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Systematic Technical Innovations Initiative Brine Disposal in the Northeast

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Systematic Technical Innovations Initiative Brine Disposal in the Northeast

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Abstract

The purpose of this study was to develop a systematic methodology to evaluate geologic formations for brine disposal by injection (New York Sate was chosen as a representative example). Currently, brine disposal is the most significant barrier to developing salt cavern storage in areas remote to ocean disposal. Potential injection formations have been identified, with emphasis on defining potential reservoirs that could accept brine, along with delineation of salt bodies that could be developed into cavern storage facilities.

Salt caverns are ideal for natural gas storage because of high deliverability rates and short cycle times. New York has salt in the Silurian Salina Group, which is thick enough and deep enough in the south central portion of the state to make caverns that meet industry standards. Currently within the state there are two operational salt cavern storage facilities and several others in various stages of completion. The greatest obstacle to completion of many of these salt caverns is disposal of the brine created during cavern development. This study was conducted to systematically analyze potential formations for their ability to accept brine within the area where the salt is thick enough and deep enough for cavern development.

Analysis of potential brine disposal reservoirs was first limited to sandstones and carbonates that have acceptable reservoir characteristics. Once potential reservoirs had been identified, more detailed reservoir characterization studies were conducted on each reservoir. The most promising prospects are the Ordovician Queenston Sandstone, the Ordovician Black River Group hydrothermal dolomite reservoirs and dolomites in the Cambro-Ordovician Beekmantown. Cores from collections of the New York State Museum were used to complete geologic studies and material properties testing and the resulting data was then linked to geophysical wire line log data. The identified injection reservoirs are presented in the context of the regional geology.

Parameters established during the characterization of potential disposal reservoirs were used by our collaborators at Sandia National Laboratories to model and quantify how effective brine disposal into these formations would be in our proposed reservoirs. After initial analyses the Trenton-Black River carbonates stand out as the most promising potential disposal reservoirs.

Executive Summary

The natural gas market has experienced greater stability since salt caverns have been utilized as underground vessels to store natural gas. During the non-heating season, gas is pumped into the caverns with the intent of withdrawal during the heating season or to help minimizes the affects of short peaks in demand. This practice allows for more consistent production and pipeline system efficiency and minimizes peaking prices during the high demand heating months. While many regions of the country have benefited greatly from this increased stability the Northeast has yet to fully enter the salt cavern storage market even though the region has the demand and bedded salt necessary for this type of project. The main obstacle to salt cavern storage in the Northeast is disposing of the large volumes of brine that are created during the solution mining of the caverns.

If the Northeast is to benefit from the increased stability offered by salt cavern storage, a reliable brine disposal method needs to be found. The purpose of this research initiative was to provide a systematic approach to overcoming the dominant barrier to developing salt cavern storage; brine disposal. This was achieved in a two-phased manor in which salt bodies suitable for salt caverns were defined and then within these areas potential brine disposal reservoirs were identified and evaluated. Cores from the evaluated intervals were sent to our collaborators at Sandia National Laboratories for rock mechanics testing. The results of this testing in conjunction with our formation evaluations were used by SNL to model the disposal potential of each proposed disposal reservoir. New York has been chosen as the representative model for this study, but application of our approach in other states and possibly regions may have similar outcomes.

In Phase I we delineated the areas of New York where salt cavern development is possible. This is areas where the salt has characteristics that are suitable for cavern development based on regulatory and industry standards. We used these characteristics of suitable salt to develop a set of criteria that allowed us to evaluate the salt interval of New York State for its potential for cavern development. The first criterion establishes salt intervals that lie at the appropriate depth for cavern development. Depths are selected where the geostatic pressure is sufficient to maintain the compression-expansion systems used to inject and withdrawal from the cavern, but shallow enough to avoid cavern closure due to creep. The suggested depths for economic cavern construction are between 2000 and 6000 feet below the surface. The second set of criteria eliminates salt that is not of the appropriate thickness and quality for cavern construction. The salt available in New York State is bedded, which dictates that caverns must be wide and short, sort of peanut shaped. To be economic caverns are typically developed in salt that is between 100 and 300 feet thick, but thicknesses greater than 200 feet are optimal. To account for salt quality, intervals of salt were considered that were at least 100 feet thick and contained no nonsalt intervals thicker than 10 feet. Higher quality salt maximizes solution mining efficiency and minimizes the amount of rubble left at the bottom of the cavern after mining is complete. The area underlain by salt that meets both of these criteria defines our study area, where work in Phase II was focused.

The salt deposits of New York are positioned within the Upper Silurian Vernon and Syracuse Formations, which are further delineated into beds with letter designations A through F. Based on the work of past researchers, the F-unit has been established as having the greatest potential for thicknesses appropriate for cavern development and was therefore the focus of the Phase I in the current evaluation. Larger portions of south central New York State are suitable for cavern development. In most of the region, the salt is greater than 2000 feet below the surface (accept in the valleys of the Finger Lakes) and only at the New York-Pennsylvania border does the salt approach the lower limit of 6000 feet. The salt reaches thicknesses sometimes greater than 400 feet in this region. Areas of particular interest for their abundance of thick salt are Stueben, Schuyler, Chemung, Tompkins and Tioga Counties.

In Phase II work was done to first identify potential disposal formations, and then to evaluate the selected formations. This process was accomplished through the use of two sets of criteria, the Disposal Formation Selection Criteria and the Disposal Formation Evaluation Criteria.

The Disposal Formation Selection Criteria were developed after a review of regulatory and industry standards for New York. These criteria are 1) Lithology, sandstones and carbonates were selected, 2) Evidence of good porosity and permeability (in previous studies or industry related data), 3) History of production (either here or in nearby states), 4) not currently used for conventional depleted reservoir storage and 5) Connate Water Salinity greater than 200,00 ppm. Criteria 1-3 allowed potential disposal reservoirs to be selected from the units present in south central New York. Criteria 4 and 5 served to eliminate formations. If a formation is already a good storage reservoir, most operators will not want to risk trying brine disposal. Additionally it is necessary that brine disposal reservoirs have high connate water salinities (greater than 200,000 ppm).

Using the Disposal Formation Selection Criteria, three stratigraphic intervals were selected as potential brine disposal reservoirs. These are the Upper Ordovician Queenston Formation, the Middle Ordovician Trenton-Black River Interval and the Cambro-Ordovician Beekmantown Group.

The Disposal Formation Evaluation Criteria were used to evaluate each of the potential disposal reservoirs to gauge their ability to accept brine at the rates necessary for cavern development. These criteria are 1) sufficient porosity and permeability to maintain an injection rate of 10 BPM, 2) reservoir volume is capable of accepting 11 MMB in 3 years, and 3) hydraulically separated from sources of potable water. These criteria were established based on projects typical of New York and the northeast which propose 5 wells and approximately 77 MMB (15.4 MMB per well) of brine must be disposed of over a 3 year period.

The Queenston formation, which is known regionally as a shale, is sand rich in the producing region of north central New York and also in south central New York where salt cavern development is possible. Though it has proven to have the capacity to accept brine at the Bath Petroleum Inc. facility, elsewhere injection tests into the Queenston formation have not proven that the formation would accept brine at the rates necessary for economic cavern development. The favorable injection achieved at the Bath Facility could be related to the existence of an open fracture system, which serves to elevate the traditionally low porosity and permeability of the formation. Another possible explanation for the success at the Bath Facility is that the formation is not completely water saturates as commonly believe, but rather it is partially gas saturated which improves the injection conditions enough to allow the brine to flow away from the well bore. Both of these options would lead to more favorable injection conditions. Further research is need to identify where these conditions exist in south central New York and how they would affect injection potential. After evaluation and modeling the Queenston Formation is not considered to have the proper characteristics of a brine disposal reservoir. Brine is accepted into the Queenston, but not at rates acceptable for cavern development projects typical of this region. Several alternatives are discussed that may improve disposal success.

The fault related hydrothermal dolomites associated with the Trenton-Black River (TBR) play that currently producing at prolific rates in New York, may also prove to be an excellent brine disposal reservoirs. The current production is located within our study area. Once depleted, the fields may prove to be unattractive for traditional depleted reservoir storage due to their heterogeneity and unknown lateral extent. If this is the case, the infrastructure already in place from production could be use at least in part to initiate brine disposal. Also, many of the fields in south central New York are long and narrow and are located in close proximity to one another meaning several fields could potentially be utilized together to develop one cavern facility. Although additional research is needed to determine if the reservoirs will be attractive for traditional storage, the TBR interval has the greatest potential as brine disposal reservoirs. The TBR meets all of the Disposal Formation Evaluation Criteria and after modeling the interval has the greatest potential as a brine disposal reservoir.

Brine disposal potential in the Beekmantown Group lies primarily in the porous sandstones of the Galway Formation. Recent production from these zones in western New York has yielded numbers as high as 0.5 BCF. The Galway Formation was tested at the Avoca Site in Stueben County, with mixed results. The first well drilled had porosity in this interval, but subsequent tests in later wells did not find porosity. This is currently rated as a possible disposal reservoir, but at this time it appears that the porous zones are too patchy and small to make it a dependable brine injection target. Current research was hindered by the lack of wells drilled into the Beekmantown Group in our study area. As new wells are drilled additional research can be conducted to determine its distribution of this Group. Modeling done on existing well cores from the Mohawk Valley indicate that the Group has permeabilities too low to maintain disposal rates necessary for cavern development.

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INTRODUCTION

GENERAL OVERVIEW OF PROBLEM

Storage is the primary means of managing fluctuations in natural gas supply and demand, and is an essential component of an efficient and reliable interstate natural gas transmission and distribution network. The stored gas is used for two primary purposes: to meet seasonal demands for natural gas (base load storage), and to meet short-term peaks in demand (peaking storage), which can range from a few hours to a few days.

To ensure that adequate natural gas supplies are available to meet seasonal base-load customer requirements in winter, industry injects large amounts of gas into underground storage reservoirs form April through October. During these non-heating season months, gas demand declines as temperatures rise. During the heating season, industry supplements pipeline capacity from the producing regions with supplies from storage to meet demands. Gas withdrawn from working gas storage can supply up to 30 percent of the daily gas demand in winter months.

Storage enables greater system efficiency by allowing more level production and transmission flows throughout the year. End-use customers gain from such system efficiency with reduced overall costs of service. Storage also allows continuous service even when production or pipeline transportation services are interrupted. This can be achieved by using or establishing new storage facilities in market areas where there is a strong seasonal variation to demand.

Industry has recognized the need to expand the existing gas storage system to meet anticipated future demand for natural gas, which is forecasted to increase by as much as 6 Tcf by 2010 and 10 Tcf by 2020. This rising demand raises concerns about the system's ability to meet peak requirements in the future.

Natural gas is distributed to virtually every region of the country through an extensive system made up of more than 1.3 million miles of pipeline, meters, compressor stations, and approximately 410 storage reservoirs. The gas industry currently has the capability to deliver approximately 75 Bcf per day during peak periods.

In 2004, total working gas storage capacity from U.S. gas storage sites was 3.1 Tcf (EIA, 2005). These sites are heavily concentrated in and near major eastern and mid continent markets. The significant shift in natural gas supply and consumption patterns expected by 2010 will create a need for new natural gas pipeline transmission and storage facilities. With the anticipated decline in production from the southwest central region, additional transmission and storage capability will be required to move gas from the Rocky Mountains and Canada to neighboring regions and to expanding markets in the northeast, southeast, and California.

Given the significantly large storage volume requirements detailed above for natural gas alone, underground storage facilities that utilize geologic formations are the only realistic alternative. If engineered correctly, underground storage facilities have the potential for larger volumes, are environmentally friendly, and present relatively safe conditions to the public. Following this rationale, utilizing underground space for storage facilities would present lowered risk to permitting, regulatory, and investment interests.

Storage of liquids and gases in solution-mined caverns in salt began approximately 60 years ago (Thoms and Gehle, 2000). Cavern use for storage and disposal is generally considered safe and efficient because salt is relatively impermeable and has proven to be a good containment vessel (when properly engineered). Use of salt caverns for “vessels” has other advantages over other rock types which include: (1) cost for creating similar size caverns in salt (by solutioning) versus hard rock by mining are significantly less for salt and (2) salt material properties are such that fractures in salt tend to heal under ambient conditions.

The question then arises, why not only store in salt? What are problems with salt storage? There are at least three types of problems with underground storage in salt. The problems are related to availability of “usable” salt, locating and engineering safe brine disposal, and development of well-engineered caverns. This research initiative was primarily focused on finding solutions to the first two of these problems.

In order for cavern development to be economic, it is necessary to dispose of brine at significant rates. This is true because most of the storage and therefore profit making cannot occur until the majority of salt solutioning and brine disposal is complete. Economics of a project, in concert with engineering, will dictate the need for brine generation and disposal rates.

The importance of delineating feasible brine disposal options has been brought to a head in New York State, where significant economic risk has been taken to initiate the highly desirable salt cavern storage facilities. For example, before cavern construction was even started, one hundred million dollars was spent at the Avoca Project in Steuben County (discussed in more detail below). This number could have been considerably less if the operators had found a suitable brine disposal reservoir prior to investing in any other infrastructure.

Much of south central New York State is underlain by salt beds suitable for salt cavern development has sustainable fresh water supplies for leaching and is within economic reach of large markets, but the lesson learned at the Avoca Project is that brine disposal is the limiting factor in siting a project. It is the purpose of this research initiative is to provide developers with disposal reservoir options chosen and supported with high quality research. The results of this study will help to minimize uncertainty and alleviate financial risk by taking steps to overcome the brine disposal barrier that is currently plaguing the industry in this region.

RESEACRCH OBJECTIVES

The goal of this research has been to develop a systems approach to overcome the dominant barrier to developing salt cavern storage in areas remote to ocean disposal: brine disposal. This system includes a three-dimensional understanding of the geology if the region (NYS was used as a test case) with a view towards identification of potential target horizons that can accept brine at the rates necessary within acceptable levels of environmental impact. The geology of potential injection formations has been determined with a view towards understanding rock properties of target hydrogeologic units on a regional geologic scale. This includes determination of rock properties from core, correlating that information to geophysical logs, and then extending that information to a regional scale.

Potential hydrogeological units for brine disposal and salt body locations have been identified. This includes the collection, assimilation and analyses of geologic, hydrologic, environmental, and regulatory information as it applies to brine disposal. This also included examining core and subsequent correlation of those results with geophysical logs, the results of this correlation were used for regional extrapolation.

A key contribution to the brine disposal issue is presentation of a clear understanding of injection mechanics such that a means to balance a desired injection rate with *in situ* conditions and rock properties is obtained while induced seismicity is minimized and brine volume acceptance is maximized. Potential volumes of brine to create needed cavern space are significantly large. Also, brine generation rates and thus brine injection rates "need" to be relatively high for a cavern to be created in a "profitable" manner. The potential for pore pressure increases to adversely modify the effective stress, exist if the injection mechanics are poorly understood or implemented. Perhaps stimulation methods, directional drilling, etc. could be used in the injection wells in order to enhance the reservoir's ability to accept brine at overall rates that meet injection needs.

This methodology and criteria has ultimately allowed us to systematically delineate potential brine disposal formations. Other items that may impact the site selection process for potential brine disposal locations includes infrastructure availability, distance from population and distance to major gas transmission lines.

The completion of this work has resulted in a regional geologic model that can be used to gain understanding of the potential brine volumes and injection rates that can be expected within specified hydrogeologic units in the New York State region. An important product of this study is a publicly available assessment of the feasibility of brine injection in areas where there is significant salt accumulations in New York State. The ability to assesses the potential for brine disposal will help companies to know when to seek alternative methods for gas storage and brine disposal. The same methods used here will likely work in other states with similar subsurface geology, such as Pennsylvania, Ohio and West Virginia.

BACKGROUND

The successful development of natural gas storage facilities in bedded salt requires the combined occurrence of several factors at the project site. This section contains a review of the background knowledge, industry standards and government regulations that outline these factors and influence site selection of salt cavern storage and related brine disposal. This information was the basis for the criteria developed for Phase I and II of this research initiative. The methods section of this report contains a discussion of the criteria used in both phases.

Salt Cavern Development Practices

Natural gas storage in salt cavern facilities is highly desirable when geologic conditions are present to make such facilities feasible. This desirability is primarily due to the fact that salt cavern facilities can be operated at high deliverability rates and relatively short cycle times. Salt cavern storage facilities are operated by compression-expansion, which leads to the high deliverability with comparably lower amounts of working immobilized gas. Working gas is the total gas storage capacity minus base gas, which is the volume of gas intended as permanent inventory of the storage reservoir used to maintain adequate pressure conditions.

Storage of liquids and gases in solution-mined caverns in salt began approximately 60 years ago (Thoms and Gehle, 2000). Cavern use for storage and disposal is generally considered safe and efficient because salt is relatively impermeable and has proven to be a good containment vessel (if engineered properly). Use of salt caverns for “vessels” has other advantages over other rock types which include: (1) cost for creating similar size caverns in salt (by solutioning) versus hard rock by mining are significantly less for salt and (2) salt material properties are such that fractures in salt tend to heal under ambient conditions.

Rock salt is exploited for natural gas storage because it is considered impermeable to hydrocarbons (capillary phenomena stemming from its petrophysical characteristics: extremely low permeability and porosity). The leaching of pressure- tight cavities, constituting gigantic gas cylinders with volumes of several hundred thousand cubic meters is possible because of the stability guaranteed by the good mechanical rupture strength of salt, even though its "ductile" or "creep" behavior leads to gradual and regular reduction in cavity volume. A storage site typically consists of one or, more often, several storage caverns.

The solubility of salt in water is utilized in the solution mining of the caverns, which is easier to implement than mechanical mining, requiring less manpower and heavy equipment (Hougout and Roger, 1990). The leaching process entails drilling a well or wells down into the target formation, and cycling large amounts of fresh water through the salt. The fresh water dissolves portions of the salt deposit, and is then cycled back up the well, leaving a large empty space that the salt used to occupy. In a single-well system (Figure 1) a fresh water stream is injected into the inner annulus of a well and the brine solution escapes through the outer annulus and is collected at the surface. In a double-well system (more typical of regions with bedded salt) one well brings fresh water down to the formation and the second well brings the created brine back to the surface (Figure 2). The double well system was proposed for the Avoca site in central New York. Figure 3 is a schematic diagram of how the leaching process would be carried out at the Avoca site from Morrill, 1996.

Industry Standards for Salt Cavern Development

Several authors have detailed the factors required for choosing a suitable location for potential salt-cavern storage facilities, e.g. Morill, 1996; Bass et al., 1996; Haddenhorst 1989. All have outlined the following standards used by operators who develop caverns in salt for the purpose of storing natural gas: (1) adequate salt thickness, (2) appropriate depth to salt, (3) suitable geographic location, (4) access to fresh water supply, and (5) a method of brine disposal. This section summarizes the findings of previous researchers.

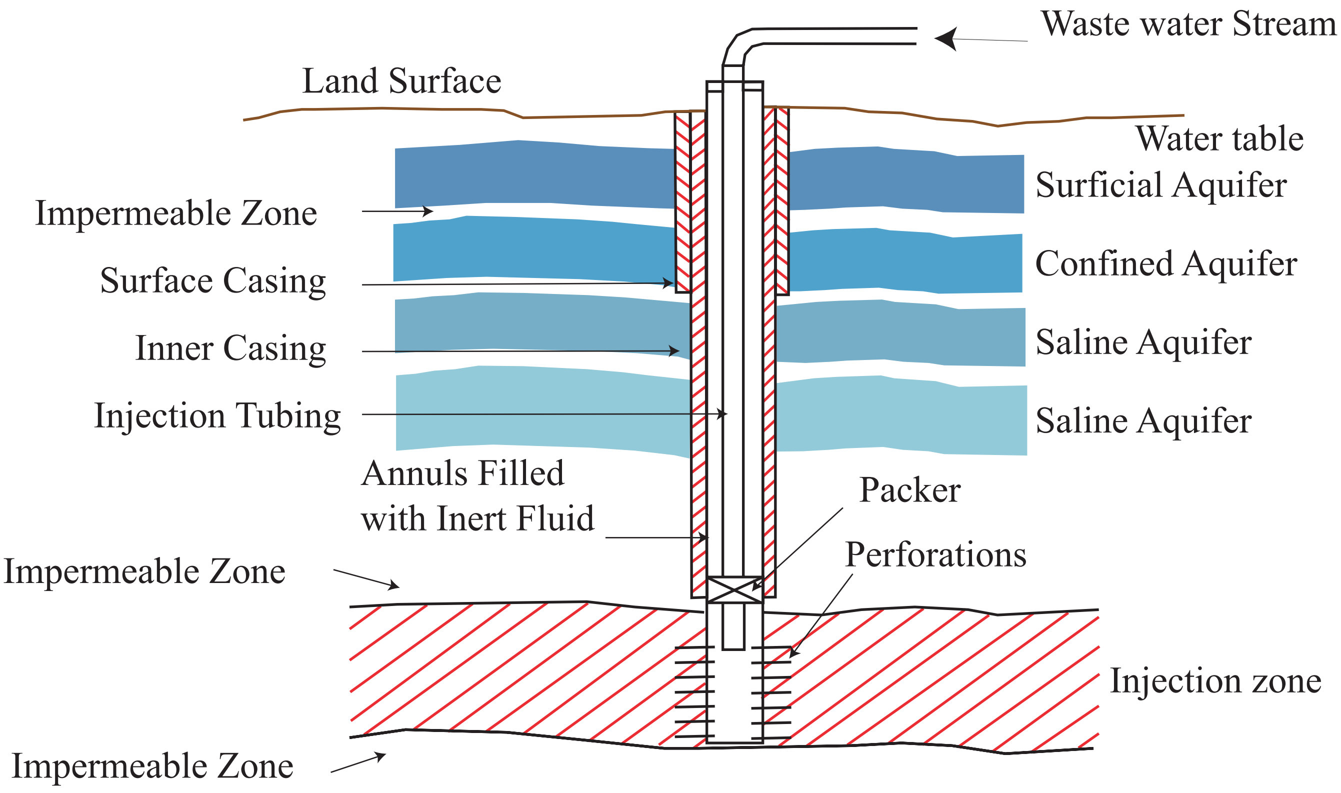


Figure 1 In a single well System (shown above) a fresh-water stream is injected into the inner annuls of a well and the brine solution escapes through the outer annuls and is collected at the surface. In a double well system (more typical of in regions with bedded salt) one well brings fresh water down to the formation and the second well brings the created brine back to the surface.

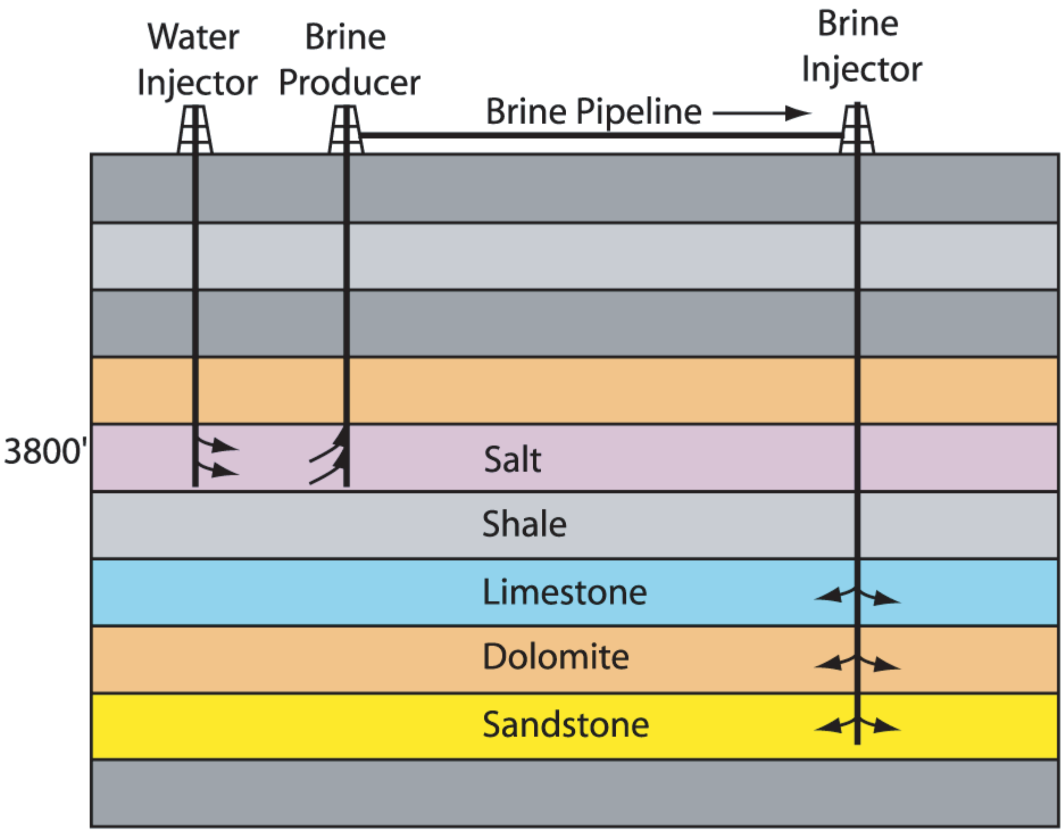


Figure 2 During cavern development a two well system is setup, where freshwater is circulated through a salt layer generating brine, which is then extracted. Ideally, this brine will then be disposed of on or near the cavern site. Limestones, sandstones and dolomite zones offer the best opportunity for finding porosity and permeability levels acceptable for brine disposal.

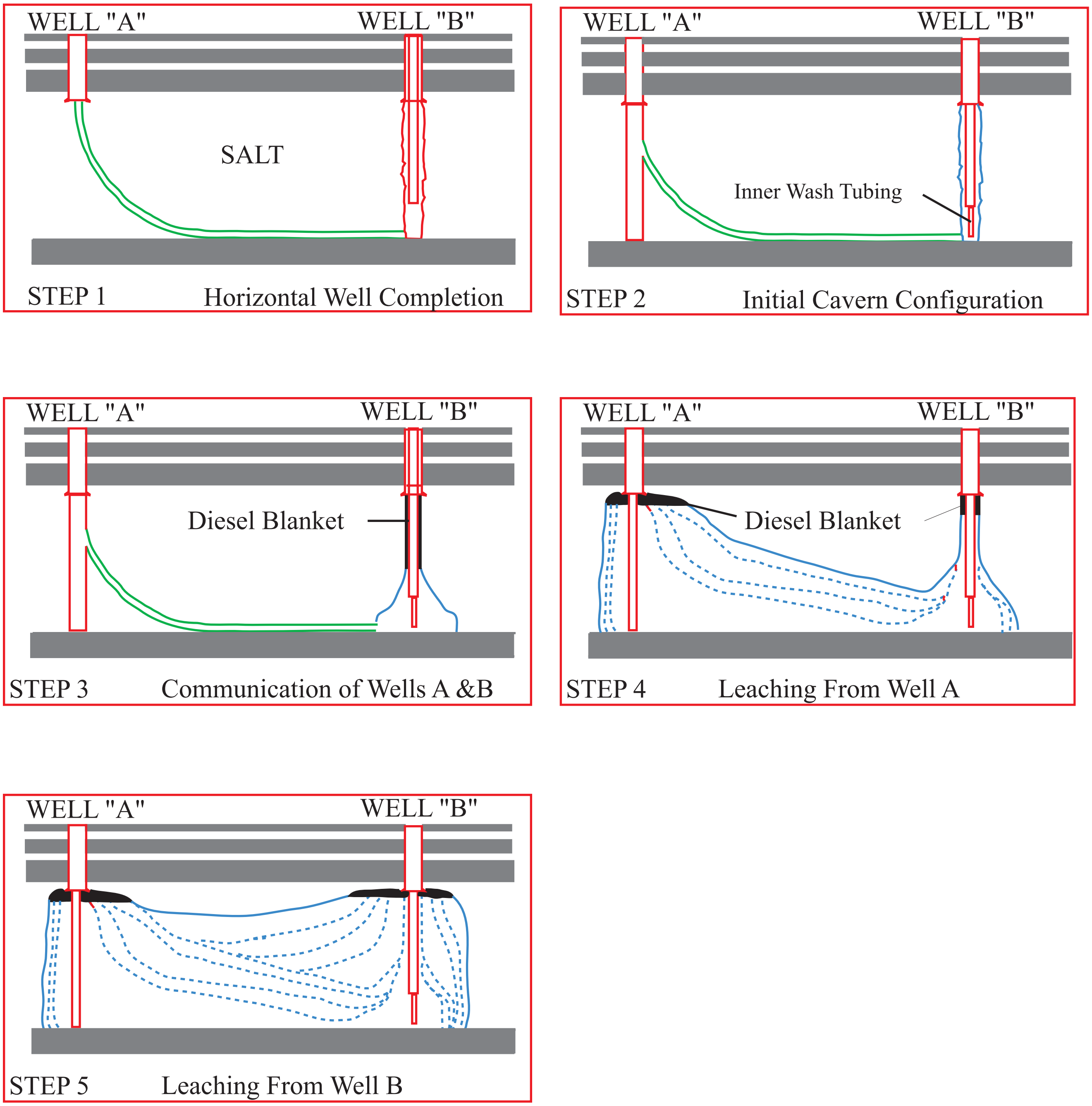


Figure 3 Five basic steps in the construction of the elongated caverns planned for the Avoca facility. Horizontal Drilling is used to connect to widely spaced boreholes.

From Morrill (1996), originally from PB-KBB Inc.

Salt Thickness. Due to the importance of retaining structural stability, the diameter of caverns developed in bedded salt is limited. To balance the need for a narrow diameter a cavern must be of sufficient thickness to be economic (Morill, 1996). This is based on the idea that several smaller caverns in thinner salt would cost much more than creating fewer larger caverns in thicker salt (Bass et al., 1996). According to Morill (1996), caverns are commonly developed in 200-300 feet of bedded salts and he cites examples from Saskatchewan, Alberta and Michigan. Anything less than 100 feet would be considered uneconomical for cavern development (Bass et al., 1996; Morrill, 1996). The proposed facility at Avoca, New York would be developed in roughly 100 feet of bedded salt.

In addition to the necessity that salt be of the appropriate thickness, salt quality is important. Salt considered for cavern development should be as homogeneous as possible, which for solution mining purposes should be for the most part free of insoluble and poorly soluble components (Haddenhorst, 1989). Interbedded among the salt units of the Salina Group are layers of insoluble or less soluble rock types, such as shale, anhydrite and dolomite (see Figure 4). If insoluble unit is thin enough, thinner than approximately 10 feet, the salt is mined away from both sides of the layer and differential pressure is applied to the layer causing it to collapse and fall to the bottom of the cavern (Bass et al., 1996). Insoluble layers thicker than 10 feet become uneconomical, as they are more difficult to break and produce a large volume of rubble at the bottom of the cavern that diminishes the cavern's storage capacity (Bass et al., 1996). In a report conducted for the Electric Power Institute in 1994, the engineering firm PB-KBB, made the statement that "The salt formation, over the intended cavern interval should contain a minimum of 60% salt."

Depth to Salt. While salt deposits are found at varying depths within sedimentary basins, cavern development can only be carried out at depths where overburden is sufficient to maintain rupture strength while remaining in balance with factors that contribute to closure due to creep. The suggested depth for the economic construction of a salt cavern for the storage of natural gas ranges from a minimum of 2,000 feet to a maximum of 6,000 feet (e.g. Morill, 1996; Friedman et al., 2002; Bass et al., 1996). At depths greater than 2,000 feet, the geostatic pressure is sufficient to operate an efficient and economical compression-expansion system necessary for short cycle

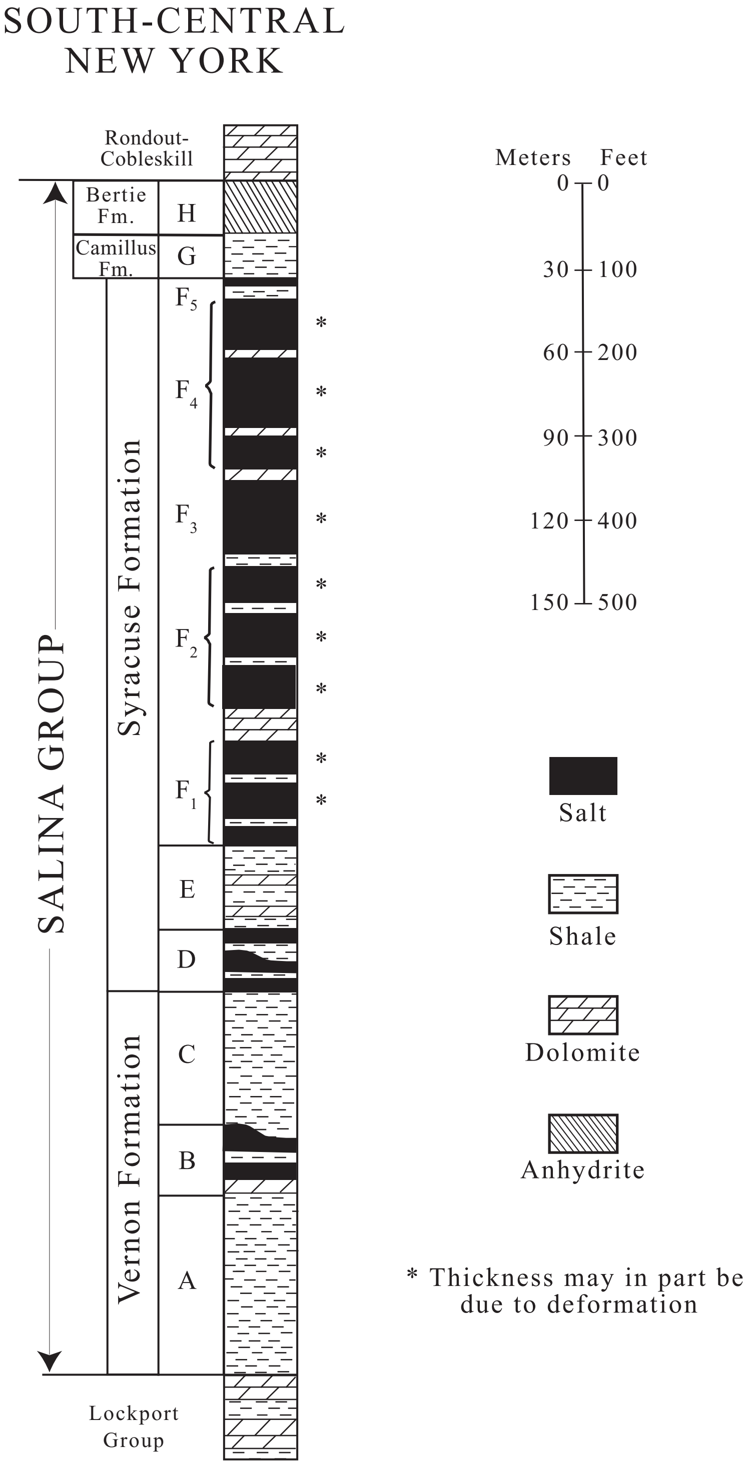


Figure 4 Generalized Columnar Section of Salina Group in South-Central New York

From EPRI Project on CAES Plants, 1994

times. At depths greater than 6,000 feet temperatures and pressures are elevated enough significantly change the plasticity of the salt and put the cavern at risk of closure due to salt creep (Bass et al., 1996).

The few proposed or active salt cavern storage facilities in New York State have, or propose varying cavern depths. The depths of these caverns are as follows: 3,440-4,050 feet for the proposed Avoca site, roughly 2,800-3,000 feet for the Bath site (currently a propane storage facility looking to convert to natural gas storage), and the New York State Electric and Gas Corporation (NYSEG) facility located near Seneca Lake has caverns at depths from roughly 2,300-2,850 feet.

Geographic Location. Several elements are required for the economic operation of any facility that stores natural gas (outlined in this section). These elements include, fresh water availability (discussed in the next section), proximity to local populations, and proximity to major electric power transmission lines. In order to avoid costly construction it is advantageous for proposed sites to be chosen where these elements already exist in close proximity.

The ideal location for a high-deliverability storage facility would be close to a market or market hub where it could be used to meet high demands during peak demand situations (Friedman et al., 2002). One option operators have is to build a pipeline to connect their facility to the closest transmission line or market hub. Distance, topography and the ability to access right of way between the facility and the pipeline could make this option costly and estimates in the range of 0.5 – 1 million dollars have been given. However, in the northeast there is enough demand for natural gas and storage that this initial cost would soon be offset in profit once that facility came online. Friedman et al. (2002) went as far as to say that for this reason, proximity to market was null as a factor for determining site suitability. For the reasons presented above, distance to market or transmission lines will not be a parameter of this study.

Fresh Water Supply. In order to develop a cavern in salt, a significant amount of fresh water is needed; in volumetric terms, about 7 times the amount of fresh water is needed as the volume of cavern to be developed. The amount of fresh water ultimately used depends on the design size and the efficiency of the leaching process.

Using liquid measure, individual caverns on the order of 1-3 million barrels (42 gal/bbl) have been considered for gas storage in New York and surrounding areas. This translates to 7 to 21 million barrels of fresh water per cavern. Fresh water injection rates are planned to complete a cavern in as short of a time as possible while in compliance with the leach plan (a fresh water injection schedule including injection rate and injection/withdrawal pipe placement) and ultimately to engineer the desired shape and dimensions for the cavern. Injection rates on the order of 100,000 bbl/day have been typical in large commercial cavern development projects. Rates plus or minus 50% of this value should be considered on a planning basis. These rates assume that brine disposal is not an issue. For some proposed gas storage projects in the NE their designs have been based on approximately 20,000 bbl/day, in part due to disposal rate restrictions (also realize that approximately 1/7 more volume needs to be disposed of than is injected for leaching). For the above range of cavern size, and an average injection rate of 100, 000 bbl/day, sustained supply would be 70 to 210 days. This is the target amount of fresh water availability (volume, rates, and duration) that would be required in a cavern project in the northeast.

Sources for this amount of water would have to be determined for the specific area of interest, but considering the general geohydrologic settings and climatic characteristics of the northeastern U.S., source water is not considered a deterring factor for a cavern development project and therefore will not be assessed in this study. Groundwater availability is well discussed in the literature (Friedman et al., 2002) in terms of aquifer types, seasonal impacts, recharge aquifer permeability and thickness and potential impacts on other uses. These factors would have to be addressed in the permitting process for the water well(s) to supply the cavern development project.

Brine Disposal. During cavern development large amounts of brine are created as salt is removed by leaching. As an example, brine generation was at a rate of 20,000 to 100,000 bbl/day during the development of the U.S. Strategic Petroleum Reserve (caverns ranging in size from 5-10 MMB). There are several methods of brine disposal currently used, e.g., deep well injection, ocean discharge, road spreading (for dust control), discharge to surface waters, evaporation, and salt plant feed. The method of brine disposal addressed by this research project is deep well injection, which is the most commonly employed method in areas remote to the ocean disposal.

A typical injection well has several concentric pipes, which extend down from the surface into the injection zone (see Figure 1). The outermost pipe or surface casing extends below the base of any underground sources of drinking water and is cemented back to the surface to prevent contamination. Directly inside the surface casing is a long string casing that extends to and sometimes into the injection zone. The casing is filled in with cement all the way back to the surface in order to seal off the injected material from the formations above. The fluid is injected through the injection tubing inside the long string casing either through perforations in the long string casing or in an open hole below the bottom of the long string. The space between the string casing and the injection tube, called the annulus, is filled with an inert, pressurized fluid, and is sealed at the bottom by a removable packer preventing injected wastewater from backing up into the annulus.

An optimal disposal reservoir should have both good porosity and high permeability to allow for reasonable injection rates. The primary porosity of sandstones, dolostones and limestones makes them potential disposal reservoirs. Especially when fractured these lithologies will provide the best porosity/permeability combinations. Permeability and porosity of reservoirs in the Appalachian Basin of New York State are generally regarded as low in comparison with those of other basins. Porosities and permeabilities on the order of 10 percent and a few millidarcies respectively, are common for the tight rocks of the state (McCann et al., 1968).

Industry Standards for Brine Disposal

There are four basic standards that determine the suitability of a given formation to act as a reservoir for brine disposal. These are:

- The disposal formation must exhibit sufficient porosity and permeability to allow reasonable injection rates at acceptable pressures.
- The connate water salinity of the disposal reservoir must be similar to injected brine.
- The disposal reservoir is located well below all fresh water aquifers and separated from the aquifers by impermeable formations.
- The reservoir volume must be capable of accepting the total volume of brine generated over an economically viable duration of time.

(After Swenson and Potashik, 1994)

Government Regulations

The following section contains brief summaries of the regulations put forth by the federal and state governments pertaining to cavern development through solution mining and brine disposal through deep well injection. Some background to the regulations is included so that the readers can follow up with more research and this is highly suggested. These are summaries, and are not intended to be used as direct statements of the laws or regulations themselves, but rather are to be used as a tool for understanding the criteria presented in this report.

New York State. The New York State Legislature, in Article 17 of the Environmental Conservation Law (ECL), has given the Department of Environmental Conservation (DEC) the authority to regulate the underground injection of industrial wastes, while ECL Article 23 addresses cavern development. With in the DEC the Minerals Resources and Water divisions have jurisdiction over cavern development, underground storage and brine disposal. That authority includes the establishment and enforcement of standards and the issuing of State Pollutant Discharge Elimination System (SPDES) permits for brine disposal.

In 1997, the DEC developed new draft regulations for the solution mining and underground storage industries, until this process is concluded the industries are regulated using the oil, gas and solution mining regulations currently on the books in 6NYCRR Parts 550-559 (Sanford, 1996). The need for new regulations was recognized by a DEC study (Briggs, 1995), which found that there was overlap between the federal and state regulatory programs concerning solution mining. Along with the overlap, Division staff also concluded that the federal program's focus was deficient in areas pertaining to reducing subsidence and subsidence related groundwater protection. To correct this, the division took the position the State's role in regulating would be to supplement the federal program in areas where they perceived a gap in regulatory interests (Sanford, 1996). The State's primary focus is to supplement injection related interests of the EPA with requirements that ensure the development of safe caverns. These requirements are not of interest to this study because they deal with engineering of the cavern and not with the initial site selection.

There are several steps that an operator looking to dispose of brine wastewater through deep-well injection must take into consideration. First the operator must file an application with the DEC Division of Mineral Resources for a permit to drill a new well or deepen, plug back or convert an existing well to a disposal well. Additionally, to use the well for disposal the operator would need to apply to the DEC Division of Water for a discharge permit under the State Pollution Elimination System or SPDES (Briggs, 2002). The SPDES program is covered by Article 17, Title 8 of the ECL and 6NYCRR Part 750 (Rules and Regulations).

Federal. The Underground Injection Control (UIC) Program, established by the US Environmental Protection Agency (EPA), regulates injection wells with the goal of preventing them from contaminating drinking water resources. Each State has the option of applying to the EPA for primary responsibility over the UIC program in their state. To do this a state must prove that they have and effective program for preventing underground injection, which would endanger drinking waters. Currently, New York has decided not to accept primary enforcement responsibility over the UIC program in the state.

According to the UIC, underground injection wells are divided in to five classes based on the type of fluid they inject and where the fluid is injected. Solution mining wells used during cavern development fall into Class III- Mining Wells. The deep injection wells used to dispose of brine generated during cavern development are Class II, which covers oil and gas production, brine disposal and other related wells. The are some general requirements for owners and operators of both Class II and III injection well that would influence the site selection of salt cavern storage and related brine disposal facilities, these are:

- Site the wells in a location that is free of faults and other adverse geological features;
- Drill to a depth that allows the injection into formations that do not contain water that can potentially be used as a source of drinking water.
- These injection zones are confined from any formation that may contain water that may potentially be used as a source of drinking waster (EPA, 2005)

The Federal UIC permit also requires certain monitoring practices. Monitoring injection pressure, rate of injection, annular pressure and accumulative volumes injected is recorded on a daily basis (Motsumoto et al., 1996). In addition, groundwater-monitoring program must be established to ensure that contaminants are not migrating towards potable aquifers. Along with these, the EPA has other general requirements for Class II and III well operation, but they are do not directly influence the facility site selection process and are therefore beyond the scope of this project. Specific details on UIC regulations can be found in the Code of Federal Regulations, Title 40, Parts 124, 144, 146 and 147.

General Geology of New York State

Most of central and western New York State is located in the northern portion of the Appalachian Basin. Except for the wide spread of Pleistocene glacial drift ranging in thickness from zero to more than 1,000 feet, all of the sedimentary rocks of New York are of Paleozoic age (Figure 5). Silurian, Ordovician and Cambrian strata rim the Adirondack uplands to the northeast (Figure 6*)*. Devonian strata cover most of the rest of the western part of the State with the exception of a few very small outcrops of Mississippian and Pennsylvanian strata in the western portion of the Southern Tier (McCann et al., 1968, Rogers et al. 1990).

The Paleozoic section ranges in thickness from zero, near the Adirondack uplift in northeastern New York, to more than 13,000 feet (3,961m) in Steuben County in the south-central part of the state (McCann, 1968; Saroff, 1987). Together Figure 5 and 6 show the general stratigraphic and

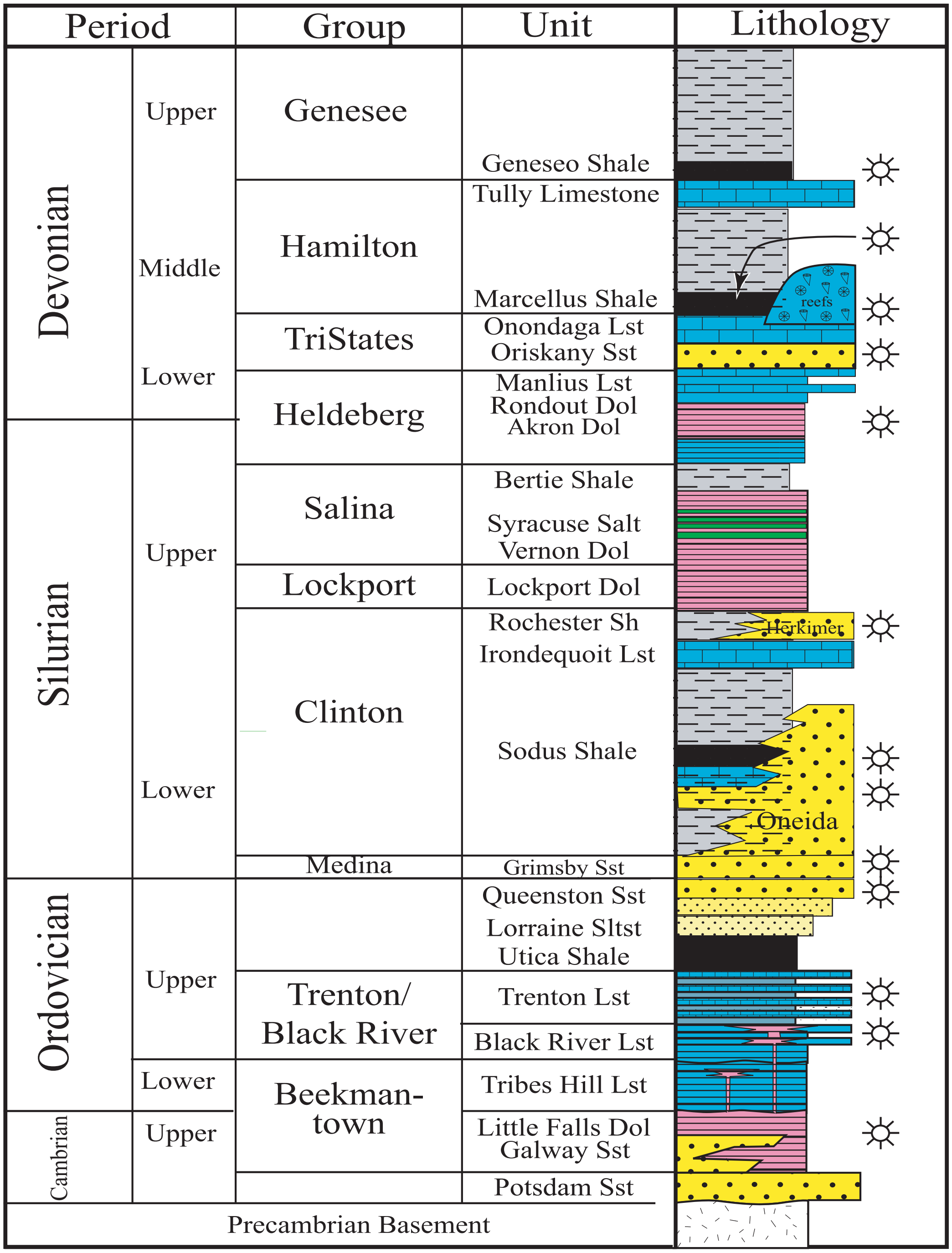


Figure 5 Stratigraphic Section of central New York. (Smith, 2005)

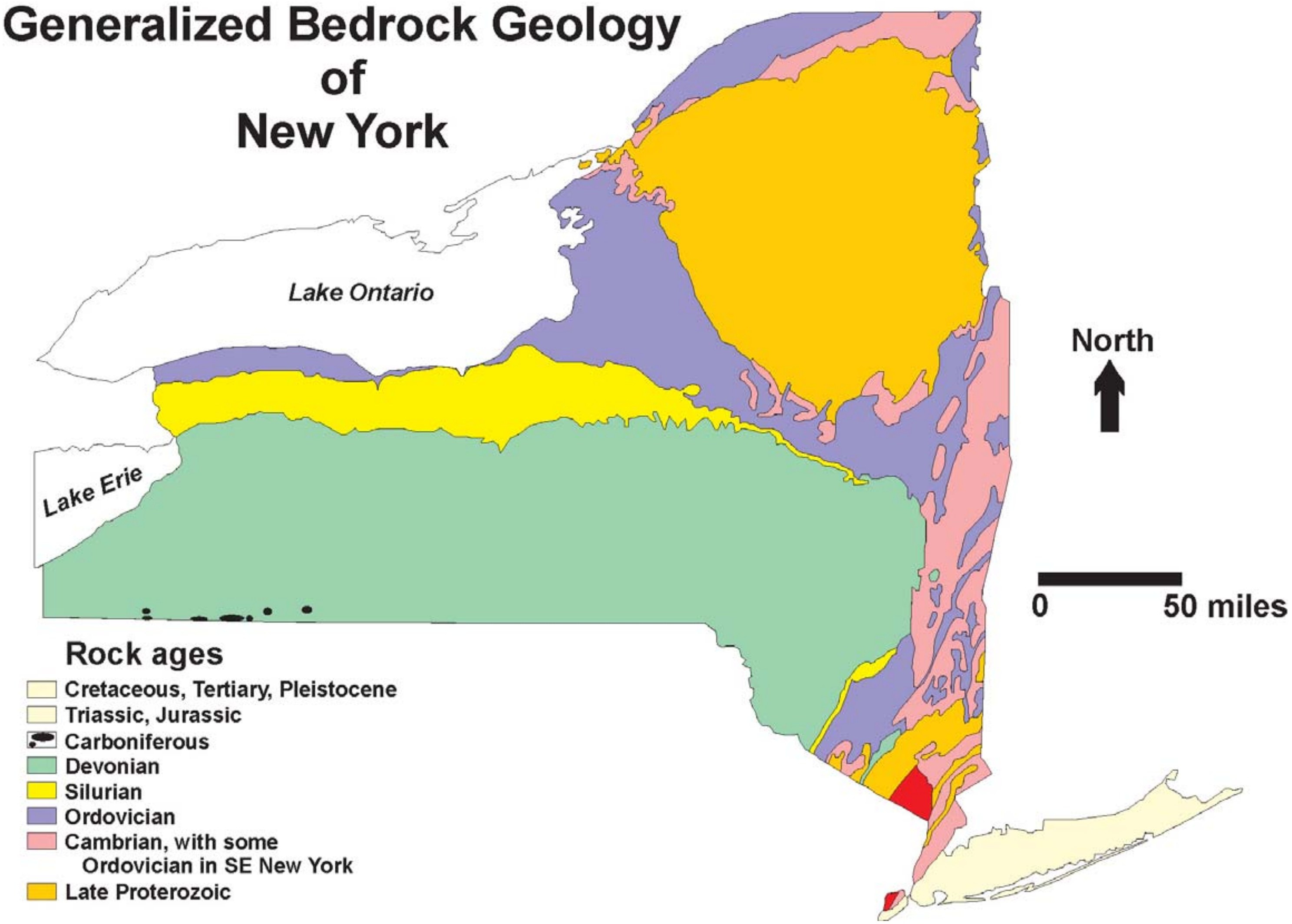


Figure 6 Generalized Bedrock Geology of New York State

spatial distribution of sedimentary strata in western and central New York State. The descriptions below are more detailed, with specific inclusion of characteristics related to the current research initiative (i.e. porosity, permeability, production, storage, etc.).

Subsurface Geology of Central New York State

At the base of the sedimentary section is the Cambro-Ordovician Beekmantown Group, which is composed of interbedded dolomite and sandstones of the Potsdam, Galway, Little Falls and Tribes Hill formations. The Upper Cambrian Potsdam Sandstone is predominantly sandstone with minor beds of dark gray and tan, very finely textured dolomite and dark gray shale. The formation crops out on the flanks of the Adirondack uplift and has some porosity and permeability near the outcrop belt. Kreidler (1963) reported shows of oil in Morrisonville well in Clinton County (Kreidler, 1963). Gas produced commercially from this formation in the Memphis Field of Onondaga County in 1897 (Robinson, 1985). Very few wells in the western part of the State have penetrated the Potsdam, but where they have it was not porous or permeable.

Overlying the Potsdam Formation is the Galway Formation (Cambrian), a dolomite with interbedded sandstone. In some places the Formation contains dark gray, laminated slightly dolomitic shale in the upper 20 to 30 feet. In west-central New York the sandy dolomite grades into a distinct sandstone facies at it upper limits. Fields that produce from this formation include Cascade Brook, Northwoods, Bockhahn, and Connoisarauley Creek fields, all of which are located in western New York. Permeability reported in the pay section varies from .75 to 3.67 mD.

The Little Falls Formation (Cambrian) is mainly a light gray, finely crystalline dolomite with a few rounded and frosted quartz grains, which was deposited in a peritidal environment. Commonly pryrite, chert, and oolites are found in this unit. Flagler (1966) delineated an oollitic chert zone present near the base of the Little Falls to define the boundary between it and the Galway. Gas show reported in northeastern part of the basin in Herkimer County. No commercial production known.

The Tribes Hill Formation (Ordovician) is a light gray, dense to very fine crystalline variably dolomitic limestone. Tribes Hill was deposited on a wave-dominated shelf with a uniform stratigraphy (Landing, 1996). Some operators and geologists argue that some wells reported to be producing from the Little Falls are actually producing from the Tribes Hill, but no documented production has occurred from this formation.

Separated from the underlying Beekmantown by the Knox unconformity, is the Black River Group (Ordovician), which consists of dark–gray to brown cherty limestone and various amounts of shale. The Black River Group is comprised of predominantly peritidal to shallow subtidal fine grained carbonates (Cornell, 2001). Hydrothermally altered dolomites of the Black River located in basement fault controlled sag features currently produce natural gas in much of south central New York State a prolific rates. Fields include, Glodes Corners Road (discovery), Muck Farms, Quacken Bush, Terry Hill South, and Wilson Hollow Fields.

