STATEWIDE ASSESSMENT OF GAS AND SEQUESTRATION POTENTIAL IN THE MARCELLUS SHALE, NY

Final Report

Prepared for

THE NEW YORK STATE
ENERGY RESEARCH AND DEVELOPMENT AUTHORITY
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NOTICE

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EXECUTIVE SUMMARY

The combination of horizontal drilling and high volume multi-stage hydraulic fracturing has helped to unlock vast natural gas resources in organic–rich shales. The shale with the best potential to produce in New York is the Middle Devonian Marcellus Shale although there is also significant potential in the Ordovician Utica Shale. Wells currently being drilled just south of the border in the Marcellus of Pennsylvania are highly productive and there is good reason to believe that once permits are issued, many productive wells will be drilled into the Marcellus in New York State. The purpose of this study was to map out a fairway for potential natural gas production in the Marcellus Shale in New York. To accomplish that goal, cuttings from 96 wells and 4 cores were sampled. Analyses including total organic carbon (TOC), calcite content, thermal maturity, rock-eval, and x-ray diffraction were used to make a series of maps and cross sections. This report includes all of the data promised in the proposal for Tasks 3, 4 and 5.

The Marcellus Subgroup is composed of two formations. The basal formation in the Marcellus is called the Union Springs and is composed of the Bakoven Member which is an organic-rich black shale with some carbonate beds and nodules, and the Stony Hollow Member which is a siltstone that only occurs in the far eastern part of the basin where it overlies the Bakoven. The Union Springs Formation is overlain by the Oatka Creek Formation, which comprises the upper part of the Marcellus Subgroup. The basal Member of the Oatka Creek Formation is the Hurley Limestone. The Hurley is, in turn, overlain by the Cherry Valley Member, a relatively thin limestone (1-5 meters thick). The Cherry Valley Limestone is overlain by the East Berne Member of the Oatka Creek Formation, which is an organic-rich shale that can be correlated from Lake Erie to the Catskills.

The key factors in mapping the fairway are TOC, thickness of organic-rich strata, burial depth, mineralogy, thermal maturity, and the degree of overpressure. Productive shales are likely to have TOC >2% and the more TOC the better in most cases. Porosity in the shales commonly forms in organic matter that has matured and expelled hydrocarbons so the more organic matter that was there in the first place the higher the porosity after the shales have entered the gas window. Organic-rich shales generally have lower density than organic-poor shale, sand, and limestone, and density logs have been used to map the organic rich units across the state. The thickness of organic-rich strata is a primary control on gas in place, and all other things being equal, thicker is better in most cases. The thickness of the entire organic rich Marcellus has been mapped, as well as the thickness of individual members of the shale. The organic-rich section is thickest in the eastern part of the basin and thinnest in western New York.

The burial depth was determined by making a structure map of the top of the organic-rich Marcellus. The Marcellus ranges from zero burial depth at the outcrop belt to more than 6,000 feet deep in Sullivan County along the PA border. Most productive shales in the United States produce from more than 4,000 feet and possibly as shallow as 3,000 feet. Hydraulic fracturing would not work well at depths shallower than 3,000 feet because the stress field changes and the needed vertical fractures would no longer form. Thermal maturity values have been measured using vitrinite reflectance and calculated vitrinite reflectance from rock eval data. Natural gas is most likely to be produced from strata that have vitrinite reflectance values (R_o) >1.1. Oil or condensate and associated gas might be produced from strata with R_o values between 0.75 and 1.1. The 1.1 R_o line runs north to south about 50 miles east of Lake Erie, and all areas east of that line have potential to produce natural gas.

The area that has good to excellent potential for natural gas production occurs in the Southern Tier in Allegheny, Steuben, Chemung, Tioga, Delaware and Sullivan counties and covers an area of roughly 2,000 square miles. The Marcellus should produce 40-50 billion cubic feet (BCF) per square mile, which would mean recoverable reserves of 40-100 trillion cubic feet (TCF) of gas in New York State. At $5/mcf, that gas would be worth 200-500 billion dollars.

Data from this study are also used to evaluate the potential to sequester carbon dioxide in the organic-rich Marcellus as a means of mitigating greenhouse gas emissions. CO_2 capacity estimates for the Utica fairway in New York have been calculated using natural gas production potential, pore volume from TOC, and sequestration with the adsorption of carbon dioxide. All three calculations estimate the sequestration potential of the Marcellus in New York to be between 0.2 and 0.6 gigatons of CO_2, or 1 to 4 years of the state's current CO_2 output.

Section 1
INTRODUCTION

The combination of horizontal drilling and high volume, multi-stage hydraulic fracturing has helped to unlock vast natural gas resources in organic–rich shales. The shale with the best potential to produce in New York is the Middle Devonian Marcellus Shale, although there is significant potential in the Ordovician Utica Shale as well. The Marcellus has been a significant source of natural gas in Pennsylvania where it has produced over 20,400,000 MCF of gas to date (https://shaleprofile.com/index.php/2017/04/25/marcellus-pa-update-through-january-2017/).

The purpose of this study is to define a fairway for potential natural gas production from the Marcellus Shale in New York. To accomplish this goal, two bedrock cores and the drill cuttings from more than 100 wells were sampled. Various amounts of these samples were analyzed for total organic carbon (TOC), carbonate content, thermal maturity, x-ray diffraction, and rock-eval pyrolysis. The results of these analyses have been used to make a series of maps and cross sections. We also used these data to calculate approximate storage capacities should the Utica Shale be used as a carbon sequestration reservoir. This report includes all of the data generated during the project.

Section 2
BACKGROUND

2.1 DEPOSITIONAL ENVIRONMENT

The Marcellus Shale was deposited in the Middle Devonian when New York was situated approximately 20 degrees south of the equator (Figure 1). Mountains and volcanoes were located to the present day east due to a collision with the microcontinent Avalon. This collision led to thrust loading of the plate and the development of a foreland basin. Some portions of North America were emergent while others were covered by a shallow sea.

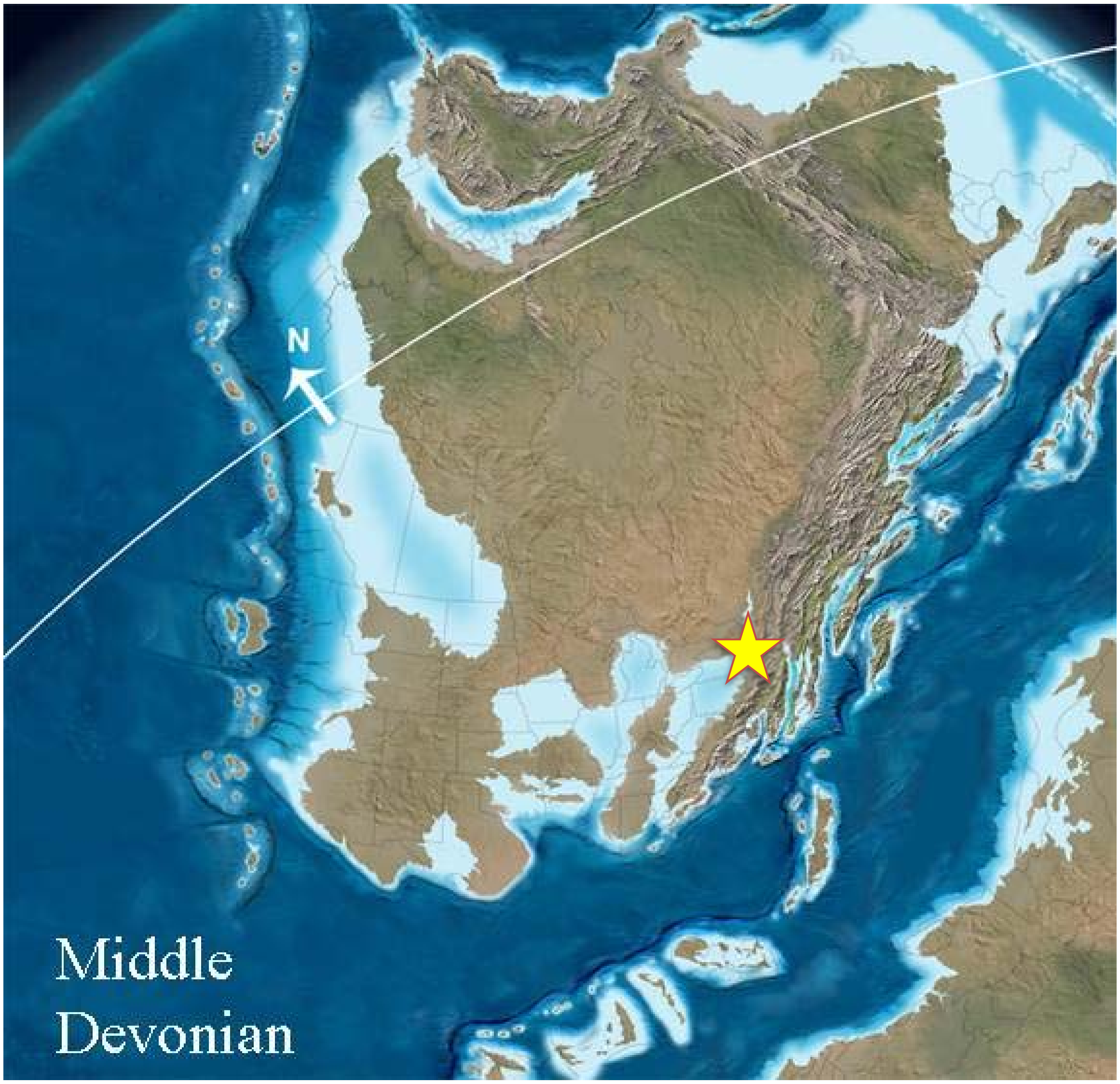


Figure 1. Paleogeographic map of North America during the Middle Devonian. Star marks New York (from https://deeptimemaps.com/).

2.2 STRATIGRAPHIC SETTING

The Marcellus Subgroup is part of the Hamilton Group which is Middle Devonian in age (Figure 2). The Marcellus is one of at least seven organic-rich shale units in the Middle and Upper Devonian of New York (Figure 2). The others are the Esopus, which is older, and the Levana, Geneseo, Middlesex, Rhinestreet, Dunkirk and Pipe Creek Shales, which are progressively younger (Figure 2).

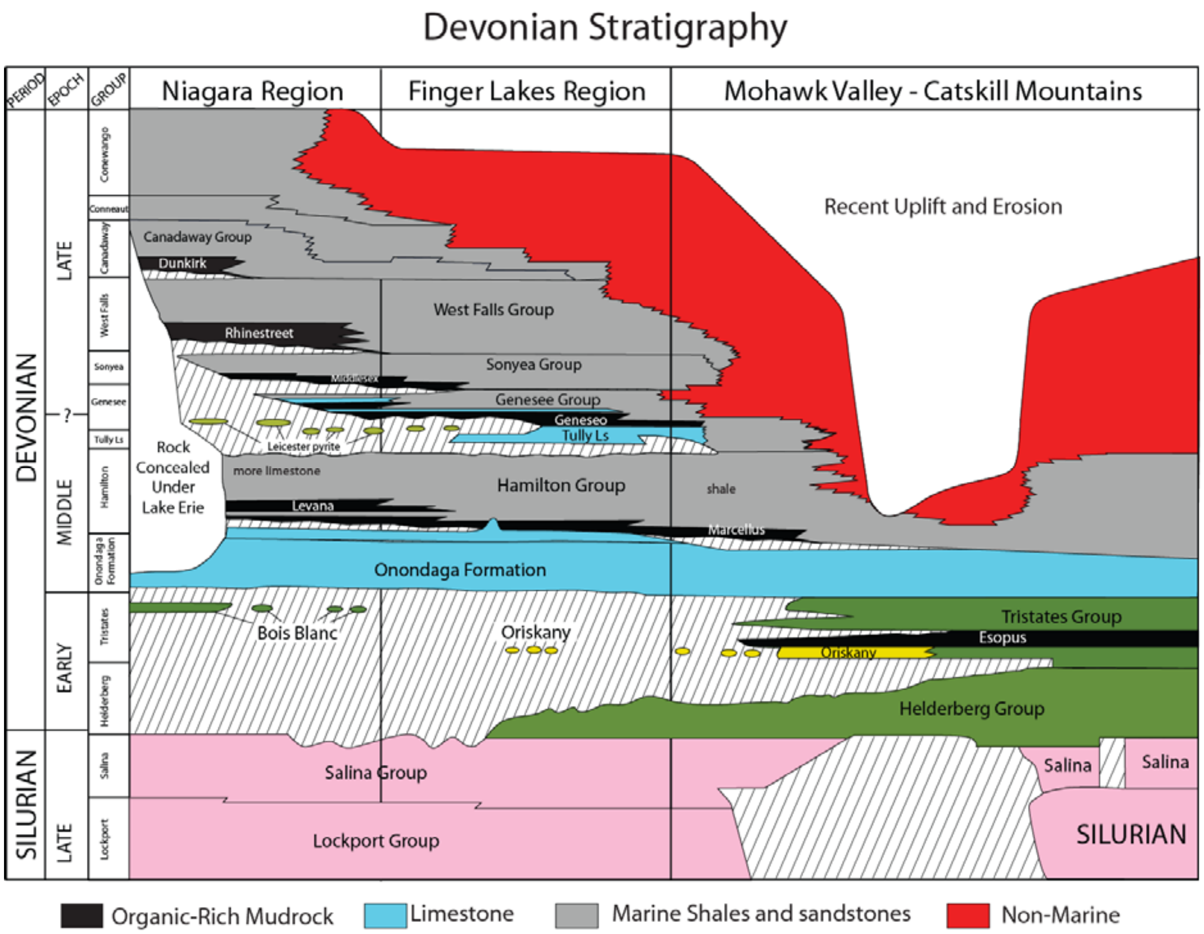


Figure 2. Revised Silurian to Upper Devonian Stratigraphy (modified from the NYS Geological Highway Map Cross Section, Educational Leaflet #33).

The Marcellus Subgroup overlies the Onondaga Limestone in New York State (Figure 3). The Onondaga is composed of several members. From oldest to youngest, these are the Edgecliff, Nedrow, Moorehouse and Seneca members (Figure 3). The Seneca Member is thin to absent in the eastern part of the basin, and has patch reefs that can extend upward 98-131 feet (30-40 meters) above the regional top of the Onondaga in the central part of the basin. There may also be an organic-rich facies of the Seneca Member that is found primarily in the subsurface. An unconformity separates the top of the Onondaga from the Marcellus in much of the basin, but it may be conformable in the south central part of the state (Ver Straeten, 2009). The unconformity is on top of the Seneca Member in the west and down within the Seneca Member or even on top of the Moorehouse Member in the east (Ver Straeten, 2011).

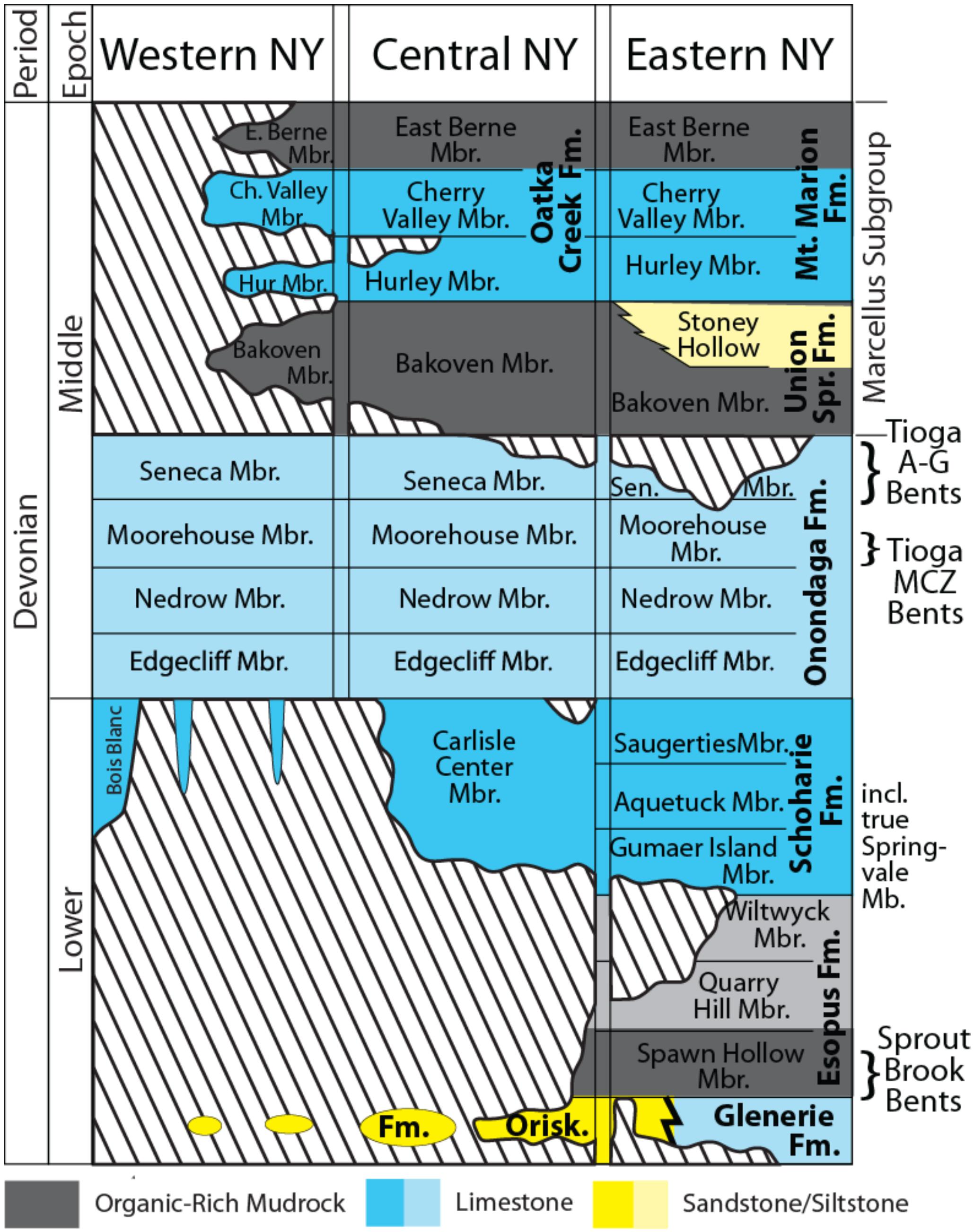


Figure 3. Stratigraphic nomenclature for the Lower and Middle Devonian of New York (modified from Ver Straeten, 2011).

Overall, the Marcellus Subgroup onlaps and thins to the west. Using the outcrop definitions of the top and base of the Marcellus, it thins from close to 700 feet (213 meters) thick in the east to less than 20 feet (6 meters) thick in the westernmost counties near Lake Erie. There are a number of names that have been applied to the various facies found in outcrop within the Marcellus. While these names can be useful when simplified, the most important stratigraphic issues for gas production are the lateral extent and correlations of organic-rich shale units. The basal formation of the Marcellus, the Union Springs, extends from the outcrop belt in the east to where it pinches out in western New York around the border of Cattaraugus and Allegheny counties. The Union Springs is composed of the Bakoven Member, which is an organic-rich black shale with some carbonate beds and nodules, and the Stony Hollow Member, which is a siltstone that only occurs in the far eastern part of the basin where it overlies the Bakoven. Most wells drilled to the Marcellus Shale will probably be landed in the Bakoven Member of the Union Springs. Where present, the Bakoven generally has the highest TOC values in the Marcellus Shale.

The Union Springs Formation is overlain by the Oatka Creek Formation, which comprises the upper part of the Marcellus Subgroup. The basal Member of the Oatka Creek Formation is the Hurley Limestone. The Hurley is, in turn, overlain by the Cherry Valley Member, a relatively thin limestone (3-16 feet, 1-5 meters thick) that can be correlated across much of the area. Moving to the west, the Cherry Valley Limestone sits directly on top of the underlying Onondaga Limestone where the Union Springs pinches out and then it, too, pinches out and is absent in the far western counties. The Cherry Valley Limestone is overlain by the East Berne Member of the Oatka Creek Formation which is an organic-rich shale that can be correlated from Lake Erie to the Catskills. The oldest parts of it onlap and pinch out from east to west and, as a result, it is much thinner in the west than it is in the east. The upper Oatka Creek is composed of organic-poor gray shale in the east.

In the subsurface, we have chosen to use a simplified stratigraphic nomenclature scheme consisting of three formations – the basal organic–rich Union Springs Formation, the overlying Cherry Valley Limestone, and the organic-rich Oatka Creek Formation. For most people working in the subsurface, the top of the organic-rich shale is the top of the Marcellus, while in the outcrop belt, the actual top of the Marcellus can be hundreds of feet above the top of the organic-rich shale.

Section 3

METHODS

Geochemical analyses on shale are the same for an unconventional play as for a source rock. One hundred wells were sampled for this study. Approximately half (59 wells) of the data in this report were produced by sending samples to Humble Geochem and Omni Labs (both now part of Weatherford Labs), who completed the rock-eval and LECO TOC analyses. Sixty-four wells were analyzed by the Museum for TOC and carbonate content. All of the data produced for this report is included in the Appendices and discussed in Section 4.

3.1 SAMPLING

The focus of this study is in the Southern Tier and western Catskills regions as earlier work suggested (Weary et al., 2000). Our choice of sample location was based on the expectation that the area of greatest Marcellus potential is in the central to eastern part of the Appalachian basin in New York (Figure 4). This includes mainly southeastern Steuben County east into Delaware and Sullivan Counties. There are limited well data to be used from Delaware and Sullivan Counties. A full list of the wells sampled and their locations is available in Table 1.

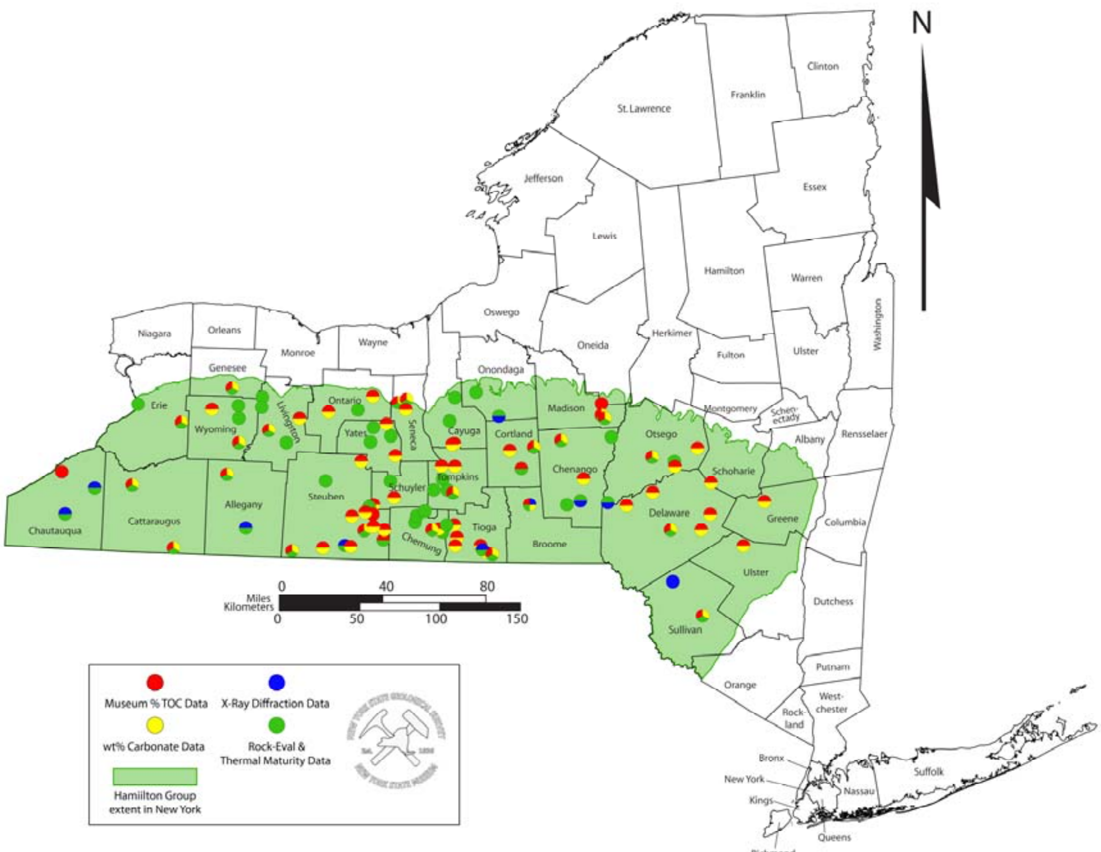


Figure 4. Map of wells sampled for TOC, Carbonate, X-Ray Diffraction, Thermal Maturity, and Rock-Eval analyses.

API	County	Latitude	Longitude	Interval Top (feet)	Interval Bottom (feet)	Museum Coulometer TOC	Museum Carbonate	Rock Eval, LECO TOC, & Thermal Maturity	XRD
31-003-04248-00-00	Allegany	42.4705	-78.1599	2250	2530	X	X	X	
31-003-11762-00-00	Allegany	42.1600	-78.0125	4280	4340			X	X
31-007-05087-00-00	Broome	42.3235	-75.9475	2430	3150	X	X	X	X
31-009-08610-00-00	Cattaraugus	42.3715	-78.8429	2500	2700	X	X	X	
31-009-09235-00-00	Cattaraugus	42.0087	-78.5685	4550	4710	X	X	X	
31-011-11632-00-00	Cayuga	42.9169	-76.5054	300	350			X	
31-011-23158-00-00	Cayuga	42.7848	-76.5427	1110	1150			X	
31-011-23840-00-00	Cayuga	42.6387	-76.5060	1390	1660	X	X		
31-011-23982-00-00	Cayuga	42.6371	-76.5140	1330	1570	X	X		
31-013-04154-00-00	Chautauqua	42.3418	-79.0881	2290	2325			X	X
31-013-04437-00-00	Chautauqua	42.1844	-79.3394	2590	2650			X	X
31-013-09939-00-00	Chautauqua	42.4158	-79.3785	1020	1230	X			
31-015-00443-00-00	Chemung	42.1986	-76.5381	2928	2984			X	
31-015-10335-00-00	Chemung	42.1691	-76.6587	3220	3530	X	X	X	
31-015-23023-00-00	Chemung	42.1698	-76.6118	3300	3600	X	X		
31-015-23146-00-00	Chemung	42.1598	-76.5741	2800	3730			X	
31-015-23228-00-00	Chemung	42.2179	-76.7667	2800	2900			X	
31-015-23913-00-00	Chemung	42.2500	-76.7582	3060	3170			X	
31-017-01160-00-00	Chenango	42.6933	-75.3451	1342	1414			X	
31-017-10608-00-00	Chenango	42.3176	-75.6709	3420	3625			X	
31-017-10609-00-00	Chenango	42.3475	-75.5884	3070	3640			X	X
31-017-23005-00-00	Chenango	42.4643	-75.5682	1934	2621	X	X		
31-017-23006-00-00	Chenango	42.6724	-75.6996	1900	1951	X	X	X	
31-023-04714-00-00	Cortland	42.5186	-76.0006	2100	2350	X		X	
31-023-21500-00-00	Cortland	42.6391	-75.9133	2210	2310	X	X	X	
31-023-26267-00-00	Cortland	42.6220	-76.0787	1900	2265	X	X		
31-025-04214-00-00	Delaware	42.1828	-74.9214	4800	5500	X	X	X	
31-025-04364-00-00	Delaware	42.3169	-75.2337	3790	4050	X	X		
31-025-04379-00-00	Delaware	42.2735	-74.6273	4120	4730	X	X		
31-025-04455-00-00	Delaware	42.3905	-75.0442	3100	3330	X	X		
31-025-10096-00-00	Delaware	42.1861	-74.6830	4480	5320	X	X		
31-029-06668-00-00	Erie	42.8033	-78.8442	110	145			X	
31-029-11730-00-00	Erie	42.7142	-78.5168	1270	1330	X	X	X	
31-037-10776-00-00	Genesee	42.9205	-78.1671	300	400	X	X	X	
31-039-03904-00-00	Greene	42.3336	-74.2303	3900	4140	X	X		
31-051-04053-00-00	Livingston	42.7650	-77.6590	1280	1380	X	X		
31-051-04069-00-00	Livingston	42.8716	-77.9321	405	420			X	
31-051-04391-00-00	Livingston	42.8276	-77.9356	706	735			X	
31-051-04630-00-00	Livingston	42.6501	-77.7552	910	945			X	
31-051-13700-00-00	Livingston	42.6973	-77.8917	870	1100	X	X	X	

Table 1. List of wells sampled including location, interval, and analyses run (continued on next 2 pages)

API	County	Latitude	Longitude	Interval Top (feet)	Interval Bottom (feet)	Museum Coulometer TOC	Museum Carbonate	Rock Eval, LECO TOC, & Thermal Maturity	XRD
31-053-04032-00-00	Madison	42.7964	-75.4043	900	1130	X	X	X	
31-053-19485-00-00	Madison	42.8088	-75.4185	1000	1310	X	X	X	
31-065-03928-00-00	Oneida	42.8680	-75.4261	300	600	X			
31-067-12148-00-00	Onondaga	42.7896	-76.1731	1670	1770			X	X
31-067-12163-00-00	Onondaga	42.9367	-76.3453	400	470			X	
31-069-04035-00-00	Ontario	42.8013	-77.4384	1040	1370	X	X		
31-069-06395-00-00	Ontario	42.8127	-77.2026	340	790			X	
31-069-11428-00-00	Ontario	42.8972	-77.1135	260	350	X	X		
31-077-04055-00-00	Otsego	42.6310	-74.7078	1500	1740	X	X		
31-077-04245-00-00	Otsego	42.5492	-74.8842	1440	2025			X	
31-077-04547-00-00	Otsego	42.5306	-74.8830	1700	1950	X	X		
31-077-10834-00-00	Otsego	42.5804	-75.0477	1700	2000	X	X	X	
31-077-10838-00-00	Otsego	42.3292	-75.3742	3200	3470			X	X
31-095-10263-00-00	Schoharie	42.4425	-74.6195	3050	3290	X	X		
31-097-19692-00-00	Schuyler	42.4325	-76.9704	2290	2310			X	
31-097-21495-00-00	Schuyler	42.2699	-76.7132	3380	3520			X	
31-097-23949-00-00	Schuyler	42.3428	-76.9415	2300	2600	X	X		
31-097-26017-00-00	Schuyler	42.3095	-77.0997	3000	3300	X	X		
31-099-04203-00-00	Seneca	42.8763	-76.8582	20	100	X	X	X	
31-099-04215-00-00	Seneca	42.8616	-76.9203	120	210	X	X	X	
31-099-04244-00-00	Seneca	42.8252	-76.8653	310	370	X	X		
31-101-00167-00-00	Steuben	42.0733	-77.2797	3947	4016			X	X
31-101-03924-00-00	Steuben	42.0634	-77.4300	3960	4080	X	X		
31-101-21468-00-00	Steuben	42.4189	-77.4519	3090	3200			X	
31-101-21692-00-00	Steuben	42.5400	-77.1820	1000	1200	X	X		
31-101-22908-00-00	Steuben	42.2541	-77.0964	3260	3370	X			
31-101-22978-00-00	Steuben	42.0322	-77.6774	4900	5250	X	X	X	
31-101-23055-00-00	Steuben	42.1677	-77.0036	3450	3520	X	X		
31-101-23085-00-00	Steuben	42.1644	-77.1496	3740	3900	X	X	X	
31-101-23101-00-00	Steuben	42.2897	-77.1068	3220	3340			X	
31-101-23155-00-00	Steuben	42.1861	-77.0930	2600	3090	X	X		
31-101-23190-00-00	Steuben	42.1142	-77.0073	3110	3600	X		X	
31-101-23968-00-00	Steuben	42.0696	-77.2472	3500	3900	X	X		
31-101-23985-00-00	Steuben	42.2516	-77.2409	3400	3660	X	X		
31-101-26011-00-00	Steuben	42.2685	-77.1340	3400	3640	X	X		
31-105-08578-00-00	Sullivan	41.9115	-74.8754	7000	7190				X
31-105-12861-00-00	Sullivan	41.7141	-74.6808	6660	7670	X	X	X	
31-107-22887-00-00	Tioga	42.0401	-76.2006	4300	4830	X	X	X	
31-107-23192-00-00	Tioga	42.0616	-76.2639	4460	4655			X	X
31-107-23883-00-00	Tioga	42.0806	-76.4847	3800	4200	X	X		

Table 1 (continued). List of wells sampled including location, interval, and analyses run

API	County	Latitude	Longitude	Interval Top (feet)	Interval Bottom (feet)	Museum Coulometer TOC	Museum Carbonate	Rock Eval, LECO TOC, & Thermal Maturity	XRD
31-107-23927-00-00	Tioga	42.1920	-76.5361	3150	3330	X	X		
31-107-23996-00-00	Tioga	42.1341	-76.4712	3600	4000	X	X		
31-107-26158-00-00	Tioga	42.0578	-76.2610	4230	4620	X	X		
31-107-26426-00-00	Tioga	42.0768	-76.2722	4110	4290	X	X		
31-109-03973-00-00	Tompkins	42.3703	-76.5060	800	1150	X	X	X	
31-109-04130-00-00	Tompkins	42.4422	-76.5924	2390	2490			X	
31-109-04467-00-00	Tompkins	42.3844	-76.5404	2100	2260			X	
31-109-05017-00-00	Tompkins	42.5215	-76.5956	1300	1490	X	X		
31-109-10243-00-00	Tompkins	42.4011	-76.6681	2850	2930			X	
31-109-13173-00-00	Tompkins	42.5230	-76.5049	1335	1431	X	X		
31-111-03199-00-00	Ulster	42.1005	-74.3838	4790	5230	X	X		
31-121-04092-00-00	Wyoming	42.6174	-78.0799	1960	2020	X	X	X	
31-121-06073-00-00	Wyoming	42.7556	-78.0993	1235	1395			X	
31-121-22042-00-00	Wyoming	42.8219	-78.0996	810	840			X	
31-121-25654-00-00	Wyoming	42.7889	-78.2908	1300	1360	X	X		
31-123-04796-00-00	Yates	42.6833	-76.9779	1051	1095			X	
31-123-04797-00-00	Yates	42.7495	-77.0036	800	1000	X	X		
31-123-13174-00-00	Yates	42.5716	-76.9342	1139	1171	X	X		
31-123-15469-00-00	Yates	42.6520	-77.1148	780	820			X	
31-123-15764-00-00	Yates	42.7290	-77.0859	1097	1101			X	

Table 1 (continued). List of wells sampled including location, interval, and analyses run

The Marcellus was sampled using mainly cuttings, but core samples were also used. A first pass was made including at least one sample from each county where the Marcellus is present. A second pass through of the state was used to fill-in gaps where the geochemistry looked most promising for better well completion. In total, 98 Marcellus wells and 4 cores were sampled for the project. The cores used in this study were the Beaver Meadow (API# 31-017-23006-00-00) from northern Chenango County, the Cargill Core Test (31-109-13173-00-00) in central Tompkins County, the Morton Salt #1 (31-123-13174-00-00) from eastern Yates County, and the O'Donnell (API# 31-105-12861-00-00) in central Sullivan County.

3.2 ROCK-EVAL

Rock Evaluation, rock-eval for short, measures the kerogen quality and remaining volumes of kerogen in a sample. The data generated by this process yield geochemical values for S1, S2, S3, Tmax (ºC), %Ro, HI, OI, S2/S3, S1/TOC, and PI. Samples from 59 wells were sent to Humble GeoChem (now part of Weatherford Labs) for rock-eval analysis. The results of these analyses are discussed in Section 4 and can be found in Appendix B.

Samples from well cuttings and cores were prepared and put into an instrument that heats the sample slowly. Four values are obtained during this process (from Tissot and Welte, 1984) (see Figure 5):

S_1 = the amount of free hydrocarbons (gas and oil) in the sample (in milligrams of hydrocarbon per gram of rock). If S_1 >1 mg/g, it may be indicative of an oil show. S_1 normally increases with depth. Contamination of samples by drilling fluids and mud can give an abnormally high value for S_1.

S_2 = the amount of hydrocarbons generated through thermal cracking of nonvolatile organic matter. S_2 is an indication of the quantity of hydrocarbons that the rock has the potential of producing should burial and maturation continue. This parameter normally decreases with burial depths >1 km.

S_3 = the amount of CO_2 (in milligrams CO_2 per gram of rock) produced during pyrolysis of kerogen. S_3 is an indication of the amount of oxygen in the kerogen and is used to calculate the oxygen index (see below). Contamination of the samples should be suspected if abnormally high S_3 values are obtained. High concentrations of carbonates that break down at temperatures lower than 390°C will also cause higher S_3 values than expected.

T_{max} = the temperature at which the maximum release of hydrocarbons from cracking of kerogen occurs during pyrolysis (top of S_2 peak). T_{max} is an indication of the stage of maturation of the organic matter.

Some other common values used in rock-eval pyrolysis are calculated from these measurements. These include:

R_o equivalent = vitrinite reflectance thermal maturity equivalent = 0.0180*Tmax-7.16. This only works when Tmax is reliable and Tmax is only reliable when S2 is >0.2 and S2>S1.

HI = Hydrogen Index = (S2x100)/TOC. This value is used to determine the type of organic matter (lacustrine, marine algae, woody plant material, etc). It can only be determined when S2 is accurate.

TR = Transformation Ratio = S1/S1+S2. This number shows the percentage of hydrocarbons generated out of the total that can possibly be generated.

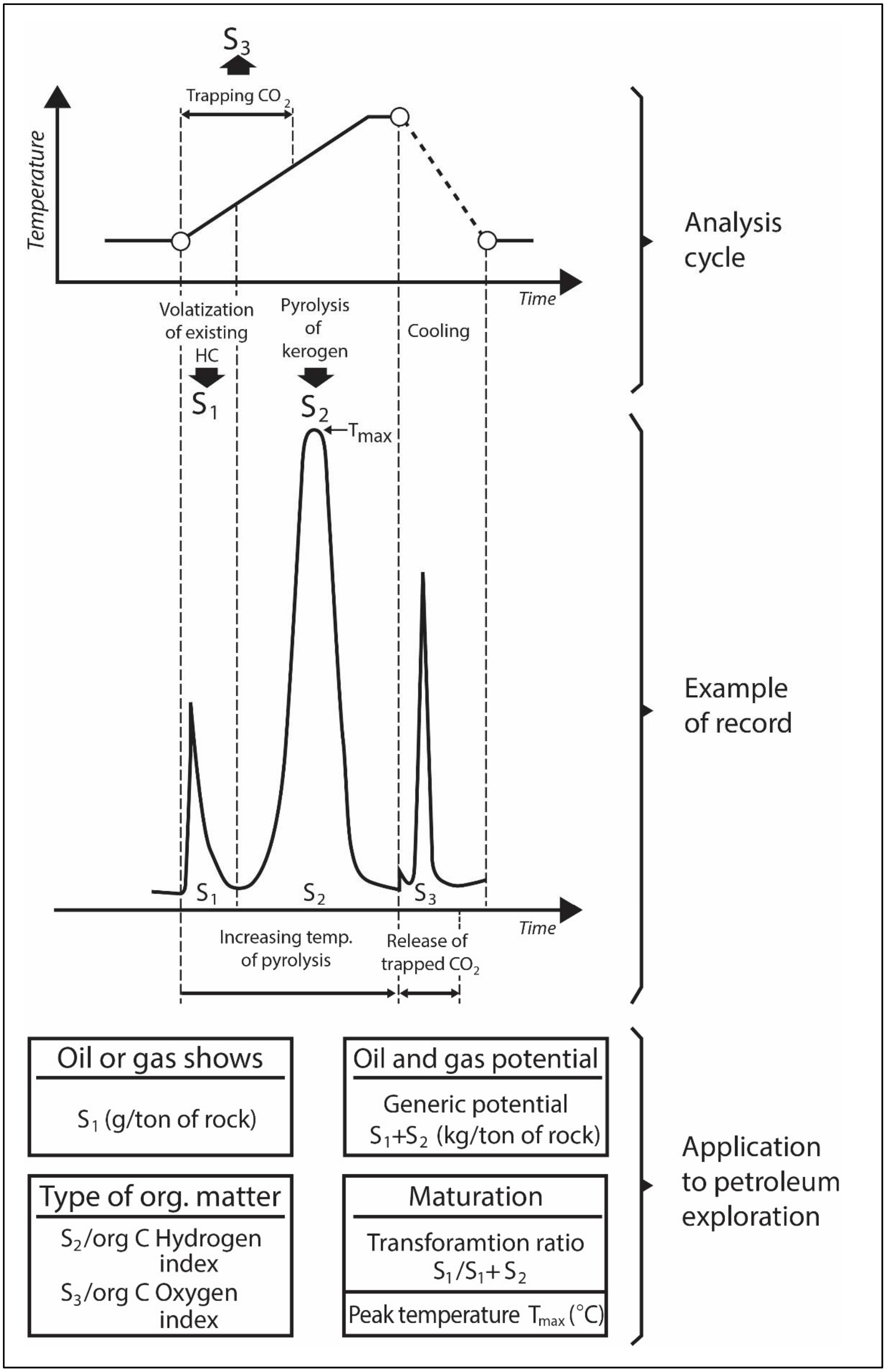


Figure 5. Example of Rock-Eval pyrolysis trace (from Tissot and Welte, 1984).

3.3 TOTAL ORGANIC CARBON

Total organic carbon (TOC) measures the percentage of total rock mass that consists of organic carbon. In the case of the Utica Shale, organic carbon is mostly made up of ancient marine algae. Reported TOC measurements are a fraction of the TOC that was in the rock at the time of deposition. As time passed and the rocks were heated during burial, the organic matter became kerogen and then that kerogen expelled oil and other liquid hydrocarbons. As these liquids were expelled, porosity was left behind within the organic matter. With further maturation and expulsion, the amount of porosity grew and the amount of remaining TOC decreased.

For this project, we sampled four cores and the cuttings from 60 wells. Approximately 40 to 100 mg of each sample was ground to a fine powder using either a mortar and pestle or shatter box. The powdered samples were then analyzed using a UIC Carbon Coulometer (Figure 6). The coulometer is able to determine the amount of organic carbon by first burning the sample in its furnace. For this study, the furnace temperature was set to 450ºC to ensure that all organ carbon would combust, but no inorganic carbon would burn. Inorganic carbon burns at temperatures greater than 530ºC. Carbon dioxide given off by the burning sample passes to a cell where the amount of carbon is measured using an electrochemical titration. This measurement is then used to calculate the total amount of organic carbon (TOC). The results of these analyses are recorded in Appendix A.

TOC values were also reported as part of Humble GeoChem's rock-eval analysis service. These measurements were made using a LECO carbon analyzer and are reported along with the rock-eval data in Appendix B.

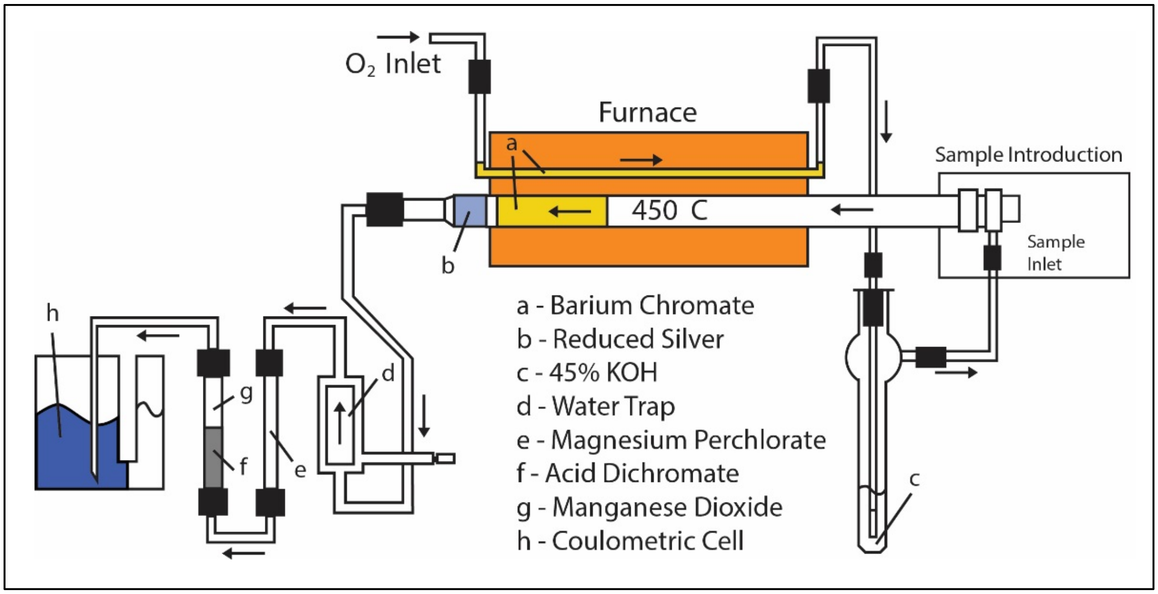


Figure 6. Principles of Carbon Coulometer Operation (from UIC website, http://www.uicinc.com/cm180/)

3.4 CARBONATE CONTENT

All but five of the wells used by the NYSM for TOC content were also analyzed for weight percent carbonate. The carbonate percentages for this study were obtained by reacting powdered rock samples with concentrated hydrochloric acid (HCl). This chemical reaction yields carbon dioxide gas (CO_2), a salt ($CaCl_2$), and water (H_2O). The carbon dioxide escapes during the reaction, while the salt and water remains in solution. By measuring the sample before and after the carbonate has been dissolved, its volume can be calculated by simple subtraction.

The process begins with an empty 50ml polypropelene centrifuge vial. This vial is weighed to the nearest 0.0001 of a gram. Next, approximately 1 gram of powered rock sample is added to the vial and it is weighed again. The sample is then exposed to 4ml of 12 normal/12 molar HCl. It is then agitaged in a vortex mixer and allowed to sit for over 12 hours. The vial is then filled to 20ml with ultra pure water and centrifuged, forcing the remaining sample materal to collect at the bottom of the vial. The solution is poured off and the process is repeated twice. The vial is placed in an oven for more than 12 hours to evaporate any remaining solution. The vial and remaining sample are then weighed again. The percentage of carbonate is calculated using the following equation:

% Carbonate = 100-((Final Mass of Sample/Initial Mass of Sample)*100)

The results of these analyses are included in Appendix A.

3.5 X-RAY DIFFRACTION

A series of 89 samples from 10 wells were sent to Omni Laboratories (now part of Weatherford Labs) for x-ray diffraction analysis (XRD). X-ray diffraction involves the detection and measurement of scatter patterns produced when crystalline materials are placed in an x-ray beam. These patterns can be used to determine the composition of a sample. The results of these tests are reported in Appendix C and briefly discussed in Section 4.5.

Section 4
DATA

4.1 ROCK-EVAL

Rock-Eval Pyrolysis is most valuable when strata are in the oil, wet gas, or lower dry gas window and is less useful when rocks are in the upper gas window, or are supermature. S_2 values of 0.2 or lower suggest that all the kerogen that could have cracked to gas has done so and there is no potential to make more gas. In cases where values of S_2 are below 0.2 or where $S_1 > S_2$, the values are considered to be unreliable and therefore cannot be used for other calculations such as T_{max}, HI, TR and R_o equivalent. Of the 423 samples tested, 289 (68%) had S_2 values less than 0.2, $S_1 > S_2$, or both. Most of these samples were from central and eastern New York. This means that the shale is not currently generating new hydrocarbons in that area. It also means that it is likely to be the area with greatest porosity, as pore space forms where organic matter is cracked to form hydrocarbons. A majority of the S_2 values greater than 0.2 were from wells in the western region of New York. The Marcellus in that area of the state is less mature and has the potential to generate additional oil or gas. All rock-eval data is available in Appendix B

4.2 THERMAL MATURITY

Oil and gas form when organic matter is heated during burial. Currently, New York has a geothermal gradient of about 20-25°C/km. That means that with each km (3,280 feet) of burial, the temperature goes up by ~25°C. So if it is 20°C on the surface on average, it is 45°C at 1km, 60°C at 2km, 85°C at 3km, etc. In the past, the geothermal gradient is likely to have been somewhat higher. Figure 7 shows how organic matter matures with increasing temperature. The figure uses a geothermal gradient of 30°C/km (which is higher than present-day New York). At a temperature of approximately 60°C, the organic matter starts to expel oil. The peak of the oil window is at about 90°C and after that the oil starts to “crack” to gas and the organic matter expels additional gas. At a temperature of about 125°C there is little oil left and the source rock is in the “gas window.”

There are a few different methods for determining the thermal maturity of a source rock, but vitrinite reflectance (R_o) is most commonly used for the Marcellus. Vitrinite reflectance is a somewhat subjective method for determining thermal maturity. Woody plant material becomes more reflective as it is heated. A scale has been developed that relates the reflectivity of vitrinite to burial temperature. On this scale, anything less than 0.5 is immature, 0.5-1.1 is in the oil window, and anything over 1.1 is in the dry gas window.

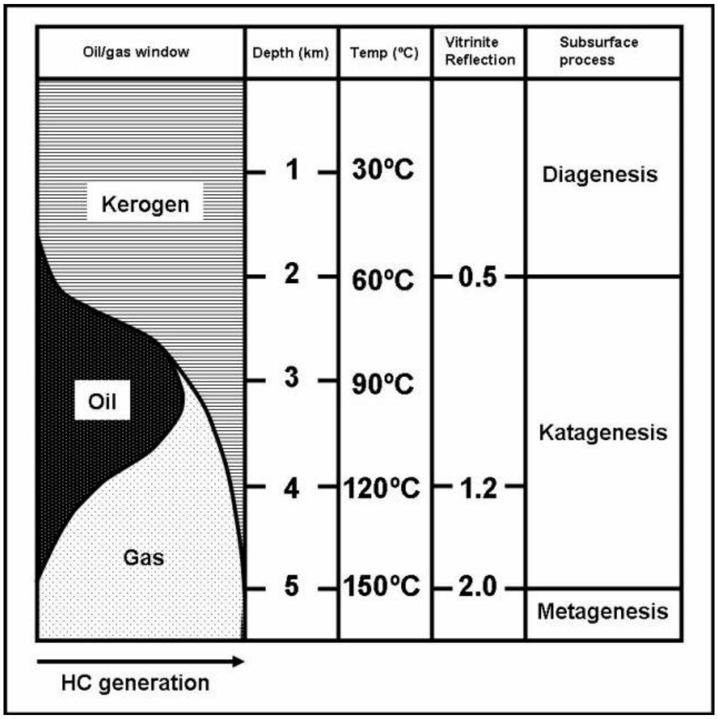


Figure 7. Thermal maturation of oil and gas source rocks or gas shales (from www.oilandgasgeology.com).

For this report, 59 wells were analyzed for vitrinite reflectance. Twenty-one samples were measured directly while 213 had vitrinite values calculated from rock-eval data. These values are recorded in Appendix B. Both measured and calculated values were used to create the contour map in Figure 8. The map shows increasing thermal maturity to the east. This is to be expected because there were once much higher mountains in the east than are there today and there has been at least 10,000-15,000 feet of erosion since the time of maximum burial. Data in the east is very sparse and more wells are needed to draw the thermal maturity lines more accurately.

Based on the thermal maturity data generated in this study, there is a region in far western New York along Lake Erie that may be immature (R_o=0.5) (Figure 8). The Marcellus is in the oil window (between values of 0.5 and 1.1 R_o). It is very thin in this area, so it may or may not be economic for the production of liquids. Condensate is being produced from the Marcellus in southwestern Pennsylvania, but its thickness is greater there. The area to the east of the 1.1 R_o line is in the dry gas window (Figure 8). Gas wells drilled in the Marcellus should be to the east of that line.

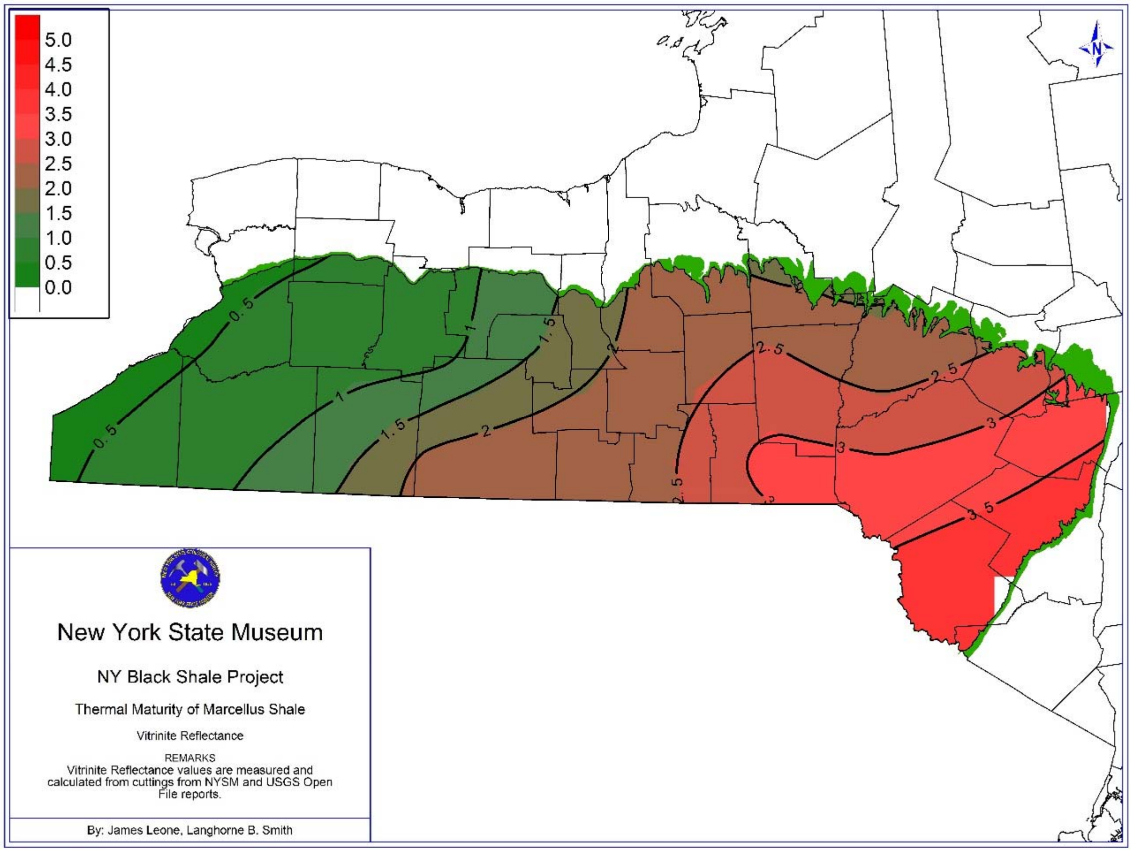


Figure 8. Contour map of vitrinite reflectance values for Marcellus Shale in New York State.

4.3 CARBONATE

A total of 1,543 samples from 59 wells were analyzed for wt% carbonate. As mentioned in Section 2.2, carbonate content is highly variable within the Marcellus. In addition to the presence of multiple limestone beds, much of the Union Springs appears to be mictric with elevated carbonate levels within the rock's matrix. This can cause values from a single well to range from less than 5% to over 90% carbonate. Rather than report the results of these analyses as a summary, we stress the importance of reviewing the data as they are presented in Appendix A.

4.4 TOTAL ORGANIC CARBON

In total, 1,771 samples from 64 wells were analyzed by the NYSM for TOC content. Sampling was unbiased and therefore included the Cherry Valley Limestone as well as carbonate beds and nodules such as those present in the Union Springs. The inclusion of these low TOC samples can have a significant effect when calculating average values. Therefore, we have chosen to present the summary of our data as a range to more accurately represent the Marcellus as a whole. Previous studies indicate that most productive shales have TOC values from 1.00 to 4.00 wt% (Peters & Cassa, 1994). Our measurements of the Marcellus Shale lie in a range of 0.01 to 21.19 wt%, with 35% of all samples run falling between 1.00 and 4.00 wt%. A full list of all TOC measurements is available in Appendix A.

Of the 1,771 samples analyzed for TOC by the NYSM, only 252 had TOC values of 4 wt% or greater. This is in part due to the inclusion of samples from the Stoney Hollow Sandstone, Cherry Valley Limestone, and several carbonate beds present throughout the Marcellus Subgroup. Although the high TOC samples account for less than 15% of all samples run, they are distributed across 50 of the 64 wells tests. This indicates that the organic-rich sections of the Marcellus may be thin, but are also laterally extensive.

4.5 X-RAY DIFFRACTION

As mentioned in Section 3.5, samples from 10 wells were sent to Omni Labs for XRD analysis. Although the results of these tests do not contribute greatly to the discussion or conclusions made in this report, there are a few important observations that can be made from this dataset.

There is a relatively large amount of quartz in nearly every sample, averaging over 25 wt% in each of the 10 wells analyzed. Pyrite is also present in every sample, with several having over 10 wt%. A large majority of the carbonate in the Marcellus is calcium-based, however dolomite is present in all but two of the 89 samples run. It may also be important to note that chlorite and illite are the main clay constituents in the Marcellus Shale.

4.6 WELL LOG CORRELATION

Figure 9 shows the wireline logs, along with calcite and TOC content, measured from the Beaver Meadows core (31-017-23006-00-00) through the Marcellus Shale. This core includes the Onondaga Limestone at the base, the Union Springs Shale, which commonly has TOC >8% and up to 21%, the Cherry Valley Limestone, which has TOC <1%, and the Oatka Creek Shale, which is organic-rich at the base and progressively less organic-rich upward. Note that calcite content is relatively high where TOC values are high in the Union Springs and basal Oatka Creek, but near zero in the upper Oatka Creek where TOC values are low. Also note that both gamma ray and density (RHOB) curves track the TOC curve. Where TOC is high, RHOB is low and GR is high. Where TOC is lower, RHOB is higher and the GR is lower. Gray shales have higher density than black shales and greater separation between the RHOB and NPHI logs (due to the presence of hydrogen ions in clay). Limestones have low gamma ray, higher density, lower NPHI values and less of a spread between NPHI and RHOB.

Density values of <2.65 g/cc line up with TOC values of >1.5%, which is probably a good cutoff between organic-rich shale that could produce gas and organic-poor gray shale that probably won't produce gas. In the cross sections that follow, this density cutoff of 2.65 g/cc is used to discriminate gray shale, which has higher density, from organic rich black shale which has lower density.

From a subsurface correlation perspective, the most important concept is that much of the stratigraphy thins and onlaps unconformities to the west. Onlap means that stratigraphic units are thinning and pinching out on unconformities to the west and that progressively younger strata overlie the unconformities to the west. So the organic-rich shale that immediately overlies the Onondaga in western New York is significantly younger in age than the organic-rich shale that immediately overlies the Onondaga in central and eastern New York.

Figure 10 shows a cross section of the Middle and Upper Devonian stratigraphy of New York using a datum above the Rhinestreet Shale that illustrates the onlapping stratigraphy. The Marcellus thins and almost pinches out completely. It is overlain by the Levana black shale which is only present in far western NY. The Geneseo thins and pinches out completely to the west. The Middlesex black shale thins and pinches out completely. The Rhinestreet black shale thins by 50% but does not pinch out and may onlap less than the underlying shales. Perhaps the clearest example of onlapping occurs in the Geneseo Shale (Figure 11).

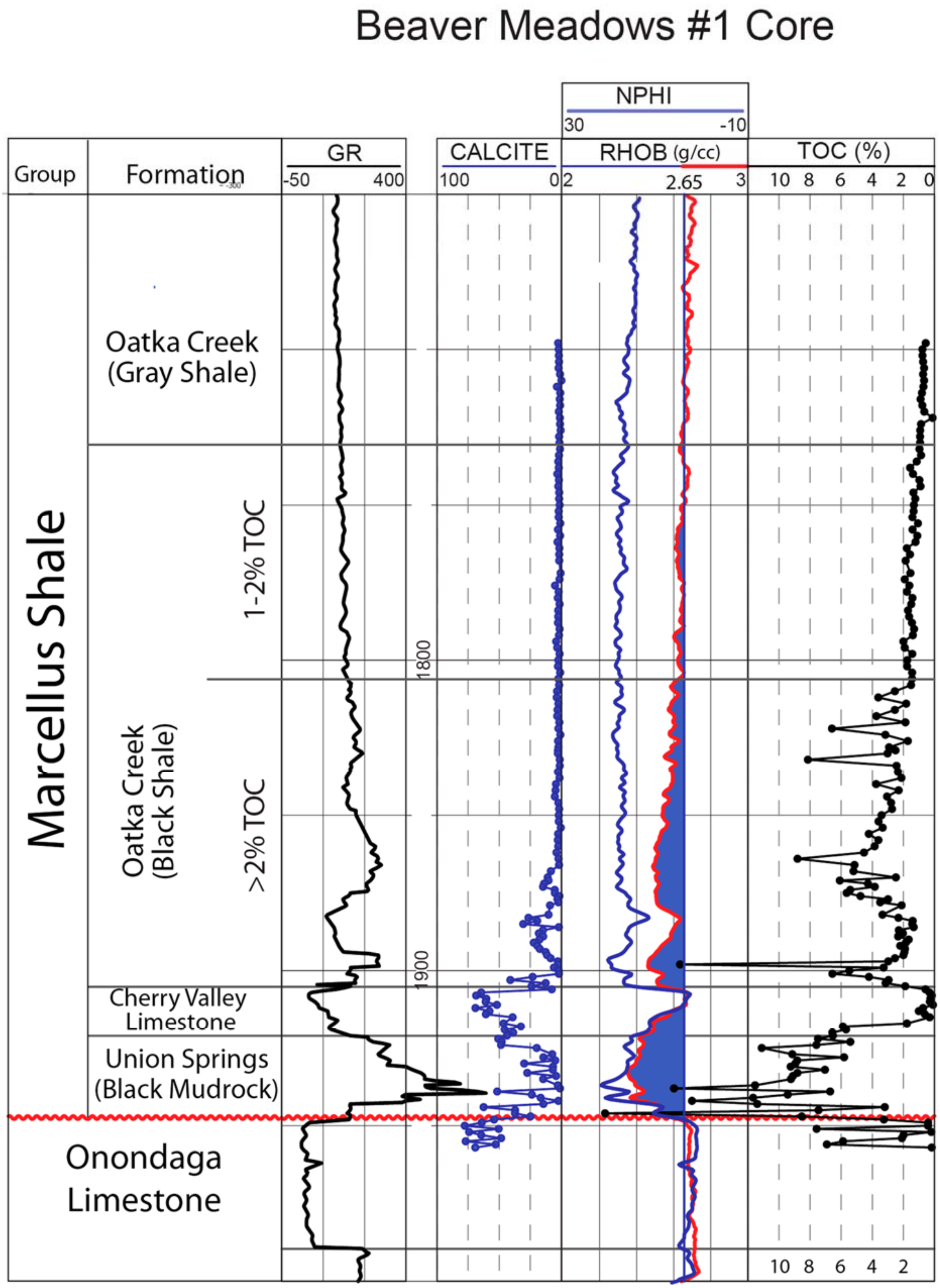


Figure 9. Wireline logs and calcite and TOC content from core in Beaver Meadows #1 well, Chenango Co., NY.

