Discovery of the Utica Shale: Update on an Evolving Giant*

William A. Zagorski¹ and Taylor G. McClain¹

Search and Discovery Article #10965 (2017)**
Posted June 26, 2017

*Adapted from oral presentation given at 2017 AAPG Annual Convention & Exhibition, Houston, Texas, April 2-5, 2017
**Datapages © 2017 Serial rights given by author. For all other rights contact author directly.

¹Range Resources Corporation (bzagorski@rangeresources.com)

Abstract

The Utica-Point Pleasant play has grown rapidly since horizontal discovery and commercialization in PA (2010) and Ohio (2011) with current production of approximately 5 BCFE/d and an active rig count of 25 as of early 2017. The U.S. portion of the play covers a large extent within the Appalachian Basin, including parts of Pennsylvania, Ohio and West Virginia. While modern horizontal drilling is focused on the organic-rich Point Pleasant Member in Eastern Ohio and Southwestern Pennsylvania, a long history of testing and development can be traced back to several key attempts to commercialize the play in both the US and Canadian portions of the Appalachian Basin beginning in 1858 in Ontario and in 1888 in northern New York. Early industry focus of the modern horizontal play was in the wet-gas and oil windows, as some touted the liquids content and possible similarity of the Utica-Point Pleasant to the evolving Eagle Ford oil play of Texas. However, current activity trends are focusing deeper and deeper into the highly over-pressured dry gas portions of the play. Key productivity drivers for the play include pore pressure gradient, depth, thermal maturity, TOC content, porosity & permeability, frac containment, gas in place, facies changes in key reservoir targets, and the regional influence of basement faulting. Although significant evolution and understanding of the play has been achieved since modern commercialization, many concepts and drivers have yet to be completely understood. Play extents are not yet fully realized and future growth potential remains quite significant.
Discovery of the Utica Shale: Update on an Evolving Giant

AAPG Discovery Thinking Session – April 5, 2017
William A. Zagorski & Taylor G. McClain
Range Resources Corporation
Current production from Utica-Point Pleasant Play is 5 BCFE/day.


Current focus is on deeper dry gas portion of the play.

Modern horizontal play commercialized in 2010.

However interest in the play started much earlier......
In 1859 – Craigleith Shale Oil Works - Reported oil production from member of Collingwood Shale. North American oil discoveries in 1858 and 1859 made the operation uneconomic by 1863.
1888 Sandy Creek Field.
- Wells were shallow 600’ to 2,800’ in the Trenton FM.
- Flow rates and pressures initially high but were low volume producers.
- Early recognition as a shale gas play by several geologists.
- Activity waned after 1940.
- Renewed interest in late 1990’s.

Previous Work

“That the gas is confined to the shale partings and shale layers can be observed at any well during the drilling of the Trenton. The drill first strikes a hard, dense limestone layer which is usually only a few inches thick but is hard to penetrate. As the drill breaks through this layer the gas rushes forth, sometimes under enormous pressure which may even blow the tools out of the hole. When drilling is again resumed it is invariably found that the layer under the hard dense limestone is a calcareous shale... No increase in volume is realized until another hard dense limestone is reached. Unquestionably the limestone acts as a cap rock.”

Early geologic review of play.
Example Well Records – Note Gas Shows and Pressures!

“When shut in, pressure lifted 633 feet of casing and drive pipe out of hole and scattered it about the land. One 80-foot length was thrown 600 feet from the well.”

-Scout card from well in Pulaski Field
After 1999 exploration efforts in the Trenton Black River play led to renewed interest in this play.

Play was recognized as a source rock/unconventional type play and was successfully tested in 2003.

Play concept was to target fractured zones defined by 2D/3D seismic and drill and complete natural.

Testing of the play stopped after 2007 as regulations in NY discouraged horizontal drilling and large scale hydraulic fracturing.

Note relationship of shows to increased shale content.

Source: Zagorski 2007
Source: Nyahay, Bray, Schultz, Smith
Discovery was Cottontree Field in Roane County, WV.

Original drilling targeted highly fractured areas in search of dolomitized Trenton Black River carbonates using mainly 2D seismic coverage.

