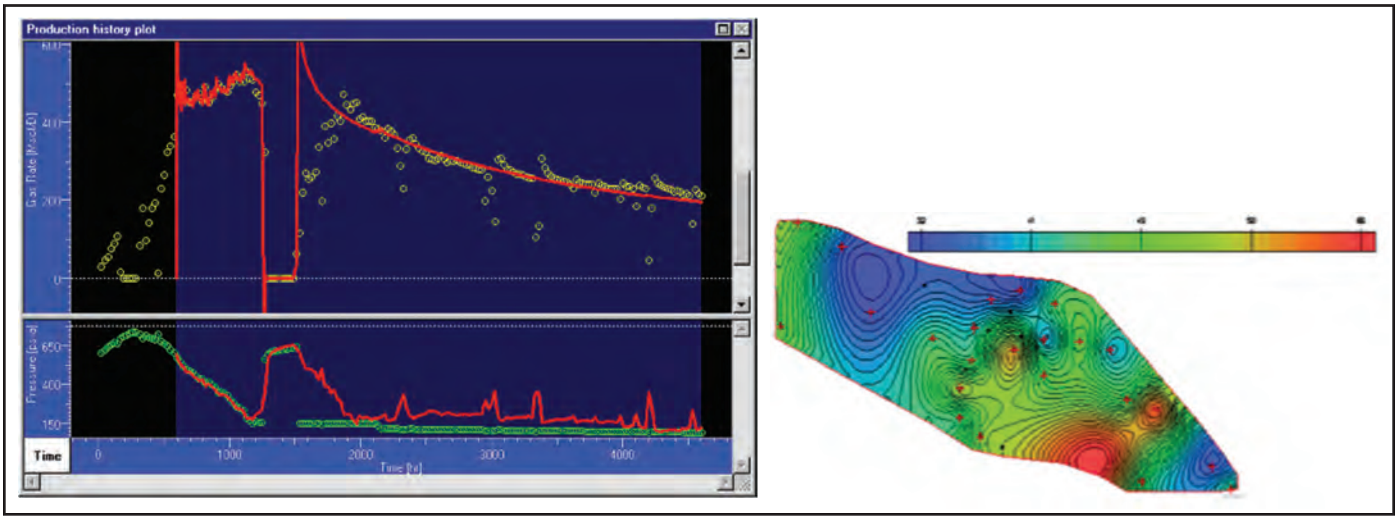
- Advanced production analysis and modeling by Texas A&M University; and
- A top-down approach utilizing artificial intelligence techniques by West Virginia University.

Analytic studies and reservoir simulations on data from two Kentucky wells are continuing, but to date, both power-law exponential depletion projections and rate-normalized pressure analyses have resulted in plausible results. In the meantime, daily pressure data provided by one of the industry partners are being used by the research team to verify the methodologies.

The top-down reservoir engineering approach begins with analyzing the production data using traditional reservoir engineering techniques–decline curve analysis, type curve matching, single-well history matching, volumetric reserve

FIGURE 5

Analytical Production Decline Analysis (left) And Panel from Top-Down Intelligent Reservoir Modeling



estimation, and recovery factor–across a field and then transferring the results to the "top-down intelligent reservoir modeling" application.

Figure 5 provides an analytical production decline analysis on the left and a panel from the top-down intelligent reservoir model on the right.

Artificial intelligence and data mining techniques subsequently are applied to fuse all information into a cohesive reservoir model, which is calibrated (history matched) using the production history of the most recent set of wells drilled in the field. The calibrated reservoir model then is used to identify the most effective field development strategies, including identifying promising locations for infill wells, remaining reserves, and characterizing underperforming wells. The capabilities of this new technique–its ease of use and much shorter development and analysis time, compared with traditional simulation and modeling–were demonstrated in the study.

At the same time, the research team at WVU has been using a publicly available numerical model specifically developed by DOE's National Energy Technology Laboratories to simulate gas production from naturally fractured reservoirs (NFRAC and NFFLOW), and to analyze the variables and their effects on productivity.

Fracture Modeling And Diagnostics

The principal focus of fracture modeling is predicting the propagation of hydraulic fractures in the presence of sealed and open natural fractures. Geologic work by the Texas Bureau of Economic Geology and a fracture modeling task at Texas A&M will be augmented to develop a fracture model that satisfies the conditions in the New Albany Shale and other similar formations.

Texas A&M has successfully simulated a hydraulic fracture propagation and its interaction with natural fractures. The numerical simulations show that the method effectively captures the salient features of this complex problem.

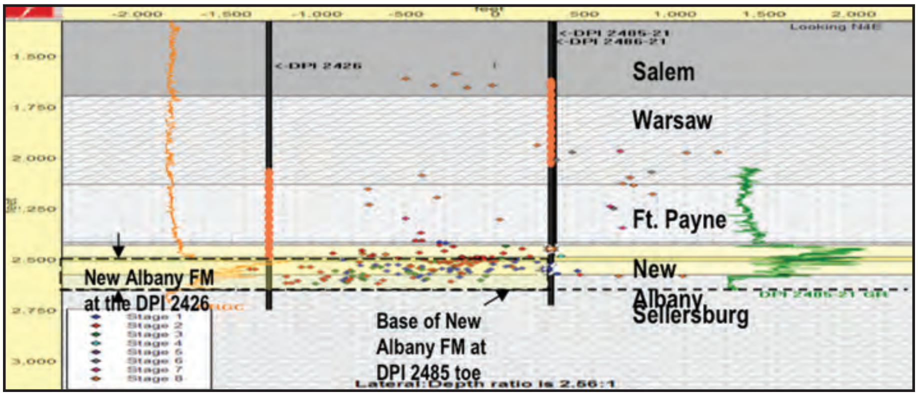
With these developments, it now is possible to simulate hydraulic fracture and natural fracture interactions within the poroelasticity framework.

Fracture modeling by Pinnacle Technologies addresses the design of hydraulic fractures in our industry cooperative wells. The project's first cooperative well was fractured in September 2009, and a second fracture treatment was scheduled for April 2010.

The scope of fracture diagnostic work

FIGURE 6

Microseismic Events Detected While Fracturing NGAS Well 2485



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includes microseismic imaging of hydraulic fractures and tiltmeter surveys, if technically appropriate and logistically possible. The first survey was carried out on a pair of wells (NGAS 2485 and 2486) in Christian County, Ky., and the second well pair using the zipper frac technique was scheduled for April-May. Figure 6 shows microseismic events detected while fracturing NGAS well 2485.

The New Albany Shale Gas Project is expected to be completed by the third quarter of this year. A comprehensive final report describing all major findings will be available through RPSEA and GTI. ❐

Editor's Note: The author extends special thanks to the New Albany Shale producers group for providing data and support, and especially thanks NGAS Resources and CNX Gas Corp. for providing the opportunity to acquire field data.