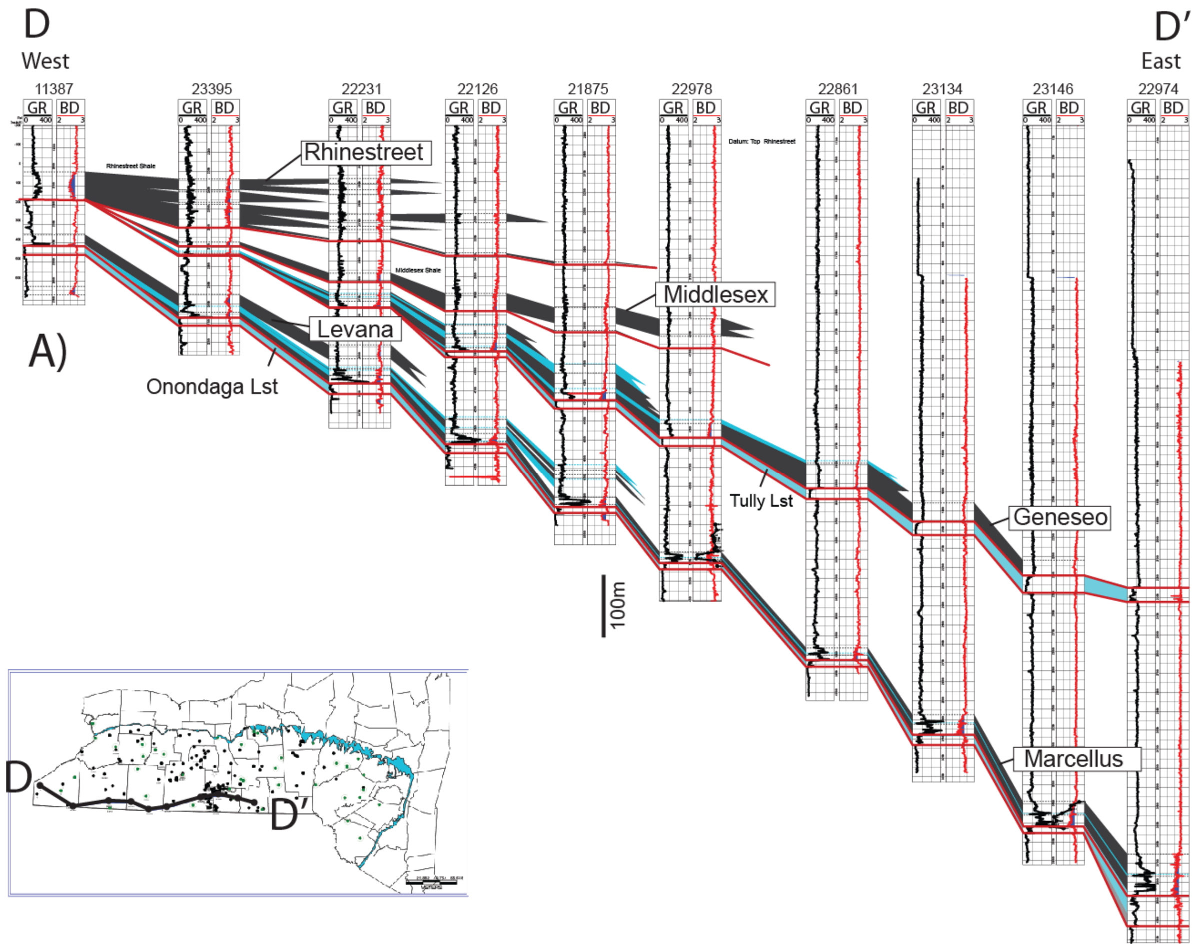


Figure 10. Cross section from western to central New York showing Rhinestreet, Middlesex, Geneseo, Levana and Marcellus Shales. Unconformities are red, organic-rich shales are black, and limestones are blue.

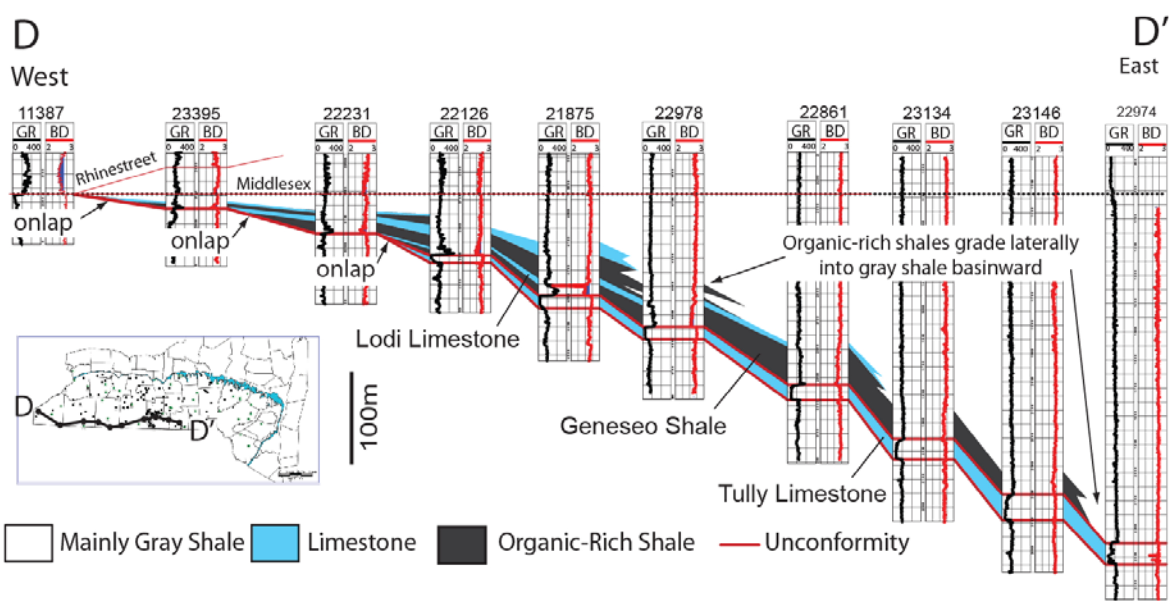


Figure 11. Close-up of cross section in Figure 10 showing the onlapping stratigraphy in the Geneseo Shale, Lodi Limestone and overlying units.

The Geneseo Shale overlies the Tully Limestone. The Tully Limestone thins and pinches out on an unconformity to the west, and is capped by a regional unconformity. It has been argued by some that this unconformity is of a submarine origin, but this seems unlikely. The upper part of the Tully has ooids and stromatolites that were likely deposited in a meter of water or less (Heckel, 1966) so water depths were very shallow just prior to the development of the unconformity. There is a massive pyrite unit to the west called the Lester Pyrite that is thought to be time-equivalent to the Tully Limestone, but it seems as though this could have just as easily formed during the subsequent transgression. Even if the unconformity is not subaerial in origin, water depths were very low immediately prior to deposition of the Geneseo Shale.

Using the density logs to determine organic-richness, the well on the right (22974) of the section shows no hint of organic-richness. The next well moving west shows a minor deflection of the bulk density curve (BD) to the left toward lower values, and the black organic-rich shale is interpreted to start there. Moving westward, the basal black Geneseo Shale gets progressively more enriched in TOC (lower BD) but also gets progressively thinner in wells 22146, 22134, 22861, 22978, 21875 and 22126. Somewhere between 22126 and 22231, the basal black Geneseo Shale pinches out or "onlaps" the unconformity. In well 22861, a limestone occurs above the black shale that was not present in the wells to the east. The limestone becomes better and better developed in the wells to the west until it, too, pinches out between wells 22126 and 22231. A second black shale is present above this limestone in 21875 that grades into gray organic-poor shale to the east and becomes more enriched in TOC but thinner to the west until it onlaps and pinches out between wells 22231 and 23395. The second black shale is overlain by a second limestone that also onlaps and pinches out to the west and a third black shale forms above it that also thins and pinches out even farther to the west.

To summarize, TOC increases from east to west with organic-poor gray shales in the east grading laterally into progressively more organic-rich shales in the west that get progressively thinner and more enriched in TOC until they onlap and pinch out. Limestone is only present where organic-rich shale is present. Limestone units get progressively cleaner to the west until they, too, onlap and pinch out on the western tectonic high.

The Marcellus Shale has a similar pattern of onlap to the west. Figure 12 shows an east to west cross section along the PA border. The Unions Springs Formation, which makes up the bulk of the reservoir in the east, onlaps and pinches out to the west between wells 22231 and 22126. The overlying Cherry Valley Limestone also onlaps and pinches out to the west between the same wells on the cross section in Figure 13. Most of the overlying black shale at the base of the Oatka Creek also thinks and pinches out in the far western counties. The Marcellus black shale present in the far western well is time-equivalent to gray shale in the east and is significantly younger than the main black shale intervals in the eastern wells.

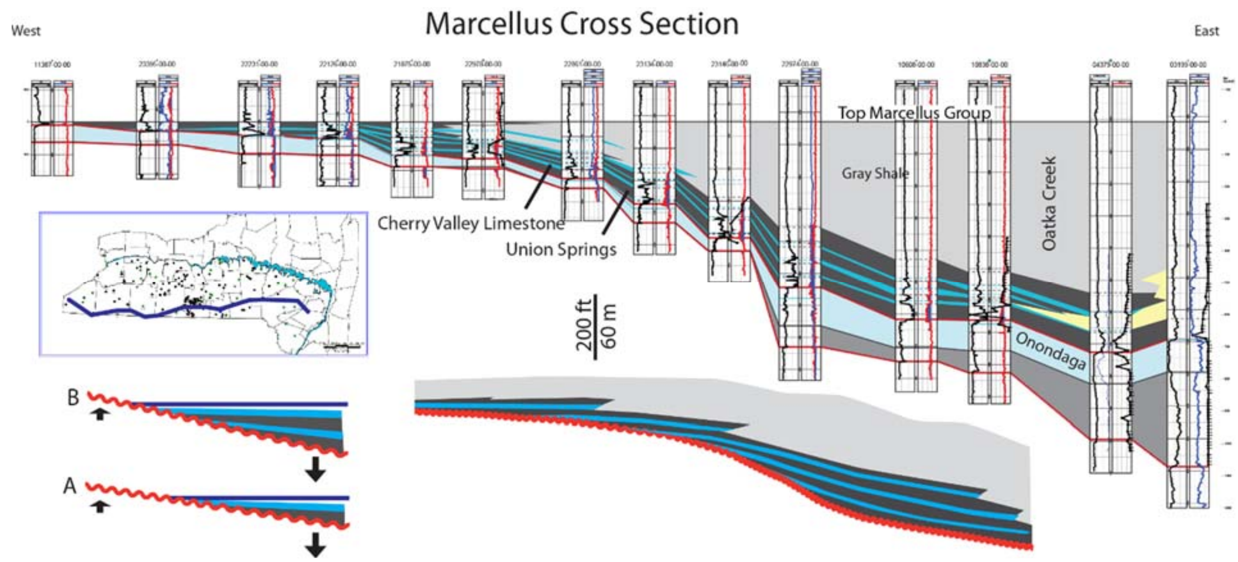


Figure 12. Basin-wide cross section of the Marcellus Shale. The shale was deposited during a period of high differential subsidence and eustatic sea-level rise that led to stratigraphy that both onlaps and thins to the west.

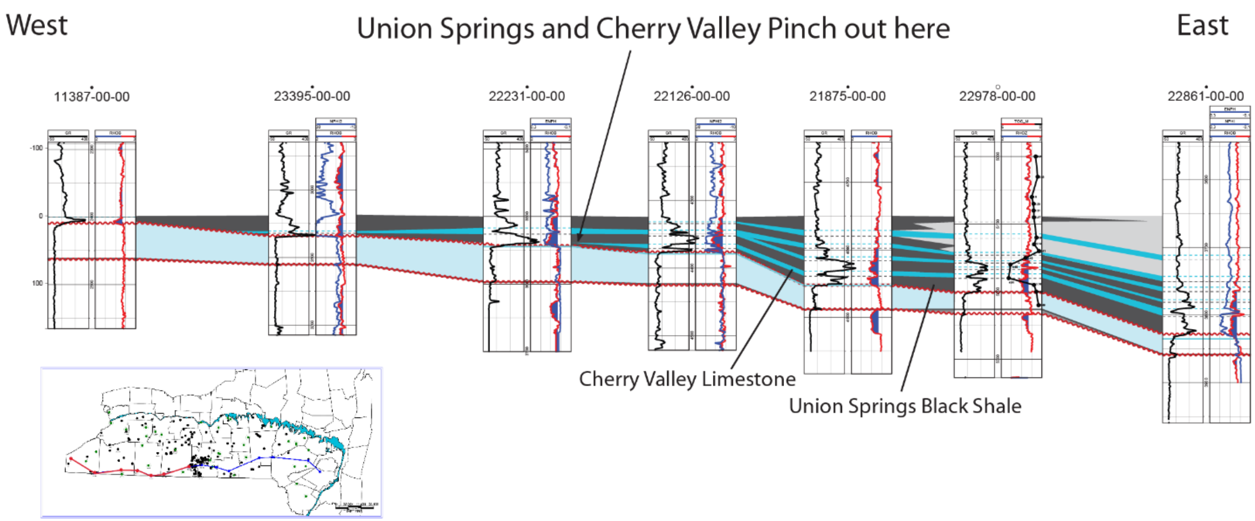


Figure 13. Blowup of western part of cross section in Figure 12. Union Springs Black Shale, Cherry Valley Limestone and basal Oatka Creek Shales all onlap and pinch out to west.

4.7 ISOPACH MAPS

Figure 14 shows the thickness of an organic-rich or porous limestone, or both, that occurs at the top of the Onondaga Limestone. This interval could add something significant to the reservoir where it is reasonably thick. If it is porous limestone, it may actually add more than an organic-rich shale.

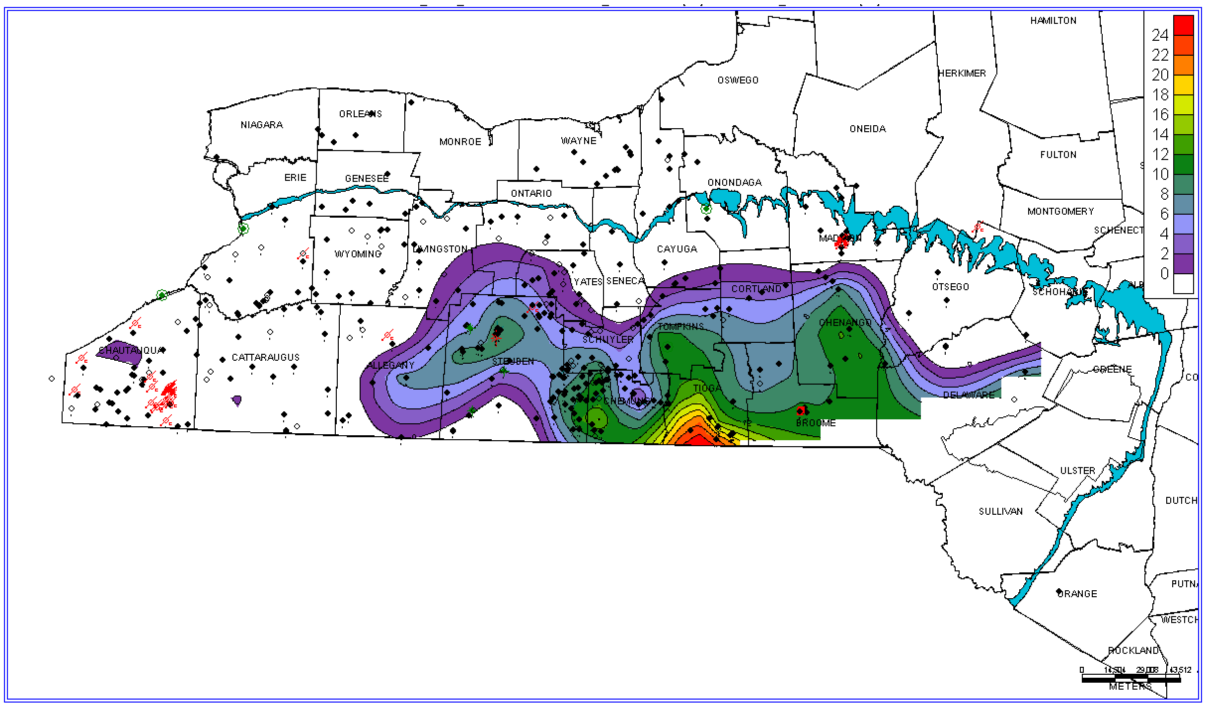


Figure 14. Thickness of basal Union Springs or Upper Onondaga organic-rich interval – this occurs beneath a prominent limestone that has organic rich shale underlying it.

Figure 15 shows the thickness of the organic-rich Union Springs Formation. The Union Springs is picked from the top of the organic-rich shale down to the top of the Onondaga Formation. The Union Springs onlaps and pinches out to the west. The organic content is lowest in the east and gets progressively higher to the west. In some wells the Union Springs may be thickened by thrusting and repeating of some sections. This is the interval where most horizontal wells should be landed because it has the highest organic content. Figure 16 is a thickness map of the Cherry Valley Limestone. It also onlaps and pinches out to the west and is absent in the westernmost counties. Figure 17 is a thickness map of the organic-rich basal Oatka Creek Formation where TOC is either measured or interpreted to be greater than 2%, a cutoff that some people use to discriminate organic-rich shale gas reservoir from ineffective. This interval, and all organic-rich shale below it, is likely to be part of the reservoir and to contain gas that can be produced. Note that this interval is thickest in central New York and is significantly thinner to the east and west. A map of the total thickness of organic rich shale with TOC interpreted to be >2% is presented in Figure 18. This map may overestimate the thickness of the organic-rich section as it includes the Cherry Valley and other organic-poor limestones.

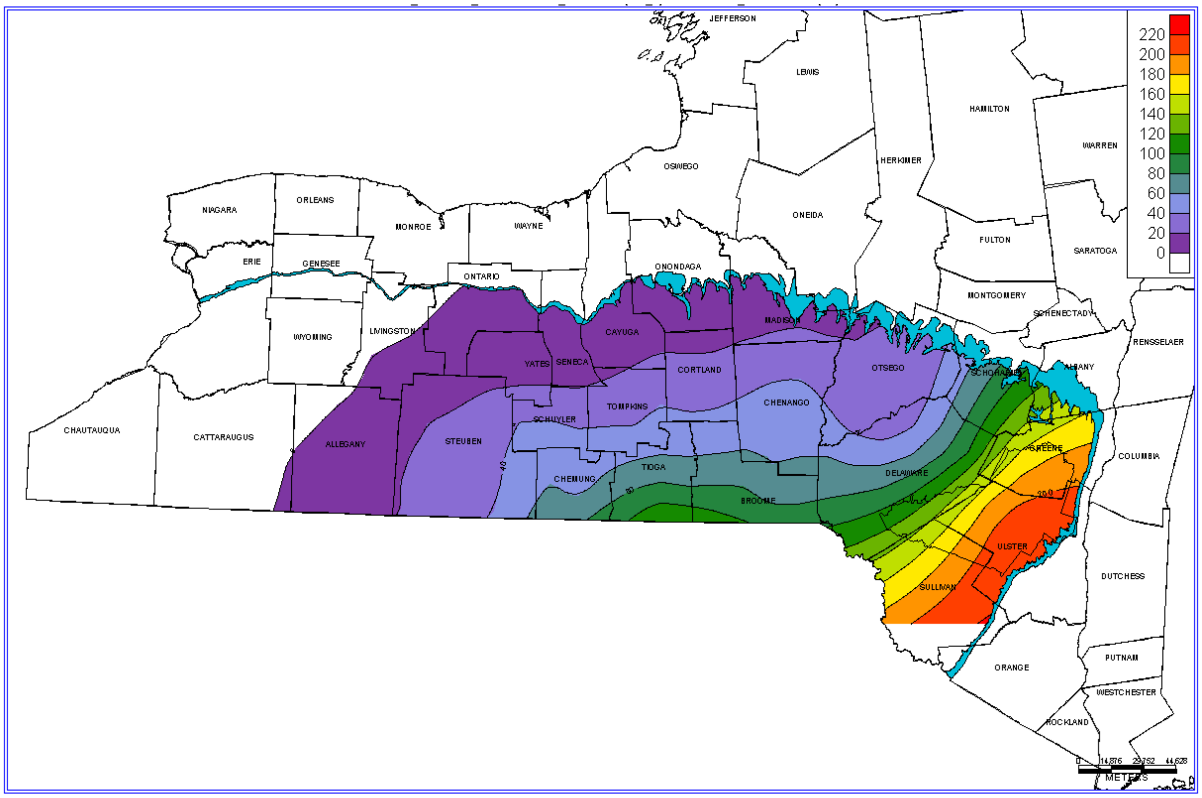


Figure 15. Thickness of the Union Springs organic-rich shale. Note that the Union Springs onlaps and pinches out in the far western counties.

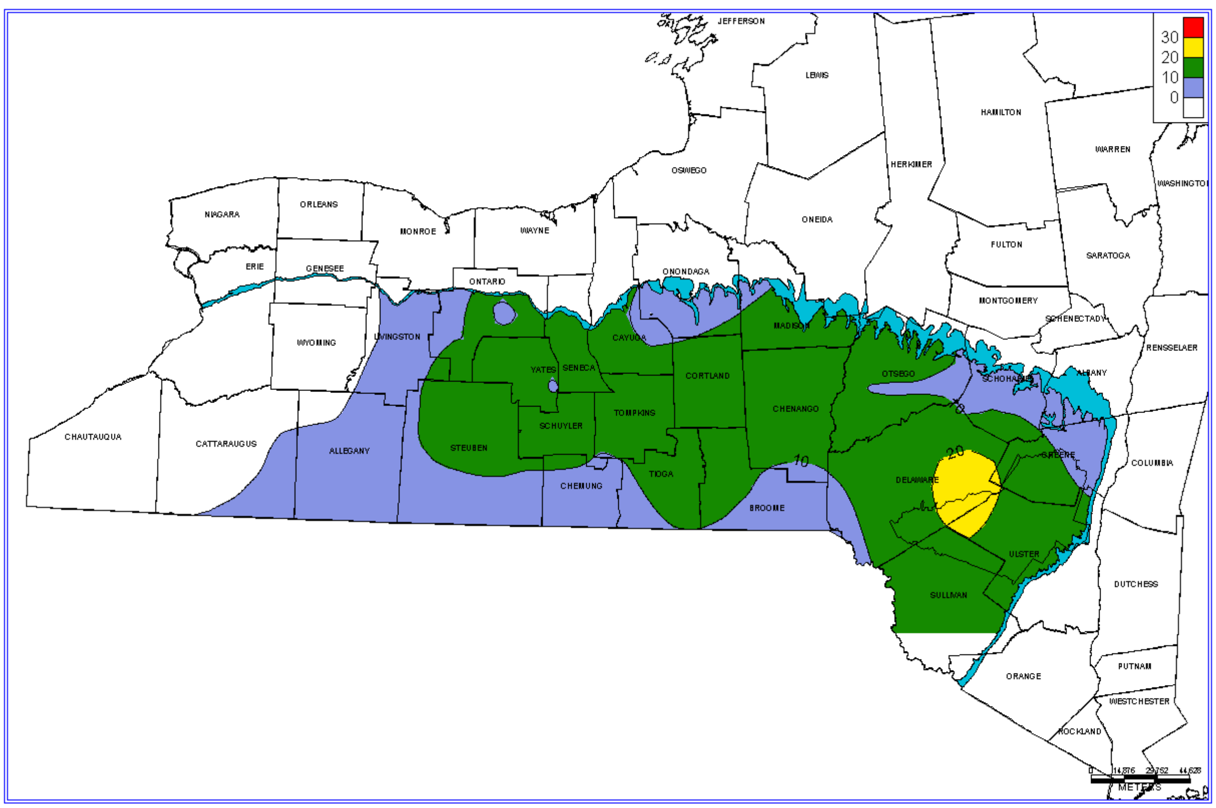


Figure 16. Thickness of Cherry Valley Limestone which onlaps and pinches out to the west.

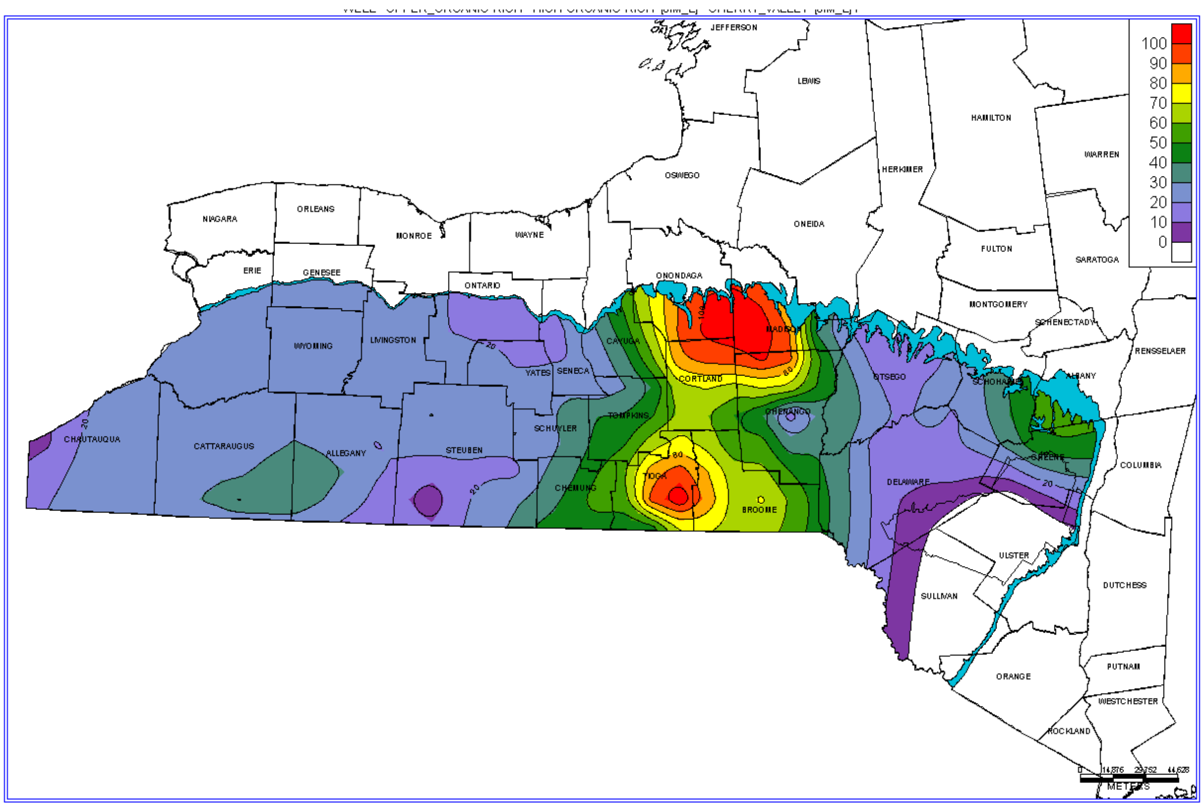


Figure 17. Gross thickness of high-organic Oatka Creek Shale (interpreted to be >2% TOC).

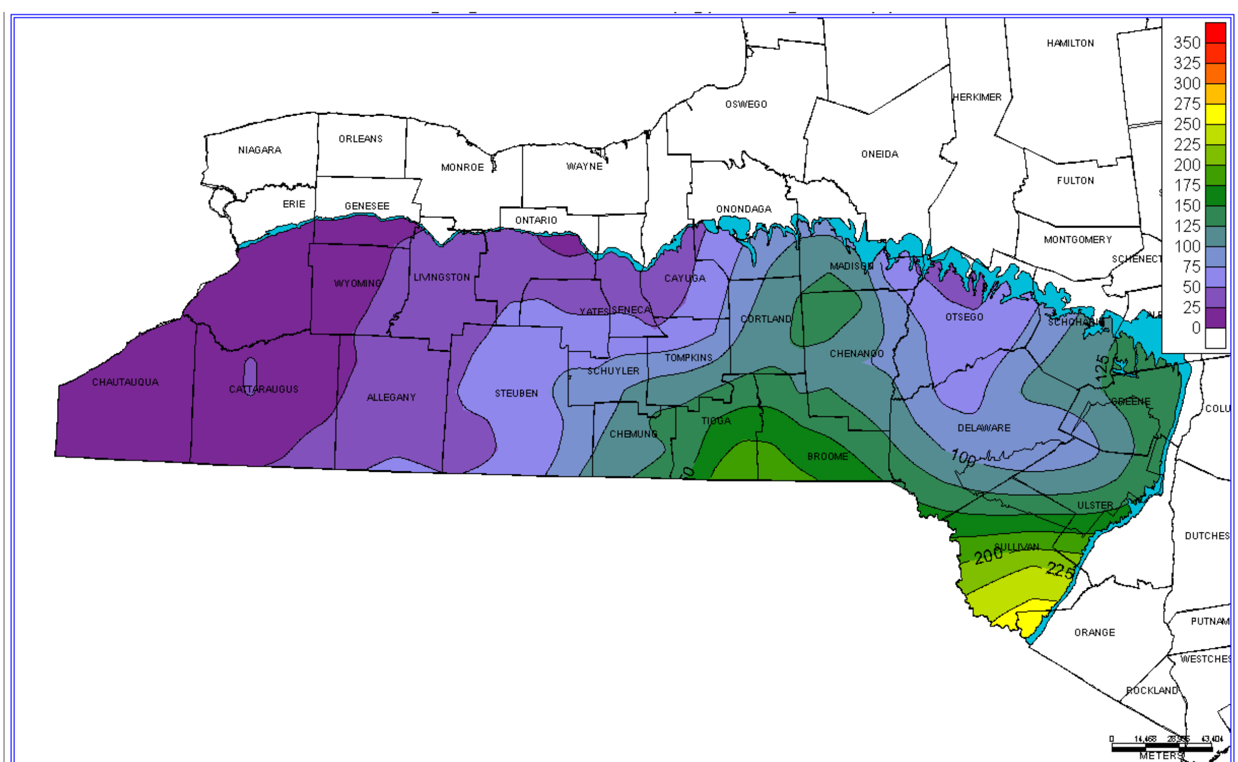


Figure 18. Total thickness of organic-rich Marcellus including Oatka Creek >2% TOC to top of organic-poor Onondaga. This includes the thickness of the Cherry Valley and other organic-poor limestones where applicable.

The maximum thickness on the map in Figure 18 is about 225 feet thick in Sullivan County, NY. A best effort has been made here to remove the effects of thrusting, which can locally increase the thickness by tens to more than one hundred feet (see Section 5.5).

One of the key questions yet to be answered is the lower limit of organic-richness for a productive reservoir. Some have used a 2% TOC cutoff and suggest that anything lower than that is too low. If that is the case, the map presented in Figure 18 is the most reliable map to use for total thickness. It may be that strata with TOC values as low as 1% could contribute to the reservoir. Figure 19 is a map showing the thickness of an interval in the Oatka Creek that overlies the interval in Figure 17. This section commonly has TOC values between 1 and 2% (See interval in Beaver Meadows Core in Figure 9). Where TOC values are absent, this interval is identified where density values are about or only slightly lower than 2.65 g/cc.

Figure 20 is a map of the total thickness of organic-rich Marcellus using a 1% cutoff rather than a 2% cutoff for the lower limit of TOC. This changes the map somewhat but the thickest areas remain the same.

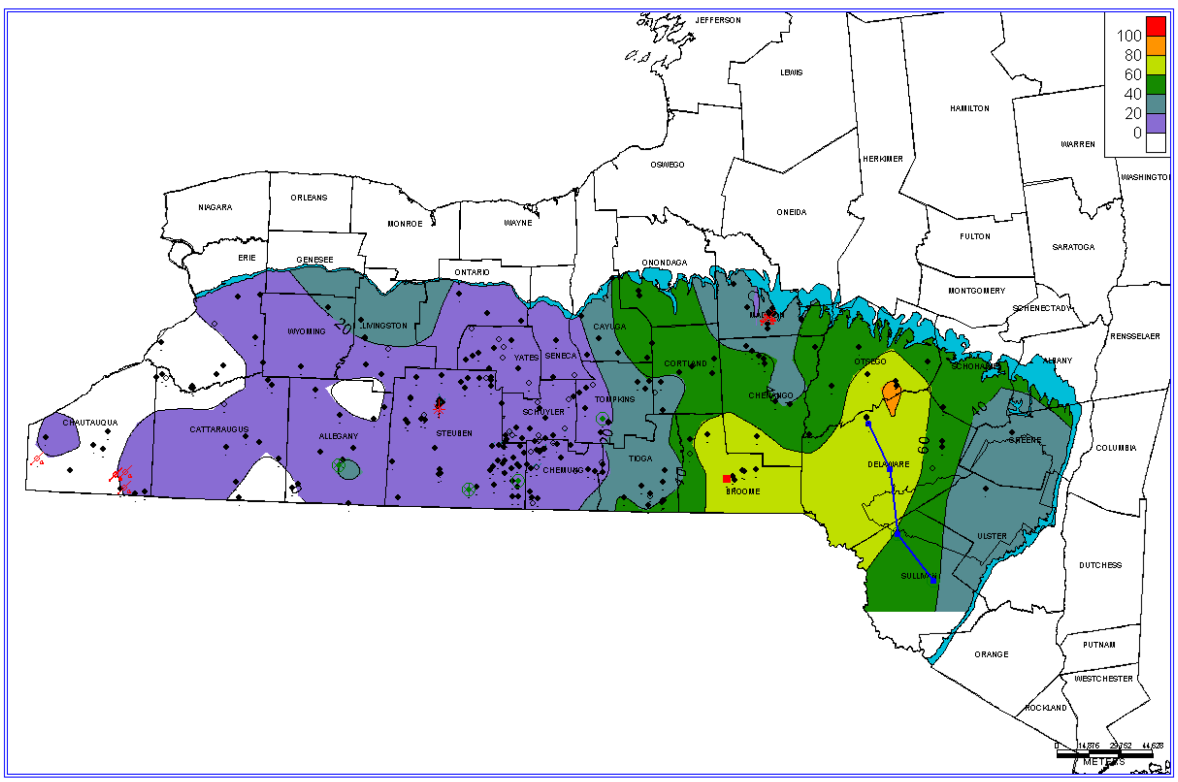


Figure 19. Thickness of 1-2% TOC Oatka Creek Formation. This may or may not contribute to gas production.

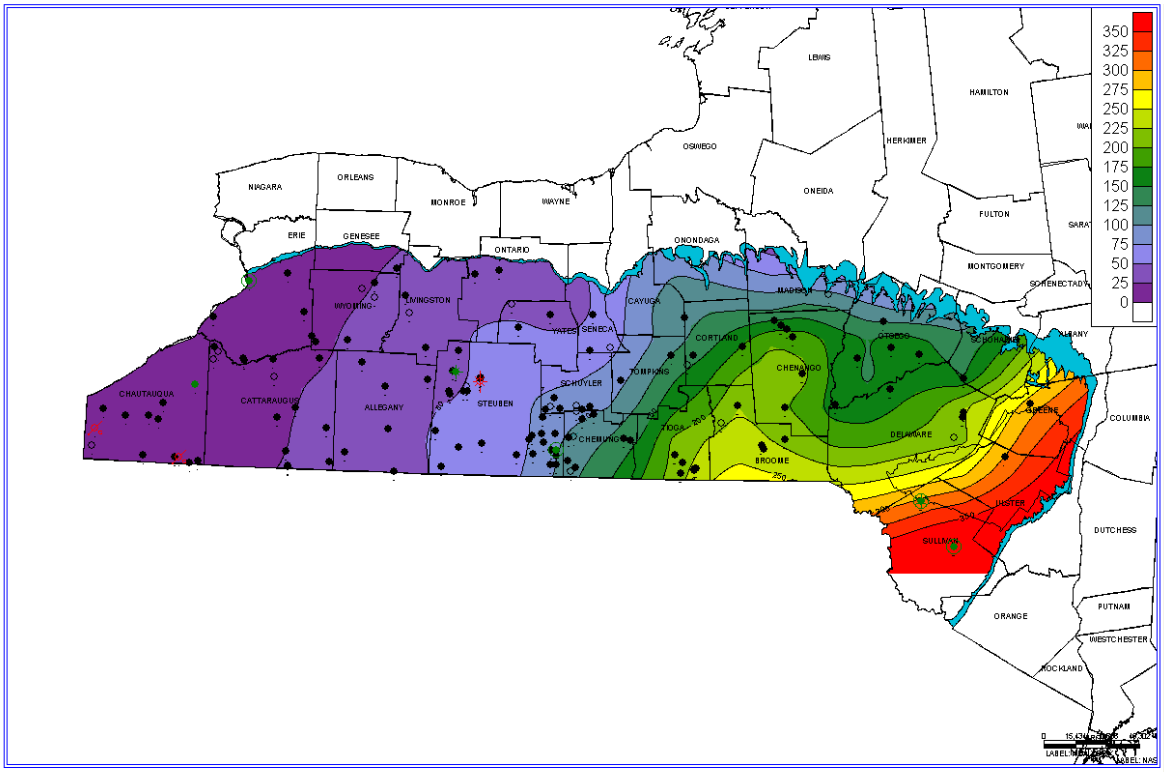


Figure 20. Total thickness of Marcellus Shale >1% TOC including limestones where present.

Section 5
DISCUSSION

5.1 DEPOSITIONAL ENVIRONMENT

For many years, the dominant paradigm for deposition of the Marcellus and other Devonian shales has been a deep, quiet, permanently anoxic model. In this model, the depositional environment because progressively deeper to the west and the black shale was deposited in a deep, quiet, permanently anoxic environment. Non-marine deposits in the east gave way westward to shallow marine siliciclastics, then turbidite facies and then the black shales in the deepest water. Figure 21 from Brett and Baird (1991) shows deposition at the toe of a slope and in deepest part of the basin in water greater than 200 meters deep in a permanently anoxic basin. Figure 22 is a modification of a commonly used figure from House and Kirchgasser (1993). This, too, shows black shales forming at the toe of the slope and in the deepest water environment. This is here called the deep downlap model with black shale strata downlapping onto the basin floor. Much of this apparent downlap is driven by the decision to use the underlying Tully Limestone as the datum for the cross section.

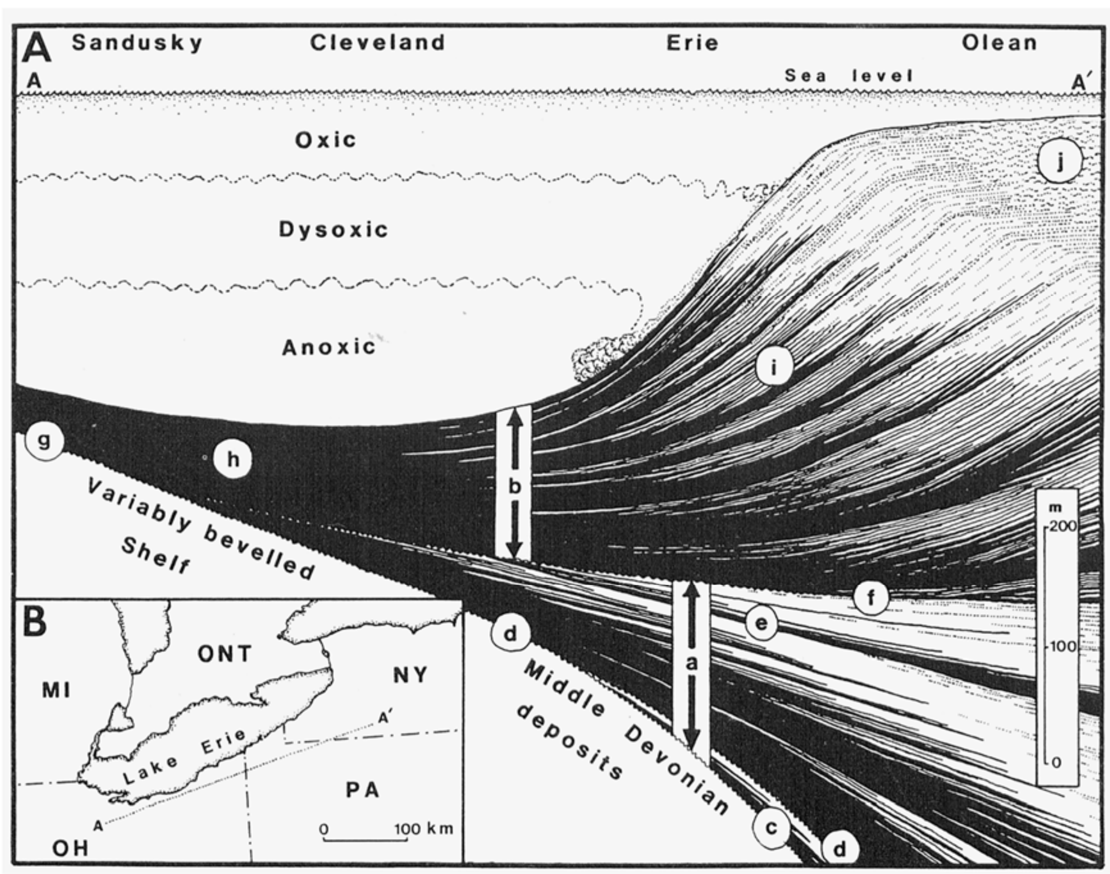


Figure 21. "Deep" depositional model for Devonian black shales (from Brett and Baird, 1991).

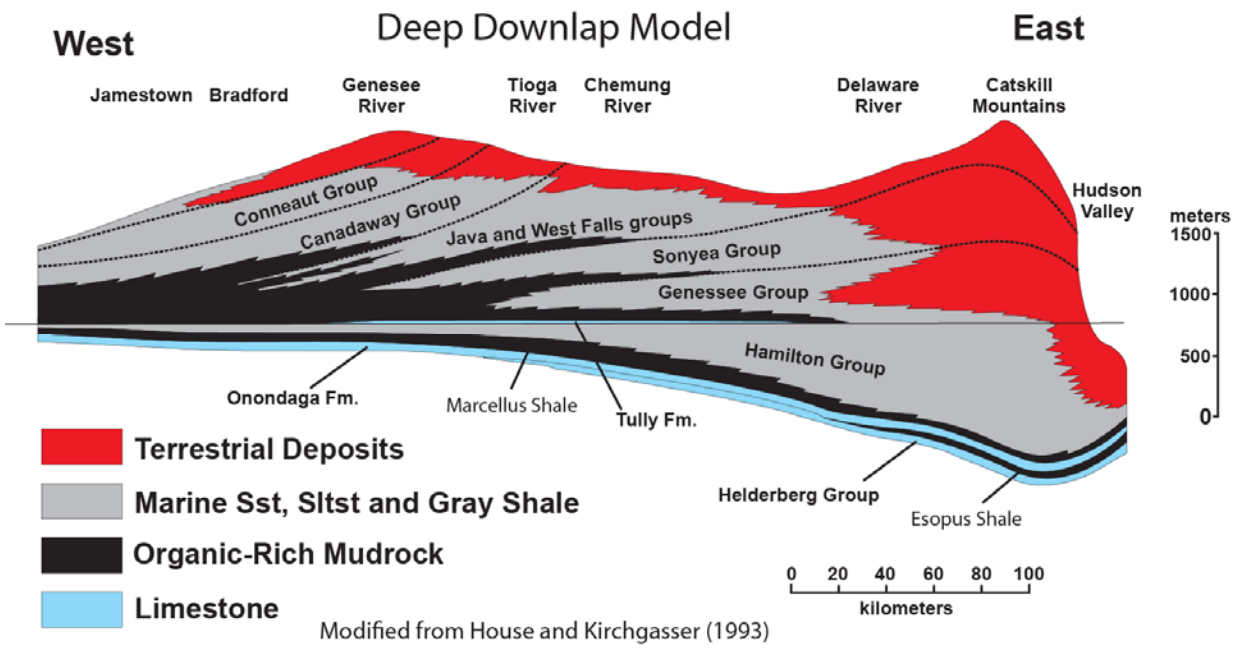


Figure 22. Middle and Upper Devonian Stratigraphy of NY (modified from House and Kirchgasser, 1993).

Although the deep model has been the dominant paradigm for the last few decades, alternatives to this model have been proposed over the years. Conant and Swanson (1961) found that the Upper Devonian Chattanooga Shale in Tennessee could not have been deposited in more than 30 meters of water. They showed the black shale onlapping an unconformity (Figure 23). Scheiber (1998) confirmed this interpretation with a sedimentological study of the Chattanooga Shale. Our work, combined with that of others suggests that a better interpretation of the depositional environment might be relatively shallow (<50 meters water depth and probably <30 meters in most cases), seasonally or periodically anoxic or dysoxic water that could have had significant currents. There now seems to be a swing back toward a shallower model for the deposition of the shales that was in part led by the work of the NYSM (Smith and Leone, 2010a, 2010b).

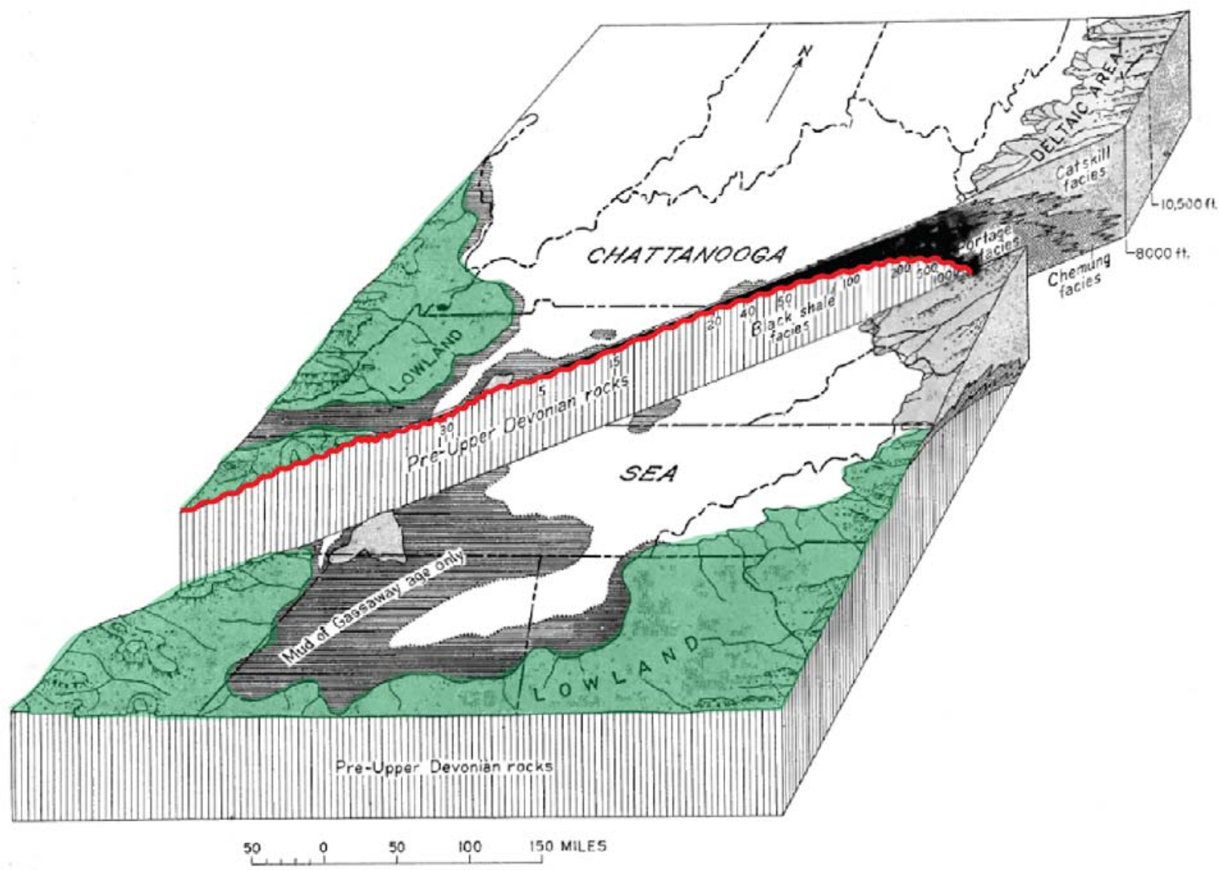


Figure 23. Shallow onlap model for Upper Devonian Chattanooga Shale (modified from Conant and Swanson, 1961). The organic-rich shale (in black) overlies an unconformity (red) and is time-equivalent to nearby subaerial exposure (green).

Figure 24 shows a new depositional model for Middle and Upper Devonian organic-rich shales of New York State. The depositional model is interesting from an academic standpoint, but also matters for exploration. The model in Figure 24 shows the black shale largely confined to the western side of the basin with the deepest part of the basin actually filled with turbidites and gray, organic-poor shale. Exploration companies looking for gas in New York will likely focus their efforts to the west, rather than in the depocenter of the basin where TOC values are much lower. The following sections discuss some of the main points captured in Figure 24.

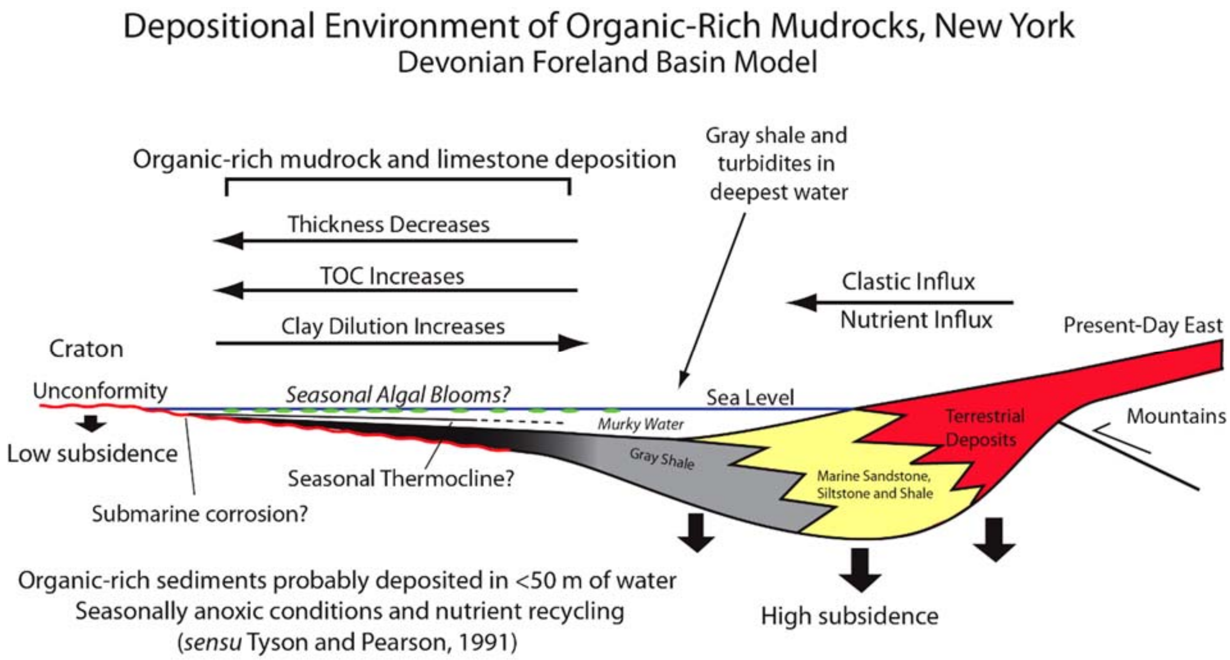


Figure 24. Proposed depositional model for Middle and Upper Devonian shales of New York.

There are several lines of evidence that suggest a shallow marine origin (less than 50 meters water depth and in most cases probably less than 30 meters) (Figure 24). The evidence laid out by Conant and Swanson (1961) is very compelling. In their study of the Upper Devonian Chattanooga Shale, they found that the black shale was deposited on a subaerial unconformity and was time-equivalent to subaerial exposure nearby (Figure 23). Similarly, Middle and Upper Devonian organic-rich black shales of New York including the Marcellus commonly overlie, onlap and are time-equivalent to unconformities, some of which may be subaerial (Figure 2). Furthermore, there were vast areas of North America that were emergent during the Middle Devonian that would likely have been submerged if there were a 100 to 200 meter sea level rise. Middle and Upper Devonian black shales are more common and more organic-rich on tectonic highs such as the Nashville Dome, Cincinnati Arch, Findley Arch and Algonquin Arches and that is true in New York as well. In far western NY on the eastern flank of the Algonquin Arch, black shale and limestone are the most common rock types. Stratigraphy thins dramatically onto these highs, suggesting that they were indeed highs during the Middle and Upper Devonian, yet the black shales are concentrated there rather than in the more rapidly subsiding areas. Throughout New York, the black shales are commonly interbedded with limestones that have shallow marine fauna such as brachiopods, bivalves and corals. Black shales of Marcellus are absent over reefs suggesting that reefs (which are up to 40m high) may have been emergent or at least at sea level during deposition of black shales (Figure 25). This puts a limit of about 40 meters on the water depth in those areas. The occurrence of organic-rich shale immediately overlying unconformities suggests that the depths could be quite shallow in some intervals, perhaps as little as 5-10 meters.

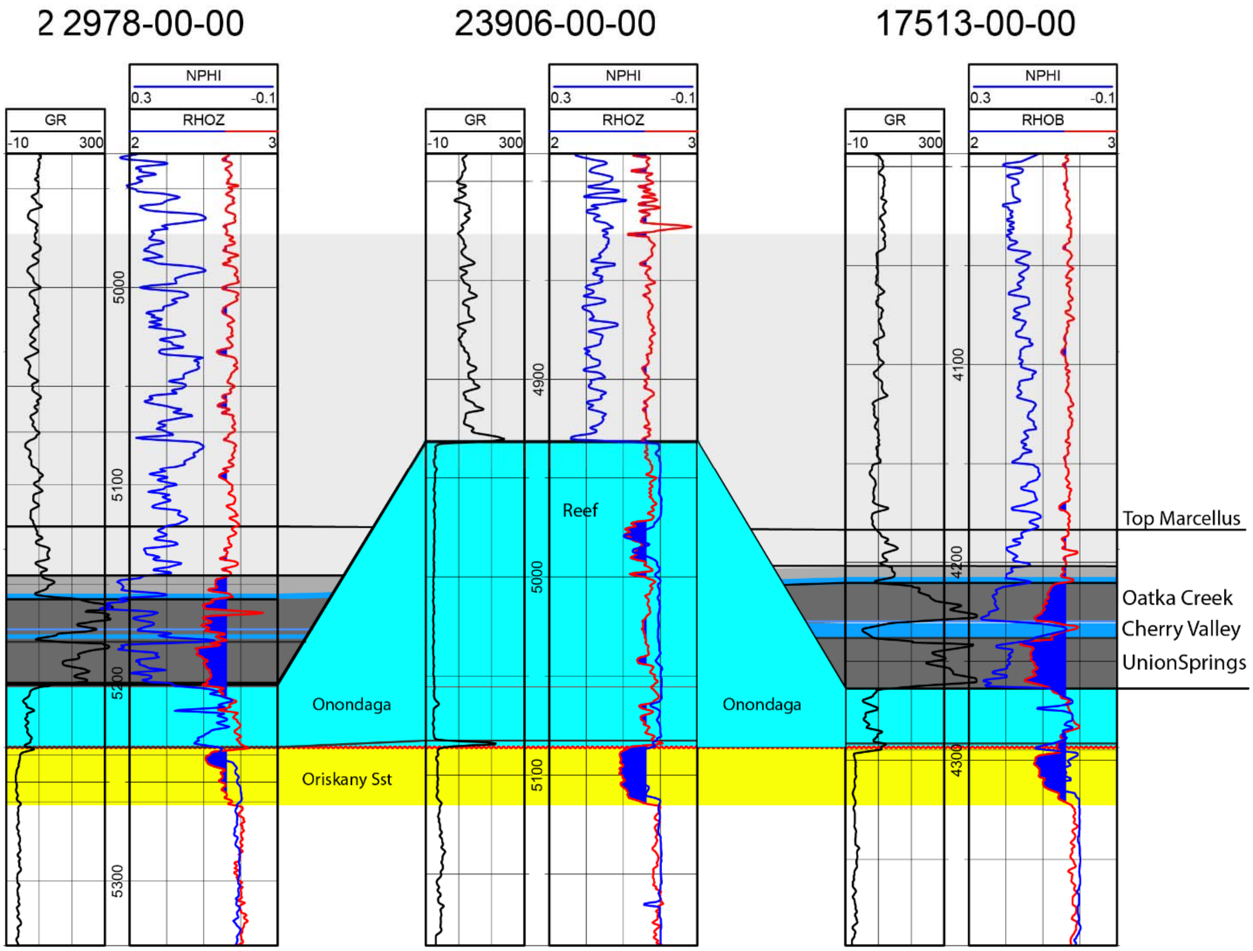


Figure 25. Log cross section showing the Onondaga Reef. The organic-rich shale does not cover the reef.

Careful examination of these shales shows reveals the presence of benthic fossils. These organisms lived on the sea floor and would have needed oxygen to survive (Figure 26). Burrowing has also been found in some of the organic-rich shales (Marathon presentation). Others have found agglutinated foraminifera, which are also benthic in origin (Scheiber, 2009; Laughrey, 2008). The presence of these fossils suggests that the water was only seasonally or periodically anoxic, and that perhaps the pycnocline (top of anoxic water zone) was coincident with the sediment-water interface. This would have prevented decay of organic matter but allowed organisms to live on the sea floor. The zone of anoxia may have extended upward into the water column seasonally or periodically (*sensu* Tyson and Pearson, 1991) but wouldn't have needed to be more than a few mm deep. Contrast that with the 100 plus meters of anoxic water in Figure 21. Many tidal flats and swamps have anoxic or dysoxic conditions just below the sediment water interface and this is a common occurrence globally. There are very few places on earth where there are tens of meters of anoxic water. These conditions do occur in the Black Sea and a few other places, but the Black Sea is something of a geological oddity that is nothing like the setting of the Marcellus Shale.

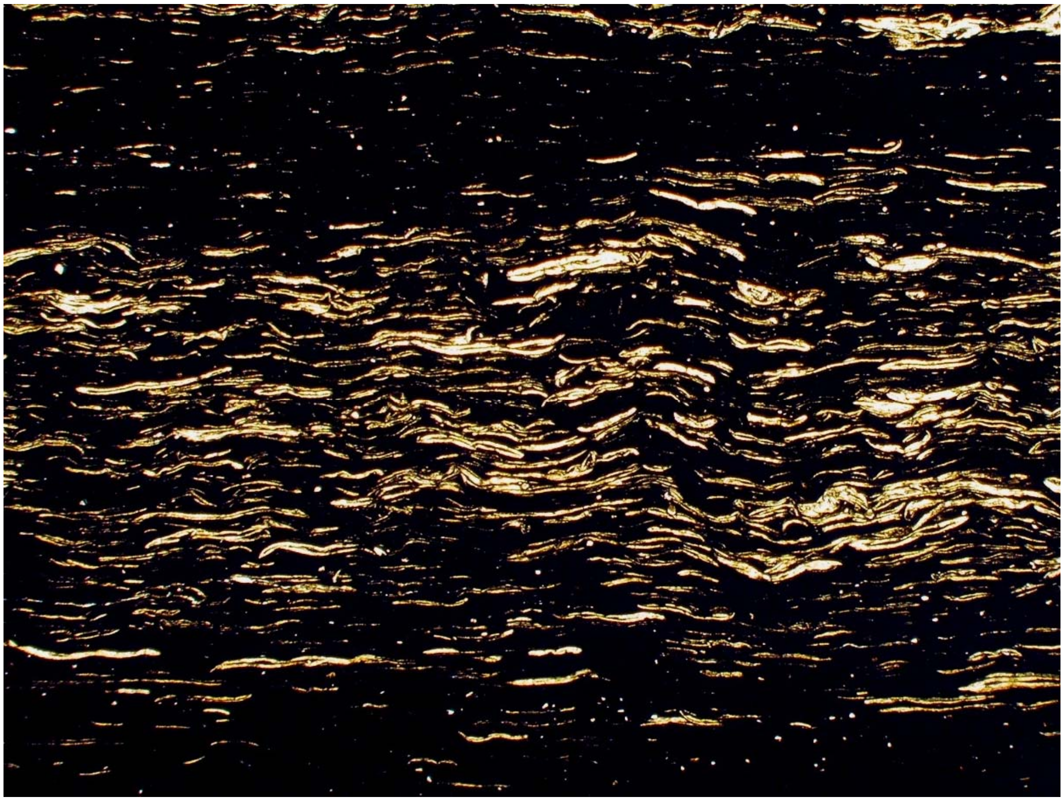


Figure 26. Bivalves or brachiopods from Union Springs Shale in sample that measured 11% TOC (Beaver Meadows Core - 1933.5 feet).