Reservoir is highly overpressured. Pervasive gas shows in section even in dry holes.

Several other tests drilled in WV but all looking for fractures not source rock plays.

Similar to Utica Point Pleasant play but thicker and less organic rich.

Play not considered source rock play initially.
Key 2003 test showing significant gas shows in Utica Point Pleasant

Key deep test in 2006 confirming reservoir quality and significant GIP

- Drilled 7/2006
- Washington Co TBR test
- Sidewall Cored
- Gas Shows throughout interval
- Organic content confirmed

Note focus on fractured graben areas
Note report from famous AAPG explorer John T. Galey!
The volumes reported in the article did not make it to the official well records.

My source – Surprise email in 2008 from D. Beardsley.....
Another famous AAPG explorer......remember the Trenton Black River play.....Cottontree? NY Steuben County discoveries?
RRC Zahn represented first successful horizontal completion of the Utica Point Pleasant in the USA.

Well tested 4.4 Mmcf/d 7 day rate from a 10 stage completion.

<table>
<thead>
<tr>
<th>GR</th>
<th>Density</th>
<th>Resistivity</th>
<th>Porosity</th>
<th>TOC</th>
<th>Perm</th>
<th>GIP</th>
<th>Sw</th>
</tr>
</thead>
</table>

Lateral Target
Unlike the Barnett and Marcellus plays, early vertical tests between 2004-2009 were unsuccessful.
• Completed PSU undergrad thesis study of Utica using publications and outcrops in New York State and Central PA to tie into subsurface.

• Initially compared to Marcellus, focus on areas of thick high-GR black shale.

Study area and well dataset

GR log tied to outcrop section
• Focus on density log, look for low bulk density signature.

• Ties to highest TOC and gas shows.
- Detailed correlation of sequence stratigraphy on smaller scale.
- Investigated the distribution of the organic-rich facies and tied to production test rates.
- Identified key reservoir facies and sequences (M5, M6, C1).
Comparing Production Trends to Sequence Stratigraphy

- Observed poor tie between GR and production rates.
- Observed strong tie with density/TOC! Content.
- Noted the strong influence of basement faulting on the play.
Thermal maturity is a key parameter to productivity in shale plays.

Early thinking of the Utica Play touted liquids content and possible analog to the evolving Eagle Ford oil play of TX.

Initial challenge was to accurately predict and project the liquids rich play fairway.

Early CAI/Ro work predicts NE-SW trending liquids window in Eastern OH and extending into Northwest PA.
Tests in Eastern OH demonstrated 40% higher IP rates than in initial industry focus areas.

A strong correlation between highest IP rates and areas of highest average Point Pleasant TOC is observed.

By 2014 industry activity was testing deeper dry gas window advancing the productive areas of the play to south and east.

Reservoir mapping projected the play to extend into SW PA.
Correlated production volumes to pressure gradient trends.

Noted trend of increasing pressure gradient with increasing depth.

Correlated seismic attributes to observed pressure trends.

Best wells are associated with gradients of greater than 0.8 psi/ft.

IP rates reported as of early 2014

Note clear association of increasing productivity with increased pressure gradient.
Comparing Reservoir Thickness to Reservoir Quality

- Wells to north contain thicker section of lower reservoir quality rock.
- High rate wells to south show condensed section of higher quality reservoir rock.

IP rates reported as of early 2014.
Regional cross sections showing facies change from organic rich Utica shale to non organic seal and IP’s.
Frac containment is a key driver when comparing IP/1000’ rates and EUR estimates. Areas with the best Point Pleasant to Utica rock property contrasts and the highest pressure gradients are optimal. Optimizing proppant placement across the highest pressure, highest porosity intervals is critical.
• By 2014, industry testing had extended the dry gas play into the WV Panhandle and PA.

• Established the relationship between overpressure/TVD, frac containment to facies change, and the projection of key reservoir quality indicators into SWPA.

• Exceptional flow rates were being reported from key wells in eastern Ohio.

• Range Resources first successful horizontal test of SWPA dry gas Utica Point Pleasant play was drilled and completed in late 2014.

