

INTEREST REMAINS HIGH IN THE APPALACHIAN BASIN'S
HOTTEST NEW PLAY:
THE ORDOVICIAN TRENTON-BLACK RIVER FORMATION

Based on the continued interest in the Trenton-Black River play in the Appalachian Basin, PTTC conducted a second workshop in August. The number of permits for drilling this target continues to increase, and operators and producers are eager for more information on exploration strategies and deep production techniques. There appears to be great potential for these rocks to form profitable reservoirs.

In addition to the one-day symposium, the August workshop was expanded to include a half-day core workshop and an evening icebreaker. Approximately 50 people attended the core workshop. The following day, over 150 interested individuals from 18 states and Canada attended the one-day PTTC symposium titled "Appalachian Update: Trenton-Black River Exploration and Production -- Round 2".

The core workshop was presented by Ian Colquhoun, Rubicon Petroleum, with the help of Steve Fletcher and Mr. Ostrawski of the Ontario Petroleum Institute. Over 100 feet of core from six wells in the Trenton-Black River in Ontario (Michigan Basin) provided a good look at the various lithofacies of the formations. The cores were chosen to display productive, as well as non-productive zones. Stratigraphic units included the Cobourg, Sherman Fall and Kirkfield formations of the Trenton Group and the Coboconk and Gull River formations of the Black River Group. All of the cores were from oil pools: Hillman, Malden, North Wheatley East, Dover, Colchester South, and Dover 7-5 VE pool. The oil fields are typically narrow and structurally controlled with a regional fracture system that provided conduits for dolomitizing fluids and hydrocarbon migration. The dolomites contain fracture-related matrix and solution porosity. On seismic sections these narrow, dolomitized reservoirs are recognized as a sag or low feature.

The day-long symposium was designed to provide participants with a solid understanding of the geologic parameters that affect exploration and production, an update on current leasing and drilling activities, and a review of what is known about the current production from these highly prospective, carbonate reservoirs. The Department of Geology and Geography at West Virginia University developed the workshop, in cooperation with the PTTC - Appalachian Region Resource Center and the Appalachian Oil and Natural Gas Research Consortium. It was held at the National Research Center for Coal and Energy, WVU, in Morgantown, WV.

Similar to the symposium in May 2001, the program began with a summary of the depositional setting of Middle and Late Ordovician limestones and an overview of deep structures of the central Appalachians. This was to accommodate the many attendees from outside the Appalachian Basin, and those within the Basin who may have been unfamiliar with the Ordovician section. *Dr Richard Smosna (Department of Geology and Geography, WVU)* opened the program with a review of the paleogeography and

depositional history of Ordovician limestones. During Cambro-Ordovician time, the passive eastern margin of North America was the site of carbonate sedimentation over a large region known as the Great American Bank. The environment changed with the onset of tectonic activity produced by the collision of the eastern margin of North America with an island arc system (the Taconic Orogeny). The stable continental shelf developed an eastward-sloping ramp that steepened into the subsiding foreland trough. Limestone deposition changed from the shallow-water carbonates of the Black River to the Trenton limestones. The Trenton records shallow-ramp conditions in the west and progressively deeper, anaerobic conditions eastward with periodic influxes of shale. The Black River and Trenton carbonates form a wedge that thickens significantly eastward. The Trenton, in particular, increases from 90 m in the west to 200 m in the east.

Dr. Robert Shumaker (Department of Geology and Geography, WVU) presented an excellent overview of basement structures in the central Appalachians. Basement deformation was produced during two plate-tectonic Wilson cycles. The Grenville orogeny, during the last part of the first Wilson deformational cycle (0.9-1.0 ga), formed the basement under all but the extreme western edge of the Appalachian foreland. The second Wilson cycle was initiated by Iapetan rifting (~0.7 ga). The New York-Alabama lineament, which Shumaker suggested, is a post-Grenville wrench fault, and the younger Rome Trough rift system formed during this second cycle. After rifting ended, Rome trough faults remained active with periodic subsidence and reactivation. Although the western Appalachian basin did not suffer intense basement deformation during subsequent Paleozoic orogenies, small offsets formed by basement movements appear to be responsible for some of the broad, low-relief structures. Reactivation along these faults may have formed the structures in some of the Trenton producing fields. In addition, as observed in several Trenton fields on the margin of the Appalachian basin and in the Michigan basin, strike-slip movement along basement faults has been shown to produce fracture porosity and provide pathways for dolomitizing fluids. Thus, underlying basement structures play an important role in Trenton-Black River exploration and production. However, low-relief detached structures at the margin of the Allegheny allochthon, with associated fracture and dolomite porosity, should not be overlooked, as suggested by production from the Rose Hill field in Virginia and the Swan Run field in Tennessee.