The Trenton Group (Ordovician) is a light to dark gray limestone beds with alternating thin, gray calcareous shale beds. The Trenton is composed almost exclusively of subtidal, shallow shelf calarenites (pack- and grainstones), and deeper ramp calcisiltites, calcilutites (limestone wackestones and mudstones) and shales (Cornell, 2001). Believed to be a fracture limestone play in the northern tier of the state, it produces initially at high volumes and than decreases quickly. Fields include Sandy Creek, Pulaski, and Camden. In Ohio and Ontario, Canada the production from the Trenton occurs in hydrothermally altered carbonates, in New York similar reservoirs are found in the Black River in New York.

Overlying the carbonates of the Beekmantown, Black River and Trenton formations is a thick succession of clastic rocks that comprise the remainder of Ordovician strata in New York State. This includes the Utica, Oswego, and Queenston formations and the Lorraine Group.

The lowermost formation, the Utica (Ordovician) is both younger and equivalent to the Trenton Formation. The formation is a dark gray to black calcareous shale with interbedded gray calcareous siltstone (Baird and Breet, 2002) with many K-bentonite beds. The Utica Formation is several hundred feet thick in central New York and up to 1,000 feet thick in the Mohawk Valley region (Saroff, 1987, McCann et al., 1968). Several researchers believe that the Utica Shale in New York has great potential as a gas shale play, but to date, only gas shows have been reported, but no commercial production.

Overlying the Utica in central New York is the Lorraine Group (Ordovician), which is another thick interval of shale. The Lorraine consists of gray, slightly calcareous shale with some interbedded fine grained sandstone and siltstone. The Lorraine group is transitional with both the underlying Utica Formation and the overlying Oswego Formation. In the subsurface of central New York this type of contact makes the break between the two very hard to notice on geophysical well logs (Saroff, 1987). The Oswego Formation (Ordovician) is a greenish-gray, very fine grained sandstone which is argillaceous and slightly calcareous. The sandstone usually has interbedded greenish-gray, brick-red and purplish–gray shales. Shows have been reported in south central New York, but there is currently no production from this formation.

The Queenston Formation (Ordovician) is a red, brown gray, and green shale siltstone and fine to medium grained sandstone. In east and central New York the Queenston is primarily a siltstone and sandstone. In the western part of the state it grades into a slightly calcareous brown to green, gray and red silty shale. It is composed of multiple, stacked, fluvial, sandstones, siltstones and shales. The producing zones are channel lag deposits and vary from braided –fluvial to tidal-inlet sandstones.

At the base of the Silurian section is the Medina Group, which is separated from the Ordovician strata by the regional Cherokee Unconformity (Swezey, 2002). It unconformably overlies the Queenston with the Whirlpool pinching out to the east. It is overlain conformably by the Silurian Clinton Formation. Medina Group was the main producing formation in New York until the new Black River play came online in the late nineties. Low volumes and longevity characterize the play. The Lakeshore Field, a Medina Field, is the largest (aerial extent) gas field in New York. Porosity ranges between 6-8% and average permeability is 0.1md. The Grimsby Formation unconformably overlies the Queenston Formation in central New York where the Whirlpool Formation is absent (pinches out farther west).

Overlying the Medina Group is the Clinton Group (Silurian), which is predominately a silty and argillaceous dark gray shale with interbedded limestone overlying a gray-white sandstone. Most of the production in Chautauqua and Erie Counties is from the Clinton Group. The Lockport Group consists of dolomites and limestones with a little interbedded shale. The Lockport is used as a marker bed in the subsurface because of its sharp contact with the Vernon shale at the top and the Rochester Shale at the base. In geophysical logs the Lockport has a consistent and easily identifiable signature over a large portion of the state. Gas has been encountered in the lower part of the formation in central New York.

The Silurian Salina Group in central New York consists of five formations in the subsurface: the Vernon Shale, Syracuse salt, the Camillus shale, the Bertie Limestone and the Cobleskill Limestone (detailed discussion below). Significant salt beds are found in the Vernon B unit and the Syracuse D, E and F units. In much of the Appalachian Basin, the evaporites of the Silurian act as a regional hydrocarbon seal. That is, petroleum reserves located below the Salina group evaporites are derived from pre-Salina source rocks, forming two distinct petroleum systems. The salt located in the Vernon and Syracuse formations of the Silina Group are mined for salt at many facilities in central and western New York. There are also two existing solution mined storage caverns in south central New York. One stores natural gas and the other propane. Several other facilities have been proposed within the state and also in Pennsylvania. The Silina Group is the focus of Phase one of this research initiative and there is a much more detailed discussion of the group later in this report. Akron dolomite facies of the Cobleskill limestone in central and eastern New York. (Ciruca and Hamell, 1994) produced oil and gas in the Bass Island field in western New York. The Akron Formation is the youngest Silurian formation in central New York State.

The Helderberg Group is the lowermost Group in the Devonian interval of central and western New York State. In central New York the Group consists of the Manlius and Roundout Limestones, which are shaley and silty limestones. Although the Helderberg Group is originally reported to be the producing formation at the Stagecoach Field in Steuben County, it was later changed to the Oriskany Formation. There is currently no production from the Helderberg.

The Oriskany Formation (Devonian) is a white to gray, fine to medium grained mature sandstone that was deposited in a shallow marine environment. The Oriskany is notoriously patchy in most of western and central New York, where it is less than 50 feet thick if present at all. No longer a major gas producer, the Oriskany did produce in the 1930's and 1940's and was at that time comparable to the Medina Play. Now most of the fields have been converted into gas storage (9 of the 22 depleted reservoir style storage fields are in the Oriskany). Most of the Oriskany sand production

The carbonates of the Onondaga Formation (Devonian) were deposited in a westward-transgressing, shallow, northeast-trending epicontinental sea (Lindemann and Feldman, 1987). The Onondaga Formation has produced gas from porous limestone in pinnacle reefs found in Steuben and Cattaraugus counties. The pinnacle reefs were found by seismic surveys in the mid 1960's. It was also the first formation used for traditional depleted reservoir style gas storage in the Zoar Field in 1916.

Though there are several additional groups and formations (Hamilton Group, Tully Formation, Genesee Group, Sonyea, Group, West Falls Group, Canadaway Group, Conneaut Group and Conewango Group) that complete the succession of strata in central New York, none of these formations are being evaluated as part of the current research initiative and therefore are not included in this summary.

Some of the general relationships discussed above can be seen in Figure 5 the Stratigraphic section for Central New York and in Figure 7, a north-south schematic cross-section through central New York.

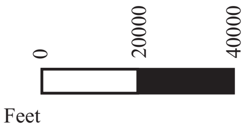
Glacial debris left behind by the retreating Pleistocene ice sheets created deposits as thick as 180 m to 300 m in valleys such as those found in the Finger Lakes (e.g. Isachsen et al., 2000). Elsewhere across the region, glacial deposits on the uplands vary in thickness from 0 to 50 m (Muller, E. H. and Cadwell, 1986; Cadwell and Nottis, 1998).

Schematic North-South Cross Section Finger Lakes Region of New York State

Prepared by : Courtney Lugert

Reservoir
Characterization
Group
at the New York State Museum

Scale:



Legend:

🟫	Shale
🟨	Sand
🟧	Sand and Shale
🟦	Limestone
🟪	Dolomite
🟫	Evaporites
⬜	Grenvillian Basement

Vertical Exaggeration: 20x

Figure 7a Legend for Schematic North-South Cross Section - Finger Lakes Region of New York State. Actual well logs and formation tops were used to compile the initial layout of the section, this version however has been simplified and is very schematic. The surface topography shown in the cross section was generated from the ground elevations on file for the wells used to generate the section and does not indicate the actual surface topography.

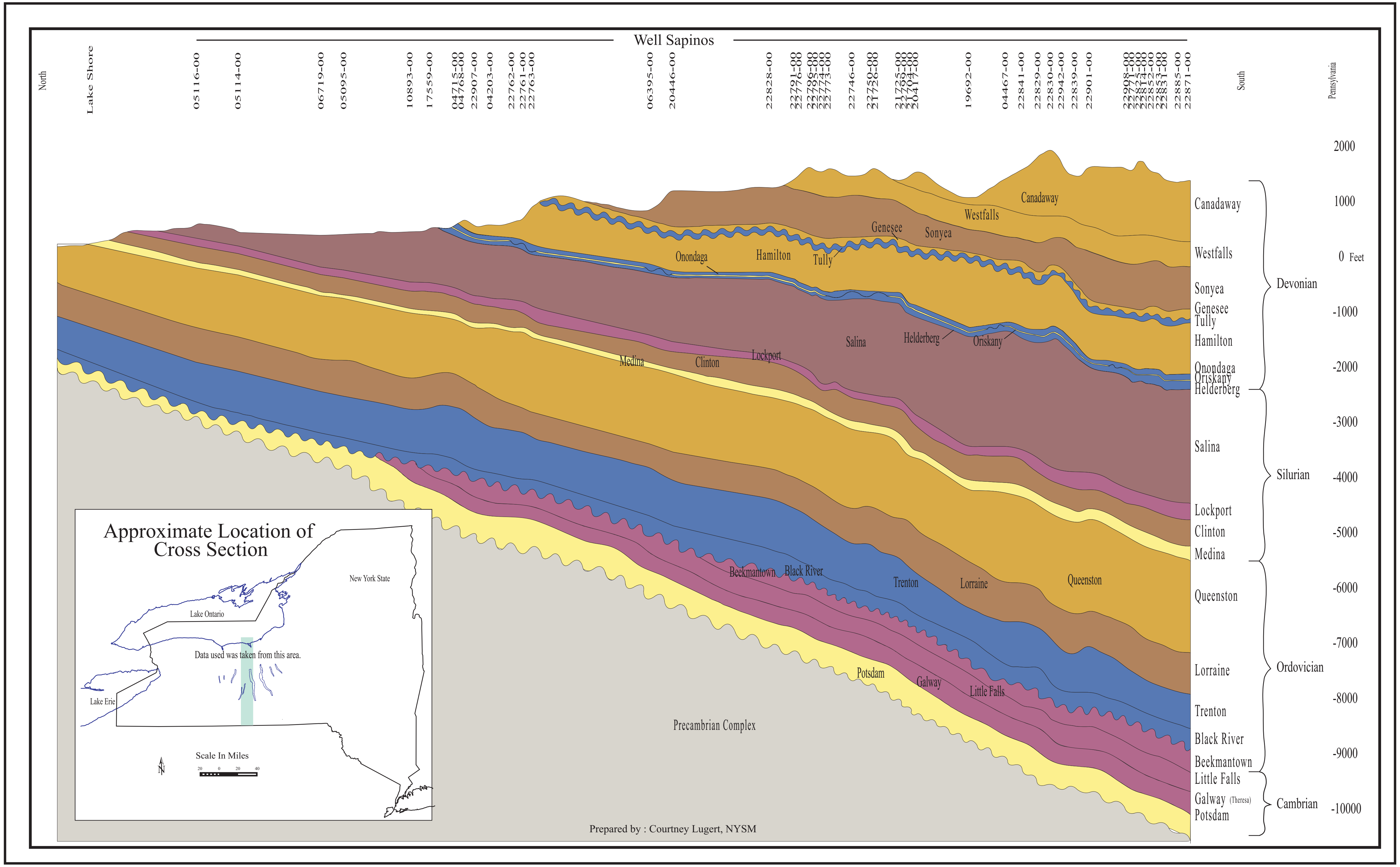


Figure 7b Schematic North-South Cross Section - Finger Lakes Region of New York State. Generated using tops picked from geophysical well logs, which are labeled along the top of the section. The surface topography shown in the cross section was generated from the ground elevations on file for the wells and does not indicate the actual surface topography.

Except in the vicinity of local faults and other local structure, the regional dip to the south never exceeds more than a few degrees and in both the surface and subsurface it is roughly 50 feet/mile or 9.5 m/km (McCann et al., 1968). Figure 8, a regional north-south seismic line through central New York clearly shows the subtle southerly dip as long as other more localized structures.

Figure 9 is a type log for the Paleozoic Section in central New York from the Precambrian crystalline basement to the upper Devonian sand and shales. Tops were obtained from ESOGIS and checked against picks from Rickard (1969), Stone and Webster (1978), Saroff (1988), Bastedo and VanTyne (1990), Kearny (1983) and Bass et al. (1996).

Characteristics of a Good Disposal Reservoir

For cavern development to be economically feasible, potential disposal reservoirs must be capable of accepting brine at the volumes and rates necessary for cavern development. This capability is a combination of several characteristics of the disposal reservoir, the viscosity of the brine, injection pressure, thickness and aerial extent of the reservoir and porosity and permeability of the formation. Potential brine disposal formations must have sufficient permeability to accept brine at high rates and enough porosity (generally greater than 10%) to store the total amount of brine generated during the leaching process. These characteristics are best if naturally occurring, but formations that are candidates for hydraulic fracturing should also be considered. Brine disposal wells are usually completed into porous saltwater aquifers (salinity greater than 200, 000 ppm) with salinity similar to the injected brine. Typically these aquifers are below and isolated from any potable freshwater aquifers (Friedman et al., 2002), to prevent the contamination of such aquifers.

Porosity and Permeability. In its most basic form, porosity is the ratio of the nonsolid portion of a rock to the solid portion or the percentage of a rock unit that consists of void space. When actually testing or defining the porosity of a formation, additional parameters must be considered.

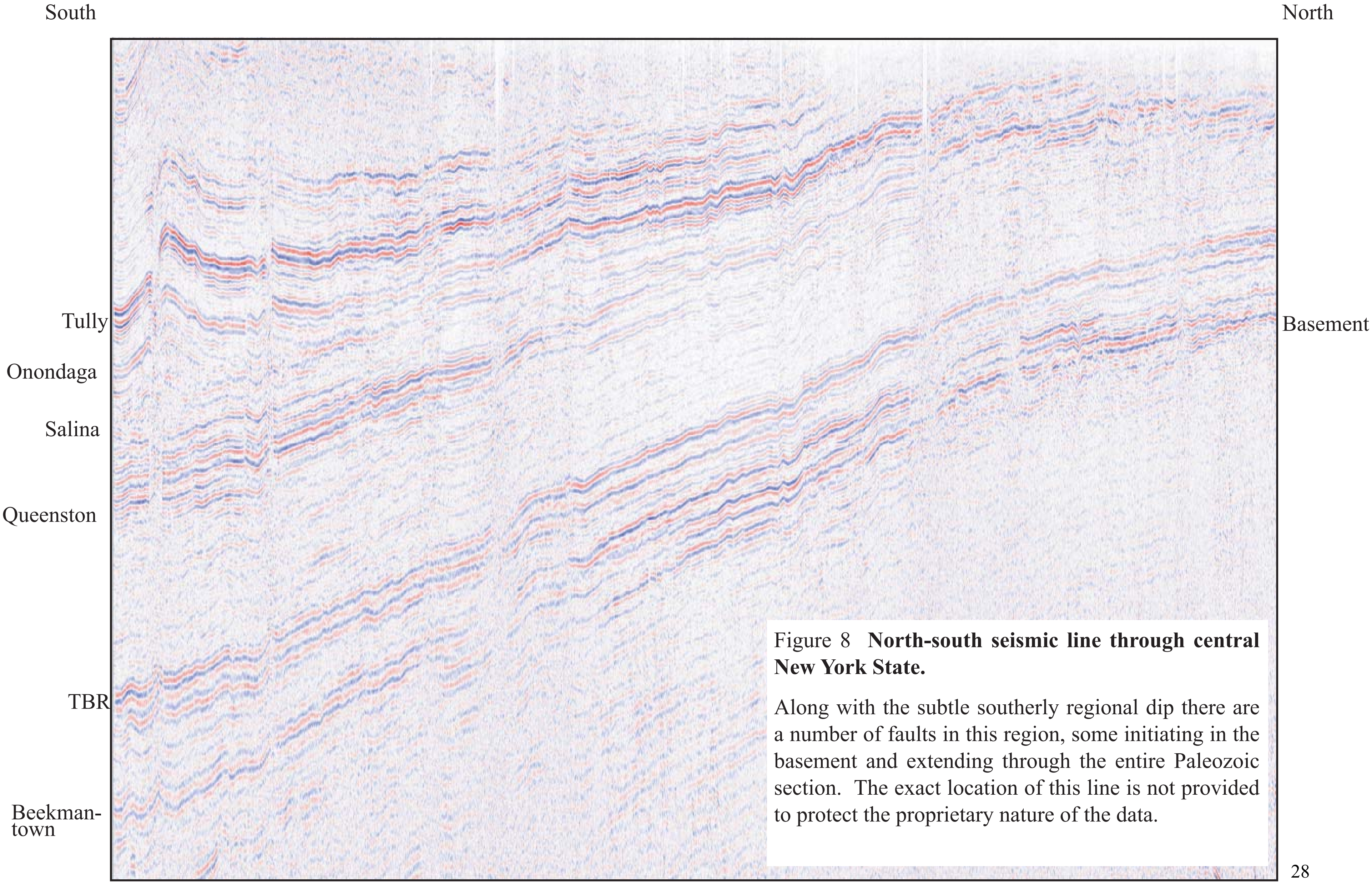


Figure 8 **North-south seismic line through central New York State.**

Along with the subtle southerly regional dip there are a number of faults in this region, some initiating in the basement and extending through the entire Paleozoic section. The exact location of this line is not provided to protect the proprietary nature of the data.

Figure 9 Type log for the Paleozoic section in central New York State. Venice View Dairy well in the town of Venice, Cayuga County, New York State.

Primary porosity is the porosity developed during the original sedimentation and compaction processes that created the rock. Porosity not attributed to the original sedimentation and compaction, due to processes such as natural fracturing and diagenesis, are considered secondary porosity.

As its name implies, porosity is an estimate of the space between the grains forming the rock, or the pores. If a rock unit has significant porosity, but the passageways between the pores (pore throats) are too small to allow for the transport of the molecules being stored or extracted (brine, gas, oil…) or aren't connected at all, the porosity wont contribute to the overall reservoir volume or performance. Effective porosity is the sum of the primary and secondary porosity that actually contributes to the reservoir volume and performance.

It is not enough to have a reservoir with the pore space to accept the brine; just as important to successful disposal, the brine must be able to flow away from the well bore and into the reservoir. Permeability is a measure of a rock's ability to defuse fluids throughout the reservoir. It is related to porosity, but not always dependent upon it. Several additional parameters determine the permeability of a reservoir. These include grain size, viscosity of the transported fluid and presence of additional fluids in the pores.

The ability of a rock to transmit a single fluid when it is 100% saturated with that fluid is referred to as absolute permeability. Effective permeability refers to the presence of two fluids in the system and is the ability of the rock to transmit a fluid in the presence of another fluid when the two fluids are immiscible (Asquith, 1982). In the case of a hydrocarbon or disposal reservoir, connate water (pore fluids) in the formation serves to inhibit the flow of hydrocarbons or the disposal fluid. This happens because the pore fluid takes up space within the pores and the pore throats, blocking or otherwise reducing the ability of other fluids to move through the formation (Asquith, 1982). It is possible to overcome this barrier, but there are limits, while injecting brine in to a disposal reservoir an operator must be very careful to work within a range of pressure that will not induce seismicity. This brings about the point that reasonable effective permeability is crucial to successful disposal.

The symbol K_a is used to represent (absolute) permeability and the darcy (d) or millidarcy (md) are the units of measure most commonly used in the petroleum industry. Permeabilities normally encountered in reservoir rocks range from less than 1 millidarcy in low porosity sands to about 50 d in fractured rock (Crain, 1986).

In general, porosity and permeability of reservoirs in New York and much of the Appalachian Basin are low when compared to the same from other regions. With a few notable exceptions, the porosity of rocks in the Appalachian Basin commonly is less than 10% and the permeability is on the order of a few millidarcies or less. In areas where natural fractures exist and induced fractures occur, permeability can be elevated significantly (McCann et. al, 1968). The low porosities and permeabilities found in New York State have contributed to brine disposal becoming a barrier to salt cavern storage in the State.

Summary of Avoca and other Projects

According to Sandford (2000), at year-end in 1999, New York had a total underground natural gas storage capacity (working gas capacity) of 90.4 Bcf. This was maintained in 21 traditional depleted reservoir storage facilities with a combined working gas capacity of 89.6 Bcf and 1 salt cavern storage facility with a working gas capacity of 0.8 Bcf.

The one operational natural gas salt cavern storage facility in New York, NYSEG – Seneca Lake Storage Inc., is located along the shore of Seneca Lake, near the town of Watkins Glen (Figure 10). This facility has a capacity of 0.8 Bcf and a deliverability rate of 80 MMCF/day and a cycle time of roughly 30 days (10 day injection and 20 day withdrawal). This facility was created by converting an existing cavern, which was original solution mined for the salt industry, to a storage cavern. Brine disposal was not a problem at this facility because the caverns were created for the purpose of harvesting the salt. New York State has many solution salt mining operations that if properly engineered have potential to be converted to natural gas storage. The problems with this type of project are related to the depth at which the cavern lie (not appropriate for natural gas storage) and that the caverns were not originally engineered and mined for natural gas storage. Also, salt quality was often not considered when mining these caverns, they tend to have an irregular shape and large amounts of non-salt ruble at the base of the cavern, meaning larger amounts of cushion gas would be needed.

In addition to the natural gas facility operated by NYSEG, there is one propane storage facility in Bath, New York (Bath Petroleum Inc.; Figure 10). The facility at Bath consists of several tall cylindrical caverns solution mined in the Salina. Brine is pumped into and removed from the caverns when propane is injected or withdrawn. Onsite there are several brine holding ponds where the brine used to displace the propane is stored while not being used. Recently, one of these brine holding ponds was breeched. The Department of Environmental Conservation (DEC) allowed the facility to temporarily dispose of the brine from that holding pond into an existing disposal well, to alleviate the emergency conditions. The reservoir targeted by this well was the upper portion of the Queenston Formation. Though the disposal was temporary, lasting only a few months, rates of 5 BPM (barrels per minute) were sustained during that time. Bath Petroleum Inc. is currently seeking to convert the facility to store natural gas rather than propane. As part of this conversion they would be expanding their cavern capacity and hope to dispose of the generated brine into the Queenston Formation. This process will need approval and permitting by the DEC.

In addition to the two operational storage facilities (Bath Petroleum Inc. and the NYSEG facility) there are several facilities that have been proposed in New York (Figure 10). We have chosen to include a discussion of the most complete of those proposed facilities, the Avoca Project. A complete discussion of the original plan for the Avoca Project can be found in Morill, 1996.

The proposed Avoca facility is located in Avoca, New York (Figure 10) in the vicinity of the Cohocton River (Figure11). The Avoca facility was originally proposed to include 6 caverns to be leached into the Salina D unit at depth of 3,500-4,000 feet (Figure 12). The salt there was judged to be of sufficient quality and thickness to make caverns. These 6 caverns would have a total capacity of 6.72 Bcf and a deliverability rate of 500 MMCF/day. In the development of the caverns, the project engineers calculated that they would generate roughly 50 million barrels of

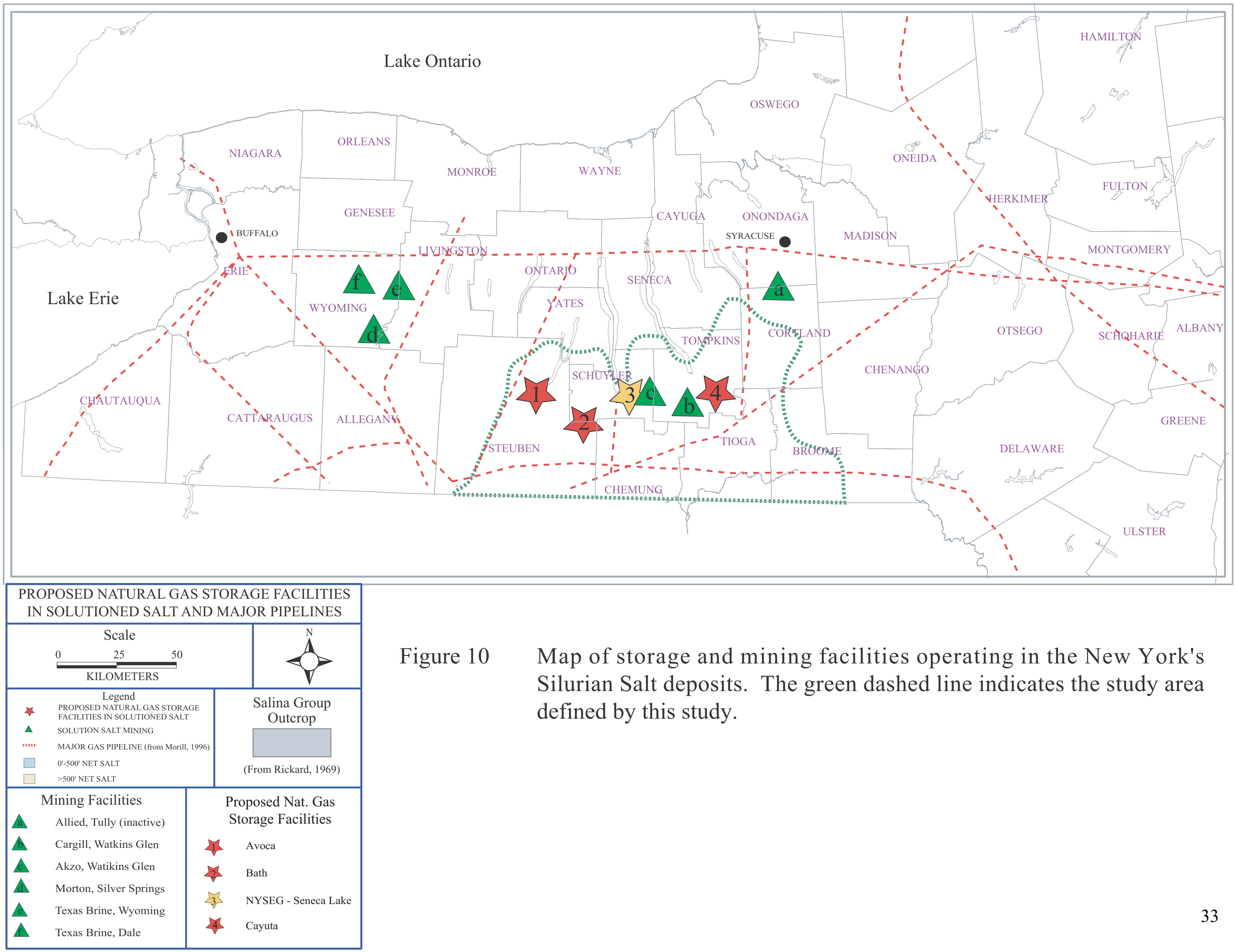


Figure 10 Map of storage and mining facilities operating in the New York's Silurian Salt deposits. The green dashed line indicates the study area defined by this study.

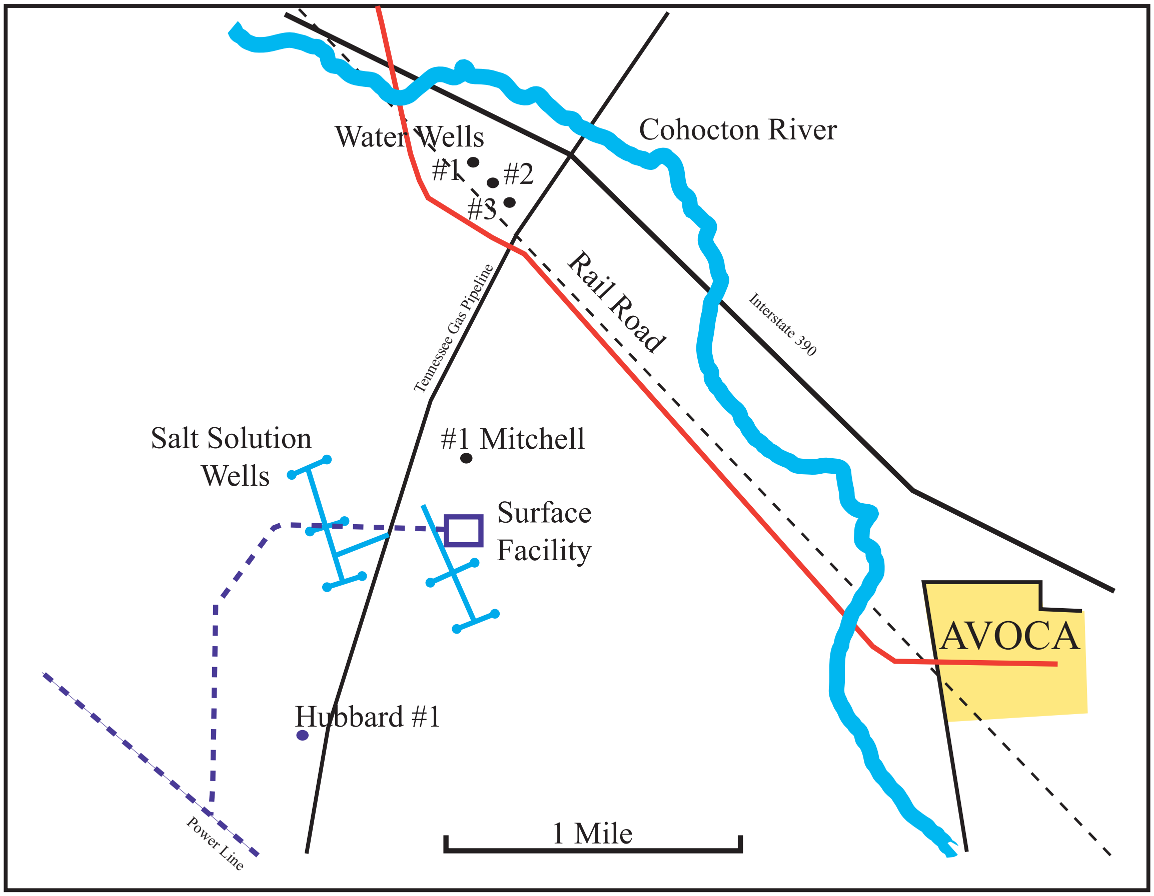


Figure 11 Avoca Project Facility Map. (Modified from Morill, 1996)

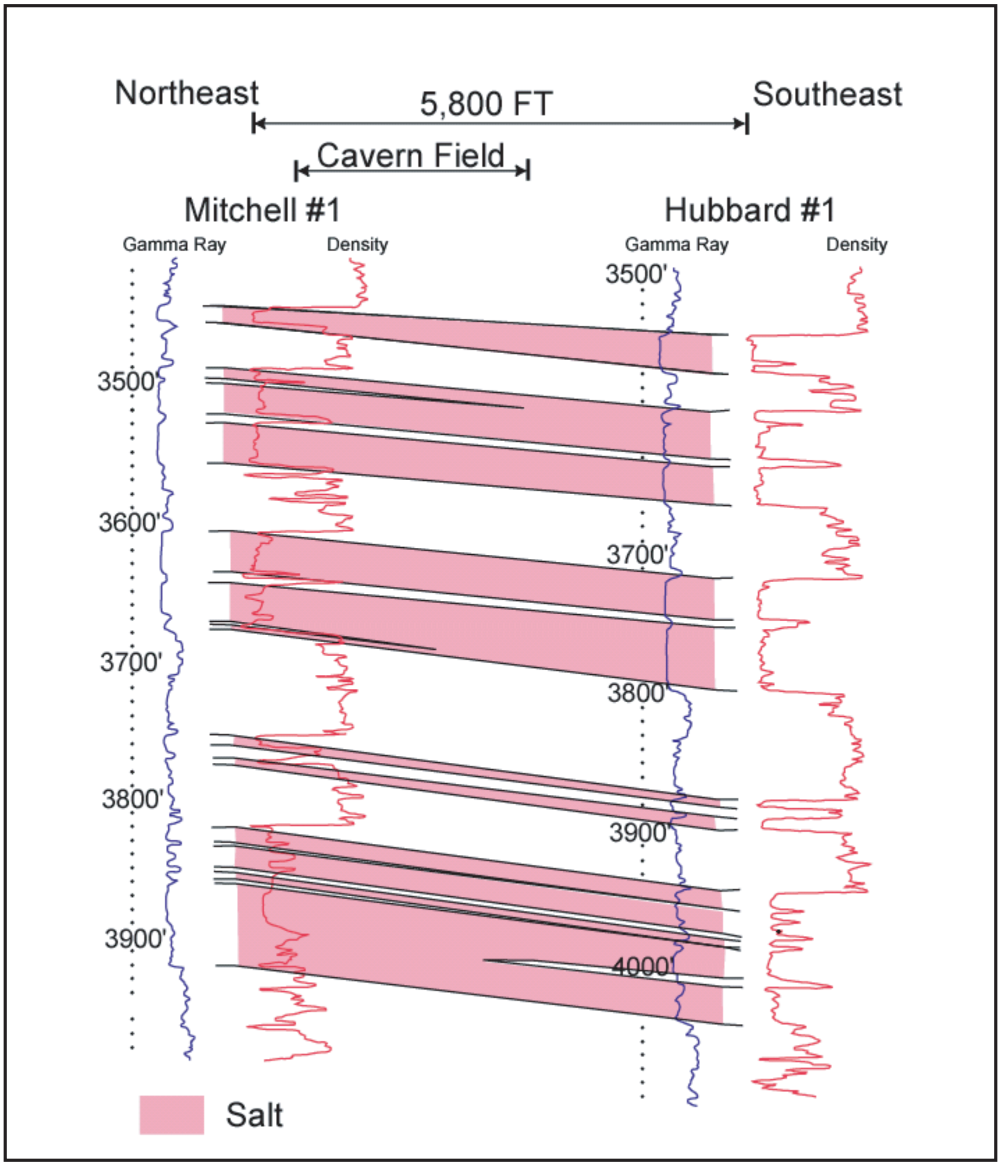


Figure 12 Correlation of the Salina D-unit at the Avoca Salt Cavern Storage Project Site. (Morrill, 1996)

brine, which were going to be disposed of in six injection wells at a rate of three million gallons per day or each well at 8-10 barrels per minute. The targeted disposal formations were located below the Utica Shale, into Cambrian Potsdam and Theresa Sandstones.

The original operators of the Avoca Site tested disposal into the Cambrian section in the Mitchell No. 1 well (Morill, 1996). Three zones of the Cambrian section were perforated and tested for injection potential. These tests recorded rates up to 8.6 barrels per minute (Morill, 1996). Further testing was conducted on the Mitchell No. 1 Well, which determined that the tested disposal zones were not limited aerially and that 6 disposal wells spaced 4,000 feet apart could adequately dispose of the brine generated during cavern leaching (Morill, 1996). These encouraging results were soon followed by very discouraging results. Subsequent testing of the same zones in a second well, the Hubbard #1, resulted in significantly poorer results. Four more disposal wells were drilled and they all had similarly poor porosity and permeability in the Cambrian section. Attempts were made to pump brine into the low permeability sandstones at elevated pressures. Small earthquakes occurred in the area at that time and the NYS Department of Environmental Conservation (DEC) shut the project down. Their position was that the injection had caused the earthquakes.

After many years and approximately $100 million dollars of expenditures, the Avoca project was abandoned because of the lack of a feasible brine disposal plan. Much of this money was spent on drilling the thirteen wells located on the Avoca site. There are six disposal wells and seven other wells, some of which were intended to be cavern development wells. Drilling wells is an expensive endeavor; it is therefore sensible that in future cavern development attempts a brine disposal method is secured prior to the drilling of the cavern wells. The project has been sold several times and there are still plans to make the caverns, but brine disposal continues to be the major obstacle to success.

Section 2

CURRENT INITIATIVE

Using the findings of previous researchers and inline with current state and federal regulations, this report outlines a set of criteria, which can be used to identify areas suitable for developing salt cavern storage facilities for natural gas. These criteria have been used to evaluate portions of New York State for its potential for salt cavern storage. In general the work was broken into two phases. During Phase I, areas having salt suitable for cavern development were defined. This initial step allowed later research to be focused into areas where cavern development is a possibility. The primary focus of Phase II was to locate formations that offer potential as brine disposal reservoirs.

Depths to formation surfaces or tops were identified and collected for each of the formations evaluated in Phase I and II of this research initiative. Tops were primarily identified using rasterized or digitized wireline (when available) logs from the collections of the New York State Museum (NYSM). The identification of formation boundaries on wireline logs, which are called picks, were based on similar picks completed in previous studies, as obtained directly from such studies or from ESOGIS (Empire State Oil and Gas Information System). The measured depths collected in this manor were entered in to a GeoPlus Petra $_{\text{TM}}$ (a well-based GIS software package designed for petroleum exploration) project for each formation being evaluated where they could be used to generate maps and cross sections. GeoPlus Petra automatically creates subsea elevations based on entered surface elevations where logging was initiated (i.e., kelly bushing, drillers floor, etc.). Figure 9 is a type log, which illustrates these picks for central New York. The elevation of these formation tops can be found in the Appendix that relates to the formation being studied under the table labeled Tops Data.

All of the contour maps presented in this report were created in the GeoPlus Petra mapping module from grids generated with the least squares method, which is appropriate for highly connected features. The grid size was computed from the z data distribution, using an average size estimate.

PHASE I – DELINEATION OF SALT SUITABLE FOR CAVERN DEVELOPMENT AND DEFINITION OF STUDY AREA BOUNDARIES

Criteria Development

After reviewing the industry standards discussed above we determined that there are two basic criteria that determine if salt in a given area is suitable for cavern development: salt thickness and salt depth. Efforts in Phase I were focused on defining areas that have the appropriate depth and thickness. The criteria used to resolve these areas are:

Criterion 1 - Depth to salt = 2,000 feet to 6,000 feet below the surface elevation

Criterion 2 - Aggregate salt thickness ⩾100 feet. (the Salina F salt was chosen because it has the greatest potential to reach a thickness of 100 feet.; after Friedman et al., 2002)

The study area for this research project was defined where the salt meets both of these requirements.

Phase I Methods

Several studies have been conducted to define the salt extent in New York State, Rickard (1969), Kreidler (1957), Stone and Webster (1978), Beinkafner (1983) and Friedman et al. (2002). After a review of the existing data and literature from previous studies it was determined that there already existed a wealth of data on the Silurian Section in New York State. Thus, a review of the wells, tops and correlations from previous work was begun. Where necessary, formation top data from the original reports were modified before being added to the database. This was done to keep a make sure that the tops used in the current research were consistent and all fit with the methods used in this project. This tops data was then combined and supplemented with additional well data for areas with little control or where new wells have been drill since the completion of the previous studies. The many new wells drilled and logged since these studies were completed have shed a new light on the extent and distribution of the Salina in central New York. A new set of isopachous and structure contour maps for the Salina (discussed below) has been generated using the newer data and the data collected by the previous researchers together. The area on these maps that is outlined by the 100 foot isopach and the 2,000 foot contour of the Salina F unit (all of the salt in NYS is shallower than 6,000 feet), defines the study area of this research.

The Museum has a collection of geophysical well logs from over 20,000 wells in New York State. Some of the wells used in this study have geophysical well logs through the Silurian and it is from these wells and logs that tops were picked. Some of the wells used in previous studies did not have associated well logs. In these cases the previous researchers data was assumed to be correct. In some of these cases, mostly in wells from Rickard's (1969) study the tops were originally obtained and verified using Geologs $_{TM}$. Geologs were created as a log of the lithologies encountered in a well as inferred from well bore cutting samples. The Geologs and some of the well bore cutting samples are also held as a collection of the museum. Most of the Geologs are proprietary and therefore cannot be displayed in this report.

General information for each well was uploaded into a Petra project from the New York State Museum's Reservoir Characterization Group's (RCG) web-based wells database, ESOGIS or Empire State Oil and Gas Information System. Information obtained from ESOGIS for this step includes latitude, longitude, total depth well name, SAPINO (short American Petroleum Institute number), well type, operator, town and county. This process generated a basic project to which, both old and new formation tops was added. Storing all of the data in this manner made mapping, cross section creation and data mining a simpler process. Appendix A contains a list of the wells and basic well information used to complete Phase I.

Using the Petra project described above in combination with the criteria described for Phase I, maps and cross sections that illustrate how each criterion affects the data set spatially were created. This was done in two steps. First a structure contour map was generated to illustrate the top of the F unit, with the surface elevation as the datum (Plate 5). As mentioned above, the F unit will be the focus in Phase I of this research because it offers the best potential for finding salt of the appropriate thickness. From the structure contour map everything was removed that fell outside of the 2000 and 6000 foot contours (highlighted in red on Figure 17 and Plate 5).

The remaining area contains F unit salt that meets Phase I Criterion 1 - salt that is between 2,000 and 6,000 feet deep.

To meet Phase I - Criterion 2 (salt that is the appropriate thickness and quality) a second map was created. Phase I wells that contained salt of the appropriate thickness (> 100 feet) and quality (no intervals of nonsalt greater than 10 feet thick) were identified using well logs. Appendix A - Salina F unit Salt Interval Characteristics is a record of what was observed during this process. The table contains the following fields:

<u>Net thickness of the F unit salt</u> – the total thickness of all salt intervals in the F unit, excludes non salt intervals (feet)

<u>Intervals of Salt Suitable for Cavern Development</u> – many of the wells contained multiple intervals of salt that meet Phase I – Criterion 2, all of the depth range of each of these intervals is listed in this field

<u>Interval Thickness</u> – the thickness of each interval of salt suitable for cavern development, only the greatest interval is used to make the corresponding map of salt suitable for cavern development.

<u>Net Thickness</u> – total thickness of salt suitable for cavern development in the F unit.

The greatest interval of salt suitable for cavern development found in each well was used to create a corresponding map - Salt with Suitable Thickness for Cavern Development. All of the colored area on this map meets Phase I - Criterion 2 (suitable thickness and quality). This is true because only wells that met the criteria were used to generate the map.

It was necessary that portions of the Salt Suitable for Cavern Development Map be rejected to create a map that illustrated the area where both of the Phase I criteria are met (that is salt that is greater than 2,000 feet below the surface and is over 100 feet. thick with no intervals of nonsalt greater than 10 feet thick). The area that was removed was the small area of salt suitable for cavern development that wasn't deep enough to meet Phase I - Criterion 1 (salt shallower than 2,000 feet). The resulting map shows the area where both criteria for Phase I are met and defines the study area for this research. The isopachs were left on the map and the color scheme is altered to highlight areas where cavern development is better suited. Remember, cavern development can be achieved in no less than 100 feet of salt, but a thickness of 200 feet is optimal. The Salt with Suitable Thickness for Cavern Development Map is discussed further below.

Phase I Results - The Occurrence of Salt in New York State

Rickard (1969) established subsurface correlation of the Salina Group in New York State. Rickard correlated the units found in New York with those established by Landes (1945) and Ells (1967) in the Michigan Basin and by Uteig (1964) for the Appalachian Basin of Ohio.

Figure 13 is a cross section of the Silurian interval in Chemung County, New York, where the salt intervals are highlighted in blue. Figure 13 illustrates that the salt intervals are often punctuated by non-salt intervals consisting of shale, dolomite and anhydrite. Correlation of both the non-salt and salt bearing intervals has allowed for a better geographic definition of where usable salt is available in New York.

The salt deposits of New York State and the Central Appalachian Basin are positioned within the Upper Silurian Vernon and Syracuse formations of the Salina Group (Figure 4). The Salina Group consists of lithologies common to evaporite series (shale, dolostone, anhydrite and halite, as seen in Figure 4) and point to deposition in restricted marine or playa lake conditions. Evaporite conditions, such as these, occurred during the late Silurian, in the Salina depositional basin that extended northeasterly from Pennsylvania into New York and shared a principle axis with the Appalachian Basin (Rickard, 1969; Stone and Webster, 1978). The Salina group is known to have great extent, occurring for hundreds of miles across the Appalachian and Michigan Basins, allowing for regional mapping of units. Figure 14 shows how the Salina Group outcrops in New York State, forming an east-east band from the Buffalo area and Rochester through Syracuse and into Herkimer County.

In New York the Salina Group is divided into the Vernon, Syracuse, Camillus and Bertie Formations. As shown in Figure 4, the Vernon is divided into A, B and C units, the Syracuse is divided into the D, E and F Units and the Camillus and Bertie Formations are designated the G and H Units respectively. The variable thickness of these formations are illustrated in Plate 1 and 2, which are east-west and north-south cross sections (respectively) through the Silurian section in western New York. An examination of wells in central New York State conducted for the current research initiative, found that the Salina Group reaches a maximum thickness of 2,207 feet in the NYS GMA 2 well in Steuben County. This thickening in south central New York is primarily due to the introduction of large thicknesses of salt in the Syracuse F unit. Elsewhere in the Appalachian Basin the group is reported (Rickard, 1969) to reach thicknesses exceeding 4,000 feet so there are similar opportunities elsewhere in the region.

Within the current study area, salt occurs in both the Vernon and Syracuse Formations, but the Syracuse D and F are the major salt bearing units (Figure 4). The D unit forms the relatively thin layer at the base of the Syracuse Formation and varies between 7 and 230 feet thick (Plate 1 and 2*)*. According to a study completed by Stone and Webster Engineering Corporation in 1978, salt in the D unit occurs throughout south-central New York, except in Broome and central Cortland Counties. Across the same area, our group observed that up to 7 salt beds occur in this unit (Plate 1 and 2*)*. Rickard (1969) found five major salt beds in the F unit that are separated by thin intervals of dolomite and/or shale. Following Rickard's (1969) designation, the locations of these beds are labeled on Plate 1 and 2. Within the F Unit, individual salt beds are generally less than 50 feet thick, but can reach thicknesses of several hundred feet and are commonly found to be interbedded with thin dolostones, anhydrites and shales.

The F unit (salt and nonsalt) is generally 100-300 feet thick. Though this range is the normal thickness observed in the F unit in much central New York, the F unit thickness is elevated in portions of south-central New York (Plate 3), which can be accounted to the introduction of many thick salt beds (Plates 1, 2 and 3 and Figure 15). Figure 16 is a seismic line shot over a thickened portion of salt in south central New York. In this figure the thickening is related to thrust faulting, which has ramped the Silurian section onto itself several times forming a thick wedge of salt, shale, gypsum and anhydrite. In some cases, overlying these thick salt wedges

Silurian Section - Chemung County, New York

LEGEND

▨ Salt Intervals

— Gamma Ray Curve

— Neutron Porosity Curve

WELL LOCATION MAP

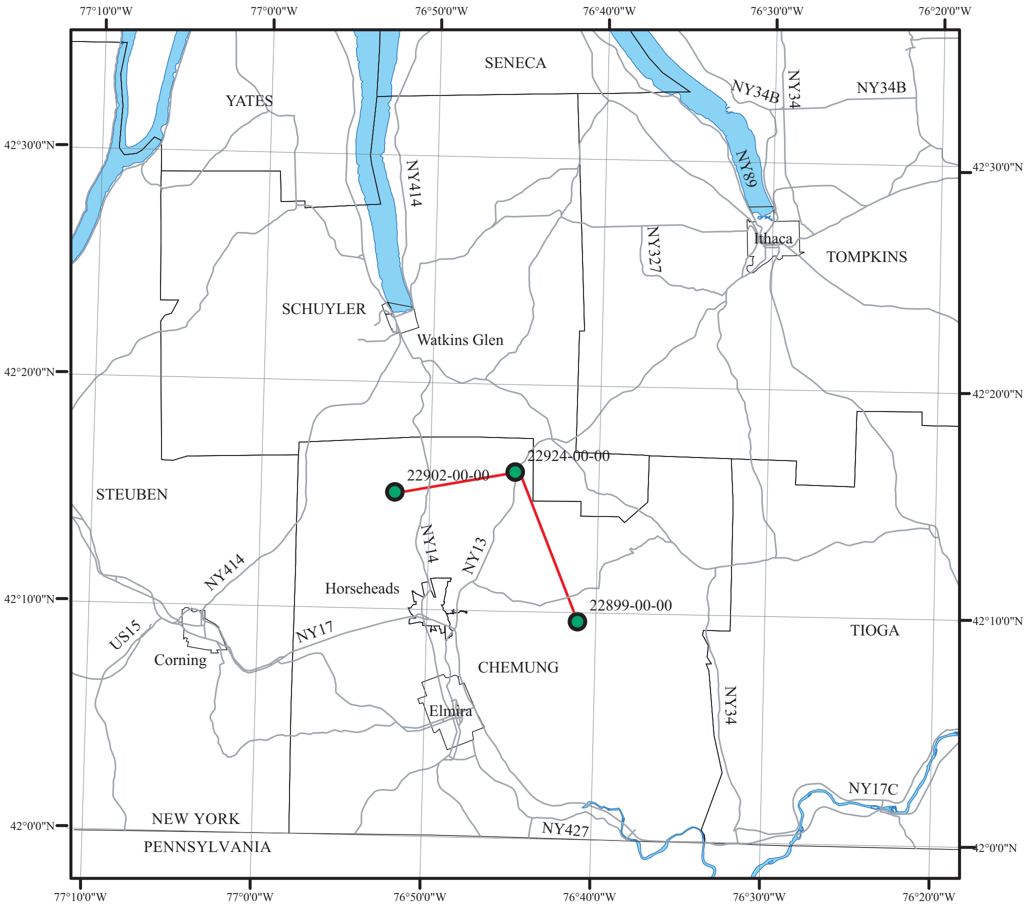


Figure 13a Cross-Section Legend and Well Location Map for Figure 17b

Figure 13b Cross-section through the Silurian Section in Chemung County, New York. Note that, the Bertie Formation was used as the datum in this section and the well spacing is not to scale, actual well spacing is indicated between the well headers. Picks were made by Lugert after Rickard (1969).

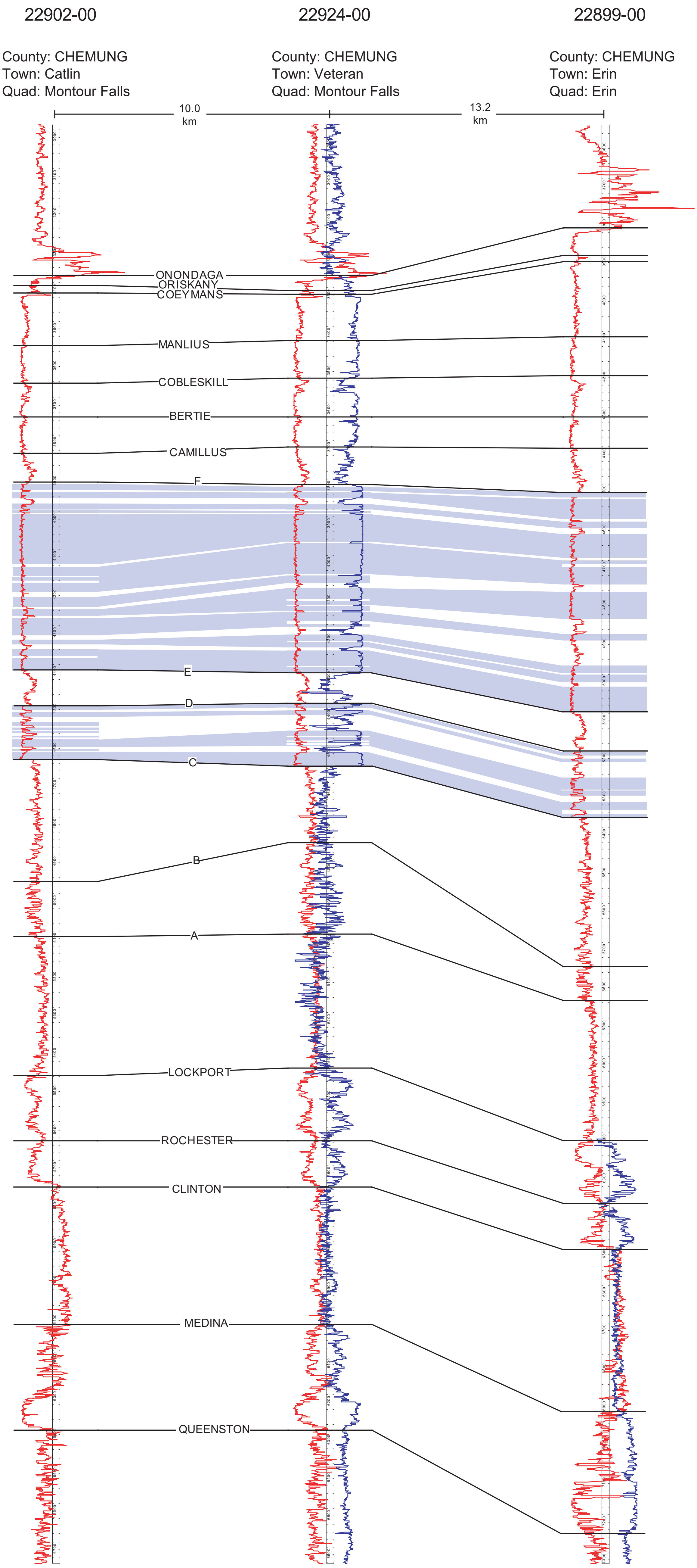


Figure 13b (Caption is located on previos page)

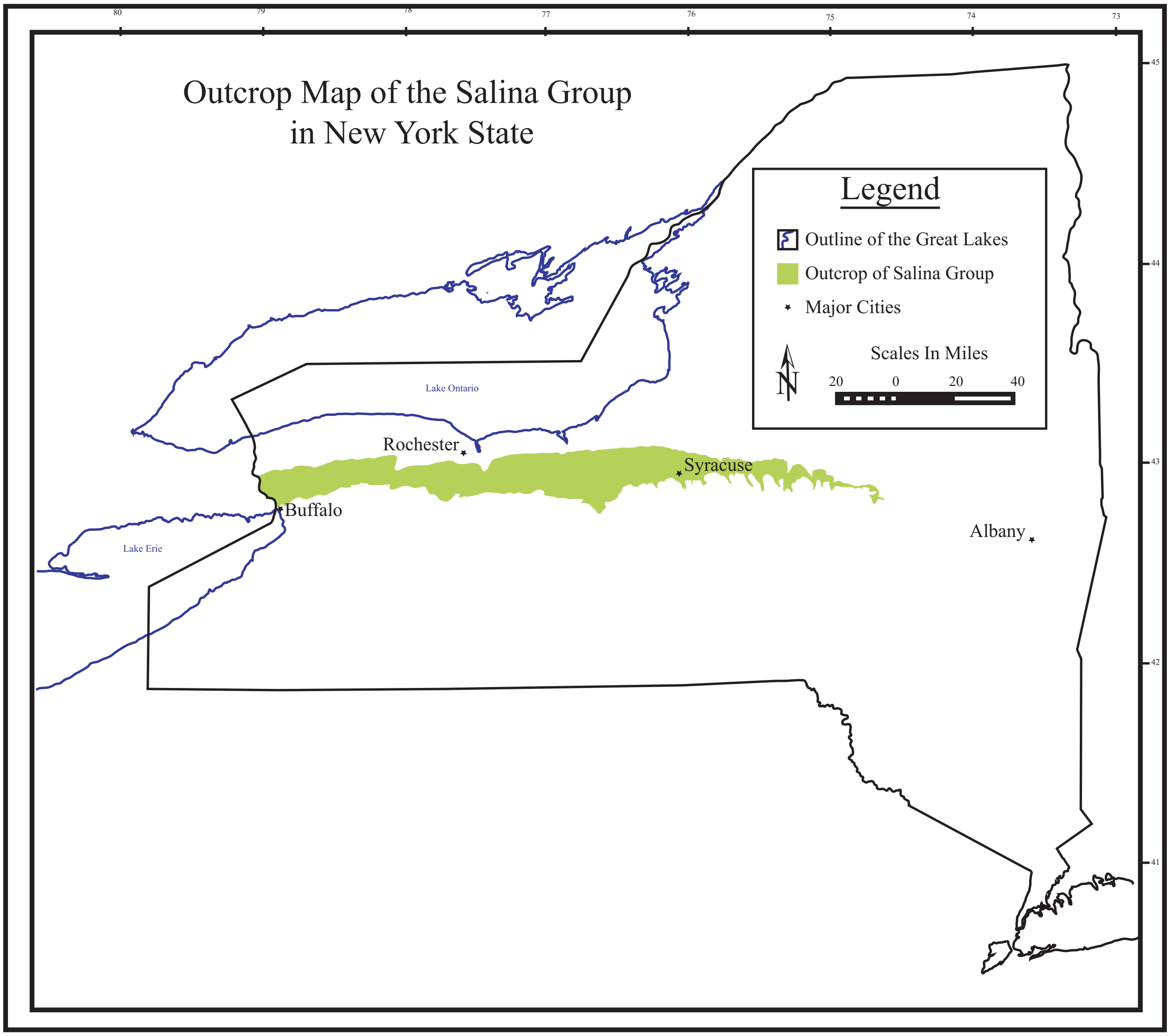


Figure 14 The Salina Group outcrops in an east-west band from near Buffalo and Rochester through Syracuse to Herkimer County. (Modified from Rickard, 1969)

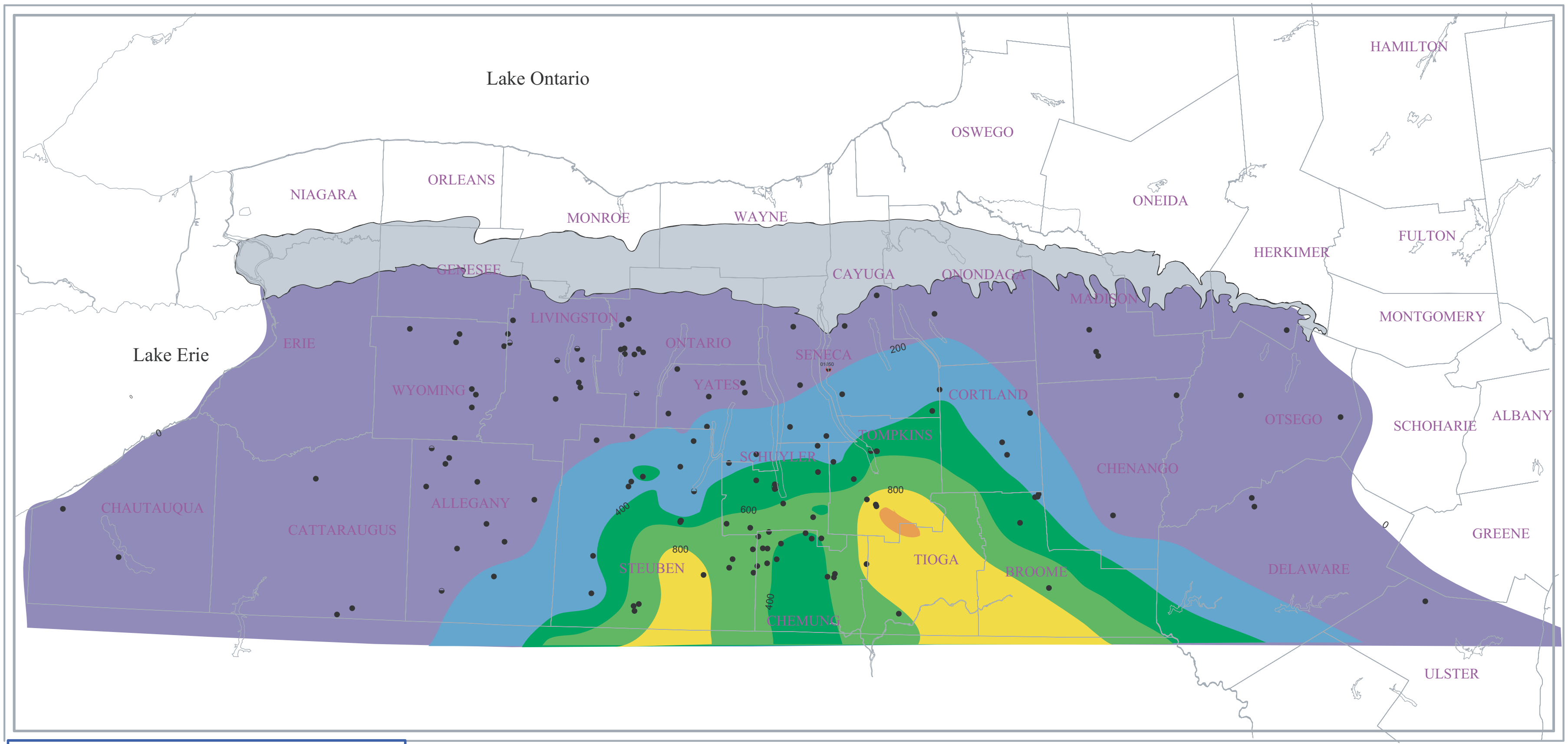


Figure 15 Salina F-Unit Isopachous Map. Areas of thick salt in this unit are located in south central New York State, in the counties of Broome, Tioga, Tompkins, Chemung, Stueben and Schuyler. The well SAPINOs are labeled in Plate 4.