Note increase of IP/1000 rates as play grows eastward.
- Targeted and drilled structurally quiet area defined by 3D seismic coverage.

- Log and core data show excellent reservoir characteristics in the Point Pleasant target.

Claysville Sportsman’s Club Point Pleasant section
**Key Point Pleasant Reservoir Quality Indicators**

FIB SEM examples from lateral target interval.

Note TOC content and well developed pore network.

<table>
<thead>
<tr>
<th></th>
<th>GR</th>
<th>Density</th>
<th>Resistivity</th>
<th>Porosity</th>
<th>Perm</th>
<th>GIP</th>
<th>Water Saturation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point Pleasant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free Gas</td>
<td>2.64</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>863.811</td>
<td>140.9</td>
</tr>
<tr>
<td>Sorbed Gas</td>
<td>2.64</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>948.299</td>
<td>154.7</td>
</tr>
<tr>
<td>Total Gas in Place</td>
<td>2.64</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>948.299</td>
<td>154.7</td>
</tr>
</tbody>
</table>

**GAS IN PLACE ANALYSIS: Claysville Sportsman 11H**

<table>
<thead>
<tr>
<th>Bulk Density (g/cc)</th>
<th>Gas Content (scf/ton)</th>
<th>GIP (scf/acre-ft)</th>
<th>GIP (BCF/section)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utica to Trenton</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free Gas</td>
<td>2.73</td>
<td>148.2</td>
<td>549,663</td>
</tr>
<tr>
<td>Sorbed Gas</td>
<td>9.9</td>
<td>36,534</td>
<td>36,534</td>
</tr>
<tr>
<td>Total Gas in Place</td>
<td>158.1</td>
<td>586,197</td>
<td>586,197</td>
</tr>
</tbody>
</table>

**GAS IN PLACE ANALYSIS: Claysville Sportsman 11H**

<table>
<thead>
<tr>
<th>Bulk Density (g/cc)</th>
<th>Gas Content (scf/ton)</th>
<th>GIP (scf/acre-ft)</th>
<th>GIP (BCF/section)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utica</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free Gas</td>
<td>2.56</td>
<td>338.5</td>
<td>1,177,676</td>
</tr>
<tr>
<td>Sorbed Gas</td>
<td>38.1</td>
<td>132,404</td>
<td>132,404</td>
</tr>
<tr>
<td>Total Gas in Place</td>
<td>376.5</td>
<td>1,310,080</td>
<td>1,310,080</td>
</tr>
</tbody>
</table>
Selection of Point Pleasant Lateral Target

- Re-interpreted offsetting well MWD data to evaluate landing target.
- Compared lateral target to production data and EUR/1000 metrics.
- Observed correlation between highest production and targeting highest porosity zone.
Drilled pilot hole and horizontal in Q3 2014.

Maintained strong gas shows throughout lateral.

No significant well control issues.

Key horizontal well establishing commerciality of the Point Pleasant dry gas play in SWPA.
Since 2013 there has been significant expansion of play into Pennsylvania, Northeast Pennsylvania, and West Virginia.
What Is The Role of Natural Fracturing?

- Fractures rare in core and vertical FMI but observed in seismic, drilling, and production.

- Level of fracturing significantly less than that observed in Marcellus.

Significant gas shows and drilling breaks while drilling through fractured interval identified on seismic.

Note karst signature! Top of Trenton curvature from 3D seismic. Karst signatures were initially deep target in 2000!

Note lack of vertical fracturing in core

Strong gas kicks, drilling breaks, fluid loss

Note gas increase across subtle 3D feature

2000 unit gas increase
Future Considerations, Concepts, Ideas

- What is the influence of fracturing and faulting?
- Have the core areas been fully established and defined?
- What other play concepts need to be tested?
- What about the Utica Interval?
- Can the oil window be commercialized?
- What is the eastern thermal maturity limit of play?
- Are there any technological limitations?
- Should we be looking at old areas with new approaches?
- Lots of exploration challenges and opportunities to cover in the future.

- Thank you!!!