Rather than being deposited at the toe of a slope or in the deepest part of the basin, field relations suggest that black shale deposition is confined to the cratonward side of the basin. The deepest water facies are likely to be gray shales and turbidites. Gravity inhibits these siliciclastics from moving up the slope on the other side of the basin which in turn leads to greater concentration of organic matter. TOC generally increases farther to the west into what is here interpreted to have been shallower water and this is mainly due to the lack of dilution from clay and silt sourced from the mountains to the east. Exploration efforts should therefore be focused to the west of the basin axis or depocenter.

Flume experiments done by Scheiber et al. (2007) show that laminations in black shales are produced by migrating ripples and traction currents rather than deposition from suspension. Laminated shales could be deposited in currents of up to 30 cm/s and apparent flat laminations could be low angle cross laminations that have been compacted by at least 50% so they presently appear to be flat. Figure 27 shows a photograph of the Beaver Meadows core in a carbonate and TOC-rich part of the Union Springs Formation that has clear lenticular bedding which is indicative of waxing and waning energy, sometimes associated with tidal flats. These may or may not be related to tides but at the very least show periodic or episodic periods of moving currents.

Some have pointed to the lack of storm beds as proof of a deeper water origin, but if the only grains present are very small fossils, clay, and organic matter, there is not much to be ripped up and included in a storm bed. Storm beds may be represented by intervals of randomly oriented fossil clasts such as that shown in Figure 28.

Figure 27. Laminations and lenticular bedding in organic- and carbonate-rich shale. Black number is TOC content and white number is percent carbonate. Lighter colored grains are fossils made of calcium carbonate. Core is 2.5 inches across.

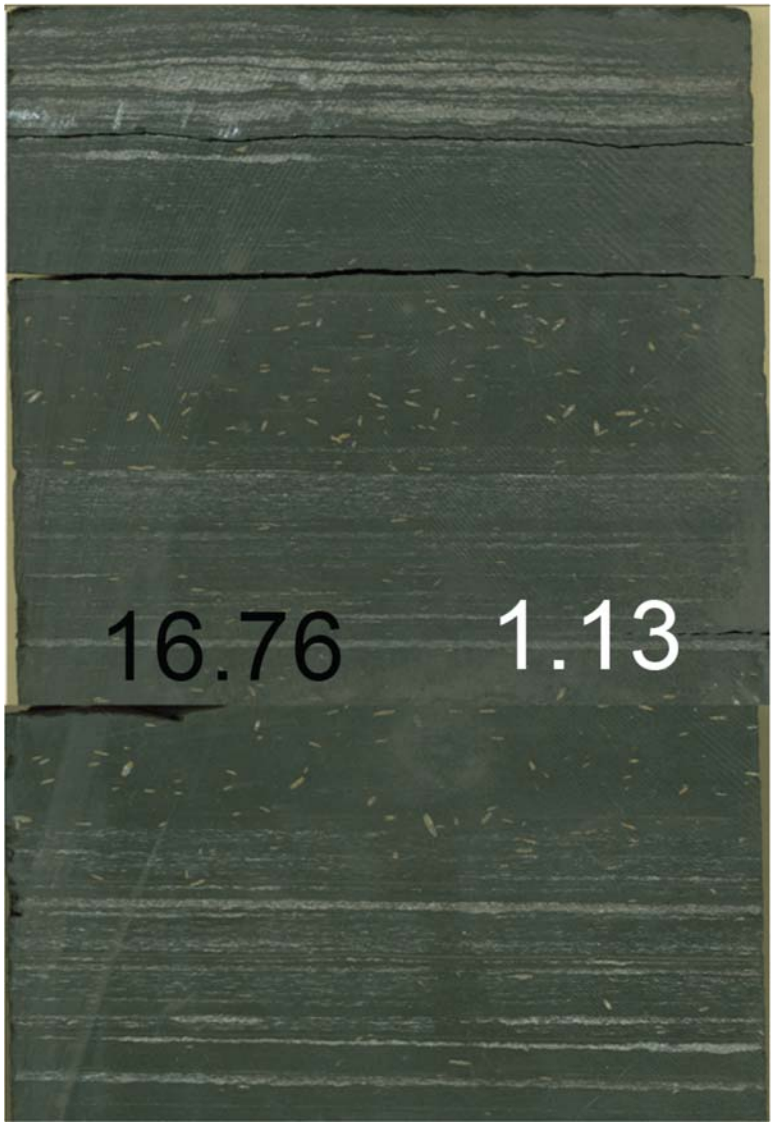


Figure 28. Intervals of laminations interbedded with intervals of randomly oriented fossil debris (lighter colored). There are two distinct intervals of chaotic bedding that could be storm beds composed of the material that is present in the laminated facies. Core is 2.5 inches across.

5.2 CARBONATE CONTENT

The amount of carbonate (typically $CaCO_3$) in a shale has a direct relationship to how brittle the formation is. Generally speaking, brittle shales respond better to hydraulic fracturing. This can be an important factor when considering the production potential of an organic-rich shale. As mentioned in Section 4.3, the organic-rich shales of the Union Springs have a relatively high carbonate content compared to that of the Oatka Creek, though all units have some intervals of high carbonate content (Appendix A). This would be considered a positive characteristic were the Union Springs of New York to be drilled and hydraulically fractured.

5.3 TOTAL ORGANIC CARBON

Only the organic-rich black shales are sources of gas and reservoirs for gas in the Marcellus. The organic matter preserved in the black shales primarily started as marine algae. Some of the algae were deposited on the sea floor, then buried before it was oxidized. As this organic material was heated during burial, it matured. During maturation, the organic matter first became kerogen, and then at about 75°C began to expel oil. The organic matter continued to expel oil with further burial and heating until it reached a temperature of about 100 to 110°C, at which point the organic matter started to expel gas along with oil. With further maturation, the organic matter finally entered the dry gas window. After all the oil had been expelled, porosity was left behind in the shale that is now filled with gas. It is that porosity that makes up most of the reservoir capacity in these shales. Consequently, the more organic matter or total organic carbon (TOC) there is, the more porosity the rocks tends to have, and the greater capacity for natural gas. In that respect, TOC is a good proxy for porosity and natural gas potential. Assuming the rock is sufficiently mature, rocks with high remaining TOC generally have high porosity and better potential for gas production. A recent study has shown that organic porosity in mature shales should equal roughly 80% of their TOC value (Schieber, 2011). So, 1.0% TOC would equal 0.8% porosity. TOC values for the Marcellus can vary greatly, however the organic rich sections of the Union Springs average about 7% TOC. This would equal 5.6% organic porosity.

TOC values can be mapped several different ways. The approach used here is to define an interval for each well with the upper limit being the first TOC values greater than 1% and the lower limit being the top of the organic-poor Onondaga. All TOC values from this interval were then averaged for the well and plotted on the map. The results of this are shown in Figure 29. TOC values generally increase from east to west until you reach the far western counties where they decrease again. The decrease in the far west may be a due to difficulties accurately sampling the very thin Marcellus Shale there.

There are two reasons TOC decreases to the east (Figure 29). One is depositional – there was much more dilution from clay and silt in the east making the overall percentage of organic matter present lower overall. The same amount of organic matter may have been preserved in the east, but it was a lower percentage of the total sediment deposited. The other reason may be thermal maturity. Thermal maturity increases to the east, and as maturation progresses, a portion of the organic carbon that turned into oil and gas can migrate out of the formation. This causes TOC values to be lower with higher thermal maturity. The lower TOC values in the far eastern part of the study area make it less appealing for production potential.

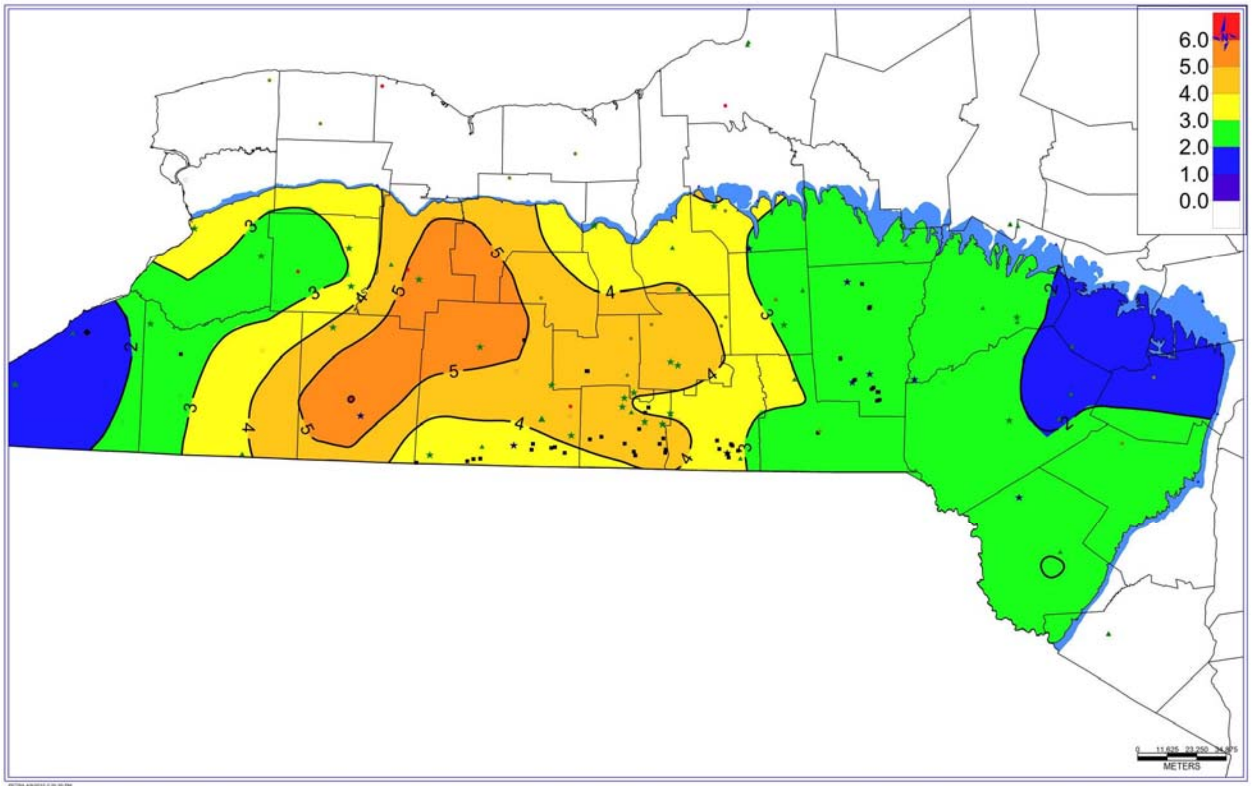


Figure 29. Average TOC values for organic-rich Marcellus. TOC generally increases to the west and decreases to the east.

5.4 THERMAL MATURITY

One important remaining question is whether there is an upper limit to thermal maturity above which gas will not flow at economic rates. It has been suggested that such a limit exists at R_o values of approximately 3.2. This idea arose from the Marcellus Shale Play in Pennsylvania where there appears to be a line separating the highly productive wells to the west from those in the east that have not produced economically. A large portion of eastern NY is above 3.2, therefore, the possibility of an upper limit in thermal maturity could play a significant role in the state's production. It is also important to note that high thermal maturity does not necessarily mean that all hydrocarbon has been burnt off. Thermal maturity is a measurement of kerogen quality. While some have speculated that thermal maturity may be the cause of uneconomical production, it may also be that changes in facies, mineralogy, structure, or pressure are the cause. At this point, it is premature to write off an area based on limited data from a different part of the basin. More wells will need to be drilled to determine if there is a thermal maturity cutoff that will affect New York's Marcellus production and where the cutoff occurs. This does make the area to the east riskier at present than areas that have lower thermal maturity values.

5.5 DRILLING IN THE MARCELLUS

Burial Depth will be a very important factor in production of the Marcellus in New York. It is not yet known how shallow wells can be drilled economically. Anecdotes from other shale basins put a cutoff at somewhere between 2,500 and 4,000 feet. The Barnett Shale is not economic to drill at depths less than 4,000 feet. The reason for this is probably the pressure. A certain amount of pressure is needed to drive the gas out of the wells at an economic rate and the pressure is generally higher at greater depths. Other shales such as the Fayetteville have been productive to depths as shallow as 3,000 feet.

There is a minimum depth of approximately 2,500 feet that is controlled by rock physics. The stress field changes between 2,000 and 3,000 feet so that the principal compressive stress rotates from vertical to horizontal. This means that induced fractures will be vertical at depths greater than ~2,500 feet and closer to horizontal at depths less than ~2,500 feet. Long horizontal wells are only worth drilling if the induced fractures are vertical, tapping into as much organic rich strata as possible. Therefore, it is very unlikely that horizontal wells will be drilled at depths less than 2,500 feet. The pressure issue may lead to a cutoff that is even deeper and many seem to agree on a cutoff of around 3,000 feet for the Marcellus in New York. The depth at which economic wells can be drilled is a key question that probably won't be answered before a number of wells are drilled at a range of depths and produced for an extended period of time. Figure 30 shows the organic-rich Marcellus greater than 2% TOC (same as Figure 18) with burial depth contours of the top of the Union Springs Formation in black.

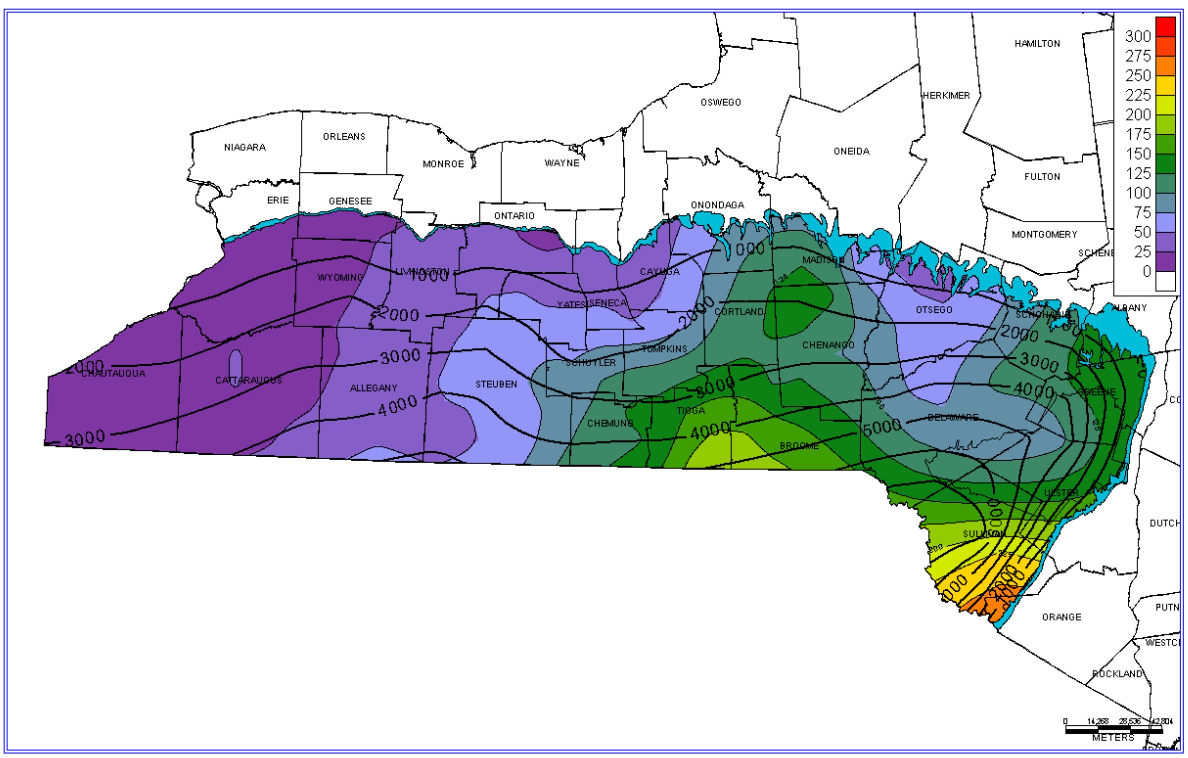


Figure 30. Organic-Rich Marcellus with a 2% TOC cut-off in Oatka Creek in colored contours (same as 5.21) and the burial depth to the top of the Union Springs in black contours.

All other things being equal, the areas on Figure 30 that are most likely to produce gas economically are where the formation is thickest and deepest. Steuben, Chemung, Tioga, Broome, Delaware and Sullivan Counties have the greatest potential based on thickness and burial depth alone. There are two other major geological factors that will also control productivity; these are TOC content and thermal maturity.

Structural complications will also play a role in the production of Marcellus in New York. During the Pennsylvanian Alleghenian Orogeny, the Union Springs Formation served as a decollement across much of the eastern Marcellus. Thrust faulting rooted in the Marcellus can lead to repeated sections as well as folded and overturned beds within the formation. This can make log correlation and mapping difficult in areas. Some wells may encounter a significantly thickened organic-rich Marcellus. These wells are generally dropped when making maps and cross sections because they make the stratigraphy look more complicated than it really is. It may become a development strategy to find areas where the organic-rich Marcellus has been repeated or thickened by thrusting. However, the natural fractures associated with that thickening are likely to have a major impact on production. Figure 31 shows a fold in the Union Springs Formation in the Oriskany Falls quarry where the Marcellus is exposed. Thrust thickening occurs across the state, but is probably more common farther to the east. This will produce heterogeneity within the reservoir where one well might encounter a single thickness of organic-rich Marcellus and a well right next to it might encounter a double thickness and produce twice as much gas.

Figure 31. Fold in the Union Springs Member of the Marcellus.

5.6 FAIRWAY MAP

All of the data produced by this project can be used to create a fairway map for the Marcellus Shale of New York. Figure 32 combines thermal maturity, thickness, and burial depth data to help define the area with greatest production potential in the state.

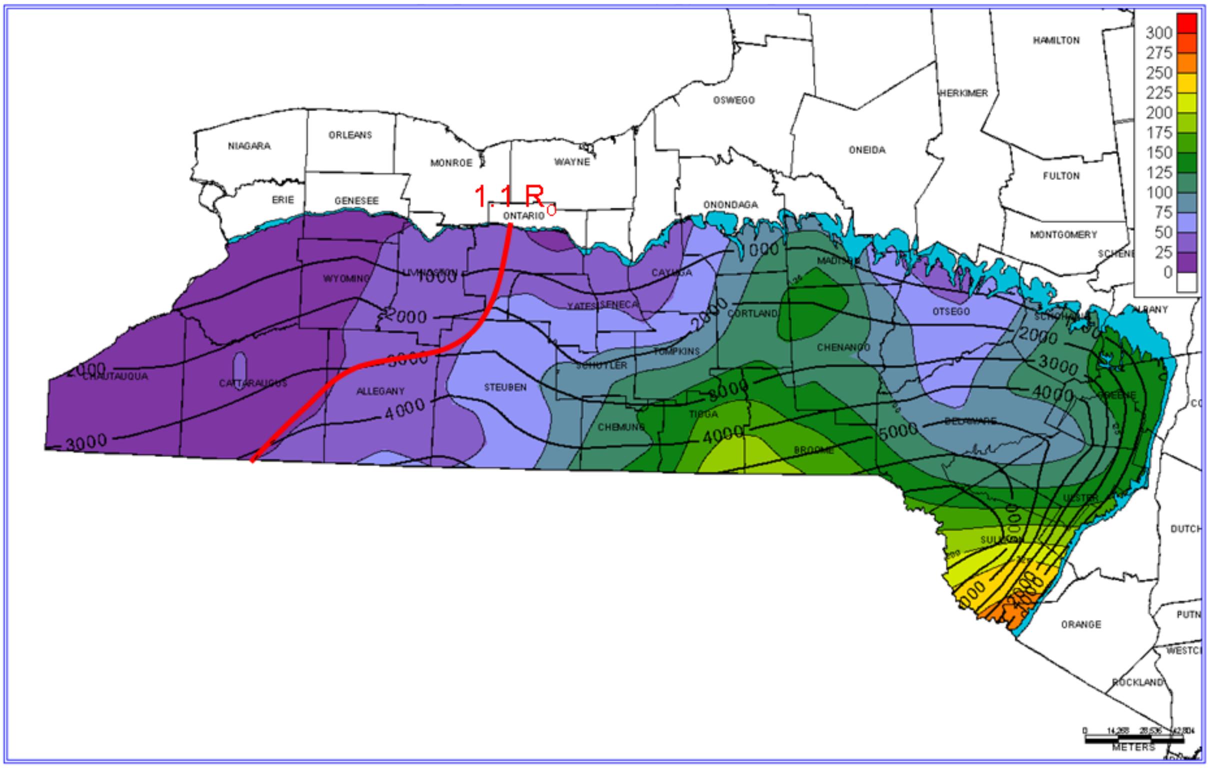


Figure 32. Combination of thermal maturity, thickness, and burial depth used to help define the fairway map.

To be productive, the Marcellus must first be present. The outcrop belt, colored light blue in Figure 32, represents the northern and eastern extents of the Marcellus. The most likely areas for gas production are to the east of the 1.1R_o line, south of the 4,000-foot burial contour, and to the west of Delaware and Sullivan Counties where thermal maturity is higher. Figure 33 uses this information and more to make a fairway map with probable and possible areas of gas and liquids production. This figure pertains to horizontal wells and associated high-volume hydraulic fracturing. It is possible that vertical wells could be drilled and hydraulically fractured at shallower burial depths.

The red area in Figure 33 is here interpreted to be the area for maximum Marcellus production. It is at least 4,000 feet deep, the organic-rich Marcellus is at least 50 feet thick, and it has thermal maturity R_o values greater than 1.1 and less than 3.2. This area is just to the north of some prolific wells drilled in northeastern PA and is very likely to produce gas economically.

The yellow area is interpreted as having a possibility for dry gas production. It is more likely to produce gas near the red area and progressively less likely to produce gas to the north, east, and west. To the north, burial depths decrease. As was previously discussed, it is not known how shallow Marcellus wells can be drilled and still be economic. There is a physical limit at around 2,500 feet where induced fractures will cease to be vertical. That would make drilling of horizontal wells impractical and uneconomic. It is around this depth that the top of the yellow area is drawn. It is possible that vertical wells may be economic at shallower depths. Therefore, Figure 33 is a fairway map for horizontal wells with high volume hydraulic fracturing. Drilling and production is the only way to really define the northern boundary of the fairway.

To the east, thermal maturity increases and TOC values decrease. The edge of the yellow possible dry gas area is drawn at the 3,000-foot burial contour, but it is likely that the true edge of economic Marcellus production is somewhere farther west, where TOC becomes too low or thermal maturity becomes too high.

The western edge of the yellow possible dry gas area is drawn at the 1.1Ro line, but the Marcellus may be too thin in Allegheny and Cattaraugus Counties to produce economically. Westward thinning of the Marcellus makes it progressively less likely that drilling will occur in that part of the state.

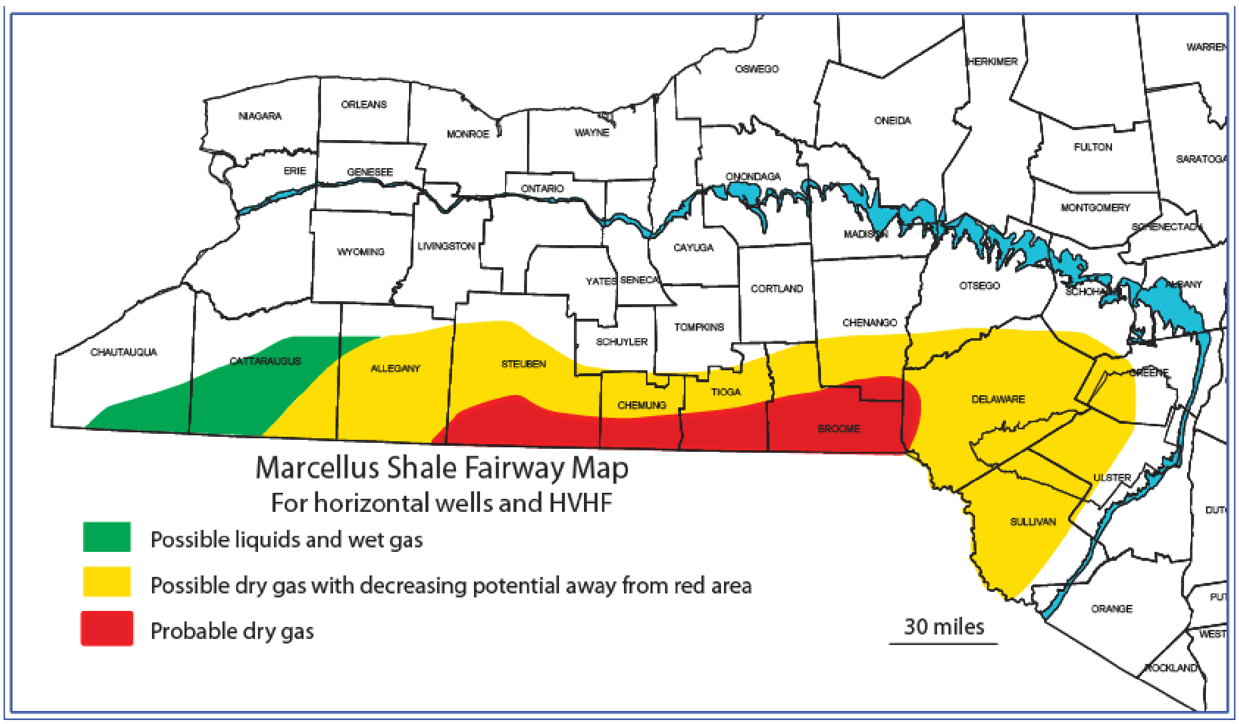


Figure 33. Marcellus Shale fairway map

The green area on the map has some potential to produce liquids from the Marcellus. Condensate is currently being produced from the Marcellus in southwest Pennsylvania. Some gas is also produced with the condensate, and together they are enough for companies to make a profit. The Marcellus is significantly thinner in western New York, but there is still some potential for liquids production in this area.

As the price of oil and gas go up, and drilling and hydraulic fracturing technologies improve, the potential of the green and yellow areas will increase. Technology is constantly improving and new technology could someday lead to a doubling, or more, of the recovery factor. That would make some areas that are currently uneconomic economic. Similarly, if the price of gas were to double, some areas that are currently uneconomic might become economic.

5.7 RESOURCE ASSESSMENT

The Marcellus Shale has the potential to produce immense quantities of gas in New York. There are many variables that factor into estimating what might eventually be produced. The geographic area, the effectiveness of the lower TOC strata at the top of the reservoir, the thrust thickening in some areas, the recovery factor, the regulatory environment, the price of gas, technological advances, and more all come into play. Right now, wells south of the state border are predicted to produce between 2 and 20 billion cubic feet (BCF) per well by one company's estimate. The DEC has stated that they would allow 6-8 wells per square mile. For this example, let us say that 8 wells are drilled per square mile and that each of them produces an average of 5 BCF over its lifetime. That would equal 40 BCF per square mile. The red area in Figure 33 is approximately 1,950 square miles. If the entire area was developed, it would yield a total of 78 trillion cubic feet (TCF) at 40 BCF/sq mi. This number would be lower if the recovery per well is lower, or if some of the red area is not economic to drill. The total could also be much higher if a significant portion of the yellow area in Figure 33 turns out to be economic. Even half of 78 TCF (39 TCF) is enough to power New York State for almost 28 years at current levels of consumption (about 1.36TCF/yr) (https://www.eia.gov/dnav/ng/ng_cons_sum_dcu_SNY_a.htm).

Section 6
CARBON SEQUESTRATION POTENTIAL

6.1 SEQUESTRATION IN SHALE

Sequestration of carbon dioxide from large stationary sources into porous and permeable rock formations is one of the techniques being developed and used around the world to help mitigate greenhouse gas emissions. Though shale is typically evaluated as a sealing unit used to prevent the escape of CO_2 from sandstone or carbonate reservoirs, organic-rich shales may also have value as potential storage units themselves. As discussed in section 5.3, TOC measurements can be used to approximate the amount of organic porosity in a shale. Based on measurements from this study, sections of the Marcellus may have an average of 5.6% porosity. This is considered an adequate amount of porosity to successfully sequester CO_2. Other characteristics such as permeability would also play a role.

6.2 SEQUESTRATION CAPACITY FROM PRODUCTION

Most permeability in the productive areas of the Marcellus is created via hydraulic fracturing, therefore sequestered CO_2 is not likely to migrate far beyond the stimulated area. One method of estimating the storage capacity of the Marcellus uses the volume of methane produced to calculate the amount of space that may be occupied by sequestered CO_2. First, the 78 Tcf of natural gas production potential from section 5.7 must be converted to reservoir barrels using a gas formation volume factor. This requires values for reservoir temperature and reservoir pressure. Both of these properties change a great deal across the Marcellus fairway as the formation depth ranges from approximately 3,000 feet in the north to 7,000 feet along the Pennsylvania border in Sullivan County. Based on the map in Figure 33, the majority of the Marcellus fairway lies between 3,000 and 5,000 feet. Formation pressure data are difficult to find for the Marcellus, therefore a graph of hydrostatic pressure published by Schlumberger Oilfield Services was used to approximate a pressure of 1,700 psia at 4,000 feet (Figure 33). Bottom hole temperatures recorded in well log headers were used to calculate an average formation temperature of 97ºF at the average depth of 4,000 feet. By entering these values into a gas formation volume factor calculator (http://www.ioilfield.com/units_correl/g_fvf.html), we find this factor is .0016 RB/scf. Therefore, 78 TCF of natural gas equals roughly 124.8 billion reservoir barrels. Assuming 9 reservoir barrels per metric ton of CO_2, this equals 13.9 Gt of CO_2 storage capacity. However, it is unrealistic to assume that all, or even most, of the space occupied by natural gas can be replaced with CO_2 after production. Formation fluids quickly migrate to fill space created during production, and the presence of this fluid reduces the sequestration potential of the reservoir. For this reason, an efficiency factor of 4% is generally used when calculating CO_2 sequestration capacities. When we apply this 4% efficiency factor to the previously calculated 13.9 Gt capacity, we arrive at 0.55 Gt. To put this into perspective, the EPA estimated New York's CO_2 output for 2014 to be 0.170 Gt (https://www.epa.gov/statelocalenergy/state-co2-emissions-fossil-fuel-combustion-1990-2014). This means that the Marcellus could sequester a little over 3 years of the state's CO_2 emissions at current rates.

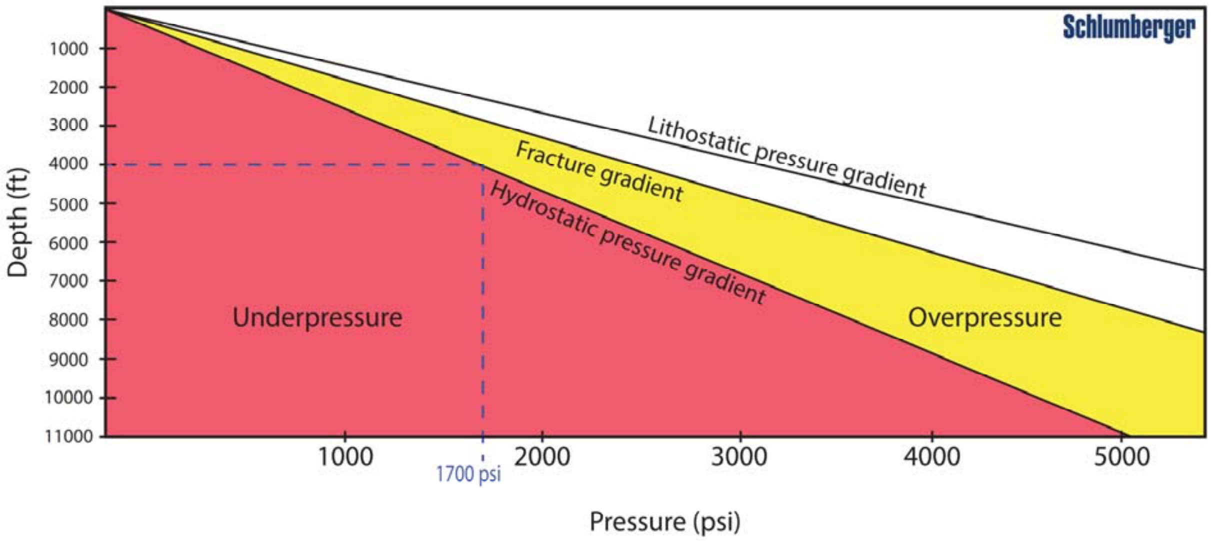


Figure 34. Graph of hydrostatic pressure gradient (modified from Schlumberger Oilfield Glossary)

6.3 SEQUESTRATION CAPACITY BY PORE VOLUME

Of the 64 wells analyzed for TOC in this study, 43 lie within the fairway outlined in Figure 33. To calculate CO_2 storage capacity from pore volume, a spreadsheet of these 43 wells was created with depth of the Marcellus, mean TOC of intervals with TOC greater than 1%, and thickness of intervals with TOC greater than 1%. Pressure values were calculated using a hydrostatic gradient of 0.44 psi/ft., and temperatures were acquired from the well log data of nearby wells. The density of CO_2 under reservoir conditions was determined using a density calculator from the National Institute of Standards and Technology (NIST) (webbook.nist.gov/chemistry/fluid/). As stated in section 5.3, porosity in an organic-rich shale is roughly equal to 80% of the TOC. The equation C=(porosity)*(thickness)*($Ƥ_{CO2}$)*(E), where $Ƥ_{CO2}$ is the density of CO_2 in pounds per cubic foot and E is an efficiency factor, was used to calculate capacity in pounds per cubic foot for each well. These capacities were then converted to tons per acre and averaged (Table 2). The average capacity per acre was then multiplied by the 4,572,800 acre (18,505 km^2) fairway area. These calculations indicate that approximately 0.53 Gt of CO_2 could be sequestered in the Marcellus fairway. This is very close to the 0.55 Gt capacity calculated in Section 6.2 using production estimates.

WELL API	TOP of Marcellus	BASE of Marcellus	MIDDLE of Marcellus	MEAN TOC (wt%)	FEET of TOC > 1%	Pressure (psi)	Temp (°F)	Density of CO_2 (lbm/ft³)	Porosity	Efficiency Factor (4%)	CO_2 Capacity (lbm/ft³)	CO_2 Capacity (lbm/acre)	CO_2 Capacity (tons/acre)
EQUATION	From Log	From Log	=(B2+C2)/2	Measured	Measured	=D2*0.44	From Log	from website	=(0.8*E2)/100	Standard	=J2*F2*I2*K2	=L2*43560	=M2/2200
31-003-11762-00-00	4280	4340	4310	4.40	50	1896	104	46.4	0.035	0.04	3.26	142211.83	64.64
31-007-05087-00-00	2430	3150	2790	3.36	240	1228	86	45.3	0.027	0.04	11.67	508529.87	231.15
31-009-09235-00-00	3620	4710	4165	1.02	40	1833	102	46.4	0.008	0.04	0.60	26328.72	11.97
31-015-00443-00-00	2928	2984	2956	6.98	10	1301	88	45.3	0.056	0.04	1.01	44070.05	20.03
31-015-10335-00-00	3220	3530	3375	2.66	80	1485	93	45.7	0.021	0.04	3.11	135426.29	61.56
31-015-23023-00-00	3300	3600	3450	3.42	170	1518	94	45.8	0.027	0.04	8.50	370346.49	168.34
31-015-23146-00-00	2800	3730	3265	4.81	80	1437	92	45.5	0.038	0.04	5.60	243931.60	110.88
31-015-23228-00-00	2800	2900	2850	4.08	30	1254	87	45.0	0.033	0.04	1.76	76736.55	34.88
31-015-23913-00-00	3060	3170	3115	3.41	30	1371	90	45.4	0.027	0.04	1.49	64848.46	29.48
31-017-10608-00-00	3420	3625	3523	3.06	210	1550	95	45.8	0.024	0.04	9.39	409186.95	185.99
31-017-10609-00-00	3070	3640	3355	2.00	70	1476	93	45.6	0.016	0.04	2.04	88951.59	40.43
31-025-04214-00-00	4800	5500	5150	1.92	350	2266	114	46.6	0.015	0.04	10.03	436708.90	198.50
31-025-04364-00-00	3790	4050	3920	2.35	210	1725	99	46.4	0.019	0.04	7.32	318879.77	144.95
31-025-04379-00-00	4120	4730	4425	2.03	380	1947	105	46.5	0.016	0.04	11.46	499317.52	226.96
31-025-04455-00-00	3100	3330	3215	2.38	150	1415	91	45.8	0.019	0.04	5.23	227932.82	103.61
31-025-10096-00-00	4480	5320	4900	1.96	120	2156	111	46.6	0.016	0.04	3.51	153026.82	69.56
31-039-03904-00-00	3900	4140	4020	1.56	10	1769	101	46.2	0.012	0.04	0.23	10047.13	4.57
31-077-10838-00-00	3200	3470	3335	2.68	220	1467	93	45.5	0.021	0.04	8.59	374170.77	170.08
31-095-10263-00-00	3050	3290	3170	1.10	160	1395	91	45.6	0.009	0.04	2.57	112017.21	50.92
31-097-21495-00-00	3380	3520	3450	3.70	60	1518	94	45.8	0.030	0.04	3.25	141728.90	64.42
31-097-26017-00-00	3000	3300	3150	3.38	110	1386	90	45.8	0.027	0.04	5.45	237200.58	107.82
31-101-00167-00-00	3947	4016	3982	3.44	50	1752	100	46.2	0.028	0.04	2.54	110773.94	50.35
31-101-03924-00-00	3960	4080	4020	3.36	90	1769	101	46.1	0.027	0.04	4.46	194314.65	88.32
31-101-21468-00-00	3090	3200	3145	1.99	60	1384	90	45.6	0.016	0.04	1.75	76067.73	34.58
31-101-22908-00-00	3260	3370	3315	6.56	90	1459	92	45.9	0.053	0.04	8.67	377596.24	171.63
31-101-22978-00-00	4900	5250	5075	3.91	50	2233	113	46.8	0.031	0.04	2.93	127467.28	57.94
31-101-23055-00-00	3450	3520	3485	4.43	60	1533	94	46.1	0.035	0.04	3.92	170929.88	77.70
31-101-23085-00-00	3740	3900	3820	3.36	110	1681	98	46.1	0.027	0.04	5.45	237499.54	107.95
31-101-23101-00-00	3220	3340	3280	4.64	110	1443	92	45.6	0.037	0.04	7.44	324141.16	147.34
31-101-23155-00-00	2600	3090	2845	1.61	170	1252	87	45.0	0.013	0.04	3.93	171031.23	77.74
31-101-23190-00-00	3110	3600	3355	2.79	180	1476	93	45.6	0.022	0.04	7.32	318889.87	144.95
31-101-23968-00-00	3500	3900	3700	1.15	90	1628	97	45.9	0.009	0.04	1.52	66351.91	30.16
31-101-23985-00-00	3400	3660	3530	4.45	50	1553	95	45.8	0.036	0.04	3.26	141940.17	64.52
31-101-26011-00-00	3400	3640	3520	6.15	110	1549	95	45.9	0.049	0.04	9.94	433088.66	196.86
31-105-12861-00-00	6660	7670	7165	2.18	560	3153	137	47.3	0.017	0.04	18.48	804832.04	365.83
31-107-22887-00-00	4300	4830	4565	2.33	260	2009	107	46.6	0.019	0.04	9.04	393643.29	178.93
31-107-23192-00-00	4460	4655	4558	3.35	200	2005	107	46.4	0.027	0.04	9.96	434001.70	197.27
31-107-23883-00-00	3800	4200	4000	3.20	170	1760	100	46.4	0.026	0.04	8.08	352049.64	160.02
31-107-23927-00-00	3150	3330	3240	3.34	150	1426	91	45.8	0.027	0.04	7.34	319946.17	145.43
31-107-23996-00-00	3600	4000	3800	4.61	120	1672	98	46.1	0.037	0.04	8.15	355016.42	161.37
31-107-26158-00-00	4230	4620	4425	3.47	200	1947	105	46.5	0.028	0.04	10.32	449379.35	204.26
31-107-26426-00-00	4110	4290	4200	2.43	170	1848	103	46.2	0.019	0.04	6.11	266082.18	120.95
31-111-03199-00-00	4790	5230	5010	2.12	90	2204	112	46.8	0.017	0.04	2.86	124422.22	56.56

Average Capacity (tons/acre)	114.92
Capacity for NY Marcellus Fairway (gigatons)	0.53

Table 2. CO_2 capacity calculations based on TOC pore volume

6.4 SEQUESTRATION WITH ADSORPTION

Calculating the Marcellus' storage capacity based on methane production alone may give a rough approximation of the amount of CO_2 that the formation can hold, however it does not take into consideration the adsorption of CO_2 and release of additional methane (CH_4) that will occur as the sequestered CO_2 interacts with the shale. Recent studies have found that CO_2 has an adsorption capacity 5 to 10 times greater than CH_4 (Kang et al, 2010). This means that capacity calculations made using estimates of production alone may be skewed toward lower values because additional methane will be released as the shale reacts with CO_2.

Dr. Brandon Nuttall of the Kentucky Geological Survey, working as part of the Midewest Regional Carbon Sequestration Partnership (MRCSP), has developed a method to account for adsorption while calculating sequestration storage capacity (Nutall et al., 2005). Field tests for CO_2 adsorption in the Marcellus Shale of Kentucky were used by Nuttall to derive a relationship between adsorption and TOC at 400 psia (Figure 35). While the pressure of the Marcellus in the New York fairway is significantly higher than that used in Nuttall's study (5 times greater in some places), we lack the means to repeat his field tests at deeper depths and have elected to use the equation from his study until more appropriate adsorption data are collected.

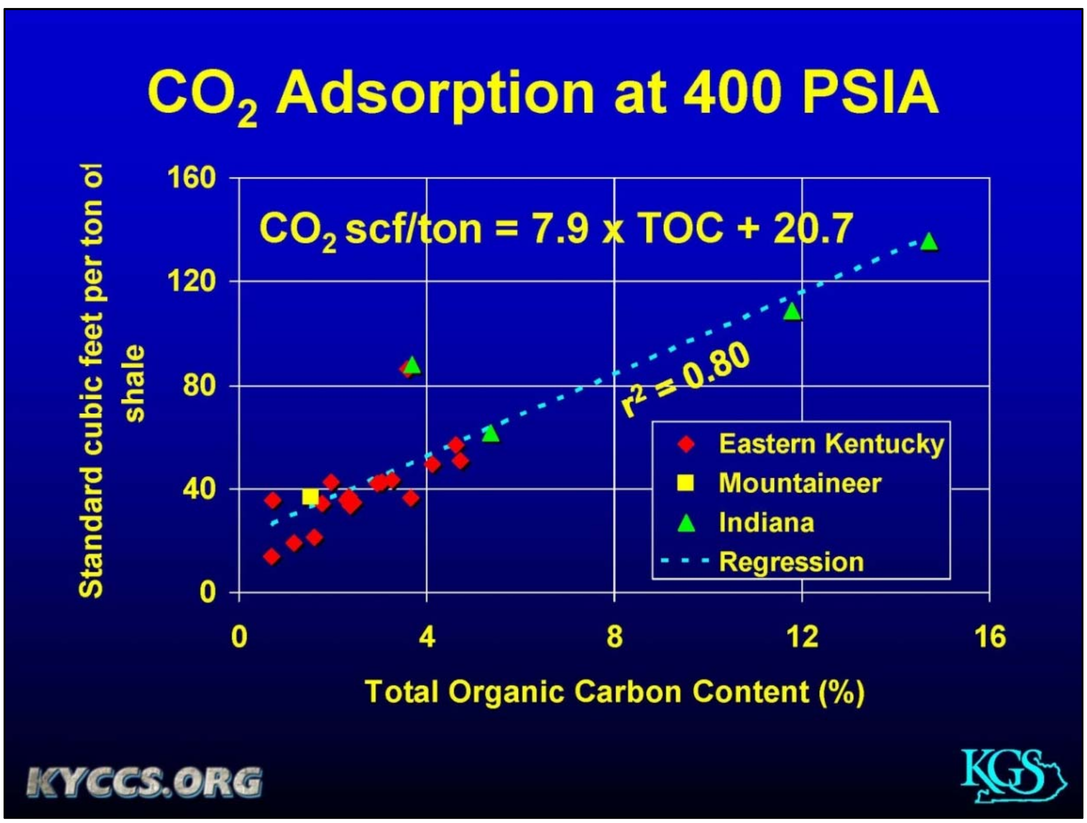


Figure 35. Graph of CO_2 adsorption vs. TOC from Kentucky Geological Survey field work (from Dr. Brandon Nuttall, Kentucky Geological Survey)

Using the average TOC value for each of the 43 wells in the fairway and the thickness of TOC greater than 1%, the equation developed by Nuttall was applied to calculate the storage capacity for the one square kilometer area surrounding each well. These results were then used to derive an average capacity per square kilometer of fairway. By multiplying this average by the 18,505 km^2 area of defined fairway, we estimate a capacity of approximately 0.18 Gt of CO_2 (Table 3). It is important to note that although this estimate may be low due to the reduced pressure used in the adsorption coefficient, it is also partially skewed toward a higher capacity because, like the pore volume capacity calculation, it assumes the entire area of the fairway will be accessible for sequestration.

6.5 CAPACITY COMPARISON

Of the three CO_2 storage potentials calculated above, the capacity estimate with adsorption was the lowest. This is surprising considering adsorption should allow for the storage of additional CO_2 beyond that of free gas replacement alone. As mentioned in section 6.4 this likely due to the use of an absorption coefficient derived from fieldwork at significantly lower pressures.

It is also important to note that the capacities based on pore volume and production are not without their own uncertainties. The TOC data acquired in this study were collected using strict laboratory practices to ensure the highest possible accuracy. The carbon coulometer was sent to UIC for a complete manufacturer calibration at the beginning of the study. Duplicate samples were run every 10 samples to test consistency, and blanks were run every 8 samples to recalculate background CO_2. However, these TOC values were then used in calculations that make broad assumptions such as 1.0 wt% TOC = 0.8% porosity. Also, the projected production of 78 Tcf used in Section 6.2 was derived from production records of the Marcellus in Pennsylvania, even though the Marcellus will certainly not be equally productive across the entire area. Perhaps the most significant caveat to these estimates is well distribution across the fairway. As mentioned in section 6.3, only 43 of the 100 wells sampled in this study lie within the Marcellus fairway we have defined. In both the pore volume and adsorption methods, the final capacity was calculated by averaging those 43 individual well capacities, then multiplying that value by the area of the fairway. Each of those 43 values were treated equally although their locations do not represent an even distribution across the fairway area. It may be the case that more wells lie in an area of higher capacity thereby shifting the average and final capacity to an inflated value. These discrepancies show the need for more data and a refinement of the method used to calculate storage capacities in shale.

WELL API	TOP of Marcellus	BASE of Marcellus	MEAN TOC (wt%)	FEET of TOC > 1%	MEAN Density	Tons of Shale per km²ft	CO_2 Adsorption @ 400 PSIA	CO_2 Capacity (mcf/km²ft)	CO_2 Capacity conversion (tons/km²ft)	Efficiency factor (4%)	CO_2 capacity of km² around well
EQUATION	From Log	From Log	Measured	Measured	From Log	= 302000*F2	= (7.9*D2)+20.7	=(G2*H2)/1000	= I2*0.052	Standard	= J2*K2*E2
31-003-11762-00-00	4280	4340	4.40	50	2.62	791240	55	43894.67	2282.52	0.04	4565.05
31-007-05087-00-00	2430	3150	3.36	240	2.50	755000	47	35665.04	1854.58	0.04	17803.99
31-009-09235-00-00	3620	4710	1.02	40	2.60	785200	29	22569.15	1173.60	0.04	1877.75
31-015-00443-00-00	2928	2984	6.98	10	2.67	806340	76	61154.44	3180.03	0.04	1272.01
31-015-10335-00-00	3220	3530	2.66	80	2.62	791240	42	32976.17	1714.76	0.04	5487.24
31-015-23023-00-00	3300	3600	3.42	170	2.62	791240	48	37727.80	1961.85	0.04	13340.55
31-015-23146-00-00	2800	3730	4.81	80	2.69	812380	59	47669.85	2478.83	0.04	7932.26
31-015-23228-00-00	2800	2900	4.08	30	2.55	770100	53	40742.65	2118.62	0.04	2542.34
31-015-23913-00-00	3060	3170	3.41	30	2.57	776140	48	36994.97	1923.74	0.04	2308.49
31-017-10608-00-00	3420	3625	3.06	210	2.57	776140	45	34799.31	1809.56	0.04	15200.34
31-017-10609-00-00	3070	3640	2.00	70	2.70	815400	36	29752.90	1547.15	0.04	4332.02
31-025-04214-00-00	4800	5500	1.92	350	2.62	791240	36	28373.86	1475.44	0.04	20656.17
31-025-04364-00-00	3790	4050	2.35	210	2.62	791240	39	31061.25	1615.19	0.04	13567.55
31-025-04379-00-00	4120	4730	2.03	380	2.62	791240	37	29046.91	1510.44	0.04	22958.68
31-025-04455-00-00	3100	3330	2.38	150	2.62	791240	40	31261.65	1625.61	0.04	9753.63
31-025-10096-00-00	4480	5320	1.96	120	2.57	776140	36	28108.32	1461.63	0.04	7015.84
31-039-03904-00-00	3900	4140	1.56	10	2.62	791240	33	26129.91	1358.76	0.04	543.50
31-077-10838-00-00	3200	3470	2.68	220	2.65	800300	42	33524.53	1743.28	0.04	15340.83
31-095-10263-00-00	3050	3290	1.10	160	2.67	806340	29	23713.84	1233.12	0.04	7891.97
31-097-21495-00-00	3380	3520	3.70	60	2.59	782180	50	39074.84	2031.89	0.04	4876.54
31-097-26017-00-00	3000	3300	3.38	110	2.62	791240	47	37484.08	1949.17	0.04	8576.36
31-101-00167-00-00	3947	4016	3.44	50	2.62	791240	48	37868.90	1969.18	0.04	3938.37
31-101-03924-00-00	3960	4080	3.36	90	2.62	791240	47	37401.14	1944.86	0.04	7001.49
31-101-21468-00-00	3090	3200	1.99	60	2.55	770100	36	28068.09	1459.54	0.04	3502.90
31-101-22908-00-00	3260	3370	6.56	90	2.62	791240	73	57401.88	2984.90	0.04	10745.63
31-101-22978-00-00	4900	5250	3.91	50	2.62	791240	52	40813.03	2122.28	0.04	4244.56
31-101-23055-00-00	3450	3520	4.43	60	2.65	800300	56	44601.92	2319.30	0.04	5566.32
31-101-23085-00-00	3740	3900	3.36	110	2.62	791240	47	37374.13	1943.45	0.04	8551.20
31-101-23101-00-00	3220	3340	4.64	110	2.62	791240	57	45365.31	2359.00	0.04	10379.58
31-101-23155-00-00	2600	3090	1.61	170	2.69	812380	33	27119.37	1410.21	0.04	9589.41
31-101-23190-00-00	3110	3600	2.79	180	2.62	791240	43	33795.43	1757.36	0.04	12653.01
31-101-23968-00-00	3500	3900	1.15	90	2.67	806340	30	24025.97	1249.35	0.04	4497.66
31-101-23985-00-00	3400	3660	4.45	50	2.60	785200	56	43840.72	2279.72	0.04	4559.44
31-101-26011-00-00	3400	3640	6.15	110	2.62	791240	69	54849.82	2852.19	0.04	12549.64
31-105-12861-00-00	6660	7670	2.18	560	2.62	791240	38	29991.54	1559.56	0.04	34934.15
31-107-22887-00-00	4300	4830	2.33	260	2.66	803320	39	31418.32	1633.75	0.04	16991.02
31-107-23192-00-00	4460	4655	3.35	200	2.62	791240	47	37334.46	1941.39	0.04	15531.14
31-107-23883-00-00	3800	4200	3.20	170	2.68	809360	46	37204.52	1934.63	0.04	13155.52
31-107-23927-00-00	3150	3330	3.34	150	2.60	785200	47	36984.75	1923.21	0.04	11539.24
31-107-23996-00-00	3600	4000	4.61	120	2.62	791240	57	45179.99	2349.36	0.04	11276.93
31-107-26158-00-00	4230	4620	3.47	200	2.62	791240	48	38041.05	1978.13	0.04	15825.08
31-107-26426-00-00	4110	4290	2.43	170	2.62	791240	40	31569.94	1641.64	0.04	11163.13
31-111-03199-00-00	4790	5230	2.12	90	2.62	791240	37	29617.99	1540.14	0.04	5544.49

no RHOB curve, used average

Average Capacity (tons/km²): 9,804

Capacity for NY Marcellus Fairway (gigatons): 0.18

Table 3. CO_2 capacity calculations with adsorption

Section 7
CONCLUSIONS

The Marcellus Shale in New York has potential to produce gas over a wide area, but there are a few variables that must be considered when evaluating this formation as a gas reservoir.

On the negative side, more than a third of the samples analyzed for rock-eval had S_2 values less than 0.2. This suggests there is a portion of the study area that may be considered supermature. Although being supermature is not encouraging, it does not indicate the absence of gas, only that all the kerogen that could have cracked to gas has done so and there is no potential to make more gas. If the existing gas has not escaped, a supermature shale may still produce economic amounts of gas.

On the positive side, the organic-rich Marcellus occurs across a large area (7,145 square miles) and TOC values are in the range of productive shales in other parts of the country. It is also quite thick in places, with one well having 630 feet of TOC greater than 3 wt%, and several others having over 100 feet of strata with greater than 3 wt% TOC. The Marcellus Shale in this area is buried deeply enough to drill horizontal wells and hydraulically fracture them across a wide area.

Sequestering carbon dioxide in organic-rich shales is a relatively new concept and therefore the methods for calculating storage capacity are still in development. We have presented estimated storage capacities for the Marcellus fairway in NY using three techniques: potential production, pore volume, and adsorption. Although these capacities vary, they all suggest that there is enough storage capacity in the productive part of the Marcellus in NY to sequester all the state's CO_2 output for over a year. However, the depth of the Marcellus may be an issue in parts of the fairway as a 2,500 foot (0.76 km) reservoir depth is required to meet the pressure and temperature requirements for supercritical CO_2 and there must still be space for a sufficient cap rock to prevent upward migration of the sequestered CO_2.

Section 8
REFERENCES:

BAIRD, G.C., BRETT, C.E. 1991. Submarine erosion on the anoxic seafloor, paleoenvironmental and temporal significance of reworked pyrite-bone deposits, 223–257. In TYSON, R.V. & PEARSON, T.H. (eds) Modern and Ancient Continental Shelf Anoxia. Geological Society Special Publication 58.

CONANT, L.C. & SWANSON, V.E. 1961. Chattanooga shale and related rocks of central Tennessee and nearby areas, USGS Professional Paper 357.

HECKEL, P. H., 1966. Stratigraphy, petrography, and depositional environment of the Tully Limestone (Devonian) in New York State and adjacent region (doctoral dissertation), Rice University, Retrieved from University Microfilms, Inc. (66-10, 346), 451 p.

HOUSE, M.R., KIRCHGASSER, W.T. 1993. Devonian goniatite biostratigraphy and timing of facies movements in the Frasnian of Eastern North America, Geological Society, London, Special Publication 70, p. 267–292.

LAUGHREY, C.D., 2008. Thermal maturity of Devonian black shale-gas reservoirs, Northwestern Pennsylvania – Evidence from organic petrology, geochemistry, and mineralogy, presented at AAPG Eastern Section Meeting, Pittsburgh, Pennsylvania.

KANG, S.M., FATHI, E., AMBROSE, R.J., AKKUTLU, I.Y., SIGAL, R.F., 2010. Carbon dioxide storage capacity of organic-rich shales. SPE 134583, p. 1–17.

NUTALL, B. C., J. A. Drahovsal, C. Eble and R. M. Bustin, 2005a, CO2 Sequestration in Gas Shales of Kentucky, Search and Discovery Article #40171, www.searchanddiscovery.net/documents/2005/nutall/index.htm

PETERS, K.E., CASSA, M.R., 1994, Applied source rock geochemistry, in Magoon, L.B., and Dow, W.G., eds., The petroleum system—From source to trap: Tulsa, Okla., American Association of Petroleum Geologists Memoir 60, p. 93-117.

ROGERS, W. B., ISACHSEN, Y. W., MOCK, T. D., NYAHAY, R. E., 1990, New York State Geological Highway Map, Educational Leaflet 33.

SCHIEBER, J., 1998, Developing a Sequence Stratigraphic Framework for the Late Devonian Chattanooga Shale of the southeastern US: Relevance for the Bakken Shale. In: J.E. Christopher, C.F. Gilboy, D.F. Paterson, and S.L. Bend (eds.), Eight International Williston Basin Symposium, Saskatchewan Geological Society Special Publication No. 13, p. 58-68.

SCHIEBER, J., SOUTHARD, J.B., and THAISEN, K., 2007, Accretion of Mudstone Beds from Migrating Floccule Ripples, Science, v. 318, p. 1760-1763.

SCHIEBER, J., 2009, Discovery of Agglutinated Benthic Foraminifera in Devonian Black Shales and Their Relevance for the Redox State of Ancient Seas. Paleogeography, Paleoclimatology, Paleoecology, v. 271, p. 292-300.

SCHIEBER, J., 2011, Summary of SEM Observations on Ion-Milled Samples from Beaver Meadows Core, New York, Unpublished Report, Bloomington, Indiana: Indiana University.

SMITH, L. B., LEONE, J., 2010, Integrated Characterization of Utica and Marcellus Black Shale Gas Plays, New York State, AAPG Search and Discovery Article #50289

SMITH, L. B., LEONE, J., 2010, An in-depth Study of the Beaver Meadow and 74-NY-5 Cores from the Ordovician Utica and Devonian Marcellus Shales, New York State, AAPG Search and Discovery Article #90116

TISSOT, B.P., WELTE, D.H., 1984, Petroleum formation and occurrence. Springer-Verlag, New York, 699 pp.

TYSON, R.V., PEARSON, T.H. 1991. Modern and ancient continental shelf anoxia: an overview, Geological Society, London, Special Publication 58, p. 1–24.

VER STRAETEN, C. A., 2009, The classic Devonian of the Catskill front: A foreland basin record of Acadian orogenesis. *In* Vollmer, F., ed., New York State Geological Association, Annual Fieldtrip guidebook, New Paltz, p. 7-1 to 7-54.

VER STRAETEN, C. A., BRETT, E. B., SAGEMAN, B. B., 2011, Mudrock sequence stratigraphy: A multi-proxy (sedimentological, palaeobiological and geochemical) approach, Devonian Appalachian Basin, Palaeogeogrpahy, Palaeoclimatlology, Palaeoecology, v. 304, p. 53-73

WEARY, D.J., RYDER, R.T., and NYAHAY, R., 2000, Thermal maturity patterns (CAI and %Ro) in the Ordovician and Devonian of the Appalachian Basin in New York State: U.S. Geological Survey Open-File Report, no. 00-496, 39 p.