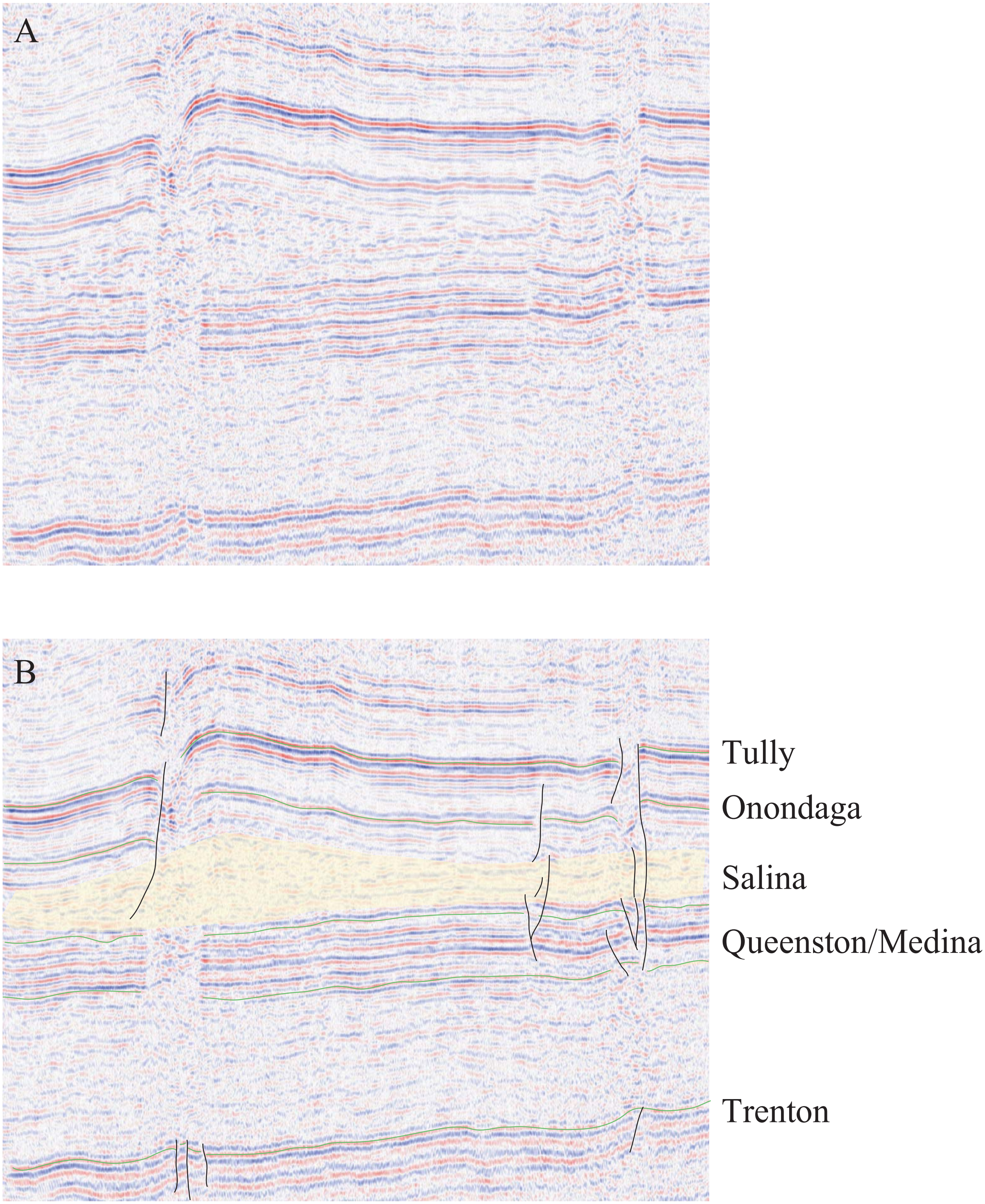


Figure 16 Uninterpreted (A) and interpreted (B) seismic line shot over an area of thickened salt.

there are fields that currently or once produced from the Oriskany Formation, which could prove to provide a brine disposal option. The Oriskany is currently used as a traditional depleted reservoir type storage field and therefore was not evaluated as part of this research. The Oriskany was not evaluated as a potential disposal reservoir in this research because operators may not want to or be able to risk, what has already proven to be a profitable storage method, to attempt brine disposal and cavern development.

Though the Salina F unit Structure Contour Map (Figure 17 and Plate 4) does indicate that there are significant portions of central New York where the F unit is deep enough for salt cavern development, it does not take into account the hilly topography of central New York, which is crucial to Phase I Criterion 1 – appropriate depth for salt cavern development. The top of the F unit, as shown in Figure 17 and Plate 4, ranges in depth from 500 feet above sea level to the north, to more than 4,000 feet below sea level at the New York-Pennsylvania border. Measured depth to the Salina F unit (Figure 18 and Plate 5) is a more appropriate estimate of depth to salt for cavern development, as it considers the entire rock column overlying the unit. In central New York, the surface depicted by the measured depth contours (Figure 18 and Plate 5) reflects the deep valleys surrounding the Finger Lakes rather than undulations in the surface of the F unit. In general, depth to the Salina F unit increases to the south, reaching depths greater than 5,500 feet at the New York-Pennsylvania border. The shaded area indicates where salt within the F unit meets Phase I Criterion 1, salt depths between 2,000 and 6,000 feet below the ground surface.

As stated earlier, in order to be suitable for salt cavern storage, individual packages of salt must be greater than 100 feet thick and contain no individual nonsalt interbeds greater than 10 feet thick. Figure 19 and Plate 6, are a map of the area underlain by F unit salt that meets these criteria. In several wells there was more than one interval of salt in the F unit that met these criteria. The interval with the greatest thickness in each well was used to create the contours on Figure 19 and Plate 6. The entire shaded region in Figure 19 and Plate 6 has at least one interval of salt that based on thickness and quality, could potentially be used to develop salt caverns for the purpose of storing natural gas. The regions highlighted in yellow are better suited for cavern development, because the salt there is thicker than 200 feet and sometimes greater than 400 feet thick.

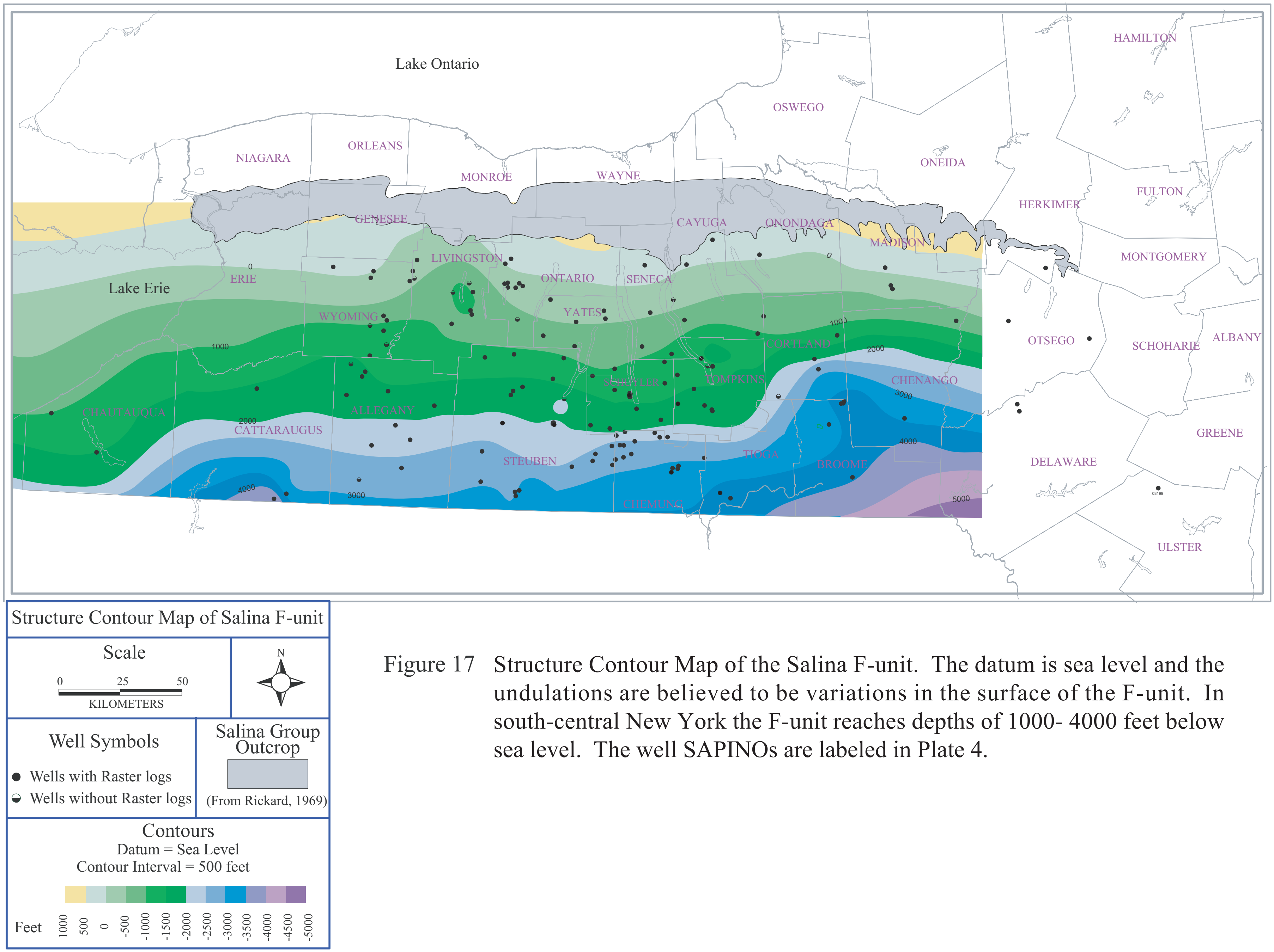


Figure 17 Structure Contour Map of the Salina F-unit. The datum is sea level and the undulations are believed to be variations in the surface of the F-unit. In south-central New York the F-unit reaches depths of 1000- 4000 feet below sea level. The well SAPINOs are labeled in Plate 4.

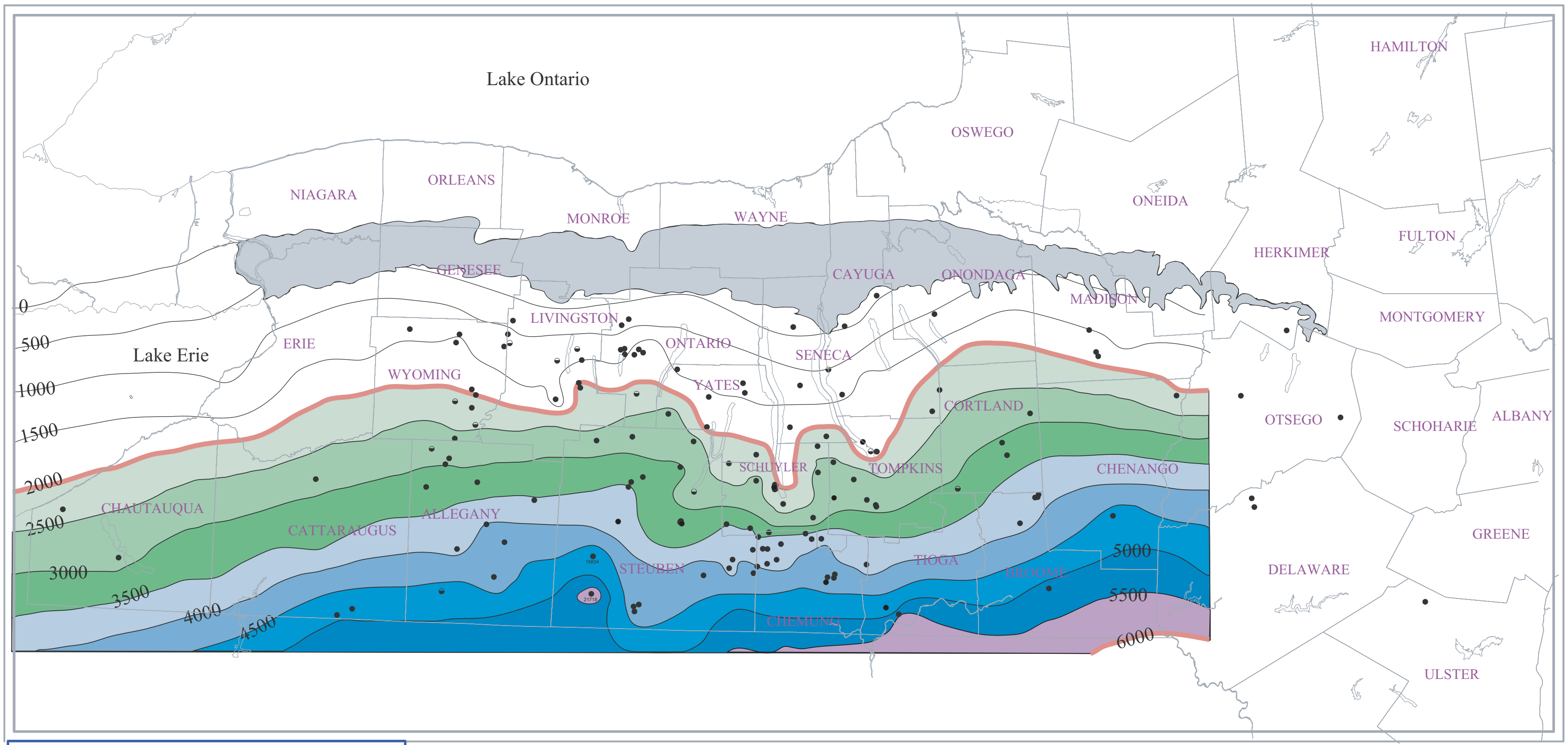


Figure 18 Measured depth to the top of the Salina F-unit in western and central New York State. Measured depth was used to take into account the hilly topography of the region covered by this map. The shaded contours highlight the portion of New York State where the Salina F-unit lies at the appropriate depth for cavern development. As stipulated in Phase I Criteria I cavern development is considered in salt at depths between 2000 and 6000 feet (red contours) below the surface. The well SAPINOs are labeled in Plate 5.

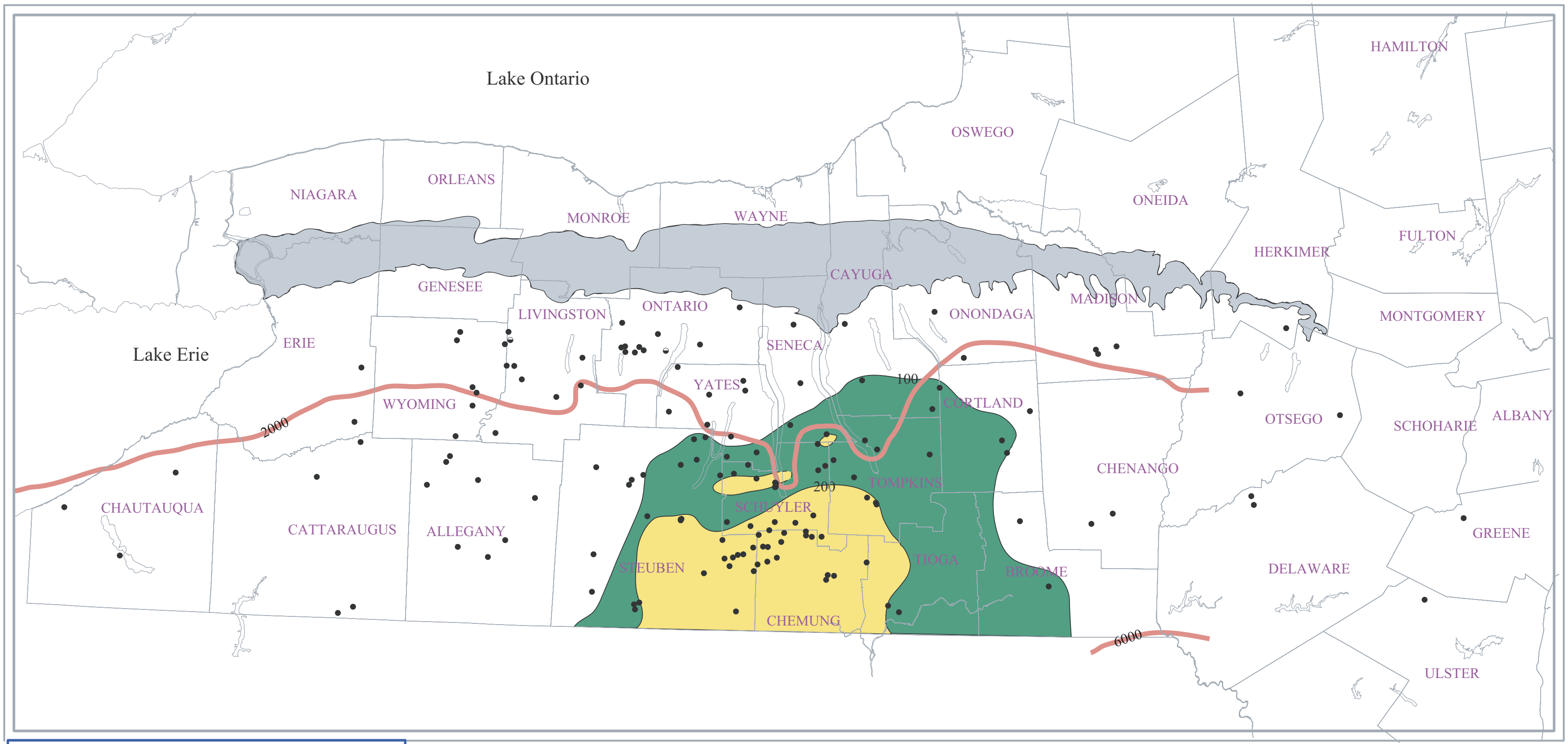


Figure 19 Map of salt with suitable thickness for cavern development. Map of the area underlain by salt that meets Phase I Criteria II, aggregate salt thickness of 100 feet or more with less than 10 feet of non salt breaks. In several wells there was more than one interval of salt in the F-unit that met these criteria, only the interval with the greatest thickness was used to generated the contours display in this map. The red contours are the 2000 and 6000 foot contours. The area between these contours is underlain by F-unit salt that also meets Phase I Criterion I (appropriate depth for cavern development), as shown on Figure 21. The well SAPINOs are labeled in Plate 6.

When the region delineated by salt that occurs at the appropriate depth (2,000-6,000 feet below the surface) is overlain on the region delineated by salt of appropriate thickness, it is possible to reject a portion of the F unit salt that are not thick enough or deep enough. The area where both criteria are met, defines the study area. Figure 20 and Plate 7 shows the study area and the area rejected based on Usable Salt Criterion 1 (dashed line). Large portions of Steuben, Chemung, Tioga, Broome Cortland, Tompkins, Allegany and Schuyler Counties are underlain by F unit salt in which a salt cavern storage facility could potentially be created.

Phase I Conclusions

The delineation of salt bodies that are appropriate for the development of Salt Cavern Natural Gas Storage Facilities has identified a large area of south central New York that could be used to develop this type of project. Areas of particular interest for their abundance of thick salt are Steuben, Schuyler, Chemung, Tompkins and Tioga Counties. The completion of Phase I of this research has also resulted in construction of a large database of information related to the Silurian Section in New York State. This database and other data related to this project will be made available on the New York State Museum's Oils and Gas web-base database, ESOGIS (Empire State Oil and Gas Information System) at www.nysm.gov/esogis.

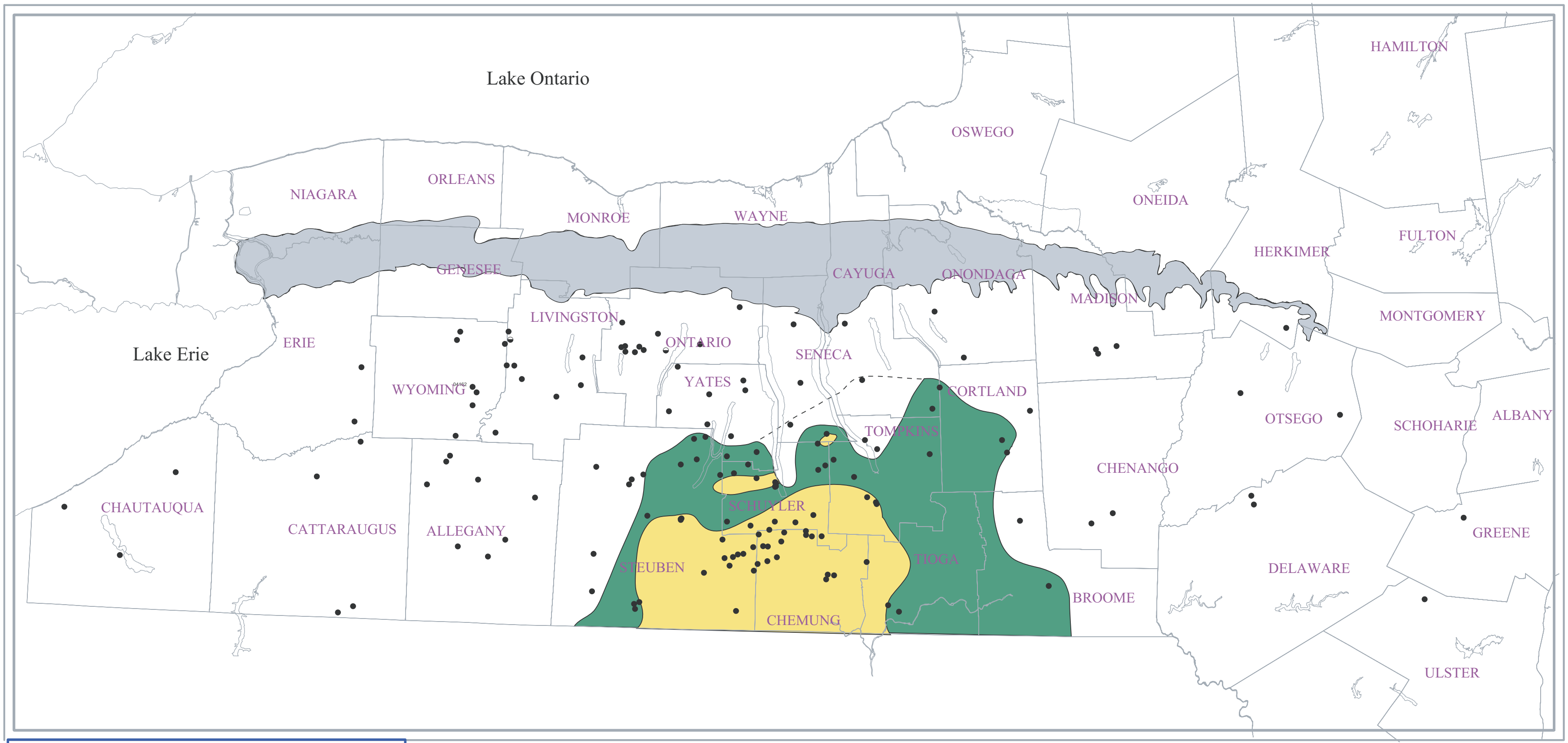


Figure 20 Study area defined in Phase I. The shaded portion of this map represents that area underlain by F-unit salt the meets both criteria for Phase one of this research. The green dashed line represents the area rejected based on Phase I Criteria I. Salt in the rejected portion, while thick enough is not deep enough for cavern development, based on industry standards. A review of the engineering and economics of developing a cavern in the rejected portion may prove that it is viable. Large portions of Stueben, Chemung, Tioga, Broome Cortland, Tompkins, Allegany and Schuyler Counties are underlain by F-unit salt in which a salt cavern storage facility could potentially be created. The well SAPINOs are labeled in Plate 7.

PHASE II - IDENTIFICATION AND EVALUATION OF POTENTIAL DISPOSAL RESERVOIRS

The area defined in Phase I could be used to develop salt caverns assuming one had an effective brine disposal solution and a source of fresh water. As stated previously in this report fresh water availability is not considered an obstacle to this type of storage in New York, therefore once salt availability has been determine, the primary factor that will determine site suitability is brine disposal potential. Research efforts in Phase II were focused on delineating and evaluating potential brine disposal reservoirs.

Criteria Development

In the background section of this report the characteristics of a good disposal reservoir were given. Those were:

- The disposal formation must exhibit sufficient porosity and permeability to allow reasonable injection rates at acceptable pressures.
- The connate water salinity of the disposal reservoir must be similar to injected brine.
- The disposal reservoir is located well below all fresh water aquifers and separated from the aquifers by impermeable formations.
- The reservoir volume must be capable of accepting the total volume of brine generated over an economically viable duration of time.

(After Swenson and Potashik, 1994)

From these characteristics two sets of criteria were defined. The first, the Disposal Formation Selection Criteria (or Selection Criteria), allowed us to high-grade potential disposal reservoirs from the geologic units present in central New York. The second set of criteria, the Disposal Formation Evaluation Criteria (or Evaluation Criteria), were used to evaluate the selected formations for their ability to perform as brine disposal reservoirs.

Disposal Formation Selection Criteria. The Disposal Formation Selection Criteria are the following:

Criterion 1-	Lithology (sandstones and carbonates);
Criterion 2 -	Evidence of good porosity and permeability (in previous studies);
Criterion 3 -	History of production either here or in nearby states; and
Criterion 4 -	Not currently used for conventional depleted reservoir storage (if a formation is already a good storage reservoir, most operators will not want to risk trying brine disposal).
Criterion 5 -	Connate water salinity greater than 200, 000 ppm.

To help organize this process the Disposal Formation Selection Matrix was created (Figure 21 and Plate 8). The matrix contains columns for Selection Criteria 1-4 (Criterion 5 is addressed separately below) and rows representing the geologic units of central New York State. Units not highlighted, are considered to have no brine disposal potential. Units highlighted in green, have potential as brine disposal reservoirs, because they meet all of the Phase II criteria after a literature review and basic evaluation. Units highlighted in yellow meet the first three criteria, but are currently used for conventional, depleted reservoir type storage and therefore may be less desirable for brine disposal.

Geologic units that have potential as brine disposal reservoirs based on Selection Criteria 1-4 are: the Upper Ordovician Queenston Formation, the Middle Ordovician Trenton-Black River Interval and the Cambro-Ordovician Beekmantown Group (Figure 22). In the Phase II Results section, each of these formations is described and then evaluated using the Disposal Formation Evaluation Criteria discussed below.

In addition to the criteria used to build the Disposal Formation Selection Matrix (Figure 21 and Plate 8), it is necessary to assess the connate water salinity (Selection Criterion 5) of the potential disposal reservoirs. Only formations with salinities greater that 200,000 ppm are considered as potential disposal reservoirs. This is true because formations with naturally occurring high

PERIOD		GROUP	UNIT	LITHOLOGY	ENVIRONMENT	POROSITY/ PERM.	OIL OR GAS RESERVOIR TYPE	CURRENTLY USED FOR STORAGE	POTENTIAL AS BRINE DISPOSAL RESERVOIR
DEVONIAN	UPPER	GENESEE	WEST RIVER ITHACA RENWICK SHERBURNE PENN YANN GENESEO	SHALE WITH MINOR SILTSTONE AND LIMESTONE	DEEP MARINE BASIN				NO
			TULLY	LIMESTONE WITH MINOR SILTSTONE AND LIMESTONE	LOW ENERGY			YES, 1, GILBERT [7]	MAYBE
	MIDDLE	HAMILTON	MOSCOW LUDLOWVILLE SKANEATELES MARCELLUS	SHALE WITH MINOR SANDSTONE AND CONGLOMERATE	DEEPBASIN, UNDERWATER DELTA CHANNELS,TIDALFLATS, OFFSHORE BARS DEEP BASIN, POOR CIRCULATION OF OXYGEN		GAS [6]		MAYBE
			ONONDAGA	FOSSILIFEROUS LIMESTONE & REEFS	SHALLOW MARINE, MEDIUM- LOW ENERGY		GAS, REEF AND FAULT GENERATED FRACTURES [6]	YES, 2, FRACTURED LS AND PINNACLE REEF [1]	MAYBE
	LOWER	TRISTATES	ORISKANY	QUARTZ SANDSTONE	NEAR SHORE, SHALLOW MARINE, HIGH ENERGY	-ave. 9% -open fractures, 200-800 md [4,1]	GAS, FORMATION PINCHES OUT LOCALLY FORMING TRAPS, ANY CLOSED STRUCTURALLY HIGHER POSITION [2,6]	YES, AT LEAST 9 [7,6]	MAYBE
		HELDERBERG	MANLIUS RONDOUT	LIMESTONE AND DOLOSTONE	TIDAL, SHALLOW MARINE SHALLOW MARINE, HIGH SALINITY				NO
SIURIAN	UPPER		AKRON-COBLESKILL	DOLOSTONE AND LIMESTONE	SHALLOW MARINE, NORMAL SALINITY	< 5% < 1md [1]	OIL AND GAS, BASS ISLAND TREND, STRUCTURAL TRAPS, FRACTURES [1]	YES [6]	MAYBE
		SALINA	BERTIE CAMILLUS SYRACUSE VERNON	SHALE, DOLOSTONE, ANHYDRITE AND HALITE	SHALLOW SHELF, HIGH SALINITY RESTRICTED MARINE PLAYA OR LAKE COASTAL PLAIN, SHALLOW SHELF			YES, 1- LPG, 1 OPERATIONAL AND SEVERAL PROPOSED NAT GAS, SOUTH-CENTRAL NY	NO
		LOCKPORT	LOCKPORT	LIMESTONE AND DOLOSTONE STROMATALITE MOUNDS	SHALLOW SHELF TO CARBONATE FLATS		GAS, PINNICALE REEF, NO MAJOR PRODUCTION		NO
	LOWER	CLINTON	ROCHESTER IRONDEQUOIT	SHALE SANDSTONE LIMESTONE	OPEN MARINE SHELF WARM, CLEAR, SHALLOWSHELF		GAS, STRATIGRAPHIC [6]		NO
			WILLOWVALE SAUQUOIT WOLCOTT SODUS BEAR CREEK FURNACEVILLE KODAK	SHALE SANDSTONE AND SHALE LIMESTONE SHALE HEMATITE & IRON ORE SANDSTONE	NEAR SHORE, SUBTIDAL QUIET WATER TO SHALLOW SHELF SHALLOW MARINE IN DEPRESSIONS BETWEEN NEAR SHORE RIDGES OF SAND				
		MEDINA	GRIMSBY WHIRLPOOL	SANDSTONE AND SHALE	DELTAIC - SHALLOW TURBULENT WATER		GAS, SAND DOMINATED CHANNEL DEPOSITS, PRODUCED FROM FRACTURES [1]	10 GAS STORAGE FIELDS IN WESTERN NEW YORK [1]	MAYBE
ORDOVICIAN	UPPER		QUEENSTON	SANDSTONE AND SHALE	DELTAIC, BRAIDED STREAM	AS HIGH AS 15%/1-.01md	GAS, UP DIP FACIES CHANGE [3]	POTENTIAL GAS STORAGE RESERVOIR [1]	YES
			OSWEGO LORRAINE UTICA	SHALEY SANDSTONE SHALE WITH SANDSTONE ANDSILTSTONE	NEAR SHORE AND BEACH SHALLOW AND MODERATELY DEEP MARINE DEEP BASIN		PORPOSED GAS, GAS SHALE		NO
	MIDDLE	TRENTON-BLACK RIVER	TRENTON BLACK RIVER	FOSSILIFEROUS LIMESTONE DOLOSTONE AND HYDROTHERMALDOLOMITE	SHALLOW MARINE, TIDALFLATS AND SLOPE SHALLOW SHELF		GAS, VUGGY HYDROTHERMAL DOLOMITE, FRACTURES-TUG HILL AREA [6]	BECAUSE OF THE HETEROGENEITY OF THE RESERVOIRS, IT IS UNLIKELY THAT MANY OF THESE FEILDS WILL BE UTILIZED FOR TRADITIONAL UNDERGROUND STORAGE	YES
	LOWER	BEEKMAN-TOWN	TRIBES HILL LITTLE FALLS	DOLOSTONE, LIMESTONE AND SILSTONE DOLOSTONE	TROPICAL COASTAL COMPLEX	Numerous porous zones in upper portion of L.F. [4]			YES
			THERESA (GALWAY)	SANDSTONE			GAS, vuggy dolomite, STRUCTURAL CLOSURE OF FRACTURE SYSTEM [5 6]	POTENIAL TRADITIONAL STORAGE RESERVOIR	
CAMB-RIAN	UPPER		POTSDAM	AND SANDY DOLOSTONE QUARTZ SANDSTONE		Basal Potsdam extremely porous and permeable [4]			
PRECAMBRIAN			MARBLE QUARTZITE etc>	METAMORPHIC AND IGNEOUS ROCKS					NO

FROM VANTINE AND COPLEY, 1984 — MODIFIED FROM ISACHSEN ET AL., 2000

1 FRIEDMAN ET AL., 2002 3 SAROFF, 1987 5 GOU ET AL., 1996 7 DEC ANNUAL REPORTS
2 DEECHIO ET AL., 198 4 MC CANN ET AL., 1968 6 BESTEDO & VAN TYNE, 1990

NEW YORK STATE POTENTIAL DISPOSAL RESERVOIR

Figure 21 The table above is a compilation of information from several sources. By bringing this information together we were able to identify formations with potential as brine disposal reservoirs. Potential brine disposal reservoirs were chosen based on Lithology, coverage in south central New York and production and storage potential and history. Formations with potential to act as brine disposal reservoirs were designated as YES or MAYBE. Formations that have produced oil or gas were designated YES based on the similar characteristics necessary for both production and disposal. The MAYBE designation was used when a formation is commonly used for storage. This becomes necessary because economically, an operator would probably profit more form getting online quickly with a storage facility that will continually operate rather than the possible slow, one-time disposal that would occur with the brine disposal use.

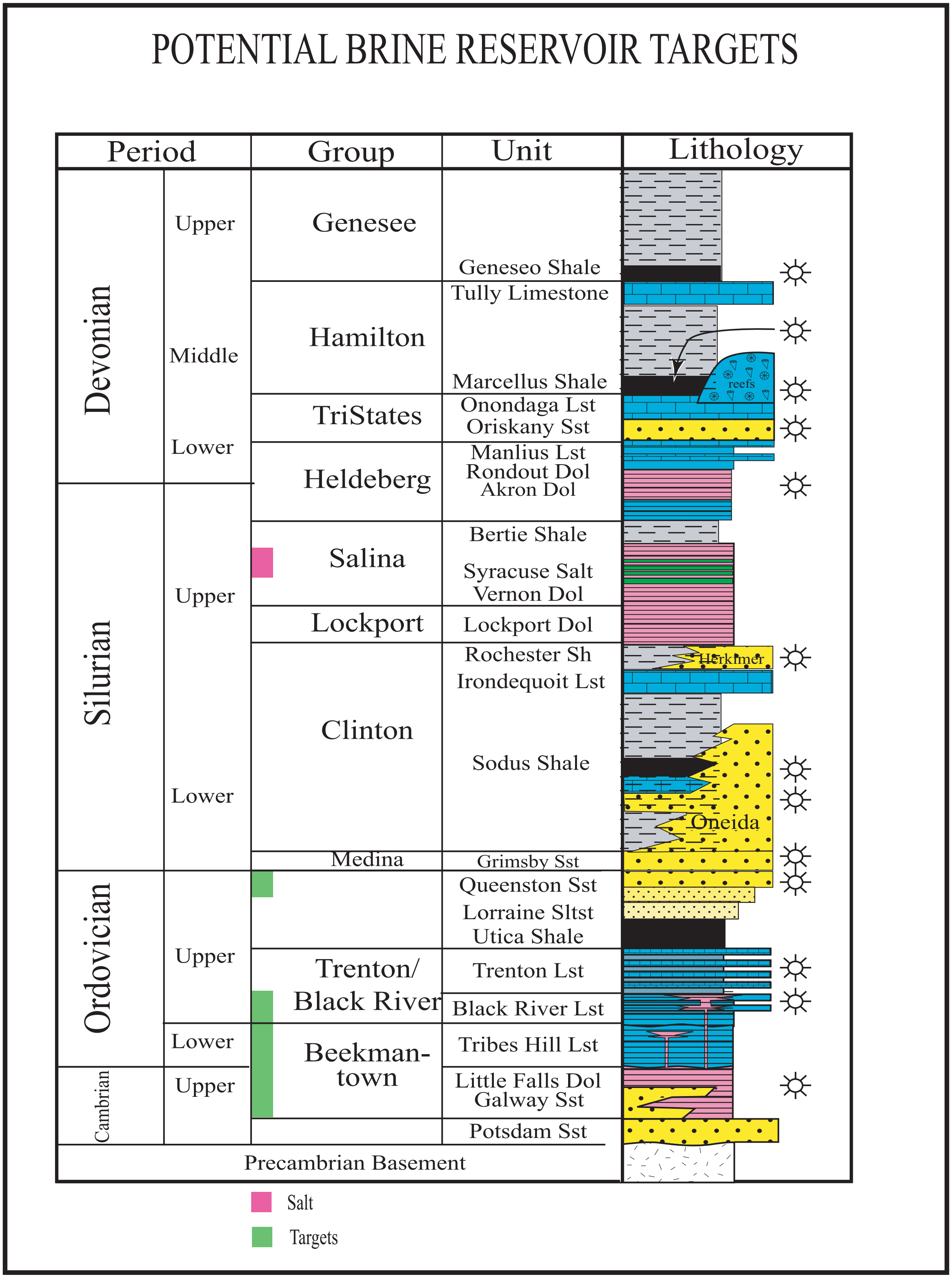


Figure 22 Stratigraphic Section of central New York. Highlighted areas represent sections that are of interest to this study. (Modified from Smith, 2005)

connate water salinities are unlikely to be considered as potential potable water sources and will be less affected by the introduction of the saturated brines generated during cavern development.

	Modified from Matsumoto et al, 1992, All Values are for New York State						From USGS, 2002
	Potsdam/ Theresa	**Queenston**	**Medina**	**Oriskany**	**Bass Island**	**Upper Devonian Oil Zones**	**Trenton** *** = Ohio,** **** = Michigan**
Measured TDS (mg/L)	300,763	298,358	292,121	231,836	232,500	156,267	
Calculated TDS (mg/L)	299,187	302,869	292,727	232,743	232,558	149,582	
Unknown Method TDS (mg/L)							232,432*, 195,592**, ***
							*** New York is discussed in the text
No. of Analyses	9	2	8	4	2	3	1, 7

Table 1 **Brine Quality Data From Selected Production Reservoirs in New York State.** Reservoirs in the Beekmantown Group (Theresa and Potsdam) and the Queenston Formation have high salinities (greater than 200,000 ppm) that are necessary for brine disposal. Reservoirs in the Trenton-Black River Interval (not shown) also have high salinities. (Modified from Matsumoto et al., 1992, Trenton Salinities from USGS, 2005)

Table 1, Brine Quality Data for Selected Oil and Gas Producing Formations in New York State (modified from Matsumoto et al., 1992 and supplemented from USGS, 2002), demonstrates that there are several deep formations that have salinities (as measured by TDS or Total Dissolved Solids) high enough to be considered suitable brine disposal reservoirs. Three of these formations were selected as potential brine disposal formations using Selection Criteria 1-4. The Potsdam/Theresa (Beekemantown sandstones and dolomites) and the Queenston Formation both have levels of salinity of roughly 300,000 ppm in New York State (Motsumoto et al., 1992), high enough to allow the formations to be considered for brine disposal. Published salinity values for the Trenton Group in New York State were not found. The carbonates of the Trenton and Black River groups are known to have brines that are 30% (by weight) salts, which is close to saturation. We consider the reservoirs within Trenton-Black River interval to be of adequate salinity for brine disposal. This conclusion is supported by the Trenton Group TDS values given in Table 1, which were collected from wells in Michigan and Ohio. In Ohio, the salinity of the Trenton Group (in the sampled well) is high enough to permit brine disposal. The value presented in Table 1 for the salinity of the Trenton Group in Michigan is an average of samples collected from 7 wells. This average is slightly below the 200,000 ppm mark that in necessary for brine disposal, but several of the individual samples were above 200,000 ppm.

Disposal Formation Evaluation Criteria. After the initial selection process, each of the three potential brine disposal reservoirs was evaluated to gauge its ability to accept brine at an economic rate.

The Disposal Formation Evaluation Criteria are the following:

Criterion 1 - Sufficient porosity and permeability to maintain an injection rate of 10 BPM (Ehgartner et al. 2005).
Criterion 2 - Reservoir volume is capable of accepting 11 MMB in 3 years (Ehgartner et al. 2005).
Criterion 3 - Hydraulically separated from sources of potable water.

Porosity and permeability are interrelated and therefore it is not possible to set a definitive number needed for each. Instead, it is necessary that these two factors together are adequate to reach the desired injection rate. The injection formations must have sufficient storage volume to handle the large quantities of brine produced in leaching salt storage caverns as well as sufficient permeability to accept the brine at reasonable cavern development rates. In general, projects are typically based on 5 wells and approximately 77 MMB (15.4 MMB per well) of brine must be disposed of over a 3 year period (Ehgartner et al. 2005). This results in an average injection rate of about 10 BPM and creates an underground cavern volume of 11 MMB (Ehgartner, 2005). Sandia National Laboratories tested and modeled the potential disposal formations to determine if the characteristics of the formations would support safe injection of typical brine volumes at the desired rate if 10 BPM over a 3 year period.

The sections below contain methods, descriptions and analyses for of each of the three potential disposal reservoirs. The description section for each formation was completed by at the New York State Museum and was used to inform the testing and modeling completed by Sandia National Laboratories. The analysis of each formation contains an evaluation of each formation's fitness to act as a brine disposal reservoir as defined by the Disposal Formation Evaluation Criteria.

Queenston Formation - Methods

Top Identification. Tops used in the evaluation of the Queenston and surrounding formations were primarily derived from comparison with the work of Saroff (1988) who worked in the producing region of the Queenston in north central New York, Kearney (1983) and Bastedo and VanTyne (1990) who worked in western New York. Figure 23 is a representative log for the tops picked in the evaluation of the Queenston Formation. Additional visual examples of the Queenston Formation pick used in this report can be seen in Figures 9, 23 and 24.

Delaney Core Description Poster. The core description poster found in Appendix B is of 342 feet (104 m) of 4 in. core taken from the Delaney #A-124-5 well (API #31-011-13645), a well located in the West Auburn field in Cayuga County, New York. Of primary interest in this description is the depositional texture and visible porosity identification; also recorded are sedimentary structures, grain size and color. The Queenston is known to vary in color from a gray green to a rich red. A discussion of the origin of these colors is given in Hughes, 1976.

The core description is displayed and correlated with the gamma ray, density and neutron logs from this portion of the well. The density log was used to determine zones within the well where the density drops below that of the accepted matrix density of sandstone, 2.65 g/cc. Figure 24, a graph used to convert formation density to porosity, shows that intervals of sandstone with densities of 2.65 g/cc are considered to have zero porosity and that porosity increases with decreasing density. At density values of 2.5 g/cc the evaluated interval has reached 10% porosity, which is considered reservoir quality rock. In the Delaney Core description, those portions of the density curve that fall to the left of the green line indicating 2.5 g/cc are representative of potential reservoir rock. This method was also used in the east-west and north-south cross sections to the Queenston Formation presented in Plates 9 and 10.

Cross Sections. Plates 9 and 10 are east-west and north-south cross sections respectively of the Queenston Formation. The cross sections show the interval from the lower Silurian Lockport Group to the Middle Ordovician Trenton Group. The cross sections are stratigraphic and are hung on the Lockport Formation, which is consistent and easily identifiable in the area covered

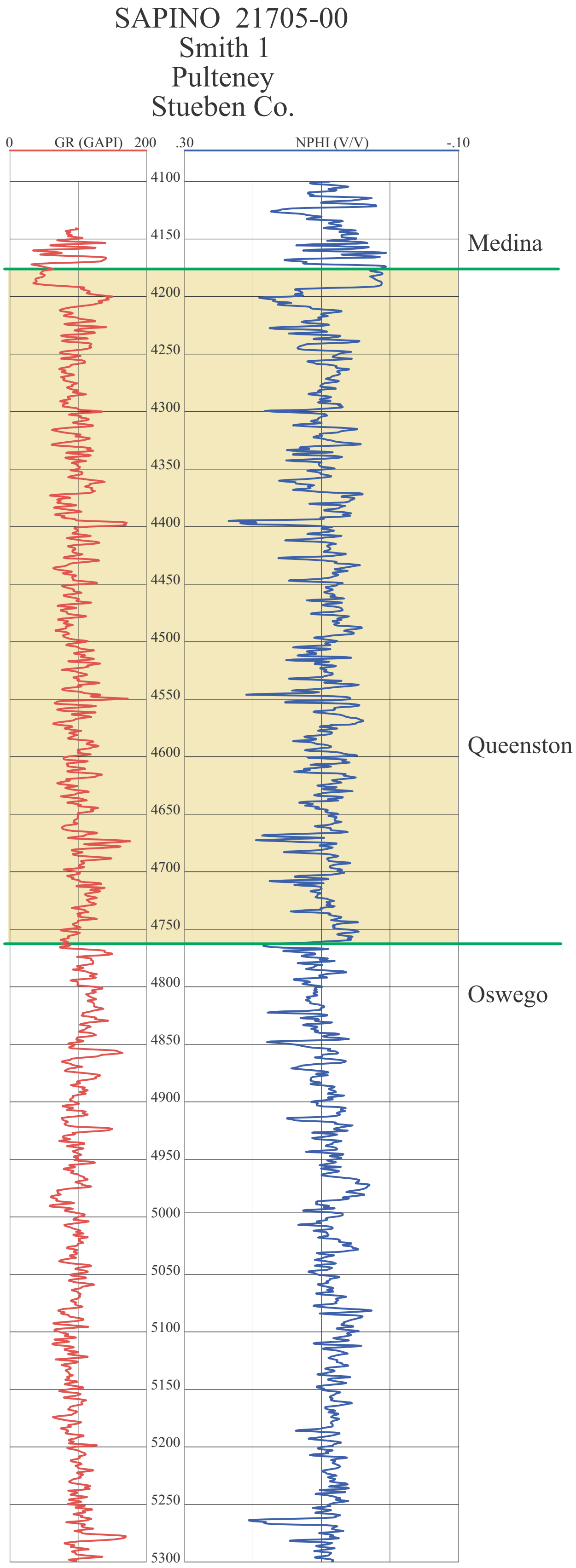


Figure 23

Queenston Formation representative log, south-central New York.

Formation Density Log Determination of Porosity

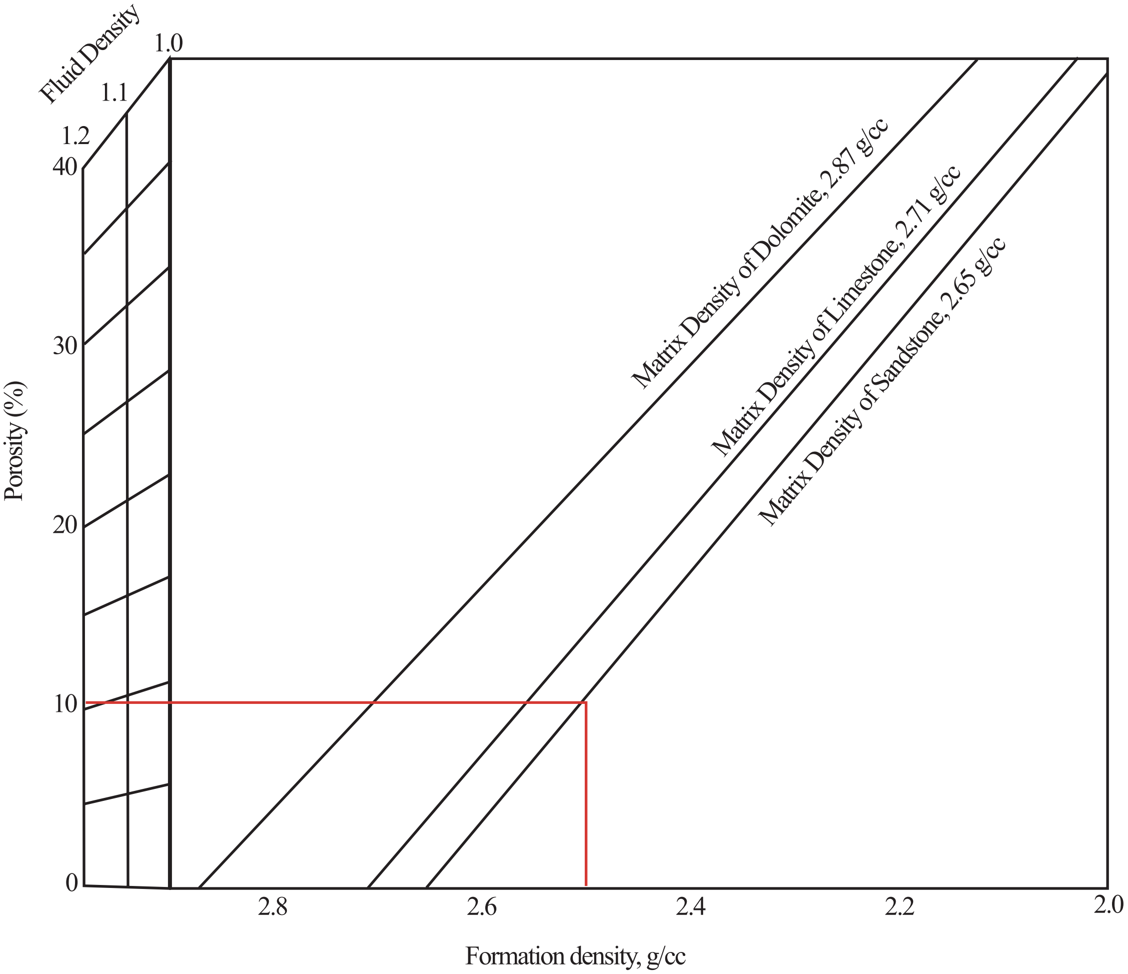


Figure 24 Chart for converting density to porosity using values picked from a density log. The red line shows the correlation between a sandstone density of 2.5 g/cc and porosity estimate of 10%. Porosities of 10% or more are needed in reservoir rocks. (Modified from Asquith, 1982)

by the sections. Geocolumn shading (described below) is used to highlight variations in lithology from the top of the Queenston Formation to the top of the Lorraine Group.

