

# A Geologic Play Book for Utica Shale Appalachian Basin Exploration

## Abstract

### Utica Play Resource Assessment

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A Utica Play resource assessment was conducted to estimate: (1) remaining recoverable hydrocarbon resources and (2) original hydrocarbon resources in-place. Remaining technically recoverable resources were determined using a probabilistic approach following an outline developed by the USGS. Original hydrocarbon in-place resources were determined using a volumetric approach.

#### **Remaining Recoverable Hydrocarbon Resources, Probabilistic (USGS-Style) Approach**

Assessment units were defined on the basis of structural geology, maturation and distribution of producing wells. Conodont alteration index (CAI) values were converted to equivalent vitrinite reflectance (%Ro), and results were combined with published values to draw a new map of thermal maturity trends in the Study area. Vitrinite reflectance equivalents were also converted to a new set of indicator variables according to whether raw Ro equivalents exceeded published thresholds for immature, oil-prone, gas-prone and overmature hydrocarbon generation windows. Each indicator variable, when contoured, gave a measure of the likelihood of exceeding each threshold. Maps of producing gas wells, liquids-rich gas wells, and oil wells superimposed on the contoured indicator variables gave specific contours from which to outline the oil, wet gas and dry gas sweet spots. Assessment unit boundaries and sweet spot outlines were compared with structure contour maps for refinement in areas of sparse or no wells.

Annual cumulative production data collected from public records in each state were graphed and fitted with a harmonic model of decline. A maximum of four years of data were available. Models were fit to median values of annual production and estimated ultimate recoveries (EURs) after forty years calculated. The fifth percentile of annual production for 2014 was used to calculate the minimum recovery within sweet spots. Maximum EUR was calculated from a model fitted visually to scatter plots of individual well production values.

This Study followed the probabilistic approach developed by the USGS and used in their 2012 assessment of undiscovered oil and gas resources of the Utica Shale. Under this approach, the geologist defines the geographic limits of an assessment unit, which is an area with expected oil or gas resources with generally the same or similar thermal maturity, organic content, lithology, source rock and trapping mechanism. The largest source of production data was a public database from the state of Ohio, which for the years available has natural gas liquids (NGLs) and gas reported as a single number. Therefore, calculation of the gas resource in the wet gas assessment unit includes a significant percentage of natural gas liquids.

The following tables present results for the three assessment units.

Oil Assessment Unit	Remaining Technically Recoverable Resources							
	Oil (MMbo)				Gas (Bcf)			
	F95	F50	F5	Mean	F95	F50	F5	Mean
Sweet Spot	733	1,677	3,744	1,908	2,231	6,636	17,722	7,949
NonSweet Spot	23	49	91	52	69	191	446	216
<b>Total</b>	<b>791</b>	<b>1,728</b>	<b>3,788</b>	<b>1,960</b>	<b>2,370</b>	<b>6,858</b>	<b>17,960</b>	<b>8,165</b>

Wet Gas Assessment Unit	Remaining Technically Recoverable Resources							
	Oil (MMbo)				Gas (Bcf)			
	F95	F50	F5	Mean	F95	F50	F5	Mean
Sweet Spot					23,840	49,601	106,550	55,980
NonSweet Spot					99	379	1,023	447
<b>Total</b>					<b>24,484</b>	<b>50,037</b>	<b>106,852</b>	<b>56,427</b>

Gas Assessment Unit	Remaining Technically Recoverable Resources							
	Oil (MMbo)				Gas (Bcf)			
	F95	F50	F5	Mean	F95	F50	F5	Mean
Sweet Spot					220,473	590,680	1,542,873	710,341
NonSweet Spot					2,862	6,584	13,835	7,238
<b>Total</b>					<b>228,478</b>	<b>598,026</b>	<b>1,549,586</b>	<b>717,579</b>

### Original In-Place Hydrocarbon Resources, Volumetric Approach

The second resource assessment method used a volumetric approach to determine original hydrocarbon-in-place. The volumetric approach provides a means to assess resource potential from fundamental data in a manner that is independent of development practice, well performance, economics and the limited geographic extent of exploratory activity that often characterize the early development of a hydrocarbon play. Basic geologic and reservoir data are used to define characteristics of a stratigraphic unit and calculate hydrocarbon volumes.

The Utica Shale, Point Pleasant Formation and Logana Member of the Trenton Limestone were each evaluated separately applying the volumetric assessment method. The overall evaluation area was separated into two regions - one to address original in-place oil resources in the western portion of the Utica Shale Play and another to address original in-place gas resources to the north and east. For each region, a single phase of either oil or gas was presumed to exist in the reservoir.

The calculation for total original hydrocarbon-in-place includes separate determination of free and adsorbed hydrocarbon volumes and was applied to individual wells for every half-foot of thickness. To derive all required parameters, a substantial amount of data was necessary. Digital petrophysical data, primarily

supplied by Utica Consortium partners, provided the foundation. Wells with gamma-ray, density/porosity, and resistivity well log data (at minimum) were selected preferentially for the Study. Additional well selection factors considered included well orientation, structural complexity, stratigraphic unit depth, geographic location and proximity to other wells. Depending on the particular stratigraphic unit, up to approximately 60 wells were selected for analysis. To augment digital log data, reservoir-specific input included or encompassed: thermal maturity, total organic carbon (TOC), gas content, pressure and temperature. Thermal maturity was determined from a map developed using equivalent %Ro values for the probabilistic resource assessment approach, while TOC was available for individual wells or extracted from stratigraphic-specific TOC maps constructed for the volumetric assessment task. Gas content, pressure and temperature were taken largely from publicly-available data, although some data were available for individual wells. After well-level calculations, summary data were gridded to interpolate between and extrapolate beyond wells. Petra®, ArcGIS and internally-developed software were used to manage, manipulate and analyze data.

The following table shows *preliminary* summary results for each stratigraphic unit evaluated using the volumetric approach.

Stratigraphic Unit	Original In-Place Resources, Average Volume Per Unit Area	
	Oil (MMbo/mi <sup>2</sup> )*	Gas (Bcf/mi <sup>2</sup> )*
Utica Shale	20.8	53.5
Point Pleasant Formation	15.8	85.1
Logana Member of Trenton Limestone	3.0	17.0

\*~ average volume per square mile in the sweet spot area; sweet spot area is as defined to estimate remaining technically recoverable resources using a probabilistic (USGS-style) approach

Based on these studies, it is estimated that the current oil recovery factor is approximately 3% and the gas recovery factor is approximately 28% in the sweet spot areas.

## Citation

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