WEBSITES:

Deep Time Maps. Ron Blakey: https://deeptimemaps.com/

iOilfield Oil & Gas Calculations: http://ioilfield.com/units_correl/g_fvf.html

National Institute of Standards and Technology, Chemistry WebBook: http://webbook.nist.gov/cgi/fluid.cgi?ID=C124389&TUnit=F&PUnit=psia&DUnit=lbm%2Fft3&HUnit=kJ%2Fmol&WUnit=m%2Fs&VisUnit=uPa*s&STUnit=N%2Fm&Type=IsoTherm&RefState=DEF&Action=Page

Oil and Gas Window: http://oilandgasgeology.com/

Schlumberger Oilfield Glossary: http://www.glossary.oilfield.slb.com/Terms/h/hydrostatic_pressure.aspx

Shale Profile, Marcellus production in Pennsylvania: https://shaleprofile.com/index.php/2017/04/25/marcellus-pa-update-through-january-2017/

UIC Inc., CM180 Carbon Analyzer: http://www.uicinc.com/cm180/

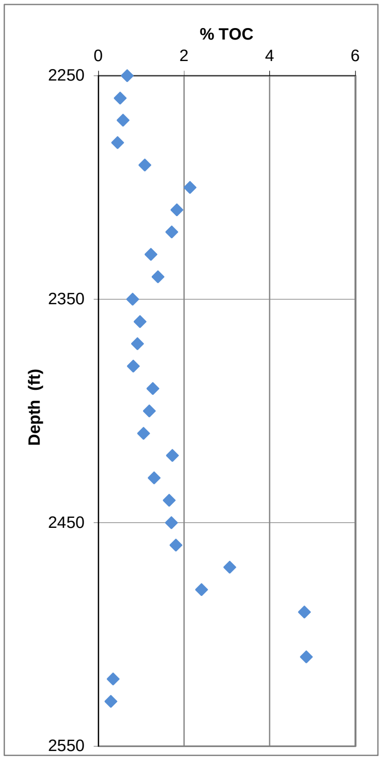
United States Energy Information Administration, NY natural gas consumption: https://www.eia.gov/dnav/ng/ng_cons_sum_dcu_SNY_a.htm

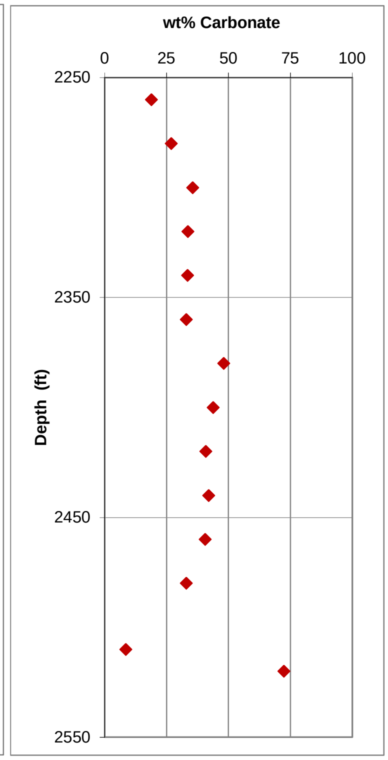
United States Environmental Protection Agency, CO_2 Emissions: https://www.epa.gov/statelocalenergy/state-co2-emissions-fossil-fuel-combustion-1990-2014

APPENDIX A

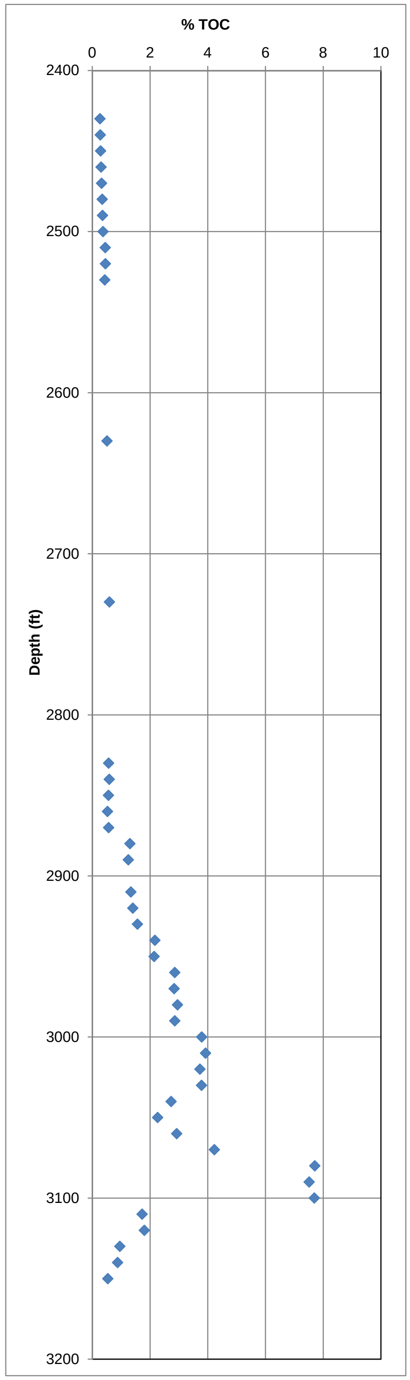
TOC and Carbonate Content Analyses

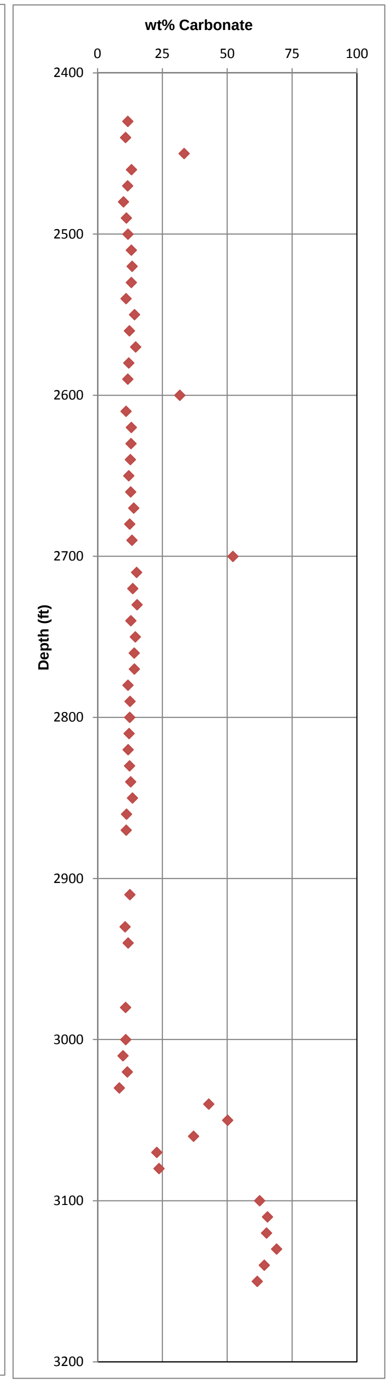
31-003-04248-00-00			
API	**Depth (ft)**	**% TOC**	**wt% Carbonate**
31-003-04248-00-00	2250	0.67	
31-003-04248-00-00	2260	0.50	18.87
31-003-04248-00-00	2270	0.58	
31-003-04248-00-00	2280	0.45	26.85
31-003-04248-00-00	2290	1.08	
31-003-04248-00-00	2300	2.13	35.49
31-003-04248-00-00	2310	1.83	
31-003-04248-00-00	2320	1.71	33.57
31-003-04248-00-00	2330	1.22	
31-003-04248-00-00	2340	1.39	33.48
31-003-04248-00-00	2350	0.80	
31-003-04248-00-00	2360	0.97	32.94
31-003-04248-00-00	2370	0.91	
31-003-04248-00-00	2380	0.81	48.06
31-003-04248-00-00	2390	1.27	
31-003-04248-00-00	2400	1.19	43.84
31-003-04248-00-00	2410	1.05	
31-003-04248-00-00	2420	1.73	40.82
31-003-04248-00-00	2430	1.30	
31-003-04248-00-00	2440	1.65	41.96
31-003-04248-00-00	2450	1.70	
31-003-04248-00-00	2460	1.81	40.58
31-003-04248-00-00	2470	3.06	
31-003-04248-00-00	2480	2.41	32.93
31-003-04248-00-00	2490	4.81	
31-003-04248-00-00	2510	4.85	8.49
31-003-04248-00-00	2520	0.34	72.31
31-003-04248-00-00	2530	0.29	
Duplicates			
31-003-04248-00-00	1470-2	1.43	
31-003-04248-00-00	1690-2	0.50	
31-003-04248-00-00	1820-2	0.71	
31-003-04248-00-00	2060-2	0.47	
31-003-04248-00-00	2190-2	0.96	
31-003-04248-00-00	2420-2	1.72	
31-003-04248-00-00	2500-3	10.20	



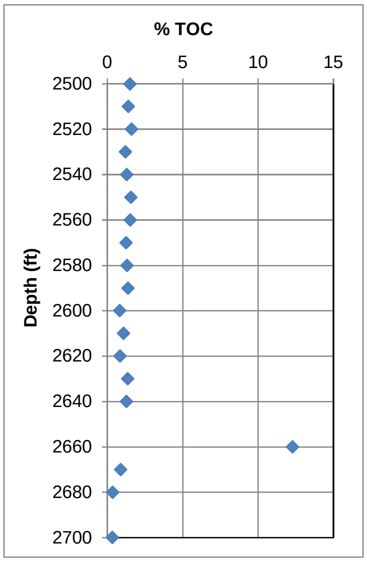


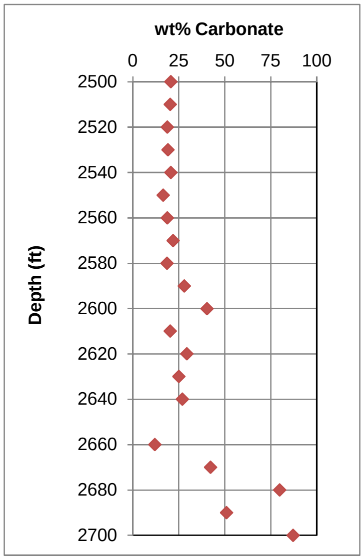
31-007-05087-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-007-05087-00-00	2430	0.26	11.58
31-007-05087-00-00	2440	0.27	10.73
31-007-05087-00-00	2450	0.29	33.35
31-007-05087-00-00	2460	0.30	13.03
31-007-05087-00-00	2470	0.32	11.58
31-007-05087-00-00	2480	0.34	9.95
31-007-05087-00-00	2490	0.35	11.08
31-007-05087-00-00	2500	0.37	11.67
31-007-05087-00-00	2510	0.44	12.94
31-007-05087-00-00	2520	0.45	13.26
31-007-05087-00-00	2530	0.43	12.99
31-007-05087-00-00	2540		10.96
31-007-05087-00-00	2550		14.18
31-007-05087-00-00	2560		12.21
31-007-05087-00-00	2570		14.61
31-007-05087-00-00	2580		11.99
31-007-05087-00-00	2590		11.64
31-007-05087-00-00	2600		31.68
31-007-05087-00-00	2610		10.95
31-007-05087-00-00	2620		12.96
31-007-05087-00-00	2630	0.51	12.88
31-007-05087-00-00	2640		12.60
31-007-05087-00-00	2650		12.01
31-007-05087-00-00	2660		12.75
31-007-05087-00-00	2670		13.86
31-007-05087-00-00	2680		12.32
31-007-05087-00-00	2690		13.23
31-007-05087-00-00	2700		52.17
31-007-05087-00-00	2710		15.02
31-007-05087-00-00	2720		13.52
31-007-05087-00-00	2730	0.59	15.19
31-007-05087-00-00	2740		12.80
31-007-05087-00-00	2750		14.48
31-007-05087-00-00	2760		14.10
31-007-05087-00-00	2770		14.13
31-007-05087-00-00	2780		11.66
31-007-05087-00-00	2790		12.45
31-007-05087-00-00	2800		12.37
31-007-05087-00-00	2810		12.12
31-007-05087-00-00	2820		11.74
31-007-05087-00-00	2830	0.56	12.28
31-007-05087-00-00	2840	0.58	12.70
31-007-05087-00-00	2850	0.55	13.42
31-007-05087-00-00	2860	0.52	11.10
31-007-05087-00-00	2870	0.56	11.01
31-007-05087-00-00	2880	1.30	
31-007-05087-00-00	2890	1.24	
31-007-05087-00-00	2910	1.33	12.41
31-007-05087-00-00	2920	1.40	
31-007-05087-00-00	2930	1.56	10.54
31-007-05087-00-00	2940	2.17	11.74
31-007-05087-00-00	2950	2.14	
31-007-05087-00-00	2960	2.86	
31-007-05087-00-00	2970	2.83	
31-007-05087-00-00	2980	2.95	10.73
31-007-05087-00-00	2990	2.86	
31-007-05087-00-00	3000	3.79	10.78
31-007-05087-00-00	3010	3.92	9.75
31-007-05087-00-00	3020	3.72	11.45
31-007-05087-00-00	3030	3.78	8.35
31-007-05087-00-00	3040	2.73	42.80
31-007-05087-00-00	3050	2.26	50.09
31-007-05087-00-00	3060	2.92	36.96
31-007-05087-00-00	3070	4.23	22.78
31-007-05087-00-00	3080	7.70	23.66
31-007-05087-00-00	3090	7.51	
31-007-05087-00-00	3100	7.69	62.47
31-007-05087-00-00	3110	1.72	65.44
31-007-05087-00-00	3120	1.80	65.09
31-007-05087-00-00	3130	0.95	68.97
31-007-05087-00-00	3140	0.87	64.23
31-007-05087-00-00	3150	0.53	61.53



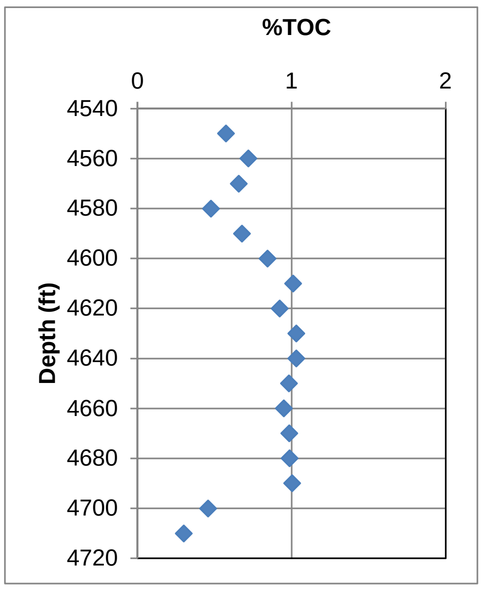


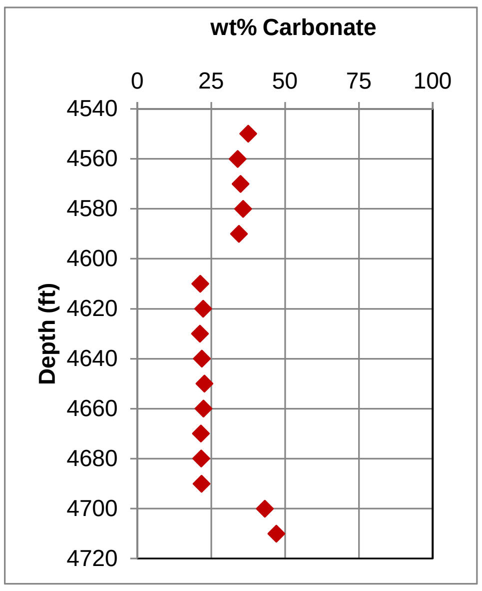
31-009-08610-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-009-08610-00-00	2500	1.50	20.61
31-009-08610-00-00	2510	1.39	20.23
31-009-08610-00-00	2520	1.60	18.70
31-009-08610-00-00	2530	1.20	19.09
31-009-08610-00-00	2540	1.27	20.74
31-009-08610-00-00	2550	1.56	16.39
31-009-08610-00-00	2560	1.50	18.70
31-009-08610-00-00	2570	1.23	21.88
31-009-08610-00-00	2580	1.30	18.61
31-009-08610-00-00	2590	1.36	27.93
31-009-08610-00-00	2600	0.82	40.30
31-009-08610-00-00	2610	1.07	20.34
31-009-08610-00-00	2620	0.84	29.37
31-009-08610-00-00	2630	1.35	24.93
31-009-08610-00-00	2640	1.27	26.85
31-009-08610-00-00	2660	12.27	12.00
31-009-08610-00-00	2670	0.88	42.25
31-009-08610-00-00	2680	0.35	79.86
31-009-08610-00-00	2690		50.91
31-009-08610-00-00	2700	0.32	87.15
Duplicates			
31-009-08610-00-00	2520-2	1.54	
31-009-08610-00-00	2600-2	0.79	



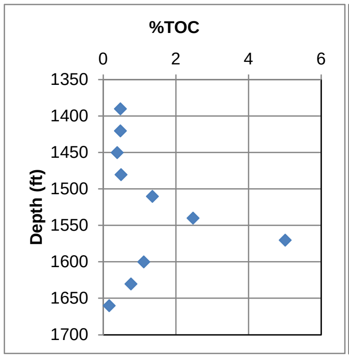


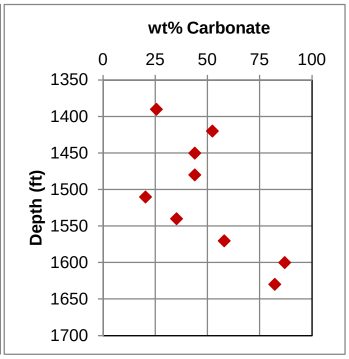
31-009-09235-00-00			
API	Depth (ft)	%TOC	wt% Carbonate
31-009-09235-00-00	4550	0.57	37.53
31-009-09235-00-00	4560	0.72	33.98
31-009-09235-00-00	4570	0.66	34.97
31-009-09235-00-00	4580	0.48	35.83
31-009-09235-00-00	4590	0.68	34.45
31-009-09235-00-00	4600	0.84	
31-009-09235-00-00	4610	1.01	21.30
31-009-09235-00-00	4620	0.92	22.29
31-009-09235-00-00	4630	1.03	21.19
31-009-09235-00-00	4640	1.03	21.87
31-009-09235-00-00	4650	0.98	22.72
31-009-09235-00-00	4660	0.95	22.38
31-009-09235-00-00	4670	0.99	21.48
31-009-09235-00-00	4680	0.99	21.69
31-009-09235-00-00	4690	1.00	21.76
31-009-09235-00-00	4700	0.46	43.21
31-009-09235-00-00	4710	0.30	47.07
Duplicates			
31-009-09235-00-00	4620-2	0.94	



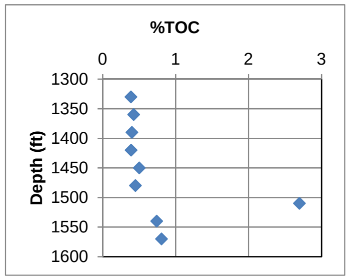


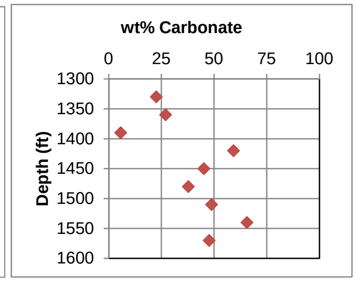
31-011-23840-00-00			
API	Depth (ft)	%TOC	wt% Carbonate
31-011-23840-00-00	1390	0.47	25.54
31-011-23840-00-00	1420	0.47	52.36
31-011-23840-00-00	1450	0.39	43.92
31-011-23840-00-00	1480	0.49	43.84
31-011-23840-00-00	1510	1.36	20.30
31-011-23840-00-00	1540	2.47	35.19
31-011-23840-00-00	1570	5.00	58.07
31-011-23840-00-00	1600	1.12	86.96
31-011-23840-00-00	1630	0.76	82.29
31-011-23840-00-00	1660	0.17	



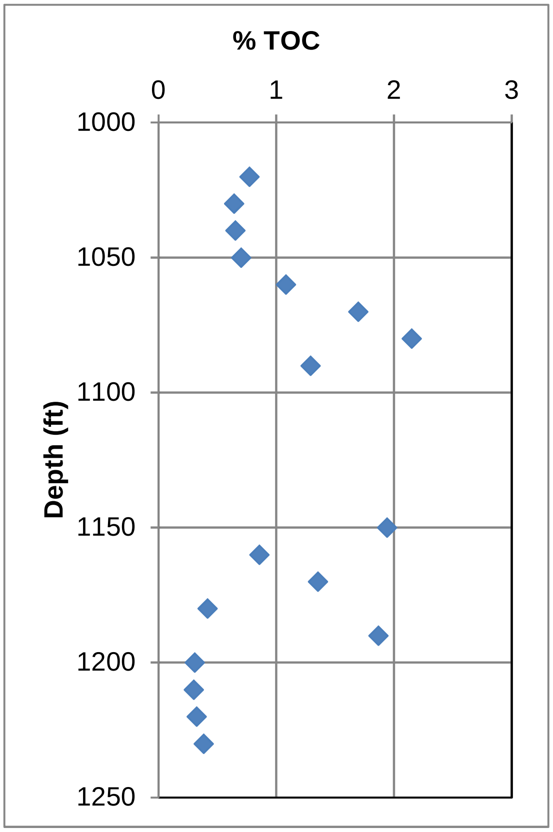


31-011-23982-00-00			
API	Depth	%TOC	wt% Carbonate
31-011-23982-00-00	1330	0.39	22.60
31-011-23982-00-00	1360	0.43	27.00
31-011-23982-00-00	1390	0.40	5.67
31-011-23982-00-00	1420	0.39	59.22
31-011-23982-00-00	1450	0.50	45.17
31-011-23982-00-00	1480	0.45	37.74
31-011-23982-00-00	1510	2.70	48.83
31-011-23982-00-00	1540	0.74	65.61
31-011-23982-00-00	1570	0.81	47.65
Duplicates			
31-011-23982-00-00	1360-2	0.43	

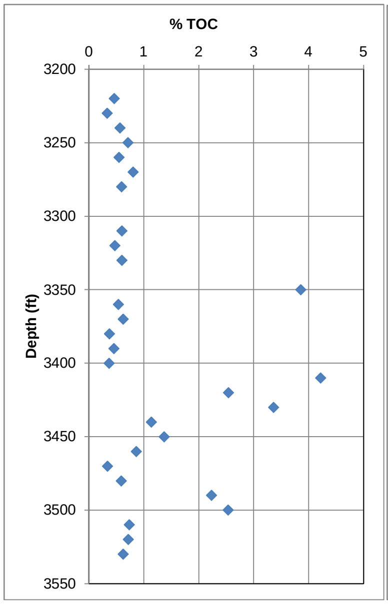


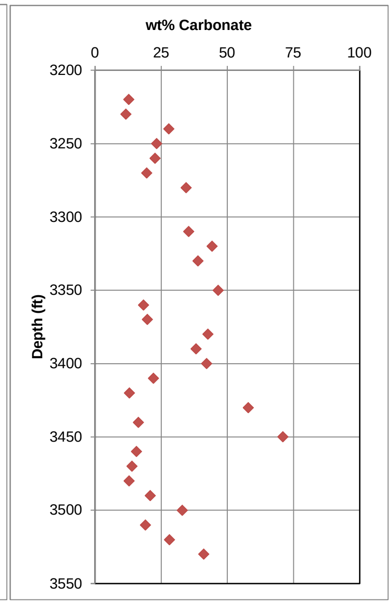


31-013-09939-00-00		
API	**Depth (ft)**	**% TOC**
31-013-09939-00-00	1020	0.77
31-013-09939-00-00	1030	0.64
31-013-09939-00-00	1040	0.65
31-013-09939-00-00	1050	0.70
31-013-09939-00-00	1060	1.08
31-013-09939-00-00	1070	1.70
31-013-09939-00-00	1080	2.15
31-013-09939-00-00	1090	1.29
31-013-09939-00-00	1100	
31-013-09939-00-00	1110	
31-013-09939-00-00	1120	
31-013-09939-00-00	1130	
31-013-09939-00-00	1140	
31-013-09939-00-00	1150	1.94
31-013-09939-00-00	1160	0.86
31-013-09939-00-00	1170	1.36
31-013-09939-00-00	1180	0.42
31-013-09939-00-00	1190	1.87
31-013-09939-00-00	1200	0.31
31-013-09939-00-00	1210	0.30
31-013-09939-00-00	1220	0.32
31-013-09939-00-00	1230	0.38
Duplicates		
31-013-09939-00-00	1170-2	1.42

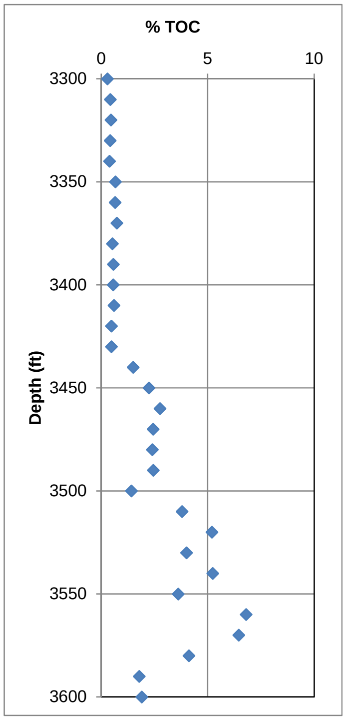


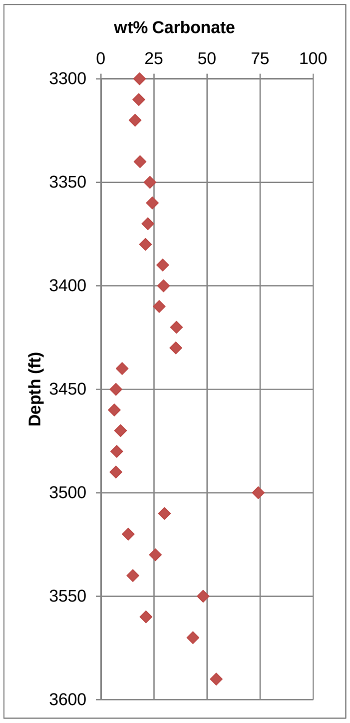
31-015-10335-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-015-10335-00-00	3220	0.46	12.75
31-015-10335-00-00	3230	0.34	11.62
31-015-10335-00-00	3240	0.56	27.89
31-015-10335-00-00	3250	0.71	23.23
31-015-10335-00-00	3260	0.55	22.66
31-015-10335-00-00	3270	0.81	19.49
31-015-10335-00-00	3280	0.60	34.38
31-015-10335-00-00	3310	0.60	35.31
31-015-10335-00-00	3320	0.47	44.18
31-015-10335-00-00	3330	0.60	38.86
31-015-10335-00-00	3350	3.86	46.47
31-015-10335-00-00	3360	0.54	18.31
31-015-10335-00-00	3370	0.62	19.73
31-015-10335-00-00	3380	0.37	42.60
31-015-10335-00-00	3390	0.46	38.13
31-015-10335-00-00	3400	0.37	42.20
31-015-10335-00-00	3410	4.22	22.01
31-015-10335-00-00	3420	2.54	12.93
31-015-10335-00-00	3430	3.36	57.89
31-015-10335-00-00	3440	1.13	16.37
31-015-10335-00-00	3450	1.37	70.91
31-015-10335-00-00	3460	0.86	15.63
31-015-10335-00-00	3470	0.34	13.90
31-015-10335-00-00	3480	0.59	12.78
31-015-10335-00-00	3490	2.23	20.88
31-015-10335-00-00	3500	2.54	32.96
31-015-10335-00-00	3510	0.74	18.97
31-015-10335-00-00	3520	0.72	28.13
31-015-10335-00-00	3530	0.62	41.10
Duplicates			
31-015-10335-00-00	3310-2	0.6011	



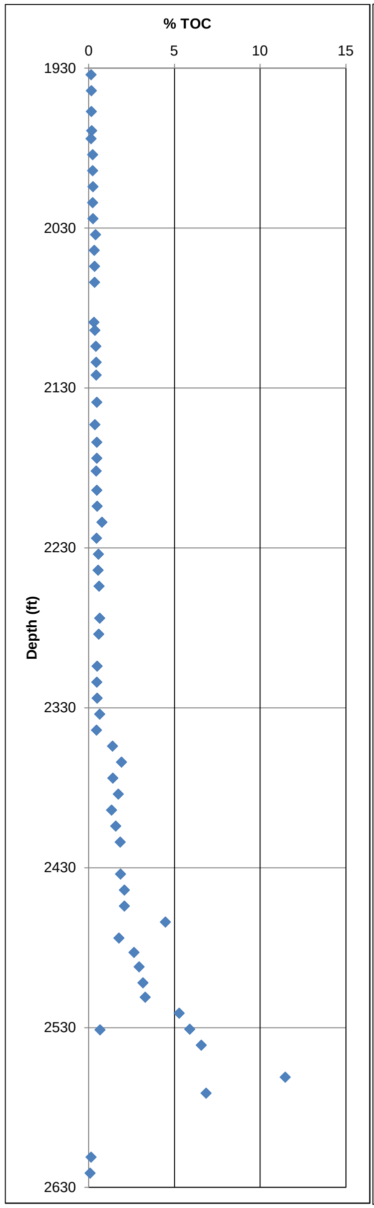


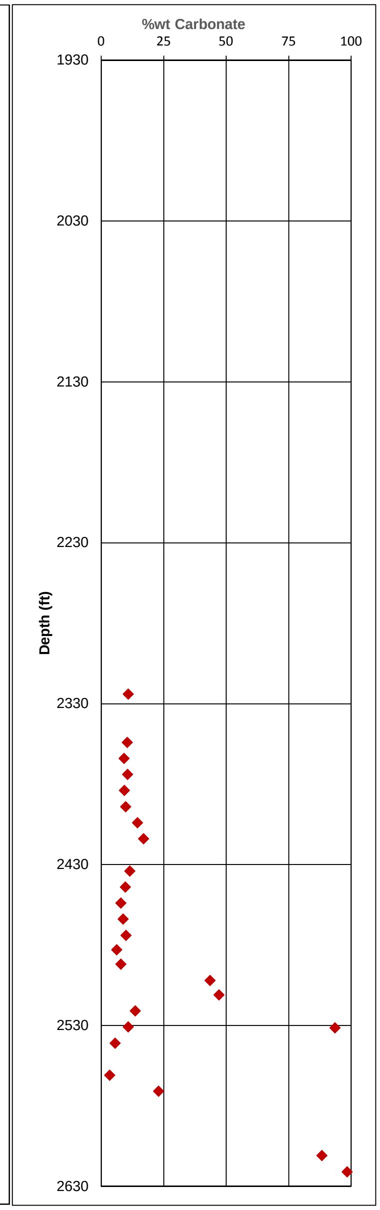
31-015-23023-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-015-23023-00-00	3300	0.28	18.16
31-015-23023-00-00	3310	0.42	17.78
31-015-23023-00-00	3320	0.45	16.05
31-015-23023-00-00	3330	0.42	
31-015-23023-00-00	3340	0.39	18.39
31-015-23023-00-00	3350	0.66	23.04
31-015-23023-00-00	3360	0.64	24.24
31-015-23023-00-00	3370	0.73	22.13
31-015-23023-00-00	3380	0.52	20.95
31-015-23023-00-00	3390	0.57	29.09
31-015-23023-00-00	3400	0.56	29.45
31-015-23023-00-00	3410	0.60	27.41
31-015-23023-00-00	3420	0.48	35.57
31-015-23023-00-00	3430	0.47	35.30
31-015-23023-00-00	3440	1.49	9.98
31-015-23023-00-00	3450	2.24	7.05
31-015-23023-00-00	3460	2.76	6.30
31-015-23023-00-00	3470	2.43	9.24
31-015-23023-00-00	3480	2.40	7.42
31-015-23023-00-00	3490	2.44	7.02
31-015-23023-00-00	3500	1.41	74.11
31-015-23023-00-00	3510	3.79	29.93
31-015-23023-00-00	3520	5.20	12.82
31-015-23023-00-00	3530	4.01	25.63
31-015-23023-00-00	3540	5.24	15.02
31-015-23023-00-00	3550	3.61	48.16
31-015-23023-00-00	3560	6.80	21.18
31-015-23023-00-00	3570	6.46	43.34
31-015-23023-00-00	3580	4.12	
31-015-23023-00-00	3590	1.78	54.30
31-015-23023-00-00	3600	1.90	
Duplicates			
31-015-23023-00-00	3390-2	0.54	



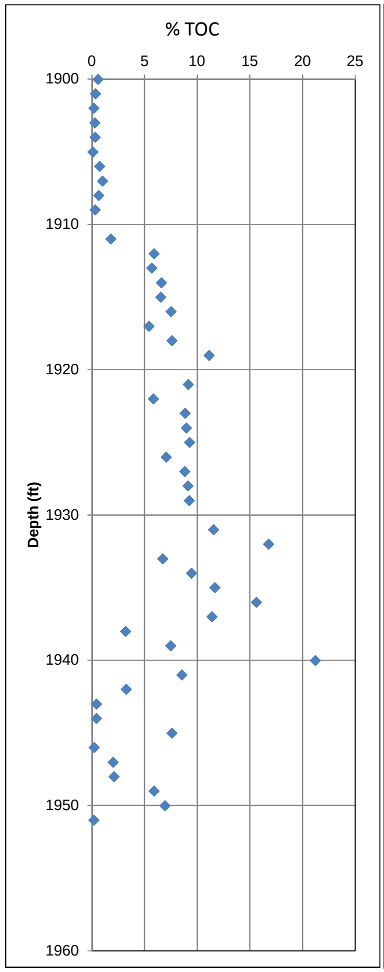


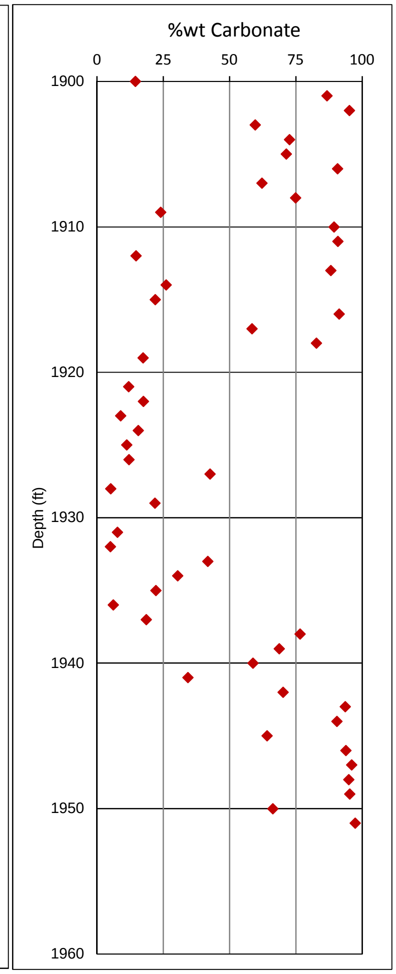
31-017-23005-00-00			
API	Depth (ft)	% TOC	%wt Carbonate
31-017-23005-00-00	1934	0.13	
31-017-23005-00-00	1944	0.15	
31-017-23005-00-00	1957	0.15	
31-017-23005-00-00	1969	0.18	
31-017-23005-00-00	1974	0.15	
31-017-23005-00-00	1984	0.22	
31-017-23005-00-00	1994	0.24	
31-017-23005-00-00	2004	0.24	
31-017-23005-00-00	2014	0.24	
31-017-23005-00-00	2024	0.26	
31-017-23005-00-00	2034	0.40	
31-017-23005-00-00	2044	0.32	
31-017-23005-00-00	2054	0.34	
31-017-23005-00-00	2064	0.34	
31-017-23005-00-00	2089	0.31	
31-017-23005-00-00	2094	0.36	
31-017-23005-00-00	2104	0.42	
31-017-23005-00-00	2114	0.44	
31-017-23005-00-00	2122	0.43	
31-017-23005-00-00	2139	0.48	
31-017-23005-00-00	2153	0.37	
31-017-23005-00-00	2164	0.47	
31-017-23005-00-00	2174	0.47	
31-017-23005-00-00	2182	0.44	
31-017-23005-00-00	2194	0.47	
31-017-23005-00-00	2204	0.49	
31-017-23005-00-00	2214	0.78	
31-017-23005-00-00	2224	0.46	
31-017-23005-00-00	2234	0.57	
31-017-23005-00-00	2244	0.55	
31-017-23005-00-00	2254	0.60	
31-017-23005-00-00	2274	0.65	
31-017-23005-00-00	2284	0.58	
31-017-23005-00-00	2304	0.50	
31-017-23005-00-00	2314	0.48	
31-017-23005-00-00	2324	0.50	10.78
31-017-23005-00-00	2334	0.65	
31-017-23005-00-00	2344	0.46	
31-017-23005-00-00	2354	1.39	10.47
31-017-23005-00-00	2364	1.91	9.20
31-017-23005-00-00	2374	1.42	10.56
31-017-23005-00-00	2384	1.72	9.23
31-017-23005-00-00	2394	1.32	9.82
31-017-23005-00-00	2404	1.58	14.49
31-017-23005-00-00	2414	1.84	16.96
31-017-23005-00-00	2434	1.86	11.42
31-017-23005-00-00	2444	2.07	9.67
31-017-23005-00-00	2454	2.08	7.85
31-017-23005-00-00	2464	4.46	8.71
31-017-23005-00-00	2474	1.76	9.98
31-017-23005-00-00	2483	2.64	6.27
31-017-23005-00-00	2492	2.94	7.85
31-017-23005-00-00	2502	3.16	43.61
31-017-23005-00-00	2511	3.30	47.11
31-017-23005-00-00	2521	5.28	13.62
31-017-23005-00-00	2531.5	0.67	93.49
31-017-23005-00-00	2531	5.90	10.80
31-017-23005-00-00	2541	6.56	5.55
31-017-23005-00-00	2561	11.47	3.39
31-017-23005-00-00	2571	6.84	23.01
31-017-23005-00-00	2611	0.14	88.30
31-017-23005-00-00	2621	0.09	98.46
Duplicates			
31-017-23005-00-00	1924-2	0.20	
31-017-23005-00-00	2164-2	0.48	
31-017-23005-00-00	2314-2	0.46	
31-017-23005-00-00	2561-2	12.97	



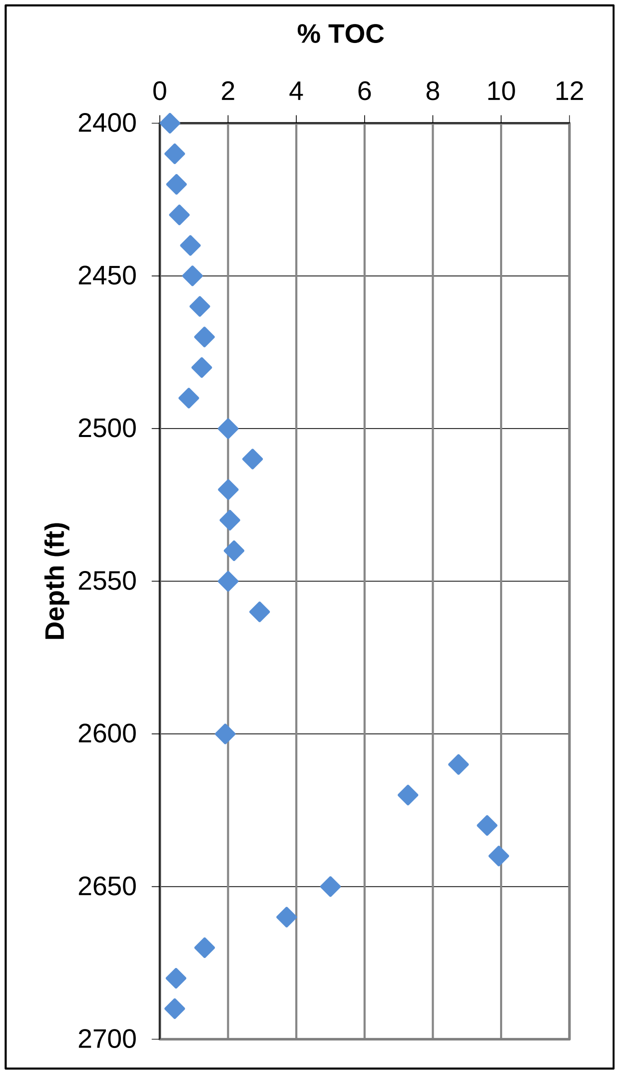


31-017-23006-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-017-23006-00-00	1900	0.57	14.51
31-017-23006-00-00	1901	0.32	86.83
31-017-23006-00-00	1902	0.17	95.24
31-017-23006-00-00	1903	0.26	59.68
31-017-23006-00-00	1904	0.29	72.67
31-017-23006-00-00	1905	0.09	71.49
31-017-23006-00-00	1906	0.73	90.72
31-017-23006-00-00	1907	1.01	62.31
31-017-23006-00-00	1908	0.62	74.96
31-017-23006-00-00	1909	0.31	24.14
31-017-23006-00-00	1910		89.43
31-017-23006-00-00	1911	1.77	90.86
31-017-23006-00-00	1912	5.89	14.83
31-017-23006-00-00	1913	5.69	88.20
31-017-23006-00-00	1914	6.57	26.17
31-017-23006-00-00	1915	6.54	22.05
31-017-23006-00-00	1916	7.49	91.42
31-017-23006-00-00	1917	5.41	58.51
31-017-23006-00-00	1918	7.60	82.74
31-017-23006-00-00	1919	11.11	17.47
31-017-23006-00-00	1921	9.15	12.06
31-017-23006-00-00	1922	5.81	17.58
31-017-23006-00-00	1923	8.83	8.94
31-017-23006-00-00	1924	8.95	15.69
31-017-23006-00-00	1925	9.25	11.34
31-017-23006-00-00	1926	7.04	12.13
31-017-23006-00-00	1927	8.81	42.70
31-017-23006-00-00	1928	9.11	5.23
31-017-23006-00-00	1929	9.23	21.94
31-017-23006-00-00	1931	11.54	7.79
31-017-23006-00-00	1932	16.76	5.09
31-017-23006-00-00	1933	6.71	41.90
31-017-23006-00-00	1934	9.44	30.51
31-017-23006-00-00	1935	11.67	22.33
31-017-23006-00-00	1936	15.60	6.18
31-017-23006-00-00	1937	11.39	18.69
31-017-23006-00-00	1938	3.20	76.61
31-017-23006-00-00	1939	7.46	68.80
31-017-23006-00-00	1940	21.19	58.89
31-017-23006-00-00	1941	8.54	34.31
31-017-23006-00-00	1942	3.25	70.21
31-017-23006-00-00	1943	0.41	93.69
31-017-23006-00-00	1944	0.42	90.53
31-017-23006-00-00	1945	7.58	64.22
31-017-23006-00-00	1946	0.20	93.94
31-017-23006-00-00	1947	1.99	96.07
31-017-23006-00-00	1948	2.09	94.97
31-017-23006-00-00	1949	5.88	95.31
31-017-23006-00-00	1950	6.92	66.40
31-017-23006-00-00	1951	0.18	97.41

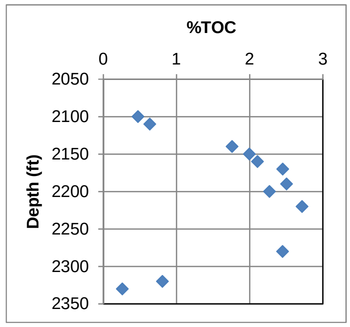


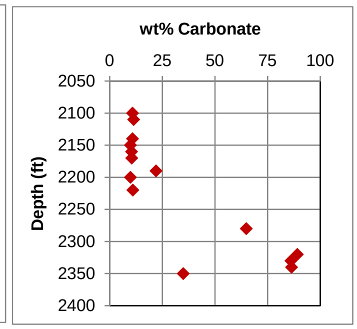


31-023-04714-00-00		
API	Depth (ft)	%TOC
31-023-04714-00-00	2400	0.30
31-023-04714-00-00	2410	0.44
31-023-04714-00-00	2420	0.49
31-023-04714-00-00	2430	0.58
31-023-04714-00-00	2440	0.90
31-023-04714-00-00	2450	0.96
31-023-04714-00-00	2460	1.17
31-023-04714-00-00	2470	1.31
31-023-04714-00-00	2480	1.23
31-023-04714-00-00	2490	0.85
31-023-04714-00-00	2500	2.00
31-023-04714-00-00	2510	2.72
31-023-04714-00-00	2520	2.01
31-023-04714-00-00	2530	2.05
31-023-04714-00-00	2540	2.18
31-023-04714-00-00	2550	2.00
31-023-04714-00-00	2560	2.93
31-023-04714-00-00	2600	1.92
31-023-04714-00-00	2610	8.75
31-023-04714-00-00	2620	7.27
31-023-04714-00-00	2630	9.59
31-023-04714-00-00	2640	9.93
31-023-04714-00-00	2650	5.00
31-023-04714-00-00	2660	3.72
31-023-04714-00-00	2670	1.31
31-023-04714-00-00	2680	0.47
31-023-04714-00-00	2690	0.44
Duplicates		
31-023-04714-00-00	2480-2	1.30
31-023-04714-00-00	2630-2	9.54

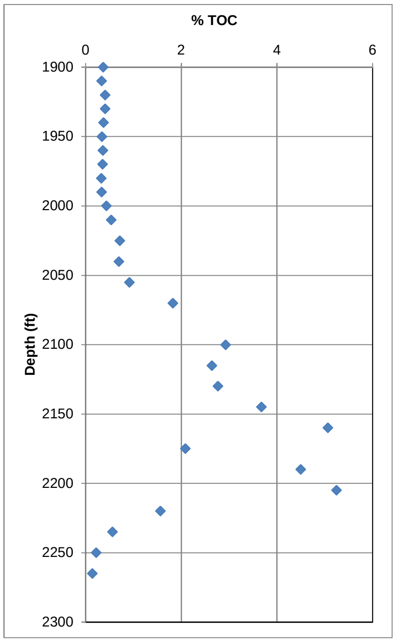


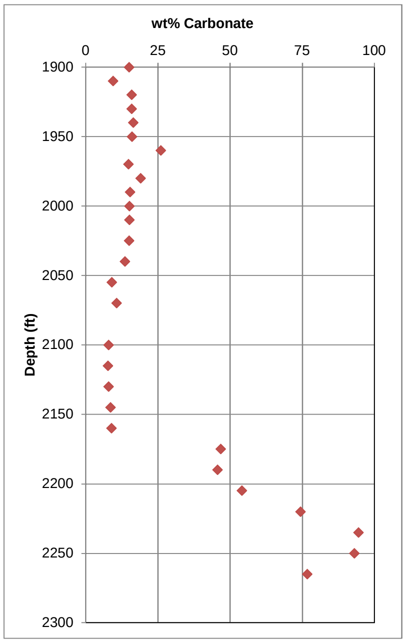
31-023-21500-00-00			
API	Depth (ft)	%TOC	wt% Carbonate
31-023-21500-00-00	2100	0.47	10.86
31-023-21500-00-00	2110	0.63	11.36
31-023-21500-00-00	2140	1.76	10.83
31-023-21500-00-00	2150	1.99	9.88
31-023-21500-00-00	2160	2.10	10.42
31-023-21500-00-00	2170	2.45	10.44
31-023-21500-00-00	2190	2.50	21.99
31-023-21500-00-00	2200	2.27	9.82
31-023-21500-00-00	2220	2.71	11.00
31-023-21500-00-00	2280	2.45	64.90
31-023-21500-00-00	2320	0.81	89.14
31-023-21500-00-00	2330	0.26	86.06
31-023-21500-00-00	2340		86.37
31-023-21500-00-00	2350		34.90



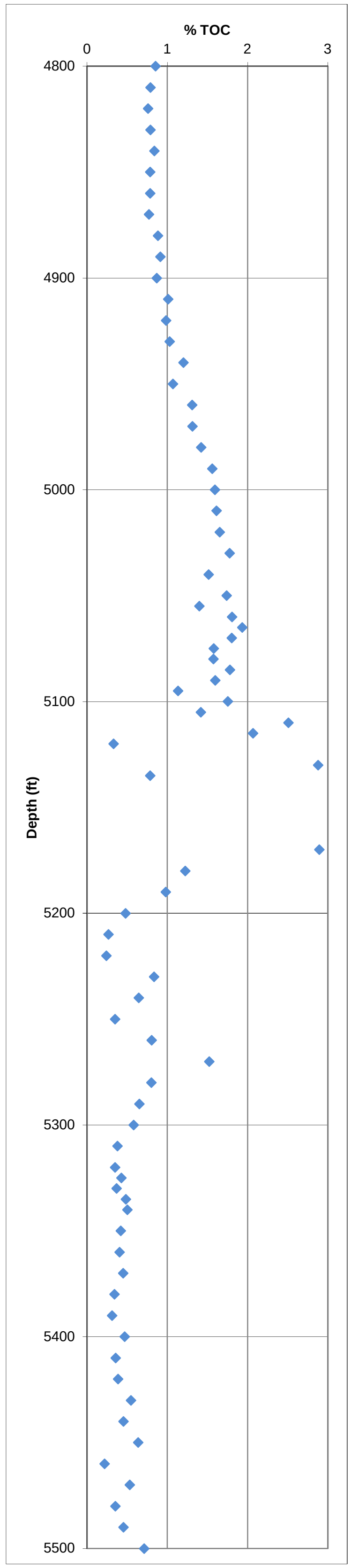


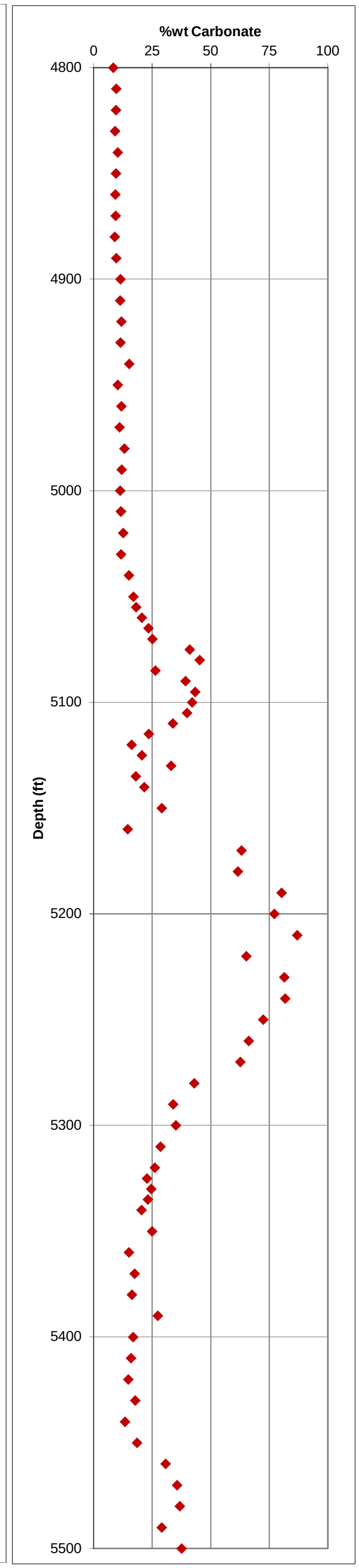
31-023-26267-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-023-26267-00-00	1900	0.37	15.00
31-023-26267-00-00	1910	0.34	9.45
31-023-26267-00-00	1920	0.41	15.87
31-023-26267-00-00	1930	0.41	15.90
31-023-26267-00-00	1940	0.37	16.42
31-023-26267-00-00	1950	0.34	15.95
31-023-26267-00-00	1960	0.36	26.01
31-023-26267-00-00	1970	0.36	14.78
31-023-26267-00-00	1980	0.33	19.01
31-023-26267-00-00	1990	0.34	15.36
31-023-26267-00-00	2000	0.44	15.11
31-023-26267-00-00	2010	0.54	15.16
31-023-26267-00-00	2025	0.72	15.00
31-023-26267-00-00	2040	0.70	13.54
31-023-26267-00-00	2055	0.92	8.97
31-023-26267-00-00	2070	1.82	10.69
31-023-26267-00-00	2100	2.93	7.89
31-023-26267-00-00	2115	2.64	7.65
31-023-26267-00-00	2130	2.77	7.88
31-023-26267-00-00	2145	3.67	8.57
31-023-26267-00-00	2160	5.07	8.94
31-023-26267-00-00	2175	2.09	46.74
31-023-26267-00-00	2190	4.50	45.63
31-023-26267-00-00	2205	5.25	54.08
31-023-26267-00-00	2220	1.56	74.34
31-023-26267-00-00	2235	0.56	94.49
31-023-26267-00-00	2250	0.23	93.04
31-023-26267-00-00	2265	0.14	76.71
Duplicates			
31-023-26267-00-00	2160-2	3.68	



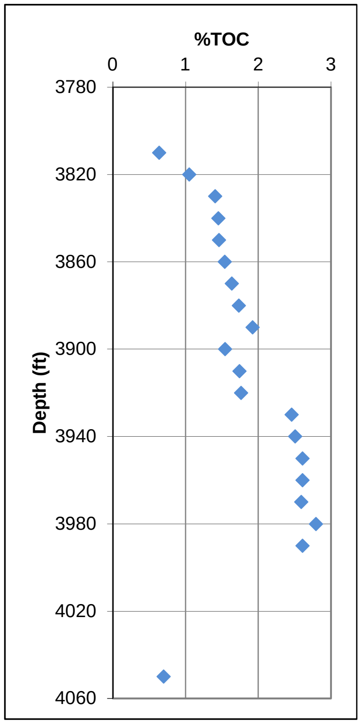


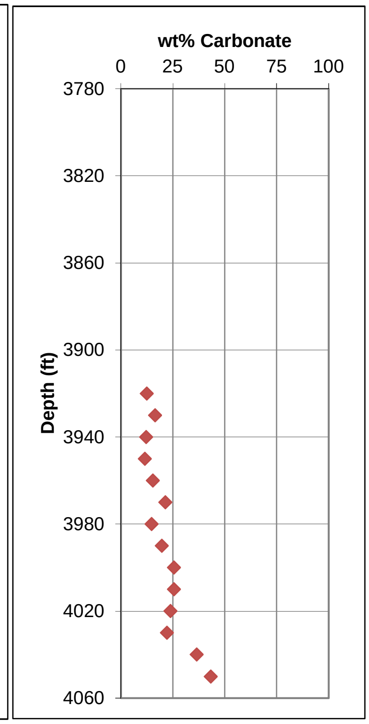
31-025-04214-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-025-04214-00-00	4800	0.86	8.28
31-025-04214-00-00	4810	0.79	9.62
31-025-04214-00-00	4820	0.76	9.41
31-025-04214-00-00	4830	0.79	9.09
31-025-04214-00-00	4840	0.84	10.23
31-025-04214-00-00	4850	0.79	9.51
31-025-04214-00-00	4860	0.79	9.16
31-025-04214-00-00	4870	0.77	9.30
31-025-04214-00-00	4880	0.88	8.97
31-025-04214-00-00	4890	0.92	9.60
31-025-04214-00-00	4900	0.87	11.38
31-025-04214-00-00	4910	1.01	11.20
31-025-04214-00-00	4920	0.99	11.83
31-025-04214-00-00	4930	1.03	11.40
31-025-04214-00-00	4940	1.20	15.07
31-025-04214-00-00	4950	1.07	10.25
31-025-04214-00-00	4960	1.31	11.79
31-025-04214-00-00	4970	1.32	11.03
31-025-04214-00-00	4980	1.42	13.02
31-025-04214-00-00	4990	1.56	11.87
31-025-04214-00-00	5000	1.60	11.30
31-025-04214-00-00	5010	1.61	11.64
31-025-04214-00-00	5020	1.65	12.48
31-025-04214-00-00	5030	1.78	11.69
31-025-04214-00-00	5040	1.52	15.01
31-025-04214-00-00	5050	1.74	16.93
31-025-04214-00-00	5055	1.40	18.10
31-025-04214-00-00	5060	1.81	20.56
31-025-04214-00-00	5065	1.94	23.38
31-025-04214-00-00	5070	1.80	25.00
31-025-04214-00-00	5075	1.58	41.01
31-025-04214-00-00	5080	1.57	45.19
31-025-04214-00-00	5085	1.78	26.33
31-025-04214-00-00	5090	1.60	39.16
31-025-04214-00-00	5095	1.14	43.25
31-025-04214-00-00	5100	1.75	41.95
31-025-04214-00-00	5105	1.42	39.79
31-025-04214-00-00	5110	2.51	33.71
31-025-04214-00-00	5115	2.07	23.43
31-025-04214-00-00	5120	0.33	16.18
31-025-04214-00-00	5125	4.78	20.54
31-025-04214-00-00	5130	2.88	32.96
31-025-04214-00-00	5135	0.79	17.94
31-025-04214-00-00	5140	3.92	21.58
31-025-04214-00-00	5150	3.80	29.04
31-025-04214-00-00	5160	3.94	14.46
31-025-04214-00-00	5170	2.89	63.03
31-025-04214-00-00	5180	1.23	61.47
31-025-04214-00-00	5190	0.98	80.18
31-025-04214-00-00	5200	0.48	77.02
31-025-04214-00-00	5210	0.27	86.86
31-025-04214-00-00	5220	0.24	65.13
31-025-04214-00-00	5230	0.84	81.37
31-025-04214-00-00	5240	0.65	81.72
31-025-04214-00-00	5250	0.35	72.30
31-025-04214-00-00	5260	0.81	66.14
31-025-04214-00-00	5270	1.52	62.60
31-025-04214-00-00	5280	0.80	42.88
31-025-04214-00-00	5290	0.65	33.91
31-025-04214-00-00	5300	0.58	34.99
31-025-04214-00-00	5310	0.38	28.45
31-025-04214-00-00	5320	0.35	26.00
31-025-04214-00-00	5325	0.43	22.69
31-025-04214-00-00	5330	0.37	24.48
31-025-04214-00-00	5335	0.48	23.10
31-025-04214-00-00	5340	0.51	20.35
31-025-04214-00-00	5350	0.42	24.92
31-025-04214-00-00	5360	0.41	15.04
31-025-04214-00-00	5370	0.45	17.46
31-025-04214-00-00	5380	0.34	16.25
31-025-04214-00-00	5390	0.32	27.29
31-025-04214-00-00	5400	0.47	16.85
31-025-04214-00-00	5410	0.36	15.90
31-025-04214-00-00	5420	0.39	14.78
31-025-04214-00-00	5430	0.55	17.74
31-025-04214-00-00	5440	0.45	13.35
31-025-04214-00-00	5450	0.64	18.50
31-025-04214-00-00	5460	0.22	30.67
31-025-04214-00-00	5470	0.53	35.52
31-025-04214-00-00	5480	0.36	36.75
31-025-04214-00-00	5490	0.46	29.02
31-025-04214-00-00	5500	0.71	37.53
Duplicates			
31-025-04214-00-00	5050-2	1.66	
31-025-04214-00-00	4900-2	0.82	
31-025-04214-00-00	5230-2	0.84	
31-025-04214-00-00	5085-2	1.85	



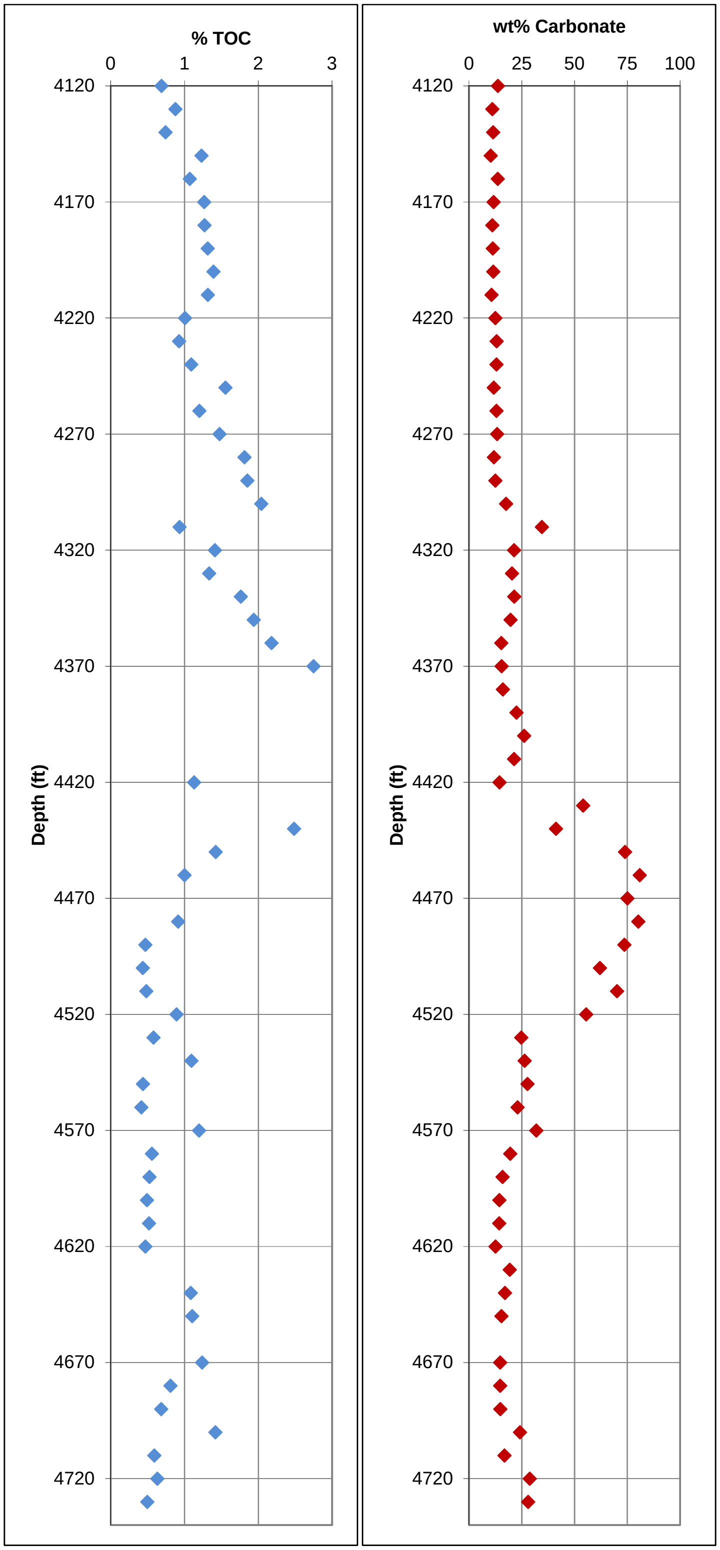


31-025-04364-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-025-04364-00-00	3790	0.95	
31-025-04364-00-00	3800	0.99	
31-025-04364-00-00	3810	0.64	
31-025-04364-00-00	3820	1.05	
31-025-04364-00-00	3830	1.41	
31-025-04364-00-00	3840	1.45	
31-025-04364-00-00	3850	1.46	
31-025-04364-00-00	3860	1.54	
31-025-04364-00-00	3870	1.63	
31-025-04364-00-00	3880	1.73	
31-025-04364-00-00	3890	1.92	
31-025-04364-00-00	3900	1.54	12.46
31-025-04364-00-00	3910	1.74	16.49
31-025-04364-00-00	3920	1.76	12.08
31-025-04364-00-00	3930	2.46	11.54
31-025-04364-00-00	3940	2.51	15.37
31-025-04364-00-00	3950	2.61	21.30
31-025-04364-00-00	3960	2.61	14.82
31-025-04364-00-00	3970	2.59	19.69
31-025-04364-00-00	3980	2.79	25.55
31-025-04364-00-00	3990	2.61	25.52
31-025-04364-00-00	4000	5.36	23.76
31-025-04364-00-00	4010		22.18
31-025-04364-00-00	4020	4.50	36.40
31-025-04364-00-00	4030	4.04	43.29
31-025-04364-00-00	4040		76.92
31-025-04364-00-00	4050	0.70	80.48
Duplicates			
31-025-04364-00-00	3820-2	1.14	