Gamma Ray logs record the natural gamma ray emissions of rocks that result from the disintegration of radioactive elements that naturally occur in the rock strata (Asquith, 1982). Figure 25 shows the relative radioactivity of selected sedimentary rocks (modified from Lynch, 1962). Clay minerals formed during the decomposition of feldspars and micas from igneous rocks tend to be enriched in radioactive material and also have the ability to absorb radioactive elements released during the decomposition of other minerals. Typically, this results in the enrichment of radioactive elements in clays and shale, compared to clean sandstones and carbonates. Based on this relationship the gamma ray log is often used to determine rock type, wherein shales will have high or "hot" gamma ray values and clean sandstones and carbonates are expected to have low values on the gamma ray curve (Lynch, 1962). The shading of the logs on the east-west and north-south cross section of the Queenston Formation (Plates 9 and 10) take advantage of this relationship to delineate what we interpret to be intervals of sandstone, shale and sandy shale. On these curves the shading is representative of the rock types and gamma ray values listed below in Table 2.

Table 2 Geocolumn shading explanation.

Rock Type	Color	Gamma Ray Values (API units)
Sandstone	Yellow	0-70
Sandy Shale	Orange	71-80
Shale	Gray	>80

Rock Mechanics Testing of Queenston Formation. Permeability tests were conducted on core samples from the Queenston sandstone from New York State. The core samples were selected from intervals of the Delaney #A-124-5 well (API #31-011-13645) that were identified as having visible porosity (see Appendix B). The test apparatus is shown in Figure 26. The test matrix

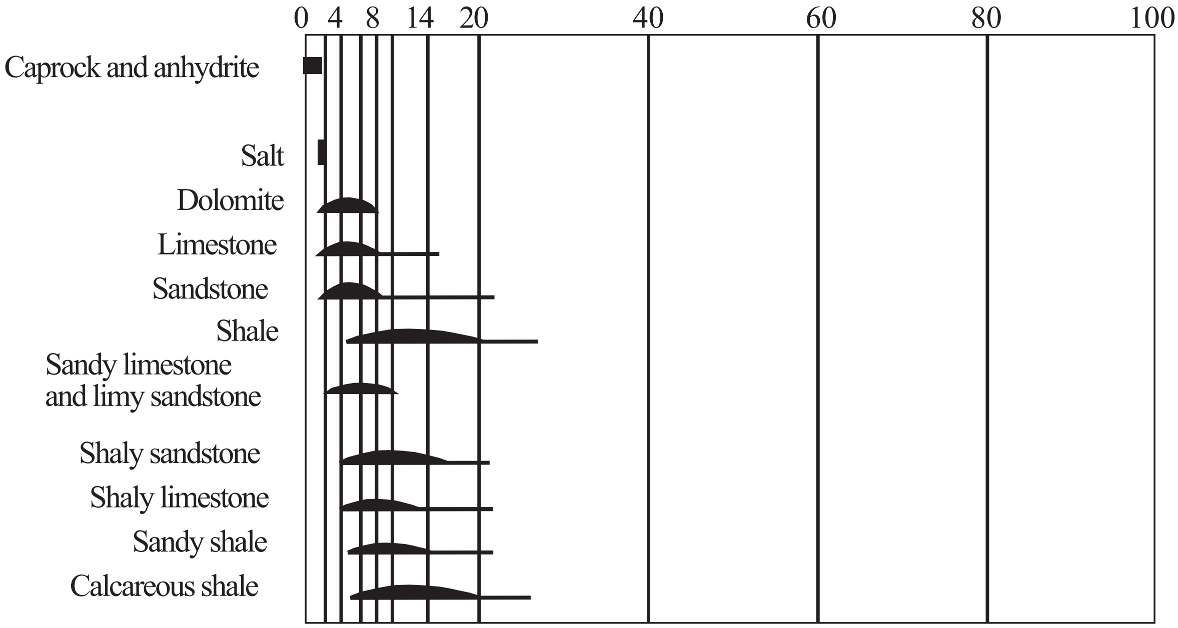
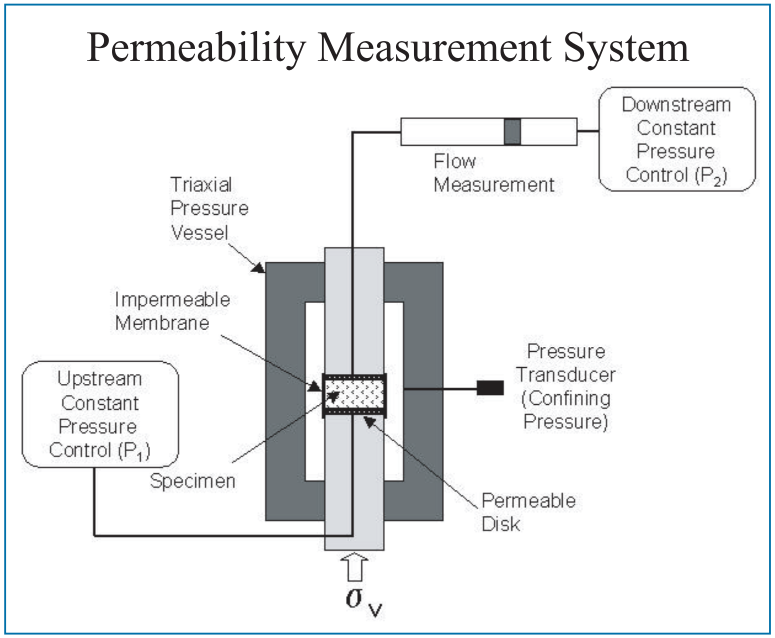
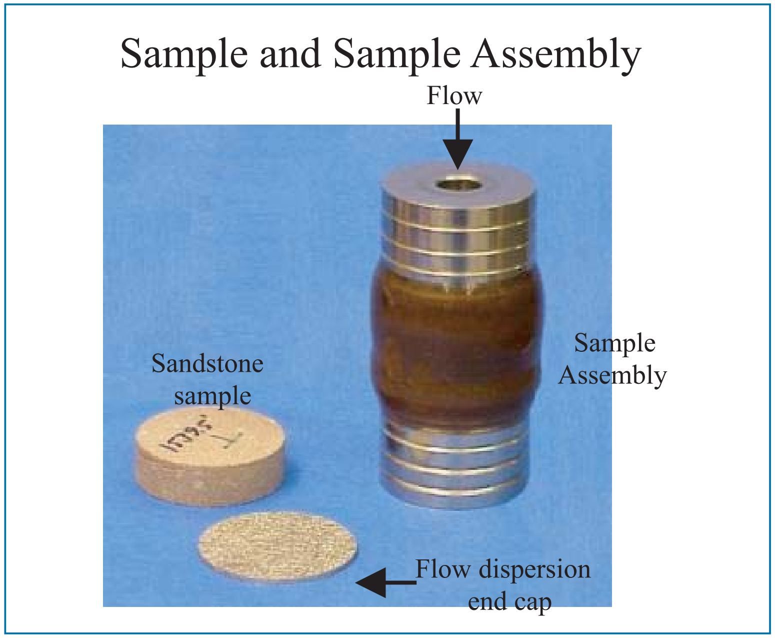


Figure 25 Relative radioactivity for selected sedimentary rocks (modified from Lynch, 1962)



Permeability Measurement System



Sample and Sample Assembly

Figure 26 Test Configuration and Picture consisted of over 80 tests preformed on 5 core samples. The confining pressure and pore pressures were varied over a wide range with the core orientated both parallel and perpendicular to the bedding planes, which were dominantly horizontal. A synthetic non-aqueous fluid (Isopar–H) was used in most of the tests, although brine and water were also used.

Modeling of Queenston Formation. A standard vertical injection well with and without stimulation was modeled. Stimulation or enhanced injection was achieved through modeling the effects of a large fracture extending radially from the well. The amount of stimulation through fracturing was varied in the modeling to determine how much stimulation was necessary to make a formation viable as a disposal reservoir.

Extensive fracturing can be problematic in tight formations, as potential for fractures to propagate out of the disposal zone and perhaps generate induced earthquakes exists. This hazard minimized with proper engineering. The injection pressure must be maintained below the minimum principal stress of the formation. Otherwise the formation could fracture. Although this is beneficial, and the practice is used to stimulate wells, it must be limited to prevent extensive fracture lengths, which could propagate outside the disposal zone and perhaps generate earthquakes. This potential was addressed in the modeling of the Queenston Formation by limiting the injection pressure to 90 percent of the minimum in situ stress.

Both 1-D radial and half-space models were used to simulate transient flow. The hydraulic conductivity of the formation was calculated from the viscosity of brine and the permeability of the rock as determined through the rock mechanic testing.

The pre-existing saturation content of the pore is important to storage. A gas filled pore enables much more brine to be disposed of than a fluid filled pore due to the compressibility of the gas. Water saturation varies from complete saturation to near gas filled pores. For purposes of these analyses the storage coefficient was based on a saturation of 50 percent. Scoping studies showed that some degree of gas saturation is an important to successful storage. In its absence, the compressibility of formation water is insufficient to accommodate the large amount of brine that needs to be disposed. The modeling of formations initially saturated with water would require the displacement of formation fluids over a very large area to reach the desired storage volumes.

The flow of brine into a formation is time dependent. At constant injection pressure, the amount of flow rate will decrease with time as the pore pressure in the formation builds up. Initially the pore pressure in the formation is assumed to be hydrostatic. The mathematical formulation for radial flow is presented below. The flow rate (q) from a well of radius r is defined as follows:

$$\dot{q} = 2\pi r T \frac{\partial h}{\partial r}$$

where T is the transmissivity of the formation and $\delta h/\delta r$ is the hydraulic gradient near the well bore or the change in head (h) with distance (r) into the formation. The transmissivity is a product of the thickness of the disposal layer times the hydraulic conductivity (K). Although most formations are commonly a hundred or more feet thick, the high permeability layer typically resides in the upper 10 to 150 feet of the formation. Therefore the assumed thickness used in the analyses is 100 feet unless otherwise noted. The injection amount scales directly with the layer thickness. Therefore the results are applicable to any thickness, provided they are scaled to the known thickness of the disposal layer. Hydraulic conductivity is related to permeability (k) and the fluid properties through the relationship:

$$K = k \frac{\rho g}{\mu}$$

where ρ is the density of the brine, g the gravitational constant, and μ the brine viscosity. The above relationships show that the injection rate into a formation is directly proportional to the formation permeability.

The hydraulic pressure gradient is dependent on the injection pressure and time. Over time, the gradient decreases as pore pressures spatially distribute in the formation. This results in less injection assuming the injection pressure in the well remains unchanged. A constant injection pressure was used in the analyses to provide the maximum amount of disposal. In practice, both the injection rate and pressure may vary as completion of the multiple injection and cavern wells is phased in over time.

The change in head over time (t) can be simulated using numerical solutions (the finite difference technique was used here) according to the following second order partial differential equation

$$\frac{\delta^2 h}{\delta r^2} + \frac{1}{r}\frac{\delta h}{\delta r} = \frac{S}{T}\frac{\delta h}{\delta t}$$

where: S is the storage coefficient or storativity of the disposal horizon. Storativity is defined as the volume of fluid that the disposal layer can accept per unit surface area of the layer per change in head.

Queenston Formation - Description

The Upper Ordovician Queenston Formation was selected as a potential brine disposal reservoir because it is a widespread sandstone that has produced gas in north-central New York for more than 60 years and it has proven to have the capacity to accept brine in current brine disposal operations in Bath, New York. Where it produces gas in north-central New York, the formation has salinity of over 200,000 ppm, which makes it appropriate for brine disposal. Data tables related to the Queenston Formation are located in Appendix B.

The Queenston Formation, which crops out just south of Lake Ontario (Kreidler, 1975) is roughly 700-1,000 feet (244-274m) thick in most of western New York. Figure 27 is a map of the Queenston surface exposures in New York State. Exposures of the Queenston Formation are limited both by the non-resistant nature of the formation and by the thick cover of Pleistocene sediments (Hughes, 1976). Kreidler (1975) reviewed available well data for the Queenston and determined that the formation for the most part is thicker in western New York and thins to the

Outcrop Map of the Queenston Formation
in New York State

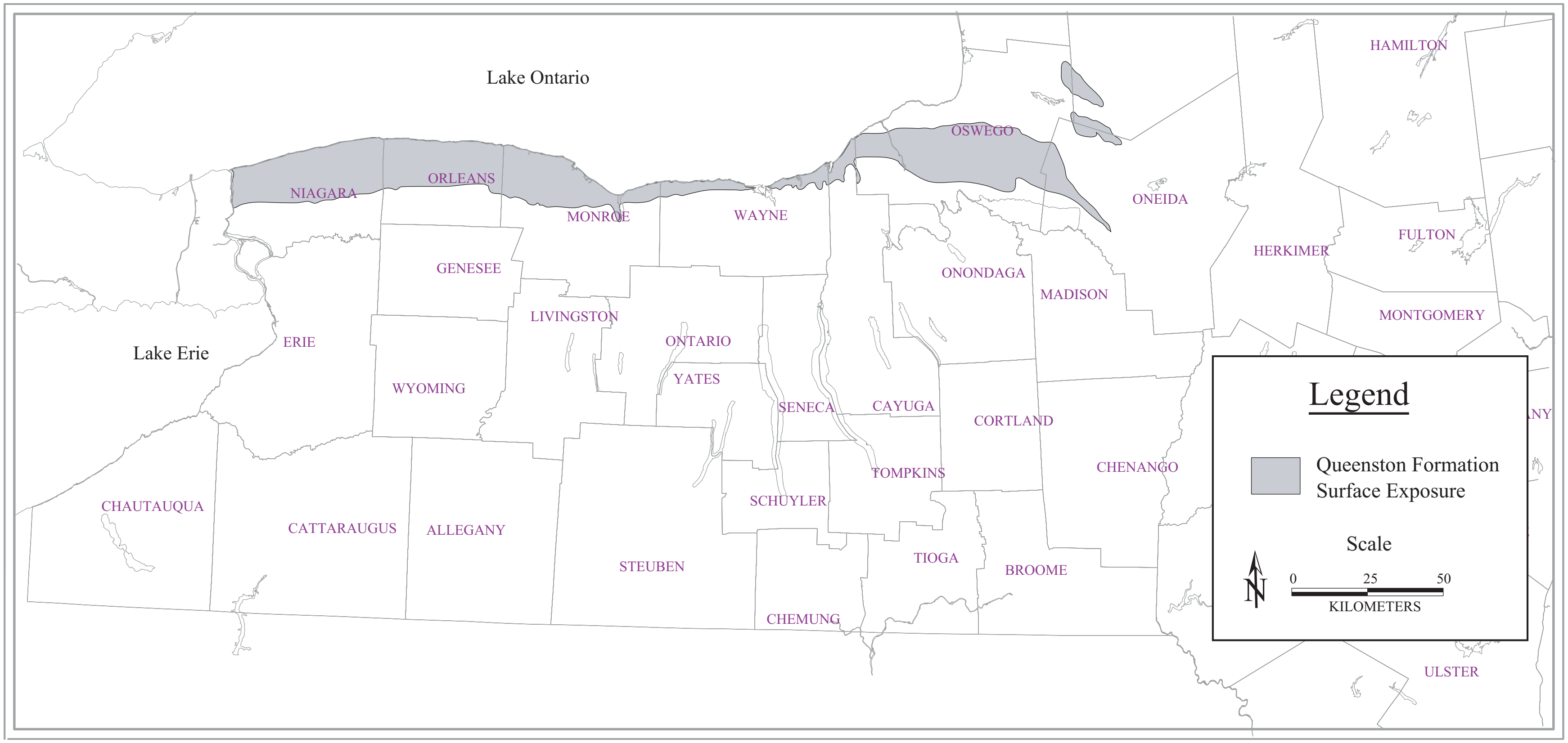


Figure 27 The Queenston Formation outcrops in an east-west band across the northern portion of western and central New York State.

east. In New York State, the lower units of the Medina Group unconformably overlie the Queenston Formation.

In the subsurface, the Queenston Formation is a thick sequence of shale, siltstone and fine- to medium-grained sandstone ranging in color from reddish brown, gray to green. The Queenston Formation was laid down as part of a sequence of detrital clastic deposits that formed a large deltaic complex. In general the clastic material comprising the Queenston becomes coarser from west to east as you get nearer to its source, the Taconic uplands. The formation is mainly composed of sandstone in the southeastern part of the study area and grades to shale and siltstone to the northwest. The thickening and coarsening of the Queenston is illustrated in Figures 28 (modified from Saroff, 1987) and Plates 9 and 10.

The top of the Queenston Formation is roughly 1,000 to 1,800 feet below sea level in the producing area in north-central New York. Figure 29 and Plate 11 are a structure contour map of the Queenston Formation. From the Producing area the formation dips to the south roughly 50 feet/mile, reaching depths of 6,000 feet or more below sea level at the New York - Pennsylvania Border. Within the study area the Queenston is between 2,500 and 6,500 feet below sea level. The formation has a consistent thickness of roughly 550 feet to 700 feet in Plates 9 and 10, but other researchers have reported thicknesses up to 1,000 feet in portions of western New York (Saroff, 1987). The shading on the regional cross section in Plates 9 and 10 indicates different lithologies as interpreted from the gamma ray log in each of the wells (see methods section). The yellow shading highlights sections with lower gamma ray values, which we interpret to be sandstone. On both the east-west and north-south cross sections, the sand content varies, but over all these sections show that the Queenston is increasingly sandy to the south and east, with the sandiest sections located in the upper portions of the well.

The Queenston Formation and underlying Oswego Formations are often grouped together in studies due to their similar lithology. Figure 30 and Plate 12 are an isopachous map of the Queenston-Oswego interval. Note that this interval is thickest in south-central New York in areas where salt cavern storage facilities could be developed. According to Kreidler (1975) the deeper portion of the basin near Corning and Binghamton, New York offers a better potential for

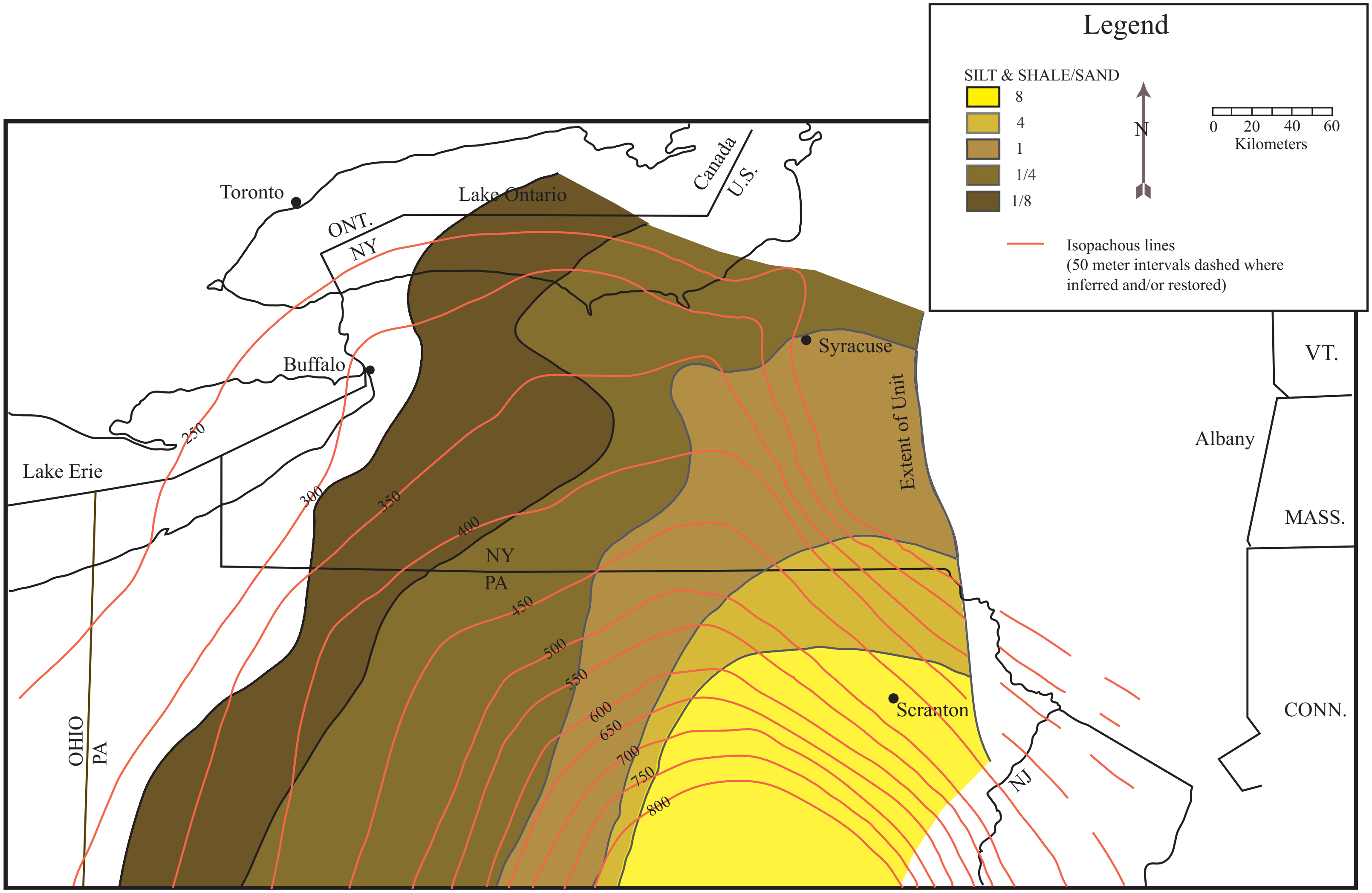


Figure 28 Upper Ordovician Oswego and Queenston Formations Isopachous and Sand/Shale ratio map (modified from Saroff, 1987).

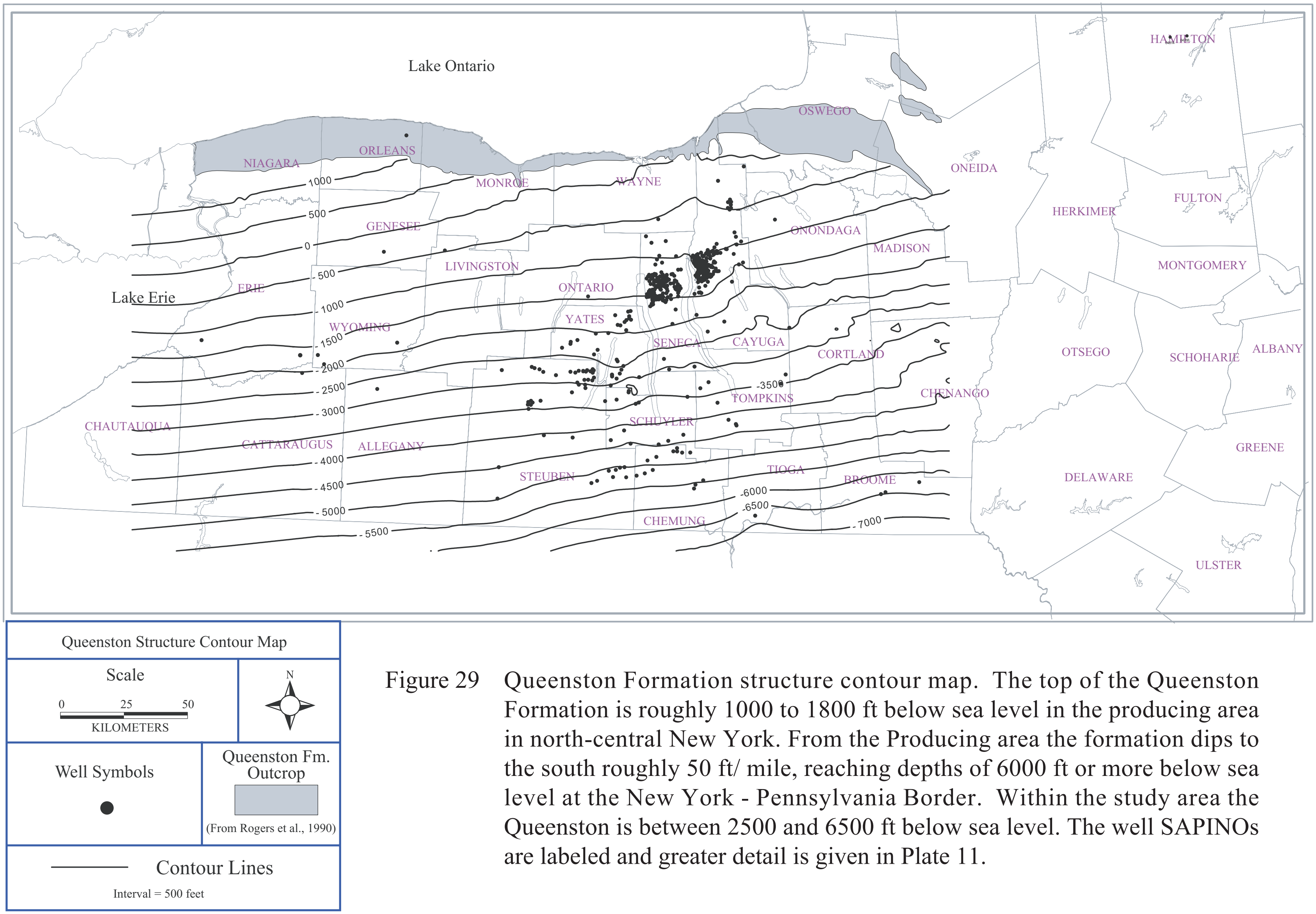


Figure 29 Queenston Formation structure contour map. The top of the Queenston Formation is roughly 1000 to 1800 ft below sea level in the producing area in north-central New York. From the Producing area the formation dips to the south roughly 50 ft/ mile, reaching depths of 6000 ft or more below sea level at the New York - Pennsylvania Border. Within the study area the Queenston is between 2500 and 6500 ft below sea level. The well SAPINOs are labeled and greater detail is given in Plate 11.

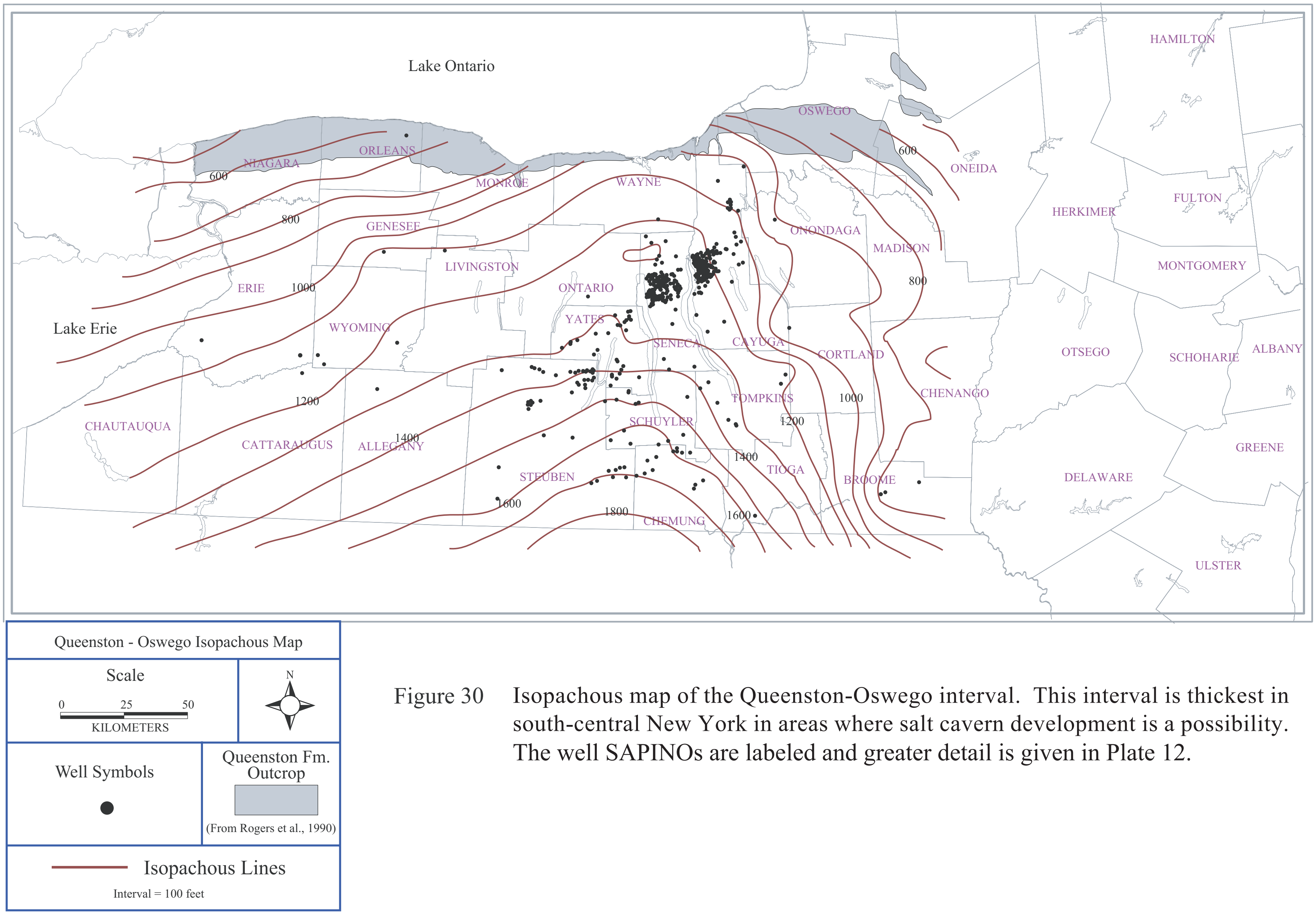


Figure 30 Isopachous map of the Queenston-Oswego interval. This interval is thickest in south-central New York in areas where salt cavern development is a possibility. The well SAPINOs are labeled and greater detail is given in Plate 12.

disposal of liquid wastes. At the time Kreidler conducted his study, few wells had been drill in this area that were deep enough to reach the Queenston.

Production from the Queenston Formation has occurred at the West Auburn Field in north-central New York (Figure 31) for over sixty years (since 1940).   Figure 32 (modified form Saroff, 1978) illustrates the mechanism that has allowed gas to be trapped and subsequently produced at economic rates in this area. Gas migrates updip within the sandstone facies of the Queenston Formation until it encounters a facies change, which acts as a permeability barrier. The Grimsby Formation overlying the Queenston is a silty shale in the Queenston producing region and therefore acts as a caprock (Saroff, 1978).

Because of the benefit to production, the Queenston Formation's petrophysical and geological attributes have been studied in the vicinity of the West Auburn Field. Ward, 1988 reported that there are 3 primary gas sands in the Queenston in the producing area and that together they have an average porosity of 13% and a permeability of roughly 0.2 md with extreme examples showing peak porosities approaching 20% and permeabilities over 5.0 md. In 1987 and 1988 Saroff reported on his study of 111 wells from the West Auburn Field. Saroff (1987 and 1988) found that the Queenston Formation contained several intervals of various thickness where the sand content is over 75% and intervals where the apparent porosity is over 10%. Saroff (1987) also stated that other authors had reported permeabilities of 0.1-1 md for the Queenston in this area.

Both Ward (1988) and Saroff (1987 and 1988) discuss the importance of the regional and local structure on the productivity of wells within the field. Saroff (1987 and 1988) noted that the better producing wells were located in areas with higher sand content, though he felt that it was more important that these wells were completed in zones of increased fracturing. Saroff determined that the zones with increased fracturing were focused “on trend” with Precambrian basement faults as recognized in regional gravity and aeromagnetic survey maps. Ward (1988) also commented that the occurrence of natural fractures are associated with gentle folding within the field and contributed to production from what is generally considered a low permeability reservoir.

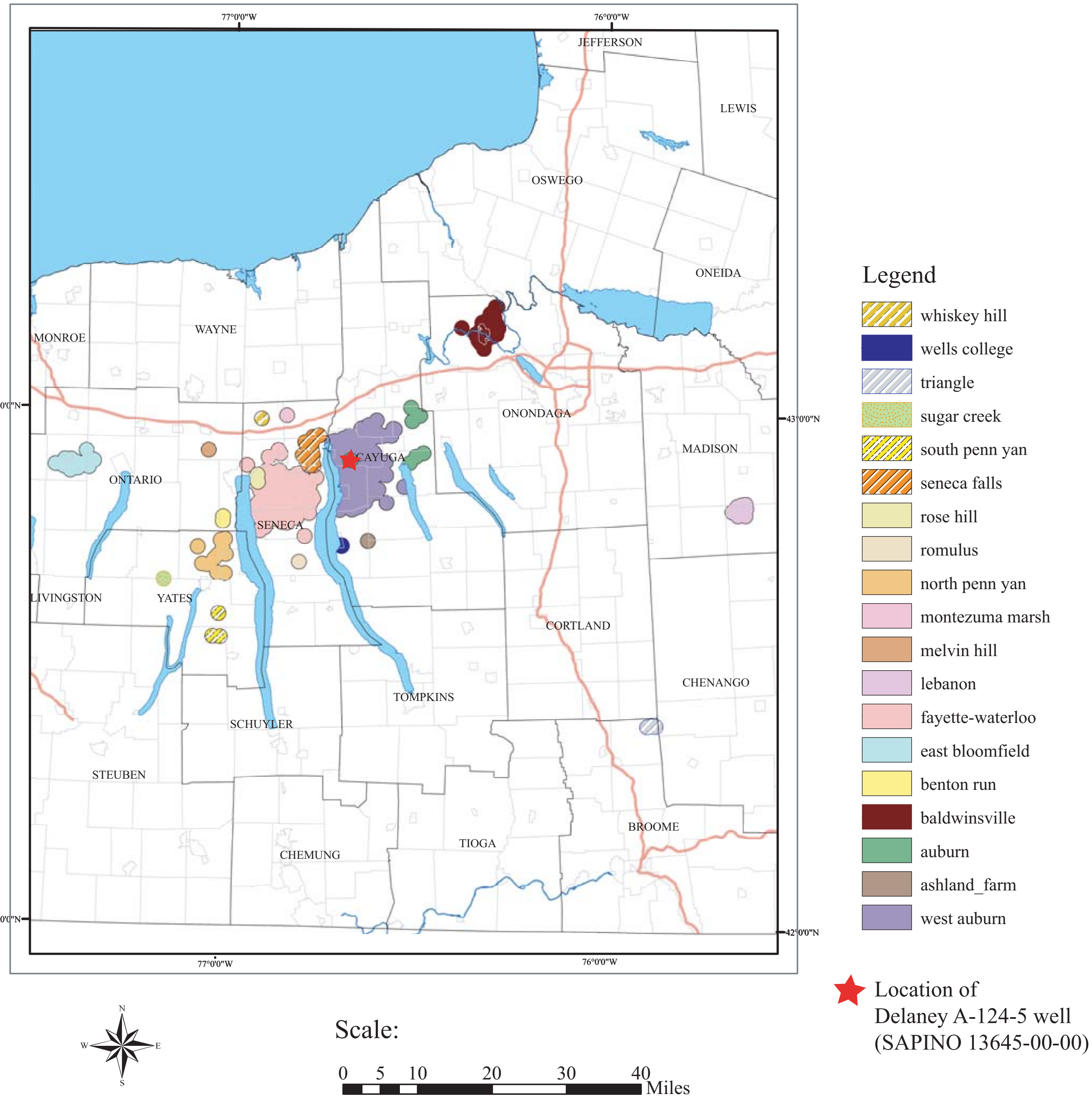


Figure 31 Map of fields producing from the Queenston Formation in north- central New York

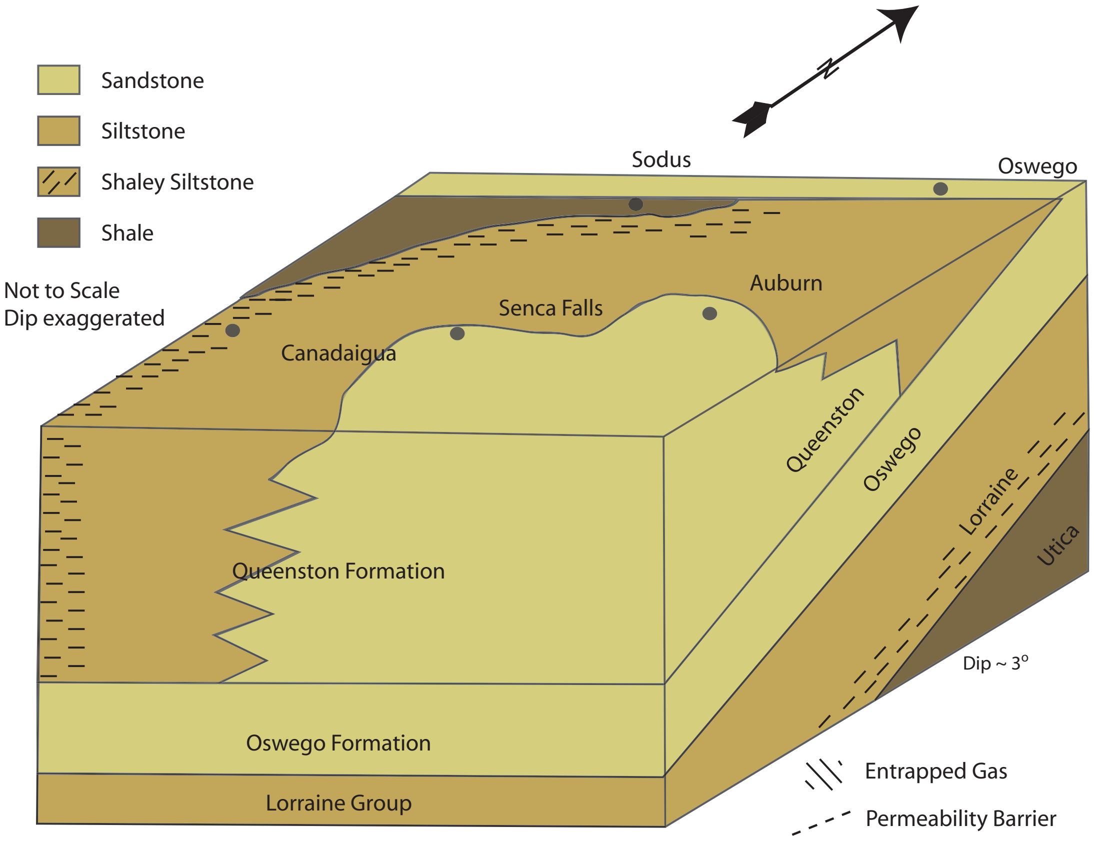


Figure 32 Model of gas entrapment. Gas migrated up dip and was subsequently trapped within the sandstone facies and against a permeability barrier within the the Queenston Formation. The Grimsby Formation, a silty shale, lies directly above the Queenston in this area, and forms a caprock (From Saroff, 1987).

Bath Petroleum Inc., in Steuben County recently disposed of brine from their holding ponds into the Queenston Formation in a well located at their facility (BPSI 8, 21551-00). This use of the Queenston was allowed by the DEC (New York State Department of Environmental Conservation) only to alleviate emergency conditions and was temporary. Bath Petroleum Inc. disposed into the formation at rates between 3-5 bbls/min for at least two months (see Appendix B). It is not known how long this might continue and whether the formation could accept brine from multiple disposal wells in the same area or if it would work elsewhere in the study area, but these results are encouraging. Bath is currently seeking permits that will allow them to use this well for disposal on a more regular basis.

Delaney A-124-5 Well – Core Description. Our group has observed lithology similar to that described by previous studies of the Queenston Formation in the cored interval from Miller Brewing Company's Delaney A-124-5 well (SAPINO = 13645-00) in the West Auburn Field, Cayuga County, New York (location marked by a star on Figure 31). Plate 13 is the entire core description for the Delaney A-124-5 well and contains many thin section and core images that are correlated to the description and geophysical well logs.

Three general rock types were observed in the core (Figure 33). A medium- to fine- quartz rich sandstone, a thinly bedded siltstone and 0.5 inch to 6 inch thick conglomeratic sections where pebble sized clasts of ripped-up siltstone have been incorporated into the sandstone (both matrix and clast supported conglomerates were observed).

Several sections of sandstone exhibit visible porosity (highlighted in red on and Plate 13). In these sections and others, intergranular porosity was also observed in thin section. Both the visible porosity in the core and the intergranular porosity observed in the thin sections are often found in linear, horizontal bands associated with horizontal fracturing. Figure 34, the upper 150 feet of the Delaney A-124-5 core description, illustrates that there are several zones of visible porosity in this section. These zones of porosity are often associated with mircrofracturing and correlate with drops below 2.5 g/cc on the density curve. Porosity was visually estimated from thin sections through out the core and varies from 0 % to as high as 15%, but is more commonly less than 5%. Appendix B contains a list of these porosity estimates by depth. While, the zones of visible porosity described in the core do occasionally align with high estimates of porosity from the thin sections, no correlation can be made.

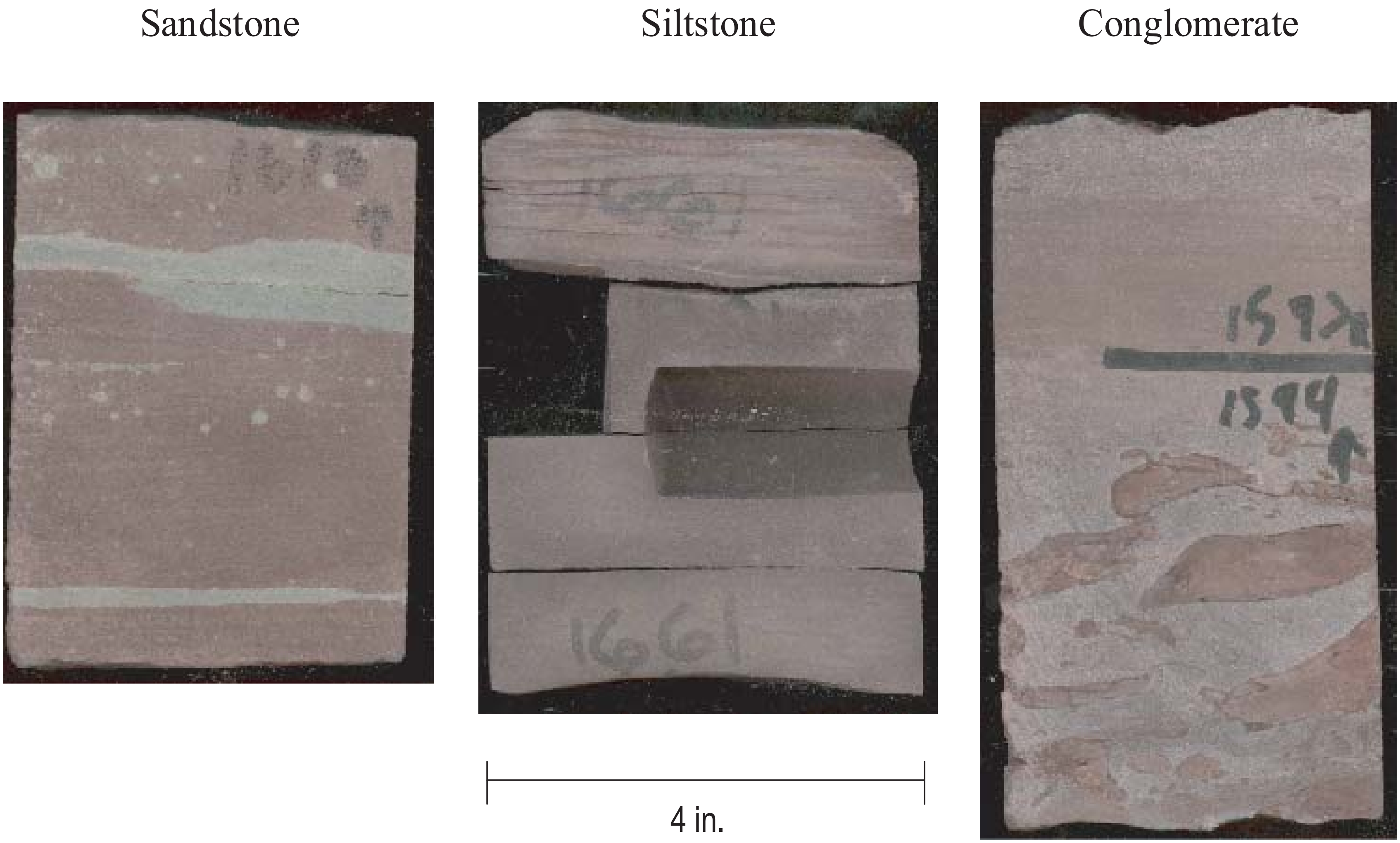
An X-ray diffraction study completed on the Delany core (H.J Gruy and Associates, 1979), concluded that the upper Queenston sandstones in this well have a high total clay content, reaching as much as 20% (5.25% Montmorillonite, 7.50% Illite, and 8.00% Kaolinite). The high clay content increases the likelihood for particle plugging between the pores, which would reduce flow of gas into the well bore or flow of water away from the well bore during injection.

<u>**Testing and Modeling Results for the Queenston Formation.**</u> The permeabilities of the Queenston Formation in the Delaney well were found to correlate to the difference in the confining and pore pressures. By necessity, the confining pressures were larger than the pore pressures. As shown in Figures 35 a smaller difference in the confining pressure resulted in the largest permeabilities. Table 3 shows the range, mean and median permeabilities measured. In some cases, samples located less than a foot a part had two orders of magnitude difference in permeability. Orientation did not seem to be a factor influencing permeability.

Table 3 Test Matrix

Formation	No. of Samples	No. of Tests	Confining Pressure	Pore Pressure	Range in Permeability (m-D)	Mean Permeability (m-D)	Median permeability (m-D)
Queenston	5	86	470 to 7000	100 to 6700	0.000027 to 0.0979	0.0162	0.0074

As stated above, Isopar-H was typically used during testing. When water was used to test the Queenston Formation, no measurable permeability resulted. It is thought that the presence of clay (discussed above in the description of the Queenston Formation) was the underlying cause for the flow resistance as clay can cause particle plugging and swelling when wetted. A sample was tested using saturated brine. The results of that test compared favorably to those using Isopar-H. The swelling of clays is limited by brine, in contrast to water. High salinity sodium


Sandstone

Siltstone

Conglomerate

Figure 33 Rock types found in the Delaney A-124-5 core (SAPINO 13645-00-00).

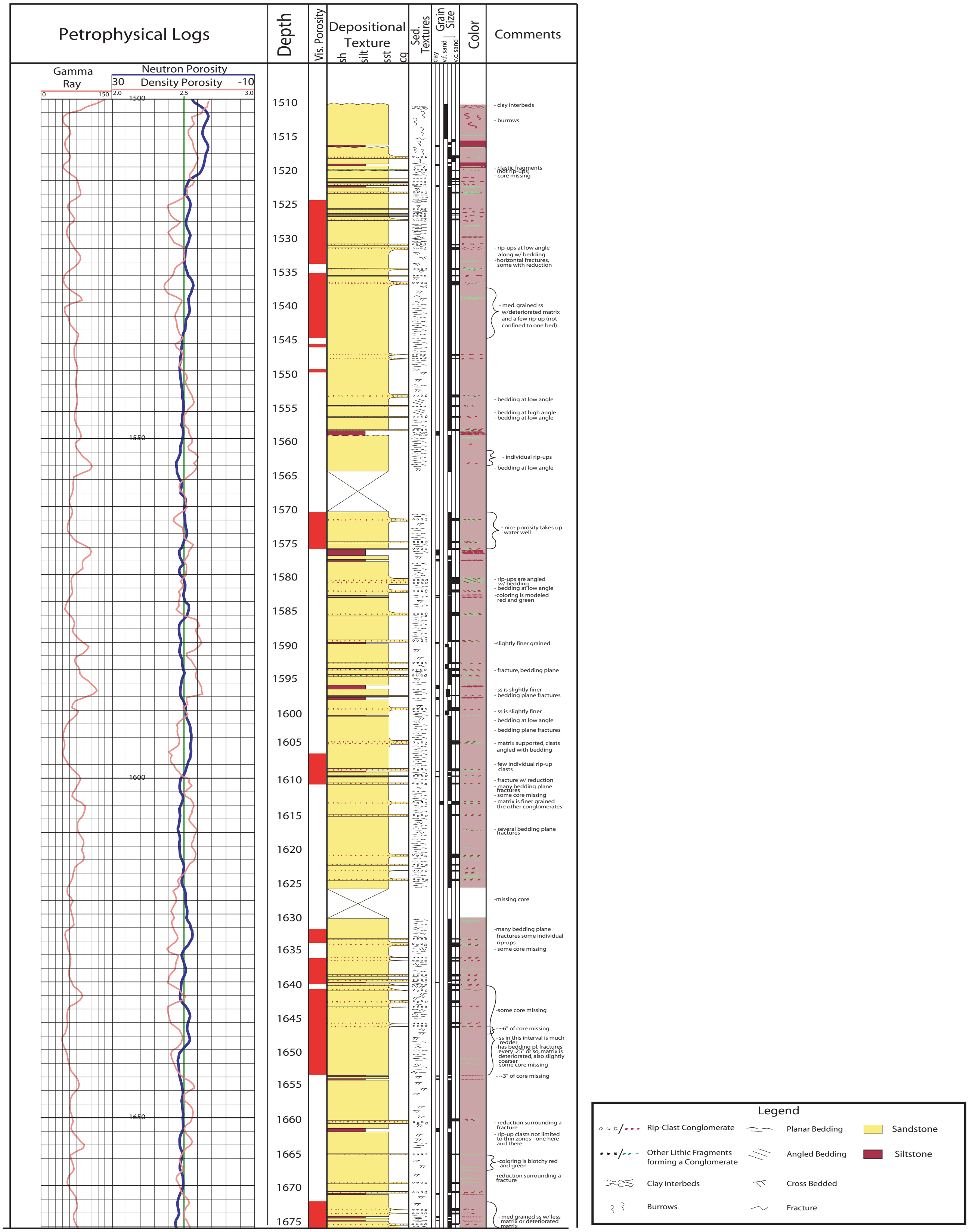


Figure 34 Queenston Formation Core Description from the Delaney A-124-5 well in Cayuga County, New York. The location of this well is shown on Figure 30.

chloride brines (s.g.>1.1) preclude the swelling of clays and minimizes clay dispersion. Therefore if clays are known to exist in the disposal formation, caution must be taken on the well completion as not to use fresh brine. Once the cavern is being leached, the salinities are high enough as to not impact on brine disposal.

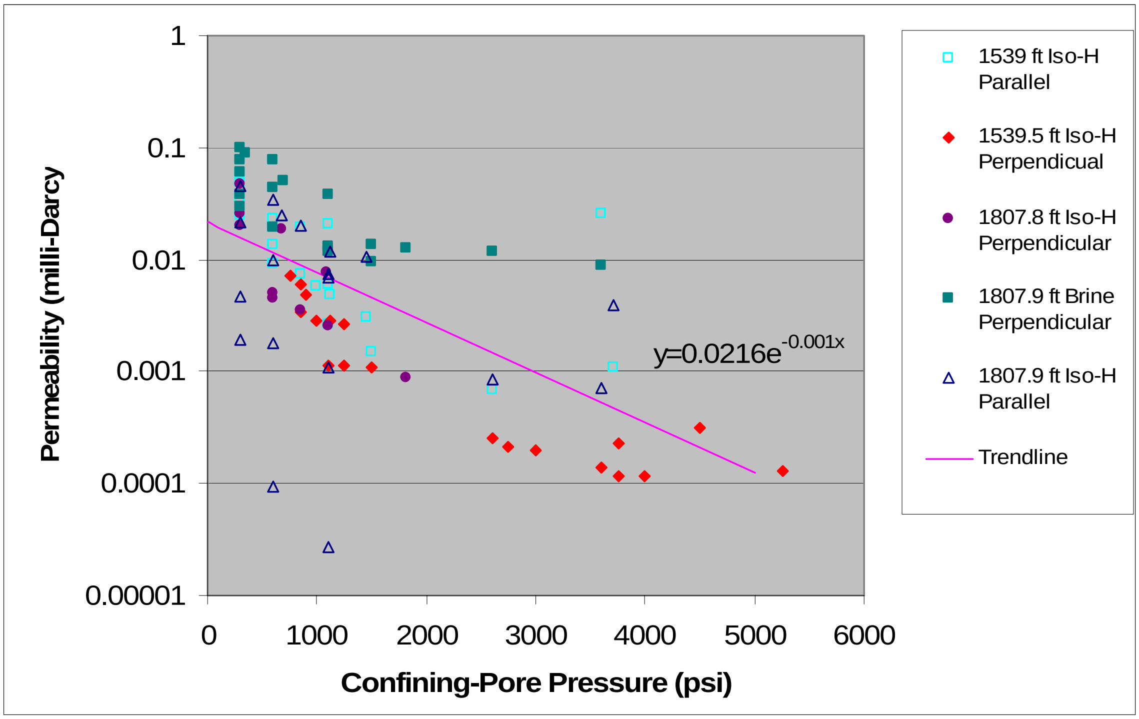


Figure 35 Queenston Sandstone Permeabilities.

The permeability of the Queenston sandstone was found to vary with porosity. A similar trend was noted in previous test conducted by H.J. Gruy and Associates, Inc. (1979) on the Queenston Formation in plugs removed from the Delany core. In that study, the permeability was found to be a strong function of porosity, and relationships were developed from tests conducted on 296 plugs and 83 whole core samples (Figure 36). The small size of the plugs used in the above testing and by Gruy and Associates resulted in a smaller permeability as shown in Figure 37. The average, minimum, and maximum porosity and permeability results are shown for the Lee plugs (current research). For purposes of analyses the relationship developed for the whole core permeability is used.

$$K\text{ (milli-Darcy)} = 0.0005\ e^{0.5478\text{porosity (\%)}}$$

The average porosity of whole cores tested was 10.8 percent, resulting in a permeability of 0.185 milli-Darcy. The porosity of the formation not only increases the permeability, but increases the storage capacity of the formation, which would enable more brine to be disposed. The excellent agreement of the current test results (current research) with previous work by Gruy and Associates suggests that the permeability of the Queenston is consistent.

When injection was modeled in into upper 100 feet of the Queenston Formation through a vertical well over a 3 year period, the brine migrated approximately 500 feet from the well (Figure 37). The total amount of brine disposed in the single well was less than 150 MB bbl, far short of the 15 MMB needed in each well. Figure 38 shows an injection rate of less than 0.1 BPM, which again is well below that needed for economical disposal (10 BPM).