The second part of the workshop provided the audience with practical information on obtaining and understanding seismic data.

Annette Evans (Evans Geophysical) explained one low-cost approach to data acquisition: brokered data and joining a group to acquire new seismic data. She explained the details and benefits of cooperative seismic surveys and how best to utilize brokered data. Benefits include free data searches, maps that include shot points, and section samples. Most important is that data can be obtained for as little as one-fifth the cost.

John Clark (Bay Geophysical) gave the audience an understanding and appreciation of the parameters that can affect the quality of seismic data. In designing a seismic survey, the object is to obtain the highest signal to noise ratio possible, with the widest possible bandwidth, and to select an appropriate frequency that will provide the

desired information. Noise falls into two categories: ambient noise, which includes the wind or traffic, and coherent noise, which is the noise from the shot. An increase in the input energy often creates an increase in noise. Frequency is also an important consideration. Low frequencies provide deeper penetrations, are less affected by ambient noise levels, and are somewhat easier to interpret. However, low frequencies also provide lower resolutions, higher levels of coherent noise, higher vibrations, and have the potential to damage structures. High-frequency surveys have higher resolution but cannot penetrate as deep. Coherent noise is decreased, vibrations are reduced and there is less potential to damage structures. John also explained the importance of secure source-receiver coupling. Poor coupling reduces frequency content, increases ambient noise, and induces false amplitude anomalies. Testing of the system is well worth money to determine if energy levels, frequencies, noise levels, and arrays are adequate. Processing cannot fix the insufficiencies resulting from poor coupling.

Mark Sterling (Sterling Seismic Services, Ltd.) stressed the importance of having accurate topographic information when processing seismic data. Because seismic data are commonly acquired along roads, which are not in a straight line, significant overlap and smear in the subsurface data can occur. Most 2-dimensional algorithms assume straight -line acquisition, therefore when processing or reprocessing seismic data it is important to know the crookedness of the line.

The third section of the program concentrated on current production and drilling activity. *John Hickman (Kentucky Geological Survey)* presented recent deep drilling activity in eastern Kentucky, which is providing new data on the Rome Trough. Although high-volume gas wells in Ordovician rocks have not been discovered in Kentucky, the play may follow the southwest extension of the Rome Trough into this region. Here the equivalent of the Trenton Limestone is the Lexington Limestone, and the Black River Formation equivalent is the High Bridge Group. These rocks outcrop in central Kentucky and produce oil and gas from multiple zones. The reservoirs are fractured and partially dolomitized. Surface exposures of the limestones show isolated dolostone bodies spatially related to mapped faults. These outcrops may provide a glimpse of the process and products of hydrothermal fluids moving along fractures and replacing the limestone with dolomite.

Kathleen Sanford (NYSDEC Division of Mineral Resources) returned with a much awaited update on drilling activity in New York. Drilling applications are up 60 percent, and new operators, such as Talisman, Seneca, Eastern Resources, Vertical Resources, and Fairman Resources, are moving into the state. It is projected that 30 wells in the Trenton/Black River will be on line by the end of 2001. In the year 2000, 38 of the 45 permitted wells in the Trenton-Black River play were spudded. Much of the activity was centered around the southern Finger Lakes area, in Stueban, Schuyler, and Chemung counties, and the wells ranged from 7000 - 10,000 feet deep. The year 2000 statistics for three fields were presented. Glodes Corners Road field, discovered in 1986 has 12 wells; production is 20 BCF. The field produces from a graben structure 7.5 miles in length and 4000 feet wide. Transcurrent faulting is present near the eastern end. Muck Farm field, discovered in 1998, has 4 wells with production of 1.46 BCF of gas. Wilson Hollow, discovered in 1999, has 3 wells and has produced 1.66 BCF of gas. The field,

another graben 1000 to 2000 feet wide, is being extended east of the original 5 wells. Kathleen also covered important information concerning leasing, permitting, reporting, and spacing regulations that drillers and producers should be aware of when operating in New York. Logs and completion data are confidential for 6 to 18 months from the spud date. Production data is collected annually and released July 1 for the previous year. Much of the data for New York can be found on their web site:

www.dec.state.ny.us/website/dmn.