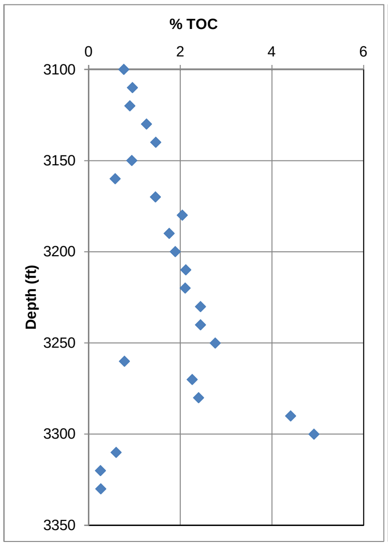


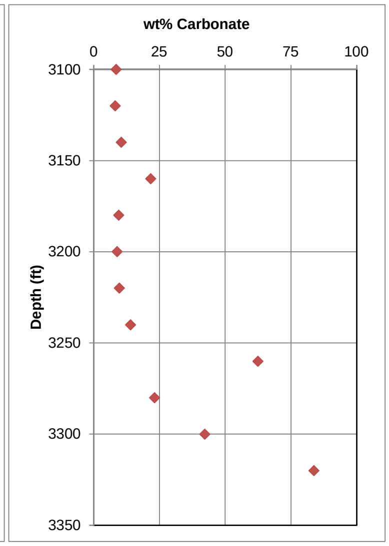


31-025-04379-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-025-04379-00-00	4120	0.69	13.73
31-025-04379-00-00	4130	0.88	11.03
31-025-04379-00-00	4140	0.74	11.41
31-025-04379-00-00	4150	1.23	10.32
31-025-04379-00-00	4160	1.07	13.60
31-025-04379-00-00	4170	1.27	11.69
31-025-04379-00-00	4180	1.27	11.04
31-025-04379-00-00	4190	1.32	11.28
31-025-04379-00-00	4200	1.39	11.53
31-025-04379-00-00	4210	1.32	10.68
31-025-04379-00-00	4220	1.01	12.47
31-025-04379-00-00	4230	0.93	13.09
31-025-04379-00-00	4240	1.09	13.01
31-025-04379-00-00	4250	1.55	11.75
31-025-04379-00-00	4260	1.20	13.05
31-025-04379-00-00	4270	1.47	13.30
31-025-04379-00-00	4280	1.81	11.83
31-025-04379-00-00	4290	1.85	12.51
31-025-04379-00-00	4300	2.04	17.58
31-025-04379-00-00	4310	0.93	34.53
31-025-04379-00-00	4320	1.41	21.36
31-025-04379-00-00	4330	1.33	20.39
31-025-04379-00-00	4340	1.76	21.43
31-025-04379-00-00	4350	1.94	19.70
31-025-04379-00-00	4360	2.18	15.32
31-025-04379-00-00	4370	2.75	15.44
31-025-04379-00-00	4380	3.97	16.08
31-025-04379-00-00	4390	5.46	22.50
31-025-04379-00-00	4400	4.71	26.11
31-025-04379-00-00	4410	4.67	21.37
31-025-04379-00-00	4420	1.13	14.44
31-025-04379-00-00	4430	5.12	54.08
31-025-04379-00-00	4440	2.48	41.21
31-025-04379-00-00	4450	1.42	73.92
31-025-04379-00-00	4460	1.00	80.88
31-025-04379-00-00	4470	4.61	75.03
31-025-04379-00-00	4480	0.91	80.18
31-025-04379-00-00	4490	0.47	73.58
31-025-04379-00-00	4500	0.44	62.01
31-025-04379-00-00	4510	0.48	70.10
31-025-04379-00-00	4520	0.89	55.49
31-025-04379-00-00	4530	0.58	24.80
31-025-04379-00-00	4540	1.09	26.34
31-025-04379-00-00	4550	0.44	27.74
31-025-04379-00-00	4560	0.42	23.06
31-025-04379-00-00	4570	1.20	31.89
31-025-04379-00-00	4580	0.56	19.56
31-025-04379-00-00	4590	0.53	15.87
31-025-04379-00-00	4600	0.49	14.39
31-025-04379-00-00	4610	0.52	14.35
31-025-04379-00-00	4620	0.47	12.58
31-025-04379-00-00	4630	3.03	19.30
31-025-04379-00-00	4640	1.08	17.04
31-025-04379-00-00	4650	1.10	15.37
31-025-04379-00-00	4670	1.24	14.76
31-025-04379-00-00	4680	0.81	14.78
31-025-04379-00-00	4690	0.68	14.83
31-025-04379-00-00	4700	1.42	24.12
31-025-04379-00-00	4710	0.59	16.80
31-025-04379-00-00	4720	0.63	28.78
31-025-04379-00-00	4730	0.50	28.06
Duplicates			
31-025-04379-00-00	4200-2	1.37	
31-025-04379-00-00	4340-2	1.80	
31-025-04379-00-00	4440-2	2.66	
31-025-04379-00-00	4580-2	0.58	
31-025-04379-00-00	4730-2	0.48	

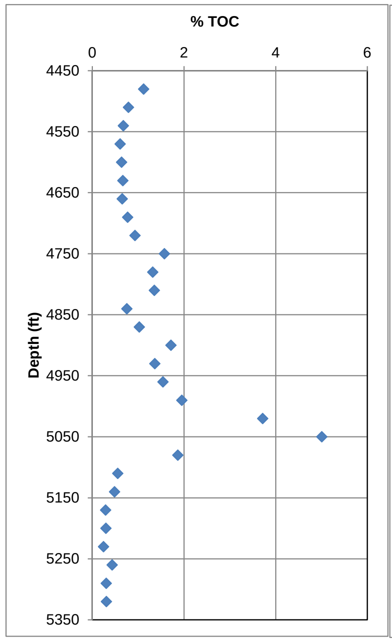


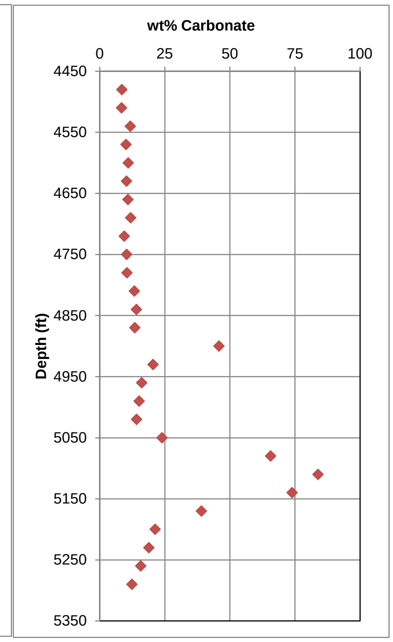
31-025-04455-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-025-04455-00-00	3100	0.76	8.52
31-025-04455-00-00	3110	0.95	
31-025-04455-00-00	3120	0.90	8.20
31-025-04455-00-00	3130	1.26	
31-025-04455-00-00	3140	1.46	10.46
31-025-04455-00-00	3150	0.94	
31-025-04455-00-00	3160	0.58	21.67
31-025-04455-00-00	3170	1.46	
31-025-04455-00-00	3180	2.04	9.53
31-025-04455-00-00	3190	1.75	
31-025-04455-00-00	3200	1.89	8.95
31-025-04455-00-00	3210	2.12	
31-025-04455-00-00	3220	2.11	9.78
31-025-04455-00-00	3230	2.44	
31-025-04455-00-00	3240	2.44	14.01
31-025-04455-00-00	3250	2.76	
31-025-04455-00-00	3260	0.78	62.48
31-025-04455-00-00	3270	2.26	
31-025-04455-00-00	3280	2.40	23.11
31-025-04455-00-00	3290	4.40	
31-025-04455-00-00	3300	4.92	42.18
31-025-04455-00-00	3310	0.60	
31-025-04455-00-00	3320	0.26	83.73
31-025-04455-00-00	3330	0.26	
Duplicates			
31-025-04455-00-00	2610-2	0.28	
31-025-04455-00-00	2690-2	0.32	
31-025-04455-00-00	1640-2	0.25	



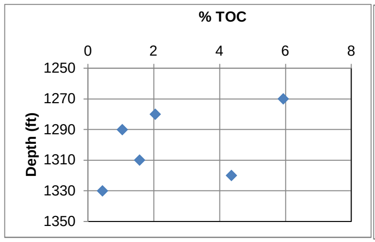


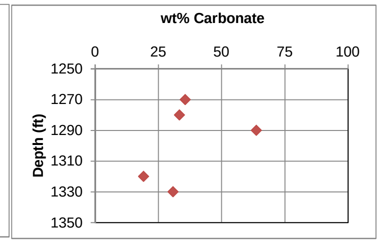
31-025-10096-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-025-10096-00-00	4480	1.12	8.42
31-025-10096-00-00	4510	0.79	8.33
31-025-10096-00-00	4540	0.68	11.68
31-025-10096-00-00	4570	0.61	10.02
31-025-10096-00-00	4600	0.64	10.88
31-025-10096-00-00	4630	0.67	10.22
31-025-10096-00-00	4660	0.65	10.77
31-025-10096-00-00	4690	0.77	11.82
31-025-10096-00-00	4720	0.93	9.39
31-025-10096-00-00	4750	1.57	10.28
31-025-10096-00-00	4780	1.32	10.44
31-025-10096-00-00	4810	1.36	13.22
31-025-10096-00-00	4840	0.75	14.03
31-025-10096-00-00	4870	1.03	13.43
31-025-10096-00-00	4900	1.72	45.76
31-025-10096-00-00	4930	1.37	20.41
31-025-10096-00-00	4960	1.54	16.04
31-025-10096-00-00	4990	1.96	15.09
31-025-10096-00-00	5020	3.72	14.13
31-025-10096-00-00	5050	5.01	23.84
31-025-10096-00-00	5080	1.87	65.57
31-025-10096-00-00	5110	0.56	83.79
31-025-10096-00-00	5140	0.49	73.82
31-025-10096-00-00	5170	0.29	39.01
31-025-10096-00-00	5200	0.30	21.21
31-025-10096-00-00	5230	0.25	18.85
31-025-10096-00-00	5260	0.43	15.69
31-025-10096-00-00	5290	0.30	12.34
31-025-10096-00-00	5320	0.31	
Duplicates			
31-025-10096-00-00	4660-2	0.66	
31-025-10096-00-00	5080-2	2.05	
31-025-10096-00-00	5320-2	0.31	



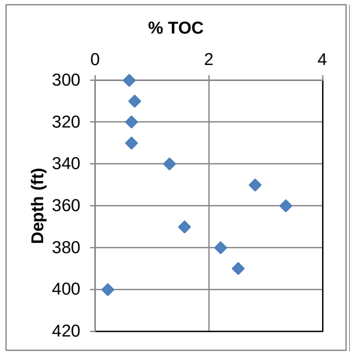


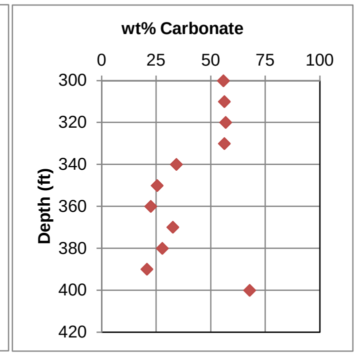
31-029-11730-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-029-11730-00-00	1270	5.94	35.57
31-029-11730-00-00	1280	2.04	33.30
31-029-11730-00-00	1290	1.05	63.72
31-029-11730-00-00	1310	1.57	
31-029-11730-00-00	1320	4.35	19.18
31-029-11730-00-00	1330	0.44	30.78



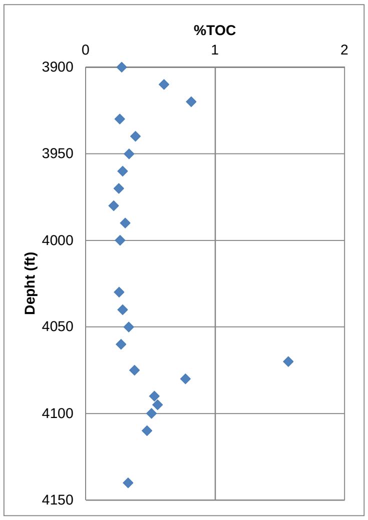


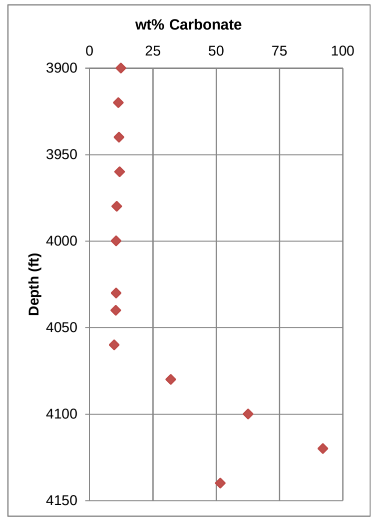
31-037-10776-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-037-10776-00-00	300	0.60	55.79
31-037-10776-00-00	310	0.70	56.22
31-037-10776-00-00	320	0.63	56.83
31-037-10776-00-00	330	0.63	56.16
31-037-10776-00-00	340	1.31	34.28
31-037-10776-00-00	350	2.82	25.37
31-037-10776-00-00	360	3.35	22.43
31-037-10776-00-00	370	1.57	32.60
31-037-10776-00-00	380	2.21	27.72
31-037-10776-00-00	390	2.51	20.78
31-037-10776-00-00	400	0.22	67.89



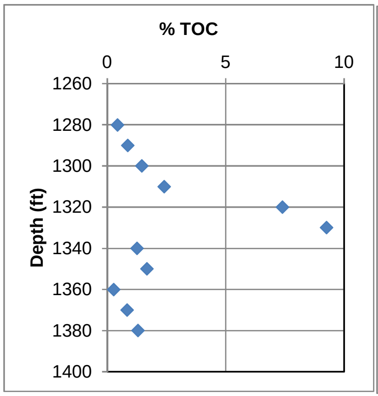


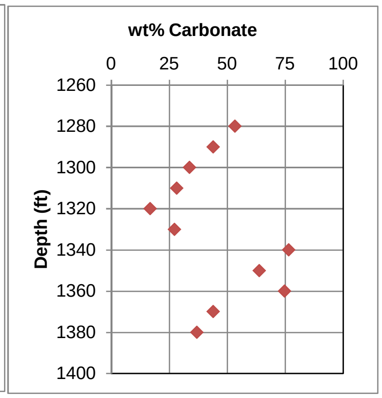
31-039-03904-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-039-03904-00-00	3900	0.28	12.48
31-039-03904-00-00	3910	0.61	
31-039-03904-00-00	3920	0.82	11.45
31-039-03904-00-00	3930	0.26	
31-039-03904-00-00	3940	0.38	11.67
31-039-03904-00-00	3950	0.33	
31-039-03904-00-00	3960	0.28	11.93
31-039-03904-00-00	3970	0.26	
31-039-03904-00-00	3980	0.22	10.83
31-039-03904-00-00	3990	0.31	
31-039-03904-00-00	4000	0.27	10.54
31-039-03904-00-00	4030	0.26	10.53
31-039-03904-00-00	4040	0.29	10.47
31-039-03904-00-00	4050	0.33	
31-039-03904-00-00	4060	0.27	9.81
31-039-03904-00-00	4070	1.56	
31-039-03904-00-00	4075	0.38	
31-039-03904-00-00	4080	0.77	32.16
31-039-03904-00-00	4090	0.53	
31-039-03904-00-00	4095	0.55	
31-039-03904-00-00	4100	0.51	62.68
31-039-03904-00-00	4110	0.47	
31-039-03904-00-00	4120		92.13
31-039-03904-00-00	4140	0.33	51.68
Duplicates			
31-039-03904-00-00	4040-2	0.28	
31-039-03904-00-00	4030-2		1.96



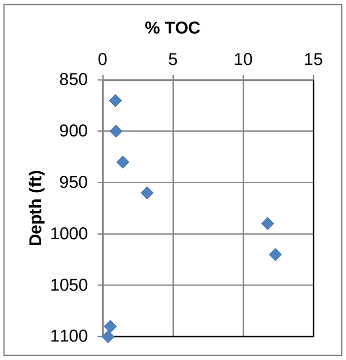


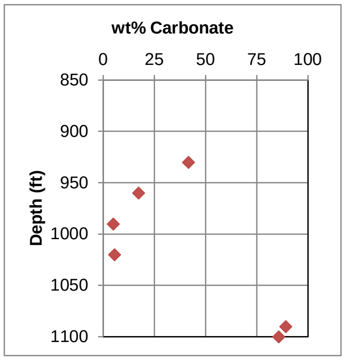
31-051-04053-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-051-04053-00-00	1280	0.44	53.34
31-051-04053-00-00	1290	0.86	43.89
31-051-04053-00-00	1300	1.46	33.75
31-051-04053-00-00	1310	2.40	28.17
31-051-04053-00-00	1320	7.39	16.67
31-051-04053-00-00	1330	9.25	27.22
31-051-04053-00-00	1340	1.25	76.42
31-051-04053-00-00	1350	1.68	63.76
31-051-04053-00-00	1360	0.27	74.69
31-051-04053-00-00	1370	0.83	43.93
31-051-04053-00-00	1380	1.30	36.87
Duplicates			
31-051-04053-00-00	1350-2	1.50	



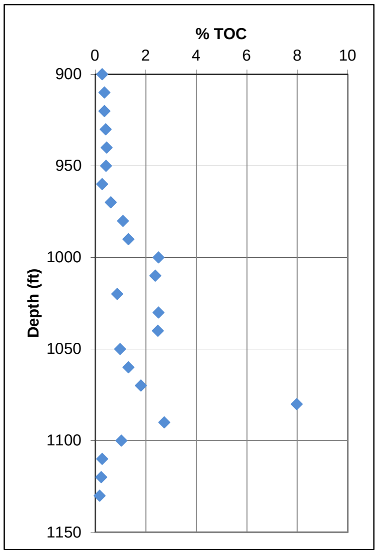


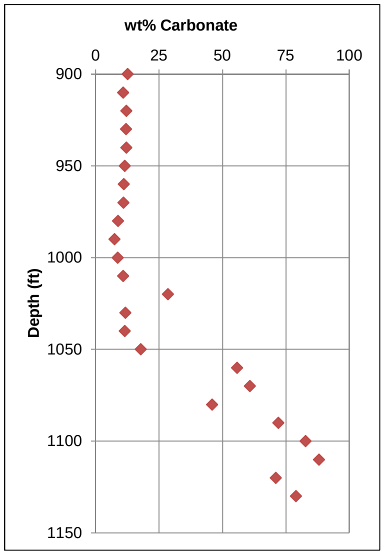
31-051-13700-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-051-13700-00-00	870	0.90	
31-051-13700-00-00	900	0.95	
31-051-13700-00-00	930	1.43	41.60
31-051-13700-00-00	960	3.16	17.22
31-051-13700-00-00	990	11.75	4.93
31-051-13700-00-00	1020	12.30	5.58
31-051-13700-00-00	1090	0.55	89.11
31-051-13700-00-00	1100	0.39	85.65
Duplicates			
31-051-13700-00-00	930-2	1.46	



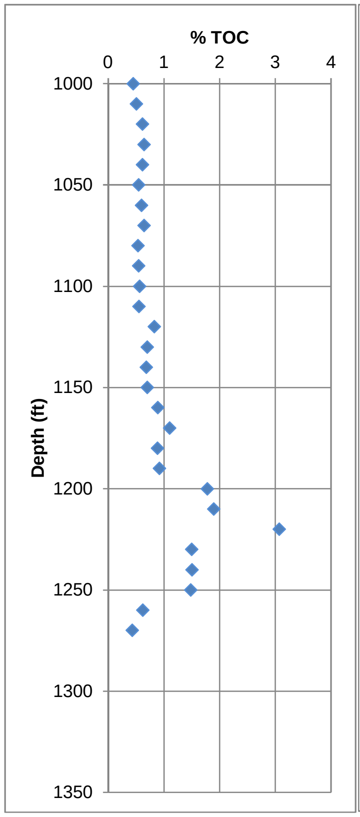


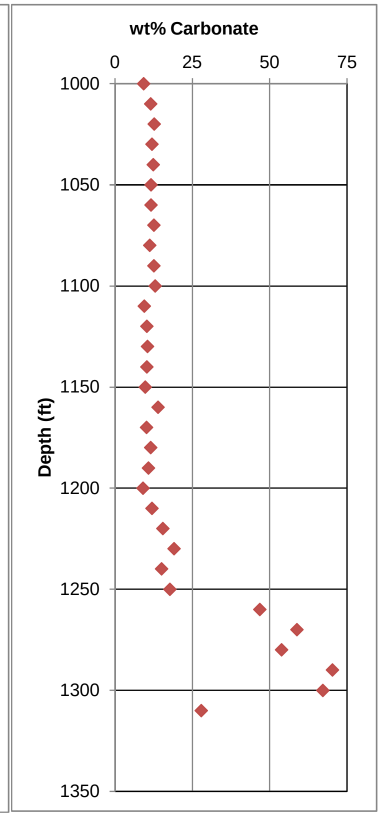
31-053-04032-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-053-04032-00-00	900	0.28	12.58
31-053-04032-00-00	910	0.37	10.81
31-053-04032-00-00	920	0.36	12.04
31-053-04032-00-00	930	0.43	12.00
31-053-04032-00-00	940	0.45	12.04
31-053-04032-00-00	950	0.44	11.42
31-053-04032-00-00	960	0.27	11.02
31-053-04032-00-00	970	0.63	10.96
31-053-04032-00-00	980	1.11	8.77
31-053-04032-00-00	990	1.32	7.44
31-053-04032-00-00	1000	2.52	8.69
31-053-04032-00-00	1010	2.38	10.82
31-053-04032-00-00	1020	0.88	28.49
31-053-04032-00-00	1030	2.52	11.67
31-053-04032-00-00	1040	2.48	11.46
31-053-04032-00-00	1050	0.99	17.80
31-053-04032-00-00	1060	1.31	55.77
31-053-04032-00-00	1070	1.82	60.73
31-053-04032-00-00	1080	7.99	45.85
31-053-04032-00-00	1090	2.73	72.07
31-053-04032-00-00	1100	1.04	82.69
31-053-04032-00-00	1110	0.28	88.04
31-053-04032-00-00	1120	0.24	71.06
31-053-04032-00-00	1130	0.18	78.93
Duplicates			
31-053-04032-00-00	970-2	0.62	



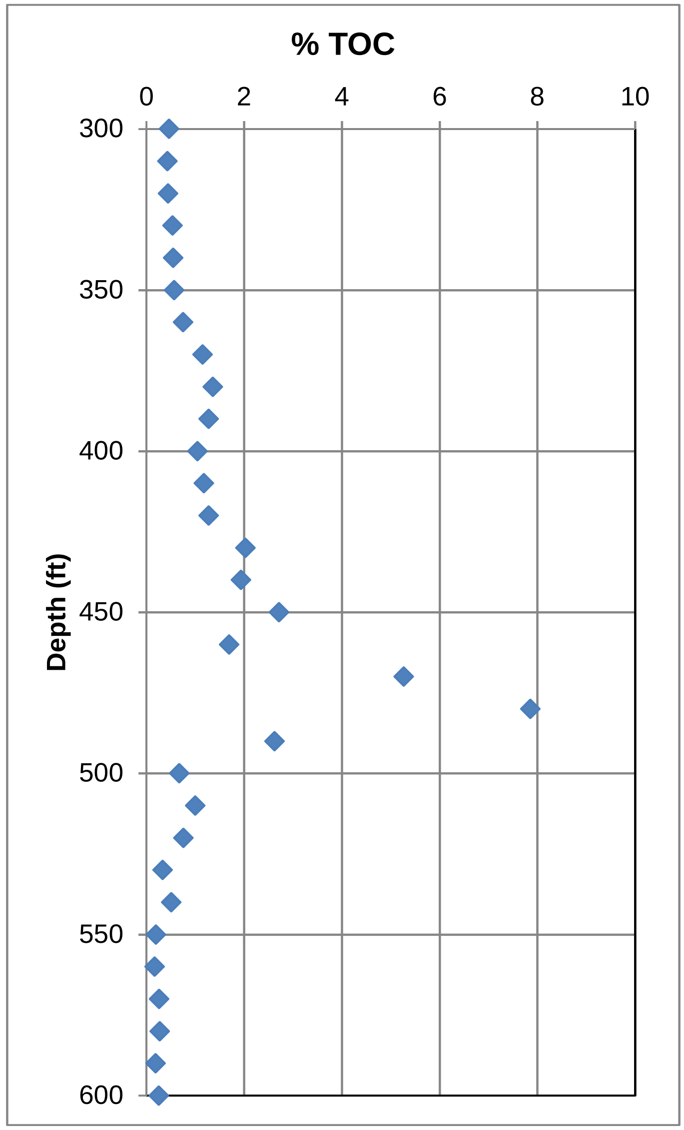


31-053-19485-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-053-19485-00-00	1000	0.45	9.23
31-053-19485-00-00	1010	0.50	11.53
31-053-19485-00-00	1020	0.61	12.68
31-053-19485-00-00	1030	0.64	11.89
31-053-19485-00-00	1040	0.61	12.32
31-053-19485-00-00	1050	0.54	11.63
31-053-19485-00-00	1060	0.60	11.66
31-053-19485-00-00	1070	0.64	12.57
31-053-19485-00-00	1080	0.53	11.24
31-053-19485-00-00	1090	0.55	12.51
31-053-19485-00-00	1100	0.56	12.92
31-053-19485-00-00	1110	0.55	9.43
31-053-19485-00-00	1120	0.83	10.29
31-053-19485-00-00	1130	0.70	10.47
31-053-19485-00-00	1140	0.69	10.22
31-053-19485-00-00	1150	0.70	9.72
31-053-19485-00-00	1160	0.89	13.88
31-053-19485-00-00	1170	1.10	10.19
31-053-19485-00-00	1180	0.89	11.50
31-053-19485-00-00	1190	0.92	10.79
31-053-19485-00-00	1200	1.78	9.07
31-053-19485-00-00	1210	1.89	11.96
31-053-19485-00-00	1220	3.07	15.49
31-053-19485-00-00	1230	1.50	19.10
31-053-19485-00-00	1240	1.50	15.07
31-053-19485-00-00	1250	1.48	17.72
31-053-19485-00-00	1260	0.62	46.80
31-053-19485-00-00	1270	0.43	58.84
31-053-19485-00-00	1280		53.82
31-053-19485-00-00	1290		70.27
31-053-19485-00-00	1300		67.16
31-053-19485-00-00	1310		27.86
Duplicates			
31-053-19485-00-00	1250-2	1.56	

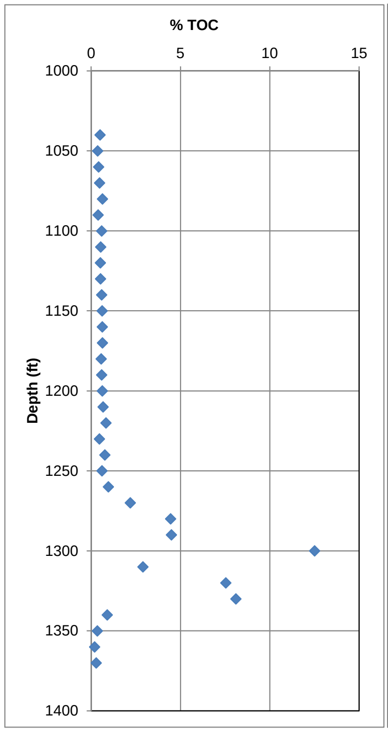


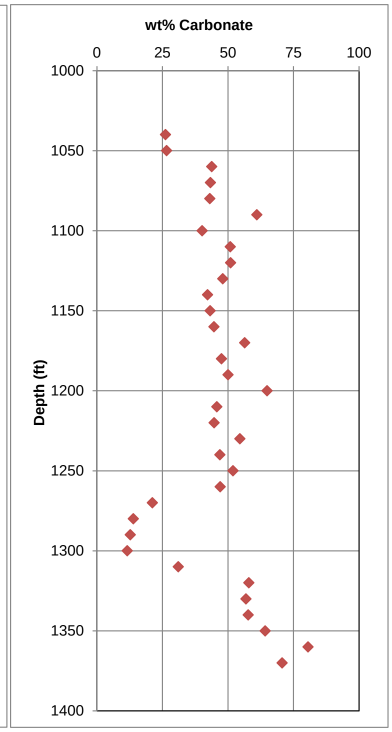


31-065-03928-00-00		
API	Depth (ft)	% TOC
31-065-03928-00-00	300	0.46
31-065-03928-00-00	310	0.43
31-065-03928-00-00	320	0.44
31-065-03928-00-00	330	0.53
31-065-03928-00-00	340	0.54
31-065-03928-00-00	350	0.57
31-065-03928-00-00	360	0.75
31-065-03928-00-00	370	1.15
31-065-03928-00-00	380	1.35
31-065-03928-00-00	390	1.27
31-065-03928-00-00	400	1.04
31-065-03928-00-00	410	1.17
31-065-03928-00-00	420	1.27
31-065-03928-00-00	430	2.02
31-065-03928-00-00	440	1.93
31-065-03928-00-00	450	2.71
31-065-03928-00-00	460	1.69
31-065-03928-00-00	470	5.26
31-065-03928-00-00	480	7.86
31-065-03928-00-00	490	2.62
31-065-03928-00-00	500	0.67
31-065-03928-00-00	510	1.00
31-065-03928-00-00	520	0.75
31-065-03928-00-00	530	0.33
31-065-03928-00-00	540	0.51
31-065-03928-00-00	550	0.19
31-065-03928-00-00	560	0.16
31-065-03928-00-00	570	0.25
31-065-03928-00-00	580	0.27
31-065-03928-00-00	590	0.19
31-065-03928-00-00	600	0.25
Duplicates		
31-065-03928-00-00	600-2	0.2622

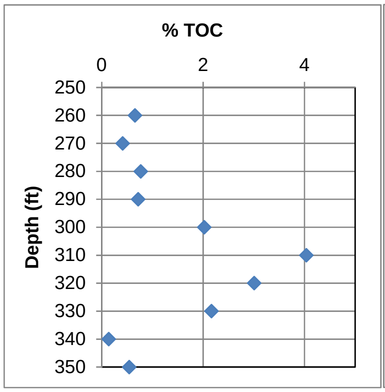


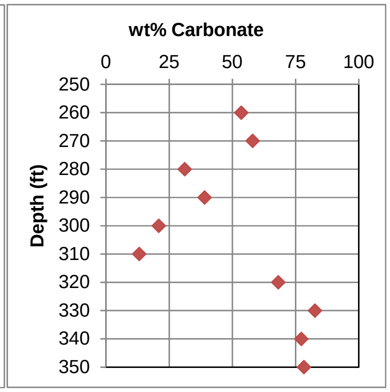
31-069-04035-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-069-04035-00-00	1040	0.50	26.06
31-069-04035-00-00	1050	0.37	26.48
31-069-04035-00-00	1060	0.42	43.73
31-069-04035-00-00	1070	0.48	43.25
31-069-04035-00-00	1080	0.64	42.98
31-069-04035-00-00	1090	0.40	60.92
31-069-04035-00-00	1100	0.59	40.08
31-069-04035-00-00	1110	0.54	50.82
31-069-04035-00-00	1120	0.52	50.91
31-069-04035-00-00	1130	0.53	47.93
31-069-04035-00-00	1140	0.59	42.11
31-069-04035-00-00	1150	0.62	43.10
31-069-04035-00-00	1160	0.62	44.58
31-069-04035-00-00	1170	0.64	56.27
31-069-04035-00-00	1180	0.56	47.41
31-069-04035-00-00	1190	0.59	49.98
31-069-04035-00-00	1200	0.63	64.85
31-069-04035-00-00	1210	0.67	45.70
31-069-04035-00-00	1220	0.83	44.66
31-069-04035-00-00	1230	0.46	54.46
31-069-04035-00-00	1240	0.77	46.80
31-069-04035-00-00	1250	0.61	51.82
31-069-04035-00-00	1260	0.97	46.94
31-069-04035-00-00	1270	2.19	21.09
31-069-04035-00-00	1280	4.45	13.82
31-069-04035-00-00	1290	4.49	12.62
31-069-04035-00-00	1300	12.51	11.49
31-069-04035-00-00	1310	2.90	30.98
31-069-04035-00-00	1320	7.54	57.91
31-069-04035-00-00	1330	8.11	56.81
31-069-04035-00-00	1340	0.91	57.65
31-069-04035-00-00	1350	0.35	64.09
31-069-04035-00-00	1360	0.19	80.48
31-069-04035-00-00	1370	0.29	70.59
Duplicates			
31-069-04035-00-00	1090-2	0.38	
31-069-04035-00-00	1190-2	0.58	
31-069-04035-00-00	1350-2	0.31	



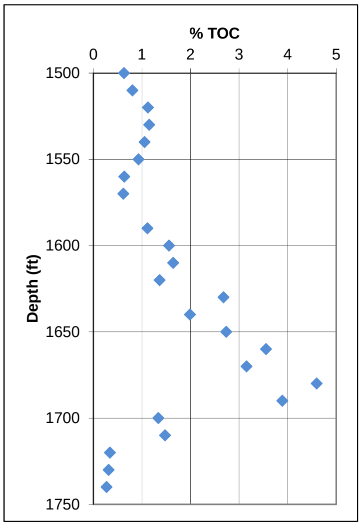


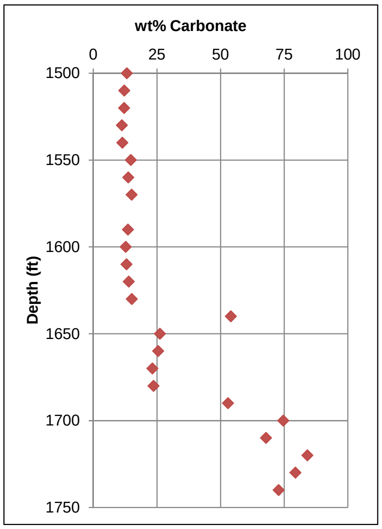
31-069-11428-00-00			
API	**Depth**	**% TOC**	**wt% Carbonate**
31-069-11428-00-00	260	0.66	53.53
31-069-11428-00-00	270	0.41	58.03
31-069-11428-00-00	280	0.77	31.15
31-069-11428-00-00	290	0.72	39.01
31-069-11428-00-00	300	2.02	20.86
31-069-11428-00-00	310	4.04	13.18
31-069-11428-00-00	320	3.01	68.17
31-069-11428-00-00	330	2.17	82.65
31-069-11428-00-00	340	0.14	77.28
31-069-11428-00-00	350	0.54	78.32
Duplicates			
31-069-11428-00-00	330-2	2.22	
31-069-11428-00-00	350-2	0.60	



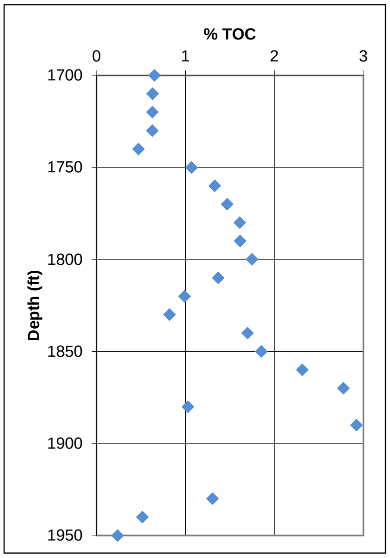


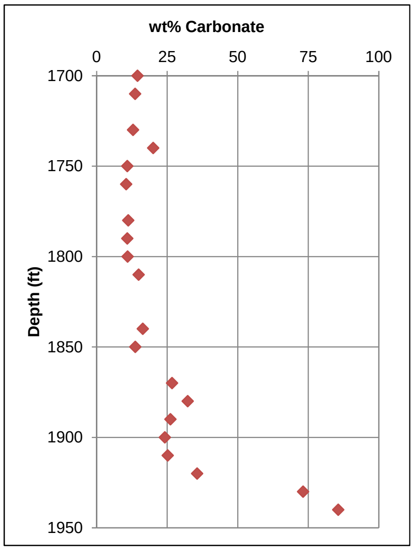
31-077-04055-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-077-04055-00-00	1500	0.63	13.14
31-077-04055-00-00	1510	0.80	12.11
31-077-04055-00-00	1520	1.12	12.05
31-077-04055-00-00	1530	1.15	11.16
31-077-04055-00-00	1540	1.05	11.38
31-077-04055-00-00	1550	0.93	14.71
31-077-04055-00-00	1560	0.63	13.72
31-077-04055-00-00	1570	0.62	15.00
31-077-04055-00-00	1590	1.11	13.56
31-077-04055-00-00	1600	1.55	12.70
31-077-04055-00-00	1610	1.64	13.03
31-077-04055-00-00	1620	1.36	13.87
31-077-04055-00-00	1630	2.68	15.07
31-077-04055-00-00	1640	1.99	54.01
31-077-04055-00-00	1650	2.73	26.13
31-077-04055-00-00	1660	3.55	25.46
31-077-04055-00-00	1670	3.15	23.17
31-077-04055-00-00	1680	4.59	23.59
31-077-04055-00-00	1690	3.89	52.88
31-077-04055-00-00	1700	1.33	74.59
31-077-04055-00-00	1710	1.47	67.82
31-077-04055-00-00	1720	0.34	84.09
31-077-04055-00-00	1730	0.31	79.37
31-077-04055-00-00	1740	0.27	72.77
Duplicates			
31-077-04055-00-00	1570-2	0.73	



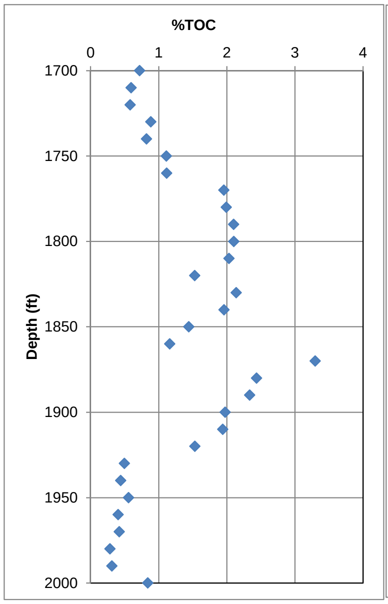


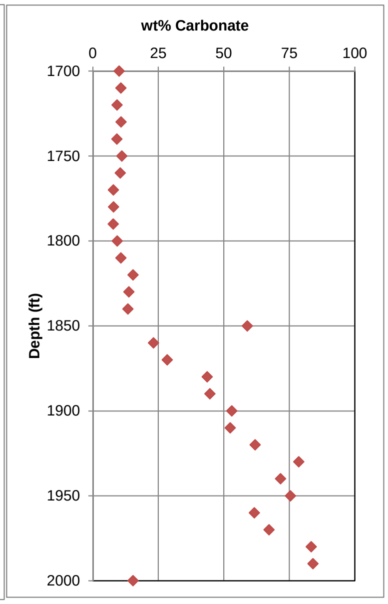
31-077-04547-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-077-04547-00-00	1700	0.65	14.51
31-077-04547-00-00	1710	0.63	13.68
31-077-04547-00-00	1720	0.63	
31-077-04547-00-00	1730	0.63	12.90
31-077-04547-00-00	1740	0.47	20.07
31-077-04547-00-00	1750	1.07	10.90
31-077-04547-00-00	1760	1.33	10.50
31-077-04547-00-00	1770	1.47	
31-077-04547-00-00	1780	1.61	11.20
31-077-04547-00-00	1790	1.61	10.90
31-077-04547-00-00	1800	1.75	10.97
31-077-04547-00-00	1810	1.37	14.88
31-077-04547-00-00	1820	0.99	
31-077-04547-00-00	1830	0.82	
31-077-04547-00-00	1840	1.70	16.38
31-077-04547-00-00	1850	1.85	13.68
31-077-04547-00-00	1860	2.31	
31-077-04547-00-00	1870	2.77	26.73
31-077-04547-00-00	1880	1.03	32.28
31-077-04547-00-00	1890	2.92	26.17
31-077-04547-00-00	1900	3.47	24.18
31-077-04547-00-00	1910	5.25	25.23
31-077-04547-00-00	1920	4.45	35.65
31-077-04547-00-00	1930	1.30	73.19
31-077-04547-00-00	1940	0.52	85.62
31-077-04547-00-00	1950	0.24	



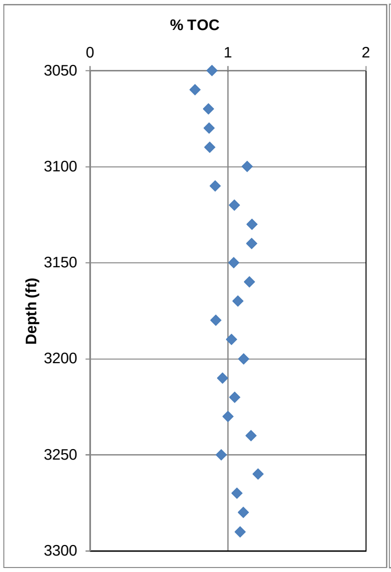


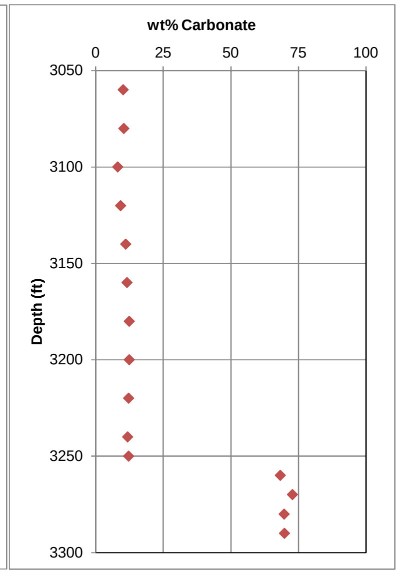
31-077-10834-00-00			
API	Depth (ft)	%TOC	wt% Carbonate
31-077-10834-00-00	1700	0.72	10.02
31-077-10834-00-00	1710	0.59	10.70
31-077-10834-00-00	1720	0.58	9.23
31-077-10834-00-00	1730	0.88	10.77
31-077-10834-00-00	1740	0.82	9.18
31-077-10834-00-00	1750	1.11	11.09
31-077-10834-00-00	1760	1.12	10.47
31-077-10834-00-00	1770	1.96	7.85
31-077-10834-00-00	1780	1.99	7.93
31-077-10834-00-00	1790	2.10	7.77
31-077-10834-00-00	1800	2.10	9.28
31-077-10834-00-00	1810	2.03	10.73
31-077-10834-00-00	1820	1.53	15.36
31-077-10834-00-00	1830	2.14	13.78
31-077-10834-00-00	1840	1.96	13.38
31-077-10834-00-00	1850	1.44	58.97
31-077-10834-00-00	1860	1.16	23.13
31-077-10834-00-00	1870	3.30	28.41
31-077-10834-00-00	1880	2.44	43.66
31-077-10834-00-00	1890	2.33	44.71
31-077-10834-00-00	1900	1.97	53.01
31-077-10834-00-00	1910	1.94	52.41
31-077-10834-00-00	1920	1.53	61.95
31-077-10834-00-00	1930	0.50	78.57
31-077-10834-00-00	1940	0.44	71.67
31-077-10834-00-00	1950	0.56	75.45
31-077-10834-00-00	1960	0.40	61.62
31-077-10834-00-00	1970	0.42	67.25
31-077-10834-00-00	1980	0.28	83.37
31-077-10834-00-00	1990	0.31	84.01
31-077-10834-00-00	2000	0.84	15.36



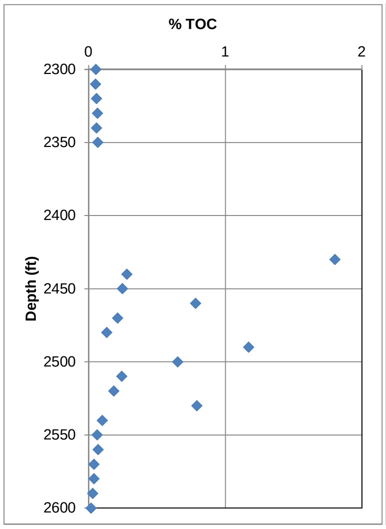


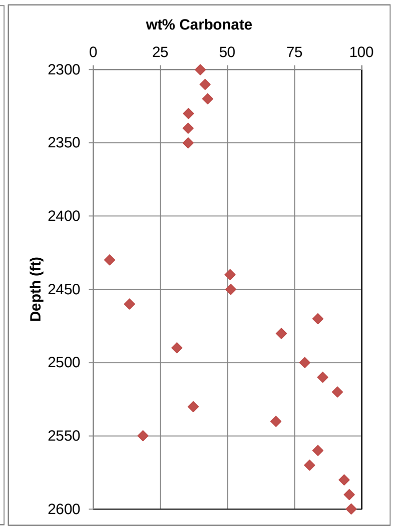
31-095-10263-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-095-10263-00-00	3050	0.88	
31-095-10263-00-00	3060	0.76	10.24
31-095-10263-00-00	3070	0.86	
31-095-10263-00-00	3080	0.86	10.44
31-095-10263-00-00	3090	0.87	
31-095-10263-00-00	3100	1.14	8.24
31-095-10263-00-00	3110	0.91	
31-095-10263-00-00	3120	1.05	9.21
31-095-10263-00-00	3130	1.17	
31-095-10263-00-00	3140	1.17	11.14
31-095-10263-00-00	3150	1.04	
31-095-10263-00-00	3160	1.16	11.62
31-095-10263-00-00	3170	1.07	
31-095-10263-00-00	3180	0.91	12.52
31-095-10263-00-00	3190	1.03	
31-095-10263-00-00	3200	1.11	12.49
31-095-10263-00-00	3210	0.96	
31-095-10263-00-00	3220	1.05	12.17
31-095-10263-00-00	3230	1.00	
31-095-10263-00-00	3240	1.17	11.84
31-095-10263-00-00	3250	0.95	12.19
31-095-10263-00-00	3260	1.22	68.32
31-095-10263-00-00	3270	1.06	72.85
31-095-10263-00-00	3280	1.11	69.80
31-095-10263-00-00	3290	1.09	69.94
Duplicates			
31-095-10263-00-00	3110-2	0.91	
31-095-10263-00-00	3190-2	1.03	
31-095-10263-00-00	3260-2	1.13	



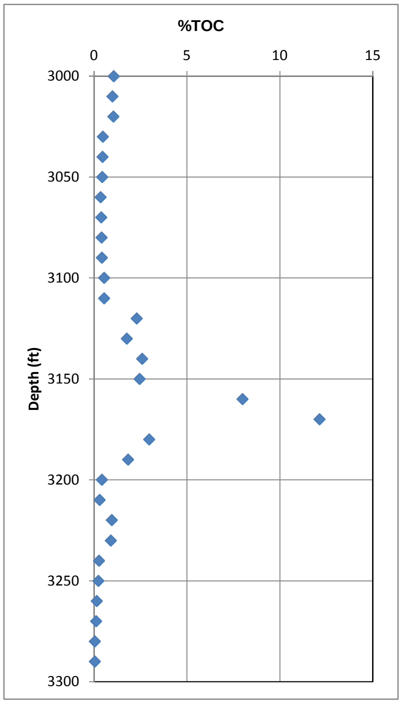


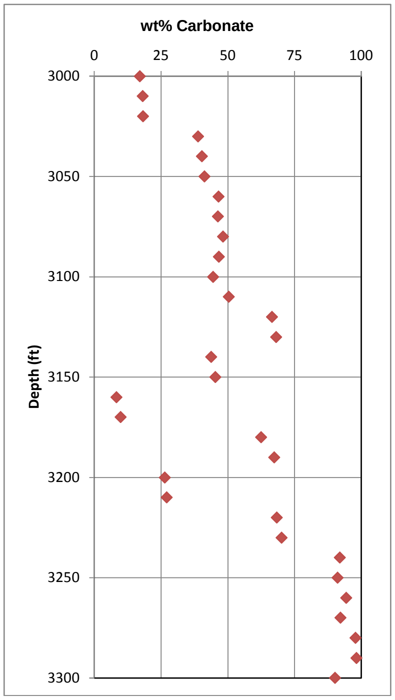
31-097-23949-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-097-23949-00-00	2300	0.05	39.85
31-097-23949-00-00	2310	0.05	41.59
31-097-23949-00-00	2320	0.06	42.57
31-097-23949-00-00	2330	0.06	35.42
31-097-23949-00-00	2340	0.06	35.32
31-097-23949-00-00	2350	0.07	35.33
31-097-23949-00-00	2430	1.80	6.02
31-097-23949-00-00	2440	0.28	50.94
31-097-23949-00-00	2450	0.25	51.14
31-097-23949-00-00	2460	0.78	13.46
31-097-23949-00-00	2470	0.21	83.63
31-097-23949-00-00	2480	0.13	70.04
31-097-23949-00-00	2490	1.17	31.17
31-097-23949-00-00	2500	0.65	78.72
31-097-23949-00-00	2510	0.24	85.39
31-097-23949-00-00	2520	0.18	90.93
31-097-23949-00-00	2530	0.79	37.17
31-097-23949-00-00	2540	0.10	68.04
31-097-23949-00-00	2550	0.06	18.49
31-097-23949-00-00	2560	0.07	83.61
31-097-23949-00-00	2570	0.04	80.56
31-097-23949-00-00	2580	0.04	93.42
31-097-23949-00-00	2590	0.03	95.36
31-097-23949-00-00	2600	0.02	96.00
Duplicates			
31-097-23949-00-00	1340-2	1.82	
31-097-23949-00-00	1600-2	0.03	



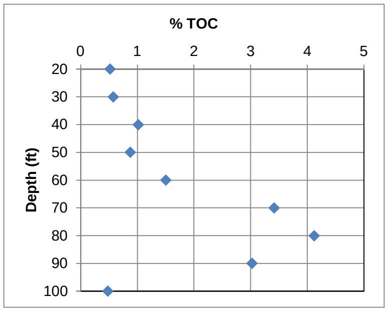


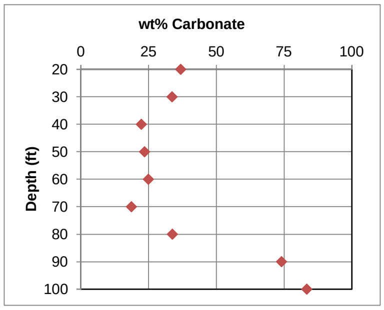
31-097-26017-00-00			
API	Depth (ft)	%TOC	wt% Carbonate
31-097-26017-00-00	3000	1.07	17.07
31-097-26017-00-00	3010	1.00	18.23
31-097-26017-00-00	3020	1.05	18.37
31-097-26017-00-00	3030	0.48	38.91
31-097-26017-00-00	3040	0.46	40.40
31-097-26017-00-00	3050	0.44	41.31
31-097-26017-00-00	3060	0.35	46.58
31-097-26017-00-00	3070	0.39	46.36
31-097-26017-00-00	3080	0.41	48.26
31-097-26017-00-00	3090	0.43	46.70
31-097-26017-00-00	3100	0.55	44.51
31-097-26017-00-00	3110	0.54	50.42
31-097-26017-00-00	3120	2.30	66.58
31-097-26017-00-00	3130	1.76	68.21
31-097-26017-00-00	3140	2.59	43.85
31-097-26017-00-00	3150	2.45	45.44
31-097-26017-00-00	3160	7.99	8.41
31-097-26017-00-00	3170	12.13	9.89
31-097-26017-00-00	3180	2.97	62.53
31-097-26017-00-00	3190	1.83	67.48
31-097-26017-00-00	3200	0.43	26.47
31-097-26017-00-00	3210	0.30	27.16
31-097-26017-00-00	3220	0.96	68.40
31-097-26017-00-00	3230	0.90	70.24
31-097-26017-00-00	3240	0.27	92.05
31-097-26017-00-00	3250	0.23	91.16
31-097-26017-00-00	3260	0.14	94.44
31-097-26017-00-00	3270	0.12	92.21
31-097-26017-00-00	3280	0.05	97.81
31-097-26017-00-00	3290	0.04	98.25
31-097-26017-00-00	3300	0.06	90.25
Duplicates			
31-097-26017-00-00	3130-2	1.87	
31-097-26017-00-00	3260-2	0.16	



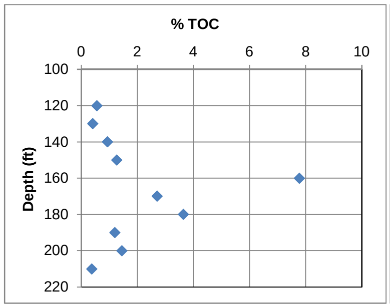


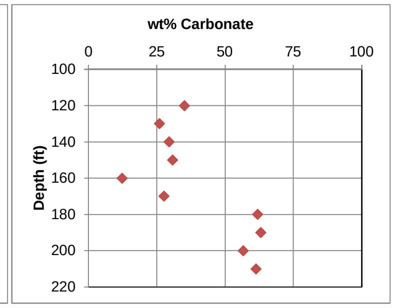
31-099-04203-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-099-04203-00-00	20	0.52	36.89
31-099-04203-00-00	30	0.58	33.65
31-099-04203-00-00	40	1.02	22.30
31-099-04203-00-00	50	0.87	23.43
31-099-04203-00-00	60	1.50	24.92
31-099-04203-00-00	70	3.41	18.61
31-099-04203-00-00	80	4.12	33.71
31-099-04203-00-00	90	3.02	74.02
31-099-04203-00-00	100	0.48	83.31
Duplicates			
31-099-04203-00-00	90-2	2.80	



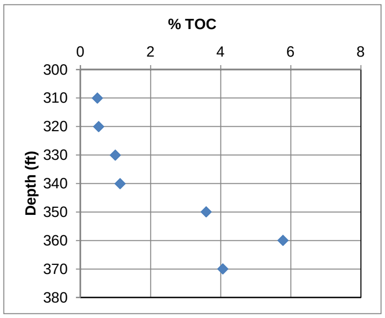


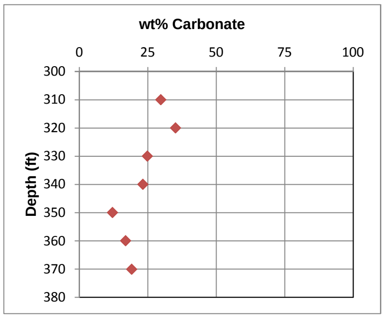
31-099-04215-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-099-04215-00-00	120	0.55	35.06
31-099-04215-00-00	130	0.40	26.04
31-099-04215-00-00	140	0.93	29.55
31-099-04215-00-00	150	1.26	30.80
31-099-04215-00-00	160	7.78	12.34
31-099-04215-00-00	170	2.70	27.63
31-099-04215-00-00	180	3.63	61.86
31-099-04215-00-00	190	1.20	63.10
31-099-04215-00-00	200	1.45	56.57
31-099-04215-00-00	210	0.37	61.34
Duplicates			
31-099-04215-00-00	190-2	1.1626	



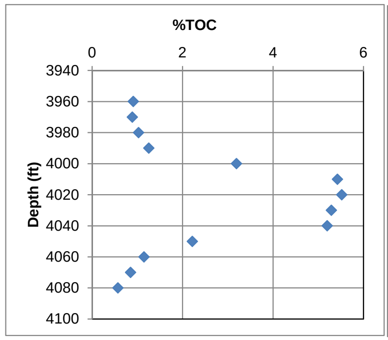


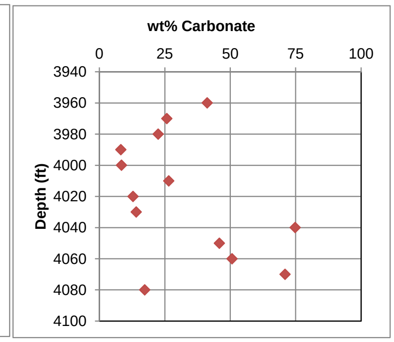
31-099-04244-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-099-04244-00-00	310	0.48	29.71
31-099-04244-00-00	320	0.52	35.13
31-099-04244-00-00	330	1.00	24.80
31-099-04244-00-00	340	1.13	23.12
31-099-04244-00-00	350	3.59	12.10
31-099-04244-00-00	360	5.78	16.87
31-099-04244-00-00	370	4.07	19.06
Duplicates			
31-099-04244-00-00	350-2	3.89	



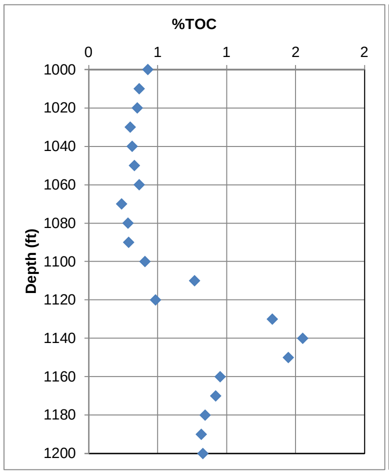


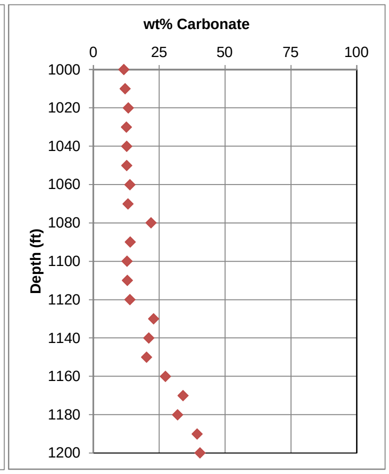
31-101-03924-00-00			
API	Depth	%TOC	wt% Carbonate
31-101-03924-00-00	3960	0.91	41.17
31-101-03924-00-00	3970	0.89	25.77
31-101-03924-00-00	3980	1.03	22.45
31-101-03924-00-00	3990	1.25	8.22
31-101-03924-00-00	4000	3.19	8.47
31-101-03924-00-00	4010	5.42	26.49
31-101-03924-00-00	4020	5.52	12.88
31-101-03924-00-00	4030	5.29	14.05
31-101-03924-00-00	4040	5.20	74.76
31-101-03924-00-00	4050	2.22	45.83
31-101-03924-00-00	4060	1.15	50.65
31-101-03924-00-00	4070	0.85	70.96
31-101-03924-00-00	4080	0.57	17.31
Duplicates			
31-101-03924-00-00	4020-2	5.65	



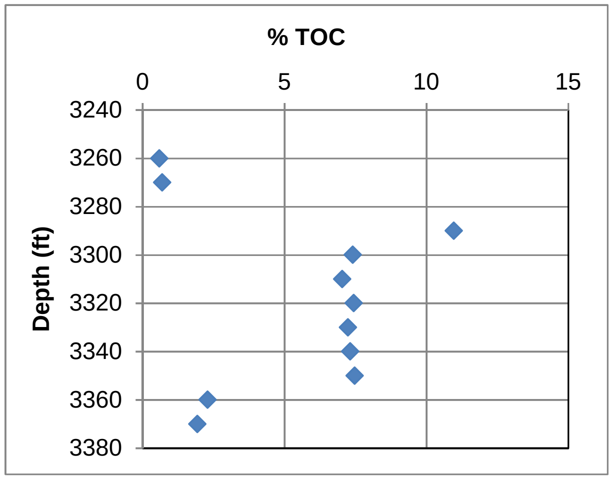


31-101-21692-00-00			
API	Depth (ft)	%TOC	wt% Carbonate
31-101-21692-00-00	1000	0.43	11.59
31-101-21692-00-00	1010	0.36	12.05
31-101-21692-00-00	1020	0.35	13.21
31-101-21692-00-00	1030	0.30	12.49
31-101-21692-00-00	1040	0.31	12.62
31-101-21692-00-00	1050	0.33	12.67
31-101-21692-00-00	1060	0.37	13.81
31-101-21692-00-00	1070	0.24	13.18
31-101-21692-00-00	1080	0.29	21.92
31-101-21692-00-00	1090	0.29	14.03
31-101-21692-00-00	1100	0.41	12.78
31-101-21692-00-00	1110	0.77	12.94
31-101-21692-00-00	1120	0.48	13.82
31-101-21692-00-00	1130	1.33	22.83
31-101-21692-00-00	1140	1.55	21.02
31-101-21692-00-00	1150	1.45	20.12
31-101-21692-00-00	1160	0.95	27.38
31-101-21692-00-00	1170	0.92	34.05
31-101-21692-00-00	1180	0.84	31.96
31-101-21692-00-00	1190	0.81	39.40
31-101-21692-00-00	1200	0.83	40.51
Duplicates			
31-101-21692-00-00	1060-2	0.35	
31-101-21692-00-00	1140-2	1.60	

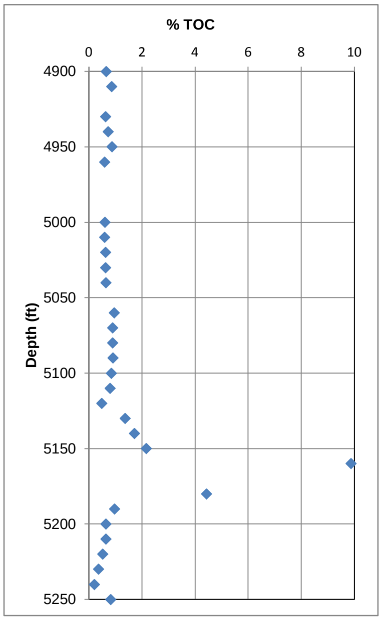


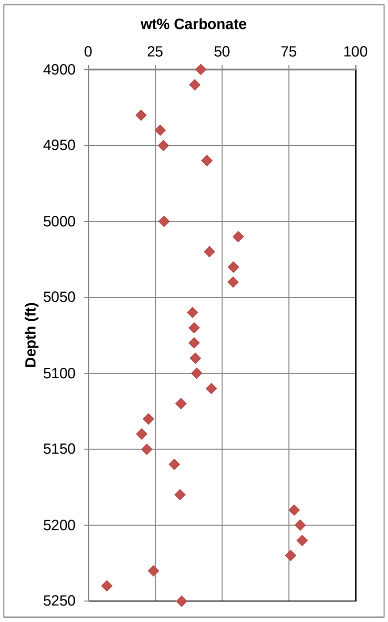


31-101-22908-00-00		
API	Depth (ft)	% TOC
31-101-22908-00-00	3260	0.59
31-101-22908-00-00	3270	0.68
31-101-22908-00-00	3280	
31-101-22908-00-00	3290	10.96
31-101-22908-00-00	3300	7.40
31-101-22908-00-00	3310	7.03
31-101-22908-00-00	3320	7.44
31-101-22908-00-00	3330	7.23
31-101-22908-00-00	3340	7.31
31-101-22908-00-00	3350	7.47
31-101-22908-00-00	3360	2.29
31-101-22908-00-00	3370	1.93