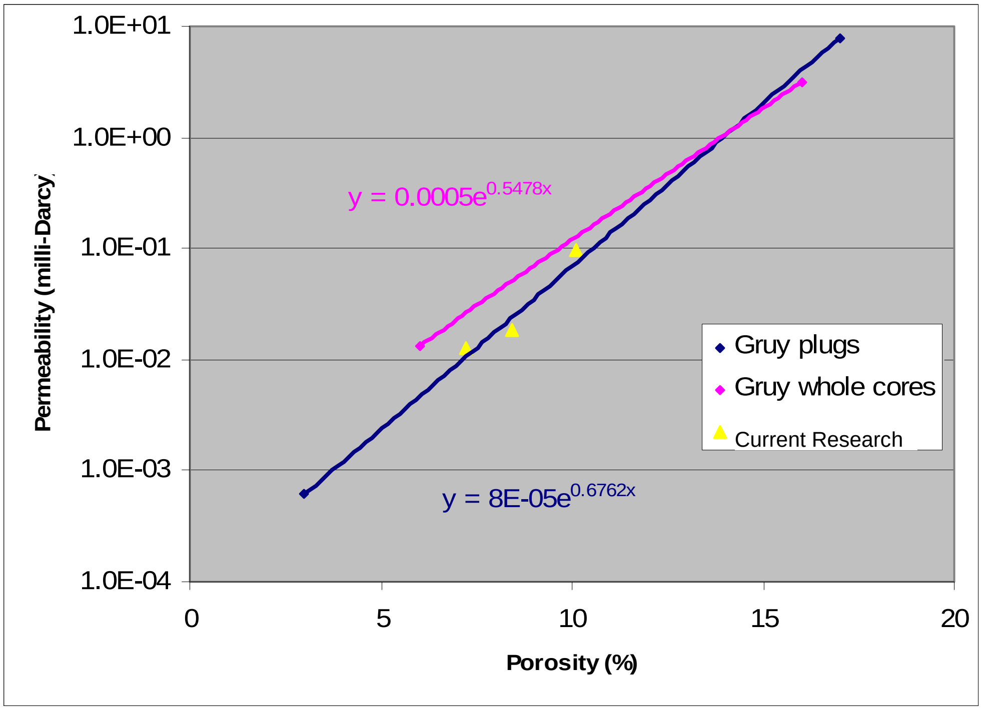


Figure 36 Comparison of Relationships Developed by Gruy and Associates in 1979 to Current Research Tests Results of Lee, 2004 for Queenston Formation.

The facility operated by Bath Petroleum Inc. was visited for this study and later the company produced injection records for the top of the Queenston (discussed above in the background section). An injection rate of 5 BPD was sustained over a several month period. These records show that the resistance to flow increases with time. In this case, the injection pressures rose 25 percent over the injection period. If pressures had been maintained as in the modeling, the injection quantities would have decreased a commensurate amount. At the Bath facility, the injection zone was 2,000 feet deep. At greater depths, the rate would increase and the difference between the hydrostatic pressure at startup and the maximum formation pressure would be greater. It has been calculated that at 4,250 feet, the injection rate would be 45 percent greater. This would result in 7.2 BPD. While the injection rate is slightly below the criteria established for disposal (Evaluation Criteria 1 - 10 BPM), it demonstrates that injection potential exists in the Queenston.

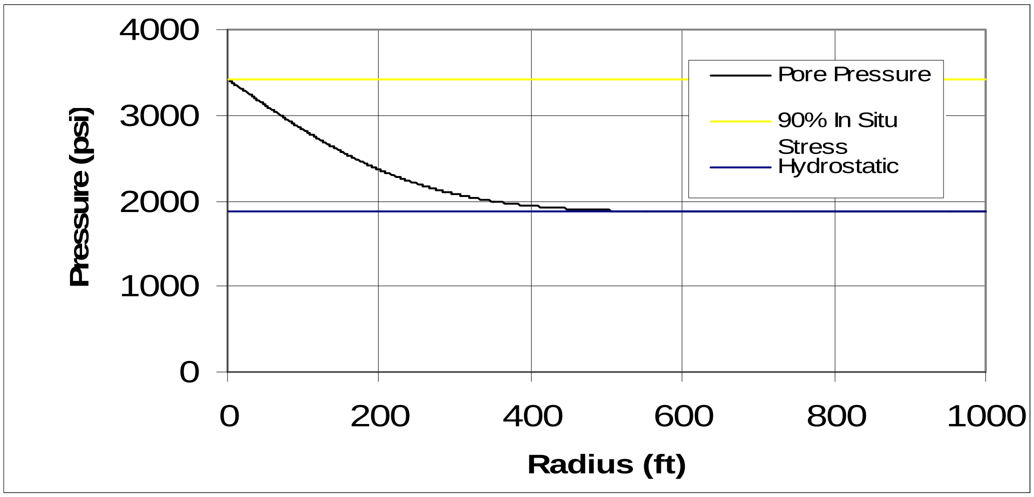


Figure 37 Brine Pressure in Queenston after 3 years (Vertical Well).

The addition of a horizontal fracture extending from the wellbore is considered in the model. The fracture is assumed to have small resistance to flow, and thus acts as a conduit for delivery of brine to the formation. The geometric configuration is illustrated in Figure 39.

Using the same porosity (10.8%), permeability (0.185 milli-Darcy), and layer thickness (100 feet), the radial distance that the fracture must extend from the wellbore can be computed to meet the criteria established for successful disposal. In this case, a fracture length of 2,950 feet enables a sufficient formation volume to be exposed for storage of the brine and at time frame that is more than adequate to accomplish disposal in 3 years (Figure 40).

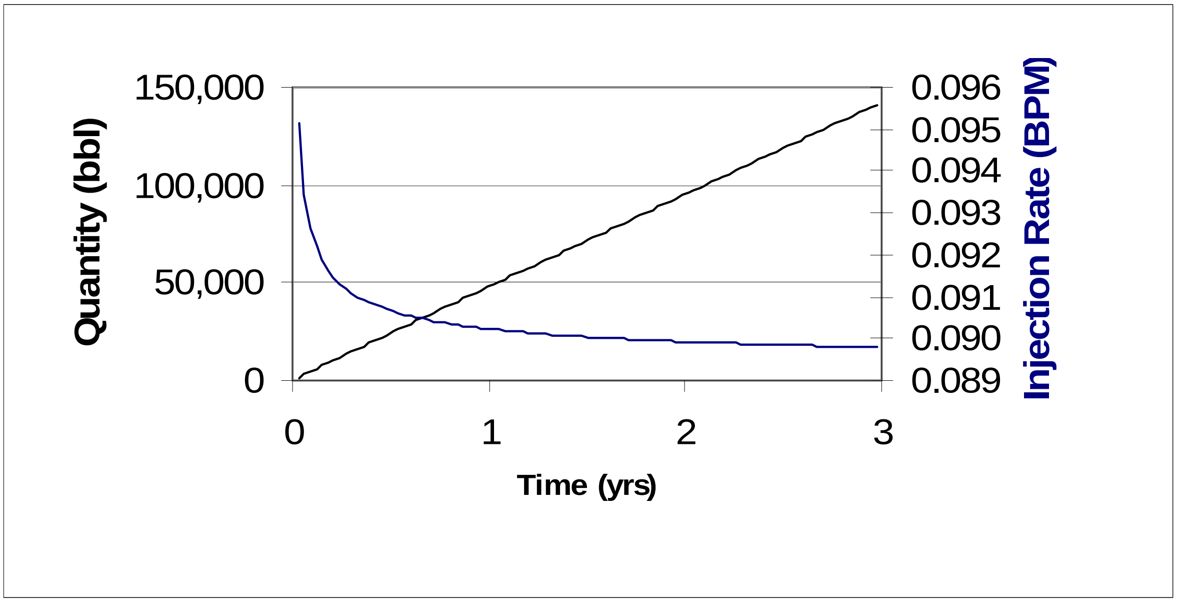


Figure 38 Brine Injection Quantity and Rate for Queenston (Vertical Well).

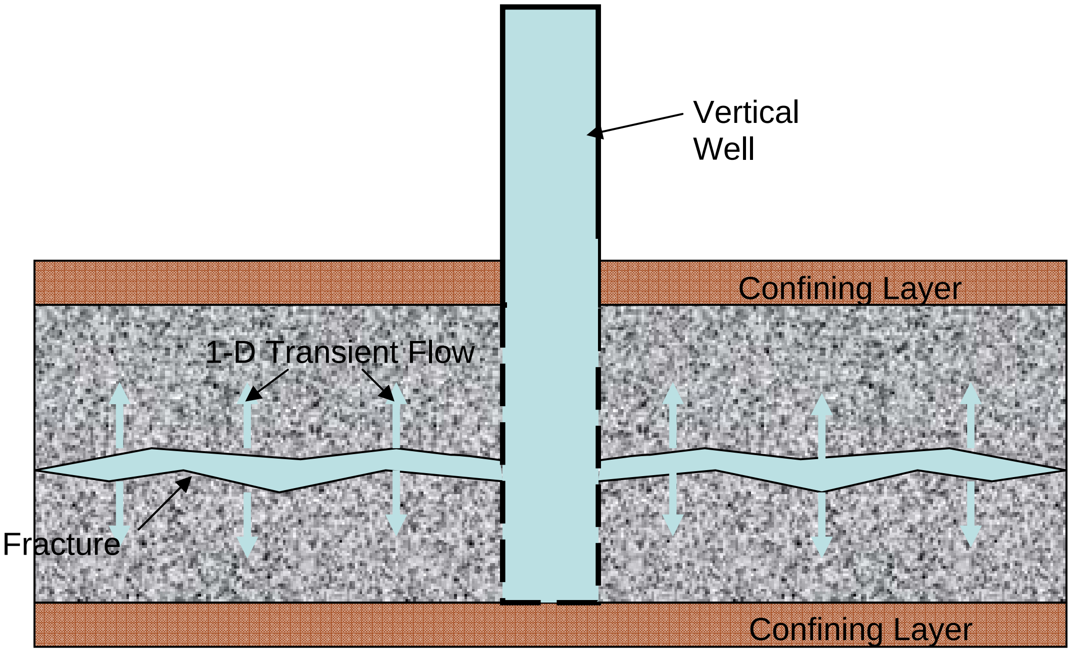


Figure 39 Illustration of Fracture Conduit.

While natural fracture lengths on the order of 3,000 feet may exist underground, they are difficult to discover and characterize prior to drilling. Advances in geophysical techniques may someday enable discovery of the necessary natural fracture system and hence guide successful well locations. In the absence of that, operators can stimulate wells through hydrofracturing. By over-pressurizing the formation, a fracture can be induced. This practice can be performed prior to brine injection whereby a proppant is used to keep the flow path open. A typical fracture length for stimulation is limited to 500 feet. While larger fracture lengths are possible, as is the practice of growing the fracture during brine disposal, the generation of large fractures can result in earthquakes. Nicholson and Wesson (1990) provide an overview of known and suspected underground injections that have resulted in earthquakes in the U.S., including a case study in the Attica-Dale area (western NY). More recently (2001), injection tests performed for a gas storage project near Avoca, NY correlated to magnitude 2.5 and 3.2 earthquakes during the 3 week test duration. Modeling of the tests predicted a fracture length of over 500 feet. It is interesting that geologists believe that some of the fracture systems that exist in NY were indeed the result of natural hydraulic fracturing (Carter et al, 2001).

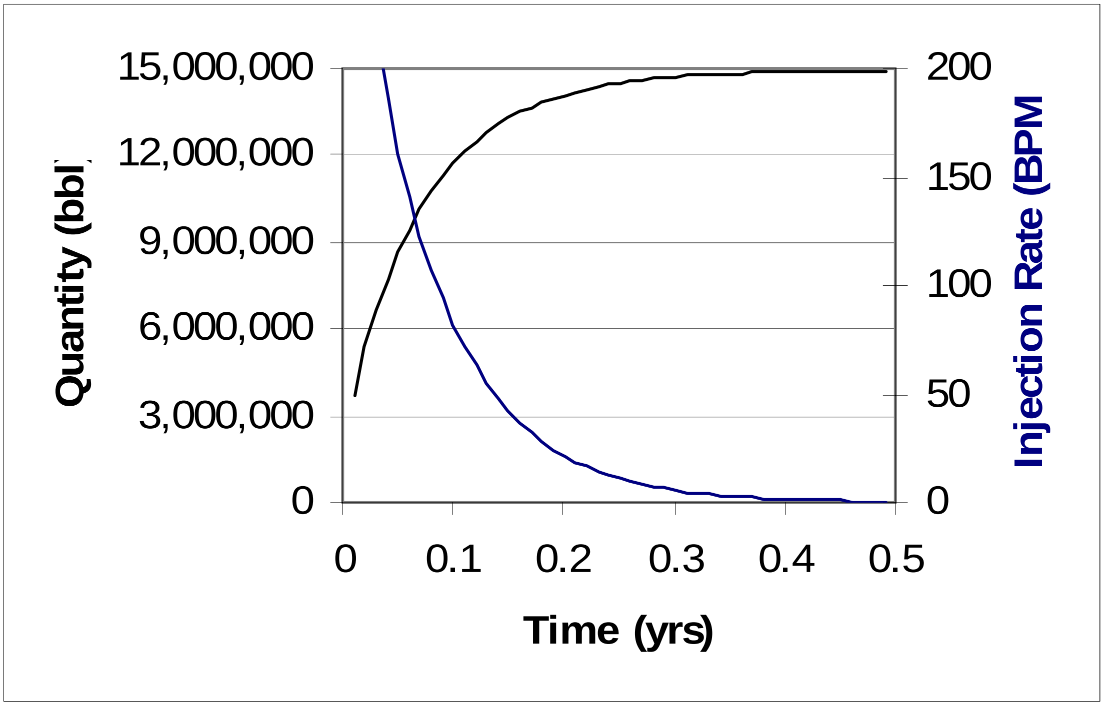


Figure 40 Fracture Conduit Flow in Queenston (Vertical Well with Fracture)

Another way to achieve higher rates of brine disposal is the emplacement of a horizontal well as illustrated in Figure 41. In this model, the height of the formation is assumed to be small compared to its lateral extent.

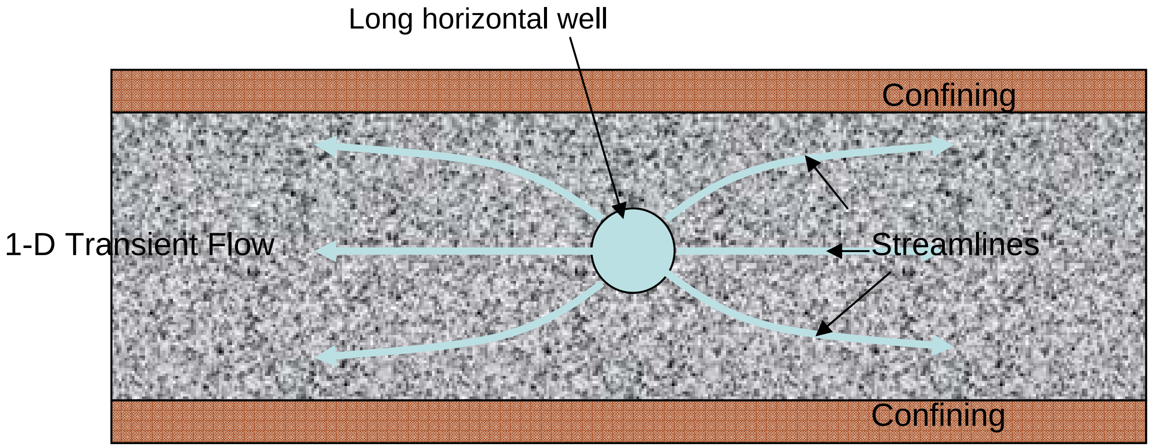


Figure 41 Illustration of Horizontal Well

In order to achieve the desired brine production over 3 years, a well with an 11 mile length through the formation is needed. The predicted brine pressures in Figure 42 show brine flow up to 600 feet from the well bore during this time, and the flow criteria is met (Figure 43). The costs of horizontal drilling are typically more expensive than a vertical well, depending upon the stimulation techniques used. An 11 mile well would be considered extensive by today's standards. Horizontal wells typically run 1 to 3 miles. The injection would be reduced in proportion to the well length.

Horizontal drilling is a relatively new technique and the state of art continues to advance. One technique involves the use of side laterals from the main horizontal well. This technique is used to drain coal bed methane in West Virginia. There the side laterals are drilled 45 degrees from the main well and 90 degrees to each other to produce a pinnate drilling and drainage pattern. This results in a square drainage area (over 1000 acres) where the wells resembled the veins in a leaf (Figure 44). This technique is a an option to the drilling of a single long well since the injection area is limited to 600 feet from the well bore.

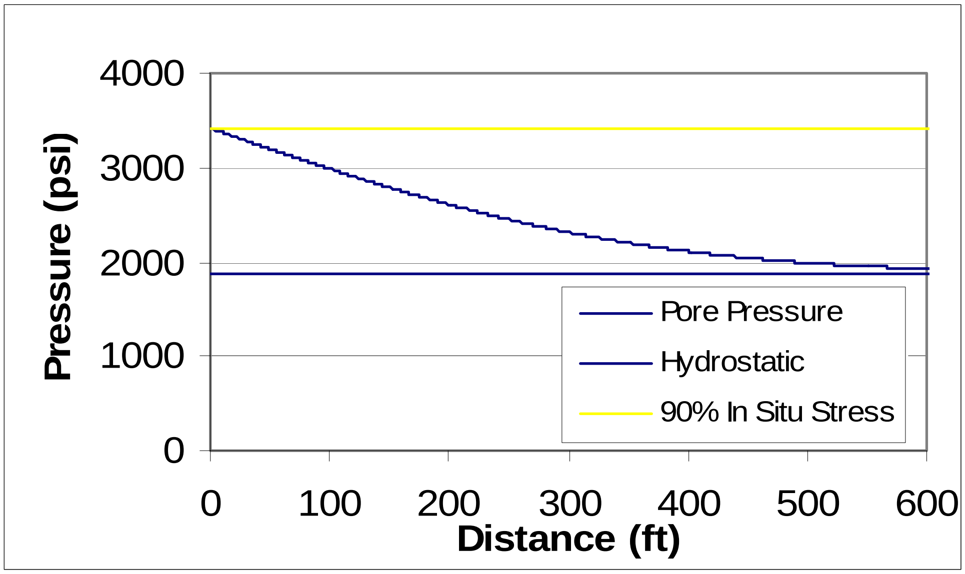


Figure 42 Brine Pressure in Queenston after 3 years (Horizontal well)

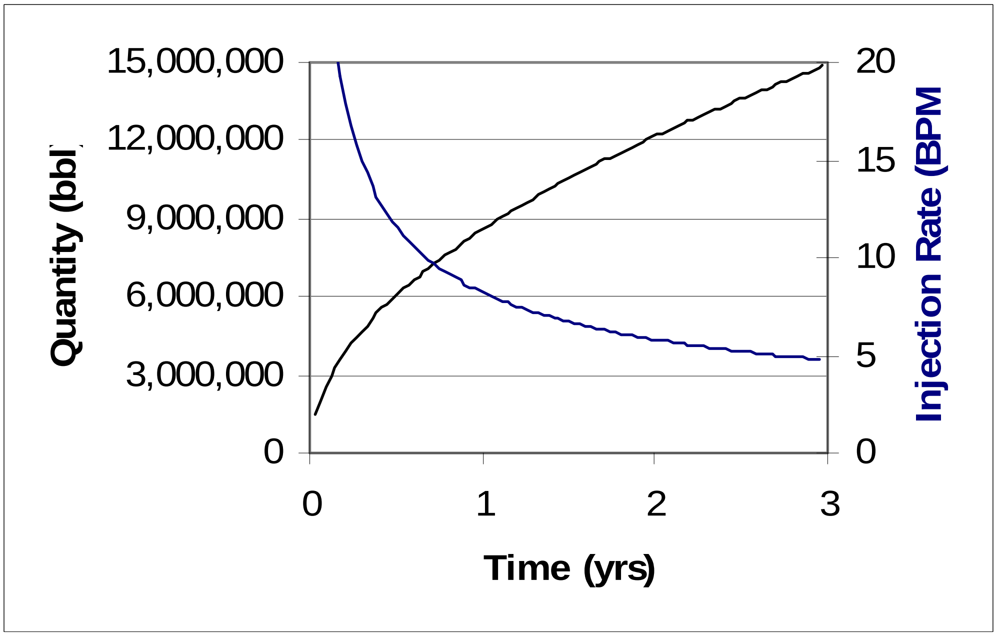


Figure 43 Brine Injection Quantity and Rate for Queenston (Horizontal Well).

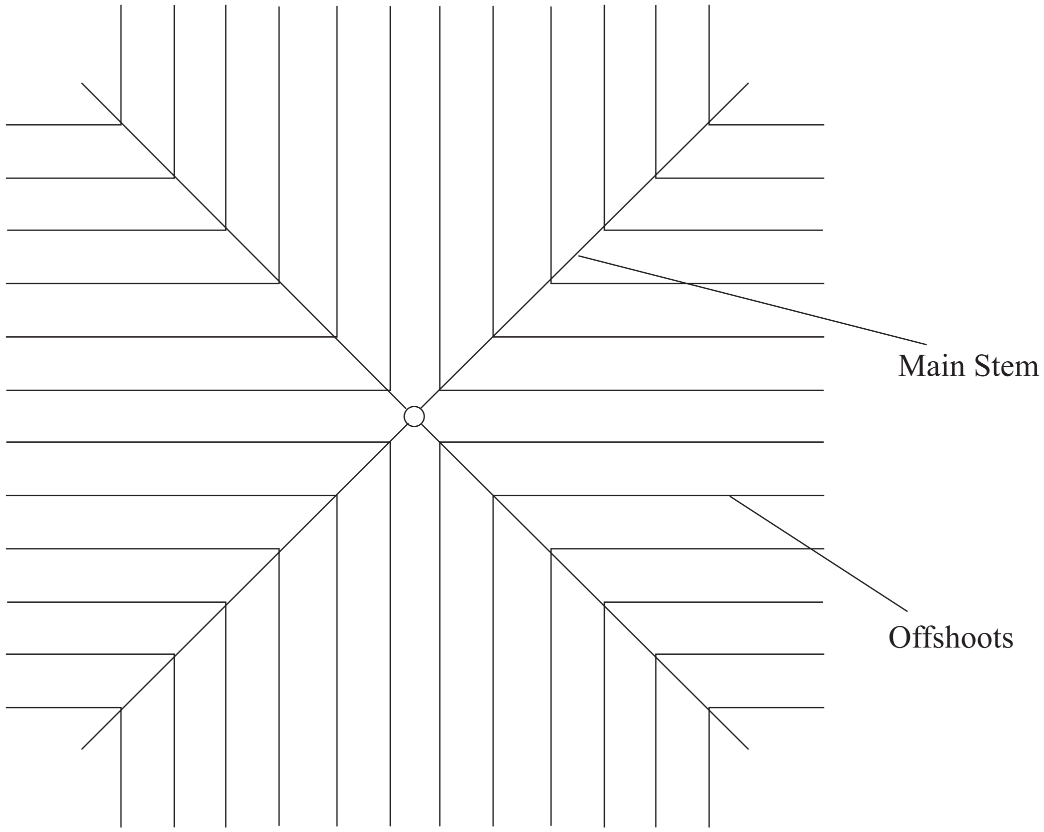


Figure 44 Schematic of a Pinnate Well Network. A pinnate horizontal well network is built from one surface well with multiple lateral completions. The main stem can be up to several thousand feet long with the offshoots offering several miles of well length total. Pinnate wells are currently in use worldwide for primary coal bed methane recovery. There is a possible opportunity to inject brine into a pinnate network for disposal during salt cavern development.

Analysis of Queenston Formation as a Potential Brine Disposal Reservoir

Though the Queenston Formation has been proven to have favorable porosity and permeability in the producing region of north central New York, modeling of disposal and actual disposal attempts have had mixed results to the south in the area where salt cavern development is possible. Similar or better lithologic conditions to those in the producing region occur farther south in the state, as the Queenston Formation becomes more sand rich in this area.

The Queenston Formation's ability to accept brine at acceptable rates and volumes is limited by the fact that the formation has low porosity and permeability. This attribute can be overcome by finding ways to expose the brine to more of the formation volume than is accomplished in a standard vertical well. During modeling the disposal rates and volumes accomplished into the Queenston Formation in a standard vertical well were far lower than those necessary to meet the disposal rate of 10 BPM established by Evaluation Criterion 1. The disposal rate of less that 0.1 BPM would not support achieving the 11 MMB in 3 years stipulated by Evaluation Criterion 2.

Techniques suggested to increase formation volume exposure and therefore disposal rates include, well stimulation (induced fracturing), drilling into a natural fracture network, the use of horizontal wells and utilizing a pinnate drilling pattern. Though all of these techniques would increase the formation volume available to the disposed brine, they are not all able to do so within realistic parameters. The use of a pinnate well pattern or multiple horizontal laterals on a vertical well may be the most realistic way to achieve, or come closer to achieving, the disposal rate necessary to meet Formation Evaluation Criteria 1 and 2 in the Queenston Formation.

The key to securing the highest production rates in the producing region has been tied to finding favorable structure (open fractures) along with zones of high permeability and porosity (Saroff, 1987 and Ward, 1988). It is highly likely that this is also the key to finding areas where the Queenston Formation is capable of accepting brine at the rates necessary for economic cavern solutioning. In addition, the Queenston Formation in south central New York has traditionally been view as completely saturated with brine, an incompressible fluid. Recent gas production from the Queenston Formation in south central New York suggests that that this is not always the case, which would also lead to more favorable injection conditions and increase the likelihood of achieving the disposal rate of 10 BPM. Additional research needs to be completed to identify where these conditions exist and how they would affect injection potential.

Evaluation Criterion 3 requires potential disposal formations be hydraulically separated from sources of potable water. The Queenston Formation is located well below any sources of potable water. In addition the Queenston is older than and located below the Clinton Group, which provides many thick shales that inhibit upward movement of the disposed brine.

Trenton-Black River Interval - Methods

Top Identification. The middle Ordovician rocks examined in the evaluation of the Trenton-Black River Groups, all produce gamma ray patterns that can be traced for miles without significant change in New York and into portions of Ontario, Ohio and Pennsylvania (Rickard, 1973). Tops used in the evaluation of the Trenton-Black River Groups and surrounding formations in this report were primarily derived from comparison with the work of Rickard (1973), Beinkafner (1983) and Flagler (1966). Figure 45 is a representative log for the tops picked in the evaluation of the Trenton-Black River Interval. Additional visual examples of the Trenton-Black River picks used in this report can be seen in Plate 14 and 15. Data tables related to the Trenton-Black River interval are located in Appendix C.

Cross Sections. Plate 14 is an east-west cross section through the Glodes Corners Road Field. These cross sections are stratigraphic and are hung on the top of the top of the Trenton Group. Intervals of hydrothermal dolomite and bentonite are highlighted and correlated. The method used to identify dolomite from wells logs is described below.

Plate 15 is an east-west cross section of the Trenton-Black River interval through south-central New York. The cross sections show the interval from the lower Utica Formation to the upper Beekmantown Group. These cross sections are stratigraphic and are hung on the top of the Black River Group. Intervals interpreted to have dolomite are highlighted in magenta (see below for an explanation how Dolomite was identified).

Dolomite Identification using Geophysical Logs The bulk density of a clean, tight limestone is roughly 2.71 g /cc and drops from there as porosity increases. Knowing this, dolomite (density 2.86 g/cc) is picked in zones where the density curve displays values above 2.75 g/cc, which is a significant increase beyond a clean limestone. This method is only practical in intervals of dolomite with little or no porosity.

In more porous intervals, the density curve can be used to identify dolomitized intervals when used in conjunction with the neutron curve. If the density curve is plotted on a limestone scale (i.e. 0% porosity = 2.71 g/cc), then there should be significant separation of the density and neutron curves in dolomitized intervals and they should plot on top of each other in limestone intervals. A positive separation of the neutron and density curves, where the density curve reads about 5.5 % less porosity than the neutron log (density curve will fall to the right of the neutron curve), is indicative of clean dolomite (see Figure 46 modified from Rider, 1986).

Where available, the Photoelectric Factor (PEF or P_e) curve is an excellent tool for distinguishing dolomite from limestone. In a simplified explanation, the photoelectric factor is a measurement of the amount of gamma ray energy a material can absorb before emitting an x ray. The amount of energy a material can absorb depends on the average atomic number (or average atomic size) of the constituents of the rocks being evaluated and it thus can be related to mineralogy (i.e. Schlumberger, 2005). Dolomite has P_e values between 2.5 and 3.2, while limestones (calcite) have P_e values between 3.8 and 5.1 (i.e. Schlumberger, 2005).

Black River Core Posters. The Black River interval from two wells is described in detail using slabbed cores and thin sections. The cores were taken from the Matejka #1 (10335-00) and Gray # 624468 (22949-00) wells in central New York State. The results of this work are displayed in poster format in Plates 16, and 17. The description includes lithology (dolomite, limestone, shale), Dunham rock texture (grainstone, packstone, wackestone, etc), sedimentary structures, fracture intensity, porosity type and more. The posters also include pictures of the cores and thin sections, which are correlated to the appropriate depth in the core description. The well logs for each well were also correlated to the description to make it possible to evaluate the log response to various features.

These are two of the three Black River cores that are publicly available in New York. The Whiteman #1 (22839-00) core is the third core available in New York, in this report core images and thin section images are included, but no description. The Matejka #1 core was from a dry hole drilled in 1975 by Shell Oil Co (Figure 47 and Plate 16). It has common dolomite but little porosity and permeability. The Gray # 624468 core was from a well that produced some gas but not at economic rates (Figure 48 and Plate 17). This core has large vugs lined with saddle dolomite, but they appear to be isolated within a low permeability matrix. The Whiteman #1 has

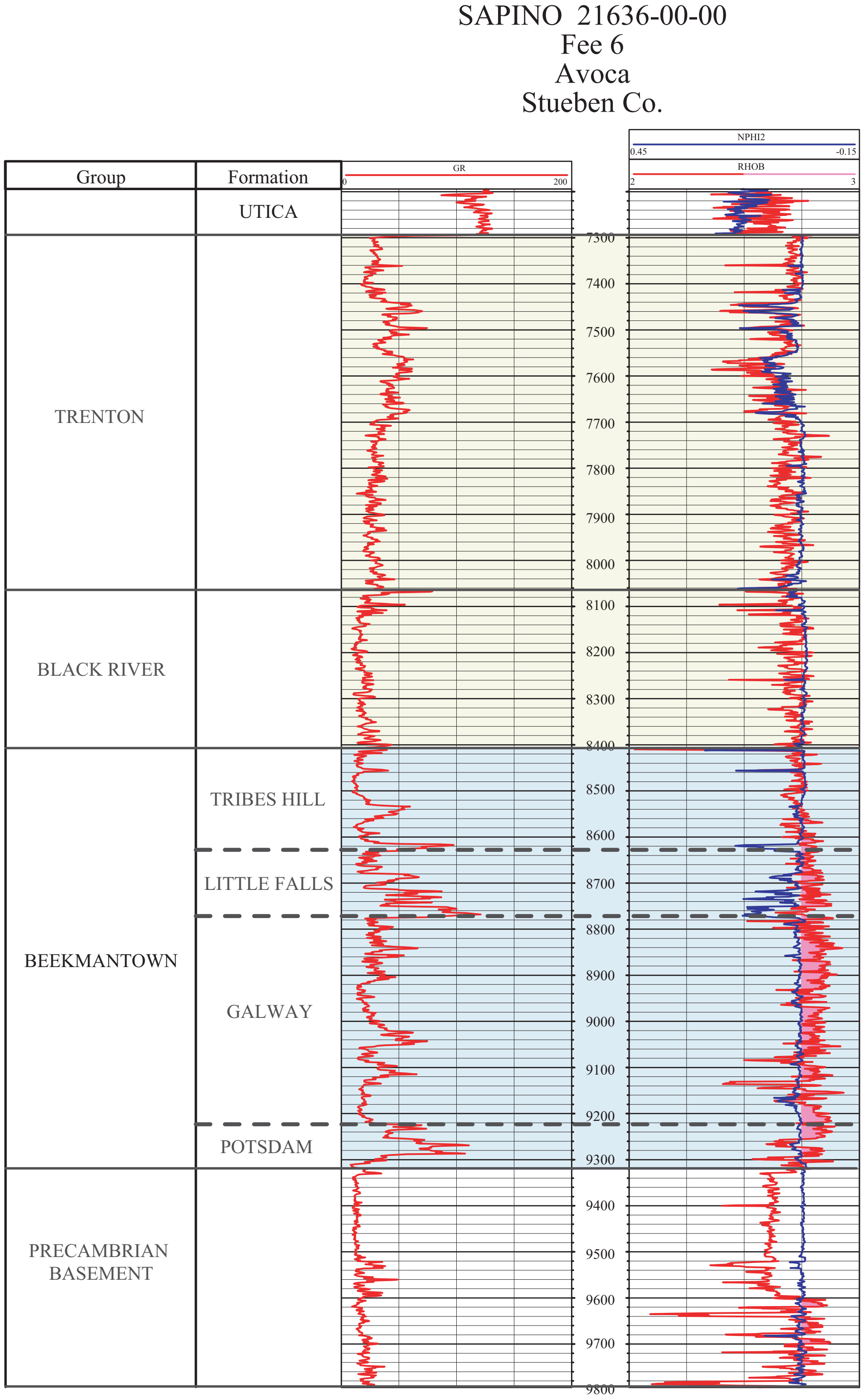


Figure 45 Representative log for the Trenton-Black River Interval and the Beekmantown Group in south central New York State.

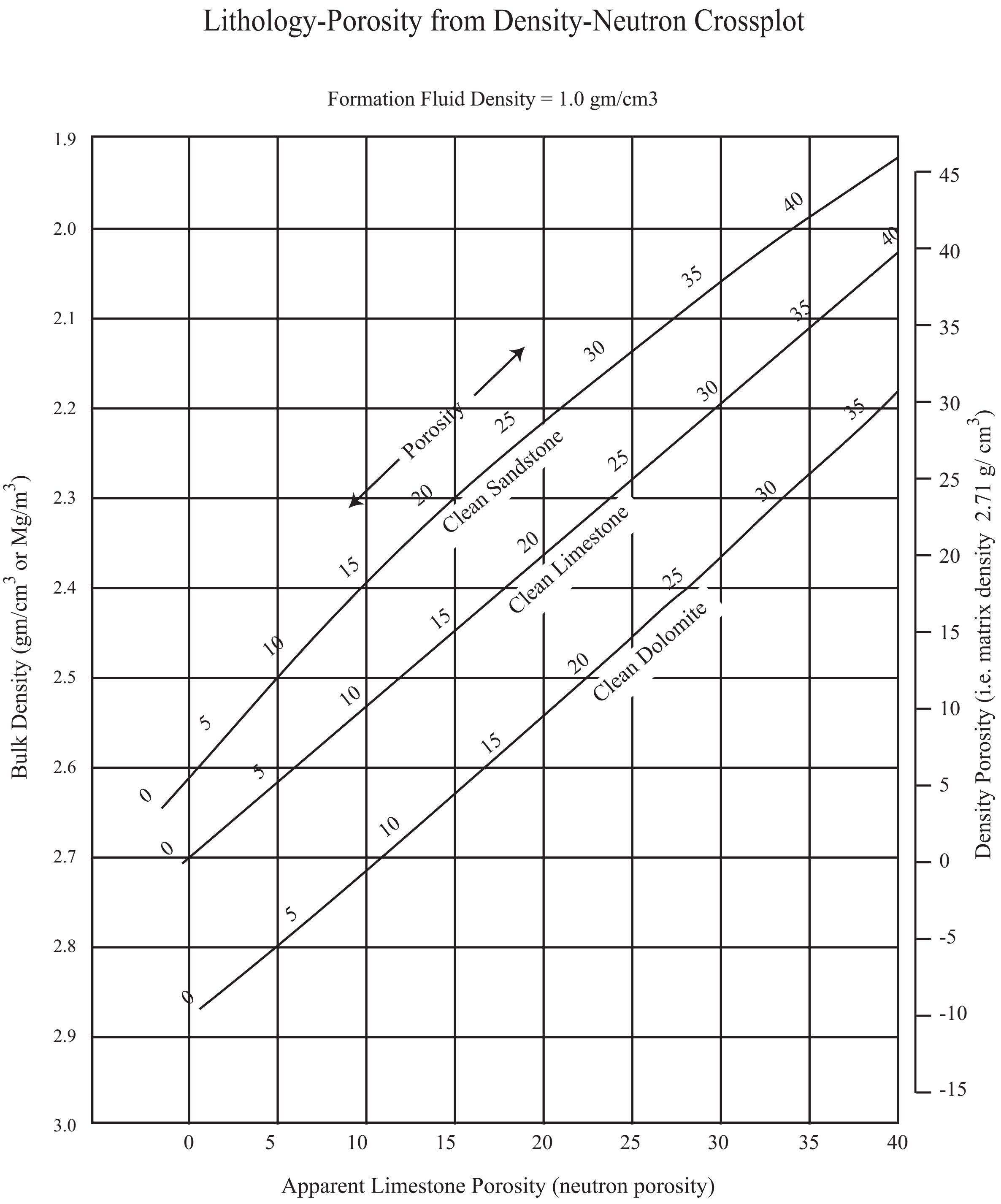


Figure 46 The density-neutron crossplot. This plot is necessary to find real, clean formation porosities because of the differing effects of matrix type on the two log types. (Modified from Rider 1986)

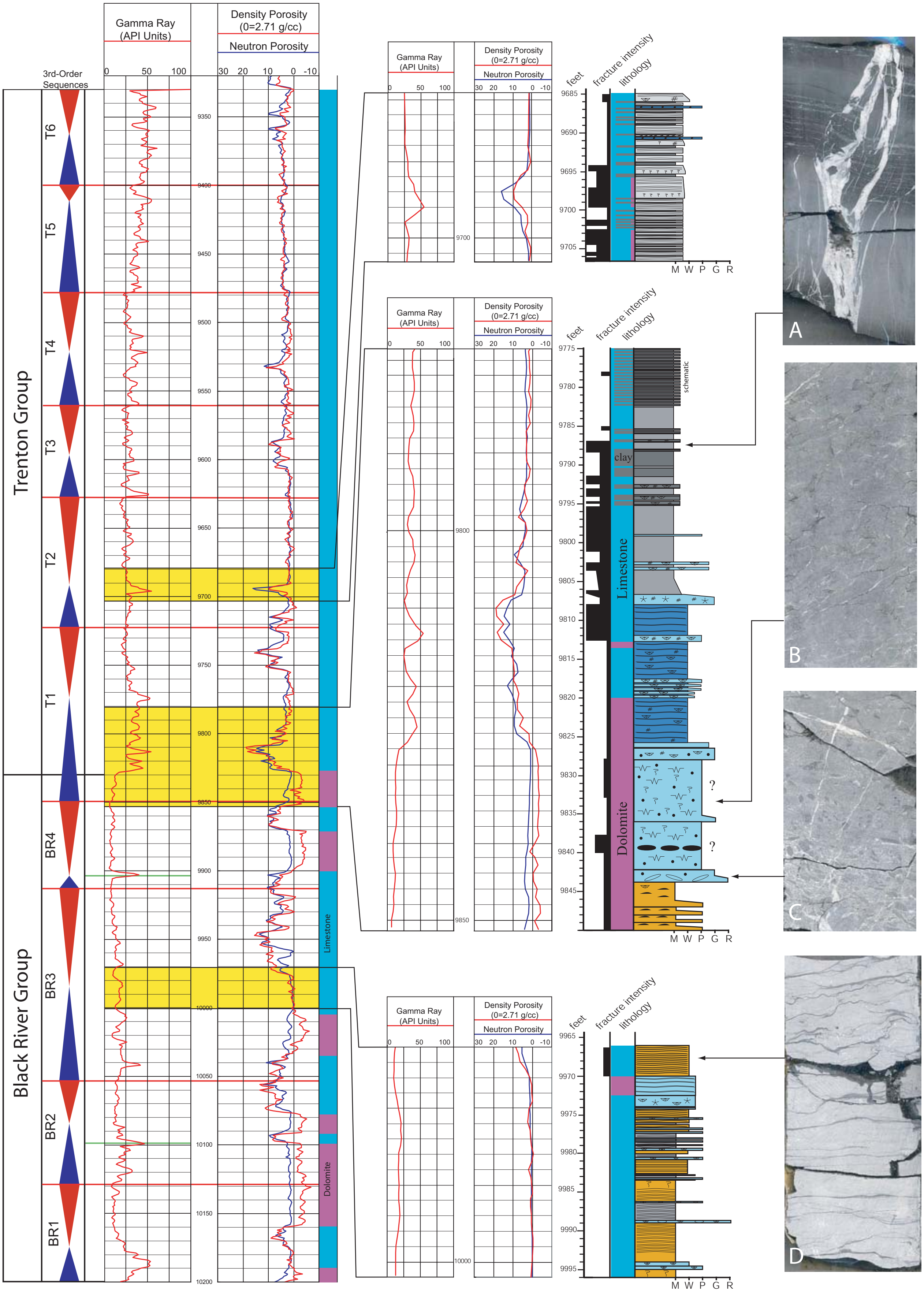


Figure 47 Core Images of the Matejka #1 well (10335-00), Chemung County, New York State.

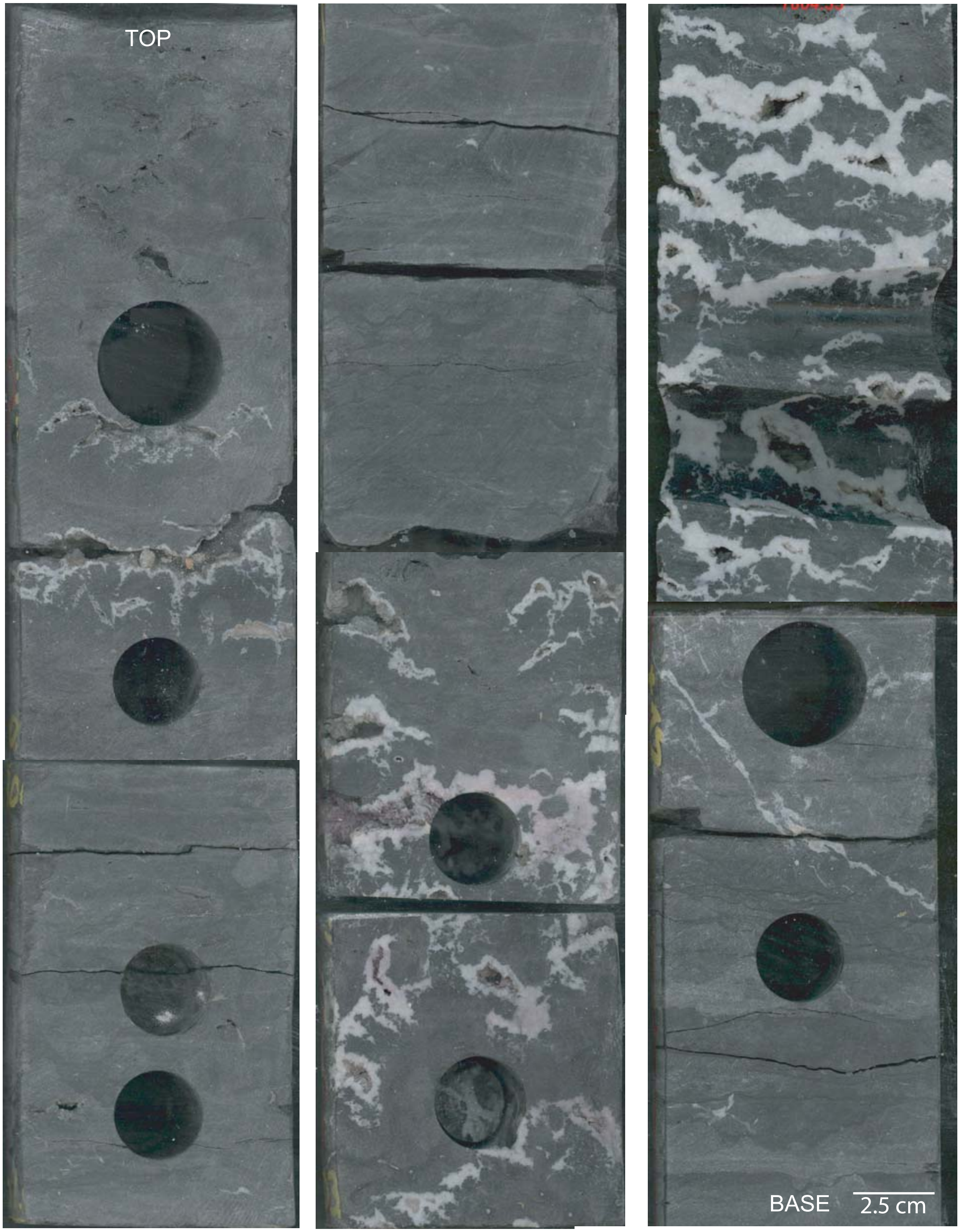


Figure 48 Core images of the Gray # 624468 well, (22949-00) Stueben County, New York State.

common fractures, breccias and vugs lined with white saddle dolomite and it has been an economic producer (Figure 49 a and b). These cores show the heterogeneity of this reservoir and the difficulty that operators have had finding porous and permeable reservoir facies.

Rock Mechanics Testing of the Trenton Black River Interval. No Trenton-Black River core was available for rock mechanics testing at the time when Sandia National Laboratories tested the Queenston and Beekmantown cores. Fortuna Energy provided porosity and permeability numbers for the Whiteman #1 well. These numbers were used to model the ability of the Trenton-Black River interval to accept brine at the rates and volumes stipulated by the Evaluation Criteria.

Modeling of the Trenton-Black River Interval. The same model was used for the Trenton-Black River interval as was used for the Queenston Formation. This substitution is acceptable as long the inputted parameters are altered to accommodate the differences in the formations. The parameters that were changed are: permeabilities changed to 60 milli-Darcy (vs. 0.185 milli-Darcy), porosities changed to 7 percent (vs. 10.8 percent), saturation changed to 30 percent (vs. 50 percent), depth changed to 9,500 feet (vs. 4,250 feet), and layer thickness changed to 20 feet (vs. 100 feet).

Description

Fault-related hydrothermal dolomite reservoirs in the Upper Ordovician Black River Group were selected as a potential brine disposal reservoir based on the following observations:

- Current production is located within the study area,
- Most wells are still active and may be converted easily,
- Most prolific producer in the Allegheny Plateau of New York State,
- The fields may prove unattractive for conventional depleted reservoir storage due to the heterogeneity, unknown lateral extent and size
- Salinities of formation water are near halite saturation

Whiteman #1 Core, County Line Field

Figure 49a Core from the upper Black River. Most porosity in the cores recovered from the Black River Fields is in vugs, fractures and breccias- there is very little matrix porosity. Some vugs are due to solution enlargement by hydrothermal fluids during early stages of alteration.

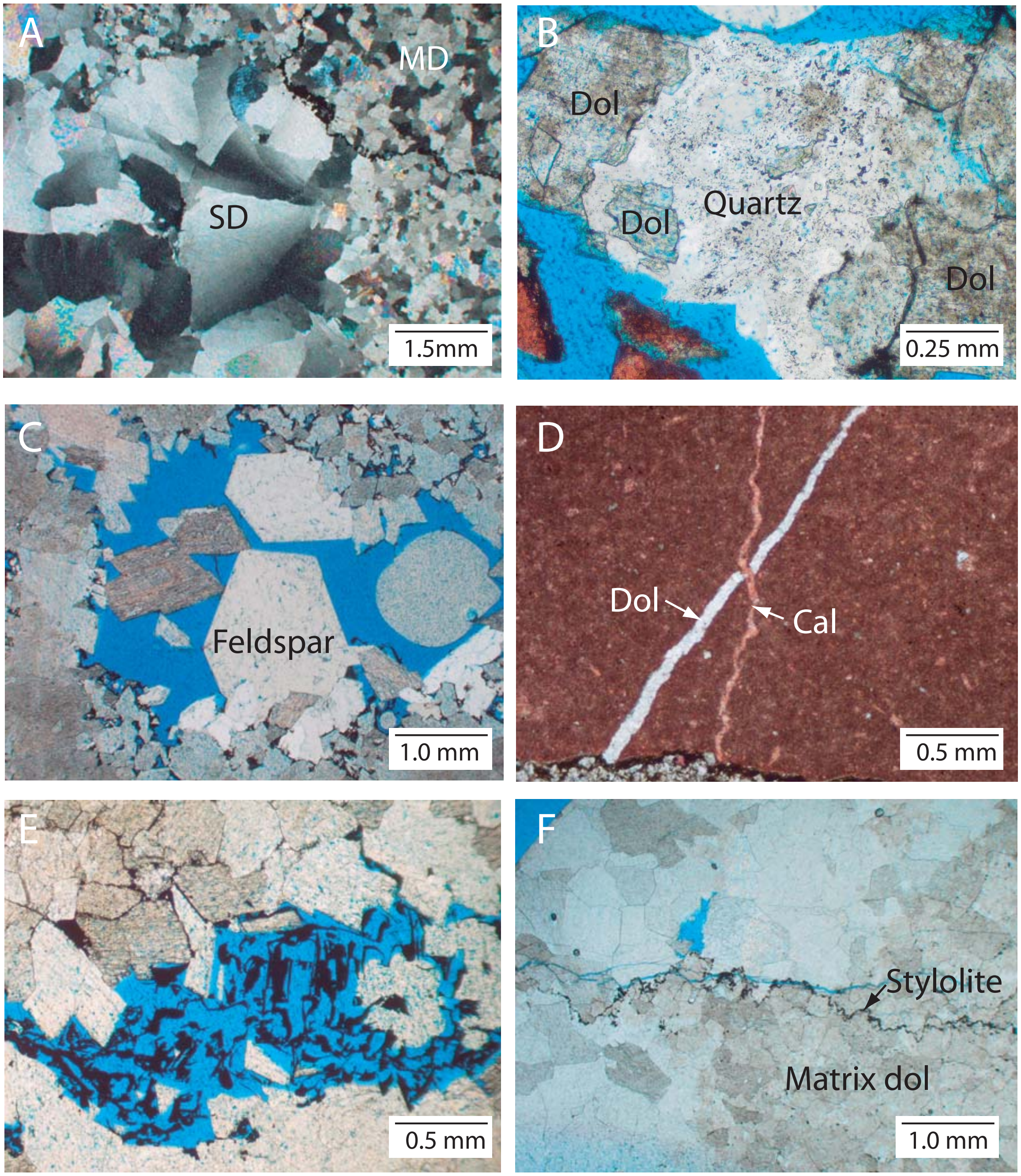


Figure 49b Trenton-Black River thin section images.

The Black River Group overlies the global Lower Ordovician Knox Unconformity, which separates the group from the Beekmantown Group below. The Black River Group is primarily composed of muddy and fine-grained shallow marine carbonates. The formation thins toward eastern New York, where it is absent in some places, and gradually thickens into the south-central part of the state where it reaches thicknesses of over 500 feet (Figure 50 and Plate 18). Current production is in these thick areas. Figure 51 and Plate 19, a structure contour map of the Black River Group, shows that the group is between 5,000 and 9,500 feet below sea level within the study area of this research.

The Black River Group is overlain by the Trenton Group, which is composed of low energy deeper water argillaceous limestones and calcareous shales and high-energy shallow marine grainstones and packstones. The Trenton is overlain by the deeper water Utica Shale, which is a black shale that blankets much of the eastern United States. This contact is diachronous as the Trenton Limestone grades laterally into the Utica Shale to the south and east. The upper part of the Trenton Limestone grades laterally into dark shales in the Appalachian Foreland Basin to the east and into the Sebree Trough to the south (Wickstrom et al., 1992). Variations in the thickness of the Trenton (Figure 52 and Plate 20) are partially due to variations in subsidence and partially due to the facies relationship with the Utica Shale. The Utica Shale is generally thick where the Trenton is thin and vice versa. The Trenton Group reaches maximum thicknesses of more than 800 feet in the Finger Lakes Region of central New York State (Figure 52 and Plate 20). From there the Trenton Group thins significantly to the east. Within the study area of this research, the Trenton Group is between 400 and 800 feet thick and is found at depths between 4,000 and 9,000 feet below sea level (Figure 53 and Plate 21).

Most of the gas in New York is produced from dolomitized intervals in the Black River Group (Plate 14). These dolomites formed from hydrothermal fluids flowing up subtle wrench faults soon after the Black River carbonates were deposited (Figure 54; Smith et al., 2003). The fields occur in subtle structural sags that form in dilational or transtensional parts of strike-slip fault zones. Figure 55 shows a 3D seismic image of Rochester Field in Ontario, which is a hydrothermal dolomite reservoir in the Trenton and Black River Groups. This map is a structure map of the top of the Trenton Group. The cooler colors (blue and green) represent lows and the

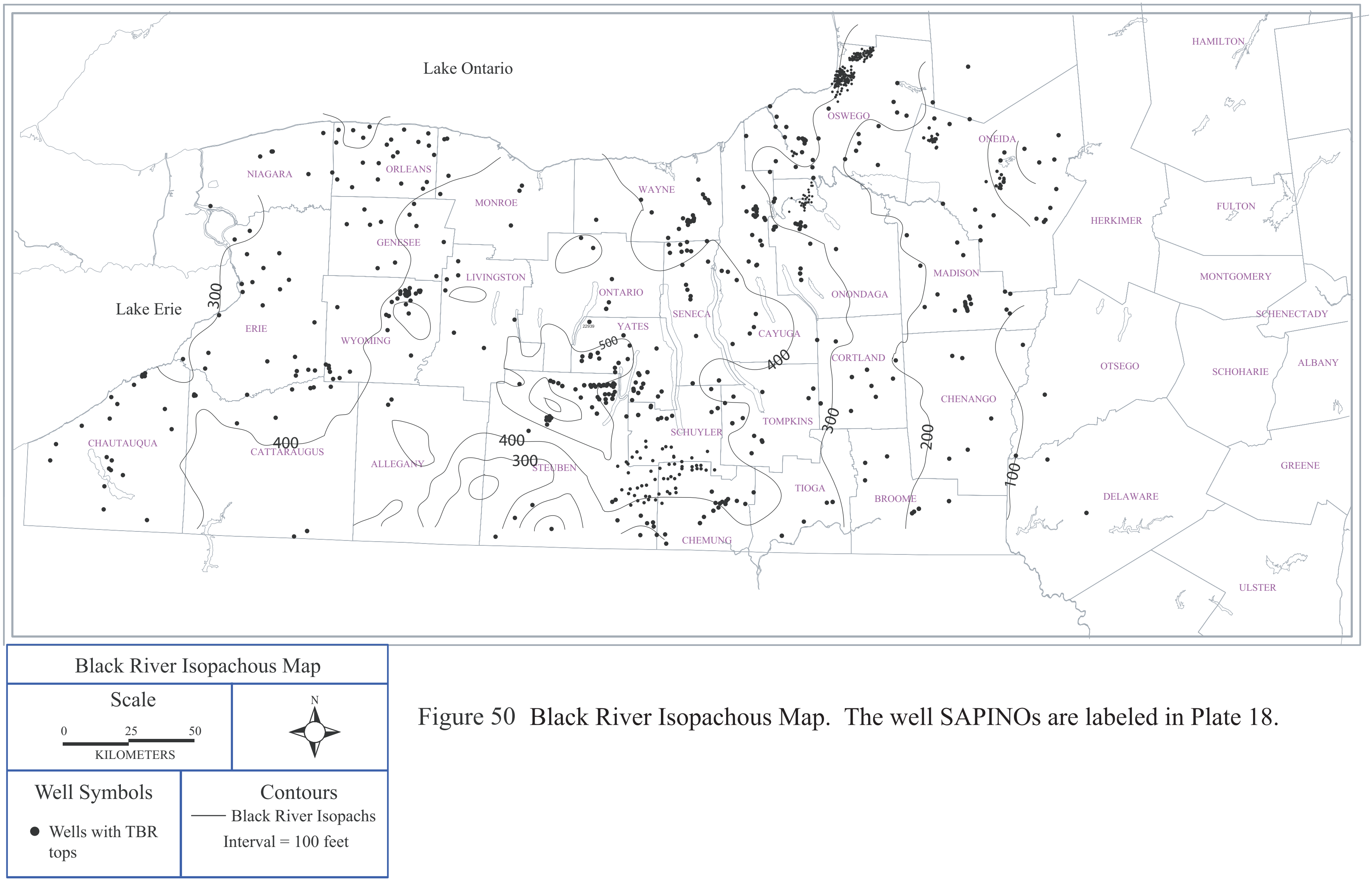


Figure 50 Black River Isopachous Map. The well SAPINOs are labeled in Plate 18.