Katharine Avary (WV Geological and Economic Survey) began with the history of Ordovician drilling in West Virginia. She reviewed the location and number of wells drilled in the Trenton-Black River, prior to the 1999 discovery well by Columbia Natural Resources in the Cottontree field. This discovery opened the eyes of industry to the potential of the Trenton-Black River play. Currently there are 2 wells on line in Roane County, WV. Over 180 wells in 15 counties have been permitted to the Trenton and deeper zones through June 2001. At least 16 wells have been drilled in six counties (Jackson, Kanawha, Lincoln, Putnam, Roane, and Wayne). A total of 6 well records have been submitted the WVGES. In 1999-2000 a total of 2.4 BCF has been produced from the Trenton-Black River in WV. Production appears to be associated with basement faults along the southeast margin of the Rome Trough.

The fourth part of the program dealt with exploration and production strategies, and where to find data. The speakers presented pertinent information about dolomitization and structural using many examples from producing fields.

Steve Fletcher (Ontario Petroleum Institute) introduced the audience to the Ontario Petroleum Institute, an industry association that is involved in research and data acquisition. It is a trustee for oil and gas resources and information in Canada. It has a library of cutting from 13,000 wells, core from 1000 wells, and file information for 20,000 wells which includes information on history, construction, geophysical logs, stratigraphy, oil-gas-water intervals, and core analyses. The Ontario Petroleum Data System (OPDS) is an Oracle database with GIS links.

Ian Colquhoun (Rubicon Petroleum, Inc.) presented his research on cores from the fractured dolostone reservoirs in southwestern Ontario. The Trenton - Black River reservoirs in this region exhibit the same narrow, linear character of fields in Michigan and those in the Appalachian Basin. On seismic sections the reservoirs are shown by a sag or structurally low feature; they have been interpreted to be formed by wrench faulting with associated dolomitization. However, the cores show that fractures, solution porosity associated with fractures, dolomitization, and compaction also played a role in forming the reservoirs. The reservoirs are characterized by high matrix porosity in dolomitized grainstones surrounded by fractured and dolomitized limestones. Porosity from core analyses ranges from 0 to 15 percent, permeabilities range from 0.01 millidarcies to 10 darcies.

Parker Gay (Applied Geophysics, Inc) showed the value of aeromagnetic techniques in mapping basement faults. Magnetic mapping using the newly developed NewMag profile technique has indicated the presence of basement faults in areas where previous magnetic studies were used without success. Deep basement faulting has been identified in Trenton-Black River producing areas such as the Albion-Scipio, Stony Point, Hanover, Deerfield, and Northville fields in Michigan, and the Parker and

Epling wells in Roane County, West Virginia, and the prolific Gray well in Steuben County, New York.

John Adams (Columbia Gas Transmission – NiSource) spoke about the economics involved in drilling deep wells. He showed the audience how exploration and development decisions are made based on a number of economic factors that assess the risk vs the expected value of the endeavor. In one scenario, a prospective budget would include the following amounts designated to each activity:

Drilling – 71%, Pipeline – 22%, Lease – 4%, Seismic – 3%.

Robert Shumaker (Department of Geology and Geography, WVU), returned to finish the symposium with an analysis of the structural setting of producing Trenton-Black River wells and other deep-well locations in West Virginia. Numerous structures, including major interior faults, detachment zones, anticlines, lineaments, basement structures, and shallow structures may have played in role in producing and trapping gas in Ordovician rocks. Well locations were divided into 5 groups. Groups 1 – 4 are within the Rome Trough. Group 1 – the southern group in Lincoln County, appears to be unrelated to a specific known structure. The area is located at the eastern end and down-plunge of a complex zone of basement faults. These faults connect the northeast face of the simple Southern West Virginia graben to a southwest facing, half-graben in Kentucky. Trenton wells follow a near surface, east flank of a low-relief structural high. Group 2 – the western group in Jackson County are positioned near the north end of the Evans flexure. Group 3 – the northwestern group lies within the Salina-salt detachment area above the west margin of the Northern West Virginia graben. The Burning Spring anticline is the dominant surface structure of the area. The anticline developed associated with a primary detachment and ramping. Group 4 – the central group, are located at the margin of Salina-detached deformation. Here are found a series of low-relief (200-300 feet) folds of varied orientations. The 2 wells of the Cottontree Field are the southern end of this group. Group 5 – the eastern group, is unique because it lies outside the Rome Trough area. The wells are along trend but down-plunge from the Webster Anticline. A detached fault occurs near the well locations of this group.