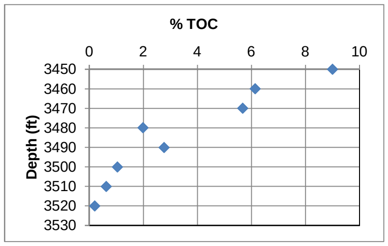


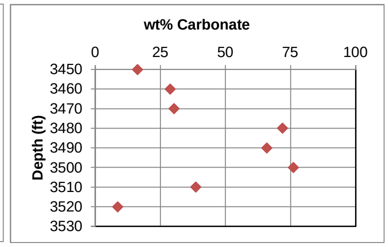
31-101-22978-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-101-22978-00-00	4900	0.66	42.04
31-101-22978-00-00	4910	0.86	39.76
31-101-22978-00-00	4930	0.63	19.70
31-101-22978-00-00	4940	0.72	26.86
31-101-22978-00-00	4950	0.87	28.08
31-101-22978-00-00	4960	0.59	44.24
31-101-22978-00-00	5000	0.60	28.28
31-101-22978-00-00	5010	0.60	56.01
31-101-22978-00-00	5020	0.62	45.28
31-101-22978-00-00	5030	0.63	54.27
31-101-22978-00-00	5040	0.64	54.10
31-101-22978-00-00	5060	0.95	38.86
31-101-22978-00-00	5070	0.90	39.45
31-101-22978-00-00	5080	0.89	39.49
31-101-22978-00-00	5090	0.91	39.93
31-101-22978-00-00	5100	0.84	40.49
31-101-22978-00-00	5110	0.80	45.94
31-101-22978-00-00	5120	0.49	34.65
31-101-22978-00-00	5130	1.36	22.44
31-101-22978-00-00	5140	1.72	19.85
31-101-22978-00-00	5150	2.16	21.86
31-101-22978-00-00	5160	9.87	32.14
31-101-22978-00-00	5180	4.43	34.25
31-101-22978-00-00	5190	0.97	76.96
31-101-22978-00-00	5200	0.64	79.22
31-101-22978-00-00	5210	0.64	79.95
31-101-22978-00-00	5220	0.52	75.61
31-101-22978-00-00	5230	0.36	24.29
31-101-22978-00-00	5240	0.20	6.85
31-101-22978-00-00	5250	0.81	34.82
Duplicates			
31-101-22978-00-00	5070-2	0.85	



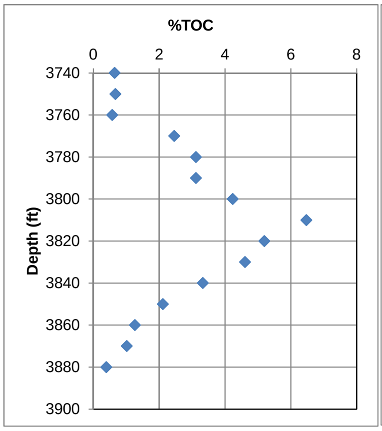


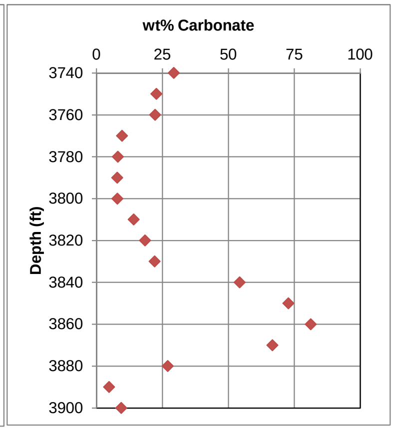
31-101-23055-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-101-23055-00-00	3450	9.00	16.27
31-101-23055-00-00	3460	6.14	28.76
31-101-23055-00-00	3470	5.68	30.28
31-101-23055-00-00	3480	1.99	71.85
31-101-23055-00-00	3490	2.77	65.91
31-101-23055-00-00	3500	1.03	76.03
31-101-23055-00-00	3510	0.62	38.53
31-101-23055-00-00	3520	0.19	8.65



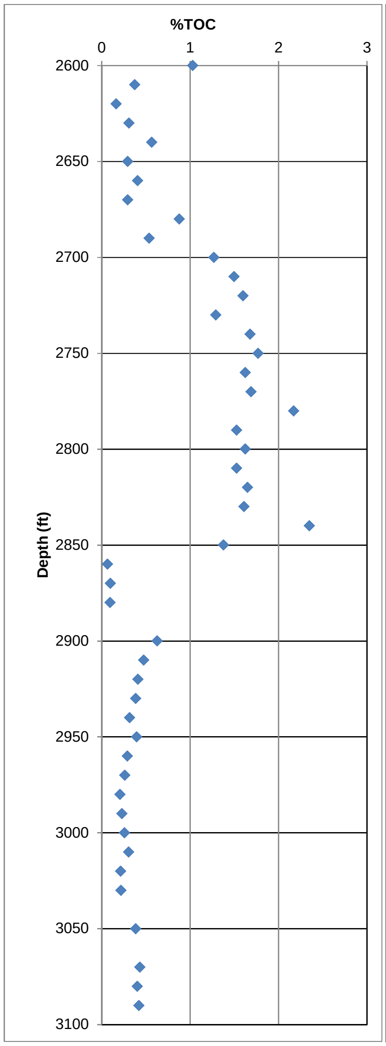


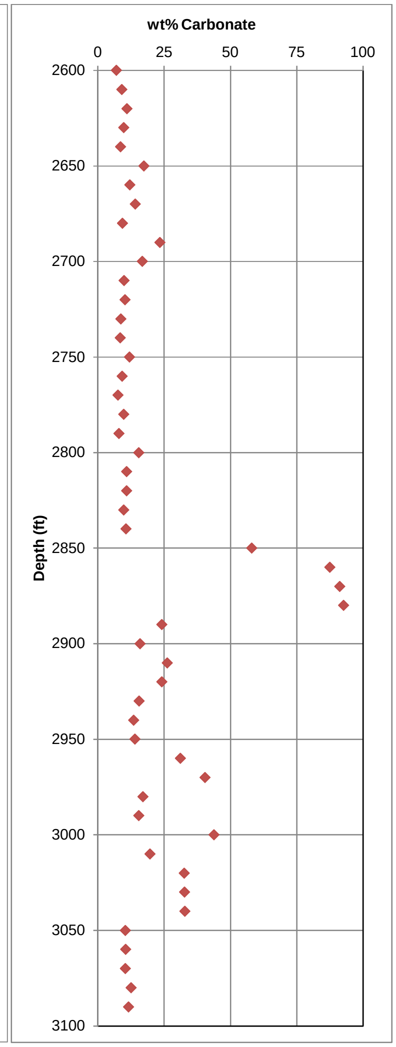
31-101-23085-00-00			
API	Depth (ft)	%TOC	wt% Carbonate
31-101-23085-00-00	3740	0.65	29.28
31-101-23085-00-00	3750	0.67	22.66
31-101-23085-00-00	3760	0.58	22.19
31-101-23085-00-00	3770	2.46	9.62
31-101-23085-00-00	3780	3.12	8.06
31-101-23085-00-00	3790	3.12	7.85
31-101-23085-00-00	3800	4.24	7.89
31-101-23085-00-00	3810	6.47	14.08
31-101-23085-00-00	3820	5.20	18.35
31-101-23085-00-00	3830	4.61	22.01
31-101-23085-00-00	3840	3.33	54.24
31-101-23085-00-00	3850	2.12	72.71
31-101-23085-00-00	3860	1.27	81.19
31-101-23085-00-00	3870	1.02	66.66
31-101-23085-00-00	3880	0.40	26.96
31-101-23085-00-00	3890		4.75
31-101-23085-00-00	3900		9.37



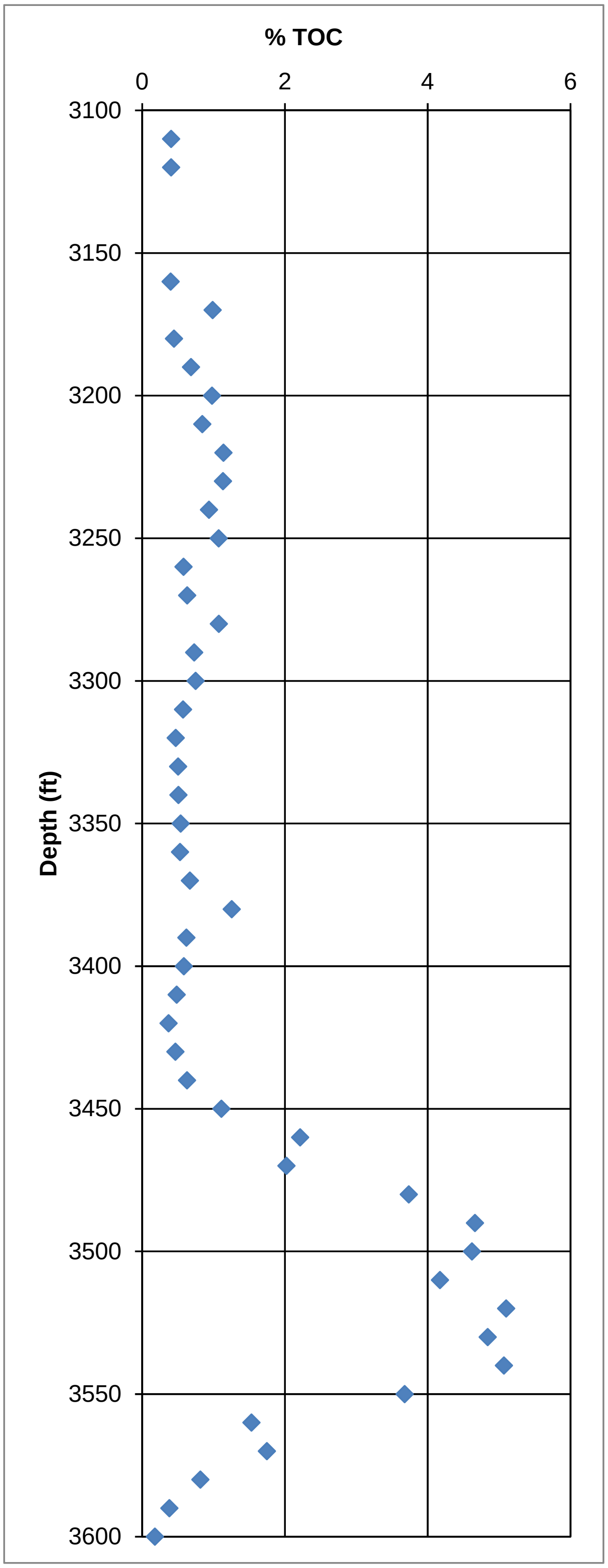


31-101-23155-00-00			
API	Depth (ft)	%TOC	wt% Carbonate
31-101-23155-00-00	2600	1.03	7.02
31-101-23155-00-00	2610	0.38	9.11
31-101-23155-00-00	2620	0.16	11.03
31-101-23155-00-00	2630	0.31	9.82
31-101-23155-00-00	2640	0.57	8.58
31-101-23155-00-00	2650	0.29	17.36
31-101-23155-00-00	2660	0.41	12.09
31-101-23155-00-00	2670	0.29	14.10
31-101-23155-00-00	2680	0.88	9.34
31-101-23155-00-00	2690	0.54	23.41
31-101-23155-00-00	2700	1.27	16.78
31-101-23155-00-00	2710	1.50	9.95
31-101-23155-00-00	2720	1.60	10.31
31-101-23155-00-00	2730	1.29	8.72
31-101-23155-00-00	2740	1.68	8.49
31-101-23155-00-00	2750	1.77	11.99
31-101-23155-00-00	2760	1.63	9.25
31-101-23155-00-00	2770	1.69	7.67
31-101-23155-00-00	2780	2.17	9.84
31-101-23155-00-00	2790	1.53	8.01
31-101-23155-00-00	2800	1.62	15.50
31-101-23155-00-00	2810	1.53	10.90
31-101-23155-00-00	2820	1.65	10.86
31-101-23155-00-00	2830	1.61	9.81
31-101-23155-00-00	2840	2.35	10.65
31-101-23155-00-00	2850	1.38	58.11
31-101-23155-00-00	2860	0.07	87.47
31-101-23155-00-00	2870	0.10	91.24
31-101-23155-00-00	2880	0.09	92.69
31-101-23155-00-00	2890		24.16
31-101-23155-00-00	2900	0.63	16.02
31-101-23155-00-00	2910	0.48	26.26
31-101-23155-00-00	2920	0.41	24.11
31-101-23155-00-00	2930	0.39	15.61
31-101-23155-00-00	2940	0.32	13.59
31-101-23155-00-00	2950	0.40	14.05
31-101-23155-00-00	2960	0.29	31.13
31-101-23155-00-00	2970	0.26	40.43
31-101-23155-00-00	2980	0.21	17.00
31-101-23155-00-00	2990	0.23	15.54
31-101-23155-00-00	3000	0.26	43.84
31-101-23155-00-00	3010	0.30	19.76
31-101-23155-00-00	3020	0.21	32.62
31-101-23155-00-00	3030	0.22	32.77
31-101-23155-00-00	3040		32.83
31-101-23155-00-00	3050	0.39	10.43
31-101-23155-00-00	3060		10.49
31-101-23155-00-00	3070	0.43	10.46
31-101-23155-00-00	3080	0.41	12.53
31-101-23155-00-00	3090	0.42	11.62
Duplicates			
31-101-23155-00-00	2720-2	1.63	
31-101-23155-00-00	2800-2	1.65	
31-101-23155-00-00	2930-2	0.36	

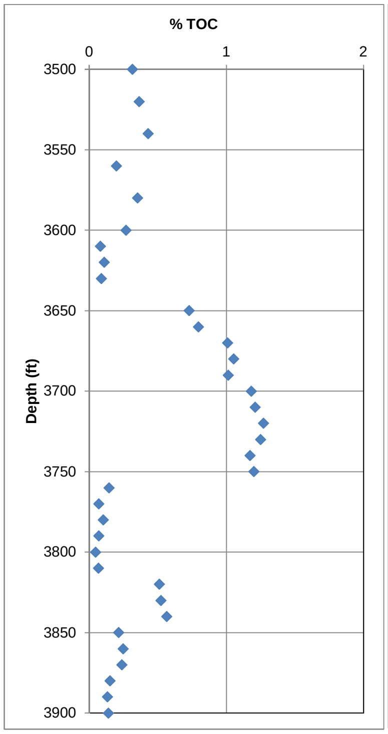


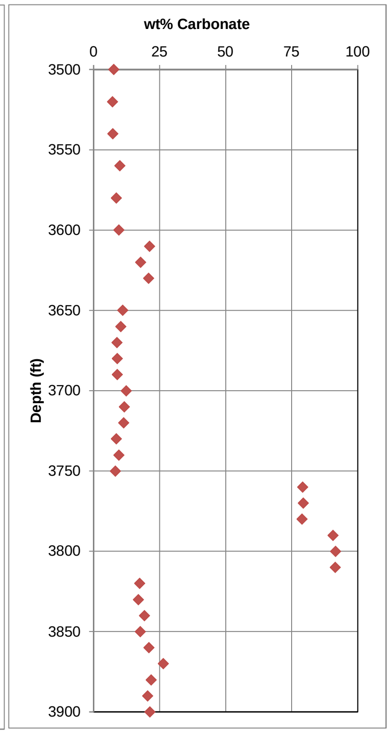


31-101-23190-00-00		
API	Depth	% TOC
31-101-23190-00-00	3110	0.41
31-101-23190-00-00	3120	0.41
31-101-23190-00-00	3160	0.40
31-101-23190-00-00	3170	0.99
31-101-23190-00-00	3180	0.45
31-101-23190-00-00	3190	0.68
31-101-23190-00-00	3200	0.98
31-101-23190-00-00	3210	0.84
31-101-23190-00-00	3220	1.14
31-101-23190-00-00	3230	1.13
31-101-23190-00-00	3240	0.94
31-101-23190-00-00	3250	1.07
31-101-23190-00-00	3260	0.58
31-101-23190-00-00	3270	0.63
31-101-23190-00-00	3280	1.07
31-101-23190-00-00	3290	0.73
31-101-23190-00-00	3300	0.75
31-101-23190-00-00	3310	0.57
31-101-23190-00-00	3320	0.47
31-101-23190-00-00	3330	0.50
31-101-23190-00-00	3340	0.51
31-101-23190-00-00	3350	0.54
31-101-23190-00-00	3360	0.53
31-101-23190-00-00	3370	0.67
31-101-23190-00-00	3380	1.25
31-101-23190-00-00	3390	0.62
31-101-23190-00-00	3400	0.58
31-101-23190-00-00	3410	0.48
31-101-23190-00-00	3420	0.37
31-101-23190-00-00	3430	0.47
31-101-23190-00-00	3440	0.63
31-101-23190-00-00	3450	1.11
31-101-23190-00-00	3460	2.21
31-101-23190-00-00	3470	2.02
31-101-23190-00-00	3480	3.73
31-101-23190-00-00	3490	4.66
31-101-23190-00-00	3500	4.62
31-101-23190-00-00	3510	4.17
31-101-23190-00-00	3520	5.10
31-101-23190-00-00	3530	4.84
31-101-23190-00-00	3540	5.07
31-101-23190-00-00	3550	3.68
31-101-23190-00-00	3560	1.53
31-101-23190-00-00	3570	1.75
31-101-23190-00-00	3580	0.82
31-101-23190-00-00	3590	0.38
31-101-23190-00-00	3600	0.18
Duplicates		
31-101-23190-00-00	3250-2	1.08
31-101-23190-00-00	3330-2	0.49
31-101-23190-00-00	3450-2	1.15

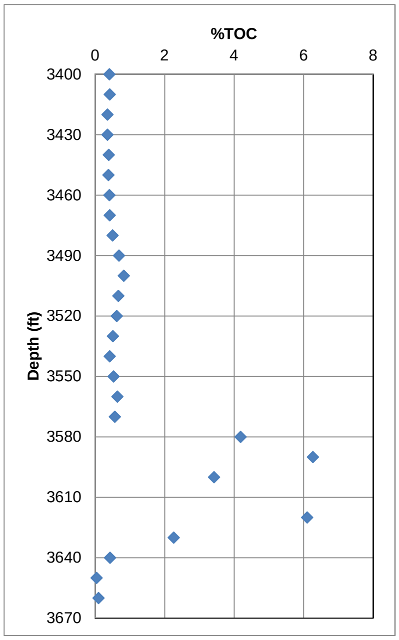


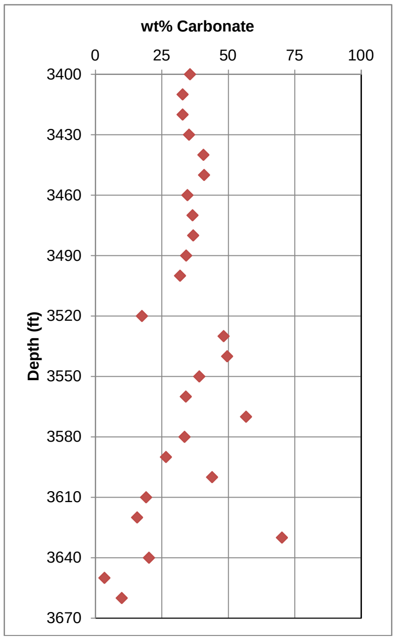
31-101-23968-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-101-23968-00-00	3500	0.31	7.59
31-101-23968-00-00	3520	0.36	7.11
31-101-23968-00-00	3540	0.43	7.26
31-101-23968-00-00	3560	0.20	10.00
31-101-23968-00-00	3580	0.35	8.66
31-101-23968-00-00	3600	0.27	9.57
31-101-23968-00-00	3610	0.08	21.20
31-101-23968-00-00	3620	0.11	17.79
31-101-23968-00-00	3630	0.09	20.88
31-101-23968-00-00	3650	0.73	11.06
31-101-23968-00-00	3660	0.80	10.36
31-101-23968-00-00	3670	1.01	8.82
31-101-23968-00-00	3680	1.05	9.01
31-101-23968-00-00	3690	1.01	9.00
31-101-23968-00-00	3700	1.18	12.42
31-101-23968-00-00	3710	1.21	11.58
31-101-23968-00-00	3720	1.27	11.44
31-101-23968-00-00	3730	1.25	8.60
31-101-23968-00-00	3740	1.17	9.55
31-101-23968-00-00	3750	1.20	8.22
31-101-23968-00-00	3760	0.15	79.11
31-101-23968-00-00	3770	0.07	79.38
31-101-23968-00-00	3780	0.10	78.90
31-101-23968-00-00	3790	0.07	90.65
31-101-23968-00-00	3800	0.05	91.61
31-101-23968-00-00	3810	0.07	91.51
31-101-23968-00-00	3820	0.51	17.46
31-101-23968-00-00	3830	0.52	17.02
31-101-23968-00-00	3840	0.57	19.24
31-101-23968-00-00	3850	0.22	17.63
31-101-23968-00-00	3860	0.25	20.95
31-101-23968-00-00	3870	0.24	26.44
31-101-23968-00-00	3880	0.15	21.76
31-101-23968-00-00	3890	0.13	20.46
31-101-23968-00-00	3900	0.14	21.37
Duplicates			
31-101-23968-00-00	3620-2	0.1127	
31-101-23968-00-00	3760-2	0.1069	



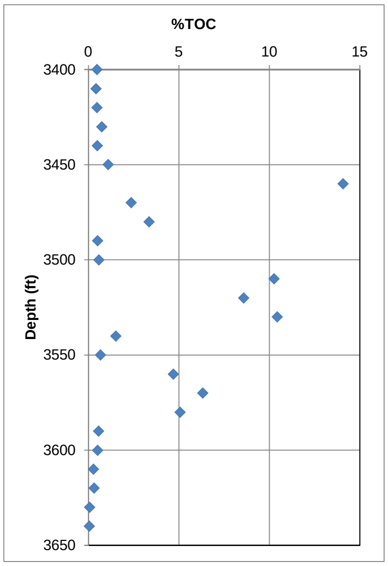


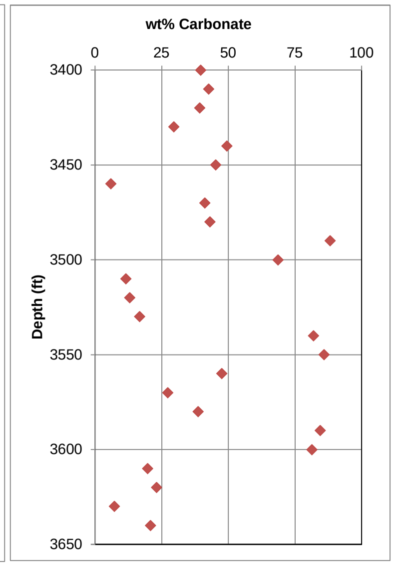
31-101-23985-00-00			
API	Depth (ft)	%TOC	wt% Carbonate
31-101-23985-00-00	3400	0.41	35.61
31-101-23985-00-00	3410	0.42	32.75
31-101-23985-00-00	3420	0.36	32.82
31-101-23985-00-00	3430	0.35	35.17
31-101-23985-00-00	3440	0.39	40.67
31-101-23985-00-00	3450	0.38	40.84
31-101-23985-00-00	3460	0.41	34.66
31-101-23985-00-00	3470	0.42	36.50
31-101-23985-00-00	3480	0.50	36.79
31-101-23985-00-00	3490	0.69	34.16
31-101-23985-00-00	3500	0.83	31.82
31-101-23985-00-00	3510	0.67	
31-101-23985-00-00	3520	0.63	17.53
31-101-23985-00-00	3530	0.52	48.19
31-101-23985-00-00	3540	0.42	49.52
31-101-23985-00-00	3550	0.53	39.06
31-101-23985-00-00	3560	0.64	34.02
31-101-23985-00-00	3570	0.57	56.73
31-101-23985-00-00	3580	4.19	33.54
31-101-23985-00-00	3590	6.26	26.56
31-101-23985-00-00	3600	3.42	43.86
31-101-23985-00-00	3610		19.10
31-101-23985-00-00	3620	6.10	15.70
31-101-23985-00-00	3630	2.26	70.21
31-101-23985-00-00	3640	0.43	20.15
31-101-23985-00-00	3650	0.04	3.39
31-101-23985-00-00	3660	0.09	9.83
Duplicates			
31-101-23985-00-00	3450-2	0.39	
31-101-23985-00-00	3550-2	0.55	



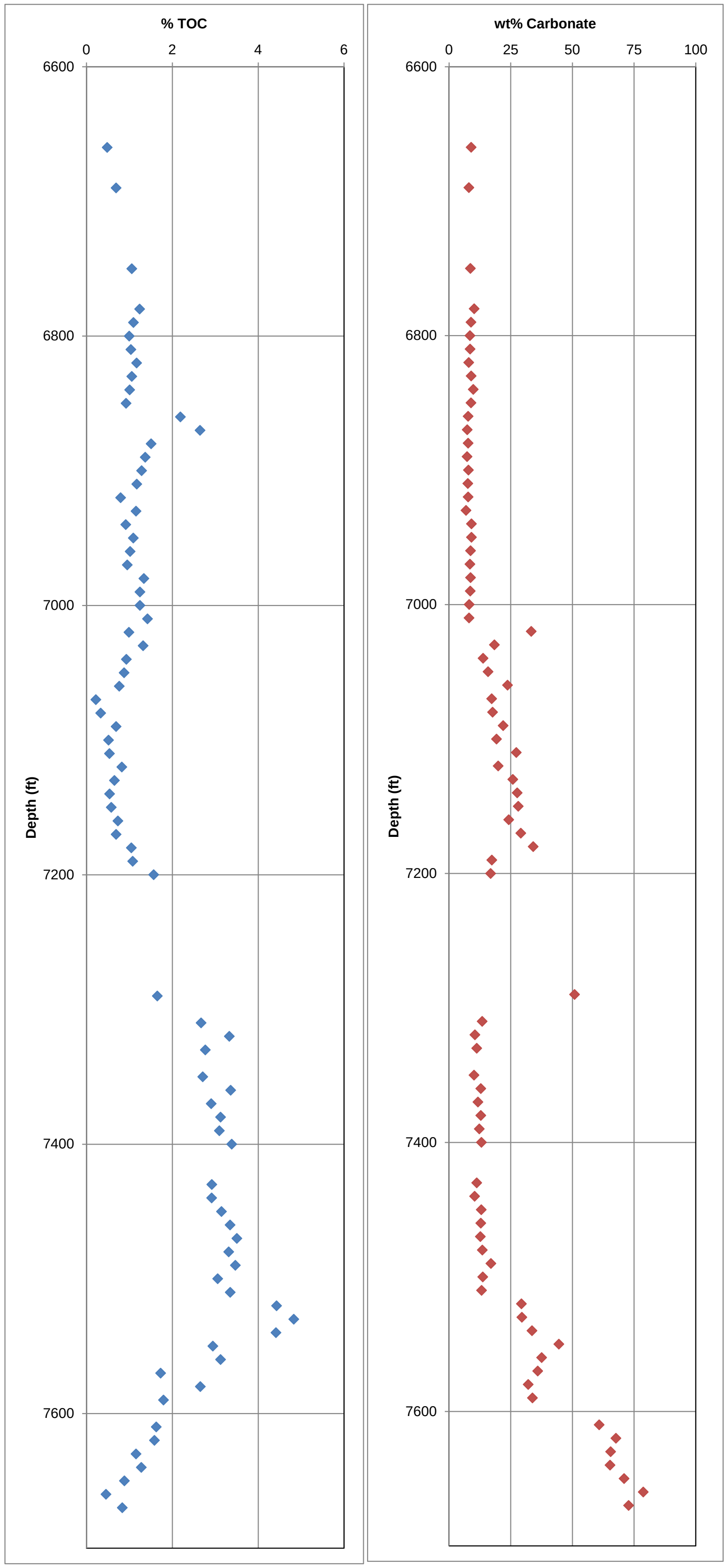


31-101-26011-00-00			
API	Depth (ft)	%TOC	wt% Carbonate
31-101-26011-00-00	3400	0.47	39.67
31-101-26011-00-00	3410	0.41	42.67
31-101-26011-00-00	3420	0.46	39.24
31-101-26011-00-00	3430	0.72	29.56
31-101-26011-00-00	3440	0.48	49.45
31-101-26011-00-00	3450	1.09	45.20
31-101-26011-00-00	3460	14.08	5.87
31-101-26011-00-00	3470	2.35	41.21
31-101-26011-00-00	3480	3.35	43.05
31-101-26011-00-00	3490	0.51	88.14
31-101-26011-00-00	3500	0.58	68.59
31-101-26011-00-00	3510	10.26	11.51
31-101-26011-00-00	3520	8.57	12.99
31-101-26011-00-00	3530	10.43	16.75
31-101-26011-00-00	3540	1.51	81.88
31-101-26011-00-00	3550	0.66	85.92
31-101-26011-00-00	3560	4.68	47.56
31-101-26011-00-00	3570	6.31	27.28
31-101-26011-00-00	3580	5.07	38.67
31-101-26011-00-00	3590	0.56	84.42
31-101-26011-00-00	3600	0.51	81.28
31-101-26011-00-00	3610	0.27	19.68
31-101-26011-00-00	3620	0.30	23.05
31-101-26011-00-00	3630	0.06	7.26
31-101-26011-00-00	3640	0.05	20.84
Duplicates			
31-101-26011-00-00	3400-2	0.45	
31-101-26011-00-00	3530-2	6.96	
31-101-26011-00-00	3640-2	0.06	

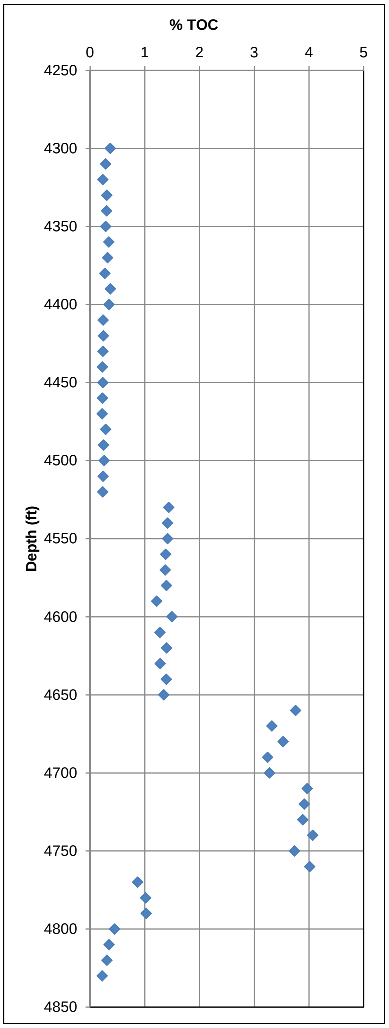


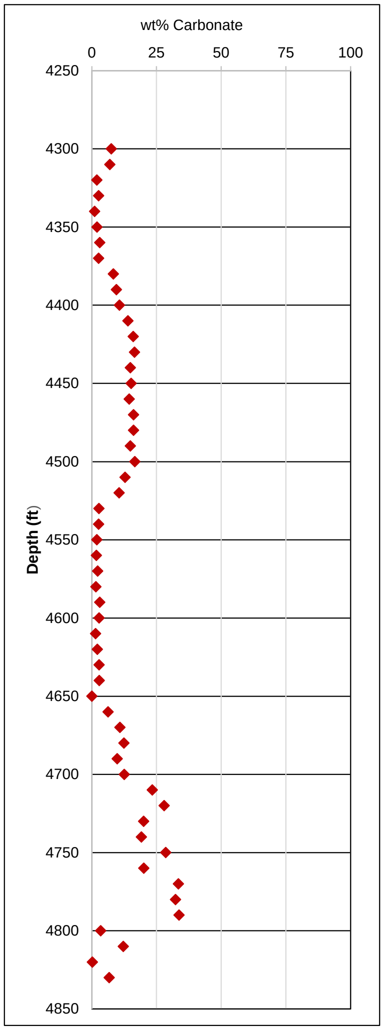


31-105-12861-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-105-12861-00-00	6660	0.48	8.89
31-105-12861-00-00	6690	0.69	7.98
31-105-12861-00-00	6750	1.06	8.61
31-105-12861-00-00	6780	1.24	10.09
31-105-12861-00-00	6790	1.10	8.86
31-105-12861-00-00	6800	1.00	8.43
31-105-12861-00-00	6810	1.04	8.46
31-105-12861-00-00	6820	1.17	7.94
31-105-12861-00-00	6830	1.06	8.88
31-105-12861-00-00	6840	1.01	9.74
31-105-12861-00-00	6850	0.92	8.82
31-105-12861-00-00	6860	2.19	7.66
31-105-12861-00-00	6870	2.65	7.28
31-105-12861-00-00	6880	1.51	7.66
31-105-12861-00-00	6890	1.37	7.26
31-105-12861-00-00	6900	1.28	7.80
31-105-12861-00-00	6910	1.17	7.55
31-105-12861-00-00	6920	0.80	7.69
31-105-12861-00-00	6930	1.16	6.81
31-105-12861-00-00	6940	0.92	9.05
31-105-12861-00-00	6950	1.09	9.04
31-105-12861-00-00	6960	1.02	8.68
31-105-12861-00-00	6970	0.95	8.39
31-105-12861-00-00	6980	1.34	8.65
31-105-12861-00-00	6990	1.25	8.52
31-105-12861-00-00	7000	1.25	8.13
31-105-12861-00-00	7010	1.42	8.03
31-105-12861-00-00	7020	0.99	33.24
31-105-12861-00-00	7030	1.32	18.30
31-105-12861-00-00	7040	0.93	13.72
31-105-12861-00-00	7050	0.88	15.74
31-105-12861-00-00	7060	0.76	23.62
31-105-12861-00-00	7070	0.22	17.20
31-105-12861-00-00	7080	0.33	17.59
31-105-12861-00-00	7090	0.69	21.88
31-105-12861-00-00	7100	0.51	19.20
31-105-12861-00-00	7110	0.54	27.17
31-105-12861-00-00	7120	0.83	19.85
31-105-12861-00-00	7130	0.65	25.76
31-105-12861-00-00	7140	0.54	27.56
31-105-12861-00-00	7150	0.58	27.98
31-105-12861-00-00	7160	0.73	24.16
31-105-12861-00-00	7170	0.69	29.04
31-105-12861-00-00	7180	1.05	34.07
31-105-12861-00-00	7190	1.08	17.27
31-105-12861-00-00	7200	1.57	16.77
31-105-12861-00-00	7290	1.65	50.84
31-105-12861-00-00	7310	2.67	13.36
31-105-12861-00-00	7320	3.33	10.45
31-105-12861-00-00	7330	2.77	11.16
31-105-12861-00-00	7350	2.71	10.03
31-105-12861-00-00	7360	3.36	12.80
31-105-12861-00-00	7370	2.91	11.66
31-105-12861-00-00	7380	3.12	12.84
31-105-12861-00-00	7390	3.10	12.19
31-105-12861-00-00	7400	3.38	13.03
31-105-12861-00-00	7430	2.92	11.15
31-105-12861-00-00	7440	2.92	10.27
31-105-12861-00-00	7450	3.15	12.97
31-105-12861-00-00	7460	3.35	12.80
31-105-12861-00-00	7470	3.50	12.61
31-105-12861-00-00	7480	3.32	13.41
31-105-12861-00-00	7490	3.47	16.90
31-105-12861-00-00	7500	3.06	13.60
31-105-12861-00-00	7510	3.35	13.11
31-105-12861-00-00	7520	4.43	29.29
31-105-12861-00-00	7530	4.83	29.48
31-105-12861-00-00	7540	4.41	33.54
31-105-12861-00-00	7550	2.94	44.41
31-105-12861-00-00	7560	3.13	37.49
31-105-12861-00-00	7570	1.73	35.91
31-105-12861-00-00	7580	2.65	32.02
31-105-12861-00-00	7590	1.80	33.74
31-105-12861-00-00	7610	1.63	60.81
31-105-12861-00-00	7620	1.58	67.55
31-105-12861-00-00	7630	1.15	65.46
31-105-12861-00-00	7640	1.28	65.17
31-105-12861-00-00	7650	0.89	70.90
31-105-12861-00-00	7660	0.46	78.67
31-105-12861-00-00	7670	0.84	72.73
Duplicates			
31-105-12861-00-00	6690-2	0.70	
31-105-12861-00-00	6820-2	1.14	
31-105-12861-00-00	6920-2	1.21	
31-105-12861-00-00	6990-2	1.27	
31-105-12861-00-00	7320-2	3.23	
31-105-12861-00-00	7450-2	3.05	
31-105-12861-00-00	7620-2	1.60	

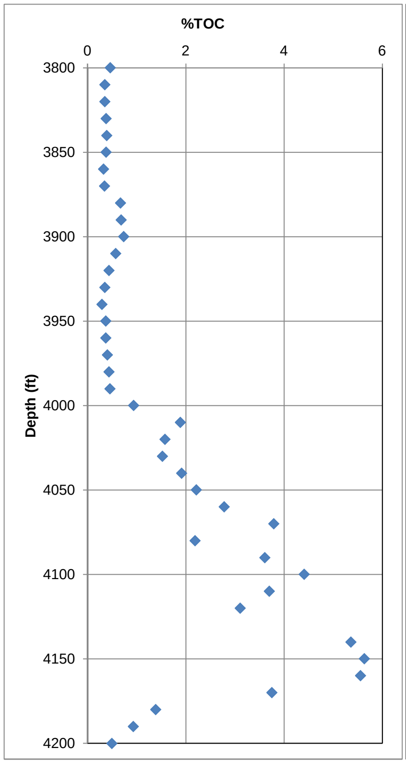


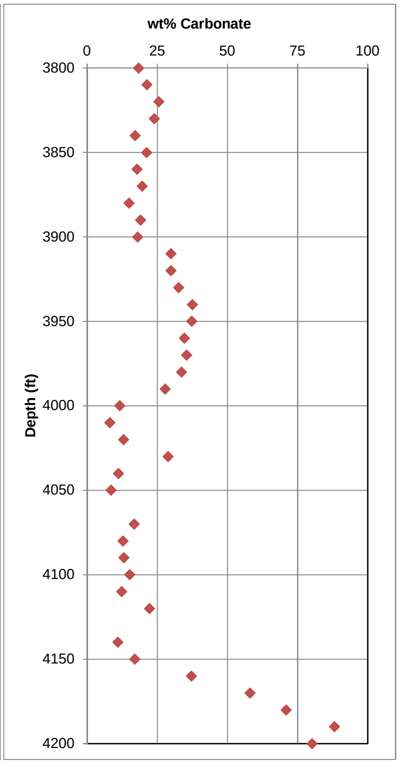
31-107-22887-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-107-22887-00-00	4300	0.37	7.49
31-107-22887-00-00	4310	0.29	6.89
31-107-22887-00-00	4320	0.23	1.90
31-107-22887-00-00	4330	0.31	2.61
31-107-22887-00-00	4340	0.30	1.05
31-107-22887-00-00	4350	0.29	1.99
31-107-22887-00-00	4360	0.35	3.04
31-107-22887-00-00	4370	0.32	2.58
31-107-22887-00-00	4380	0.27	8.28
31-107-22887-00-00	4390	0.37	9.46
31-107-22887-00-00	4400	0.35	10.65
31-107-22887-00-00	4410	0.24	13.90
31-107-22887-00-00	4420	0.24	15.94
31-107-22887-00-00	4430	0.24	16.43
31-107-22887-00-00	4440	0.22	14.85
31-107-22887-00-00	4450	0.23	15.13
31-107-22887-00-00	4460	0.23	14.39
31-107-22887-00-00	4470	0.22	16.05
31-107-22887-00-00	4480	0.29	16.06
31-107-22887-00-00	4490	0.25	14.83
31-107-22887-00-00	4500	0.26	16.60
31-107-22887-00-00	4510	0.24	12.82
31-107-22887-00-00	4520	0.23	10.52
31-107-22887-00-00	4530	1.44	2.70
31-107-22887-00-00	4540	1.42	2.59
31-107-22887-00-00	4550	1.42	1.91
31-107-22887-00-00	4560	1.38	1.70
31-107-22887-00-00	4570	1.37	2.23
31-107-22887-00-00	4580	1.40	1.56
31-107-22887-00-00	4590	1.22	3.01
31-107-22887-00-00	4600	1.50	2.76
31-107-22887-00-00	4610	1.28	1.43
31-107-22887-00-00	4620	1.40	2.09
31-107-22887-00-00	4630	1.28	2.75
31-107-22887-00-00	4640	1.39	2.82
31-107-22887-00-00	4650	1.35	0.00
31-107-22887-00-00	4660	3.76	6.24
31-107-22887-00-00	4670	3.32	10.80
31-107-22887-00-00	4680	3.53	12.36
31-107-22887-00-00	4690	3.24	9.74
31-107-22887-00-00	4700	3.28	12.48
31-107-22887-00-00	4710	3.97	23.30
31-107-22887-00-00	4720	3.91	27.87
31-107-22887-00-00	4730	3.89	19.98
31-107-22887-00-00	4740	4.07	19.10
31-107-22887-00-00	4750	3.74	28.50
31-107-22887-00-00	4760	4.01	20.04
31-107-22887-00-00	4770	0.87	33.38
31-107-22887-00-00	4780	1.02	32.31
31-107-22887-00-00	4790	1.03	33.64
31-107-22887-00-00	4800	0.45	3.41
31-107-22887-00-00	4810	0.35	12.12
31-107-22887-00-00	4820	0.31	0.19
31-107-22887-00-00	4830	0.22	6.70



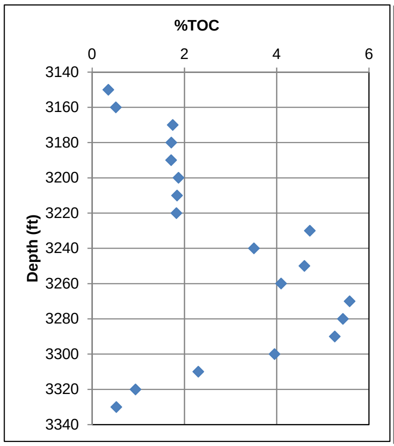


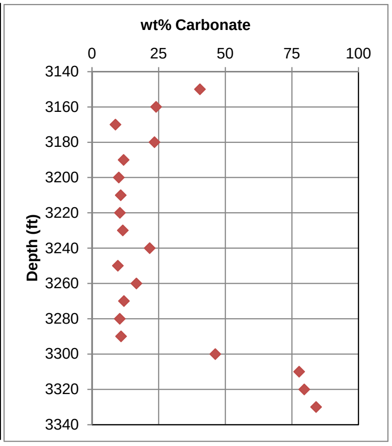
31-107-23883-00-00			
API	Depth (ft)	%TOC	wt% Carbonate
31-107-23883-00-00	3800	0.46	18.39
31-107-23883-00-00	3810	0.35	21.36
31-107-23883-00-00	3820	0.35	25.49
31-107-23883-00-00	3830	0.38	23.89
31-107-23883-00-00	3840	0.39	17.12
31-107-23883-00-00	3850	0.38	21.23
31-107-23883-00-00	3860	0.33	17.82
31-107-23883-00-00	3870	0.34	19.58
31-107-23883-00-00	3880	0.67	14.90
31-107-23883-00-00	3890	0.68	19.04
31-107-23883-00-00	3900	0.74	17.98
31-107-23883-00-00	3910	0.57	29.84
31-107-23883-00-00	3920	0.44	29.92
31-107-23883-00-00	3930	0.35	32.60
31-107-23883-00-00	3940	0.29	37.52
31-107-23883-00-00	3950	0.37	37.25
31-107-23883-00-00	3960	0.37	34.67
31-107-23883-00-00	3970	0.40	35.42
31-107-23883-00-00	3980	0.44	33.59
31-107-23883-00-00	3990	0.46	27.84
31-107-23883-00-00	4000	0.93	11.68
31-107-23883-00-00	4010	1.89	8.10
31-107-23883-00-00	4020	1.58	12.96
31-107-23883-00-00	4030	1.53	28.85
31-107-23883-00-00	4040	1.92	11.21
31-107-23883-00-00	4050	2.21	8.54
31-107-23883-00-00	4060	2.78	
31-107-23883-00-00	4070	3.79	16.72
31-107-23883-00-00	4080	2.19	12.73
31-107-23883-00-00	4090	3.61	13.05
31-107-23883-00-00	4100	4.41	15.11
31-107-23883-00-00	4110	3.70	12.30
31-107-23883-00-00	4120	3.11	22.22
31-107-23883-00-00	4140	5.36	10.98
31-107-23883-00-00	4150	5.63	17.00
31-107-23883-00-00	4160	5.55	37.15
31-107-23883-00-00	4170	3.75	58.06
31-107-23883-00-00	4180	1.39	70.90
31-107-23883-00-00	4190	0.93	88.16
31-107-23883-00-00	4200	0.49	80.20
Duplicates			
31-107-23883-00-00	3820-2	0.3398	



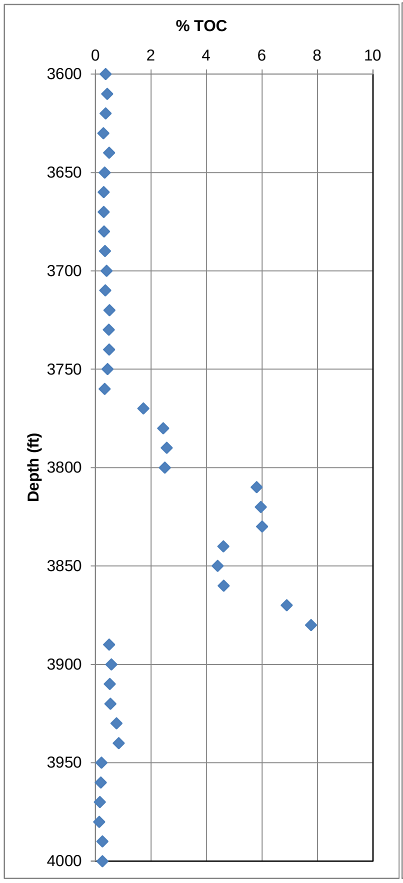


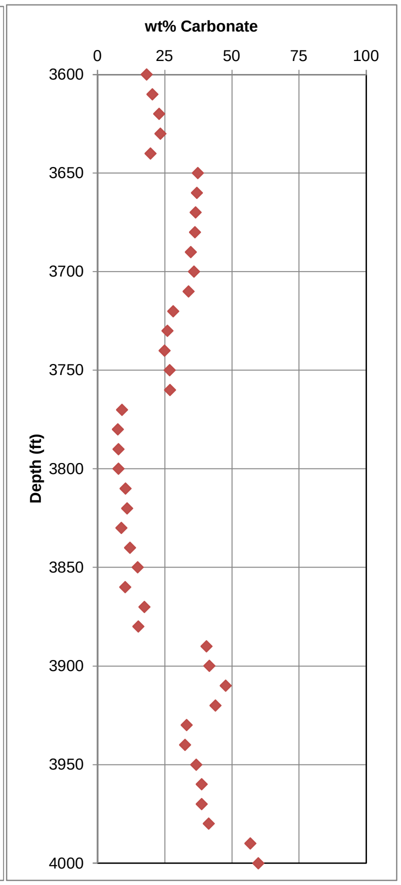
31-107-23927-00-00			
API	Depth (ft)	%TOC	wt% Carbonate
31-107-23927-00-00	3150	0.35	40.50
31-107-23927-00-00	3160	0.51	24.09
31-107-23927-00-00	3170	1.74	8.81
31-107-23927-00-00	3180	1.71	23.49
31-107-23927-00-00	3190	1.71	11.90
31-107-23927-00-00	3200	1.87	10.05
31-107-23927-00-00	3210	1.84	10.83
31-107-23927-00-00	3220	1.83	10.50
31-107-23927-00-00	3230	4.72	11.59
31-107-23927-00-00	3240	3.50	21.69
31-107-23927-00-00	3250	4.60	9.69
31-107-23927-00-00	3260	4.09	16.69
31-107-23927-00-00	3270	5.58	11.98
31-107-23927-00-00	3280	5.43	10.47
31-107-23927-00-00	3290	5.26	10.90
31-107-23927-00-00	3300	3.95	46.26
31-107-23927-00-00	3310	2.30	77.70
31-107-23927-00-00	3320	0.94	79.63
31-107-23927-00-00	3330	0.52	84.09
Duplicates			
31-107-23927-00-00	3230-2	4.96	
31-107-23927-00-00	3290-2	5.07	



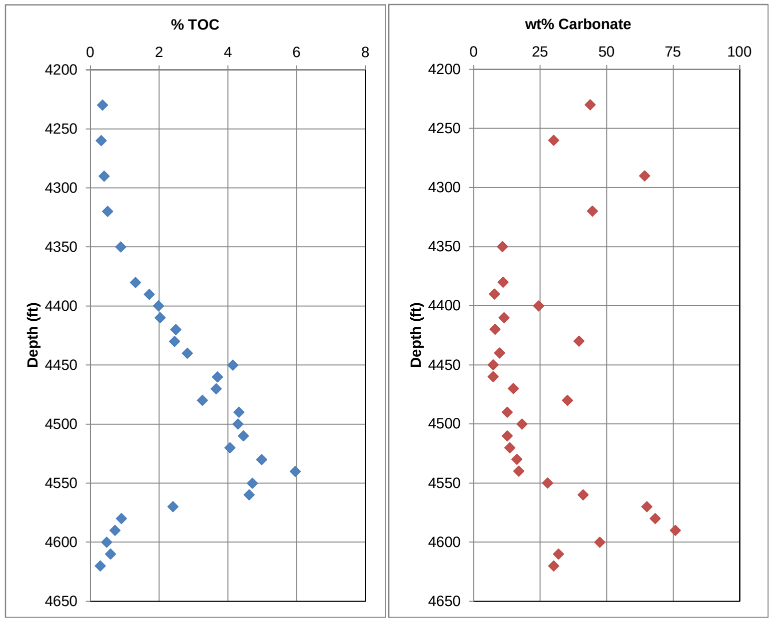


31-107-23996-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-107-23996-00-00	3600	0.37	18.29
31-107-23996-00-00	3610	0.42	20.36
31-107-23996-00-00	3620	0.36	22.91
31-107-23996-00-00	3630	0.29	23.35
31-107-23996-00-00	3640	0.49	19.70
31-107-23996-00-00	3650	0.33	37.36
31-107-23996-00-00	3660	0.29	37.01
31-107-23996-00-00	3670	0.30	36.52
31-107-23996-00-00	3680	0.31	36.23
31-107-23996-00-00	3690	0.34	34.67
31-107-23996-00-00	3700	0.41	35.93
31-107-23996-00-00	3710	0.36	33.85
31-107-23996-00-00	3720	0.51	28.10
31-107-23996-00-00	3730	0.49	26.03
31-107-23996-00-00	3740	0.49	24.94
31-107-23996-00-00	3750	0.44	26.79
31-107-23996-00-00	3760	0.33	27.00
31-107-23996-00-00	3770	1.72	9.12
31-107-23996-00-00	3780	2.45	7.56
31-107-23996-00-00	3790	2.56	7.75
31-107-23996-00-00	3800	2.49	7.82
31-107-23996-00-00	3810	5.80	10.40
31-107-23996-00-00	3820	5.96	11.01
31-107-23996-00-00	3830	6.00	8.90
31-107-23996-00-00	3840	4.62	12.12
31-107-23996-00-00	3850	4.40	14.95
31-107-23996-00-00	3860	4.62	10.26
31-107-23996-00-00	3870	6.89	17.39
31-107-23996-00-00	3880	7.77	15.13
31-107-23996-00-00	3890	0.49	40.52
31-107-23996-00-00	3900	0.57	41.65
31-107-23996-00-00	3910	0.52	47.68
31-107-23996-00-00	3920	0.54	43.83
31-107-23996-00-00	3930	0.76	33.20
31-107-23996-00-00	3940	0.84	32.54
31-107-23996-00-00	3950	0.22	36.70
31-107-23996-00-00	3960	0.19	38.76
31-107-23996-00-00	3970	0.16	38.69
31-107-23996-00-00	3980	0.14	41.40
31-107-23996-00-00	3990	0.26	56.84
31-107-23996-00-00	4000	0.25	59.78
Duplicates			
31-107-23996-00-00	3880-2	7.29	

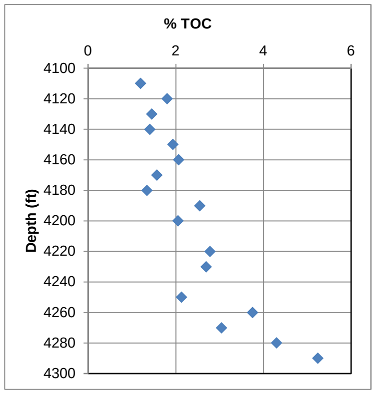


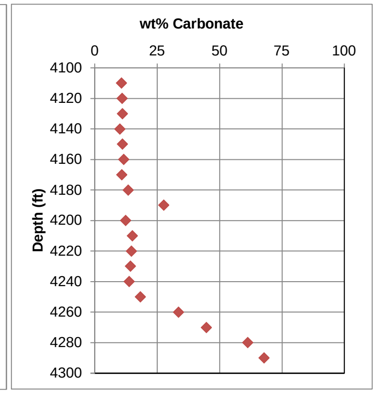


31-107-26158-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-107-26158-00-00	4230	0.36	43.76
31-107-26158-00-00	4260	0.32	30.02
31-107-26158-00-00	4290	0.40	64.22
31-107-26158-00-00	4320	0.50	44.64
31-107-26158-00-00	4350	0.88	10.80
31-107-26158-00-00	4380	1.31	11.06
31-107-26158-00-00	4390	1.71	7.82
31-107-26158-00-00	4400	1.99	24.45
31-107-26158-00-00	4410	2.02	11.44
31-107-26158-00-00	4420	2.48	8.09
31-107-26158-00-00	4430	2.45	39.60
31-107-26158-00-00	4440	2.82	9.72
31-107-26158-00-00	4450	4.14	7.35
31-107-26158-00-00	4460	3.69	7.30
31-107-26158-00-00	4470	3.66	14.88
31-107-26158-00-00	4480	3.25	35.25
31-107-26158-00-00	4490	4.32	12.66
31-107-26158-00-00	4500	4.29	18.18
31-107-26158-00-00	4510	4.45	12.57
31-107-26158-00-00	4520	4.06	13.58
31-107-26158-00-00	4530	4.98	16.24
31-107-26158-00-00	4540	5.96	16.89
31-107-26158-00-00	4550	4.71	27.75
31-107-26158-00-00	4560	4.62	41.16
31-107-26158-00-00	4570	2.40	65.04
31-107-26158-00-00	4580	0.90	68.24
31-107-26158-00-00	4590	0.71	75.78
31-107-26158-00-00	4600	0.47	47.46
31-107-26158-00-00	4610	0.58	31.87
31-107-26158-00-00	4620	0.29	30.02
Duplicates			
31-107-26158-00-00	4550-2	4.57	

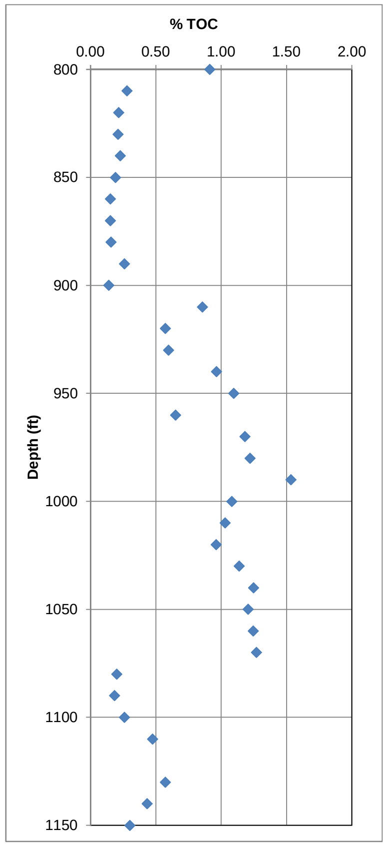


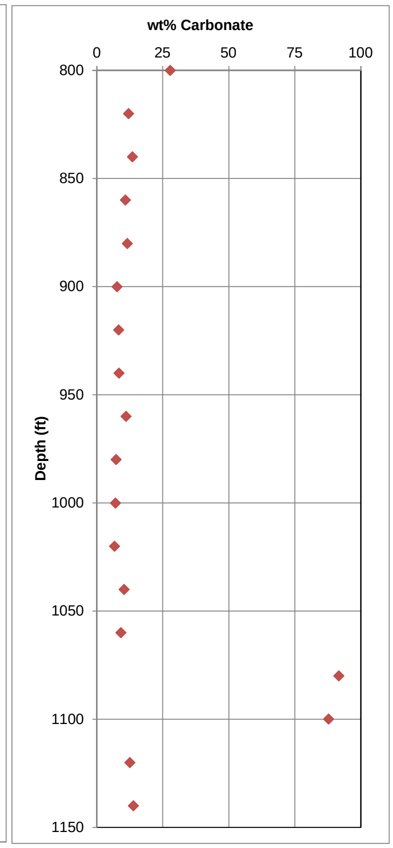
31-107-26426-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-107-26426-00-00	4110	1.20	10.74
31-107-26426-00-00	4120	1.80	11.00
31-107-26426-00-00	4130	1.45	11.04
31-107-26426-00-00	4140	1.41	10.05
31-107-26426-00-00	4150	1.93	11.15
31-107-26426-00-00	4160	2.06	11.63
31-107-26426-00-00	4170	1.57	10.87
31-107-26426-00-00	4180	1.34	13.45
31-107-26426-00-00	4190	2.55	27.61
31-107-26426-00-00	4200	2.05	12.45
31-107-26426-00-00	4210		15.03
31-107-26426-00-00	4220	2.78	14.67
31-107-26426-00-00	4230	2.69	14.26
31-107-26426-00-00	4240		13.84
31-107-26426-00-00	4250	2.13	18.29
31-107-26426-00-00	4260	3.75	33.57
31-107-26426-00-00	4270	3.04	44.71
31-107-26426-00-00	4280	4.30	61.28
31-107-26426-00-00	4290	5.24	67.82
Duplicates			
31-107-26426-00-00	4220-2	2.88	



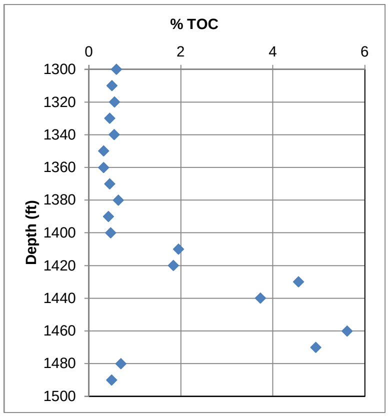


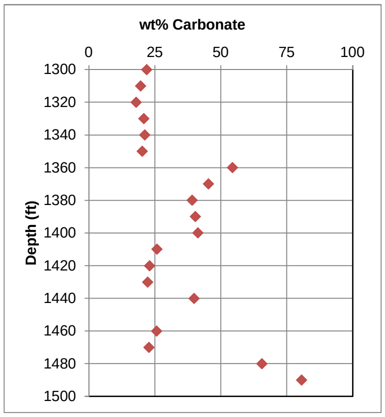
31-109-03973-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-109-03973-00-00	800	0.91	27.80
31-109-03973-00-00	810	0.28	
31-109-03973-00-00	820	0.22	12.03
31-109-03973-00-00	830	0.21	
31-109-03973-00-00	840	0.23	13.50
31-109-03973-00-00	850	0.19	
31-109-03973-00-00	860	0.15	10.86
31-109-03973-00-00	870	0.15	
31-109-03973-00-00	880	0.16	11.58
31-109-03973-00-00	890	0.26	
31-109-03973-00-00	900	0.14	7.69
31-109-03973-00-00	910	0.86	
31-109-03973-00-00	920	0.57	8.32
31-109-03973-00-00	930	0.60	
31-109-03973-00-00	940	0.96	8.42
31-109-03973-00-00	950	1.09	
31-109-03973-00-00	960	0.65	11.05
31-109-03973-00-00	970	1.18	
31-109-03973-00-00	980	1.22	7.31
31-109-03973-00-00	990	1.53	
31-109-03973-00-00	1000	1.08	7.01
31-109-03973-00-00	1010	1.03	
31-109-03973-00-00	1020	0.96	6.67
31-109-03973-00-00	1030	1.14	
31-109-03973-00-00	1040	1.25	10.36
31-109-03973-00-00	1050	1.21	
31-109-03973-00-00	1060	1.24	9.15
31-109-03973-00-00	1070	1.27	
31-109-03973-00-00	1080	0.20	91.67
31-109-03973-00-00	1090	0.18	
31-109-03973-00-00	1100	0.26	87.79
31-109-03973-00-00	1110	0.48	
31-109-03973-00-00	1120		12.54
31-109-03973-00-00	1130	0.57	
31-109-03973-00-00	1140	0.43	13.80
31-109-03973-00-00	1150	0.30	
Duplicates			
31-109-03973-00-00	870-2	0.1583	
31-109-03973-00-00	1020-2	1.0067	
31-109-03973-00-00	1060-2	1.3520	
31-109-03973-00-00	1080-2	0.1647	