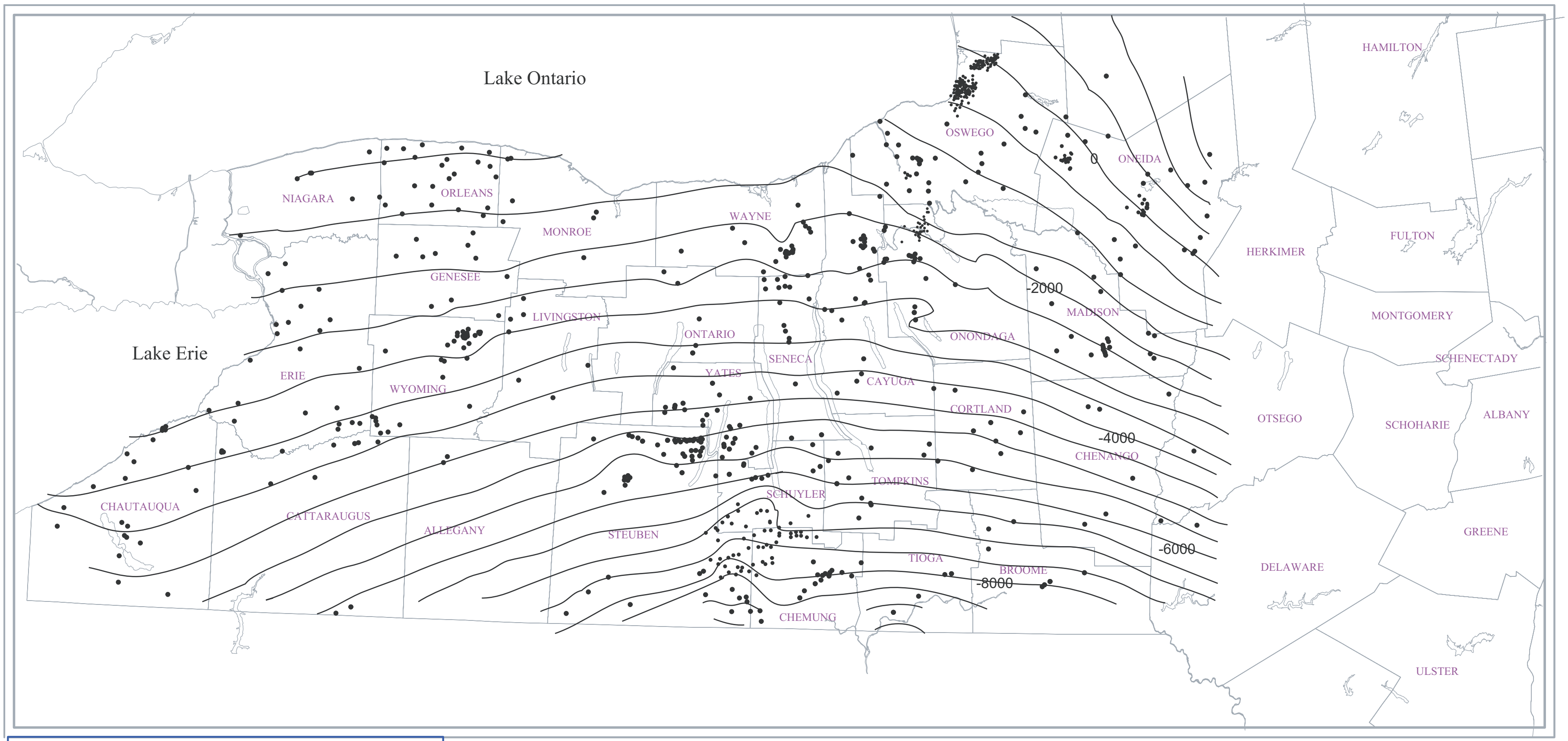


Figure 51 Black River Structure Contour Map. The well SAPINOs are labeled in Plate 19.

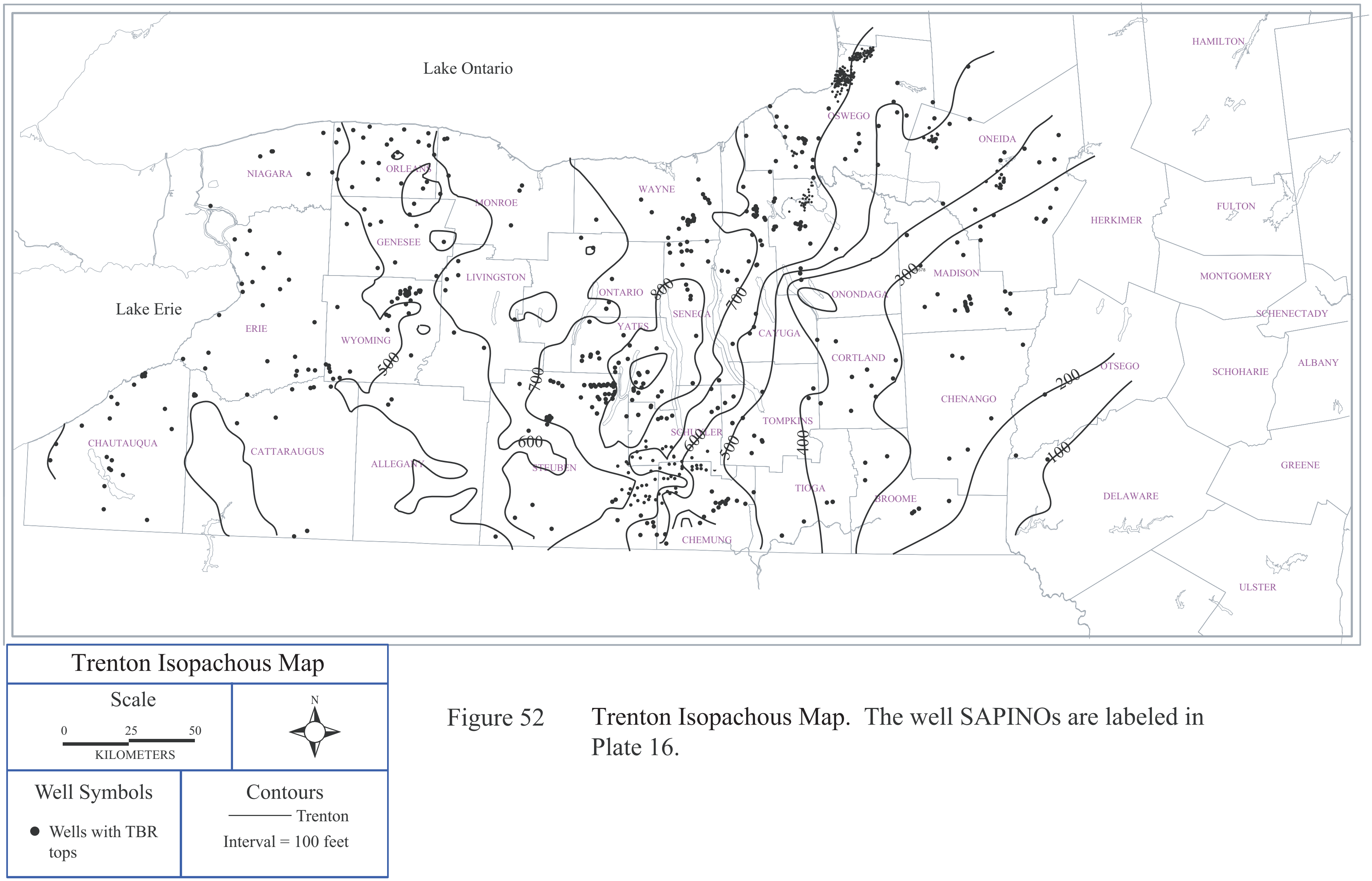


Figure 52 Trenton Isopachous Map. The well SAPINOs are labeled in Plate 16.

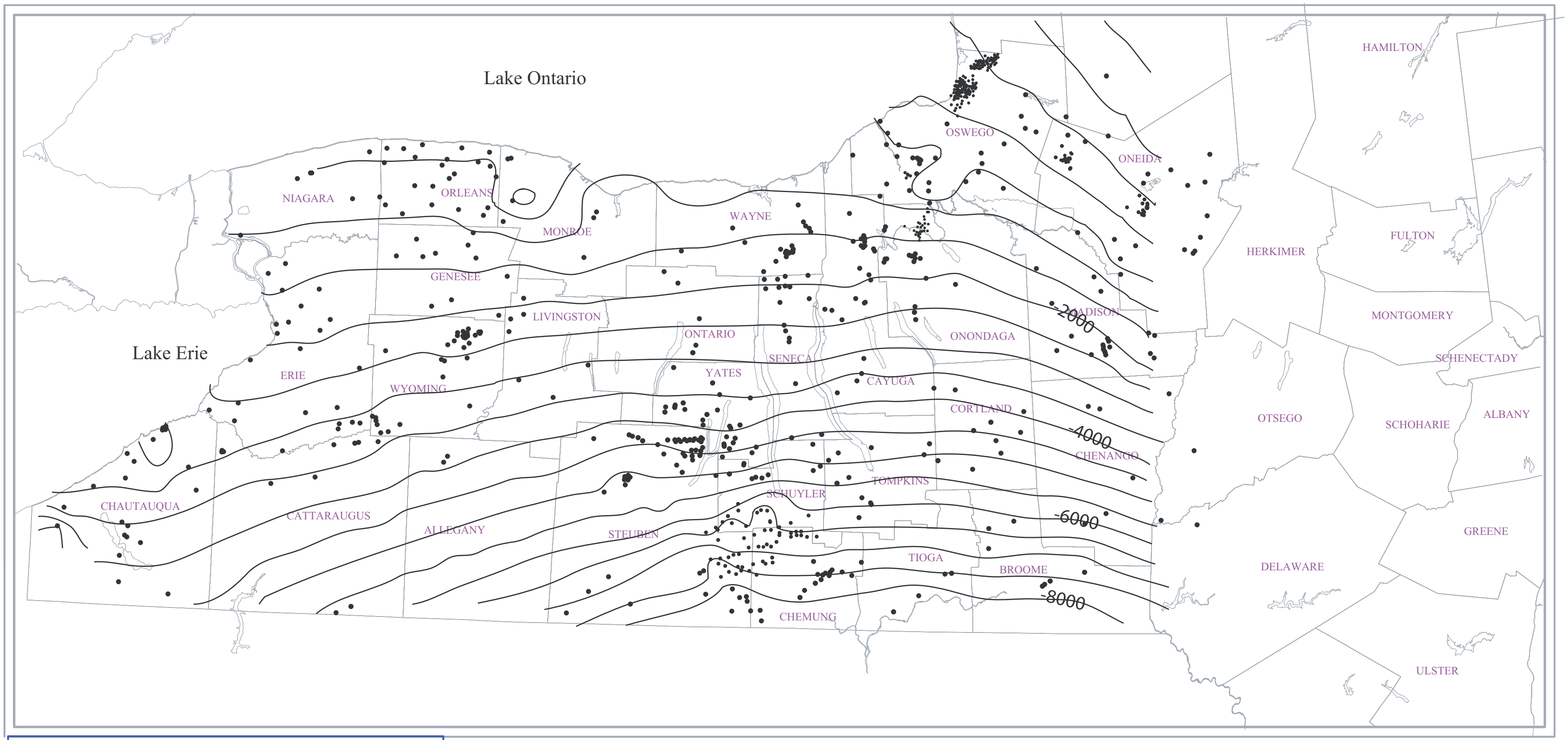
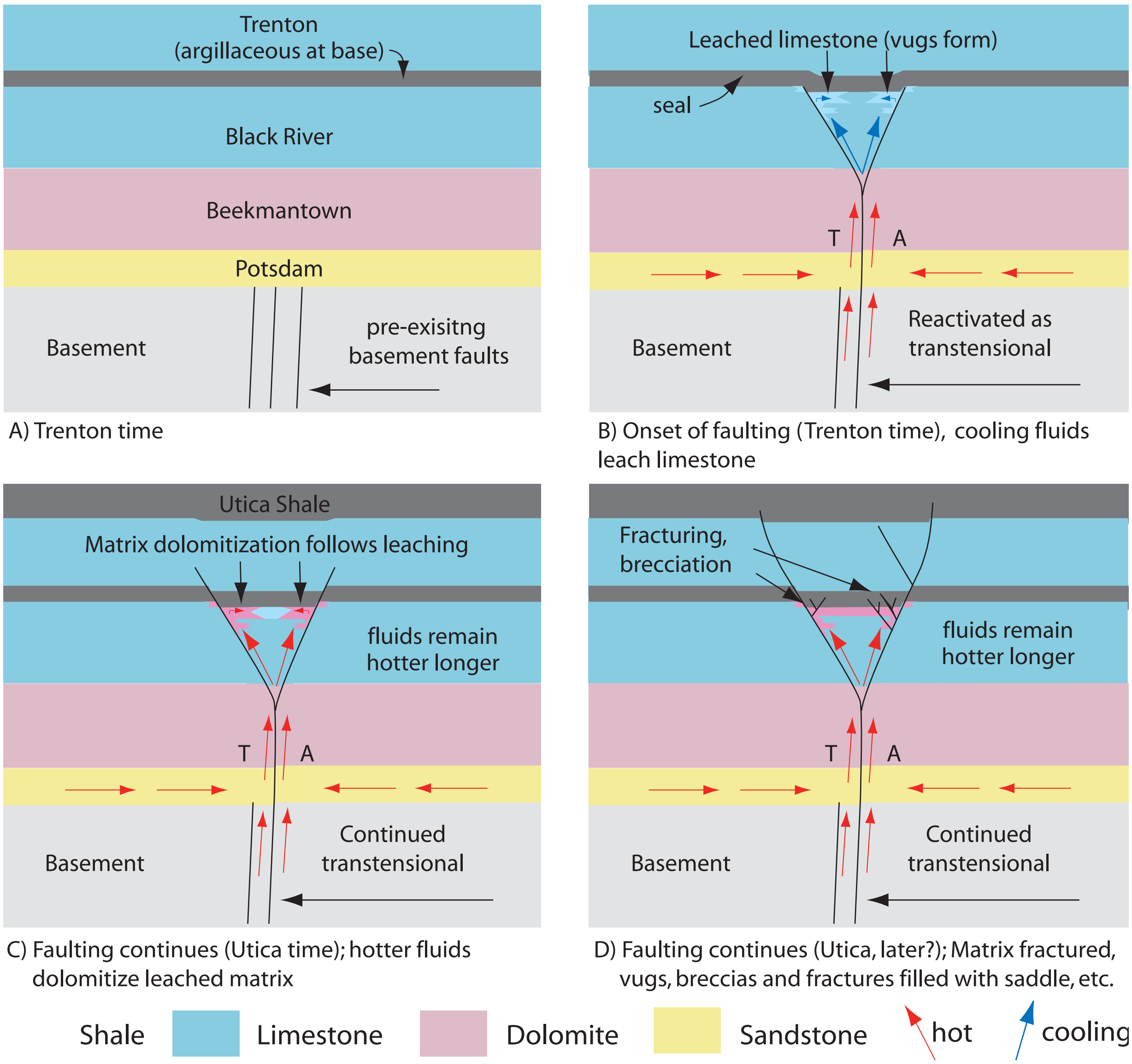


Figure 53 Trenton Structure Contour Map. The well SAPINOs are labeled in Plate 19.



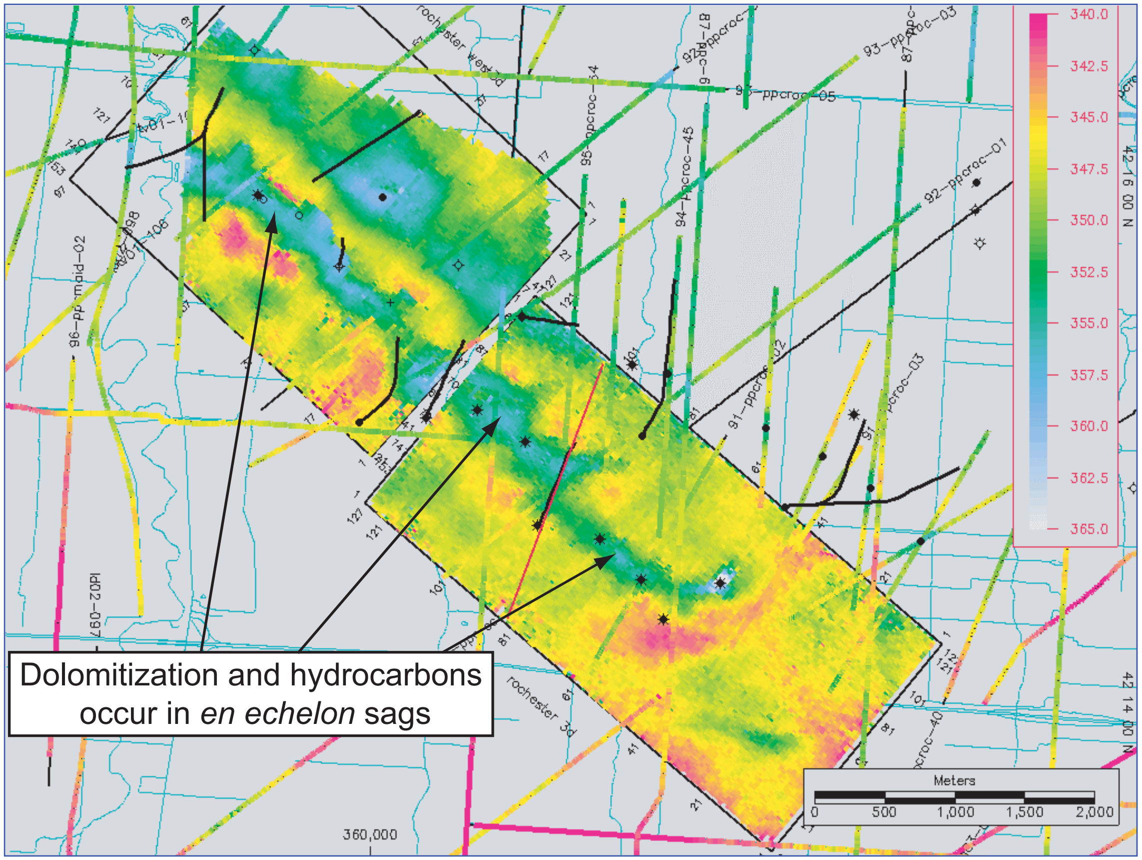
A) Trenton time

B) Onset of faulting (Trenton time), cooling fluids leach limestone

C) Faulting continues (Utica time); hotter fluids dolomitize leached matrix

D) Faulting continues (Utica, later?); Matrix fractured, vugs, breccias and fractures filled with saddle, etc.

Figure 54 Model for hydrothermal leaching and dolomization that has lead to the formation of reservoirs in the Black River carbonates of south central New York.



Dolomitization and hydrocarbons occur in *en echelon* sags

Figure 55 The Trenton and Black River hydrothermal reservoirs occur in fault-bounded structural "sags" or "grabens" that are visible on seismic. The 3D map above is a top Trenton time structure map from the Rochester Field in Ontario, Canada (courtesy of Talisman Energy).

warmer colors (red and yellow) represent structural highs. The dolomite, porosity and hydrocarbons all occur in the structural lows.

Figure 56 shows the seismic expression of two hydrothermal dolomite reservoirs in the Southern Tier of New York. The porosity and gas occur in the subtle structural lows marked as the Glodes Corners Road sag and the Muck Farm Sag. These fields can be very productive but are difficult to discover and develop due to their heterogeneity.

Many wells in New York penetrate dolomitized Black River Group carbonates but do not produce gas. There is very little matrix porosity preserved in the dolomites in New York. It appears that much of the reservoir porosity is in vugs, fractures and between breccia clasts (Figures 49 a and b). Some vugs are connected and contribute to production while others are isolated and will not produce gas at economic rates. For instance, the core shown in Figure 49 a and b is from dry hole even though it looks very porous.

The two cores that were described illustrate this heterogeneity (Plates 16 and 17). The Matejka #1 core and the Gray # 624468 core described in Plates 16 and 17 are both considered "tight" dolomite wells in that they have significant quantities of dolomite, but very low permeability. Most of the dolomite in these wells is matrix dolomite with little or no porosity. The Matejka well has tens of feet of dolomite but no vugs and few open fractures (Figure 47). The Gray # 624468 core (Figure 48) does have numerous open vugs, but they are isolated because there are few fractures and the matrix dolomite between them has little or no permeability. In many cases, bitumen, quartz or other minerals occur between the dolomite rhombs and may plug what would otherwise be effective porosity.

The Whiteman #1 core has high permeability in several beds that have vuggy and fracture porosity (Figure 49a and b) and the well has been a good producer. This suggests that penetration of at least some open fractures may be essential to drilling a productive well in the Black River dolomite play in New York. The abundance of fractures and saddle dolomite suggest that the Whiteman #1 core may be closer to a fault than the Matejka #1 and Gray # 624468 wells.

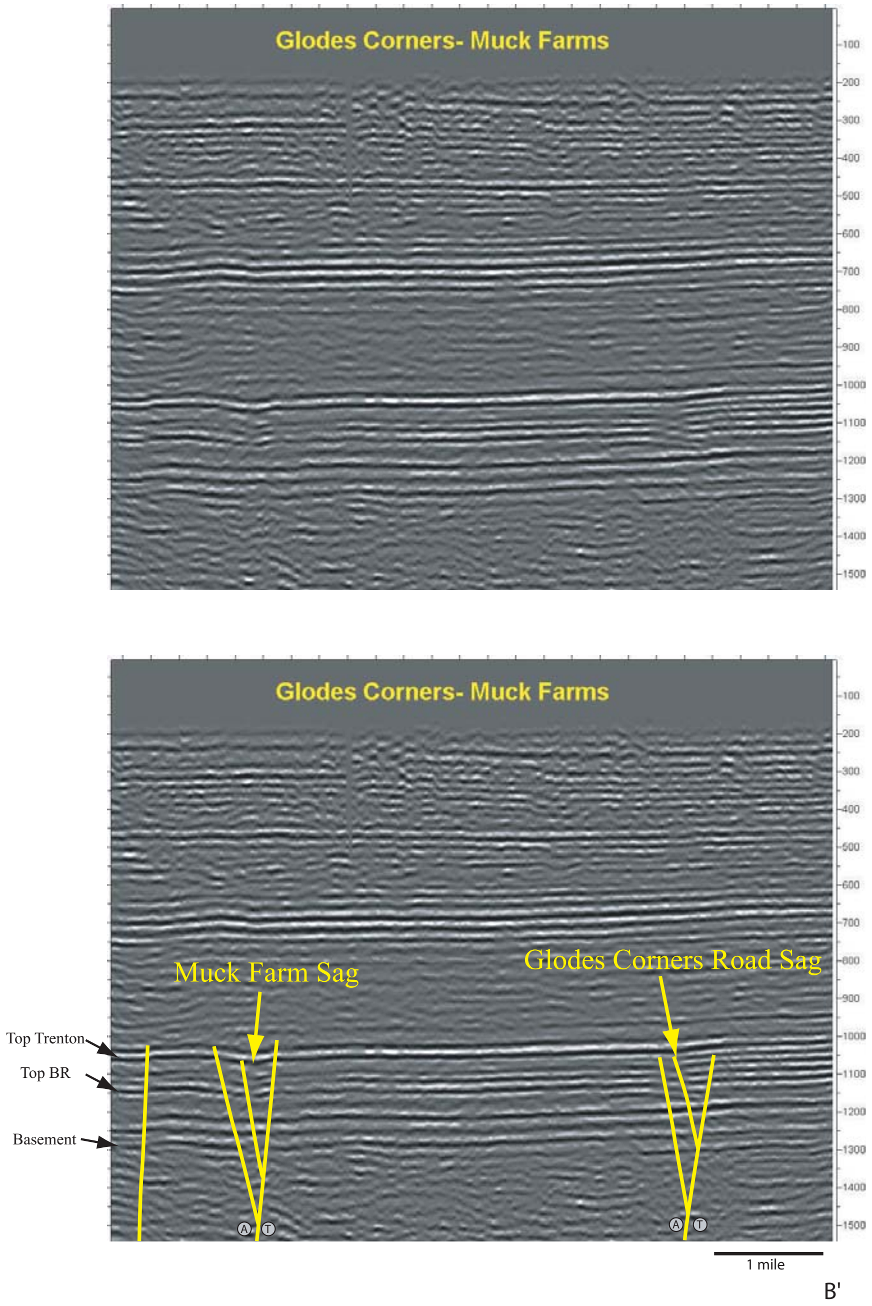
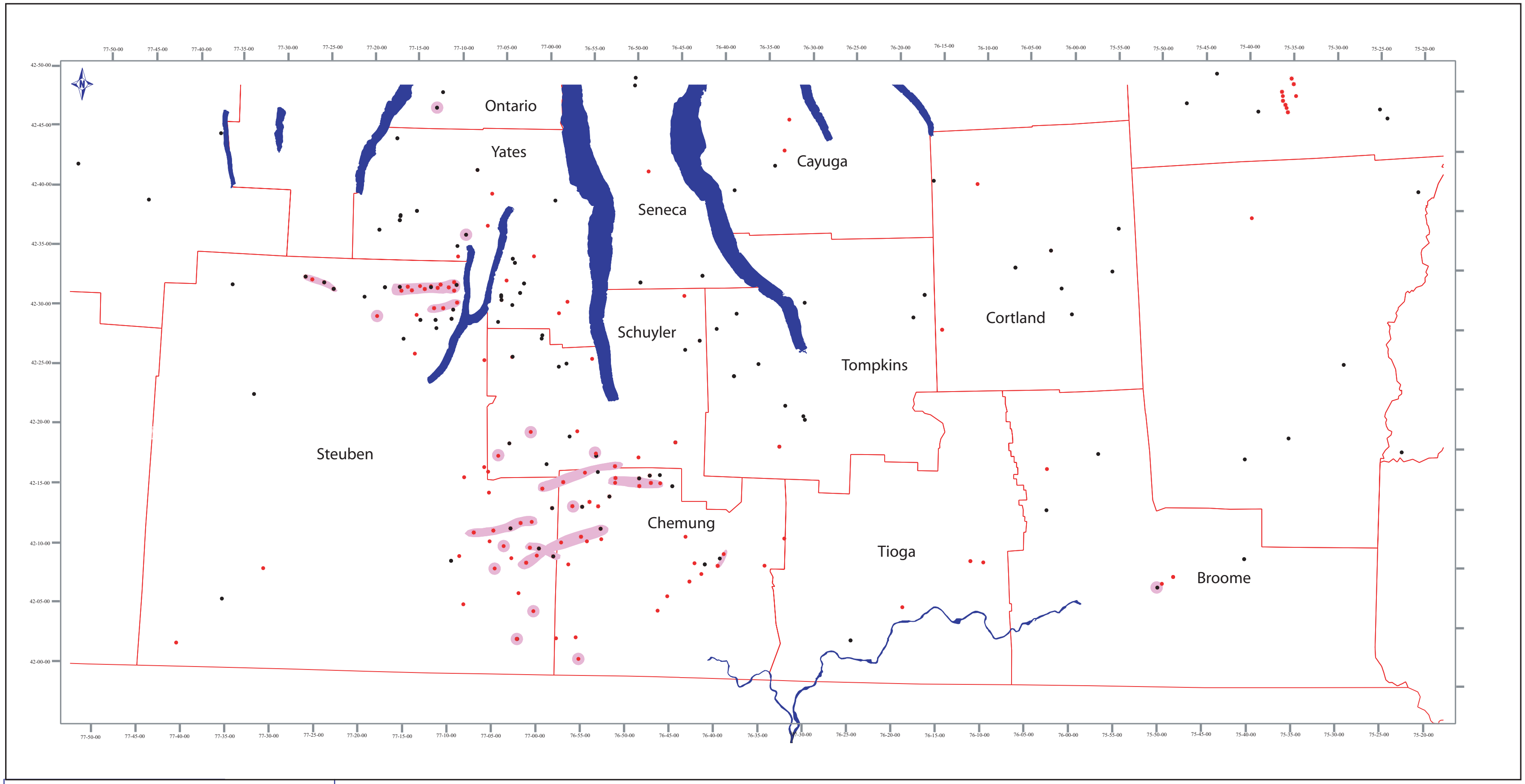


Figure 56 Seismic expression of the Glodes Corners Road and Muck Farms Fields in south central New York State. Porosity and therefore production occur in subtle structural lows called sags.

The cores studied as part of this research suggest that penetrating open faults, fractures and breccias and vugs connected by fractures may be the key to drilling a successful well in this play. Most of the early wells in the trend were vertical wells that were commonly sidetracked once or twice after encountering tight dolomite or limestone. The probability of success on a vertical development well was about 35% (Bob Bonnar, Talisman Energy, pers. comm). This may be because the wells were less likely to penetrate faults and fractures. More recently, a series of horizontal wells have been drilled that have a more consistent level of success (about 60%) along with much higher initial production rates and greater cumulative production. Because horizontal wells cut across the fault and fracture zones and penetrate the formation at a range of distances from the faults, they have a much higher probability of success. It may also be the case that some successful producers have good matrix porosity, but that no cores have been acquired from these wells.

Figure 57 shows the distribution of producing Trenton Black River hydrothermal dolomite wells and fields in New York. Note that many of these fields are in the process of being drilled and extended and that this map is likely to look quite different when all drilling is completed. Two of the more mature fields in the play, Muck Farms and Glodes Corners Road, are about 6miles (10 km) long and .4 miles (0.7 km) wide. This proportion of length to width appears to be common for Trenton Black River Fields in New York. The linear nature of the fields strongly suggests an underlying fault control.

Note the many features with the classic Trenton-Black River sag style structure on Figure 8, which illustrates the potential that this region of the state holds for production from this already prolific play. We are confident that many if not all of the structures are dolomitized. Though there are many structures to be explored, finding the productive zones within the structures in the difficult part. The Trenton-Black River reservoirs are notoriously heterogeneous on the scale of a single field. This proves to be a high risk factor in exploring for Trenton-Black River reservoirs, but should not serve to deter potential brine disposal considerations. A cavern developer should seek to utilize inactive, depleted fields for brine disposal where the most porous and permeable zones have already been delineated and infrastructure is already in place.



WELL SYMBOLS

✹	gas exploration	▨	Gas Field
●	Dry wildcat		
●	gas well		
●	New Symbol	■	Water Body
✹	gas development		
●	dry hole		
☐	storage well	—	County line
∅	Disposal		
⌖ SG	stratigraphic test		

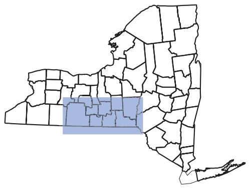


Figure 57 Map of fields producing from the Trenton-Black River Hydrothermal Dolomites - Current to 2003

Cross section E-E' (Plate 15) includes several producing wells that are dolomitized in the Black River along with wells between fields that are predominantly composed of limestone in the Black River. The laterally discontinuous nature of the dolomite suggests that the dolomitization process was highly localized. When these cross sections are referenced to seismic data it becomes clear that dolomitization is localized around subtle wrench faults.

Testing and Modeling Results for the Trenton-Black River Interval. The permeabilities from the Whiteman #1well (data courtesy of Fortuna Energy) indicate that the permeabilities of the Trenton-Black River interval are high. Like the Queenston Formation, the permeability of the Trenton-Black River interval is also a function of its porosity, with porosity of 7 percent resulting in a 60 milli-Darcy permeability. The presented permeabilities are horizontal, while those in the vertical direction are much lower. Figure 58 shows the permeability as a function of porosity for the Whiteman #1 well. The permeabilities are horizontal. The 20 foot thickness mutes the impact of the lower vertical permeabilities on flow. The formation is 30 percent saturated, thus the effective compressibility of the pore is reduced slightly from the analyses presented for the Queenston Formation.

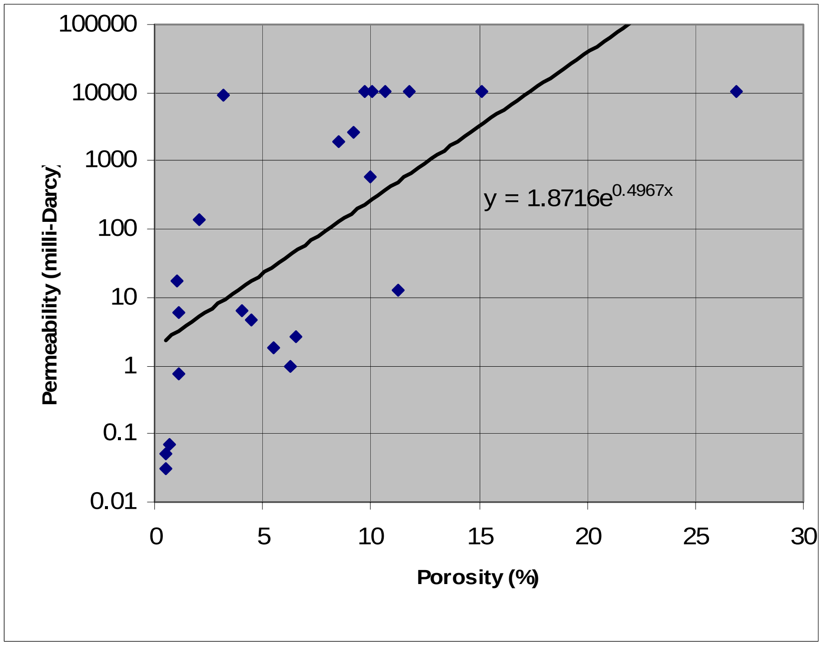


Figure 58 Permeability of Trenton-Black River.

During modeling of the Trenton-Black River interval, the length of a horizontal well was adjusted until Evaluation Criteria 1 and 2 are reached and exceeded (10 BPM leading to 15 MMB of brine over a 3 year period). This resulted in a well length of 2.8 miles in the Trenton-Black River. The injection rate (Figure 59) was very similar to the results of the 11 mile hole for the Queenston even though there are considerable differences in the inputted formation parameters.

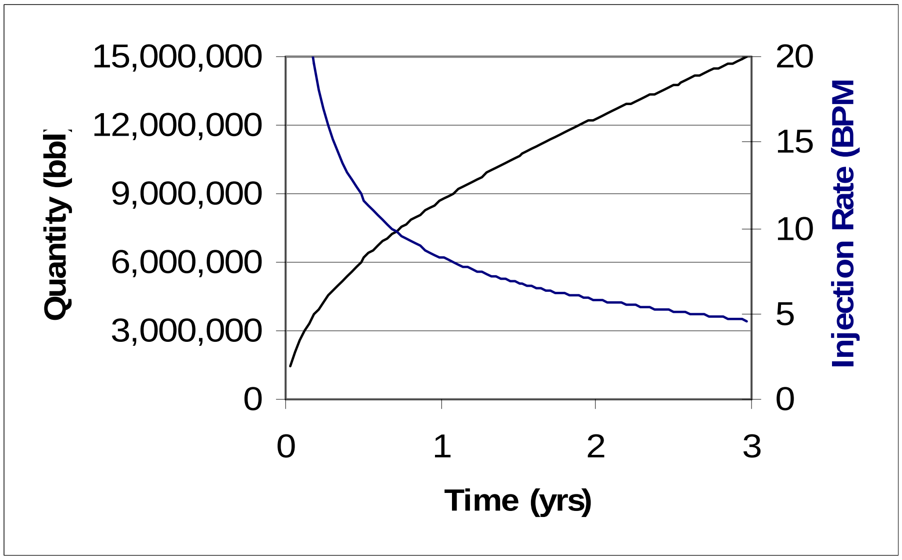


Figure 59 Brine Injection Quantity and Rate for Trenton-Black River (Horizontal Well).

What differs most in the Trenton-Black River vs. Queenston predictions is the lateral extent of flow from the well. The relatively high permeability of the Trenton-Black River in combination with its lower porosity and formation thickness, result in a lateral flow exceeding 2 miles (Figure 60). Thus a single well can distribute brine over a large formation area.

Analysis of the Trenton-Black River Interval as a Potential Brine Disposal Reservoir

Unlike the Queenston Formation, the Trenton-Black River interval has porosity and permeabilities that support injection at acceptable rates. Evaluation Criterion 1 and 2 would be met in a vertical well, but the horizontal wells typically used to produce from the Trenton-Black River interval would only increase the effectiveness of this formation. Due to production from the formation in the area of usable salt many of these horizontal wells already exist into the most favorable portions of the reservoirs.

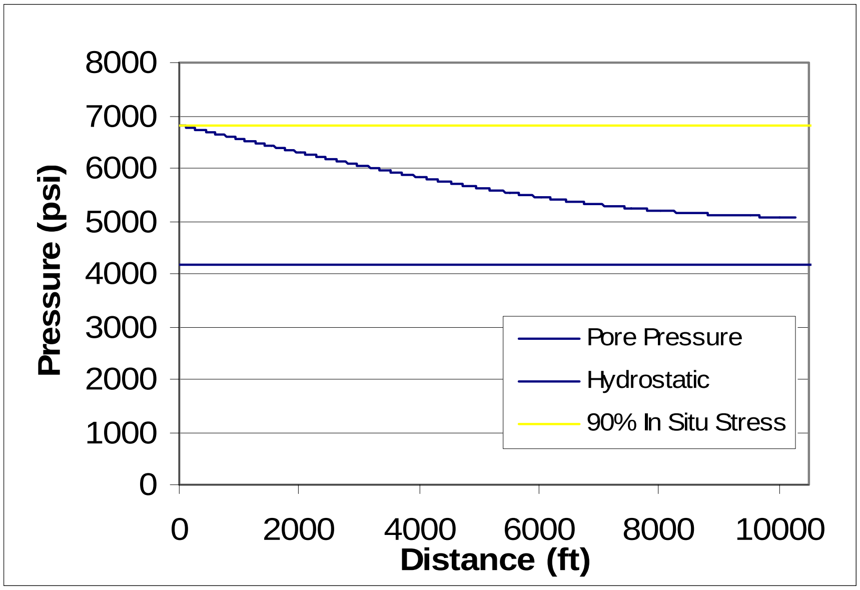


Figure 60 Brine Pressure in Trenton-Black River after 3 years (Horizontal well).

Because these fields are so heterogeneous and their lateral extent is unknown, they may make poor gas storage reservoirs themselves. In this scenario, gas might be injected and flow to an area where it cannot be recovered. Also, some of the bigger fields (>100 BCF) may be too big make good gas storage fields because too much gas would have to be used as cushion gas.

If they do not make good gas storage reservoirs due to their heterogeneity, unknown extent or size, the newly discovered Trenton Black River Fields could prove to be excellent brine disposal reservoirs. The heterogeneity is not a problem for brine injection, especially with fields that have already been discovered because the well porosity and permeability is already known and these good wells can be reused for disposal.

Using the calculations in Appendix C, a rule of thumb is that the brine produced from creation of 1 BCF of cavern space will fill the space in a Black River reservoir that produced 10 BCF of gas.

This will vary somewhat based on the depth of the field (shallower fields might accept a bit more brine per BCF of production than deeper fields). The Black River Fields discovered to date have produced between 1-50 BCF. Two of the largest Trenton-Black River fields, the Quackenbush and the Wilson Hollow fields are estimated to have 150 Bcf and 50 Bcf of gas in reserve and many fields are still being delineated and could produce similar quantities of gas. A 50 BCF field should be able to accept enough brine to make a 5 BCF salt cavern storage facility and this is a big enough to make a project economically feasible.

Because the fields are near each other, multiple fields could be used to dispose of brine from a single facility. Another obvious benefit to this approach is that many wells have already been drilled to the Black River and these well bores could be re-used as disposal wells. Any gas storage facility could also use the existing pipelines and other infrastructure, which would improve the economics of any salt cavern project considerably. Caverns could be mined directly above the reservoirs using new sidetracks completed from wells already drilled and brine could be injected into the highest perm wells (Figure 61). This could be an excellent opportunity for operators of these fields.

Like the Queenston Formation the Trenton-Black River interval is located below the salt and well below and sources of potable water. The groups are further separated from any potable water by several shale intervals, including the extremely thin Utica Formation and the Clinton Group. These facts establish that the Trenton-Black River interval meets Evaluation Criteria 3, which stipulates that formations mush be hydraulically separated from sources of potable water.

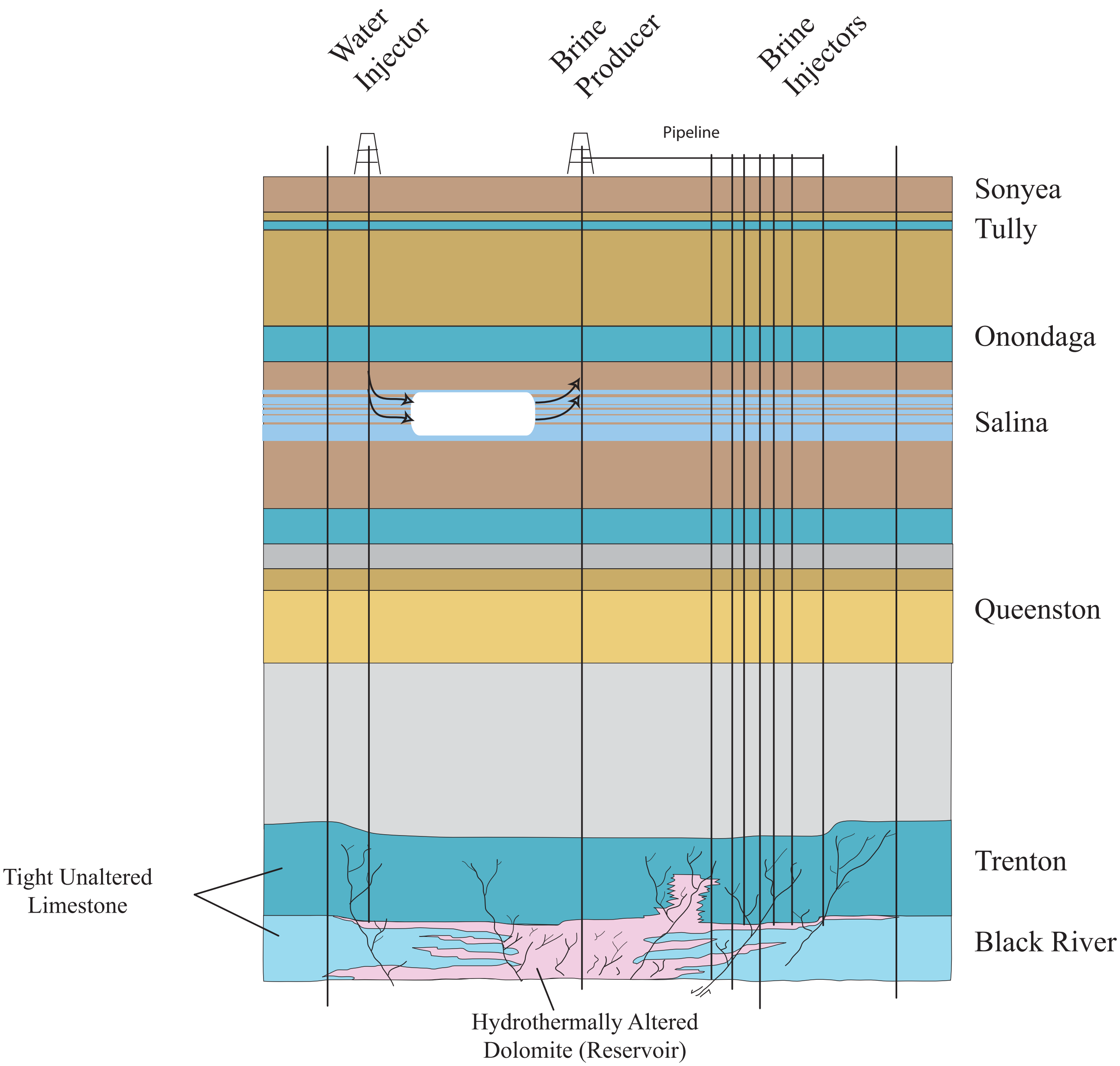


Figure 61 Glodes Corner Road Field used as an example of how existing Trenton field infrastructure could be used to develop salt-cavern storage facilities with brine disposal on or near site.

Beekmantown Group - Methods

Top Identification. The Cambro-Ordovician rocks used in the evaluation of the Beekmantown Group, while not as recognizable as the Middle Ordovician rocks, produce petrophysical log patterns that are identifiable over a great extent (Rickard, 1973). Tops used in the evaluation of the Beekmantown Group and surrounding formations in this report were primarily derived from review of Rickard (1973), Flagler (1966) and Bass, Sarwar and Friedman (1996). Figure 45 is a representative log for the tops picked in the evaluation of the Beekmantown Group. Additional visual examples of the Beekmantown Group picks used in this report can be seen in Plates 22 and 23.

The contact between the Galway and the overlying Little Falls is hard to distinguish and causes considerable confusion among operators. McCann et al. (1968) places the contact between the Galway (the author refers to the formation as the Theresa, see explanation below) and the Little Falls at a relatively consistent “kick” at the top of the major sandstone facies in the upper part of the Galway section. Figure 62, a gamma ray log through the Sauk Sequence from Bass et al (1996), demonstrates this pick and shows that both Bass et al (1996) and McCann et al. (1968) were in agreement as to where the top should be placed.

Cross Sections. Plate 23 is an east-west cross section of the Beekmantown Group from the Mohawk Valley, where cores are available, into south-central New York State where cavern development is possible. The cross sections show the entire Cambro-Ordovician section that comprises the Beekmantown Group, Tribes Hill, Little Falls, Galway (sometimes referred to as the Theresa, see explanation below) and Potsdam Formations as well as the Trenton and Black River Groups and the Precambrian Basement. These are stratigraphic cross sections that are hung on the top of the Trenton Group. Intervals interpreted to have dolomite are highlighted in magenta (see below for an explanation how Dolomite was identified).

Dolomite Identification using Geophysical Logs. Like the carbonates of the Trenton-Black River interval, the limestones of the Beekmantown Group have been hydrothermally altered in some areas. These altered dolomites are localized, but it is possible to locate them using

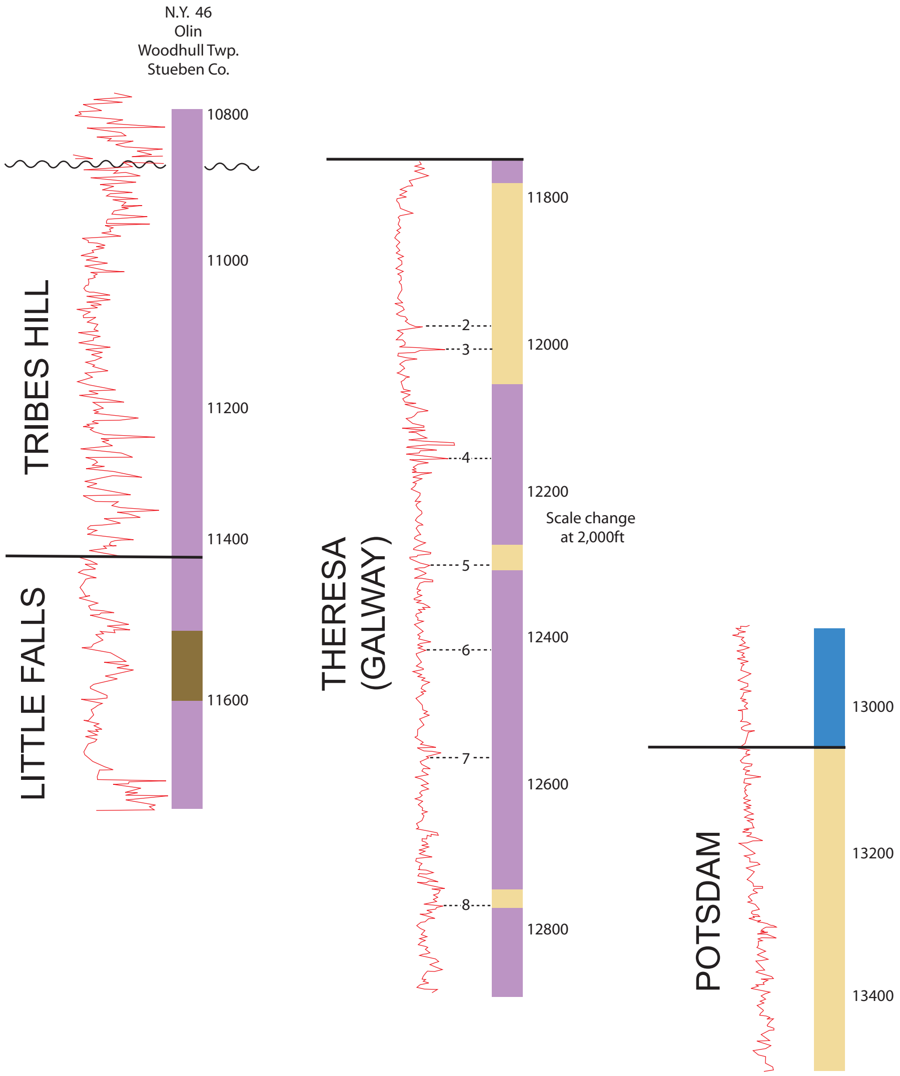


Figure 62 Stratigraphic Profile and Type Log for the Sauk Sequence, Stueben County, New York. (Modified from Bass et al., 1996)

geophysical well logs. See explanation given above in the Trenton-Black River methods under the same heading for a detailed description of how geophysical well logs can be used to identify intervals of dolomite.

Mohawk Valley Core Description and Correlation Poster. This report contains descriptions of three cores from the Beekmantown Group near the outcrop belt in the Mohawk Valley. The descriptions include: lithology (dolomite, limestone, shale), Dunham rock texture (grainstone, packstone, wackestone, etc), sedimentary structures, fracture intensity, porosity type and more. All of this information is captured in posters. The cores have been correlated to one another, allowing the sequence and cycle boundaries to be picked. We are confident that the sequences and the porosity units within them correlate across the study area.

Rock Mechanics Testing of the Beekmantown Formation Core Samples . Permeability tests were conducted on core samples from the Beekmantown Limestone from the Mohawk Valley of New York State. The core samples were from the Little Falls Formation in the 74NY-1 and 74NY-2 wells (these wells were drilled for mineral exploration and therefore has no API number). The test apparatus is shown in Figure 26. The configuration for the porosity and permeability testing of the Beekmantown samples was the same as that of the Queenston Formation.

Modeling of the Beekmantown Group. Since no major distinction was found between the permeabilities measured in the Queenston sandstone and the Beekmantown limestone, these rock types were not evaluated separately. Instead, rock properties were based on the typical 10.8 percent porosity, which yields a permeability of 0.185 milli-Darcy (same as those used for the Queenston Formation). See methods section for Queenston Formation for a detailed description of the modeling methods used.

Beekmantown Group - Description

The Cambro-Ordovician Beekmantown group was selected as a potential brine disposal reservoir based on the following generalizations:

- Reservoir is in porous dolomite and sandstones,
- Porosity may be widespread, as demonstrated by the Beekmantown Study in Ohio and core analysis in the Mohawk Valley of New York State,
- Beekmantown Group is thick within the study area.

The Beekmantown Group represents the Cambro-Ordovician succession of the Sauk Sequence in New York State. As defined by Sloss (1963), the Sauk Sequence encompasses those strata that overlie an interregional unconformity cut on the late Precambrian and older rocks and underlie an interregional unconformity at the base of the succeeding Tippecanoe Sequence (the Black River Group in central New York). In more detail, the succession includes (Figure 63):

Tribes Hill Formation (where present)
Little Falls Formation
Galway Formation (often referred to as the Theresa, explained below)
Potsdam Formation

Together this succession of strata consists of sandstones, sandy dolostone and dolostone. In general the dolostone increases and sandstone decreases from the bottom of the section to the top (Bass et al., 1996, Rickard, 1973). For the purpose of this study the lower three units, the Little Falls, Galway and Potsdam Formations will be considered, as they offer the best disposal potential.

Bass et al. (1996) thought that the Potsdam and Galway (Theresa) Formations offered the best potential for brine disposal. The authors made this comment after reviewing the average porosities of the two formations in the Mitchell # 1 well at the site of the Avoca Storage Project, Steuben County, New York. In stratigraphic tests of the of the Potsdam Formation in the well, porosities as high as 10% were recorded along with permeabilities ranging from 200-960 md. Bastedo and Van Tyne (1990) commented that the sandstones of both the Galway and Potsdam Formations often have shows of gas and salt water, but that structural closure or fracture systems were necessary to form a trap.