FOCUSED TECHNOLOGY WORKSHOP REPORT

APPALACHIAN UPDATE: TRENTON-BLACK RIVER EXPLORATION AND PRODUCTION

AUGUST 7, 2001

Assessment of the Core Workshop and Symposium

Because of the high level of interest and excitement in this relatively new and potentially profitable gas play, the workshop was well attended by over 150 individuals from 18 states and Canada. Most of the registrants were from industry: exploration, production, and service companies. State and federal government agencies were well represented too. Based on the needs expressed in the evaluations from the May 2001 workshop, we expanded this workshop to include a half-day core workshop, an icebreaker, in addition to the full-day symposium.

The core workshop provided a 'hands-on' look at the reservoir. This was very well received by the 50 attendees. The core workshop, with its informal atmosphere, and the subsequent ice-breaker, provided the attendees with the enough time to talk and network with each other, a suggestion that was repeated many times during and after the May 2001 workshop.

The full-day symposium was divided into four parts. The morning session began with a summary of the depositional setting that produced the Middle to Late Ordovician limestones. The second talk presented an overview of deep structures of the central Appalachians, with emphasis on the Rome trough. The eastern margin of the Rome trough is the site of much of the activity in West Virginia. Because the play is relatively new and companies outside of the basin are interested in becoming potential players, the organizers wanted to be sure that all the participants had a thorough understanding of the background geology.

The second part of the morning session presented practical information on planning a seismic survey, pitfalls in the processing old and new seismic data, and how and where to access relatively low-cost seismic data. This information was the topic most suggested by those attending the May symposium.

Part three presented current production, drilling, and leasing activities in New York, West Virginia, and Kentucky. These presentations provided a summary of reservoir information and locations where Trenton - Black River production has been profitable in the past and the areas where some operators see a potential for future development. Also addressed were the state regulations on leasing and well spacing that are particularly important considerations when working in New York.

Part four concentrated on specific characteristics of the Trenton - Black River reservoirs, how these characteristics develop, what geologic features control their development, and what kind of information producers can use to help in their search. This session was very useful because it combined the many components of reservoir development: dolomite geochemistry, dolomite replacement, basement structures, wrench faulting, core and petrographic analyses, and aeromagnetism.

Overall, the audience was pleased with the program and felt the speakers provided pertinent and up-to-date information. Eighty-seven percent of those who filled out evaluations rated the program good to excellent. The written comments were very insightful. A number of participants submitted suggestions which are summarized below. Some of the suggestions are not within the scope of PTTC.

Suggestions for workshops:

Gas storage in depleted reservoirs

Exploration for Elk sandstone reservoirs

Seismic case studies

Expert interpretation of magnetic/gravity data; mapping with Landsat imagery.

Basic seismic acquisition and interpretation

Utilization of CO₂ to increase oil and gas recovery

Knox wells – paraffin problems and resolutions

Geochemical analyses

Basement-related faulting and structures

Private sector exploration company papers

Production in fractured carbonates

Reservoirs, storage, permeability directions

Regional – big picture talks, history of oil and gas business in Appalachian basin

Remote sensing – Oriskany workshop

Detailed discussion of Appalachian orogenies

Comments:

Start at 8:00 am; do not go past 4:00 pm

Room too cold

Presentations of excellent quality, well organized, well managed

More frequent and shorter breaks

More updates, update for Pennsylvania

Great lunch

Improve sound system

More operations -oriented, like John Adam's talk

Attendee List

A list of paid registrants is attached, along with a list of speakers.

Event Feedback Forms

Seventy-one paid registrants submitted an evaluation form. A copy of each is attached.