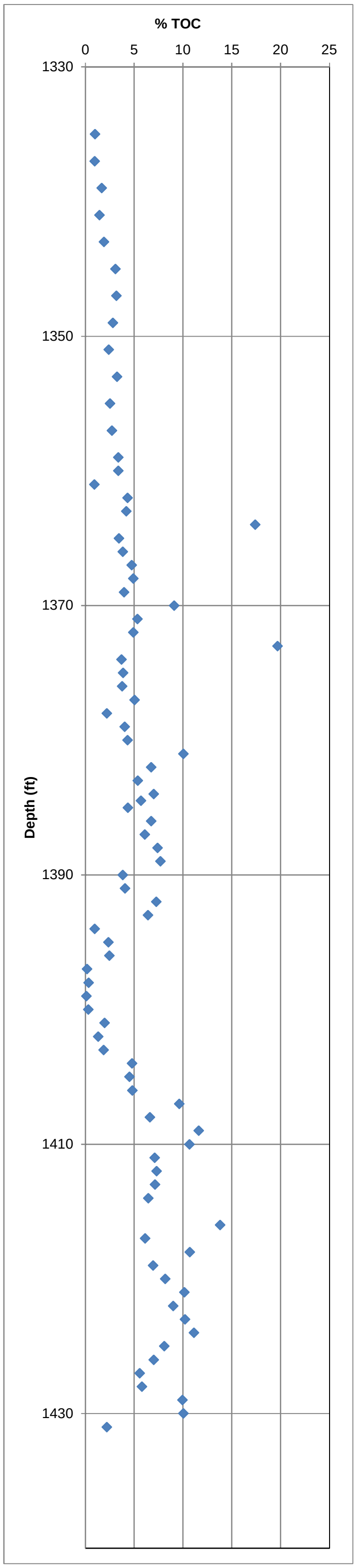


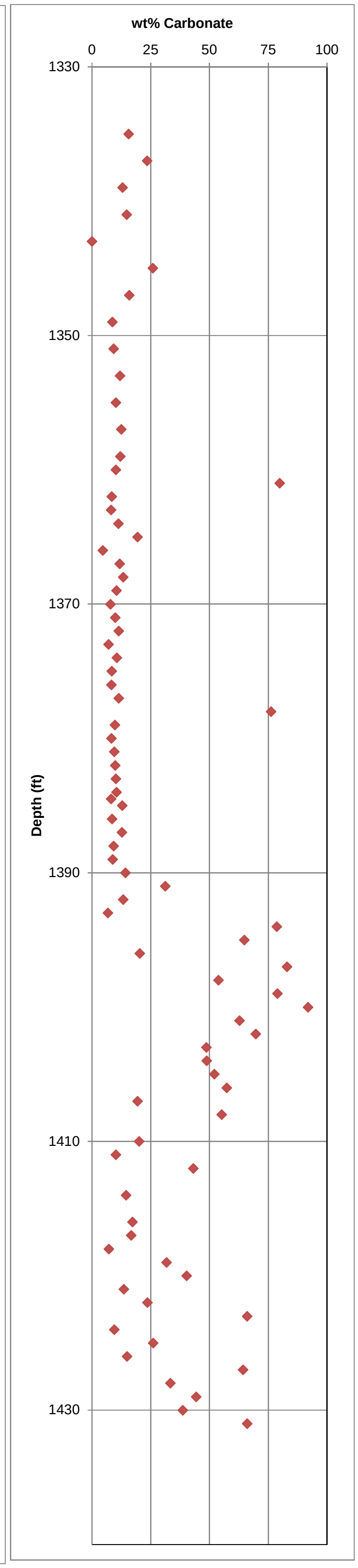
31-109-05017-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-109-05017-00-00	1300	0.60	21.84
31-109-05017-00-00	1310	0.50	19.61
31-109-05017-00-00	1320	0.56	17.91
31-109-05017-00-00	1330	0.45	20.76
31-109-05017-00-00	1340	0.55	21.21
31-109-05017-00-00	1350	0.32	20.14
31-109-05017-00-00	1360	0.32	54.41
31-109-05017-00-00	1370	0.45	45.31
31-109-05017-00-00	1380	0.64	39.13
31-109-05017-00-00	1390	0.43	40.33
31-109-05017-00-00	1400	0.47	41.31
31-109-05017-00-00	1410	1.95	25.75
31-109-05017-00-00	1420	1.84	23.03
31-109-05017-00-00	1430	4.56	22.25
31-109-05017-00-00	1440	3.73	39.85
31-109-05017-00-00	1460	5.61	25.68
31-109-05017-00-00	1470	4.93	22.73
31-109-05017-00-00	1480	0.69	65.59
31-109-05017-00-00	1490	0.49	80.59
Duplicates			
31-109-05017-00-00	1360-2	0.31	



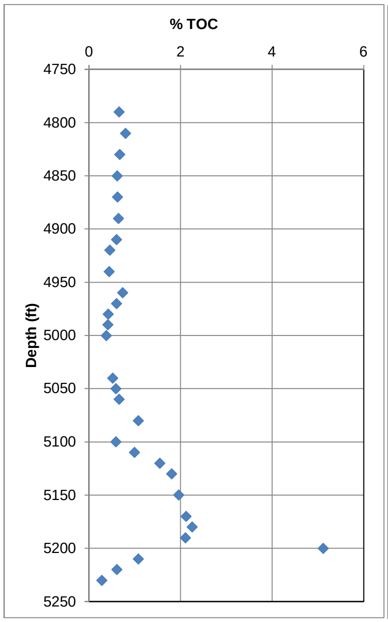


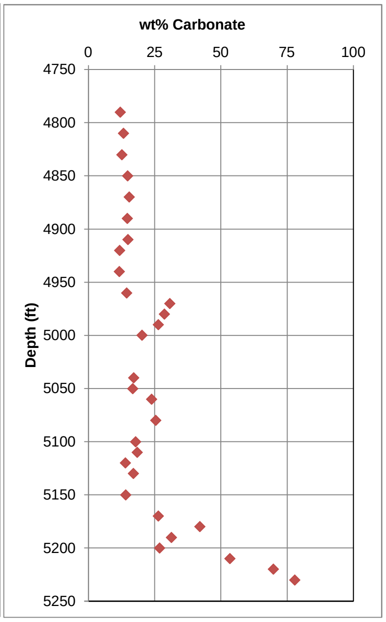
31-109-13173-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-109-13173-00-00	1335	1.00	15.68
31-109-13173-00-00	1337	0.97	23.53
31-109-13173-00-00	1339	1.70	13.04
31-109-13173-00-00	1341	1.47	14.89
31-109-13173-00-00	1343	1.92	0.00
31-109-13173-00-00	1345	3.08	26.02
31-109-13173-00-00	1347	3.19	15.92
31-109-13173-00-00	1349	2.81	8.78
31-109-13173-00-00	1351	2.39	9.23
31-109-13173-00-00	1353	3.24	12.00
31-109-13173-00-00	1355	2.53	10.29
31-109-13173-00-00	1357	2.71	12.51
31-109-13173-00-00	1359	3.37	12.07
31-109-13173-00-00	1360	3.37	10.28
31-109-13173-00-00	1361	0.92	79.95
31-109-13173-00-00	1362	4.34	8.53
31-109-13173-00-00	1363	4.19	8.23
31-109-13173-00-00	1364	17.39	11.28
31-109-13173-00-00	1365	3.46	19.48
31-109-13173-00-00	1366	3.83	4.60
31-109-13173-00-00	1367	4.75	11.82
31-109-13173-00-00	1368	4.91	13.34
31-109-13173-00-00	1369	3.98	10.46
31-109-13173-00-00	1370	9.12	7.94
31-109-13173-00-00	1371	5.34	9.94
31-109-13173-00-00	1372	4.93	11.51
31-109-13173-00-00	1373	19.70	7.13
31-109-13173-00-00	1374	3.72	10.58
31-109-13173-00-00	1375	3.88	8.44
31-109-13173-00-00	1376	3.77	8.35
31-109-13173-00-00	1377	5.04	11.47
31-109-13173-00-00	1378	2.19	76.30
31-109-13173-00-00	1379	4.05	9.78
31-109-13173-00-00	1380	4.31	8.33
31-109-13173-00-00	1381	10.07	9.61
31-109-13173-00-00	1382	6.74	10.01
31-109-13173-00-00	1383	5.39	10.27
31-109-13173-00-00	1384	7.02	10.54
31-109-13173-00-00	1384.5	5.70	8.15
31-109-13173-00-00	1385	4.35	12.98
31-109-13173-00-00	1386	6.73	8.54
31-109-13173-00-00	1387	6.10	12.81
31-109-13173-00-00	1388	7.39	9.25
31-109-13173-00-00	1389	7.69	8.85
31-109-13173-00-00	1390	3.83	14.27
31-109-13173-00-00	1391	4.07	31.19
31-109-13173-00-00	1392	7.26	13.41
31-109-13173-00-00	1393	6.43	6.84
31-109-13173-00-00	1394	0.97	78.74
31-109-13173-00-00	1395	2.36	64.89
31-109-13173-00-00	1396	2.48	20.38
31-109-13173-00-00	1397	0.18	83.00
31-109-13173-00-00	1398	0.35	53.87
31-109-13173-00-00	1399	0.12	78.92
31-109-13173-00-00	1400	0.31	91.96
31-109-13173-00-00	1401	1.96	62.83
31-109-13173-00-00	1402	1.33	69.76
31-109-13173-00-00	1403	1.88	48.75
31-109-13173-00-00	1404	4.77	48.84
31-109-13173-00-00	1405	4.53	52.07
31-109-13173-00-00	1406	4.83	57.48
31-109-13173-00-00	1407	9.61	19.44
31-109-13173-00-00	1408	6.62	55.20
31-109-13173-00-00	1409	11.63	
31-109-13173-00-00	1410	10.67	20.08
31-109-13173-00-00	1411	7.11	10.26
31-109-13173-00-00	1412	7.31	43.18
31-109-13173-00-00	1413	7.15	
31-109-13173-00-00	1414	6.45	14.55
31-109-13173-00-00	1416	13.82	17.32
31-109-13173-00-00	1417	6.13	16.73
31-109-13173-00-00	1418	10.70	7.23
31-109-13173-00-00	1419	6.95	31.81
31-109-13173-00-00	1420	8.19	40.30
31-109-13173-00-00	1421	10.15	13.56
31-109-13173-00-00	1422	9.02	23.64
31-109-13173-00-00	1423	10.22	66.15
31-109-13173-00-00	1424	11.13	9.51
31-109-13173-00-00	1425	8.08	26.06
31-109-13173-00-00	1426	7.00	15.01
31-109-13173-00-00	1427	5.56	64.33
31-109-13173-00-00	1428	5.81	33.42
31-109-13173-00-00	1429	9.94	44.43
31-109-13173-00-00	1430	10.04	38.67
31-109-13173-00-00	1431	2.21	66.05
Duplicates			
31-109-13173-00-00	1417-2	7.45	
31-109-13173-00-00	1425-2	8.61	



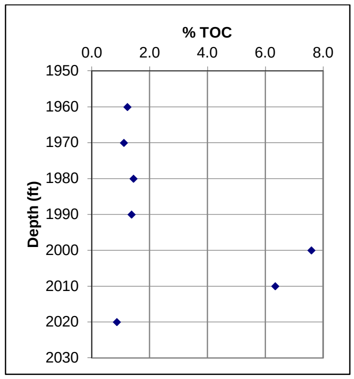


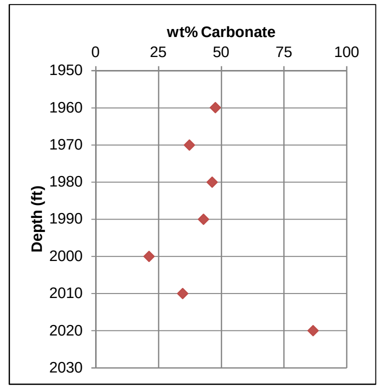
31-111-03199-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-111-03199-00-00	4790	0.66	12.04
31-111-03199-00-00	4810	0.80	13.20
31-111-03199-00-00	4830	0.67	12.59
31-111-03199-00-00	4850	0.61	14.78
31-111-03199-00-00	4870	0.62	15.34
31-111-03199-00-00	4890	0.64	14.66
31-111-03199-00-00	4910	0.60	14.89
31-111-03199-00-00	4920	0.45	11.78
31-111-03199-00-00	4940	0.44	11.69
31-111-03199-00-00	4960	0.74	14.36
31-111-03199-00-00	4970	0.60	30.70
31-111-03199-00-00	4980	0.42	28.68
31-111-03199-00-00	4990	0.41	26.33
31-111-03199-00-00	5000	0.37	20.22
31-111-03199-00-00	5040	0.52	17.02
31-111-03199-00-00	5050	0.59	16.65
31-111-03199-00-00	5060	0.65	23.87
31-111-03199-00-00	5080	1.08	25.42
31-111-03199-00-00	5100	0.58	17.82
31-111-03199-00-00	5110	0.99	18.32
31-111-03199-00-00	5120	1.55	13.91
31-111-03199-00-00	5130	1.81	16.98
31-111-03199-00-00	5150	1.96	13.99
31-111-03199-00-00	5170	2.12	26.32
31-111-03199-00-00	5180	2.25	41.97
31-111-03199-00-00	5190	2.11	31.25
31-111-03199-00-00	5200	5.11	26.77
31-111-03199-00-00	5210	1.08	53.39
31-111-03199-00-00	5220	0.61	69.84
31-111-03199-00-00	5230	0.28	77.90
Duplicates			
31-111-03199-00-00	5000-2	0.44	



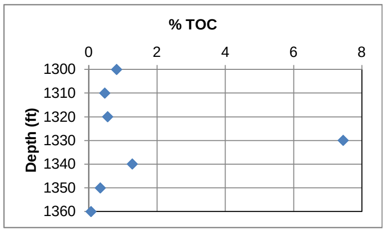


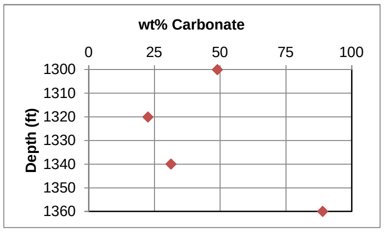
31-121-04092-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-121-04092-00-00	1960	1.22	47.56
31-121-04092-00-00	1970	1.10	37.27
31-121-04092-00-00	1980	1.43	46.27
31-121-04092-00-00	1990	1.37	42.86
31-121-04092-00-00	2000	7.59	21.19
31-121-04092-00-00	2010	6.34	34.50
31-121-04092-00-00	2020	0.85	86.52



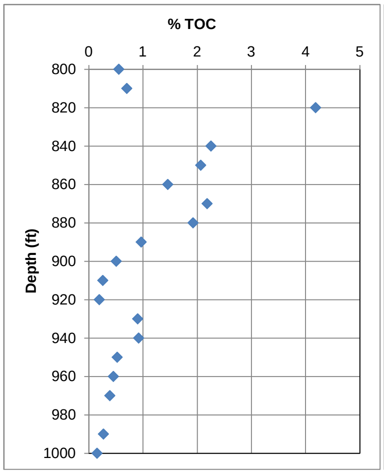


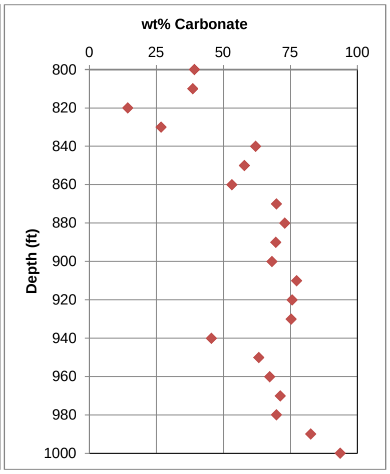
31-121-25654-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-121-25654-00-00	1300	0.82	48.95
31-121-25654-00-00	1310	0.47	
31-121-25654-00-00	1320	0.55	22.47
31-121-25654-00-00	1330	7.45	
31-121-25654-00-00	1340	1.28	31.30
31-121-25654-00-00	1350	0.34	
31-121-25654-00-00	1360	0.06	88.98



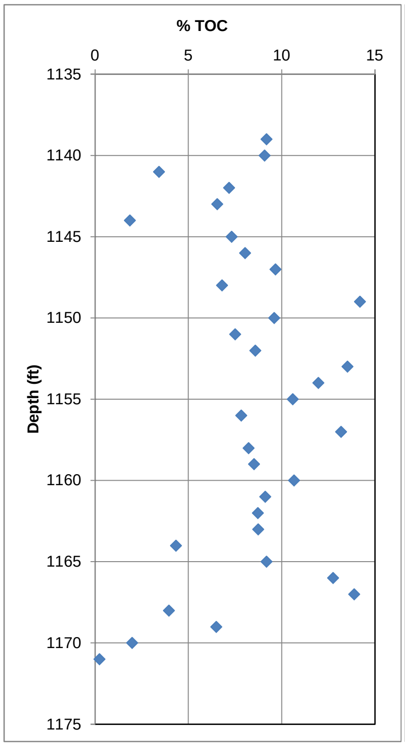


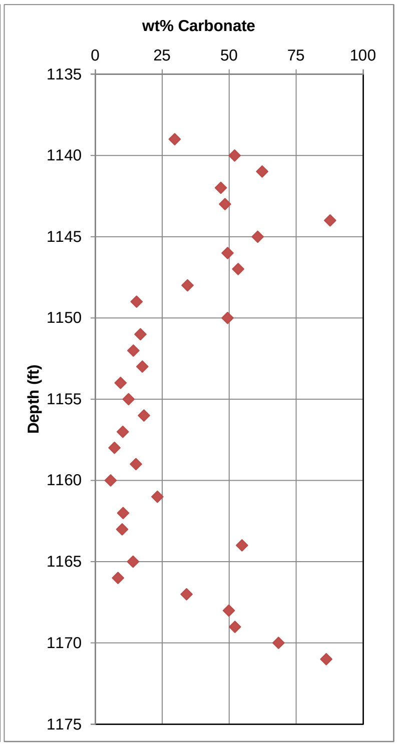
31-123-04797-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-123-04797-00-00	800	0.56	39.17
31-123-04797-00-00	810	0.70	38.64
31-123-04797-00-00	820	4.18	14.30
31-123-04797-00-00	830		26.80
31-123-04797-00-00	840	2.25	62.09
31-123-04797-00-00	850	2.07	57.89
31-123-04797-00-00	860	1.45	53.15
31-123-04797-00-00	870	2.18	69.84
31-123-04797-00-00	880	1.92	72.93
31-123-04797-00-00	890	0.97	69.55
31-123-04797-00-00	900	0.50	68.10
31-123-04797-00-00	910	0.26	77.33
31-123-04797-00-00	920	0.20	75.61
31-123-04797-00-00	930	0.90	75.30
31-123-04797-00-00	940	0.92	45.57
31-123-04797-00-00	950	0.52	63.27
31-123-04797-00-00	960	0.46	67.28
31-123-04797-00-00	970	0.39	71.20
31-123-04797-00-00	980		69.79
31-123-04797-00-00	990	0.27	82.62
31-123-04797-00-00	1000	0.15	93.57
Duplicates			
31-123-04797-00-00	840-2	2.31	
31-123-04797-00-00	920-2	0.19	





31-123-13174-00-00			
API	Depth (ft)	% TOC	wt% Carbonate
31-123-13174-00-00	1139	9.18	29.65
31-123-13174-00-00	1140	9.08	52.00
31-123-13174-00-00	1141	3.42	62.32
31-123-13174-00-00	1142	7.16	46.83
31-123-13174-00-00	1143	6.54	48.39
31-123-13174-00-00	1144	1.86	87.60
31-123-13174-00-00	1145	7.31	60.64
31-123-13174-00-00	1146	8.03	49.41
31-123-13174-00-00	1147	9.66	53.32
31-123-13174-00-00	1148	6.80	34.35
31-123-13174-00-00	1149	14.18	15.32
31-123-13174-00-00	1150	9.59	49.38
31-123-13174-00-00	1151	7.50	16.79
31-123-13174-00-00	1152	8.57	14.14
31-123-13174-00-00	1153	13.51	17.51
31-123-13174-00-00	1154	11.95	9.40
31-123-13174-00-00	1155	10.58	12.43
31-123-13174-00-00	1156	7.83	18.18
31-123-13174-00-00	1157	13.17	10.26
31-123-13174-00-00	1158	8.22	7.13
31-123-13174-00-00	1159	8.50	15.16
31-123-13174-00-00	1160	10.65	5.74
31-123-13174-00-00	1161	9.12	23.10
31-123-13174-00-00	1162	8.72	10.39
31-123-13174-00-00	1163	8.72	9.98
31-123-13174-00-00	1164	4.32	54.78
31-123-13174-00-00	1165	9.18	14.03
31-123-13174-00-00	1166	12.74	8.39
31-123-13174-00-00	1167	13.88	34.10
31-123-13174-00-00	1168	3.95	49.85
31-123-13174-00-00	1169	6.48	52.10
31-123-13174-00-00	1170	1.98	68.37
31-123-13174-00-00	1171	0.22	86.20
Duplicates			
31-123-13174-00-00	1145-2	8.01	
31-123-13174-00-00	1168-2	4.35	





APPENDIX B

Humble GeoChem Rock Eval Analyses

Weatherford Laboratories
Geochemistry Group
143 Vision Park Blvd. 281-540-6050
Shenandoah, TX 77384 www.weatherfordlabs.com

Geochemical Data - DUANE A WOLFER #1 Well

Operator	N Y STATE NAT GAS
API #	31003042480000

State	NY
County	ALLEGANY

Basin	Appalachian
Location	-Hume-

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2 TOC	OI 100*S3 TOC	NOC 100*S1 TOC	Check	Pyrogram	Sample ID
2480	2490	2485	Marcellus	M Dev	cuttings	1.93	1.62	2.84	62.1	0.57	439	0.74		147	30	84	✓	n;ltS2sh	204776
2490	2500	2495	Marcellus	M Dev	cuttings	3.96	2.91	6.23	136.3	0.59	436	0.69		157	15	73		n	204777
2500	2510	2505	Marcellus	M Dev	cuttings	7.43	5.43	14.12	309.0	0.69	432	0.62		190	9	73	✓	n	204778
2510	2520	2515	Marcellus	M Dev	cuttings	4.39	2.72	6.21	135.8	0.58	435	0.67		141	13	62	✓	n	204779

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - O'Brien, F #20330 Well

Operator	Columbia Gas Trans. Corp
API #	31003117620000

State	NY
County	Allegany

Basin	Appalachian
Location	--

						Present Day Values													
Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
4280	4280	4280	Marcellus	M Dev	cuttings	1.29	5.92	1.09	23.8	0.59	371			84	46	459		f	145099
4300	4300	4300	Marcellus	M Dev	cuttings	1.68	4.13	1.19	25.9	0.48	461	1.14		71	29	246		n;lts2sh	145100
4320	4320	4320	Marcellus	M Dev	cuttings	6.26	9.02	4.03	88.1	0.51	462	1.16		64	8	144		n;lts2sh	145101
4330	4330	4330	Marcellus	M Dev	cuttings	8.08	10.94	5.15	112.6	0.58	469	1.28		64	7	135	✓	n;lts2sh	145102
4340	4340	4340	Marcellus	M Dev	cuttings	4.70	6.51	2.58	56.4	0.52	472	1.34		55	11	138		n;lts2sh	145103

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - RICHARDS #1 Well

Operator	Joyce Western Corp.
API #	31007050870000

State	NY
County	Broome

Basin	Appalachian
Location	--

						Present Day Values													
Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
2880	2890	2885	Marcellus	M Dev	cuttings	1.35	0.46	0.84		0.26	-1	-1.00		62	19	34		hts2p	06-3593-139578
2890	2900	2895	Marcellus	M Dev	cuttings	1.36	0.33	0.19		0.23	472	1.34		14	17	24		f	06-3593-139579
2910	2920	2915	Marcellus	M Dev	cuttings	1.44	0.35	0.21		0.20	356	-1.00		15	14	24		f	06-3593-139580
2920	2930	2925	Marcellus	M Dev	cuttings	1.55	0.48	0.33		0.24	-1	-1.00		21	15	31		f	06-3593-139581
2930	2940	2935	Marcellus	M Dev	cuttings	1.78	0.43	0.21		0.19	515	2.11		12	11	24		f	06-3593-139582
2940	2950	2945	Marcellus	M Dev	cuttings	2.28	0.53	0.24		0.25	343	-1.00		11	11	23		f	06-3593-139583
2950	2960	2955	Marcellus	M Dev	cuttings	2.39	0.50	0.54		0.31	-1	-1.00		23	13	21		hts2p	06-3593-139584
2960	2970	2965	Marcellus	M Dev	cuttings	3.18	0.64	0.45		0.26	-1	-1.00		14	8	20		hts2p	06-3593-139585
2970	2980	2975	Marcellus	M Dev	cuttings	3.06	0.65	0.58		0.24	-1	-1.00		19	8	21		hts2p	06-3593-139586
2980	2990	2985	Marcellus	M Dev	cuttings	3.02	0.62	0.37		0.28	590	3.46		12	9	21		f	06-3593-139587
2990	3000	2995	Marcellus	M Dev	cuttings	3.14	0.62	0.60		0.25	-1	-1.00		19	8	20		hts2p	06-3593-139588
3000	3010	3005	Marcellus	M Dev	cuttings	3.96	0.78	0.76		0.30	-1	-1.00		19	8	20		hts2p	06-3593-139589
3010	3020	3015	Marcellus	M Dev	cuttings	4.1	0.76	0.55		0.30	595	3.55		13	7	19		hts2p	06-3593-139590
3020	3030	3025	Marcellus	M Dev	cuttings	4.18	0.78	0.57		0.29	594	3.53		14	7	19		hts2p	06-3593-139591
3030	3040	3035	Marcellus	M Dev	cuttings	4.25	0.92	0.54		0.23	536	2.49		13	5	22		f	06-3593-139592
3040	3050	3045	Marcellus	M Dev	cuttings	2.76	0.73	0.55		0.28	471	1.32		20	10	26		f	06-3593-139593
3060	3070	3065	Marcellus	M Dev	cuttings	2.93	0.85	0.63		0.34	476	1.41		22	12	29		f	06-3593-139594
3070	3080	3075	Marcellus	M Dev	cuttings	4.32	1.01	0.71		0.23	505	1.93		16	5	23		f	06-3593-139595
3080	3090	3085	Marcellus	M Dev	cuttings	7.87	1.54	1.17		0.40	574	3.17		15	5	20		hts2p	06-3593-139596
3090	3100	3095	Marcellus	M Dev	cuttings	7.81	1.57	1.13		0.41	581	3.30		14	5	20		hts2p	06-3593-139597
3100	3110	3105	Marcellus	M Dev	cuttings	8.04	1.54	1.55		0.65	566	3.03		19	8	19		hts2p	06-3593-139598

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Geochemical Data - MANNING (IGC 2380) #1 Well

Operator	Iroquois Gas
API #	31009086100000

State	NY
County	Cattaragus

Basin	Appalachian
Location	--

						Present Day Values														
Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2 / TOC	OI 100*S3 / TOC	NOC 100*S1 / TOC	Check	Pyrogram	Sample ID
2650	2660	2655	Marcellus	M Dev	cuttings	5.77	4.02	12.80	280.1	0.29	432	0.62	0.49	222	5	70			016608

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - ENT TRNST STATE #ET-1 Well

Operator	PENNZOIL & AMOCO
API #	31009092350000

State	NY
County	CATTARAUGUS

Basin	Appalachian
Location	--

						Present Day Values													
Top Depth (ft)	**Bottom Depth (ft)**	**Median Depth (ft)**	Formation **Name**	**Age**	**Sample Type**	**TOC (wt%)**	**S1 (mg/g)**	**S2 (mg/g)**	**S2 (bbl/a-ft)**	**S3 (mg/g)**	**Tmax (°C)**		**Tmax** Calc. %Ro	**Meas. %Ro**	**HI** 100*S2 / **TOC**	**OI** 100*S3 / **TOC**	**NOC** 100*S1 / **TOC**	**Check**	**Pyrogram**	Sample **ID**
4630	4630	4630	Marcellus	M Dev	cuttings	1.09	0.83	0.83	18.1	0.27	431		0.60		76	25	76	✓	lts2p	137714
4650	4650	4650	Marcellus	M Dev	cuttings	1.11	0.71	0.68	14.8	0.24	452		0.98		61	22	64		lts2p	137715
4670	4670	4670	Marcellus	M Dev	cuttings	1.09	0.72	0.82	17.8	0.26	421		0.42		75	24	66		lts2p	137716
4740	4740	4740	Marcellus	M Dev	cuttings	0.42	0.19	0.15	3.2	0.14	441	*	0.78		36	33	45	✓	f	137717

Notes:
TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - Steimle #9 Well

Operator	Venango Petroleum
API #	31011116320000

State	NY
County	Cayuga

Basin	Appalachian
Location	--

						Present Day Values														
Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
300	350	325	Marcellus	M Dev	cuttings	3.54	0.60	0.61	13.3	0.34	361		2.05	17	10	17			016609

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - CARTER #1 Well

Operator	Hens Oil Co
API #	31011231580000

State	NY
County	CAYUGA

Basin	Appalachian
Location	--

						Present Day Values													
Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)		Tmax Calc. %Ro	Meas. %Ro	HI 100*S2 / TOC	OI 100*S3 / TOC	NOC 100*S1 / TOC	Check	Pyrogram	Sample ID
1110	1110	1110	Marcellus	M Dev	cuttings	4.46	0.45	1.07	23.3	0.29	518		2.16		24	7	10		hts2p	145112
1150	1150	1150	Marcellus	M Dev	cuttings	4.02	0.43	0.17	3.6	0.25	575	*	3.19		4	6	11		f	145113

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - SHADLE #1 Well

Operator	HUMBLE OIL
API #	31013041540000

State	NY
County	CHAUTAUQUA

Basin	Appalachian
Location	--

						Present Day Values													
Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
2280	2290	2285	Marcellus	M Dev	cuttings	0.91	0.78	0.73	15.9	0.28	447	0.89		80	31	86		n;lts2sh	139674
2300	2310	2305	Marcellus	M Dev	cuttings	3.55	3.92	7.44	162.8	0.51	437	0.71		210	14	110		n	139675
2320	2330	2325	Marcellus	M Dev	cuttings	5.52	5.20	13.28	290.6	0.57	432	0.62		241	10	94		n	139676

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - HARRINGTON #1 Well

Operator	WOLFS HEAD OIL
API #	31013044370000
State	NY
County	CHAUTAUQUA
Basin	Appalachian
Location	--

						Present Day Values													
Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
2590	2600	2595	Marcellus	M Dev	cuttings	1.13	1.62	2.00	43.7	0.46	445	0.85		177	41	143		n;lts2sh	139629
2610	2620	2615	Marcellus	M Dev	cuttings	2.71	3.02	8.54	186.8	0.56	442	0.80		315	21	111	✓	n;lts2sh	139630
2640	2650	2645	Marcellus	M Dev	cuttings	1.33	1.82	2.77	60.5	0.38	440	0.76		208	29	137		n	139631

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - KESSELRING E C #1 Well

Operator	N Y State Nat Gas	State	NY	Basin	Appalachian
API #	31015004430000	County	Chemung	Location	--

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2 TOC	OI 100*S3 TOC	NOC 100*S1 TOC	Check	Pyrogram	Sample ID
2928	2984	2956	Marcellus	M Dev	cuttings	6.98	1.23	0.87	18.9	0.78	374		1.50	12	11	18			016611

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - JOSEPH MATEJKA JR #1 Well

Operator	SHELL OIL
API #	31015103350000

State	NY
County	CHEMUNG

Basin	Appalachian
Location	--

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
3330	3330	3330	Marcellus	M Dev	cuttings	0.59	0.23	0.10	2.1	0.14	389 *			17	24	39	✓	f	137694
3350	3350	3350	Marcellus	M Dev	cuttings	2.81	0.80	0.27	5.8	0.24	357 *			10	9	28	✓	f	137695
3370	3370	3375	Marcellus	M Dev	cuttings	0.64	0.23	0.05	1.0	0.13	312 *			8	20	36		f	137696
3390	3390	3390	Marcellus	M Dev	cuttings	0.44	0.12	0.02	0.3	0.13	*			5	29	27		f	137697
3410	3410	3410	Marcellus	M Dev	cuttings	5.33	0.61	0.38	8.2	0.28	352 *			7	5	11		f	137698
3420	3420	3420	Marcellus	M Dev	cuttings	4.00	0.81	0.15	3.2	0.26	347 *			4	6	20		f	137699
3430	3430	3430	Marcellus	M Dev	cuttings	4.76	1.02	0.38	8.2	0.34	360 *			8	7	21		f	137700
3450	3450	3450	Marcellus	M Dev	cuttings	1.82	0.73	0.31	6.7	0.22	360 *			17	12	40	✓	f	137701

Notes:
TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - SEKELLA #1 Well

Operator	Fortuna Energy Inc
API #	31015231460000

State	NY
County	CHEMUNG

Basin	Appalachian
Location	--

						Present Day Values													
Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2 / TOC	OI 100*S3 / TOC	NOC 100*S1 / TOC	Check	Pyrogram	Sample ID
3590	3590	3590	Marcellus	M Dev	cuttings	0.78	0.18	0.07	1.4	0.09	312 *			9	12	23		f	137730
3610	3610	3610	Marcellus	M Dev	cuttings	2.50	0.24	0.05	1.0	0.09	312 *			2	4	10	✓	f	137731
3630	3630	3630	Marcellus	M Dev	cuttings	2.71	0.22	0.06	1.2	0.08	403 *	0.09		2	3	8		f	137732
3650	3650	3650	Marcellus	M Dev	cuttings	4.40	0.38	0.23	4.9	0.09	362 *			5	2	9	✓	f	137733
3670	3670	3670	Marcellus	M Dev	cuttings	6.10	1.04	0.51	11.1	0.17	414	0.29		8	3	17		f	137734
3690	3690	3690	Marcellus	M Dev	cuttings	5.52	0.40	0.95	20.7	0.18	394			17	3	7		lts2p	137735
3710	3710	3710	Marcellus	M Dev	cuttings	6.27	0.33	0.37	8.0	0.17	521 *	2.22		6	3	5		f	137736
3720	3720	3720	Marcellus	M Dev	cuttings	6.86	0.54	0.57	12.4	0.18	537	2.51		8	3	8		f	137737
3730	3730	3730	Marcellus	M Dev	cuttings	4.10	0.59	0.41	8.9	0.15	584 *	3.35		10	4	14	✓	f	137738

Notes:
TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - LITTLE #1 Well

Operator	Fortuna Energy Inc	State	NY	Basin	Appalachian
API #	31015232280000	County	CHEMUNG	Location	--

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values: TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
2800	2800	2800	Marcellus	M Dev	cuttings	2.62	0.39	0.21	4.5	0.10	392 *			8	4	15		f	137747
2850	2850	2850	Marcellus	M Dev	cuttings	5.17	0.30	0.35	7.6	0.15	506 *	1.95		7	3	6		f	137748
2900	2900	2900	Marcellus	M Dev	cuttings	4.44	0.50	0.46	10.0	0.13	582 *	3.32		10	3	11		f	137749

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - DIFASI #1 Well

Operator	Fortuna Energy Inc
API #	31015239130000

State	NY
County	Chemung

Basin	Appalachian
Location	--

						Present Day Values													
Top Depth (ft)	**Bottom Depth (ft)**	**Median Depth (ft)**	Formation **Name**	**Age**	**Sample Type**	**TOC (wt%)**	**S1 (mg/g)**	**S2 (mg/g)**	**S2 (bbl/a-ft)**	**S3 (mg/g)**	**Tmax (°C)**	**Tmax** Calc. %Ro	**Meas. %Ro**	**HI** 100*S2 **TOC**	**OI** 100*S3 **TOC**	**NOC** 100*S1 **TOC**	**Check**	**Pyrogram**	Sample **ID**
3060	3060	3060	Marcellus	M Dev	cuttings	0.98	0.06	0.16		0.18	490	1.66		16	18	6		f	
3090	3090	3090	Marcellus	M Dev	cuttings	2.66	0.06	0.25		0.06	507	1.97		9	2	2		f	
3130	3130	3130	Marcellus	M Dev	cuttings	1.02	0.06	0.12		0.05	362			12	5	6		f	
3170	3170	3170	Marcellus	M Dev	cuttings	6.56	0.33	0.78		0.20	353	2.47		12	3	5		htS2p	

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data for C Lobdell #1 Well

API #	Operator	Well	County	Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values: TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
31017011600000	Bradley Prod Corp	C Lobdell 1	Chenango	1342	1414	1378	Marcellus	M Dev	cuttings	2.19	0.41	0.58	12.6	0.24	505	1.93	1.89	26	11	19			016612

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - M A SMALL #1 Well

Operator	Amoco Production Co.
API #	31017106080000

State	NY
County	CHENANGO

Basin	Appalachian
Location	--

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values: TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2 / TOC	OI 100*S3 / TOC	NOC 100*S1 / TOC	Check	Pyrogram	Sample ID
3330	3360	3345	Marcellus	M Dev	cuttings	0.48	0.21	0.10	2.1	0.10	357 *			21	21	44		f	215366
3360	3370	3365	Marcellus	M Dev	cuttings	0.48	0.17	0.09	1.9	0.11	303 *			19	23	35		f	215367
3370	3380	3375	Marcellus	M Dev	cuttings	0.46	0.22	0.12	2.5	0.15	349 *			26	33	48		f	215368
3380	3390	3385	Marcellus	M Dev	cuttings	0.51	0.27	0.18	3.8	0.11	350 *			35	22	53		ltS2p	215369
3390	3400	3395	Marcellus	M Dev	cuttings	0.67	0.57	0.44	9.5	0.18	348 *			66	27	85	✓	ltS2p	215370
3400	3410	3405	Marcellus	M Dev	cuttings	1.10	1.02	1.73	37.8	0.43	368			157	39	93	✓	ltS2p	215371
3410	3420	3415	Marcellus	M Dev	cuttings	0.53	0.29	0.29	6.2	0.22	372 *			55	41	55	✓	ltS2p	215372
3420	3430	3425	Marcellus	M Dev	cuttings	1.76	0.74	0.75	16.3	0.26	360			43	15	42		ltS2p	215373
3430	3440	3435	Marcellus	M Dev	cuttings	1.91	0.72	0.75	16.3	0.21	360			39	11	38		ltS2p	215374
3440	3450	3445	Marcellus	M Dev	cuttings	1.90	0.96	0.56	12.2	0.24	351			29	13	50	✓	ltS2p	215375
3450	3460	3455	Marcellus	M Dev	cuttings	1.96	1.28	2.09	45.7	0.36	377			107	18	65	✓	ltS2p	215376
3460	3470	3465	Marcellus	M Dev	cuttings	1.64	0.75	0.85	18.5	0.32	373			52	20	46		ltS2p	215377
3470	3480	3475	Marcellus	M Dev	cuttings	2.41	0.93	0.54	11.7	0.34	358			22	14	39		ltS2p	215378
3480	3490	3485	Marcellus	M Dev	cuttings	2.31	0.73	0.79	17.2	0.22	367			34	10	32	✓	ltS2p	215379
3490	3500	3495	Marcellus	M Dev	cuttings	1.97	0.56	0.71	15.4	0.21	365			36	11	28		ltS2p	215380
3500	3510	3505	Marcellus	M Dev	cuttings	2.52	0.63	0.54	11.7	0.23	365			21	9	25		ltS2p	215381
3510	3520	3515	Marcellus	M Dev	cuttings	2.72	0.71	0.45	9.8	0.18	338 *			17	7	26	✓	ltS2p	215382
3520	3530	3525	Marcellus	M Dev	cuttings	2.33	0.74	0.72	15.7	0.24	371			31	10	32		ltS2p	215383
3530	3540	3535	Marcellus	M Dev	cuttings	2.07	0.64	0.91	19.8	0.20	378			44	10	31	✓	ltS2p	215384
3540	3550	3545	Marcellus	M Dev	cuttings	2.97	0.83	0.74	16.1	0.26	388			25	9	28	✓	ltS2p	215385
3550	3560	3555	Marcellus	M Dev	cuttings	2.14	0.57	0.43	9.3	0.30	379 *			20	14	27	✓	ltS2p	215386
3560	3570	3565	Marcellus	M Dev	cuttings	2.57	0.97	1.99	43.5	0.43	419	0.38		77	17	38		n	215387
3570	3580	3575	Marcellus	M Dev	cuttings	3.61	0.72	0.64	13.9	0.37	405	0.13		18	10	20	✓	ltS2p	215388
3580	3590	3585	Marcellus	M Dev	cuttings	4.30	0.75	0.66	14.3	0.22	354			15	5	17		ltS2p	215389
3590	3600	3595	Marcellus	M Dev	cuttings	4.06	0.85	0.62	13.5	0.31	347			15	8	21		ltS2p	215390
3600	3610	3605	Marcellus	M Dev	cuttings	5.66	1.02	1.06	23.1	0.37	406	0.15		19	7	18	✓	ltS2p	215391
3610	3620	3615	Marcellus	M Dev	cuttings	6.08	1.36	2.12	46.3	0.36	419	0.38		35	6	22		n;ltS2sh	215392
3620	3630	3625	Marcellus	M Dev	cuttings	7.27	2.39	3.06	66.9	0.52	421	0.42		42	7	33	✓	n;ltS2sh	215393

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - HENRY L HULBERT #1 Well

Operator	Amoco Production Co.
API #	31017106090000

State	NY
County	CHENANGO

Basin	Appalachian
Location	--

						Present Day Values													
Top Depth (ft)	**Bottom Depth (ft)**	**Median Depth (ft)**	Formation **Name**	**Age**	**Sample Type**	**TOC (wt%)**	**S1 (mg/g)**	**S2 (mg/g)**	**S2 (bbl/a-ft)**	**S3 (mg/g)**	**Tmax (°C)**	**Tmax** Calc. %Ro	**Meas. %Ro**	**HI** 100*S2 **TOC**	**OI** 100*S3 **TOC**	**NOC** 100*S1 **TOC**	**Check**	**Pyrogram**	Sample **ID**
3070	3070	3070	Marcellus	M Dev	cuttings	0.48	0.31	0.23	4.9	0.14	373 *			48	29	64		lts2p	146797
3170	3170	3170	Marcellus	M Dev	cuttings	0.65	0.31	0.45	9.8	0.14	376 *			69	22	48		lts2p	146798
3270	3270	3270	Marcellus	M Dev	cuttings	0.75	0.98	0.55	11.9	0.26	360			73	35	130		lts2p	146799
3370	3370	3370	Marcellus	M Dev	cuttings	1.20	5.96	1.55	33.8	0.37	375			129	31	496		lts2p	146800
3370	3370	3370	Marcellus	M Dev	cuttings	1.24	7.24	1.41	30.8	0.41	375			114	33	583		lts2p	146800
3470	3470	3470	Marcellus	M Dev	cuttings	1.73	0.45	0.38	8.2	0.17	355 *			22	10	26		lts2p	146801
3510	3510	3510	Marcellus	M Dev	cuttings	1.89	0.43	0.30	6.5	0.14	429 *	0.56		16	7	23	✓	lts2p	146802
3550	3550	3550	Marcellus	M Dev	cuttings	3.10	0.48	0.39	8.4	0.19	569 *	3.08		13	6	15		hts2p	146803
3600	3600	3600	Marcellus	M Dev	cuttings	3.40	0.73	0.52	11.3	0.17	574	3.17		15	5	21		hts2p	146804
3640	3640	3640	Marcellus	M Dev	cuttings	1.43	0.45	0.31	6.7	0.22	429 *	0.56		22	15	31		lts2p	146805

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - BEAVER MEADOW #1 Well

Operator	GRASEN ENERGY INC
API #	31017230060000

State	NY
County	CHENANGO

Basin	Appalachian
Location	--

						Present Day Values													
Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2 TOC	OI 100*S3 TOC	NOC 100*S1 TOC	Check	Pyrogram	Sample ID
1309	1309	1309	Marcellus	M Dev	core	0.77	0.04	0.02	0.3	0.10	371 *			3	13	5	✓	f	151643
1312	1312	1312	Marcellus	M Dev	core	0.53	0.05	0.02	0.3	0.11	341 *			4	21	9		f	151644
1318	1318	1318	Marcellus	M Dev	core	0.69	0.03	0.04	0.8	0.08	392 *			6	12	4		f	151645
1320	1320	1320	Marcellus	M Dev	core	0.62	0.08	0.06	1.2	0.11	438 *	0.72		10	18	13	✓	f	151646
1329	1329	1329	Marcellus	M Dev	core	0.57	0.01	0.01	0.1	0.07	383 *			2	12	2		f	151647
1342	1342	1342	Marcellus	M Dev	core	0.46	0.01			0.12	*				26	2		f	151648
1349	1349	1349	Marcellus	M Dev	core	0.47	0.02	0.01	0.1	0.12	344 *			2	25	4		f	151649
1354	1354	1354	Marcellus	M Dev	core	0.54	0.01			0.10	*				18	2	✓	f	151650
1366	1366	1366	Marcellus	M Dev	core	0.54	0.03	0.04	0.8	0.08	318 *			7	15	6		f	151651
1374	1374	1374	Marcellus	M Dev	core	0.52	0.02			0.04	*				8	4		f	151652
1389	1389	1389	Marcellus	M Dev	core	0.61	0.04	0.01	0.1	0.05	357 *			2	8	7		f	151653
1395	1395	1395	Marcellus	M Dev	core	0.64	0.08	0.21	4.5	0.08	342 *			33	12	12		f	151654
1407	1407	1407	Marcellus	M Dev	core	0.52	0.07	0.13	2.7	0.05	345 *			25	10	13	✓	f	151655
1417	1417	1417	Marcellus	M Dev	core	0.62	0.05	0.14	3.0	0.08	439 *	0.74		23	13	8	✓	f	151656
1424	1424	1424	Marcellus	M Dev	core	0.56	0.06	0.04	0.8	0.08	313 *			7	14	11	✓	f	151657
1436	1436	1436	Marcellus	M Dev	core	0.55	0.03	0.04	0.8	0.08	328 *			7	15	5		f	151658
1443	1443	1443	Marcellus	M Dev	core	0.55	0.07	0.16	3.4	0.05	311 *			29	9	13	✓	f	151659
1459	1459	1459	Marcellus	M Dev	core	0.58	0.03	0.01	0.1	0.04	*			2	7	5		f	151660
1475	1475	1475	Marcellus	M Dev	core	0.60	0.04	0.06	1.2	0.06	355 *			10	10	7		f	151661
1486	1486	1486	Marcellus	M Dev	core	0.66	0.03	0.09	1.9	0.02	360 *			14	3	5	✓	f	151662
1495	1495	1495	Marcellus	M Dev	core	0.61	0.04	0.05	1.0	0.07	425 *	0.49		8	11	7		f	151663
1505	1505	1505	Marcellus	M Dev	core	0.64	0.04	0.12	2.5	0.05	355 *			19	8	6		f	151664
1516	1516	1516	Marcellus	M Dev	core	0.60	0.04	0.11	2.3	0.05	*			18	8	7		f	151665
1528	1528	1528	Marcellus	M Dev	core	0.52	0.03	0.01	0.1	0.04	368 *			2	8	6		f	151666
1536	1536	1536	Marcellus	M Dev	core	0.60	0.05	0.18	3.8	0.05	412 *	0.26		30	8	8		f	151667
1545	1545	1545	Marcellus	M Dev	core	0.63	0.03	0.09	1.9	0.07	378 *			14	11	5		f	151668
1565	1565	1565	Marcellus	M Dev	core	0.57	0.04	0.16	3.4	0.07	373 *			28	12	7		f	151669
1577	1577	1577	Marcellus	M Dev	core	0.62	0.04	0.09	1.9	0.06	365 *			14	10	6		f	151670
1586	1586	1586	Marcellus	M Dev	core	0.58	0.01	0.07	1.4	0.69	325 *			12	119	2		f	151671
1595	1595	1595	Marcellus	M Dev	core	0.59	0.04	0.09	1.9	0.08	334 *			15	14	7	✓	f	151672
1608	1608	1608	Marcellus	M Dev	core	0.67	0.03	0.09	1.9	0.06	337 *			13	9	4		f	151673
1615	1615	1615	Marcellus	M Dev	core	0.63	0.04	0.07	1.4	0.06	441 *	0.78		11	10	6		f	151674
1624	1624	1624	Marcellus	M Dev	core	0.63	0.04	0.04	0.8	0.05	314 *			6	8	6	✓	f	151675
1633	1633	1633	Marcellus	M Dev	core	0.72	0.06	0.02	0.3	0.08	425 *	0.49		3	11	8		f	151676
1645	1645	1645	Marcellus	M Dev	core	0.75	0.01			0.04	*				5	1		f	151677
1655	1655	1655	Marcellus	M Dev	core	0.77	0.04	0.01	0.1	0.06	337 *			1	8	5		f	151678
1663	1663	1663	Marcellus	M Dev	core	0.77	0.03			0.03	*				4	4		f	151679
1678	1678	1678	Marcellus	M Dev	core	0.79	0.01	0.01	0.1	0.06	332 *			1	8	1		f	151680
1696	1696	1696	Marcellus	M Dev	core	0.90	0.01			0.05	*				6	1		f	151681
1703	1703	1703	Marcellus	M Dev	core	1.01	0.04	0.02	0.3	0.08	335 *			2	8	4	✓	f	151682
1721	1721	1721	Marcellus	M Dev	core	1.17	0.03	0.01	0.1	0.01	308 *			1	1	3		f	151683
1725	1725	1725	Marcellus	M Dev	core	1.36	0.06	0.05	1.0	0.05	337 *			4	4	4		f	151684
1737	1737	1737	Marcellus	M Dev	core	1.30	0.04	0.04	0.8	0.06	359 *			3	5	3		f	151685
1747	1747	1747	Marcellus	M Dev	core	1.53	0.06	0.14	3.0	0.05	381 *			9	3	4		f	151686
1756	1756	1756	Marcellus	M Dev	core	1.88	0.02	0.02	0.3	0.04	418 *	0.36		1	2	1		f	151687
1765	1765	1765	Marcellus	M Dev	core	2.06	0.06	0.07	1.4	0.08	454 *	1.01		3	4	3	✓	f	151688
1774	1774	1774	Marcellus	M Dev	core	1.83	0.03	0.04	0.8	0.03	394 *			2	2	2		f	151689
1784	1784	1784	Marcellus	M Dev	core	1.61	0.03	0.04	0.8	0.04	396 *			2	2	2		f	151690
1795	1795	1795	Marcellus	M Dev	core	2.15	0.04	0.06	1.2	0.05	443 *	0.81		3	2	2		f	151691
1812	1812	1812	Marcellus	M Dev	core	3.21	0.09	0.10	2.1	0.05	526 *	2.31		3	2	3		f	151692
1822	1822	1822	Marcellus	M Dev	core	3.40	0.09	0.10	2.1	0.05	500 *	1.84		3	1	3		f	151693
1831	1831	1831	Marcellus	M Dev	core	2.60	0.07	0.09	1.9	0.04	435 *	0.67		3	2	3		f	151694
1843	1843	1843	Marcellus	M Dev	core	2.61	0.07	0.09	1.9	0.08	391 *			3	3	3		f	151695
1851	1851	1851	Marcellus	M Dev	core	4.40	0.18	0.30	6.5	0.09	513 *	2.07		7	2	4	✓	f	151696
1864	1864	1864	Marcellus	M Dev	core	4.44	0.10	0.26	5.6	0.10	476 *	1.41		6	2	2		f	151697
1872	1872	1872	Marcellus	M Dev	core	3.94	0.19	0.17	3.6	0.13	441 *	0.78		4	3	5		f	151698
1875	1875	1875	Marcellus	M Dev	core	0.79	0.03	0.05	1.0	0.04	334 *			6	5	4		f	151699
1881	1881	1881	Marcellus	M Dev	core	2.25	0.08	0.22	4.7	0.11	446 *	0.87		10	5	4	✓	f	151700
1884	1884	1884	Marcellus	M Dev	core	0.84	0.02	0.05	1.0	0.05	376 *			6	6	2		f	151701
1890	1890	1890	Marcellus	M Dev	core	3.20	0.08	0.32	6.9	0.10	539 *	2.54		10	3	2		hts2p	151702
1900	1900	1900	Marcellus	M Dev	core	3.56	0.10	0.33	7.1	0.11	499 *	1.82		9	3	3		hts2p	151703
1911	1911	1911	Marcellus	M Dev	core	8.83	0.22	0.47	10.2	0.15	*			5	2	2	✓	hts2p	151704
1917	1917	1917	Marcellus	M Dev	core	7.27	0.17	0.74	16.1	0.18	550	2.74		10	2	2	✓	hts2p	151705
1930	1930	1930	Marcellus	M Dev	core	8.37	0.20	0.60	13.0	0.14	497	1.79		7	2	2		hts2p	151706
1939	1939	1939	Marcellus	M Dev	core	5.22	0.28	0.44	9.5	0.14	546 *	2.67		8	3	5		hts2p	151707

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - CLOUGH #1 Well

Operator	DELTA DRILLING CO
API #	31023047140000

State	NY
County	CORTLAND

Basin	Appalachian
Location	-Freetown-

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values: TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
2470	2470	2490	Marcellus	M Dev	cuttings	2.11	0.13	0.14	3.0	0.24	511 *	2.04	1.99	7	11	6			016613
2600	2600	2600	Marcellus	M Dev	cuttings	6.06	0.86	0.51	11.1	0.27	479	1.46		8	4	14		f	139792
2610	2610	2610	Marcellus	M Dev	cuttings	6.17	0.69	0.52	11.3	0.28	482	1.52		8	5	11		f	139793
2620	2620	2620	Marcellus	M Dev	cuttings	7.97	0.79	1.06	23.1	0.29	569	3.08		13	4	10	✓	hts2p	139794
2630	2630	2630	Marcellus	M Dev	cuttings	8.09	0.99	0.92	20.0	0.31	576	3.21		11	4	12		hts2p	139795
2640	2640	2640	Marcellus	M Dev	cuttings	5.33	0.76	0.65	14.1	0.23	568	3.06		12	4	14		hts2p	139796
2650	2650	2650	Marcellus	M Dev	cuttings	4.13	0.97	0.47	10.2	0.26	540 *	2.56		11	6	23		f	139797

Notes:
TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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HUMBLE

Geochemical Data - N.Y.S. REFORESTATION 6 #1 Well

Operator	QUAKER STATE INC	**State**	NY	**Basin**	Appalachian
API #	31023215000000	**County**	CORTLAND	**Location**	--

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values: TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
2210	2210	2210	Marcellus	M Dev	cuttings	2.85	0.31	0.23	4.9	0.13	468 *	1.26		8	5	11		f	139765
2230	2230	2230	Marcellus	M Dev	cuttings	3.38	0.34	0.37	8.0	0.13	542 *	2.60		11	4	10		f	139766
2240	2240	2240	Marcellus	M Dev	cuttings	3.60	0.38	0.27	5.8	0.19	547 *	2.69		7	5	11		f	139767
2250	2250	2250	Marcellus	M Dev	cuttings	4.75	0.47	0.41	8.9	0.15	552 *	2.78		9	3	10	✓	f	139768
2270	2270	2270	Marcellus	M Dev	cuttings	3.05	0.53	0.37	8.0	0.18	359 *			12	6	17		f	139769
2290	2290	2290	Marcellus	M Dev	cuttings	5.51	0.66	0.58	12.6	0.18	579	3.26		11	3	12	✓	f	139770
2300	2300	2300	Marcellus	M Dev	cuttings	3.58	0.43	0.37	8.0	0.13	577 *	3.23		10	4	12		f	139771
2310	2310	2310	Marcellus	M Dev	cuttings	7.25	0.38	0.89	19.4	0.29	551	2.76		12	4	5		hts2p	139772

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - H A-M W CAMPBELL #1 Well

Operator	Gulf Oil
API #	31025042140000

State	NY
County	DELAWARE

Basin	Appalachian
Location	--

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
4900	4905	4902.5	Marcellus	M Dev	cuttings	1.18	0.26	0.11	2.3	0.09	313 *			9	8	22	✓	f	139648
4920	4925	4922.5	Marcellus	M Dev	cuttings	1.36	0.18	0.18	3.8	0.07	448 *	0.90		13	5	13	✓	f	139649
4940	4945	4942.5	Marcellus	M Dev	cuttings	1.22	0.48	0.16	3.4	0.08	425 *	0.49		13	7	39		f	139650
4960	4965	4962.5	Marcellus	M Dev	cuttings	1.54	0.17	0.13	2.7	0.07	470 *	1.30		8	5	11		f	139651
4980	4985	4982.5	Marcellus	M Dev	cuttings	1.77	0.32	0.17	3.6	0.08	352 *			10	5	18		f	139652
5000	5005	5002.5	Marcellus	M Dev	cuttings	1.72	0.24	0.18	3.8	0.08	379 *			10	5	14		f	139653
5020	5025	5022.5	Marcellus	M Dev	cuttings	1.84	0.20	0.17	3.6	0.09	419 *	0.38		9	5	11		f	139654
5040	5045	5042.5	Marcellus	M Dev	cuttings	1.52	0.22	0.22	4.7	0.12	424 *	0.47		14	8	14		f	139655
5060	5065	5062.5	Marcellus	M Dev	cuttings	2.20	0.23	0.13	2.7	0.12	350 *			6	5	10		f	139656
5080	5085	5082.5	Marcellus	M Dev	cuttings	1.79	0.35	0.20	4.3	0.13	407 *	0.17		11	7	20	✓	f	139657
5100	5105	5102.5	Marcellus	M Dev	cuttings	1.59	0.36	0.19	4.1	0.13	355 *			12	8	23	✓	f	139658
5120	5125	5122.5	Marcellus	M Dev	cuttings	3.76	0.26	0.21	4.5	0.16	543 *	2.61		6	4	7	✓	f	139659
5135	5140	5137.5	Marcellus	M Dev	cuttings	4.09	0.38	0.21	4.5	0.18	466 *	1.23		5	4	9		f	139660

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - Fee #1 Well

Operator	Bethlehem Steel corp.
API #	31029066680000

State	NY
County	Erie

Basin	Appalachian
Location	-Hamburg-

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values: TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
110	120	115	Marcellus	M Dev	cuttings	0.87	0.77	1.26	27.5	0.14	436	0.69		145	16	88	✓	n;ltS2sh	204804
120	130	125	Marcellus	M Dev	cuttings	0.83	0.73	1.39	30.3	0.19	430	0.58		167	23	88	✓	n;ltS2sh	204805
130	140	135	Marcellus	M Dev	cuttings	6.46	5.14	21.34	467.0	0.48	427	0.53		330	7	80	✓	n	204806
140	150	145	Marcellus	M Dev	cuttings	1.36	1.24	3.22	70.4	0.33	429	0.56		237	24	91		n	204807

Notes:
TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - FOSS #1241 Well

Operator	FLINT OIL & GAS INC
API #	31029117300000

State	NY
County	Erie

Basin	Appalachian
Location	--

						Present Day Values												
Top Depth (ft)	**Bottom Depth (ft)**	**Median Depth (ft)**	Formation **Name**	**Age**	**Sample Type**	**TOC (wt%)**	**S1 (mg/g)**	**S2 (mg/g)**	**S2 (bbl/a-ft)**	**S3 (mg/g)**	**Tmax (°C)**	**Tmax** Calc. %Ro	**Meas. %Ro**	**HI** 100*S2 / **TOC**	**OI** 100*S3 / **TOC**	**NOC** 100*S1 / **TOC**	**Check**	**Pyrogram**	Sample **ID**
1260	1270	1265	Marcellus	M Dev	cuttings	1.47	1.46	2.54		0.76	435			173	52	99		n;ltS2sh	-204763
1270	1280	1275	Marcellus	M Dev	cuttings	2.35	2.38	4.30		0.75	438			183	32	101		n;ltS2sh	-204764
1300	1310	1305	Marcellus	M Dev	cuttings	4.86	3.20	6.73		0.50	434	0.50		138	10				
1310	1320	1315	Marcellus	M Dev	cuttings	1.39	1.12	1.91		0.65	437			137	47	81		n;ltS2sh	-204765
1320	1330	1325	Marcellus	M Dev	cuttings	2.82	2.38	4.26		0.76	438			151	27	84		n	-204766

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - BELT #1 Well

Operator	Flint Oil & Gas Inc
API #	31037107760000

State	NY
County	Genesee

Basin	Appalachian
Location	--

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values: TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
350	380	365	Marcellus	M Dev	cuttings	5.70	1.82	10.78	235.9	0.43	436	0.69	0.45	189	8	32			016615

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - Mc Donald #1 Well

Operator	N Y State Natural Gas
API #	31051040690000

State	NY
County	Livingston

Basin	Appalachian
Location	--

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values: TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
405	420	412.5	Marcellus	M Dev	cuttings	11.05	6.48	29.04	635.6	0.56	429	0.56	0.53	263	5	59			016616

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - PARNELL 883 Well

Operator	N Y State Natural Gas	**State**	NY	**Basin**	Appalachian
API #	31051043910000	**County**	Livingston	**Location**	--

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values: TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
706	735	720.5	Marcellus	M Dev	cuttings	6.60	3.58	15.69	343.4	0.41	435	0.67	0.78	238	6	54			016617

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - ARTHUR KENNEDY #1 Well

Operator	BLAIR & ASSOCIATES INCORPORATED
API #	31051046300000

State	NY
County	LIVINGSTON

Basin	Appalachian
Location	-Sparta-

						Present Day Values													
Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
900	910	905	Marcellus	M Dev	cuttings	1.79	2.95	3.32	72.6	0.62	441	0.78		185	35	165	✓	n;ltS2sh	204758
900	940	920	Marcellus	M Dev	cuttings	6.24	3.71	9.69	212.0	0.48	433	0.63	0.54	155	8	59			016618
910	920	915	Marcellus	M Dev	cuttings	5.41	4.49	13.70	299.8	0.75	429	0.56		253	14	83	✓	n	204759
920	930	925	Marcellus	M Dev	cuttings	7.64	5.44	17.28	378.2	0.72	429	0.56		226	9	71	✓	n	204760
930	940	935	Marcellus	M Dev	cuttings	5.64	4.45	12.75	279.0	0.75	431	0.60		226	13	79	✓	n	204761
940	950	945	Marcellus	M Dev	cuttings	5.44	4.41	11.29	247.0	0.77	431	0.60		207	14	81	✓	n	204762

Notes:
TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - HILTS 20617-T Well

Operator	Columbia Gas Trans Corp
API #	31051137000000

State	NY
County	Livingston

Basin	Appalachian
Location	--

						Present Day Values													
Top Depth (ft)	**Bottom Depth (ft)**	**Median Depth (ft)**	Formation **Name**	**Age**	**Sample Type**	**TOC (wt%)**	**S1 (mg/g)**	**S2 (mg/g)**	**S2 (bbl/a-ft)**	**S3 (mg/g)**	**Tmax (°C)**	**Tmax** Calc. %Ro	**Meas. %Ro**	**HI** 100*S2 **TOC**	**OI** 100*S3 **TOC**	**NOC** 100*S1 **TOC**	**Check**	**Pyrogram**	Sample **ID**
120	150	135	Marcellus	M Dev	cuttings	13.01	11.50	33.59	735.2	0.88	431	0.60		258	7	88		n	204767

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data for J Danisevich #1 Well

Operator	N Y State Nat Gas
API #	31053040320000

State	NY
County	MADISON

Basin	Appalachian
Location	--

						Present Day Values													
Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2 TOC	OI 100*S3 TOC	NOC 100*S1 TOC	Check	Pyrogram	Sample ID
963	993	978	Marcellus	M Dev	cuttings	1.71	0.34	0.23	4.9	0.30	392 *		0.82	13	18	20			016619

Notes:
TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - LARKIN UNIT #1 Well

Operator	STEAD F L & ASSOC
API #	31053194850000

State	NY
County	MADISON

Basin	Appalachian
Location	--

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values: TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
1270	1270	1270	Marcellus	M Dev	cuttings	0.54	0.47	0.15	3.2	0.12	356 *			28	22	87		f	139721