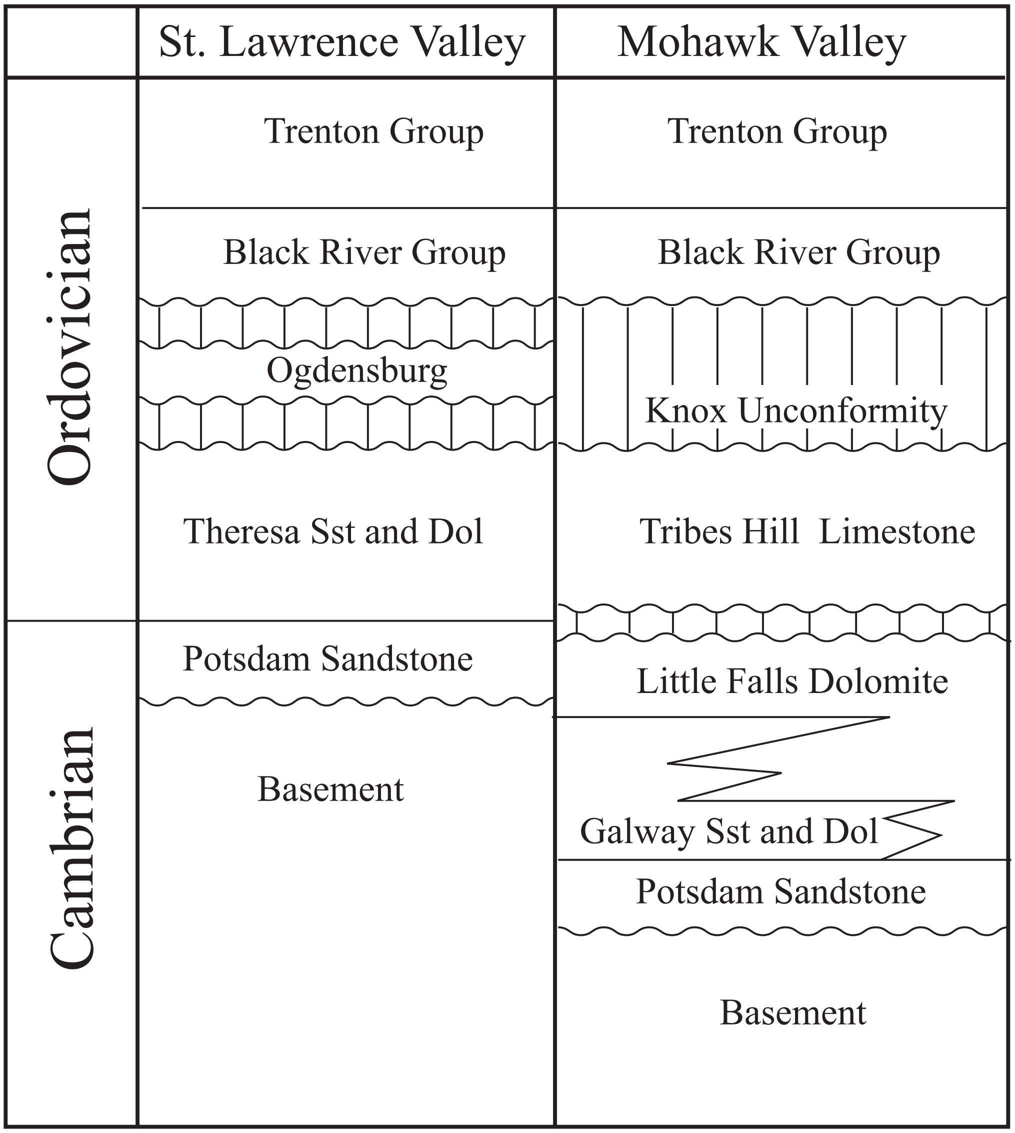


Figure 63 Comparison of the stratigraphy of the Cambro-Ordovician strata in the St. Lawrence Valley and the Mohawk Valley. In the study area of south central New York the stratigraphy most closely resembles that of the Mohawk Valley.

Potsdam Sandstone. The middle Cambrian Potsdam Sandstone lies unconformably over the eroded surface of the Precambrian Basement (Kreidler, 1975) and is the oldest sedimentary unit recognized in western New York State. Outcrops of the Potsdam sandstone are observed along the northern edge of the Adirondack uplift. In the subsurface of central New York, the Potsdam Formation is very fine- to medium-grained, light brown to gray sandstone with both silica and carbonate cement, frosted sand grains, muscovite and orthoclase feldspar (Saroff, 1987). The top of Potsdam is differentiated from the basal sandstone stringers of the Galway by the coarseness of the sandstone and by the higher feldspar content which is observed as an increase on the gamma ray curve (McCann et al., 1968). Rickard (1973) observed that the contact between the Potsdam sandstone and the Galway was difficult to ascertain in some wells due to the Potsdam sandstone being gradually replaced upwards by the quartzose dolostones and dolostones of the Galway Formation.

The Potsdam strikes generally east-west and regionally dips southward at an average rate of 100 feet/mile (~19 m/km). It ranges in depth from 3,000 feet (915 m) in western New York (near Buffalo) to nearly 13,000 feet (3,962 m) in south central New York (Steuben County near the Pennsylvania Border). On average the thickness of the Potsdam is 100 feet, but thicknesses up to 410 feet (125 m) have been reported in Oneida County (McCann et al., 1968).

According to McCann et al. (1968), the basal portion of the Potsdam is extremely porous and permeable in some places. This zone is believed to have produced natural gas around the turn of the century from several fields in western New York and Ontario. Natural gas was also produced from the basal Potsdam Sandstone in the Memphis area of Onondaga County in 1897 (Robinson , 1983). Where tested in Cattaraugus, Wyoming and Livingston Counties it produced brine (McCann et al., 1968).

Within the study area, no continuous zones of porosity were identified, but the small number of wells that reach this formation limited the sample size. The Mitchell #1 had some porosity and permeability, but the other injection wells at Avoca had none. This again is now rated as a possible brine injection target, but it has already proven unreliable as a primary target.

Galway Sandstone and Dolomite - (sometimes called the Theresa). Overlying the Potsdam in central New York is a late Cambrian aged formation that consists of sandstones and dolostones (Rickard, 1973). Researchers working primarily in the oil and gas industry (i.e. Flagler, 1966) have traditionally and erroneously referred to this formation as the Theresa, which has brought about much confusion in later attempts to characterize the formation. The Theresa outcrops mostly along the northern rim of the Adirondack uplift, where in type section it overlies the Little Falls. There the Theresa is an Ordovician in aged sandstone with interbedded dolomite. Rickard (1973) recommended that the name Galway be used because the type Theresa, located north of Watertown New York, is not continuous with what has been called the Theresa in the subsurface of central New York. This distinction was necessary, primarily because of discrepancies between the age and stratigraphic position (Figure 63) of the strata in the type locality and that of the rocks in the subsurface of central New York (Fischer and Hanson, 1951; Rickard 1973; Fisher, 1977; Zenger, 1981).

This study considers the late Cambrian sands and dolostones overlying the Potsdam in central New York to be the Galway Formation. The Theresa sandstone does not occur in the subsurface of western New York. Cambrian aged strata that is referred to as Theresa, is most likely the Galway Formation. This is primarily a nomenclature problem, but is relevant as much of the literature regarding this interval, especially prior to Rickard's work in 1973, refers to the Galway Formation as the Theresa. When citing papers where this is the case, Theresa will appear in parenthesis after Galway so that it will be clear to the reader what was used in the original text.

In the subsurface of central New York, the Galway (Theresa) Formation contains a combination of interbedded dolostones and sandstones, which varies dramatically both vertically and laterally. In many locations the Galway reportedly changes from unconsolidated sandstone to a hard orthoquartzite (Flagler, 1966; Saroff, 1987). East of Cayuga County, the Galway (Theresa) is predominantly a dolostone with few interbedded sandstones. West and southwest of Cayuga and Tompkins Counties, the formation contains considerably more sand and few interbedded carbonate layers (Kreidler, 1975; Saroff, 1987). Saroff noted that in the NYSERDA City of Auburn Well in Cayuga County, central New York, the Galway Sandstone is a light gray, calcitic cemented, subangular to subrounded sandstone with traces of granular hematite.

The subsurface strike of the Galway is east-west and the regional dip is southward at an average rate of 100 feet/mile. (~19 m/km) or slightly more. The average subsurface thickness of the Theresa is 700 feet (213 m), reaching a max thickness of 1,486 feet (453 m) in southern Steuben County, New York.

There has recently been production from the Galway sandstones in western New York to the north and west of the study area (Copley, 2004). These new wells may make as much as 0.5 BCF. This sandstone play may occur over a wide area, but its extent is not known at this time. This could be a possible brine disposal target if it can be demonstrated that the porous sandstones extend over a wide area. There was porosity in these sandstones in the Mitchell #1 at Avoca, but there was very little porosity in this formation in subsequent disposal wells drilled for that project. This is currently rated as a possible disposal reservoir, but at this time it appears that the porous zones are too patchy and small to make it a dependable brine injection target.

Little Falls Formation. The Little Falls in New York State is primarily dolostone with minor amounts of shale, sandstone and siltstone (Kreidler, 1975). The Little Falls outcrops along the southern and eastern edge of the Adirondack Uplift. At its type locality in Little Falls, Herkimer County, New York, the formation is reported to be roughly 200 feet (61 m) thick (McCann et al., 1968). Several authors have noted that the Little Falls in the subsurface is different from its type section (McCann et al., 1968; Rickard, 1973; Saroff, 1987).

In our study of the Beekmantown Group near the outcrop belt in the Mohawk Valley, there were zones of relatively high intercrystalline porosity in the dolomites of the Little Falls that correlated from well to well (see intervals shaded in green on Plate22). The Beekmantown dolomites have also produced significant quantities of gas in Ohio, which gave us further encouragement.

The subsurface distribution of the Little Falls is limited primarily to the southern extents of western New York. In the subsurface the formation is described as a light tan to brown, finely to medium-crystalline dolostone containing a lot of very fine to coarse quartz sand and in places thinly bedded siltstones (McCann et al., 1968; Saroff, 1987). The strike of the Little Falls Dolomite is east-west across the state; regional dip is southward at approximately 100 feet/mile. (~19 m/km). The thickness of the formation in the subsurface varies considerably, ranging from 0-300 feet (0-91m) in southeastern New York (Rickard, 1973; Saroff, 1987).

There are numerous porous zones in the upper Little Falls that have yielded salt water in test wells (McCann et al., 1968) in the subsurface. The authors thought that these porous zones were relatively continuous and believed that they could be potential disposal reservoirs. However, after and examination of all wells in the study area for which logs are available, we have not found many continuous porosity zones in the subsurface in that region. There was no porosity in the Little Falls at the site of the Avoca Project and it was not considered to be a good injection candidate there. We have subsequently downgraded the Little Falls as an injection candidate for this reason.

Mohawk Valley Core Description. In cores analyzed from the Mohawk Valley (Plate 21), there are zones of excellent high permeability intercrystalline porosity that appear to be laterally extensive. The correlation in Plate 22 shows that large-scale sequences (on the order of 50-100 feet thick) can be correlated over a distance of several tens of miles. Sequences are generally picked at the tops of high-energy shallow marine grainstones. The strong dolomitization makes it hard to pick sequence boundaries with confidence, but the sequences as picked do appear to correlate pretty well. The best porosity zones occur in sequences LF 4 and LF 5 at both sections, which strongly suggests good lateral extent to reservoir facies. The big "collapse" breccia horizon appears to correlate pretty well and is mostly in sequence LF 7. The tectonic breccia zones do not correlate well. The Galway onlaps the basement to the west rather than interfingering with Little Falls.

Similar laterally extensive porosity zones in the Beekmantown also occur in parts of western New York studied by the Beekmantown Consortium (Smith, 2003). If such a porosity zone could be located in the area where the salt is thick enough, the Beekmantown could easily accept large quantities of brine. Additional work needs to be done to determine the lateral extent of the porosity zones with in the Beekmantown and distribution of the formation within the study area.

Testing and Modeling Results for the Beekmantown Group. The mean and median permeabilities of the Beekmantown samples were similar to those of the Queenston Formation samples (Table 4). Like those of the Queenston Formation the Beekmantown permeabilities were found to correlate the difference in the confining and pore pressures. A smaller confining and pore pressure resulted in the largest permeabilities, though to a lesser extent in the Beekmantown than in the Queenston Formation (Figure 64 and 35).

Results from testing samples of the Beekmantown Group and the Queenston Formation, were similar enough that only one model was necessary to represent both sets of samples. Rock properties were based on a porosity of 10.8 percent, which yields a permeability of 0.185 milli-Darcy. See Testing and Modeling Results section for Queenston Formation for a detail description of model results. Both formations lack porosity and permeability at levels that would make brine disposal possible with out utilizing drilling techniques to increase the amount of formation volume available to the volume of brine to be disposed.

Table 4. Test Matrix

Formation	No. of Samples	No. of Tests	Confining Pressure (PSI)	Pore Pressure (PSI)	Range in Permeability (m-D)	Mean Permeability (m-D)	Median permeability (m-D)
Queenston	5	86	470 to 7000	100 to 6700	0.000027 to 0.0979	0.0162	0.0074
Beekman-town	5	84	1000 to 7000	320 to 6700	0.000091 to 2.90	0.132	0.00274

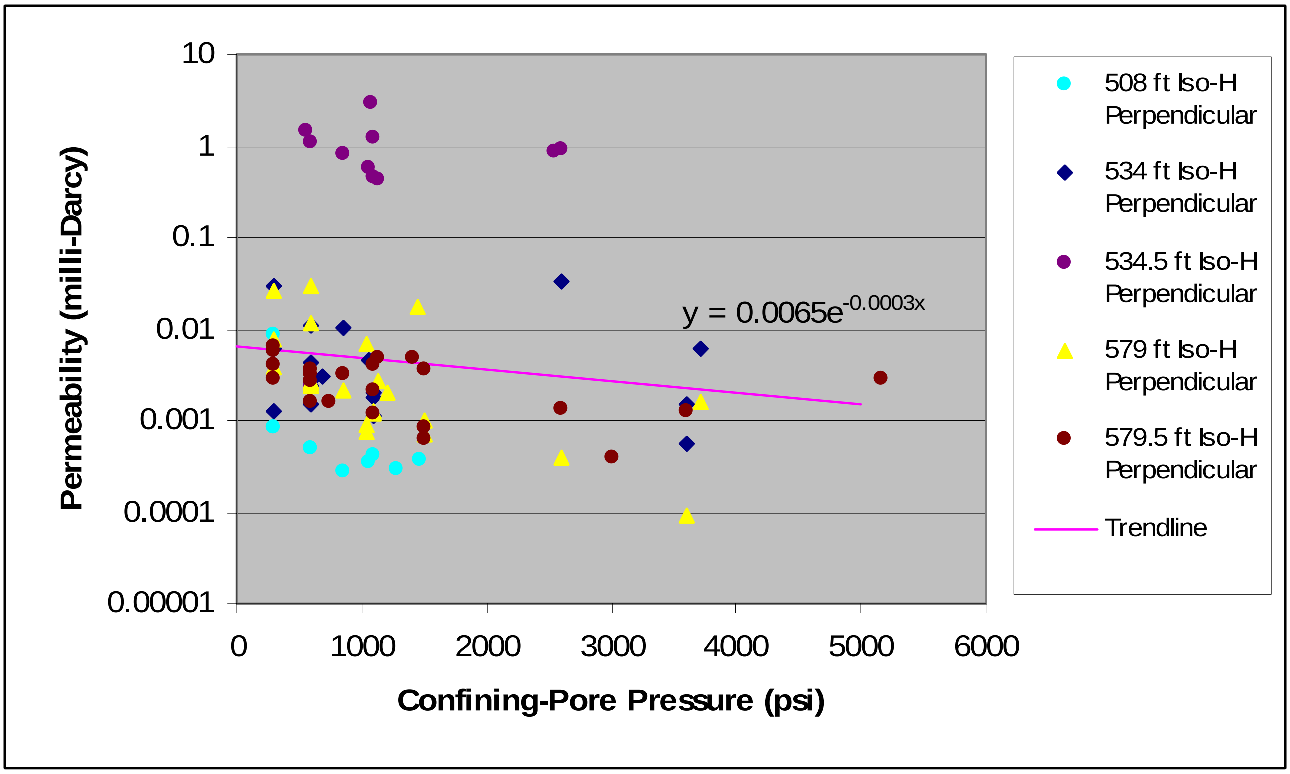


Figure 64. Beekmantown Limestone Permeabilities.

Section 4

CONCLUSIONS

Formations that have good porosity and permeability, have history of production, but are not currently being considered for traditional depleted reservoir type storage were considered for their ability to act as brine disposal reservoirs. The Ordovician Queenston Formation, the Early Ordovician Trenton-Black River Group and the Cambrian Beekmantown were initially selected as potential brine disposal reservoirs in the first cut of this selection process.

The sandstone reservoir of the Queenston was promising, because it is widespread and sand rich in the area of usable salt, it has shown to have the capacity to accept brine in current disposal operations and it has produced to the north for over 35 years. Reservoir potential in the Beekmantown Group was initially identified in the porous dolomites intervals and also possibly in the sandstones and hydrothermally altered breccias. Porosity in the Beekmantown is widespread and it is known to be thick in the area of usable salt. Modeling of both the Queenston Formation and the Beekmantown Group limestones showed that neither met Evaluation Criteria 1 and 2 because of the low permeability of each. Neither formation would be able to accept brine at the rates necessary for economic cavern development (10 BPM) without well stimulation or drilling programs that are not practical in New York State.

The Trenton-Black River carbonates have the greatest potential as brine disposal reservoirs. They are the most prolific producers in recent times, the fields are active and located within the area of central New York where salt cavern storage is a possibility; it is possible that the fields will be unattractive for depleted reservoir type storage due to their heterogeneity and unknown lateral extent. Reservoirs in the Trenton-Black River would be found in the vuggy dolomite of the upper Black River section. The Trenton-Black River interval meets and exceeds all three of the Disposal Formation Evaluation Criteria and stands out as the best option for brine disposal. We have been in contact with the companies currently producing gas from these fields and they are interested in either building salt caverns themselves or selling the fields to a gas storage company when they are depleted.

Drilling and well stimulation techniques will continue to improve along with geophysical techniques. The primary motivation of advances in industrial technology is reservoir development and storage of natural gas, not brine. Never-the-less, the same technology is often applicable to brine disposal. Such advances will better locate potential injection areas and increase well injectivities in the future. At some point, even the marginal brine disposal units discussed above will become economical.

The methodology used in this report could prove effective in other states or regions where brine disposal has negatively affected the progression of salt cavern development. In all areas, it would be important to first identify locations where salt cavern storage would be possible. The criteria governing this evaluation process may differ in other regions or states based on differing state regulation of cavern development or if the material to be stored in the cavern is not natural gas (criteria presented in this report were for natural gas). As in this study, narrowing the area of study will allow future efforts to be focused into areas with cavern development potential. Any evaluation of potential brine disposal reservoirs should first select formations that offer the best potential for successful brine disposal. Beyond selection, modeling informed by parameters from the potential disposal formation can be used quantify the ability of each formation to accept brine at an economic rates and volumes.

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Appendices

A – Silurian Data
B – Queenston Formation Data
C- Trenton-Black River Data

Appendix A

Silurian Data

Apppendix - A - Table 1 - Silurian - General Well Data

API #	Hole #	Name	Lat	Lon	Town	County	Total Depth
31101002160000	00216	Herrington [n593s]	42.0688	-77.4108	Woodhull	STEUBEN	8625
31003002460000	00246	Chadwick F 1	42.0938	-78.1709	Wirt	ALLEGANY	4850
31101003290000	00329	Champlin 2	42.4032	-77.21	Urbana	STEUBEN	4507
31015004430000	00443	Kesselring 1	42.1986	-76.5381	Van Etten	CHEMUNG	11145
31011004780000	00478	Mahaney J C	42.6848	-76.6443	Ledyard	CAYUGA	6166
31109004810000	00481	Farkas Joe 1	42.5292	-76.5074	Lansing	TOMPKINS	6210
31097005610000	00561	Best 2 [h122]	42.4805	-77.0778	Tyrone	SCHUYLER	4459
31011010500000	01050	Aurora 1	42.7534	-76.7047	Ledyard	CAYUGA	1068
31003011590000	01159	King Adelbert 1	42.1348	-77.9712	Scio	ALLEGANY	5025
31017011600000	01160	Lobdell 1	42.6933	-75.3451	Columbus	CHENANGO	5701
31109022860000	02286	Cayuga Rock Salt	42.5303	-76.5293	Lansing	TOMPKINS	1964
31023023080000	02308	Overbaugh Philip 1	42.4221	-76.2015	Harford	CORTLAND	3218
31101026790000	02679	Blair 1	42.3075	-77.2567	Bath	STEUBEN	3350
31003029670000	02967	McElroy 1	42.5011	-78.2297	Centerville	ALLEGANY	5505
31111031990000	03199	A Herdman 1	42.1004	-74.3842	Shandaken	ULSTER	6400
31003032640000	03264	Herdman Jos 1	42.2849	-78.0074	Angelica	ALLEGANY	5475
31051032770000	03277	Livonia Salt Shaft 1	42.8016	-77.6786	Livonia	LIVINGSTON	1432
31051033050000	03305	Hunt 1	42.6996	-77.6685	Conesus	LIVINGSTON	3411
31121038650000	03865	Lockwood Harold 1	42.5704	-78.0789	Genesee Falls	WYOMING	3583
31069038660000	03866	Male Merle 1	42.6785	-77.4431	South Bristol	ONTARIO	3850
31121038800000	03880	Fee 14	42.6546	-78.0662	Castile	WYOMING	2368
31101038940000	03894	Hargrave [n588s]	42.0486	-77.4264	Woodhull	STEUBEN	9790
31101039240000	03924	Olin [n650s]	42.063	-77.4307	Woodhull	STEUBEN	13500
31109039380000	03938	Fee 20	42.5482	-76.5531	Lansing	TOMPKINS	2125
31097039400000	03940	International 29	42.4201	-76.8947	Reading	SCHUYLER	2698
31051039420000	03942	Martuccio 1	42.6853	-77.6618	Conesus	LIVINGSTON	3549
31003039560000	03956	Cook G M 2	42.453	-78.1743	Hume	ALLEGANY	7337
31053039700000	03970	Branangan Donald 1	42.8048	-75.6505	Lebanon	MADISON	5703
31069039710000	03971	Treble 1	42.785	-77.4926	Richmond	ONTARIO	2506
31109039730000	03973	Shepard 1	42.3702	-76.5063	Danby	TOMPKINS	10438
31069039910000	03991	Kage 1	42.7847	-77.4558	Bristol	ONTARIO	2902
31043039930000	03993	Skranko 1	42.8807	-74.9168	Warren	HERKIMER	3581
31069039970000	03997	Clement 1	42.7979	-77.5089	Richmond	ONTARIO	2308
31053040020000	04002	Parteko N-748	42.817	-75.6591	Lebanon	MADISON	2794

API #	Hole #	Name	Lat	Lon	Town	County	Total Depth
31069040050000	04005	Allen 1	42.8012	-77.4943	Richmond	ONTARIO	2591
31109040070000	04007	Smiley Jean H 1	42.3654	-76.5033	Danby	TOMPKINS	8555
31121040080000	04008	Cornwell 757	42.7965	-77.9631	Perry	WYOMING	2210
31069040270000	04027	Mills Lewis 1	42.7915	-77.4218	Bristol	ONTARIO	3072
31069040350000	04035	Gladding Phil 1	42.8007	-77.439	Bristol	ONTARIO	2986
31051040530000	04053	Nivers 1	42.7649	-77.6593	Livonia	LIVINGSTON	3020
31077040550000	04055	Lum Paul B et al 1	42.6309	-74.7082	Worcester	OTSEGO	5511
31011040680000	04068	Shoemaker 1 (768-1)	42.8811	-76.6398	Springport	CAYUGA	1967
31051040690000	04069	Mc Donald	42.8716	-77.9321	York	LIVINGSTON	5090
31025040730000	04073	Hirsch K 1	42.3739	-75.0426	Franklin	DELAWARE	5327
31099040820000	04082	Stein 1	42.8759	-76.84	Fayette	SENECA	2286
31053040850000	04085	Doroshenko 1	42.8798	-75.6867	Eaton	MADISON	2988
31121040920000	04092	Veith D 1	42.6173	-78.0802	Gainesville	WYOMING	7182
31109041300000	04130	Grund GH	42.4421	-76.5928	Enfield	TOMPKINS	8900
31051041510000	04151	Smith N834	42.8132	-77.9422	Leicester	LIVINGSTON	2079
31121041620000	04162	Fee 17	42.6701	-78.0826	Gainesville	WYOMING	2431
31051041880000	04188	Austin 1	42.7664	-77.7551	Geneseo	LIVINGSTON	2625
31003042480000	04248	Wolfer Duane A 1	42.4704	-78.1602	Hume	ALLEGANY	7560
31011043650000	04365	Johnson 1	42.9705	-76.5169	Sennett	CAYUGA	2000
31121043850000	04385	Wesley Johns 1	42.63	-78.1538	Gainesville	WYOMING	0
31097044000000	04400	Watkins Storage 1	42.3677	-76.8639	Dix	SCHUYLER	2726
31121044320000	04432	Schuelte Harriett 1	42.8359	-78.3324	Bennington	WYOMING	0
31121044470000	04447	Warren 1	42.8026	-78.1501	Middlebury	WYOMING	5820
31069044500000	04450	Gonenhauser Max 1	42.8863	-77.4817	West Bloomfield	ONTARIO	2053
31109044670000	04467	Fee Richarson 1	42.3844	-76.5407	Newfield	TOMPKINS	9390
31051045310000	04531	Hunn 1	42.8319	-77.9501	York	LIVINGSTON	2182
31121045360000	04536	Page Henry 1	42.8267	-78.1384	Middlebury	WYOMING	6233
31051046300000	04630	Kennedy 1	42.6502	-77.756	Sparta	LIVINGSTON	6388
31023047140000	04714	Clough K & O 1	42.5185	-76.0009	Freetown	CORTLAND	8272
31123047960000	04796	Fee 1	42.6838	-77.0222	Benton	YATES	3061
31007048540000	04854	Quarella 1	42.399	-75.8804	Triangle	BROOME	5831
31067049020000	04902	Frost Gg Jr 1	42.9204	-76.2904	Marcellus	ONONDAGA	2760
31007050870000	05087	Richards 1	42.3235	-75.9479	Triangle	BROOME	9640
31007066360000	06636	Smith Charles E 1	42.4062	-75.8774	Triangle	BROOME	5907
31007083420000	08342	Gerst 1	42.3977	-75.8906	Triangle	BROOME	6420
31009092350000	09235	Enterprise Transit St 1	42.0087	-78.5687	Allegany	CATTARAUGUS	11680

API #	**Hole #**	**Name**	**Lat**	**Lon**	**Town**	**County**	**Total Depth**
31123098460000	09846	Christenson 1	42.7115	-77.0306	Benton	YATES	2971
31107098480000	09848	Robinson Francis 1	42.0759	-76.4521	Barton	TIOGA	5220
31077101380000	10138	Schwerd Frederick W 1	42.6934	-75.095		OTSEGO	2723
31109102430000	10243	Place Ruth A 1	42.401	-76.6684	Enfield	TOMPKINS	3670
31015103350000	10335	Matejka 1	42.169	-76.659	Erin	CHEMUNG	10614
31017106090000	10609	Hulbert 1	42.3475	-75.5887	Oxford	CHENANGO	6427
31011121490000	12149	Michael Deptuch 1	42.6414	-76.2933	Summerhill	CAYUGA	4542
31069121950000	12195	Champlin 1	42.8685	-77.5086	West Bloomfield	ONTARIO	2122
31101124020000	12402	Kish 1	42.3167	-77.3894	BathN	STEUBEN	5879
31097128580000	12858	Akzo 57	42.4223	-76.898	ReadingN	SCHUYLER	2770
31097128590000	12859	Akzo 56	42.4088	-76.8976	ReadingN	SCHUYLER	2936
31109131730000	13173	Cargill Core Test	42.523	-76.5052	LansingN	TOMPKINS	2784
31121133080000	13308	Shattuck,M 1	42.5279	-78.1413	PikeN	WYOMING	3700
31101136990000	13699	NYS Reforestation 6	42.4662	-77.2654	Wheeler	STEUBEN	9794
31101137360000	13736	Wagner20615-T	42.4347	-77.4091	Wheeler	STEUBEN	4849
31003155120000	15512	Barker b-1	42.3857	-78.2452	Rushford	ALLEGANY	4205
31101158340000	15834	Bush Hill 1	42.2032	-77.5924	Canisteo	STEUBEN	6595
31003186510000	18651	Kozoil 1	42.4048	-78.0481	Allen	ALLEGANY	4851
31023194840000	19484	Jones 1	42.7028	-76.2662	Scott	CORTLAND	5616
31101194970000	19497	Evangelos 21436-T	42.5407	-77.2162	Pulteney	STEUBEN	7961
31023195400000	19540	Vander Ploeg 1	42.5543	-76.0209	Freetown	CORTLAND	7820
31099196860000	19686	Townsend 1	42.5882	-76.8443	Lodi	SENECA	4100
31097196920000	19692	Perigo 21578 Tpi	42.4325	-76.9704	Reading	SCHUYLER	8384
31003200230000	20023	Friendship Dairies 1	42.2114	-78.1173	Friendship	ALLEGANY	5236
31099204460000	20446	Compton 1 (4177)	42.7086	-76.8085	Romulus	SENECA	6366
31123205620000	20562	Castner 1-S	42.6695	-77.1622	Potter	YATES	3674
31025210050000	21005	Grant, C. 1a	42.399	-75.0527	Franklin	DELAWARE	5580
31003211130000	21113	Lucey, J 1	42.2354	-77.9352	Ward	ALLEGANY	6057
31003211150000	21115	Loree, M 1a	42.3589	-77.8256	Almond	ALLEGANY	5251
31101214680000	21468	Mitchell 1	42.4196	-77.4535	Avoca	STEUBEN	9887
31097214950000	21495	Bale 1	42.2699	-76.7139	Cayuta	SCHUYLER	11823
31101214960000	21496	Hubbard No. 1	42.4053	-77.4635	Avoca	STEUBEN	10051
31023215000000	21500	NYS REF 6 Well 01	42.639	-75.9136	Taylor	CORTLAND	6886
31101215510000	21551	BPSI 8	42.3116	-77.2567	Bath	STEUBEN	6000
31101215840000	21584	BPSI 10	42.3094	-77.26	Bath	STEUBEN	3596
31101215870000	21587	BPSI 9	42.3094	-77.2591	Bath	STEUBEN	3766

API #	Hole #	Name	Lat	Lon	Town	County	Total Depth
31101215880000	21588	BPSI 11	42.3111	-77.2585	Bath	STEUBEN	3777
31101215890000	21589	BPSI 12	42.3073	-77.2596	Bath	STEUBEN	3601
31101217180000	21718	Demun 1	42.0956	-77.5943	Troupsburg	STEUBEN	11166
31009218090000	21809	Hebdon 1	42.3954	-78.6722	Ashford	CATTARAUGUS	7502
31013224980000	22498	Butts 1-B	42.1438	-79.4174	North Harmony	CHAUTAUQUA	7620
31123227430000	22743	Sensenig 1	42.5073	-76.9726	Starkey	YATES	7241
31109227530000	22753	Koskinen 623513	42.4903	-76.6733	Ulysses	TOMPKINS	7462
31097227540000	22754	Gunning 1	42.4601	-76.7321	Hector	SCHUYLER	7999
31101227580000	22758	S & D Farms 623504	42.5494	-77.4542	Cohocton	STEUBEN	7416
31097227930000	22793	Cook 1	42.5355	-76.7359	Hector	SCHUYLER	7587
31123227970000	22797	Bedient 1 (623788)	42.5834	-77.1663	Jerusalem	YATES	6887
31101228140000	22814	Howe 1300	42.2048	-77.0545	Hornby	STEUBEN	0
31015228270000	22827	Bennett Family 1	42.2841	-76.775	Veteran	CHEMUNG	9442
31097228300000	22830	Grand Prix 624066	42.306	-77.0808	Orange	SCHUYLER	9745
31015228310000	22831	Lovell 1323	42.1867	-76.9585	Big Flats	CHEMUNG	9386
31015228390000	22839	Whiteman 1	42.2852	-76.9165	Catlin	CHEMUNG	9372
31123228500000	22850	Watson 1	42.6179	-77.317	Italy	YATES	7136
31015228530000	22853	Rhodes 1322	42.1953	-76.9212	Big Flats	CHEMUNG	9682
31101228590000	22859	Huber 1	42.5356	-77.5922	Wayland	STEUBEN	7535
31101228610000	22861	NYS GMA 2	42.1575	-77.1649	Erwin	STEUBEN	10524
31101228710000	22871	Henkel 1359	42.1671	-76.9727	Corning City	STEUBEN	0
31101228840000	22884	Fratarcangelo 1371	42.2345	-76.977	Hornby	STEUBEN	9840
31101228850000	22885	Corning Game Club 624460	42.1799	-77.0665	Corning	STEUBEN	10050
31015228910000	22891	Parker 1401	42.2379	-76.9389	Catlin	CHEMUNG	10323
31015228990000	22899	Trimber 624536	42.1603	-76.6871	Erin	CHEMUNG	10530
31015229010000	22901	Roy 1	42.2713	-76.957	Catlin	CHEMUNG	9487
31015229020000	22902	Lederer 1412	42.2525	-76.8694	Catlin	CHEMUNG	9602
31015229110000	22911	Schmidt 624537	42.1467	-76.6931	Erin	CHEMUNG	10366
31015229180000	22918	Gregory 1446	42.2072	-76.8847	Catlin	CHEMUNG	9402
31015229190000	22919	Hardy 1447	42.2374	-76.9205	Catlin	CHEMUNG	9859
31015229240000	22924	Johnson 1	42.2689	-76.7512	Veteran	CHEMUNG	9803
31015229330000	22933	Usack 624684	42.1586	-76.6625	Erin	CHEMUNG	10338
31107229340000	22934	Manwaring 624470	42.0578	-76.4101	Tioga	TIOGA	11552
31097229350000	22935	Wonderview Farms 1	42.3303	-76.7472	Catharine	SCHUYLER	8762
31123229390000	22939	Button 624469	42.7464	-77.2875	Middlesex	YATES	5582
31097229420000	22942	Bonham 1	42.2959	-76.9894	Orange	SCHUYLER	10069

API #	**Hole #**	**Name**	**Lat**	**Lon**	**Town**	**County**	**Total Depth**
31099229500000	22950	Ziefle 1	42.5641	-76.7023	Covert	SENECA	7497
31007229950000	22995	Beagell 2	42.1372	-75.8339	Kirkwood	BROOME	10260
31013232470000	23247	Hayner 2	42.2736	-79.6413	Westfield	CHAUTAUQUA	5953
31009234350000	23435	Geiger Hollow 1	42.0284	-78.5116	Allegany	CATTARAUGUS	9346
31097611920000	61192	Akzo 36	42.413	-76.8954	Reading	SCHUYLER	2857
31097612050000	61205	Akzo 49	42.4098	-76.8979	Reading	SCHUYLER	2951
31097612060000	61206	Akzo 50	42.4103	-76.8947	Reading	SCHUYLER	2530

Appendix A - Table 2 - Salina F-unit Interval Data

Study (see key at bottom of column)	**SAPINO (short API)**	**Net Thickness F-unit salt (ft.)**	**Intervals of Salt Suitable for Cavern Development** (> 100ft of continuous salt with less than 10 ft. of nonsalt layers)	**Thickness of Salt Suitable for Cavern Development (ft)** (when more than one interval of salt is present, the greatest is used for mapping)	**Net Thickness of Salt Suitable for Cavern Development (ft.)**	**Comments**
STW	**00216-00**	443	4327-4600	273	383	
			4770-4880	110		
STWWOR	**00246-00**					
STWWOR	**00329-00**					
RKD	**00443-00**	564	3833-4003	170	653	
			4210-4576	366		
			4458-4575	117		
RKD	**00478-00**	50				no 100 ft intervals
STWWOR	**00481-00**					
STW	**00561-00**					well not deep enough
STWWOR	**01050-00**					
LOC	**01160-00**					no f salt
STWWOR	**02286-00**					
STWWOR	**02308-00**					
STWWOR	**02679-00**					
STWWOR	**02967-00**					
RKD	**03199-00**	0		0	0	no salt
RKD	**03264-00**					no logs
STWWOR	**03277-00**					
FR	**03305-00**					only caliper log available
STWWOR	**03865-00**					
STWWOR	**03866-00**					
STW	**03880-00**	57		0	0	no 100 ft intervals
STW	**03894-00**	390	4840-4975	135	240	
			4500-4605	105		
RKD	**03904-00**	0		0	0	no f salt
RKD	**03924-00**	338	4545-4660	115		
RKD	**03938-00**	339	1706-1846	140	272	
			1994-2126	132		
STWWOR	**03939-00**					
STW	**03940-00**	348	1938-2136	198	334	
			2276-2412	136		
STW	**03942-00**	5		0	0	no 100 ft intervals
STW	**03956-00**	20		0	0	no 100 ft intervals
STW	**03970-00**	0		0	0	no f salt
STW	**03971-00**	0		0	0	no f salt
RKD	**03973-00**	730	2927-3111	184	656	
			3320-3620	300		
			3710-3882	172		
STW	**03991-00**	36		0	0	
RKD	**03993-00**	0		0	0	no f salt
STW	**03997-00**	47		0	0	no 100 ft intervals
STWWOR	**03999-00**	0		0	0	no f salt
STW	**04002-00**	0		0	0	no f salt
STW	**04005-00**	15		0	0	no 100 ft intervals
RKD	**04007-00**	772	2945-3078	133	470	
			3140-3245	105		
			3700-3825	125		

Study (see key at bottom of column)	**SAPINO (short API)**	**Net Thickness F-unit salt (ft.)**	**Intervals of Salt Suitable for Cavern Development** (> 100ft of continuous salt with less than 10 ft. of nonsalt layers)	**Thickness of Salt Suitable for Cavern Development (ft)** (when more than one interval of salt is present, the greatest is used for mapping)	**Net Thickness of Salt Suitable for Cavern Development (ft.)**	**Comments**
			3838-3945	107		
STW	**04008-00**	0		0	0	no f salt
STW	**04027-00**	62		0	0	no 100 ft intervals
STW	**04035-00**	0		0	0	no f salt
STW	**04053-00**	39		0	0	no 100 ft intervals
RKD	**04055-00**	0		0	0	no f salt
RKD	**04068-00**	0		0	0	no f salt
RKD	**04069-00**	0		0	0	poor logs
RKD	**04073-00**	0		0	0	no f salt
RKD	**04082-00**	0		0	0	no f salt
RKD	**04085-00**					no logs available for interval
RKD	**04092-00**	0		0	0	no f salt
RKD	**04130-00**	334	3047-3183	136	236	
			3415-3515	100		
STWWOR	**04151-00**	0		0	0	no f salt-log is bad in this section
STW	**04162-00**	98		0	0	
STWWOR	**04188-00**					
RKD	**04248-00**	0		0	0	no salt
STW	**04447-00**	0		0	0	no f salt
RKD	**04467-00**	482	2846-3140	294	294	
STW	**04531-00**	5		0	0	no 100ft intervals
STW	**04536-00**	7		0	0	no 100ft intervals
STW	**04630-00**	89		0	0	no 100ft intervals
STW	**04714-00**	0		0	0	no usable salt
STW	**04796-00**	53		0	0	no 100 ft intervals
RKD	**04902-00**	64		0	0	no 100ft intervals
RKD	**05087-00**	241		0	0	no 100ft intervals
LOC	**09235-00**	25		0	0	no 100ft intervals
STW	**09846-00**	0		0	0	no salt
LOC	**09848-00**	218	4600-4773	173	173	
LOC	**10138-00**	7		0	0	no 100 ft intervals
STW	**10243-00**	64		0	0	no 100 ft intervals
LOC	**10609-00**	0		0	0	no f salt
FR	**12149-00**	317	2550-2660	110	228	
			2400-2518	118		
LOC	**12195-00**	43		0	0	no 100ft intervals
FR	**12402-00**	370	4345-4610	265	390	
			4860-4985	125		
FR	**12858-00**	316	2036-2238	202	304	
			2398-2500	102		
FR	**12859-00**	251	2530-2644	114	114	
LOC	**13173-00**	369	1939-2042	103	103	
LOC	**13308-00**	0		0	0	no salt in f unit
FR	**13699-00**	242	3428-3568	140	140	
FR	**13736-00**	269	3236-3371	135	135	
FR	**15834-00**	182		0	0	no usable salt
LOC	**18651-00**	0		0	0	no salt in f unit
FR	**19484-00**	254	2474-2593	119	119	
FR	**19497-00**	134	2836-2944	112	112	
FR	**19540-00**	280	3150-3275	125	125	

Study (see key at bottom of column)	**SAPINO (short API)**	**Net Thickness F-unit salt (ft.)**	**Intervals of Salt Suitable for Cavern Development** (> 100ft of continuous salt with less than 10 ft. of nonsalt layers)	**Thickness of Salt Suitable for Cavern Development (ft)** (when more than one interval of salt is present, the greatest is used for mapping)	**Net Thickness of Salt Suitable for Cavern Development (ft.)**	**Comments**
FR	**19686-00**	204	2005-2120	115	115	
FR	**19692-00**	416	2790-3100	310	451	
			3149-3290	141		
LOC	**20023-00**	42		0	0	no usable salt
FR	**20446-00**	0		0	0	? Friedman didn't say there was salt here
LOC	**20562-00**	80		0	0	no usable salt
LOC	**21005-00**	0		0	0	no salt in F-unit, raster not saved
LOC	**21113-00**	64		0	0	no usable salt
LOC	**21115-00**	78		0	0	no usable salt
FR	**21468-00**	270	3810-3920	110	110	
FR	**21495-00**	410	4425-4587	162	422	
			4108-4368	260		
FR	**21496-00**	160		0	0	no 100 ft intervals
FR	**21500-00**	125		0	0	no 100 ft intervals
LOC	**21551-00**	271	3050-3257	187	187	
LOC	**21584-00**	315	3004-3269	265	265	
LOC	**21587-00**	457	2997-336	363	473	
			3410-3520	110		
LOC	**21588-00**	302	3109-3350	241	241	
LOC	**21589-00**	412	3008-3310	302	302	
LOC	**21718-00**	86		0	0	no usable salt
LOC	**21809-00**	0		0	0	no salt in f unit
LOC	**22498-00**	0		0	0	no salt in f unit
LOC	**22743-00**	184	2120-2226	106	106	
LOC	**22753-00**	100	2620-2780	160	160	
LOC	**22754-00**	294	3158-3288	130	130	
LOC	**22758-00**	110				no usable salt
LOC	**22793-00**	189	2475-2637	162	162	no 100 ft intervals
LOC	**22797-00**	168		0	0	no 100 ft intervals
LOC	**22814-00**	516	4220-4425	205	205	
			4438-4620	102		
LOC	**22827-00**	430	4110-4247	137	336	
			3789-3990	199		
LOC	**22830-00**	483	3630-3730	100	230	
			4104-4234	130		
LOC	**22831-00**	512	4070-4286	216	402	
			4314-4500	186		
LOC	**22839-00**	701	3453-3776	323	543	
			3953-4173	220		
LOC	**22850-00**	89		0	0	no 100 ft intervals
LOC	**22853-00**	467	4017-4365	340	340	
LOC	**22859-00**	67				no usable salt
LOC	**22861-00**	646	4320-4550	230	710	
			4710-4990	280		
			5087-5287	200		
LOC	**22871-00**	455	4062-4290	228	370	
			4398-4540	142		
LOC	**22884-00**	483	3821-4201	380	491	
			4254-4365	111		

Study (see key at bottom of column)	**SAPINO (short API)**	**Net Thickness F-unit salt (ft.)**	**Intervals of Salt Suitable for Cavern Development** (> 100ft of continuous salt with less than 10 ft. of nonsalt layers)	**Thickness of Salt Suitable for Cavern Development (ft)** (when more than one interval of salt is present, the greatest is used for mapping)	**Net Thickness of Salt Suitable for Cavern Development (ft.)**	**Comments**
LOC	**22885-00**	485	3777-3972	195	432	
			3991-4101	110		
			4313-4440	127		
LOC	**22891-00**	386	4310-4528	218	333	
			4680-4795	115		
LOC	**22899-00**	406	4610-4830	220	347	
			4953-5080	127		
LOC	**22901-00**	531	3290-3554	264	490	
			3610-3721	111		
			3851-3966	115		
LOC	**22902-00**	360	3960-4227	267	267	
LOC	**22911-00**	494	4233-4672	439	569	
			4830-4960	130		
LOC	**22918-00**	523	3650-3910	260	364	
			3950-4054	104		
LOC	**22919-00**	400	4290-4490	200	323	
			4657-4780	123		
LOC	**22924-00**	382	3846-4166	320	420	
			4190-4290	100		
LOC	**22933-00**	608	4257-4725	468	596	
			4880-5008	128		
LOC	**22934-00**	176	5975-6080	105	105	
LOC	**22935-00**	850	2566-3008	442	645	
			3414-3515	101		
			3550-3652	102		
LOC	**22939-00**	32		0	0	no usable salt
LOC	**22942-00**	556	3584-3897	313	508	
			4135-4330	195		
LOC	**22950-00**	331	2426-2690	246	246	
LOC	**22995-00**	127	5785-5920	135	135	
LOC	**23247-00**	0		0	0	no salt in f unit
LOC	**23435-00**	27		0	0	no 100 ft intervals
FR	**61192-00**	148	2060-2222	162	162	not complete log of interval
FR	**61205-00**	336	2530-2642	112	214	
			2150-2252	102		
FR	**61206-00**	421	2294-2424	130	302	
			2434-2606	172		

LOC = current NYSM study
FR = Friedman et al., 2002
STW = Stone and Webster Eng. Report, 1978
STWOR = Stone and Webster Eng. Report, 1978 (well without raster log)
RKD = Rickard, 1963

Appendix A - Table 3 - Formation Tops

														Syracuse			Vernon					
API Number	**Well Label**		**ONONDAGA**	**SCHOHARIE**	**CARLISLE CENTER**	**ESOPUS**	**ORISKANY**	**HELDER-BERG**	**BECRAFT**	**COEYMANS**	**MANLIUS**	**RONDOUT/ COBLESKILL**	**BERTIE**	**CAMILLUS**	**F_UNIT**	**E_UNIT**	**D_UNIT**	**C_UNIT**	**B_UINT**	**A_UNIT**	**LOCKPORT**	**CLINTON**	**ROCHESTER**
31101002160000	**00216**														5872	6631							
31003002460000	**00246**														4620	4812							
31101003290000	**00329**														3127	3587							
31015004430000	**00443**														3700	4582							
31011004780000	**00478**														1425	1750							
31109004810000	**00481**														3062	3432							
31097005610000	**00561**														2156	2600							
31011010500000	**01050**														1338								
31003011590000	**01159**														4197	4442							
31017011600000	**01160**														2053	2111							
31109022860000	**02286**														1813	2494							
31023023080000	**02308**														4229								
31101026790000	**02679**														2951								
31003029670000	**02967**														5099	5194							
31111031990000	**03199**		5195	5289	5348	5450	5580	5650	5700	5739	5877	5932	5980	6025	6045	6092	6125	6135					
31003032640000	**03264**														4055	4244							
31051032770000	**03277**														2265	2342							
31051033050000	**03305**														3692	3786							
31121038650000	**03865**														4030								
31069038660000	**03866**														2245	2435							
31121038800000	**03880**														3229	3319							
31101038940000	**03894**														4345	4985							
31101039240000	**03924**		4045				4075			4135	4175	4210	4280	4365	4450	4970	5337	5420	5922	5995	6380	6669	6529
31109039380000	**03938**														1674								
31097039400000	**03940**														1930	2403							
31051039420000	**03942**														2162	2252							
31003039560000	**03956**		2700									2800	2810	2902	2957	3052	3167	3204	3375	3495		3825	
31053039700000	**03970**		1250				1320	1330				1502	1576	1667	1795	1885	1995	2040	2200	2300		2561	
31069039710000	**03971**														1180	1297							
31109039730000	**03973**		2359				2420	2440		2440	2515	2615	2725	2810	2873	3857	4025	4118	4372	4490	4832	5100	4970
31069039910000	**03991**														1564	1669							
31043039930000	**03993**														647	727							
31069039970000	**03997**														967	1057							
31053040020000	**04002**		1342				1391	1398		1577		1577	1652	1730	1877	1952	2012	2100	2265	2307		2630	

															Syracuse			Vernon					
API Number	**Well Label**		**ONONDAGA**	**SCHOHARIE**	**CARLISLE CENTER**	**ESOPUS**	**ORISKANY**	**HELDER-BERG**	**BECRAFT**	**COEYMANS**	**MANLIUS**	**RONDOUT/ COBLESKILL**	**BERTIE**	**CAMILLUS**	**F_UNIT**	**E_UNIT**	**D_UNIT**	**C_UNIT**	**B_UINT**	**A_UNIT**	**LOCKPORT**	**CLINTON**	**ROCHESTER**
31069040050000	**04005**														1270	1358							
31109040070000	**04007**		2327				2475			2487	2490	2590	2687	2787	2860	3930	4085	4175	4442	4525	4890	5170	5012
31121040080000	**04008**		900										1040	1100	1169	1255	1340	1350	1480	1580		1760	
31069040270000	**04027**														1730	1854							
31069040350000	**04035**														1666	1759							
31051040530000	**04053**														1623	1713							
31077040550000	**04055**		1725	1830	1842	1870				1895	2025	2130	2175		2250	2307	2360						
31011040680000	**04068**		55				155				165	185	230	310	390	513	650	660	885	984	1225	1560	1383
31051040690000	**04069**														695	780							
31025040730000	**04073**		3946	4032	408	4110	4130	4132	4190	4220	4374	4408	4488	4556	4669	4721	4816	4840				5186	5188
31099040820000	**04082**		15									100	115	180	265	386	511	530	745	846		1098	
31053040850000	**04085**														1465	1568							
31121040920000	**04092**		2010										2155	2205	2255	2355	2466	2478	2614	2740	2910	3110	3065
31109041300000	**04130**		2500				2545			2570	2655	2745	2825	2935	3034	3502	3650	3749	3975	4100	4430	4675	4540
31051041510000	**04151**		700										850	920	985	1065	1130	1150	1298	1480		1585	
31121041620000	**04162**		1712				1848						1856	1910	1990	2150							
31051041880000	**04188**														2510	2585							
31003042480000	**04248**		2512				2623					2630	2643	2695	2747	2863	2995	3014	3175	3290	3447	3650	3555
31011043650000	**04365**														398	500							
31121043850000	**04385**														4063								
31097044000000	**04400**														1797	2417							
31121044320000	**04432**														1345	1405							
31121044470000	**04447**		1255										1400	1450	1515	1595	1690	1700	1808	1911		2070	
31069044500000	**04450**														772	875							
31109044670000	**04467**		2260				2310			2342	2428	2532	2620	2730	2806	3456	3630	3730	3979	4067	4435	4695	4565
31051045310000	**04531**		810										948	1010	2187	2267	1253	1265	1390	1482		1648	
31121045360000	**04536**		1120										1285	1320	1385	1465	1565	1572	1675	1775			
31051046300000	**04630**		9040				1048					1052	1112	1182	1257	1404	1534	1584	1746	1870		2058	
31023047140000	**04714**														4889	5274							
31123047960000	**04796**														1356	1481							
31007048540000	**04854**		3120				3200	3218				3480	3555	3694	5250	5645	4320	4395	4580	4660	5025	5150	
31067049020000	**04902**		617				686				700	751	812	906	1020	1208	1336	1362	1542	1636	1890	2002	1952
31007050870000	**05087**		3100				3172	3177	3227	3265	3353	3440	3540	3640	3812	4247	4360	4400	4622	4700	5090	5287	5185
31007066360000	**06636**		3095					3217				3530	3572	3853	5480	5719	4370	4435	4610	4687	5029		5116
31007083420000	**08342**														5374	5760							

															Syracuse			Vernon					
API Number	**Well Label**		**ONONDAGA**	**SCHOHARIE**	**CARLISLE CENTER**	**ESOPUS**	**ORISKANY**	**HELDER-BERG**	**BECRAFT**	**COEYMANS**	**MANLIUS**	**RONDOUT/ COBLESKILL**	**BERTIE**	**CAMILLUS**	**F_UNIT**	**E_UNIT**	**D_UNIT**	**C_UNIT**	**B_UINT**	**A_UNIT**	**LOCKPORT**	**CLINTON**	**ROCHESTER**
31009092350000	**09235**														7245	7380							
31123098460000	**09846**														1328	1455							
31107098480000	**09848**		4196				4260	4290							4584								
31077101380000	**10138**														1927	1995							
31109102430000	**10243**														3568								
31015103350000	**10335**		3398				3448	3493				3770	3820	3970	5458	6328		5227	5540	5690	5690	6165	
31017106090000	**10609**		3601					3771	3754	3870	4015	4125	4225	4465	4778	4909	4960	5035	5200	5300	5690	5760	5856
31011121490000	**12149**														2338	2814							
31069121950000	**12195**														804	897							
31101124020000	**12402**														3998								
31097128580000	**12858**														2024	2492							
31097128590000	**12859**														2163	2639							
31109131730000	**13173**														1930	2569							
31121133080000	**13308**														2501	2597							
31101136990000	**13699**														3173	3543							
31101137360000	**13736**														2999	3479							
31003155120000	**15512**		2766					2796				2827	2876	2931	3028	3130	3184	3272	3423	3555	3728	3919	3950
31101158340000	**15834**														4841	5238							
31003186510000	**18651**														3179	3274							
31023194840000	**19484**														2458	2856							
31101194970000	**19497**														2728	2902							
31023195400000	**19540**													2930	3090	3472	3512	3445	3805	3915		4205	
31099196860000	**19686**		1548					1592				1675	1735	1810	1912	2225	2345	2447	2710	2825	3097	3235	
31097196920000	**19692**							2425				2550	2600	2697	2792	3298	3445	3570	3660	2770	4270	4440	
31003200230000	**20023**		3619					3690				3721	3755	3813	3885	4014	4133	4230	4428	4500	4680	4900	
31099204460000	**20446**		815				870	878				915	980	1053	1161	1301	1400	1500	1704	1855	2110	2232	2382
31123205620000	**20562**		1305					1355					1430	1468	1550	1720	1838	1956	2265	2340	2580		2680
31025210050000	**21005**		3420	3510	3560	3580			3640	3675	3844	3875	3950	4050	4142	4195	4270	4300	4505	4582	4653		4727
31003211130000	**21113**		4070					4130				4195	4230	4290	4352	4530	4650	4745	5025	5090	5303		5420
31003211150000	**21115**		3252					3270				3354	3394	3456	3520	3695	3819	3919	4170	4210	4410	4410	4538
31101214680000	**21468**		3162									3225	3282	3358	3426	3925	4126	4230	4330	4380	4503	4656	
31097214950000	**21495**		3513								3668	3795	3892	3950	4065	4590					5610	5915	
31101214960000	**21496**		3260							3276	3290	3329	3386	3456	3527	3800	3936	4037	4228	4304	4424		
31023215000000	**21500**		2302				2352			2362	2415	2525	2602	2695	2870	3075	3205	3265	3444	3580	3870		3980
31101215510000	**21551**		2620					2652				2760	2855	2965	3052	3450	3495	3720	4050	4178	4435		

															Syracuse			Vernon					
API Number	**Well Label**		**ONONDAGA**	**SCHOHARIE**	**CARLISLE CENTER**	**ESOPUS**	**ORISKANY**	**HELDERBERG**	**BECRAFT**	**COEYMANS**	**MANLIUS**	**RONDOUT/COBLESKILL**	**BERTIE**	**CAMILLUS**	**F_UNIT**	**E_UNIT**	**D_UNIT**	**C_UNIT**	**B_UINT**	**A_UNIT**	**LOCKPORT**	**CLINTON**	**ROCHESTER**
31101215840000	**21584**		2650					2680				2778	2842	2920	3005	3515							
31101215870000	**21587**		2650					2670				2770	2834	2918	2998	3500	3641						
31101215880000	**21588**		2636				2658	2665				2755	2818	2905	3109	3495	3616	3744					
31101215890000	**21589**		2660					2687				2784	2845	2933	3037	3537							
31101217180000	**21718**		5095					5131				5351	5425	5566	5694	5840	5944	6050	6296	6434	6644		
31009218090000	**21809**		2545					2581				2639	2705	2750	2814	2900	2950	2990	3145	3170	3250	3550	3519
31013224980000	**22498**		2520									2550	2715	2810	2870	2970	3035	3098	3300	3330	3425	3630	
31123227430000	**22743**		1720											2020	2120	2450	2580	2700					
31109227530000	**22753**		1888					1960				2201	2325	2445	2520	2780	2915	3020	3265	3370	3655	3810	
31097227540000	**22754**		2390					2470				2600	2670	2770	2868	3288	3412	3522	3775	3885	4188	4458	4460
31101227580000	**22758**		2495										2578	2678	2773	2950	3080	3192	3426	3490	3739	3890	
31097227930000	**22793**		2055					2098				2212	2295	2390	2467	2817	2945	3050	3300	3402	3683	3825	
31123227970000	**22797**		1378					1455				1504	1560	1642	1725	1990	2100	2220	2490	2598	2870		
31101228140000	**22814**		3687					3735				3965	4032	4141	4220	4825	4985	5140	5485	5564	5935		
31015228270000	**22827**		3242									3500	3582	3680	3748	4248	4332	4488	4800	4935	5270	5433	
31097228300000	**22830**		3340				3391	3396		3430	3480	3468	3497	3518	3560	4340	4417	4602	4920	4950	5367		5665
31015228310000	**22831**		3462					3520				3746	3860	3990	4070	4705	4834	4970	5320	5450	5784		5955
31015228390000	**22839**		2912					2952				3140	3248	3330	3410	4264							
31123228500000	**22850**		2405					2480					2545	2613	2685	2865	2898	2945	3380	3470	3725		
31015228530000	**22853**		3360							3420	3570	3670	3780	3885	3944	4510	4680	4822	5180	5311	5625	5834	
31101228590000	**22859**		2325	2380									2380	2460	2580	2740	2860	2955	3238	3300	3505	3700	
31101228610000	**22861**		3830									3920	4053	4132	4280	5225	5467	5662	6010	6260	6755		
31101228710000	**22871**		3499					3596				3770	3895	4000	4050	4722	4820	5034	5378	5510	5857	6020	
31101228840000	**22884**		3260					3310				3550	3612	3710	5170	5752	4505	4650	5040	5138	5480	5647	
31101228850000	**22885**		3235							3295	3403	3513	3600	3668	3768	4441	4610	4741	5050	5200	5490	5695	
31015228910000	**22891**		3755							3800	3962	4062	4145	4228	4310	4793	4948	5060	5370	5532	5875	6045	
31015228990000	**22899**		3816				3887	3887		3904	4100	4201	4310	4390	4500	5080	5180	5358	5633	5838	6205		6480
31015229010000	**22901**		2726					2778				2976	3084	3172	3245	3966	4198	4294	4626	4714	5100		5262
31015229020000	**22902**		3365							3412	3600	3648	3738	3633	3908	4400	4490	4630	4798	5098	5460		5742
31015229110000	**22911**		3595																				
31015229180000	**22918**		2950							3000	3151	3250	3350	3458	3528	4240	4404	4530	4870	5032	5395	5570	
31015229190000	**22919**		3685							3730	3774	3978	4067	4140	5955	6510	4892	4990	5300	5460	5805	5975	
31015229240000	**22924**		3264				3292	3302		3303	3422	3520	3618	3702	3800	4290	4370	4535	4791	4980	5330		5628
31015229330000	**22933**			3610				3650				3838	3973	4135	4336	4996	5174	5270	5680	5764			
31107229340000	**22934**														5384	6066							

															Syracuse			Vernon					
API Number	**Well Label**		**ONONDAGA**	**SCHOHARIE**	**CARLISLE CENTER**	**ESOPUS**	**ORISKANY**	**HELDER-BERG**	**BECRAFT**	**COEYMANS**	**MANLIUS**	**RONDOUT/ COBLESKILL**	**BERTIE**	**CAMILLUS**	**F_UNIT**	**E_UNIT**	**D_UNIT**	**C_UNIT**	**B_UINT**	**A_UNIT**	**LOCKPORT**	**CLINTON**	**ROCHESTER**
31097229350000	**22935**		2062					2132				2290	2367	2480	2562	3653	3755	3975	4268	4390	4725	4892	4995
31123229390000	**22939**		1050					1125					1200	1238	1310	1440	1800	1720	1927	1978		2180	
31097229420000	**22942**		3118					3160				3306	3400	3500	3573	4330	4600	4830	5170	5310	5640		5812
31099229500000	**22950**		1902					1940				2100	2165	2212	2272	2690	2815	2920	3185	3298	3565		3857
31007229950000	**22995**		4680				4825					4830	4965	5015	5146	5876	6080	6170	6470	6580	7008	7110	
31013232470000	**23247**		1972									2016	2120	2282	2344	2406	2454	2496	2586	2650	2855		2946
31009234350000	**23435**		4520									4590	4642	4748	4805	4951	5078	5145					
31097611920000	**61192**		1558									1803	1885	1975	2055								
31097612050000	**61205**														2165	2645							
31097612060000	**61206**		1562									1806	1894	1988	2054	2604	2744						

Appendix B

Queenston Data

Table 1	General Well Data
Table 2	Formation Tops
Table 3	Delaney Well Thin Section Porosity Estimates
Table 4	Sample Injection Data From Bath Petroleum Inc.