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - VAN PATTEN #1 Well

Operator	Pominex, Inc.
API #	31067121480000

State	NY
County	Onondaga

Basin	Appalachian
Location	--

						Present Day Values													
Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2 TOC	OI 100*S3 TOC	NOC 100*S1 TOC	Check	Pyrogram	Sample ID
1670	1670	1670	Marcellus	M Dev	cuttings	1.31	0.54	0.19		0.16	331	-1.00		15	12	41		f	
1700	1700	1700	Marcellus	M Dev	cuttings	0.32	1.18	0.77		0.27	337	-1.00		24	9	37		ltS2p	
1730	1730	1730	Marcellus	M Dev	cuttings	4.86	2.79	1.16		0.43	335	-1.00		24	9	57		ltS2p	
1750	1750	1750	Marcellus	M Dev	cuttings	3.07	1.17	0.69		0.21	337	-1.00		22	7	38		ltS2p	
1770	1770	1770	Marcellus	M Dev	cuttings	4.82	2.07	1.02		0.38	330	-1.00		21	8	43		ltS2p	

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - ROBERT G HARRISON #1 Well

Operator	POMINEX INC
API #	31067121630000

State	NY
County	ONONDAGA

Basin	Appalachian
Location	-Marcellus-

						Present Day Values													
Top Depth (ft)	**Bottom Depth (ft)**	**Median Depth (ft)**	Formation **Name**	**Age**	**Sample Type**	**TOC (wt%)**	**S1 (mg/g)**	**S2 (mg/g)**	**S2 (bbl/a-ft)**	**S3 (mg/g)**	**Tmax (°C)**	**Tmax** Calc. %Ro	**Meas. %Ro**	**HI** 100*S2 **TOC**	**OI** 100*S3 **TOC**	**NOC** 100*S1 **TOC**	**Check**	**Pyrogram**	Sample **ID**
400	400	400	Marcellus	M Dev	cuttings	4.32	1.37	1.10	24.0	0.27				25	6	32		hts2p	139798
410	410	410	Marcellus	M Dev	cuttings	5.36	1.14	0.69	15.0	0.24				13	4	21		hts2p	139799
420	420	420	Marcellus	M Dev	cuttings	3.94	0.86	0.49	10.6	0.26	465 *	1.21		12	7	22		lts2p	139800
460	460	460	Marcellus	M Dev	cuttings	4.55	1.24	0.55	11.9	0.19	347			12	4	27		lts2p	139801
470	470	470	Marcellus	M Dev	cuttings	3.03	0.65	0.29	6.2	0.18	580 *	3.28		10	6	21		f	139802

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - GEORGE C FRANKISH #1 Well

Operator	HOOVER NOBLE C	**State**	NY	**Basin**	Appalachian
API #	31069063950000	**County**	ONTARIO	**Location**	--

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
750	750	750	Marcellus	M Dev	cuttings	1.13	0.67	0.51	11.1	0.22	407	0.17		45	19	59		lts2p	146791
780	780	780	Marcellus	M Dev	cuttings	1.77	0.72	0.93	20.3	0.43	446	0.87		53	24	41	✓	ltS2sh	C-06-4
790	790	790	Marcellus	M Dev	cuttings	3.32	1.76	1.98	43.2	0.45	466	1.23		60	14	53		lts2p	146792

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - E F BAUM SR #1 Well

Operator	N Y STATE NAT GAS
API #	31077042450000

State	NY
County	OTSEGO

Basin	Appalachian
Location	--

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
1440	1440	1440	Marcellus	M Dev	cuttings	0.66	2.07	1.05	22.9	0.46	377			159	70	313		lts2p	145104
1490	1490	1490	Marcellus	M Dev	cuttings	0.61	1.43	1.06	23.1	0.34	369			173	56	234	✓	lts2p	145105
1530	1530	1530	Marcellus	M Dev	cuttings	0.69	2.18	1.55	33.8	0.45	382			224	65	315		lts2p	145106
1570	1570	1570	Marcellus	M Dev	cuttings	0.65	1.54	0.82	17.8	0.37	362			126	57	237		lts2p	145107
1610	1610	1610	Marcellus	M Dev	cuttings	0.53	0.14	0.21	4.5	0.05	523 *	2.25		40	9	26		f	145108
1960	1960	1960	Marcellus	M Dev	cuttings	1.91	0.27	0.24	5.2	0.07	502 *	1.88		13	4	14	✓	f	145109
2025	2025	2025	Marcellus	M Dev	cuttings	3.08	0.28	0.21	4.5	0.10	579 *	3.26		7	3	9		f	145110

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - HAROLD S HOOSE #1 Well

Operator	Amoco Production Co.	**State**	NY	**Basin**	Appalachian
API #	31077108340000	**County**	OTSEGO	**Location**	-Laurens-

						Present Day Values													
Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
1500	1510	1505	Marcellus	M Dev	cuttings	0.42	0.19	0.16	3.4	0.15	355 *			38	36	45	✓	f	204808
1590	1600	1595	Marcellus	M Dev	cuttings	0.53	0.40	0.22	4.7	0.14	355 *			41	26	75	✓	f	204809
1690	1700	1695	Marcellus	M Dev	cuttings	0.64	0.35	0.21	4.5	0.09	346 *			33	14	55	✓	f	204810
1750	1760	1755	Marcellus	M Dev	cuttings	4.40	0.42	0.19	4.1	0.11	346 *			4	2	10	✓	f	204811
1780	1790	1785	Marcellus	M Dev	cuttings	2.00	0.52	0.31	6.7	0.18	344 *			15	9	26	✓	f	204812
1800	1810	1805	Marcellus	M Dev	cuttings	2.06	0.62	0.38	8.2	0.11	342 *			18	5	30	✓	f	204813
1820	1830	1825	Marcellus	M Dev	cuttings	1.51	0.44	0.31	6.7	0.10	383 *			21	7	29	✓	f	204814
1840	1850	1845	Marcellus	M Dev	cuttings	1.92	0.55	0.41	8.9	0.18	422 *	0.44		21	9	29	✓	f	204815
1890	1900	1895	Marcellus	M Dev	cuttings	2.07	0.79	0.54	11.7	0.18	348			26	9	38	✓	ltS2p	204816
1910	1920	1915	Marcellus	M Dev	cuttings	1.72	0.58	0.47	10.2	0.14	356 *			27	8	34	✓	ltS2p	204817
1920	1930	1925	Marcellus	M Dev	cuttings	1.17	0.68	0.50	10.8	0.25	387			43	21	58	✓	ltS2p	204818

Notes:
TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - JOHNSON #1 Well

Operator	Amoco Production Co.	**State**	NY	**Basin**	Appalachian
API #	31077108380000	**County**	Ostego	**Location**	--

						Present Day Values													
Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2 TOC	OI 100*S3 TOC	NOC 100*S1 TOC	Check	Pyrogram	Sample ID
3200	3200	3200	Marcellus	M Devonian	cutting	1.00	0.05	0.35		0.08	509	2.00		35	8	5		htS2p	
3210	3210	3210	Marcellus	M Devonian	cutting	1.06	0.05	0.12		0.12	541	2.58		11	11	5		f	
3220	3220	3220	Marcellus	M Devonian	cutting	1.15	0.04	0.17		0.12	555	2.83		15	10	3		f	
3230	3230	3230	Marcellus	M Devonian	cutting	1.10	0.03	0.14		0.10	554	2.81		13	9	3		f	
3240	3240	3240	Marcellus	M Devonian	cutting	1.23	0.01	0.21		0.08	546	2.67		17	7	1		f	
3270	3270	3270	Marcellus	M Devonian	cutting	1.41	0.11	0.14		0.19	512	2.06		10	13	8		f	
3280	3280	3280	Marcellus	M Devonian	cutting	1.43	0.36	0.23		0.17	348			16	12	25		itS2p	
3290	3290	3290	Marcellus	M Devonian	cutting	0.95	0.01	0.14		0.09	519	2.18		15	9	1		f	
3300	3300	3300	Marcellus	M Devonian	cutting	0.93	0.00	0.08		0.08	545	2.65		9	9	0		f	
3310	3310	3310	Marcellus	M Devonian	cutting	1.55	0.06	0.28		0.17	513	2.07		18	11	4		htS2p	
3320	3320	3320	Marcellus	M Devonian	cutting	2.12	0.03	0.15		0.13	532	2.42		7	6	1		htS2p	
3330	3330	3330	Marcellus	M Devonian	cutting	2.15	0.34	0.30		0.12	350	–		14	6	16		itS2p	
3340	3340	3340	Marcellus	M Devonian	cutting	2.03	0.09	0.34		0.16	542	2.6		17	8	4		htS2p	
3350	3350	3350	Marcellus	M Devonian	cutting	2.18	0.07	0.44		0.18	554	2.81		20	8	3		htS2p	
3360	3360	3360	Marcellus	M Devonian	cutting	1.75	0.06	0.36		0.18	531	2.4		21	10	3		htS2p	
3370	3370	3370	Marcellus	M Devonian	cutting	2.15	0.05	0.25		0.13	516	2.13		12	6	2		htS2p	
3380	3380	3380	Marcellus	M Devonian	cutting	2.54	0.06	0.42		0.17	518	2.16		17	7	2		htS2p	
3390	3390	3390	Marcellus	M Devonian	cutting	2.82	0.09	0.59		0.19	556	2.85		21	7	3		htS2p	
3400	3400	3400	Marcellus	M Devonian	cutting	2.82	0.04	0.65		0.17	537	2.51		23	6	1		htS2p	
3410	3410	3410	Marcellus	M Devonian	cutting	0.42	0.02	0.01		0.08	543	2.61		2	19	5		f	
3420	3420	3420	Marcellus	M Devonian	cutting	5.65	0.06	0.94		0.3	548	2.7		17	5	1		htS2p	
3430	3430	3430	Marcellus	M Devonian	cutting	4.3	0.13	0.7		0.23	574	3.17		16	5	3		htS2p	
3440	3440	3440	Marcellus	M Devonian	cutting	12.57	0.04	1.46		0.29	552	2.78		12	2	0		htS2p	
3450	3450	3450	Marcellus	M Devonian	cutting	2.32	0.03	0.39		0.24	559	2.9		17	10	1		htS2p	
3470	3470	3470	Marcellus	M Devonian	cutting	3.68	0.03	0.3		0.16	565	3.01		8	4	1		htS2p	

Notes:
TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - PERIGO 21578 TPI Well

Operator	Columbia Natural Resc
API #	31097196920000

State	NY
County	Schulyer

Basin	Appalachian
Location	--

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values: TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
2290	2310	2300	Marcellus	M Dev	cuttings	5.77	0.39	0.89	19.4	0.27	504	1.91	0.96	15	5	7			016621

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - BALE #1 Well

Operator	JMC AVOCA INC
API #	31097214950000

State	NY
County	SCHUYLER

Basin	Appalachian
Location	--

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values: TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
3380	3380	3380	Marcellus	M Dev	cuttings	0.97	0.31	0.34	7.3	0.18	361 *			35	19	32		lts2p	146779
3400	3400	3400	Marcellus	M Dev	cuttings	0.78	0.54	0.47	10.2	0.28	361 *			60	36	69		lts2p	146780
3420	3420	3420	Marcellus	M Dev	cuttings	2.07	0.35	0.19	4.1	0.12	353 *			9	6	17	✓	lts2p	146781
3440	3440	3440	Marcellus	M Dev	cuttings	3.26	0.33	0.24	5.2	0.09	536 *	2.49		7	3	10		f	146782
3460	3460	3460	Marcellus	M Dev	cuttings	2.71	0.29	0.15	3.2	0.09	432 *	0.62		6	3	11		f	146783
3480	3480	3480	Marcellus	M Dev	cuttings	5.33	0.68	0.67	14.6	0.20	370			13	4	13	✓	lts2p	146784
3500	3500	3500	Marcellus	M Dev	cuttings	6.41	0.47	0.54	11.7	0.16	548	2.70		8	2	7		hts2p	146785
3520	3520	3520	Marcellus	M Dev	cuttings	2.44	0.43	0.16	3.4	0.16	585 *	3.37		7	7	18	✓	f	146786

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - SCHAFFER #2 Well

Operator	United Prod Co
API #	31099042030000

State	NY
County	Seneca

Basin	Appalachian
Location	--

						Present Day Values													
Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2 TOC	OI 100*S3 TOC	NOC 100*S1 TOC	Check	Pyrogram	Sample ID
50	80	65	Marcellus	M Dev	cuttings	1.72	0.28	0.19	4.1	0.31	437 *	0.71	1.00	11	18	16			016622

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - M GARRETT ETAL #1 Well

Operator	N Y STATE NAT GAS	State	NY	Basin	Appalachian
API #	31099042150000	County	SENECA	Location	--

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values: TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
132	132	132	Marcellus	M Dev	cuttings	1.07	0.23	0.24	5.2	0.15	477 *	1.43		22	14	21		f	145095
145	145	145	Marcellus	M Dev	cuttings	1.85	0.41	0.36	7.8	0.15	466 *	1.23		19	8	22		f	145096
160	160	160	Marcellus	M Dev	cuttings	5.68	1.05	0.88	19.2	0.27	500	1.84		15	5	18	✓	n	145097
175	175	175	Marcellus	M Dev	cuttings	3.62	0.66	0.61	13.3	0.18	569	3.08		17	5	18		f	145098

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - DINNINEY Well

Operator	National Fuel Gas Supply
API #	31101001670000

State	NY
County	Steuben

Basin	Appalachian
Location	--

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values: TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
3947	3947	3947	Marcellus	M Dev	cuttings	0.92	0.23	0.19		0.14	425	0.49		21	15	25		f	
3973	3973	3973	Marcellus	M Dev	cuttings	1.82	0.32	0.31		0.23	353			17	13	18		f	
3984	3984	3984	Marcellus	M Dev	cuttings	3.51	0.83	0.59		0.13	344			17	4	24		ltS2p	
3992	3992	3992	Marcellus	M Dev	cuttings	4.27	0.91	0.73		0.33	350			17	8	21		ltS2p	
4008	4008	4008	Marcellus	M Dev	cuttings	3.79	0.79	0.56		0.23	519	2.18		15	6	21		ltS2p	
4016	4016	4016	Marcellus	M Dev	cuttings	3.80	0.97	0.69		0.35	351			18	9	26		f	

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - MITCHELL #1 Well

Operator	JMC AVOCA INC	**State**	NY	**Basin**	Appalachian
API #	31101214680000	**County**	STEUBEN	**Location**	-Avoca-

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
3090	3100	3095	Marcellus	M Dev	cuttings	0.66	0.32	0.29	6.2	0.26	443 *	0.81		44	39	48		f	204780
3100	3110	3105	Marcellus	M Dev	cuttings	0.66	0.22	0.22	4.7	0.21	457 *	1.07		33	32	33	✓	f	204781
3110	3120	3115	Marcellus	M Dev	cuttings	0.64	0.24	0.23	4.9	0.23	453 *	0.99		36	36	37		f	204782
3110	3140	3125	Marcellus	M Dev	cuttings	1.57	0.55	0.56	12.2	0.21	459	1.10	0.77	36	13	35			016623
3120	3130	3125	Marcellus	M Dev	cuttings	0.95	0.35	0.32	6.9	0.17	453 *	0.99		34	18	37	✓	f	204783
3130	3140	3135	Marcellus	M Dev	cuttings	1.05	0.47	0.53	11.5	0.26	456	1.05		50	25	45	✓	n	204784
3140	3150	3145	Marcellus	M Dev	cuttings	2.59	1.23	1.42	31.0	0.16	453	0.99		55	6	47	✓	n;ltS2sh	204785
3150	3160	3155	Marcellus	M Dev	cuttings	0.49	0.23	0.21	4.5	0.13	444 *	0.83		43	26	47	✓	f	204786
3160	3170	3165	Marcellus	M Dev	cuttings	2.52	1.29	1.53	33.4	0.18	455	1.03		61	7	51	✓	n	204787
3170	3180	3175	Marcellus	M Dev	cuttings	2.30	0.89	1.09	23.8	0.14	456	1.05		47	6	39		n	204788
3180	3190	3185	Marcellus	M Dev	cuttings	1.93	0.88	1.10	24.0	0.14	453	0.99		57	7	46	✓	n	204789
3190	3200	3195	Marcellus	M Dev	cuttings	0.24	0.09	0.07	1.4	0.09	461 *	1.14		29	37	37	✓	f	204790

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - BALLYMONEY #1 Well

Operator	Fortuna Energy Inc		**State**	NY		**Basin**	Appalachian
API #	31101229780000		**County**	STEUBEN		**Location**	--

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values: TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
5000	5000	5000	Marcellus	M Dev	cuttings	0.91	0.17	0.08	1.7	0.06	347 *			9	7	19	✓	f	137753
5030	5030	5030	Marcellus	M Dev	cuttings	0.63	0.30	0.10	2.1	0.10	421 *	0.42		16	16	48	✓	f	137754
5060	5060	5060	Marcellus	M Dev	cuttings	1.50	0.29	0.14	3.0	0.10	350 *			9	7	19		f	137755
5070	5070	5070	Marcellus	M Dev	cuttings	1.23	0.21	0.13	2.7	0.10	391 *			11	8	17		f	137756
5080	5080	5080	Marcellus	M Dev	cuttings	1.21	0.17	0.13	2.7	0.11	426 *	0.51		11	9	14		f	137757
5090	5090	5090	Marcellus	M Dev	cuttings	1.17	0.21	0.19	4.1	0.09	383 *			16	8	18		f	137758
5120	5120	5120	Marcellus	M Dev	cuttings	0.80	0.17	0.10	2.1	0.08	311 *			12	10	21	✓	f	137759
5130	5130	5130	Marcellus	M Dev	cuttings	1.14	0.25	0.16	3.4	0.11	348 *			14	10	22		f	137760
5140	5140	5140	Marcellus	M Dev	cuttings	0.41	0.24	0.18	3.8	0.09	353 *			44	22	58		f	137761
5150	5150	5150	Marcellus	M Dev	cuttings	2.42	0.23	0.17	3.6	0.08	353 *			7	3	10		f	137762
5160	5160	5160	Marcellus	M Dev	cuttings	4.65	0.36	0.41	8.9	0.15	535 *	2.47		9	3	8		f	137763
5180	5180	5180	Marcellus	M Dev	cuttings	4.91	0.48	0.39	8.4	0.13	480 *	1.48		8	3	10		f	137764
5190	5190	5190	Marcellus	M Dev	cuttings	1.16	0.28	0.14	3.0	0.11	384 *			12	9	24		f	137765
5200	5200	5200	Marcellus	M Dev	cuttings	0.83	0.17	0.03	0.6	0.10	311 *			4	12	20		f	137766
5220	5220	5220	Marcellus	M Dev	cuttings	0.49	0.12	0.06	1.2	0.08	312 *			12	16	24	✓	f	137767

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - ERWIN WMA #1 Well

Operator	Fortuna Energy Inc	**State**	NY	**Basin**	Appalachian
API #	31101230850000	**County**	STEUBEN	**Location**	--

						Present Day Values													
Top Depth (ft)	**Bottom Depth (ft)**	**Median Depth (ft)**	Formation **Name**	**Age**	**Sample Type**	**TOC (wt%)**	**S1 (mg/g)**	**S2 (mg/g)**	**S2 (bbl/a-ft)**	**S3 (mg/g)**	**Tmax (°C)**	**Tmax** Calc. %Ro	**Meas. %Ro**	**HI** 100*S2 / **TOC**	**OI** 100*S3 / **TOC**	**NOC** 100*S1 / **TOC**	**Check**	**Pyrogram**	Sample **ID**
3770	3770	3770	Marcellus	M Dev	cuttings	2.72	0.43	0.34	7.3	0.12	468 *	1.26		12	4	16		f	137739
3790	3790	3790	Marcellus	M Dev	cuttings	3.86	0.44	0.54	11.7	0.13	469	1.28		14	3	11		f	137740
3810	3810	3810	Marcellus	M Dev	cuttings	3.13	0.44	0.45	9.8	0.13	525 *	2.29		14	4	14		f	137741
3830	3830	3830	Marcellus	M Dev	cuttings	5.33	0.57	0.70	15.2	0.14	478	1.44		13	3	11		f	137742
3850	3850	3850	Marcellus	M Dev	cuttings	3.94	0.61	0.76	16.5	0.15	530	2.38		19	4	15	✓	f	137743

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - Steuben Reforestation Area 3 #2 Well

Operator	Fortuna Energy Inc
API #	31101231010000

State	NY
County	STEUBEN

Basin	Appalachian
Location	-Bradford-

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
3220	3220	3220	Marcellus	M Dev	cuttings	0.73	0.23	0.24	5.2	0.13	380 *			33	18	31	✓	f	204791
3230	3230	3230	Marcellus	M Dev	cuttings	2.48	0.53	0.54	11.7	0.09	471	1.32		22	4	21	✓	n;ltS2sh	204792
3240	3240	3240	Marcellus	M Dev	cuttings	3.83	0.56	1.00	21.8	0.10	477	1.43		26	3	15	✓	n;ltS2sh	204793
3250	3250	3250	Marcellus	M Dev	cuttings	3.10	0.41	0.79	17.2	0.11	489	1.64		25	4	13	✓	n;ltS2sh	204794
3260	3260	3260	Marcellus	M Dev	cuttings	6.47	0.60	1.76	38.4	0.16	474	1.37		27	2	9	✓	n;ltS2sh	204795
3270	3270	3270	Marcellus	M Dev	cuttings	7.25	0.71	1.98	43.2	0.17	475	1.39		27	2	10		n;ltS2sh	204796
3280	3280	3280	Marcellus	M Dev	cuttings	7.04	0.65	2.00	43.7	0.19	485	1.57		28	3	9	✓	n;ltS2sh	204797
3290	3290	3290	Marcellus	M Dev	cuttings	6.85	0.73	1.83	40.0	0.18	475	1.39		27	3	11	✓	n;ltS2sh	204798
3300	3300	3300	Marcellus	M Dev	cuttings	5.13	0.63	1.67	36.5	0.13	493	1.71		33	3	12	✓	n;ltS2sh	204799
3310	3310	3310	Marcellus	M Dev	cuttings	5.47	0.60	1.62	35.4	0.13	497	1.79		30	2	11	✓	n;ltS2sh	204800
3320	3320	3320	Marcellus	M Dev	cuttings	2.14	0.40	0.05	1.0	0.10	356 *			2	5	19	✓	f	204801
3330	3330	3330	Marcellus	M Dev	cuttings	1.25	0.38	0.42	9.1	0.12	500 *	1.84		34	10	30	✓	n;ltS2sh	204802
3340	3340	3340	Marcellus	M Dev	cuttings	0.74	0.19	0.15	3.2	0.12	497 *	1.79		20	16	26	✓	f	204803

Notes:
TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - STUART #1 Well

Operator	Fortuna Energy Inc	**State**	NY	**Basin**	Appalachian
API #	31101231900000	**County**	STEUBEN	**Location**	--

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values: TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
3400	3400	3400	Marcellus	M Dev	cuttings	0.09	0.02	0.15	3.2	0.15	436 *	0.69		165	165	22	✓	f	145157
3450	3450	3450	Marcellus	M Dev	cuttings	0.16	0.05	0.00	-0.1	0.01	*			0	6	31		f	139715
3460	3460	3460	Marcellus	M Dev	cuttings	0.17	0.07	0.06	1.2	0.08	*			35	47	41	✓	f	139716
3470	3470	3470	Marcellus	M Dev	cuttings	0.17	0.10	0.05	1.0	0.02	310 *			29	12	58	✓	f	139717
3480	3480	3480	Marcellus	M Dev	cuttings	0.23	0.08	0.06	1.2	0.06	*			26	26	35	✓	f	139718
3490	3490	3490	Marcellus	M Dev	cuttings	0.19	0.08	0.04	0.8	0.04	580 *	3.28		21	21	42		f	139719
3500	3500	3500	Marcellus	M Dev	cuttings	0.23	0.08	0.21	4.5	0.09	*			91	39	35		hts2p	145158

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - F E ODONNELL #1 Well

Operator	Gulf Oil
API #	31105128610000

State	NY
County	SULLIVAN

Basin	Appalachian
Location	-Thompson-

						Present Day Values													
Top Depth (ft)	**Bottom Depth (ft)**	**Median Depth (ft)**	Formation **Name**	**Age**	**Sample Type**	**TOC (wt%)**	**S1 (mg/g)**	**S2 (mg/g)**	**S2 (bbl/a-ft)**	**S3 (mg/g)**	**Tmax (°C)**	**Tmax** Calc. %Ro	**Meas. %Ro**	**HI** 100*S2 **TOC**	**OI** 100*S3 **TOC**	**NOC** 100*S1 **TOC**	**Check**	**Pyrogram**	Sample **ID**
6640	6640	6640	Marcellus	M.Dev	core	0.55	0.20	0.14	3.0	0.07	371 *	-1.00		25	13	36		f	204747
6650	6650	6650	Marcellus	M.Dev	core	0.73	0.10	0.06	1.2	0.05	311 *	-1.00		8	7	14		f	204748
6660	6660	6660	Marcellus	M.Dev	core	0.65	0.11	0.03	0.6	0.05	-6 *	-1.00		5	8	17	✓	f	204749
6670	6670	6670	Marcellus	M.Dev	core	0.84	0.07	0.07	1.4	0.08	311 *	-1.00		8	10	8		f	204750
6680	6680	6680	Marcellus	M.Dev	core	0.71	0.07	0.02	0.3	0.05	-6 *	-1.00		3	7	10	✓	f	204751
6690	6690	6690	Marcellus	M.Dev	core	0.91	0.09	0.05	1.0	0.07	311 *	-1.00		5	8	10		f	204752
7201	7201	7201	Marcellus	M Dev	core	0.82	0.06	0.01	0.1	0.05	-6 *	-1.00		1	6	7		f	204753
7210	7210	7210	Marcellus	M Dev	core	2.69	0.23	0.13	2.7	0.17	358 *	-1.00		5	6	9	✓	f	204754
7220	7220	7220	Marcellus	M Dev	core	2.94	0.36	0.20	4.3	0.30	367 *	-1.00		7	10	12		ltS2p	204755
7230	7230	7230	Marcellus	M Dev	core	3.08	0.18	0.10	2.1	0.18	368 *	-1.00		3	6	6	✓	f	204756
7240	7240	7240	Marcellus	M Dev	core	2.33	0.25	0.15	3.2	0.19	378 *	-1.00		6	8	11	✓	f	204757

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - CNYOG #4 Well

Operator	Central NY Oil & Gas Co
API #	31107228870000

State	NY
County	TIOGA

Basin	Appalachian
Location	--

						Present Day Values													
Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2 / TOC	OI 100*S3 / TOC	NOC 100*S1 / TOC	Check	Pyrogram	Sample ID
4580	4580	4580	Marcellus	M Dev	cuttings	1.81	0.37	0.22	4.7	0.19	361 *			12	10	20		f	145122
4600	4600	4600	Marcellus	M Dev	cuttings	1.88	0.36	0.29	6.2	0.21	359 *			15	11	19		f	145123
4620	4620	4620	Marcellus	M Dev	cuttings	1.75	0.33	0.25	5.4	0.20	392 *			14	11	19		f	145124
4640	4640	4640	Marcellus	M Dev	cuttings	1.85	0.30	0.22	4.7	0.19	424 *	0.47		12	10	16	✓	f	145125
4660	4660	4660	Marcellus	M Dev	cuttings	4.37	0.56	0.30	6.5	0.25	379 *			7	6	13	✓	f	145126
4680	4680	4680	Marcellus	M Dev	cuttings	4.08	0.66	0.32	6.9	0.33	356 *			8	8	16		f	145127
4700	4700	4700	Marcellus	M Dev	cuttings	4.08	0.59	0.36	7.8	0.30	357 *			9	7	14		f	145128
4740	4740	4740	Marcellus	M Dev	cuttings	4.78	0.88	0.39	8.4	0.31	366 *			8	6	18		f	145129
4760	4760	4760	Marcellus	M Dev	cuttings	4.67	0.81	0.39	8.4	0.29	406 *	0.15		8	6	17		f	145130

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - Pimpinella #1 Well

Operator	MEGA ENERGY OP INC
API #	31107231920000

State	NY
County	TIOGA

Basin	Appalachian
Location	--

						Present Day Values													
Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2 TOC	OI 100*S3 TOC	NOC 100*S1 TOC	Check	Pyrogram	Sample ID
4460	4470	4465	Marcellus	M Dev	cuttings	1.17	0.01	0.03	0.6	0.06	*			3	5	1	✓	f	218448
4470	4480	4475	Marcellus	M Dev	cuttings	1.66	0.05	0.05	1.0	0.03	*			3	2	3	✓	f	218449
4480	4490	4485	Marcellus	M Dev	cuttings	1.45	0.02	0.04	0.8	0.06	*			3	4	1	✓	f	218450
4490	4500	4495	Marcellus	M Dev	cuttings	1.57	0.07	0.05	1.0	0.07	*			3	4	4	✓	f	218451
4500	4510	4505	Marcellus	M Dev	cuttings	1.92	0.20	0.07	1.4	0.06	*			4	3	10		f	218452
4510	4520	4515	Marcellus	M Dev	cuttings	1.98	0.08	0.05	1.0	0.08	*			3	4	4	✓	f	218453
4520	4530	4525	Marcellus	M Dev	cuttings	2.32	0.14	0.06	1.2	0.09	*			3	4	6	✓	f	218454
4530	4540	4535	Marcellus	M Dev	cuttings	2.52	0.14	0.07	1.4	0.04	*			3	2	6	✓	f	218455
4540	4550	4545	Marcellus	M Dev	cuttings	2.73	0.06	0.05	1.0	0.10	*			2	4	2	✓	f	218456
4550	4560	4555	Marcellus	M Dev	cuttings	3.71	0.14	0.10	2.1	0.10	316 *			3	3	4	✓	f	218457
4560	4570	4565	Marcellus	M Dev	cuttings	3.83	0.12	0.05	1.0	0.16	321 *			1	4	3	✓	f	218458
4570	4580	4575	Marcellus	M Dev	cuttings	4.01	0.09	0.05	1.0	0.26	*			1	6	2	✓	f	218459
4580	4590	4585	Marcellus	M Dev	cuttings	3.57	0.14	0.12	2.5	0.21	343 *			3	6	4	✓	f	218460
4590	4600	4595	Marcellus	M Dev	cuttings	2.60	0.07	0.06	1.2	0.21	*			2	8	3	✓	f	218461
4600	4610	4605	Marcellus	M Dev	cuttings	4.42	0.10	0.12	2.5	0.24	*			3	5	2		f	218462
4610	4620	4615	Marcellus	M Dev	cuttings	4.95	0.21	0.16	3.4	0.16	352 *			3	3	4	✓	f	218463
4620	4630	4625	Marcellus	M Dev	cuttings	4.83	0.09	0.08	1.7	0.28	314 *			2	6	2	✓	f	218464
4630	4640	4635	Marcellus	M Dev	cuttings	5.43	0.20	0.09	1.9	0.26	321 *			2	5	4	✓	f	218465
4640	4650	4645	Marcellus	M Dev	cuttings	6.06	0.26	0.13	2.7	0.28	318 *			2	5	4	✓	f	218466
4650	4660	4655	Marcellus	M Dev	cuttings	6.32	0.19	0.14	3.0	0.27	378 *			2	4	3		f	218467

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - JOHN SHEPHERD #1 Well

Operator	N Y STATE NAT GAS
API #	31109039730000

State	NY
County	TOMPKINS

Basin	Appalachian
Location	--

						Present Day Values													
Top Depth (ft)	**Bottom Depth (ft)**	**Median Depth (ft)**	Formation **Name**	**Age**	**Sample Type**	**TOC (wt%)**	**S1 (mg/g)**	**S2 (mg/g)**	**S2 (bbl/a-ft)**	**S3 (mg/g)**	**Tmax (°C)**	**Tmax** Calc. %Ro	**Meas. %Ro**	**HI** 100*S2 **TOC**	**OI** 100*S3 **TOC**	**NOC** 100*S1 **TOC**	**Check**	**Pyrogram**	Sample **ID**
2240	2250	2245	Marcellus	M Dev	cuttings	5.48	3.78	2.01	43.9	0.50	352			37	9	69		lts2p	139710
2250	2260	2255	Marcellus	M Dev	cuttings	5.21	1.88	1.12	24.4	0.42	354			21	8	36		lts2p	139711
2260	2270	2265	Marcellus	M Dev	cuttings	5.49	1.97	1.08	23.5	0.39	382			20	7	36	✓	lts2p	139712
2280	2290	2285	Marcellus	M Dev	cuttings	5.47	1.93	1.28	27.9	0.46	358			23	8	35		lts2p	139713
2300	2310	2305	Marcellus	M Dev	cuttings	5.54	2.48	1.56	34.0	0.53	357			28	10	45		lts2p	139714

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - CARL H GRUND #1 Well

Operator	N Y STATE NAT GAS
API #	31109041300000

State	NY
County	TOMPKINS

Basin	Appalachian
Location	--

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values: TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
2390	2400	2395	Marcellus	M Dev	cuttings	2.40	1.19	0.48	10.4	0.17	374 *			20	7	50	✓	f	139692
2410	2420	2415	Marcellus	M Dev	cuttings	2.20	0.86	0.57	12.4	0.20	360			26	9	39		lts2p	139693
2420	2430	2425	Marcellus	M Dev	cuttings	4.45	1.52	0.81	17.6	0.23	352			18	5	34		lts2p	139694
2430	2440	2435	Marcellus	M Dev	cuttings	4.62	1.46	0.60	13.0	0.26	349			13	6	32		lts2p	139695
2440	2450	2445	Marcellus	M Dev	cuttings	4.63	1.59	0.75	16.3	0.27	356			16	6	34		f	139696
2460	2470	2465	Marcellus	M Dev	cuttings	1.79	0.80	0.33	7.1	0.16	359 *			18	9	45	✓	lts2p	139697
2470	2480	2475	Marcellus	M Dev	cuttings	6.04	2.65	1.20	26.2	0.40	359			20	7	44		lts2p	139698
2490	2500	2495	Marcellus	M Dev	cuttings	3.23	1.53	0.90	19.6	0.25	357			28	8	47		lts2p	139699

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - NYSNG CORP #1 Well

Operator	N Y STATE NAT GAS	**State**	NY	**Basin**	Appalachian
API #	31109044670000	**County**	TOMPKINS	**Location**	--

						Present Day Values													
Top Depth (ft)	**Bottom Depth (ft)**	**Median Depth (ft)**	Formation **Name**	**Age**	**Sample Type**	**TOC (wt%)**	**S1 (mg/g)**	**S2 (mg/g)**	**S2 (bbl/a-ft)**	**S3 (mg/g)**	**Tmax (°C)**	**Tmax** Calc. %Ro	**Meas. %Ro**	**HI** 100*S2 / **TOC**	**OI** 100*S3 / **TOC**	**NOC** 100*S1 / **TOC**	**Check**	**Pyrogram**	Sample **ID**
2100	2110	2105	Marcellus	M Dev	cuttings	0.84	0.83	1.37	29.9	0.31	412	0.26		163	37	99		n	139605
2130	2140	2135	Marcellus	M Dev	cuttings	1.08	1.22	2.67	58.3	0.43	429	0.56		247	40	113		n;lts2sh	139606
2140	2150	2145	Marcellus	M Dev	cuttings	4.00	1.72	1.25	27.3	0.28	361			31	7	43		lts2p	139607
2150	2160	2155	Marcellus	M Dev	cuttings	3.71	0.94	0.87	18.9	0.17	373			23	5	25	✓	lts2p	139608
2160	2170	2165	Marcellus	M Dev	cuttings	4.00	1.39	1.09	23.8	0.22	362			27	5	35		lts2p	139609
2170	2180	2175	Marcellus	M Dev	cuttings	4.59	1.55	0.59	12.8	0.18	409	0.20		13	4	34	✓	f	139610
2180	2190	2185	Marcellus	M Dev	cuttings	4.04	1.08	0.64	13.9	0.17	358			16	4	27		lts2p	139611
2190	2200	2195	Marcellus	M Dev	cuttings	3.74	0.36	1.16	25.3	0.23	412	0.26		31	6	10		n;lts2sh	139612
2200	2210	2205	Marcellus	M Dev	cuttings	4.34	0.64	1.23	26.8	0.29	410	0.22		28	7	15		n;lts2sh	139613
2220	2230	2225	Marcellus	M Dev	cuttings	7.82	1.72	1.93	42.1	0.34	384			25	4	22		lts2p	139614
2230	2240	2235	Marcellus	M Dev	cuttings	9.01	1.10	2.49	54.4	0.35	426	0.51		28	4	12	✓	n;lts2sh	139615
2250	2260	2255	Marcellus	M Dev	cuttings	3.28	3.78	5.66	123.8	0.49	436	0.69		173	15	115		n;lts2sh	139616

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - RUTH A PLACE #1 Well

Operator	Shell Oil Company
API #	31109102430000

State	NY
County	Tompkins

Basin	Appalachian
Location	--

						Present Day Values													
Top Depth (ft)	**Bottom Depth (ft)**	**Median Depth (ft)**	Formation **Name**	**Age**	**Sample Type**	**TOC (wt%)**	**S1 (mg/g)**	**S2 (mg/g)**	**S2 (bbl/a-ft)**	**S3 (mg/g)**	**Tmax (°C)**	**Tmax** Calc. %Ro	**Meas. %Ro**	**HI** 100*S2/**TOC**	**OI** 100*S3/**TOC**	**NOC** 100*S1/**TOC**	**Check**	**Pyrogram**	Sample **ID**
2850	2930	2890	Marcellus	M Dev	cuttings	0.58	0.08	0.40	8.7	0.15	348 *		1.37	69	26	14			016624

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - DORIS VEITH #1 Well

Operator	N Y STATE NAT GAS	State	NY	Basin	Appalachian
API #	31121040920000	County	WYOMING	Location	-Gainesville-

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
1980	1990	1985	Marcellus	M Dev	cuttings	1.38	1.24	2.34	51.1	0.51	439	0.74		169	37	90		n;ltS2sh	204772
1990	2000	1995	Marcellus	M Dev	cuttings	1.80	1.58	3.12	68.2	0.53	441	0.78		173	29	88		n;ltS2sh	204773
2000	2010	2005	Marcellus	M Dev	cuttings	5.92	4.57	14.49	317.1	0.63	430	0.58		245	11	77	✓	n	204774
2010	2020	2015	Marcellus	M Dev	cuttings	3.12	2.02	5.90	129.1	0.52	433	0.63		189	17	65	✓	n	204775

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - FRANK FISHER #1 Well

Operator	FLANIGAN BROTHERS
API #	31121060730000

State	NY
County	WYOMING

Basin	Appalachian
Location	-Warsaw-

						Present Day Values													
Top Depth (ft)	**Bottom Depth (ft)**	**Median Depth (ft)**	Formation **Name**	**Age**	**Sample Type**	**TOC (wt%)**	**S1 (mg/g)**	**S2 (mg/g)**	**S2 (bbl/a-ft)**	**S3 (mg/g)**	**Tmax (°C)**	**Tmax** Calc. %Ro	**Meas. %Ro**	**HI** 100*S2 / **TOC**	**OI** 100*S3 / **TOC**	**NOC** 100*S1 / **TOC**	**Check**	**Pyrogram**	Sample **ID**
1235	1245	1240	Marcellus	M Dev	cuttings	1.66	1.56	4.82	105.4	0.48	440	0.76		290	29	94	✓	n	204768
1245	1265	1255	Marcellus	M Dev	cuttings	1.40	0.93	3.82	83.5	0.59	441	0.78		273	42	66	✓	n	204769
1358	1373	1365.5	Marcellus	M Dev	cuttings	4.41	2.96	12.06	263.9	0.67	428	0.54		273	15	67	✓	n	204770
1383	1395	1389	Marcellus	M Dev	cuttings	2.74	1.89	6.88	150.5	0.62	430	0.58		251	23	69	✓	n	204771

Notes:
TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - TITUS BROTHERS #4 Well

Operator	Power Gas Corp	**State**	NY	**Basin**	Appalachian
API #	31121220420000	**County**	Wyoming	**Location**	--

Top Depth (ft)	Bottom Depth (ft)	Median Depth (ft)	Formation Name	Age	Sample Type	Present Day Values: TOC (wt%)	S1 (mg/g)	S2 (mg/g)	S2 (bbl/a-ft)	S3 (mg/g)	Tmax (°C)	Tmax Calc. %Ro	Meas. %Ro	HI 100*S2/TOC	OI 100*S3/TOC	NOC 100*S1/TOC	Check	Pyrogram	Sample ID
810	840	825	Marcellus	M Dev	cuttings	7.07	2.84	14.97	327.6	0.39	437	0.71	0.54	212	6	40			016625

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - FEE #1 Well

Operator	Zimmerman, Ivan L. & Lois N.
API #	31123047960000

State	NY
County	Yates

Basin	Appalachian
Location	--

						Present Day Values													
Top Depth (ft)	**Bottom Depth (ft)**	**Median Depth (ft)**	Formation **Name**	**Age**	**Sample Type**	**TOC (wt%)**	**S1 (mg/g)**	**S2 (mg/g)**	**S2 (bbl/a-ft)**	**S3 (mg/g)**	**Tmax (°C)**	**Tmax** Calc. %Ro	**Meas. %Ro**	**HI** 100*S2/**TOC**	**OI** 100*S3/**TOC**	**NOC** 100*S1/**TOC**	**Check**	**Pyrogram**	Sample **ID**
1051	1095	1073	Marcellus	M Dev	cuttings	6.22	0.31	0.69	15.0	0.25	535	2.47	1.74	11	4	5			016626

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - Jerusalem #1 Well

Operator	Pennzoil Co. Inc.	**State**	NY
API #	31123154690000	**County**	Yates
Basin	Appalachian	**Location**	--

						Present Day Values													
Top Depth (ft)	**Bottom Depth (ft)**	**Median Depth (ft)**	Formation **Name**	**Age**	**Sample Type**	**TOC (wt%)**	**S1 (mg/g)**	**S2 (mg/g)**	**S2 (bbl/a-ft)**	**S3 (mg/g)**	**Tmax (°C)**	**Tmax** Calc. %Ro	**Meas. %Ro**	**HI** 100*S2 **TOC**	**OI** 100*S3 **TOC**	**NOC** 100*S1 **TOC**	**Check**	**Pyrogram**	Sample **ID**
780	790	785	Marcellus	M Dev	cuttings	2.76	1.27	1.35	29.5	0.24	465	1.21		49	9	46	✓	n;ltS2sh	230289
790	800	795	Marcellus	M Dev	cuttings	2.86	1.02	1.25	27.3	0.25	463	1.17	1.32	44	9	36	✓	n	229720
800	810	805	Marcellus	M Dev	cuttings	2.29	0.78	0.65	14.1	0.15	389			28	7	34		n;ltS2sh	230290
810	820	815	Marcellus	M Dev	cuttings	2.98	0.91	1.01	22.0	0.16	458	1.08	1.41	34	5	31		n	229721

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

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Geochemical Data - Shirley Roe #1 Well

Operator	Pennzoil Co. Inc.
API #	31123157640000

State	NY
County	Yates

Basin	Appalachian
Location	--

						Present Day Values													
Top Depth (ft)	**Bottom Depth (ft)**	**Median Depth (ft)**	Formation **Name**	**Age**	**Sample Type**	**TOC (wt%)**	**S1 (mg/g)**	**S2 (mg/g)**	**S2 (bbl/a-ft)**	**S3 (mg/g)**	**Tmax (°C)**	**Tmax** Calc. %Ro	**Meas. %Ro**	**HI** 100*S2 **TOC**	**OI** 100*S3 **TOC**	**NOC** 100*S1 **TOC**	**Check**	**Pyrogram**	Sample **ID**
1097	1105	1101	Marcellus	M Dev	cuttings	4.63	0.95	0.74	16.1	0.21	466	1.23	1.20	16	5	21	✓	n	229714

Notes:

TOC = Total Organic Carbon.
S1 = Volatile hydrocarbon content.
S2 = Remaining potential to generate hydrocarbons.
S3 = Carbon dioxide content.
Tmax= Temperature at maximum of S2 peak.
* Low S2, Tmax has higher uncertaintiy.

Tmax Cal. %Ro = Calculated vitrinite reflectance based on Tmax.
Meas. %Ro = Measured vitrinite reflectance.
HI = Hydrogen index = S2 x 100 / TOC.
OI = Oxygen Index = S3 x 100 / TOC
NOC = Normalized oil content = S1 x 100/ TOC.
NOC = Highlight in light green = possible oil show.
#N/A = No vitrinite reflectance determination possible.

Pyrogram:
n = normal.
ltS2sh = low temperature S2 shoulder.
ltS2p = low temperature S2 peak.
htS2p = high temperature S2 peak.
f = flat S2 peak.
✓ Analytical results confirmed.

APPENDIX C

Omni Labs X-Ray Diffraction Analyses

OMNI LABORATORIES
X-RAY DIFFRACTION
(WEIGHT %)

Client: OMNI Laboratories
Well: Columbia Gas Trans. Corp, O'Brien, F 20330
API #: 31003117620000
Area: Allegany County, New York
Sample Type: Cuttings

File No: HH-39674
Date: 09/08/08
Analyst: G. Walker

Sample Depth (ft)	CLAYS				CARBONATES			OTHER MINERALS						TOTALS		
	Chlorite	Kaolinite	Illite	Mx I/S*	Calcite[1]	Fe-Dol	Siderite	Quartz	K-spar	Plag.	Pyrite	Apatite	Barite	Clays	Carb.	Other
4310-4320	13	Tr	17	4	30	1	Tr	23	1	4	6	1	0	34	31	35
4320-4330	14	1	19	5	1	0	Tr	35	1	8	15	1	0	39	1	60
4330-4340	12	Tr	17	4	3	1	Tr	39	1	7	15	1	0	33	4	63
4340-4350	12	Tr	15	4	30	3	Tr	20	1	4	10	1	0	31	33	36
AVERAGE	13	Tr	17	4	16	1	Tr	29	1	6	12	1	0	34	17	49

* Ordered interstratified mixed-layer illite/smectite; Approximately 10-15% expandable interlayers
[1] May include the Fe-rich variety

Weatherford LABORATORIES

OMNI Laboratories

OMNI LABORATORIES
X-RAY DIFFRACTION
(WEIGHT %)

Client: OMNI Laboratories
Well: Joyce Western Corp, Richards 1
API #: 31007050870000
Area: Broome County, New York
Sample Type: Cuttings

File No: HH-39674
Date: 09/08/08
Analyst: G. Walker

Sample	CLAYS				CARBONATES			OTHER MINERALS						TOTALS		
Depth (ft)	Chlorite	Kaolinite	Illite	Mx I/S*	Calcite[1]	Fe-Dol	Siderite	Quartz	K-spar	Plag.	Pyrite	Apatite	Barite	Clays	Carb.	Other
2930-2940	16	1	22	5	Tr	3	Tr	36	1	8	6	2	0	44	3	53
2940-2950	17	1	23	5	1	2	Tr	36	1	6	7	1	0	46	3	51
2950-2960	17	1	22	5	0	2	Tr	37	1	6	6	3	0	45	2	53
2960-2970	16	1	20	5	0	2	Tr	37	1	7	9	2	0	42	2	56
2970-2980	17	1	20	5	0	2	Tr	37	1	7	8	2	0	43	2	55
2980-2990	15	1	20	5	0	3	Tr	38	1	7	9	1	0	41	3	56
2990-3000	16	1	21	5	0	2	Tr	38	1	6	9	1	0	43	2	55
3000-3010	16	1	22	5	0	2	Tr	36	1	7	9	1	0	44	2	54
3010-3020	16	1	22	5	0	2	Tr	36	1	6	10	1	0	44	2	54
3020-3030	15	1	20	5	1	2	Tr	37	1	7	10	1	0	41	3	56
3030-3040	15	1	19	5	1	2	Tr	36	1	7	12	1	0	40	3	57
3040-3050	11	1	14	3	34	4	Tr	23	1	2	7	Tr	0	29	38	33
3050-3060	9	Tr	12	3	39	7	Tr	22	1	2	5	Tr	0	24	46	30
3060-3070	12	1	17	4	27	5	Tr	23	1	3	6	1	0	34	32	34
3070-3080	14	1	18	4	16	3	Tr	28	1	4	10	1	0	37	19	44
3080-3090	10	Tr	12	3	17	4	Tr	35	1	4	13	1	0	25	21	54
3090-3100	10	Tr	13	3	17	3	Tr	36	1	4	13	Tr	0	26	20	54
AVERAGE	14	1	19	4	9	3	Tr	34	1	5	9	1	0	38	12	50

* Ordered interstratified mixed-layer illite/smectite; Approximately 10-15% expandable interlyaers

[1] May include the Fe-rich variety

Weatherford LABORATORIES

OMNI Laboratories

OMNI LABORATORIES
X-RAY DIFFRACTION
(WEIGHT %)

Client: OMNI Laboratories
Well: Humble Oil & Refining Co, Shadle S 1
API #: 31013041540000
Area: Chautauqua County, New York
Sample Type: Cuttings

File No: HH-39674
Date: 09/09/08
Analyst: G. Walker

Sample	CLAYS				CARBONATES			OTHER MINERALS						TOTALS		
Depth (ft)	Chlorite	Kaolinite	Illite	Mx I/S*	Calcite[1]	Fe-Dol	Siderite	Quartz	K-spar	Plag.	Pyrite	Apatite	Barite	Clays	Carb.	Other
2300-2310	18	1	23	6	2	1	Tr	36	1	5	5	2	0	48	3	49
2310-2320	19	1	24	6	1	1	Tr	32	1	5	8	2	0	50	2	48
2320-2330	17	1	22	6	4	1	Tr	30	1	5	11	2	0	46	5	49
2330-2340	2	Tr	3	1	81	5	Tr	6	Tr	Tr	2	Tr	0	6	86	8
AVERAGE	14	1	18	4	22	2	Tr	26	1	4	6	2	0	37	24	39

* Ordered interstratified mixed-layer illite/smectite; Approximately 10-15% expandable interlayers
[1] May include the Fe-rich variety

Weatherford LABORATORIES

OMNI Laboratories

OMNI LABORATORIES
X-RAY DIFFRACTION
(WEIGHT %)

Client: OMNI Laboratories
Well: Pennzoil Products Co, Harrington 1
API #: 31013044370000
Area: Chautauqua County, New York
Sample Type: Cuttings

File No: HH-39674
Date: 09/09/08
Analyst: G. Walker

Sample	CLAYS				CARBONATES			OTHER MINERALS						TOTALS		
Depth (ft)	Chlorite	Kaolinite	Illite	Mx I/S*	Calcite[1]	Fe-Dol	Siderite	Quartz	K-spar	Plag.	Pyrite	Apatite	Barite	Clays	Carb.	Other
2590-2600	15	1	19	5	24	2	Tr	26	1	3	3	1	0	40	26	34
2600-2610	18	1	22	6	11	2	Tr	30	1	3	4	2	0	47	13	40
2610-2620	19	1	25	6	1	0	Tr	36	1	5	4	2	0	51	1	48
2620-2630	19	1	25	5	2	1	Tr	33	1	5	6	2	0	50	3	47
2630-2640	15	1	20	5	13	1	Tr	28	1	4	10	2	0	41	14	45
2640-2650	10	1	12	3	42	6	Tr	15	1	2	7	1	0	26	48	26
AVERAGE	16	1	21	5	15	2	Tr	28	1	4	6	1	0	43	17	40

* Ordered interstratified mixed-layer illite/smectite; Approximately 10-15% expandable interlayers

[1] May include the Fe-rich variety

Weatherford LABORATORIES

OMNI Laboratories

OMNI LABORATORIES
X-RAY DIFFRACTION
(WEIGHT %)

Client: OMNI Laboratories
Well: Amoco Production Co, Hulbert 1
API #: 31017106090000
Area: Chenango County, New York
Sample Type: Cuttings

File No: HH-39674
Date: 09/09/08
Analyst: G. Walker

Sample	CLAYS				CARBONATES			OTHER MINERALS						TOTALS		
Depth (ft)	Chlorite	Kaolinite	Illite	Mx I/S*	Calcite[1]	Fe-Dol	Siderite	Quartz	K-spar	Plag.	Pyrite	Apatite	Barite	Clays	Carb.	Other
3550-3560	15	1	19	4	2	2	Tr	36	1	8	10	2	0	39	4	57
3560-3570	14	1	19	4	12	5	Tr	32	1	6	5	1	0	38	17	45
3570-3580	13	1	19	4	17	7	Tr	30	1	5	2	1	0	37	24	39
3580-3590	14	1	19	4	10	6	Tr	33	1	5	5	2	0	38	16	46
3590-3600	15	1	20	4	3	2	Tr	36	1	7	10	1	0	40	5	55
3600-3610	14	1	19	4	8	4	Tr	31	1	7	10	1	0	38	12	50
3610-3620	7	Tr	9	2	45	4	Tr	23	1	2	6	1	0	18	49	33
3620-3630	9	Tr	13	3	36	3	Tr	23	1	2	9	1	0	25	39	36
3630-3640	6	Tr	7	2	55	3	Tr	17	1	2	7	Tr	0	15	58	27
3640-3650	5	Tr	6	1	59	5	Tr	19	1	1	3	Tr	0	12	64	24
AVERAGE	11	1	15	3	25	4	Tr	28	1	4	7	1	0	30	29	41

* Ordered interstratified mixed-layer illite/smectite; Approximately 10-15% expandable interlayers

[1] May include the Fe-rich variety

OMNI LABORATORIES, INC.
X-RAY DIFFRACTION
(WEIGHT %)

Client: Whitmar
Well: Van Patton 1
Area: Onondaga County, NY
Sample Type: Cuttings

File No: HH-37911
Date: 10/23/07
Analyst: G. Walker

Sample	CLAYS				CARBONATES			OTHER MINERALS						TOTALS		
Depth (ft)	Chlorite	Kaolinite	Illite	Mx I/S*	Calcite[1]	Dol/Ank	Siderite	Quartz	K-spar	Plag.	Pyrite	Apatite	Barite	Clays	Carb.	Other
1660-1670	13	5	30	2	2	1	1	37	1	4	4	Tr	0	50	4	46
1680-1690	13	5	31	4	1	1	1	37	1	4	2	Tr	0	53	3	44
1700-1710	12	4	33	4	1	Tr	Tr	38	1	4	3	Tr	0	53	1	46
1740-1750	12	5	30	3	6	1	Tr	32	1	3	6	Tr	0	51	7	42
1770-1780	6	2	14	2	47	1	Tr	21	1	1	5	Tr	0	24	48	28
1780-1790	2	1	5	1	81	1	Tr	6	1	1	1	Tr	0	9	82	9
AVERAGE	10	3	24	3	23	1	Tr	29	1	3	3	Tr	0	40	24	36

* Ordered interstratified mixed-layer illite/smectite; Approximately 15-20% expandable interlayers
[1] May include the Fe-rich variety

OMNI LABORATORIES, INC.
X-RAY DIFFRACTION
(WEIGHT %)

Client: Whitmar
Well: Johnson 1
Area: Otesego County, NY
Sample Type: Cuttings

File No: HH-38219
Date: 12/12/07
Analyst: G. Walker

Sample	CLAYS				CARBONATES			OTHER MINERALS						TOTALS		
Depth (ft)	Chlorite	Kaolinite	Illite	Mx I/S*	Calcite[1]	Dol/Ank	Siderite	Quartz	K-spar	Plag.	Pyrite	Zeolite	Barite	Clays	Carb.	Other
3330-3340	7	1	28	10	Tr	2	Tr	37	1	8	6	0	0	46	2	52
3340-3350	8	1	29	10	Tr	1	Tr	37	1	6	7	0	0	48	1	51
3350-3360	7	1	29	10	Tr	2	1	36	1	7	6	0	0	47	3	50
3360-3370	7	1	29	9	Tr	1	Tr	38	1	7	7	0	0	46	1	53
3370-3380	8	1	29	9	3	3	Tr	34	1	6	6	0	0	47	6	47
3380-3390	7	1	26	8	1	2	1	39	1	5	9	0	0	42	4	54
3390-3400	6	1	23	8	1	1	1	37	1	4	17	0	0	38	3	59
3400-3410	7	1	27	9	9	3	Tr	30	1	7	6	0	0	44	12	44
3410-3420	5	1	18	6	29	4	1	26	1	2	7	0	0	30	34	36
3420-3430	6	1	25	8	10	2	Tr	31	1	5	11	0	0	40	12	48
3430-3440	7	1	28	8	14	3	1	24	1	2	11	0	0	44	18	38
3440-3450	6	1	23	8	11	1	Tr	31	1	3	15	0	0	38	12	50
3450-3460	6	1	22	6	22	1	Tr	28	1	1	12	0	0	35	23	42
AVERAGE	7	1	26	8	8	2	Tr	33	1	5	9	0	0	42	10	48

* Ordered interstratified mixed-layer illite/smectite; Approximately 15-20% expandable interlayers
[1] May include the Fe-rich variety

OMNI LABORATORIES, INC.
X-RAY DIFFRACTION
(WEIGHT %)

Client: Whitmar
Well: Dinniney (SC291)
Area: Steuben County, NY
Sample Type: Cuttings

File No: HH-37913
Date: 10/24/07
Analyst: G. Walker

Sample	CLAYS				CARBONATES			OTHER MINERALS						TOTALS		
Depth (ft)	Chlorite	Kaolinite	Illite	Mx I/S*	Calcite[1]	Dol/Ank	Siderite	Quartz	K-spar	Plag.	Pyrite	Apatite	Barite	Clays	Carb.	Other
3947-3954	13	1	25	8	16	1	1	23	1	6	4	1	0	47	18	35
3973-3984	15	1	27	3	9	1	Tr	29	1	9	4	1	0	46	10	44
3984-3992	14	1	27	5	3	1	Tr	29	1	9	10	Tr	0	47	4	49
3992-4001	15	1	27	6	2	Tr	Tr	30	1	8	9	1	0	49	2	49
4008-4016	10	1	26	5	8	Tr	Tr	31	1	8	9	1	0	42	8	50
4016-4023	11	1	28	5	6	Tr	Tr	31	1	7	9	1	0	45	6	49
AVERAGE	13	1	27	5	7	1	Tr	29	1	8	7	1	0	46	8	46

* Ordered interstratified mixed-layer illite/smectite; Approximately 10-15% expandable interlayers

[1] May include the Fe-rich variety

OMNI LABORATORIES, INC.
X-RAY DIFFRACTION
(WEIGHT %)

Client: Whitmar
Well: Shandalee Hunting Club 1
Area: Sullivan County, NY
Sample Type: Cuttings

File No: HH-38218
Date: 12/11/07
Analyst: G. Walker

Sample	CLAYS				CARBONATES			OTHER MINERALS						TOTALS		
Depth (ft)	Chlorite	Kaolinite	Illite	Mx I/S*	Calcite[1]	Dol/Ank	Siderite	Quartz	K-spar	Plag.	Pyrite	Zeolite	Barite	Clays	Carb.	Other
7100-7110	5	2	27	7	12	2	1	26	1	7	10	0	0	41	15	44
7110-7120	4	1	19	5	23	2	Tr	28	1	9	8	0	0	29	25	46
7120-7130	3	1	13	3	34	4	1	30	1	5	5	0	0	20	39	41
7130-7140	2	1	10	2	52	3	1	20	1	4	4	0	0	15	56	29
7140-7150	1	1	7	2	63	2	Tr	16	1	4	3	0	0	11	65	24
7150-7160	3	1	9	2	58	2	1	19	1	2	2	0	0	15	61	24
7160-7170	2	1	6	2	72	4	Tr	10	1	1	1	0	0	11	76	13
7170-7180	1	1	6	2	76	2	1	8	1	1	1	0	0	10	79	11
7180-7190	1	Tr	3	1	83	4	Tr	5	1	1	1	0	0	5	87	8
7190-7200	1	Tr	3	1	79	4	Tr	9	1	1	1	0	0	5	83	12
AVERAGE	2	1	10	3	55	3	1	17	1	3	4	0	0	16	59	25

* Ordered interstratified mixed-layer illite/smectite; Approximately 15-20% expandable interlayers
¹ May include the Fe-rich variety

OMNI LABORATORIES, INC.
X-RAY DIFFRACTION
(WEIGHT %)

Client: Whitmar
Well: Pimpinella 1
Area: Tioga County, USA
Sample Type: Cuttings

File No: HH-38167
Date: 12/06/07
Analyst: G. Walker

Sample	CLAYS				CARBONATES			OTHER MINERALS							TOTALS		
Depth (ft)	Chlorite	Kaolinite	Illite	Mx I/S*	Calcite[1]	Dol/Ank	Siderite	Quartz	K-spar	Plag.	Pyrite	Apatite	Barite	Clays	Carb.	Other
4500-4510	7	5	33	1	0	1	Tr	38	1	7	6	1	0	46	1	53
4520-4530	7	5	34	1	0	1	Tr	35	1	6	9	1	0	47	1	52
4530-4540	8	5	34	1	2	3	Tr	32	1	6	6	2	0	48	5	47
4540-4550	8	5	35	1	Tr	1	Tr	34	1	5	9	1	0	49	1	50
4550-4560	8	5	34	1	1	2	Tr	32	1	5	8	3	0	48	3	49
4560-4570	7	5	34	1	1	2	Tr	31	1	6	10	1	0	48	3	49
4570-4580	8	5	33	1	Tr	2	Tr	34	1	6	9	1	0	47	2	51
4580-4590	6	4	27	1	20	4	Tr	21	1	4	10	2	0	38	24	38
4600-4610	7	4	26	1	7	2	Tr	33	1	5	12	2	0	38	9	53
4610-4620	6	4	25	1	8	3	Tr	34	1	3	14	1	0	36	11	53
4620-4630	7	4	31	1	6	3	Tr	31	1	5	10	1	0	43	9	48
4630-4640	6	4	30	1	7	2	Tr	30	1	5	12	2	0	41	9	50
4640-4650	5	3	24	1	7	2	Tr	38	1	5	13	1	0	33	9	58
AVERAGE	7	4	31	1	5	2	Tr	33	1	5	10	1	0	43	7	50

* Ordered interstratified mixed-layer illite/smectite; Approximately 5-10% expandable interlayers
[1] May include the Fe-rich variety