Appendix B - Table 1 - Queenston Wells General Data

API #	SAPINO	WELL NAME	OPERATOR	TOWN	COUNTY	Total Depth	Lat	Lon
31011004780000	**00478-00-00**	Mahaney J C	Reserve Oil Co.	Ledyard	Cayuga	6166	42.6848	-76.644
31121006150000	**00615-00-00**	Fee 1	Wilson K.E.	Arcade	Wyoming	7144	42.5307	-78.4233
31017011600000	**01160-00-00**	Lobdell 1	Bradley Producing Corp.	Columbus	Chenango	5701	42.6934	-75.3447
31003039560000	**03956-00-00**	Cook G M 2	Parsons Bros	Hume	Allegany	7337	42.453	-78.174
31109039730000	**03973-00-00**	Shepard 1	CNG Transmission Corp.	Danby	Tompkins	10438	42.3703	-76.506
31109040070000	**04007-00-00**	Smiley Jean H 1	NYS Natural Gas Corp.	Danby	Tompkins	8555	42.3655	-76.503
31011040380000	**04038-00-00**	Ford 1 (789-1)	Columbia Natural Resources LLC	Aurelius	Cayuga	1644	42.9452	-76.6413
31099040640000	**04064-00-00**	Dewall 1 (796-1)	Columbia Natural Resources LLC	Fayette	Seneca	2069	42.8667	-76.8571
31011040680000	**04068-00-00**	Shoemaker 1 (768-1)	Columbia Natural Resources LLC	Springport	Cayuga	1967	42.8812	-76.6395
31099040820000	**04082-00-00**	Stein 1	Benedum Paul G.	Fayette	Seneca	2286	42.876	-76.8396
31121040920000	**04092-00-00**	Veith D 1	NYS Natural Gas Corp.	Gainesville	Wyoming	7182	42.6174	-78.0799
31099041110000	**04111-00-00**	Schaffer 1 (798-1)	Columbia Natural Resources LLC	Fayette	Seneca	2306	42.8578	-76.8547
31011041120000	**04112-00-00**	Klock 1 (767-1)	Klock Ronald F. & Carol H.	Springport	Cayuga	2313	42.8722	-76.6364
31109041300000	**04130-00-00**	Grund GH	NYS Natural Gas Corp.	Enfield	Tompkins	8900	42.4422	-76.5925
31099041580000	**04158-00-00**	Andrews 1	Monile Albert	Waterloo	Seneca	1650	42.9177	-76.8627
31099042030000	**04203-00-00**	Schaffer 2	United Productions	Fayette	Seneca	1921	42.8763	-76.8582
31099042440000	**04244-00-00**	Robson 1	NYS Natural Gas Corp.	Fayette	Seneca	2261	42.8252	-76.8653
31011043890000	**04389-00-00**	Patterson 1 (784-1)	Columbia Natural Resources LLC	Aurelius	Cayuga	1749	42.9026	-76.6633
31099044080000	**04408-00-00**	Unger 1	Murphy-Roberts	Waterloo	Seneca	1637	42.9283	-76.8865
31011044480000	**04448-00-00**	Bacon 1 (785-1)	Columbia Natural Resources LLC	Aurelius	Cayuga	1768	42.9018	-76.6781
31109044670000	**04467-00-00**	Fee Richarson 1	NYS Natural Gas Corp.	Newfield	Tompkins	9390	42.3844	-76.5404
31011044910000	**04491-00-00**	Juli 1 (788-1)	Juli Donald W. & Joan S.	Aurelius	Cayuga	1740	42.9493	-76.6235
31011044930000	**04493-00-00**	Burtless 2 (793-1)	Columbia Natural Resources LLC	Aurelius	Cayuga	1741	42.9233	-76.6609
31011044970000	**04497-00-00**	Whitcomb 1 (792-1)	Ford Cregg	Aurelius	Cayuga	1760	42.9352	-76.6391
31011045120000	**04512-00-00**	Picciano 1	Ashland Exploration Co.	Throop	Cayuga	1757	42.9616	-76.6097
31011045180000	**04518-00-00**	Janusz 1 (795-1)	Janusz Joseph	Throop	Cayuga	1777	42.954	-76.6453
31011045190000	**04519-00-00**	Smith E 1	Ashland Exploration Co.	Throop	Cayuga	1843	42.9553	-76.5922
31011045210000	**04521-00-00**	Nugent Patrick J 1	Midwest Oil Corp.		Cayuga	1775	42.9622	-76.6273
31011045400000	**04540-00-00**	Shank 771-1	Meridian Exploration Corp.	Springport	Cayuga	1893	42.893	-76.6465
31099045440000	**04544-00-00**	Garrett 2	CNG Transmission Corp.	Fayette	Seneca	2075	42.869	-76.9264
31051045670000	**04567-00-00**	Johnson 1	Stein Paul E. & Sons	Caledonia	Livingston	4839	42.9324	-77.8838
31011045710000	**04571-00-00**	Fabian 1 (773-1)	Columbia Natural Resources LLC	Springport	Cayuga	1818	42.8915	-76.6624
31099046000000	**04600-00-00**	Christensen 1	Brown Edward J. and Anne D.	Fayette	Seneca	2075	42.8749	-76.9217
31011046240000	**04624-00-00**	Wasielewski 1	Humble Oil & Refining Co.	Ira	Cayuga	3055	43.2526	-76.4907
31011046280000	**04628-00-00**	Jellinghaus 1 (775-1)	Rose State Custom Service Inc	Springport	Cayuga	1938	42.8814	-76.6544
31011046520000	**04652-00-00**	Case E K 1	Midwest Oil Corp.	Aurelius	Cayuga	1826	42.9466	-76.7026
31011047150000	**04715-00-00**	Alnutt R 1	Midwest Oil Corp.	Aurelius	Cayuga	4853	42.9218	-76.6713
31099047680000	**04768-00-00**	Dutton 1	Dutton Judson J.	Seneca Falls	Seneca	1905	42.8953	-76.7745
31123047950000	**04795-00-00**	Jepsen 1	Shirk Benjamin Z. Susanna M.	Benton	Yates	2896	42.7181	-77.0219

API #	SAPINO	WELL NAME	OPERATOR	TOWN	COUNTY	Total Depth	Lat	Lon
31123047960000	**04796-00-00**	Fee 1	Borglum Bruce	Benton	Yates	3061	42.6838	-77.0219
31123047970000	**04797-00-00**	Loree 2	Loree Ann E.	Benton	Yates	2757	42.7495	-77.0035
31099048140000	**04814-00-00**	Jodiet 1	Sampson Creek Acres Inc.	Seneca Falls	Seneca	1850	42.8948	-76.787
31011049990000	**04999-00-00**	Parker Robert A 1	Duchscherer William J.	Brutus	Cayuga	4260	43.0261	-76.5285
31011050000000	**05000-00-00**	Ripley 1	Urban Snow Gas Co. Inc.	Cato	Cayuga	3756	43.1051	-76.5524
31011050110000	**05011-00-00**	O'Neil 1	Duchscherer William J.	Cato	Cayuga	3573	43.1042	-76.5531
31011050310000	**05031-00-00**	Smith L W 1	Duchscherer William J.	Victory	Cayuga	3415	43.2016	-76.6097
31117050320000	**05032-00-00**	Kaiser W 1	Duchscherer William J.	Galen	Wayne	3915	43.0592	-76.8958
31073050690000	**05069-00-00**	Nowak 1	Duchscherer William J.	Kendall	Orleans	2325	43.3191	-78.0821
31099050950000	**05095-00-00**	Reed 1	Duchscherer William J.	Junius	Seneca	4149	43.0067	-76.94
31011054670000	**05467-00-00**	House Louis and Mary 1	Hodges Michael W.	Cato	Cayuga	3368	43.1008	-76.5124
31011057940000	**05794-00-00**	Pethybridge 1 (776-1)	Columbia Natural Resources LLC	Springport	Cayuga	1850	42.8804	-76.6691
31011060600000	**06060-00-00**	Staehr 1 (778-1)	Columbia Natural Resources LLC	Springport	Cayuga	1985	42.8688	-76.6529
31011067790000	**06779-00-00**	Karim 1	Karim Raja Abdul	Cato	Cayuga	3128	43.1093	-76.5612
31011067800000	**06780-00-00**	Cole 1	Urban Snow Gas Co. Inc.	Cato	Cayuga	3096	43.1091	-76.5466
31123098460000	**09846-00-00**	Christenson 1	Noble Ray A.	Benton	Yates	2971	42.7116	-77.0303
31011107010000	**10701-00-00**	Rindfleisch Anna 2	Columbia Natural Resources LLC	Springport	Cayuga	1801	42.8763	-76.7056
31011107020000	**10702-00-00**	Rindfleisch Anna 1	Columbia Natural Resources LLC	Springport	Cayuga	1820	42.8766	-76.6925
31037107760000	**10776-00-00**	Belt 1	Flint Oil & Gas Inc.	Bethany	Genesee	4340	42.9205	-78.1671
31099108930000	**10893-00-00**	Kinney 1	Hoover Moble C.	Waterloo	Seneca	4741	42.9412	-76.8764
31029110020000	**11002-00-00**	Brown Ralph H 1	Great Lakes Energy Partners	Sardinia	Erie	6293	42.5575	-78.5354
31029111140000	**11114-00-00**	Lietz 2	Perkins Cooper & Gondree	Brant	Erie	4822	42.5981	-78.9841
31011111290000	**11129-00-00**	Joshanski 1	Urban Snow Gas Co. Inc.	Cato	Cayuga	3057	43.1207	-76.5477
31011114320000	**11432-00-00**	Rindfleisch 3	Columbia Natural Resources LLC	Springport	Cayuga	1901	42.872	-76.6917
31011114960000	**11496-00-00**	Rindfleisch Wn-1386	Columbia Natural Resources LLC	Springport	Cayuga	1896	42.8719	-76.7009
31011115460000	**11546-00-00**	Cunningham 6	OI Auburn Inc.	Aurelius	Cayuga	1855	42.9135	-76.6772
31011115480000	**11548-00-00**	Malinowski 1	Miller Brewing Co.	Throop	Cayuga	1852	42.9738	-76.6202
31011115870000	**11587-00-00**	Thurston 3	OI Auburn Inc.	Throop	Cayuga	1844	42.9639	-76.6512
31011116000000	**11600-00-00**	Day T101-V1	Miller Brewing Co.	Throop	Cayuga	1849	42.9856	-76.6108
31099116180000	**11618-00-00**	Stahl 1	Columbia Natural Resources LLC	Fayette	Seneca	2164	42.8385	-76.789
31011116320000	**11632-00-00**	Steimle 9	Steimle John L & Shirley L.	Owasco	Cayuga	2471	42.917	-76.5051
31011116330000	**11633-00-00**	Manrow S100-V5	Miller Brewing Co.	Sennett	Cayuga	1902	42.9693	-76.5671
31011116560000	**11656-00-00**	Potter 723-1	Columbia Natural Resources LLC	Sennett	Cayuga	1875	42.985	-76.5174
31099116660000	**11666-00-00**	Hoster 1	Columbia Natural Resources LLC	Fayette	Seneca	2110	42.8452	-76.787
31099117080000	**11708-00-00**	Reigel 1	Columbia Natural Resources LLC	Fayette	Seneca	2171	42.8386	-76.7786
31099120510000	**12051-00-00**	Neal	Columbia Natural Resources LLC	Fayette	Seneca	2669	42.8481	-76.8076
31099120520000	**12052-00-00**	Olsowske	Columbia Natural Resources LLC	Fayette	Seneca	2233	42.8545	-76.7943
31099120530000	**12053-00-00**	Partee	Columbia Natural Resources LLC	Fayette	Seneca	2214	42.858	-76.8015
31101124020000	**12402-00-00**	Kish 1	Anderson Oil Co.	Bath	Steuben	5879	42.3168	-77.3892
31011135530000	**13553-00-00**	Pollard A1098	OI Auburn Inc.	Aurelius	Cayuga	2040	42.9356	-76.6561
31011135540000	**13554-00-00**	Edmunds A108-5	OI Auburn Inc.	Aurelius	Cayuga	2065	42.9357	-76.69

API #	SAPINO	WELL NAME	OPERATOR	TOWN	COUNTY	Total Depth	Lat	Lon
31011135620000	**13562-00-00**	Wormuth S101-3	OI Auburn Inc.	Sennett	Cayuga	2200	42.9684	-76.563
31011135880000	**13588-00-00**	Shank Sp100-2	OI Auburn Inc.	Springport	Cayuga	1955	42.8936	-76.6873
31011135890000	**13589-00-00**	Shank Sp100-1	OI Auburn Inc.	Springport	Cayuga	2100	42.8935	-76.6921
31011135980000	**13598-00-00**	Sosniak T120-8	OI Auburn Inc.	Throop	Cayuga	2120	42.9543	-76.6101
31011135990000	**13599-00-00**	Patterson William A130-2	OI Auburn Inc.	Aurelius	Cayuga	2130	42.9085	-76.6992
31011136000000	**13600-00-00**	Ball C & W A102-8	OI Auburn Inc.	Aurelius	Cayuga	1954	42.9521	-76.6595
31011136010000	**13601-00-00**	Delaney Tom & Mary T119-2	OI Auburn Inc.	Throop	Cayuga	2030	42.9584	-76.6363
31011136060000	**13606-00-00**	Delaney Tom & Mary T120-6	OI Auburn Inc.	Throop	Cayuga	2025	42.954	-76.6182
31011136370000	**13637-00-00**	Cuff Sid & Oletha A123b-3	OI Auburn Inc.	Aurelius	Cayuga	2180	42.9193	-76.7052
31011136390000	**13639-00-00**	Helenski A-104-6	OI Auburn Inc.	Aurelius	Cayuga	1895	42.9442	-76.669
31011136440000	**13644-00-00**	Ball C & W T113-11	OI Auburn Inc.	Throop	Cayuga	1985	42.9567	-76.654
31011136450000	**13645-00-00**	Delaney Dave & Ann A124-5	OI Auburn Inc.	Aurelius	Cayuga	1984	42.915	-76.6899
31011136460000	**13646-00-00**	O'Hara Farms Inc A132-5	OI Auburn Inc.	Aurelius	Cayuga	2010	42.9107	-76.6687
31011136550000	**13655-00-00**	Bench G & L A-119-6	OI Auburn Inc.	Aurelius	Cayuga	2040	42.9251	-76.6678
31099136750000	**13675-00-00**	Poorman 2503	Columbia Natural Resources LLC	Fayette	Seneca	2518	42.8646	-76.8375
31099136760000	**13676-00-00**	Vannostrand 4035	Columbia Natural Resources LLC	Fayette	Seneca	2300	42.8555	-76.8371
31101136990000	**13699-00-00**	NYS Reforestation 6	Columbia Gas Trans. Corp.	Wheeler	Steuben	9794	42.4662	-77.2651
31101137360000	**13736-00-00**	Wagner20615-T	CNG Transmission Corp.	Wheeler	Steuben	4849	42.4347	-77.4088
31011137840000	**13784-00-00**	Bacon 1	F & G Exploration	Springport	Cayuga	2023	42.883	-76.6867
31011153770000	**15377-00-00**	Staehr 2 (782-1)	Columbia Natural Resources LLC	Springport	Cayuga	1935	42.8622	-76.6626
31123154060000	**15406-00-00**	Havens Corner 1	Newman Edgar F	Benton	Yates	3000	42.7338	-77.0743
31101154380000	**15438-00-00**	Kassow 1	Minter Lee E.	Pulteney	Steuben	7956	42.5394	-77.2158
31011155000000	**15500-00-00**	Patterson William 130-1	OI Auburn Inc.	Aurelius	Cayuga	2020	42.9089	-76.6944
31011155010000	**15501-00-00**	Patterson William 123-5	OI Auburn Inc.	Aurelius	Cayuga	2002	42.9121	-76.7024
31011155020000	**15502-00-00**	Delaney Dave & Ann A124-4	OI Auburn Inc.	Aurelius	Cayuga	2012	42.9203	-76.6906
31011155290000	**15529-00-00**	Wells College 1	Wells College	Ledyard	Cayuga	2626	42.7414	-76.6973
31011156110000	**15611-00-00**	Delaney Dave & Ann A124-6	OI Auburn Inc.	Aurelius	Cayuga	1809	42.9174	-76.6869
31011156120000	**15612-00-00**	O'Hara Farms Inc. A132-4	OI Auburn Inc.	Aurelius	Cayuga	2005	42.9132	-76.668
31011156430000	**15643-00-00**	NYS Electric & Gas T121-5	OI Auburn Inc.	Throop	Cayuga	2005	42.9544	-76.605
31011156500000	**15650-00-00**	Simmons Theodore A131-2	OI Auburn Inc.	Aurelius	Cayuga	1819	42.9107	-76.6813
31011156610000	**15661-00-00**	Emery D & D A123-B1	OI Auburn Inc.	Aurelius	Cayuga	2009	42.9196	-76.6957
31011156620000	**15662-00-00**	Kirschner H & J 123-B2	OI Auburn Inc.	Aurelius	Cayuga	2012	42.9199	-76.7005
31011156630000	**15663-00-00**	Kirschner H & J 123-2	OI Auburn Inc.	Aurelius	Cayuga	1804	42.9159	-76.7004
31011156640000	**15664-00-00**	Foster A-119-2	OI Auburn Inc.	Aurelius	Cayuga	1823	42.9272	-76.672
31011156650000	**15665-00-00**	Schwartz A119-4	OI Auburn Inc.	Aurelius	Cayuga	1827	42.9247	-76.6757
31011157020000	**15702-00-00**	Cunningham F & Aa124-1	OI Auburn Inc.	Aurelius	Cayuga	2001	42.921	-76.6776
31011157030000	**15703-00-00**	Cuff Sid & Oletha A123-3	OI Auburn Inc.	Aurelius	Cayuga	2004	42.9156	-76.7054
31011157040000	**15704-00-00**	Pattersonn A130-3	OI Auburn Inc.	Aurelius	Cayuga	2000	42.9078	-76.7045
31011157070000	**15707-00-00**	Delaney Dave & Ann A124-7	OI Auburn Inc.	Aurelius	Cayuga	2000	42.9154	-76.6828
31011157080000	**15708-00-00**	Cunningham F & Aa124-8	OI Auburn Inc.	Aurelius	Cayuga	1996	42.917	-76.6781
31011157090000	**15709-00-00**	Simmons Theodore A131-5	OI Auburn Inc.	Aurelius	Cayuga	2000	42.9063	-76.6884

API #	SAPINO	WELL NAME	OPERATOR	TOWN	COUNTY	Total Depth	Lat	Lon
31011157100000	**15710-00-00**	Shank Karl M. A137-4	OI Auburn Inc.	Aurelius	Cayuga	2015	42.9022	-76.6947
31011157450000	**15745-00-00**	Foster A119-3	OI Auburn Inc.	Aurelius	Cayuga	2000	42.9281	-76.6761
31011157560000	**15756-00-00**	Shank Karl M. A137-3	OI Auburn Inc.	Aurelius	Cayuga	2000	42.8975	-76.6921
31101158340000	**15834-00-00**	Bush Hill 1	Pennzoil Producing Co.	Canisteo	Steuben	6595	42.2032	-77.5921
31011158500000	**15850-00-00**	Foster A132-3	OI Auburn Inc.	Aurelius	Cayuga	2000	42.9151	-76.6703
31011159620000	**15962-00-00**	Staehr 3 (783-2)	Columbia Natural Resources LLC	Springport	Cayuga	1994	42.8604	-76.6675
31011159630000	**15963-00-00**	McIntosh Fee 2	Key Trust Co of Ohio N.A. Trustee	Springport	Cayuga	2050	42.8132	-76.7085
31011161200000	**16120-00-00**	Venice View Dairy 1-11	Devonian Energy Corp.	Venice	Cayuga	7346	42.7202	-76.568
31011161230000	**16123-00-00**	Adams 780-2	A.D.C.O. Well Services	Springport	Cayuga	1793	42.8876	-76.6621
31011161490000	**16149-00-00**	Patterson 794-2	Columbia Natural Resources LLC	Aurelius	Cayuga	1735	42.9057	-76.6665
31011161510000	**16151-00-00**	Fabian Patterson 781-3	Columbia Natural Resources LLC	Springport	Cayuga	1752	42.8909	-76.6669
31011169910000	**16991-00-00**	Gable 1a	Union Springs School District	Springport	Cayuga	2150	42.8539	-76.6931
31011175080000	**17508-00-00**	Hunter A&B 1	Urban Snow Gas Co. Inc.	Cato	Cayuga	3658	43.1291	-76.5614
31011175090000	**17509-00-00**	Hunter C 1	Urban Snow Gas Co. Inc.	Cato	Cayuga	2866	43.1306	-76.5468
31011175100000	**17510-00-00**	Keysor K 1	Urban Snow Gas Co. Inc.	Cato	Cayuga	3649	43.1384	-76.5518
31011175170000	**17517-00-00**	Fuller A118-6	OI Auburn Inc.	Aurelius	Cayuga	2011	42.9546	-76.6824
31011175550000	**17555-00-00**	Springler 7241	Meridian Exploration Corp.	Sennett	Cayuga	2058	42.9956	-76.4967
31011175560000	**17556-00-00**	Smith 7261	Smith Alice E.	Owasco	Cayuga	2539	42.9235	-76.4862
31011175570000	**17557-00-00**	Dickman 7281	Dickman Richard H.	Fleming	Cayuga	2684	42.8575	-76.5359
31011175580000	**17558-00-00**	Provo 7271	Meridian Exploration Corp.	Sennett	Cayuga	4555	43.0112	-76.5212
31011175590000	**17559-00-00**	Quill 7251	Columbia Natural Resources LLC	Aurelius	Cayuga	5038	42.9244	-76.6995
31099175650000	**17565-00-00**	Seneca Co Home 2504	Columbia Natural Resources LLC	Fayette	Seneca	2133	42.8784	-76.8179
31099175670000	**17567-00-00**	Macgill 1 (4047)	Equitable Resources Exploraration	Fayette	Seneca	2164	42.8668	-76.8442
31099175700000	**17570-00-00**	Melcher 1 (4052)	Equitable Resources Exploraration	Fayette	Seneca	2063	42.8737	-76.8048
31099175720000	**17572-00-00**	D'Amico 2508	A.D.C.O. Well Services	Fayette	Seneca	2323	42.8344	-76.8452
31099175730000	**17573-00-00**	Martin 1 (4055)	Equitable Resources Exploraration	Fayette	Seneca	2218	42.8469	-76.821
31099175760000	**17576-00-00**	Hagadorn 2506	Columbia Natural Resources LLC	Fayette	Seneca	2247	42.8487	-76.8539
31099175780000	**17578-00-00**	Martin 2505	A.D.C.O. Well Services	Fayette	Seneca	2108	42.8602	-76.8287
31099175790000	**17579-00-00**	Dendis 1 (4060)	Rasmussen Ronnie O.	Fayette	Seneca	2099	42.8845	-76.8648
31011175950000	**17595-00-00**	Wimmer A118-1	OI Auburn Inc.	Aurelius	Cayuga	1878	42.9284	-76.6809
31011175990000	**17599-00-00**	Wimmer A118-5	OI Auburn Inc.	Aurelius	Cayuga	1850	42.9249	-76.6807
31123194030000	**19403-00-00**	Cook 1	Ardent Resources Inc.	Barrington	Yates	4220	42.5608	-77.0307
31099194590000	**19459-00-00**	Murray 2512	Columbia Natural Resources LLC	Fayette	Seneca	2336	42.8154	-76.7848
31099194610000	**19461-00-00**	Karlsen 1 (4088)	Columbia Natural Resources LLC	Varick	Seneca	2509	42.7937	-76.9044
31099194620000	**19462-00-00**	Harris 1 (4079)	Columbia Natural Resources LLC	Fayette	Seneca	2470	42.845	-76.8741
31099194630000	**19463-00-00**	Ritter 1 (4082)	Columbia Natural Resources LLC	Varick	Seneca	2769	42.7963	-76.8838
31099194640000	**19464-00-00**	Larsen 1 (4083)	Columbia Natural Resources LLC	Varick	Seneca	2662	42.8042	-76.8904
31099194650000	**19465-00-00**	Utzman 1 (4076)	Columbia Natural Resources LLC	Fayette	Seneca	2575	42.8382	-76.8697
31099194670000	**19467-00-00**	Tompkins 1 (4075)	Columbia Natural Resources LLC	Fayette	Seneca	2515	42.838	-76.8838
31099194700000	**19470-00-00**	Lerch 1 (4085)	Columbia Natural Resources LLC	Varick	Seneca	3364	42.8051	-76.8615
31099194810000	**19481-00-00**	Robson 3 (4073)	Columbia Natural Resources LLC	Fayette	Seneca	2316	42.8378	-76.8539

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31099194820000	**19482-00-00**	Ritter 3 (4086)	Columbia Natural Resources LLC	Varick	Seneca	2559	42.7917	-76.8737
31023194840000	**19484-00-00**	Jones 1	F. L. Stead & Associates Inc.	Scott	Cortland	5616	42.7029	-76.2659
31053194850000	**19485-00-00**	Larkin 1	F. L. Stead & Associates Inc.	Brookfield	Madison	5083	42.8088	-75.4185
31099194900000	**19490-00-00**	Ritter 4 (4092)	Columbia Natural Resources LLC	Varick	Seneca	2552	42.7912	-76.8863
31099194910000	**19491-00-00**	Ritter 2 (4084)	Columbia Natural Resources LLC	Varick	Seneca	2606	42.7953	-76.896
31101194970000	**19497-00-00**	Evangelos 21436-T	Columbia Natural Resources LLC	Pulteney	Steuben	7961	42.5408	-77.2159
31011194980000	**19498-00-00**	Quill 762-1	Columbia Natural Resources LLC	Aurelius	Cayuga	1800	42.929	-76.7138
31011195000000	**19500-00-00**	Kirshner(Quill)763-2	Columbia Natural Resources LLC	Aurelius	Cayuga	1828	42.9246	-76.7051
31011195010000	**19501-00-00**	Riford 765-3	Columbia Natural Resources LLC	Aurelius	Cayuga	1799	42.9302	-76.6948
31099195030000	**19503-00-00**	Martin/Wise 1 (4103)	Columbia Natural Resources LLC	Varick	Seneca	2418	42.8034	-76.7845
31099195040000	**19504-00-00**	Somerville/Gilbert (4104)	Columbia Natural Resources LLC	Varick	Seneca	2598	42.804	-76.9055
31099195050000	**19505-00-00**	Somerville 2 (4108)	Columbia Natural Resources LLC	Varick	Seneca	2623	42.7879	-76.9033
31099195060000	**19506-00-00**	St Thomas 1 (4099)	Columbia Natural Resources LLC	Fayette	Seneca	2557	42.805	-76.9387
31099195350000	**19535-00-00**	Johnson 1 (4100)	Columbia Natural Resources LLC	Fayette	Seneca	2515	42.8231	-76.896
31099195410000	**19541-00-00**	Swartley 2 (4090)	Columbia Natural Resources LLC	Varick	Seneca	2522	42.8023	-76.8758
31099195420000	**19542-00-00**	Swartley 3 (4095)	Columbia Natural Resources LLC	Varick	Seneca	2523	42.7976	-76.8692
31099195440000	**19544-00-00**	Karlsen 3 (4106)	Columbia Natural Resources LLC	Varick	Seneca	2493	42.7984	-76.9018
31099195450000	**19545-00-00**	Somerville 4 (4110)	Columbia Natural Resources LLC	Varick	Seneca	2550	42.783	-76.9008
31099195480000	**19548-00-00**	Heitmann 1 (4112)	Columbia Natural Resources LLC	Varick	Seneca	2570	42.7895	-76.8385
31099195490000	**19549-00-00**	McCarthy 1 (4116)	Columbia Natural Resources LLC	Fayette	Seneca	2507	42.8669	-76.8696
31099195500000	**19550-00-00**	Dickenson 1 (4113)	Columbia Natural Resources LLC	Varick	Seneca	2550	42.8066	-76.8186
31099195510000	**19551-00-00**	Swartley 1 (4098)	Columbia Natural Resources LLC	Fayette	Seneca	2465	42.8275	-76.8933
31099195530000	**19553-00-00**	Karlsen 4 (4101)	Columbia Natural Resources LLC	Varick	Seneca	2585	42.7887	-76.8554
31099195540000	**19554-00-00**	Dey 1 (4094)	Columbia Natural Resources LLC	Fayette	Seneca	2402	42.8087	-76.9292
31099195550000	**19555-00-00**	Larsen 1 (4130)	Columbia Natural Resources LLC	Fayette	Seneca	2484	42.833	-76.8877
31099195560000	**19556-00-00**	Larsen 2 (4131)	Columbia Natural Resources LLC	Fayette	Seneca	2472	42.8344	-76.8776
31099195570000	**19557-00-00**	Nielson 1 (4129)	Columbia Natural Resources LLC	Fayette	Seneca	2495	42.818	-76.9208
31099195580000	**19558-00-00**	Kisner 2551	Columbia Natural Resources LLC	Fayette	Seneca	2472	42.8125	-76.9201
31099195620000	**19562-00-00**	Hamilton 1 (4121)	Columbia Natural Resources LLC	Varick	Seneca	2430	42.8001	-76.9208
31099195630000	**19563-00-00**	Hamilton 2 (4125)	Columbia Natural Resources LLC	Varick	Seneca	2415	42.7985	-76.93
31099195740000	**19574-00-00**	Kime 2550	Columbia Natural Resources LLC	Fayette	Seneca	2293	42.8536	-76.9196
31099195790000	**19579-00-00**	Nielsen 2544	Columbia Natural Resources LLC	Fayette	Seneca	2359	42.8243	-76.9044
31099195800000	**19580-00-00**	Sorensen 1 (4119)	Columbia Natural Resources LLC	Fayette	Seneca	2385	42.8018	-76.926
31099195830000	**19583-00-00**	Freier 1	Rasmussen Ronnie O.	Fayette	Seneca	2151	42.8511	-76.8982
31099195840000	**19584-00-00**	Skinner 1	Rasmussen Ronnie O.	Fayette	Seneca	2100	42.8663	-76.8833
31099195850000	**19585-00-00**	Seitz Farms 1	Seitz Farms Inc.	Junius	Seneca	1910	42.9846	-76.9138
31099195860000	**19586-00-00**	Deming 1	Mitchell Exploration Corp.	Seneca Falls	Seneca	1780	42.9406	-76.798
31099195870000	**19587-00-00**	Worden 1	Mitchell Exploration Corp.	Tyre	Seneca	1675	42.9917	-76.8475
31099195880000	**19588-00-00**	Ritter 6 (4138)	Columbia Natural Resources LLC	Varick	Seneca	2580	42.792	-76.8801
31099195890000	**19589-00-00**	Covert 1 (4137)	Dunbar Helen A. Covert	Varick	Seneca	2445	42.7582	-76.7948
31099195970000	**19597-00-00**	Guilfoos 1 (4142)	Columbia Natural Resources LLC	Varick	Seneca	2717	42.7832	-76.8425

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31099196210000	**19621-00-00**	Stengle 4158	Columbia Natural Resources LLC	Varick	Seneca	2585	42.8005	-76.8546
31099196230000	**19623-00-00**	Somerville 5 (4155)	Columbia Natural Resources LLC	Varick	Seneca	2515	42.7907	-76.8937
31099196310000	**19631-00-00**	Lynd (4166)	Columbia Natural Resources LLC	Fayette	Seneca	2550	42.8137	-76.9098
31011196340000	**19634-00-00**	Chappell 1 415-1	Columbia Natural Resources LLC	Aurelius	Cayuga	1821	42.9442	-76.7196
31011196360000	**19636-00-00**	Quill (Casler)419-3	Meridian Exploration Corp.	Aurelius	Cayuga	1791	42.9372	-76.7091
31011196370000	**19637-00-00**	Quill (Casler)420-4	Columbia Natural Resources LLC	Aurelius	Cayuga	1791	42.9337	-76.7101
31011196380000	**19638-00-00**	Riford (Case)421-2	Columbia Natural Resources LLC	Aurelius	Cayuga	1761	42.9387	-76.6958
31011196400000	**19640-00-00**	Quill (Kirschner) 423-5	Columbia Natural Resources LLC	Aurelius	Cayuga	1800	42.9288	-76.7056
31011196410000	**19641-00-00**	Quill Unit 424-6	Columbia Natural Resources LLC	Aurelius	Cayuga	1826	42.9283	-76.6998
31011196420000	**19642-00-00**	Case Unit 425-1	Meridian Exploration Corp.	Aurelius	Cayuga	1800	42.9451	-76.6995
31011196430000	**19643-00-00**	Case Unit 426-2	Meridian Exploration Corp.	Aurelius	Cayuga	1800	42.9492	-76.6974
31011196440000	**19644-00-00**	McPherson Unit 427-1	Columbia Natural Resources LLC	Aurelius	Cayuga	1800	42.9451	-76.6759
31011196450000	**19645-00-00**	McPherson Unit 428-2	Columbia Natural Resources LLC	Aurelius	Cayuga	1800	42.9416	-76.6731
31011196650000	**19665-00-00**	Ventafido 1 (434-1)	Columbia Natural Resources LLC	Aurelius	Cayuga	1825	42.9188	-76.7144
31011196660000	**19666-00-00**	Chappell 431-3	Meridian Exploration Corp.	Aurelius	Cayuga	1761	42.9389	-76.7215
31099196720000	**19672-00-00**	Martin 1 (4160)	Columbia Natural Resources LLC	Varick	Seneca	2500	42.8	-76.8326
31099196730000	**19673-00-00**	Boyle 1 (4115)	Columbia Natural Resources LLC	Varick	Seneca	2570	42.7937	-76.8169
31011196740000	**19674-00-00**	Heintz 432-1	Meridian Exploration Corp.	Aurelius	Cayuga	1791	42.942	-76.7082
31099196750000	**19675-00-00**	Draper Farms 2555	Columbia Natural Resources LLC	Fayette	Seneca	2173	42.8623	-76.9326
31099196860000	**19686-00-00**	Townsend 1	Mitchell Exploration Corp.	Lodi	Seneca	4100	42.5882	-76.844
31097196920000	**19692-00-00**	Perigo 21578 Tpi	Columbia Natural Resources LLC	Reading	Schuyler	8384	42.4326	-76.9701
31099204130000	**20413-00-00**	Leonard 2574	A.D.C.O. Well Services	Fayette	Seneca	2355	42.8213	-76.8339
31099204150000	**20415-00-00**	Swartley 1	Pioneer Resources Inc.	Fayette	Seneca	2495	42.8084	-76.915
31099204160000	**20416-00-00**	Stengle-Swartley 1	Pioneer Resources Inc.	Fayette	Seneca	2436	42.8083	-76.9083
31097204170000	**20417-00-00**	Epstein 21624-Pi	Columbia Natural Resources LLC	Reading	Schuyler	8520	42.4372	-76.9558
31011204200000	**20420-00-00**	Patterson 212-2	Columbia Natural Resources LLC	Springport	Cayuga	1998	42.8665	-76.6615
31011204210000	**20421-00-00**	Bacon J 3	F & G Exploration	Springport	Cayuga	1998	42.8665	-76.683
31011204220000	**20422-00-00**	Bacon J 2	F & G Exploration	Springport	Cayuga	1998	42.8624	-76.6839
31099204230000	**20423-00-00**	Gordner 2575	Columbia Natural Resources LLC	Fayette	Seneca	2525	42.8124	-76.8554
31099204240000	**20424-00-00**	Karlsen 2 (4172)	Columbia Natural Resources LLC	Varick	Seneca	2501	42.7928	-76.8561
31099204290000	**20429-00-00**	Lerch 2 (4175)	Columbia Natural Resources LLC	Varick	Seneca	2514	42.8	-76.8638
31099204300000	**20430-00-00**	Adler 2 (4162)	Columbia Natural Resources LLC	Varick	Seneca	2527	42.7867	-76.8489
31099204310000	**20431-00-00**	Clemens 1 (4171)	Columbia Natural Resources LLC	Varick	Seneca	2511	42.7952	-76.8644
31099204320000	**20432-00-00**	Swartley 2571	Columbia Natural Resources LLC	Fayette	Seneca	2487	42.8133	-76.8967
31011204360000	**20436-00-00**	Bacon 1	F & G Exploration	Aurelius	Cayuga	1945	42.9068	-76.6722
31011204370000	**20437-00-00**	Bacon 2	F & G Exploration	Aurelius	Cayuga	1998	42.9094	-76.6757
31099204460000	**20446-00-00**	Compton 1 (4177)	Equitable Resources Exploraration	Romulus	Seneca	6366	42.7086	-76.8082
31099204470000	**20447-00-00**	Pearce 2577	Columbia Natural Resources LLC	Fayette	Seneca	2359	42.8437	-76.9135
31099204480000	**20448-00-00**	Deal 1 (4180)	Columbia Natural Resources LLC	Fayette	Seneca	2305	42.8262	-76.7863
31011204510000	**20451-00-00**	Bacon 1 (521-2)	Columbia Natural Resources LLC	Aurelius	Cayuga	1825	42.9029	-76.6829
31011204540000	**20454-00-00**	Bacon 1 (606-5)	Columbia Natural Resources LLC	Aurelius	Cayuga	1838	42.8983	-76.6779

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31011204550000	**20455-00-00**	Bacon 1 613-6	Columbia Natural Resources LLC	Aurelius	Cayuga	1855	42.8995	-76.6733
31011204560000	**20456-00-00**	Patterson E 1 (644-3)	Columbia Natural Resources LLC	Aurelius	Cayuga	1845	42.9	-76.6678
31099204590000	**20459-00-00**	Poorman 1 (2578-1)	Meridian Exploration Corp.	Fayette	Seneca	2510	42.8134	-76.8397
31011204600000	**20460-00-00**	O'Hara (401-3)	Columbia Natural Resources LLC	Aurelius	Cayuga	1840	42.913	-76.6578
31011204610000	**20461-00-00**	O'Hara (406-4)	Columbia Natural Resources LLC	Aurelius	Cayuga	1855	42.9095	-76.6568
31011204640000	**20464-00-00**	O'Hara (520-7)	Columbia Natural Resources LLC	Aurelius	Cayuga	1860	42.8987	-76.6581
31011204670000	**20467-00-00**	Fabian Unit 685-5	Columbia Natural Resources LLC	Springport	Cayuga	1874	42.8953	-76.6622
31011204880000	**20488-00-00**	Fee 1	Union Springs School District	Springport	Cayuga	2205	42.8355	-76.6879
31011204990000	**20499-00-00**	Fabian 347-7	Columbia Natural Resources LLC	Springport	Cayuga	1972	42.8895	-76.6574
31011205010000	**20501-00-00**	Pethybridge 349-2	Columbia Natural Resources LLC	Springport	Cayuga	1905	42.8841	-76.6706
31011205030000	**20503-00-00**	Jellinghaus 708-2	Columbia Natural Resources LLC	Springport	Cayuga	2032	42.8845	-76.6506
31011205060000	**20506-00-00**	Staehr 800-2	Columbia Natural Resources LLC	Springport	Cayuga	2130	42.8717	-76.6562
31011205070000	**20507-00-00**	Staehr 801-3	Columbia Natural Resources LLC	Springport	Cayuga	2128	42.8737	-76.6518
31011205080000	**20508-00-00**	Staehr 802-4	Columbia Natural Resources LLC	Springport	Cayuga	2102	42.8738	-76.6468
31011205110000	**20511-00-00**	Klock 805-2	Columbia Natural Resources LLC	Springport	Cayuga	2175	42.8742	-76.6409
31011205150000	**20515-00-00**	Downing 809-7	Columbia Natural Resources LLC	Springport	Cayuga	1844	42.8874	-76.6764
31011205160000	**20516-00-00**	Burtless 810-2	Columbia Natural Resources LLC	Aurelius	Cayuga	1833	42.9249	-76.6563
31011205170000	**20517-00-00**	Burtless 811-3	Columbia Natural Resources LLC	Aurelius	Cayuga	1817	42.9203	-76.6649
31099205230000	**20523-00-00**	Larsen 818-2	Columbia Natural Resources LLC	Fayette	Seneca	2266	42.8525	-76.8874
31011205250000	**20525-00-00**	Schenck 820-5	Columbia Natural Resources LLC	Springport	Cayuga	2229	42.8553	-76.648
31099205260000	**20526-00-00**	Schaffer 821-2	Columbia Natural Resources LLC	Fayette	Seneca	2230	42.8608	-76.8582
31123205370000	**20537-00-00**	Fulkrod B 1	Ardent Resources Inc.	Benton	Yates	3225	42.7245	-77.0094
31123205390000	**20539-00-00**	Barden 1	Ardent Resources Inc.	Benton	Yates	3034	42.6997	-77.0492
31123205440000	**20544-00-00**	Schiek 1a	Ardent Resources Inc.	Benton	Yates	3100	42.7201	-77.0006
31123205460000	**20546-00-00**	Lewis 1	Ardent Resources Inc.	Benton	Yates	3005	42.7472	-77.0146
31011205530000	**20553-00-00**	O'Hara Farms 932-8	Columbia Natural Resources LLC	Aurelius	Cayuga	1866	42.9065	-76.6539
31011205540000	**20554-00-00**	Downing 936-1	Columbia Natural Resources LLC	Springport	Cayuga	1820	42.8882	-76.6869
31011205550000	**20555-00-00**	O'Hara Farms 944-9	Columbia Natural Resources LLC	Aurelius	Cayuga	1796	42.9142	-76.6634
31011205560000	**20556-00-00**	O'Hara Farms 950-10	Columbia Natural Resources LLC	Aurelius	Cayuga	1836	42.9132	-76.6527
31011205600000	**20560-00-00**	Staehr 937-3	Columbia Natural Resources LLC	Springport	Cayuga	2044	42.8609	-76.6724
31011205610000	**20561-00-00**	Shank 952-4	Columbia Natural Resources LLC	Springport	Cayuga	1955	42.8952	-76.6501
31123205620000	**20562-00-00**	Castner 1-S	Ardent Resources Inc.	Potter	Yates	3674	42.6696	-77.1619
31123205700000	**20570-00-00**	Fulkrod A 1	Ardent Resources Inc.	Benton	Yates	3208	42.7316	-77.0094
31123205710000	**20571-00-00**	Martin 1	Ardent Resources Inc.	Benton	Yates	3487	42.701	-77.0619
31011206090000	**20609-00-00**	Klock 1040-3	Columbia Natural Resources LLC	Springport	Cayuga	2220	42.8749	-76.6317
31011206140000	**20614-00-00**	Staehr 1039-3	Columbia Natural Resources LLC	Springport	Cayuga	1970	42.8622	-76.6772
31011206150000	**20615-00-00**	Gould 1033-1	Columbia Natural Resources LLC	Aurelius	Cayuga	1975	42.9101	-76.6419
31011206160000	**20616-00-00**	Gould 1046-3	Columbia Natural Resources LLC	Aurelius	Cayuga	1978	42.9135	-76.6463
31011206170000	**20617-00-00**	Gould 1062-4	Columbia Natural Resources LLC	Aurelius	Cayuga	1930	42.9093	-76.6483
31011206180000	**20618-00-00**	Shoemaker 1051-3	Columbia Natural Resources LLC	Springport	Cayuga	2165	42.8783	-76.6436
31011206210000	**20621-00-00**	Patreal Corp 1 (1057-3)	Columbia Natural Resources LLC	Springport	Cayuga	1860	42.8815	-76.6992

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31011206240000	**20624-00-00**	Lockwood Ray 1 (1047-1)	Columbia Natural Resources LLC	Aurelius	Cayuga	2074	42.911	-76.6335
31011206250000	**20625-00-00**	Webster Ralph 1 (1064-1)	Columbia Natural Resources LLC	Aurelius	Cayuga	2213	42.9253	-76.6209
31011206260000	**20626-00-00**	Delaney Wm 1 (1058-1)	Columbia Natural Resources LLC	Fleming	Cayuga	2221	42.8816	-76.6252
31099206270000	**20627-00-00**	Sigrist 1041-3	Columbia Natural Resources LLC	Fayette	Seneca	2249	42.8557	-76.8608
31099206290000	**20629-00-00**	Larsen 1059-3	A.D.C.O. Well Services	Fayette	Seneca	2243	42.852	-76.8792
31011206320000	**20632-00-00**	Carr Bruce 1038-1	Columbia Natural Resources LLC	Springport	Cayuga	2250	42.8415	-76.6591
31011206380000	**20638-00-00**	Patterson W W 1063-1	Columbia Natural Resources LLC	Aurelius	Cayuga	2064	42.9219	-76.6156
31011206390000	**20639-00-00**	Patterson W W 1065-1	Columbia Natural Resources LLC	Springport	Cayuga	2096	42.8563	-76.6766
31011206490000	**20649-00-00**	O'Hara Farm 1080-3	Columbia Natural Resources LLC	Aurelius	Cayuga	2104	42.9063	-76.6339
31011206500000	**20650-00-00**	O'Hara Farm 1081-4	Columbia Natural Resources LLC	Aurelius	Cayuga	2121	42.9055	-76.6264
31011206510000	**20651-00-00**	Ward 1067-1	Columbia Natural Resources LLC	Aurelius	Cayuga	2339	42.9013	-76.6126
31011206530000	**20653-00-00**	Doody 1085-2	A.D.C.O. Well Services	Fleming	Cayuga	2246	42.8927	-76.5983
31011206560000	**20656-00-00**	Patterson 1093-6	Columbia Natural Resources LLC	Springport	Cayuga	2080	42.8708	-76.6709
31011206630000	**20663-00-00**	Costello 1068-1	Columbia Natural Resources LLC	Fleming	Cayuga	2254	42.8907	-76.6204
31011206730000	**20673-00-00**	Riford 1076-1	Columbia Natural Resources LLC	Aurelius	Cayuga	2034	42.9214	-76.6221
31011206750000	**20675-00-00**	Marine Midland 1100-1	Columbia Natural Resources LLC	Fleming	Cayuga	2420	42.8923	-76.6055
31011206810000	**20681-00-00**	Bacon 1	F & G Exploration	Springport	Cayuga	1997	42.8635	-76.6921
31099206830000	**20683-00-00**	Sigrist 1066-6	D-J's Farms Inc.	Fayette	Seneca	2249	42.855	-76.8665
31099206940000	**20694-00-00**	Freir 1126-1	Columbia Natural Resources LLC	Fayette	Seneca	2243	42.8262	-76.7928
31011206950000	**20695-00-00**	Jordan 1142-1	Columbia Natural Resources LLC	Springport	Cayuga	2483	42.818	-76.6884
31099207000000	**20700-00-00**	Keefer 970-1	Columbia Natural Resources LLC	Varick	Seneca	2388	42.8038	-76.915
31099207010000	**20701-00-00**	Clemens 984-1	Meridian Exploration Corp.	Varick	Seneca	2486	42.7741	-76.9001
31099207020000	**20702-00-00**	Hurst 968-1	Columbia Natural Resources LLC	Fayette	Seneca	2179	42.8315	-76.7736
31099207070000	**20707-00-00**	Clemens 991-2	Columbia Natural Resources LLC	Varick	Seneca	2475	42.7722	-76.9056
31099207080000	**20708-00-00**	Freir 994-2	Columbia Natural Resources LLC	Fayette	Seneca	2190	42.8287	-76.7979
31099212330000	**21233-00-00**	Dewall 1004-3	Columbia Natural Resources LLC	Fayette	Seneca	2137	42.8679	-76.8521
31099212360000	**21236-00-00**	Swartley 1131-1	Columbia Natural Resources LLC	Varick	Seneca	2468	42.8037	-76.8696
31011212380000	**21238-00-00**	Jellinghause 975-6	Columbia Natural Resources LLC	Springport	Cayuga	2036	42.8812	-76.6595
31099212480000	**21248-00-00**	Hurrin 1001-1	Columbia Natural Resources LLC	Varick	Seneca	2456	42.7766	-76.9058
31099212490000	**21249-00-00**	Christensen 1018-1	Columbia Natural Resources LLC	Fayette	Seneca	2154	42.8619	-76.9052
31099212500000	**21250-00-00**	Lynd 1128-2	Columbia Natural Resources LLC	Fayette	Seneca	2380	42.8224	-76.9164
31011212530000	**21253-00-00**	Pethybridge 1143-1	Columbia Natural Resources LLC	Springport	Cayuga	2400	42.8163	-76.6772
31099212690000	**21269-00-00**	Johnson 1135-1	Meridian Exploration Corp.	Varick	Seneca	2500	42.7677	-76.9127
31099212860000	**21286-00-00**	Jensen 1160-1	Columbia Natural Resources LLC	Fayette	Seneca	2125	42.8664	-76.9055
31099212930000	**21293-00-00**	D.J. Farms 1158-1	Columbia Natural Resources LLC	Fayette	Seneca	2276	42.8415	-76.8562
31099212970000	**21297-00-00**	Christenson 1125-2	Columbia Natural Resources LLC	Fayette	Seneca	2199	42.8616	-76.9118
31099212980000	**21298-00-00**	Jensen 1173-2	Columbia Natural Resources LLC	Fayette	Seneca	2185	42.8661	-76.9114
31099213150000	**21315-00-00**	Larsen 1194-5	Columbia Natural Resources LLC	Fayette	Seneca	2180	42.8621	-76.8776
31099213190000	**21319-00-00**	Jensen 1200	Columbia Natural Resources LLC	Fayette	Seneca	2048	42.874	-76.8949
31099213230000	**21323-00-00**	Robson 1201	Columbia Natural Resources LLC	Fayette	Seneca	2175	42.8447	-76.8517
31067213350000	**21335-00-00**	Halloran 1	Eastern States Exploration Co.	Camillus	Onondaga	4044	43.0661	-76.3526

API #	SAPINO	WELL NAME	OPERATOR	TOWN	COUNTY	Total Depth	Lat	Lon
31099213540000	**21354-00-00**	Freir 1210	Columbia Natural Resources LLC	Fayette	Seneca	2131	42.8357	-76.8021
31099213550000	**21355-00-00**	Martin 1187	A.D.C.O. Well Services	Fayette	Seneca	2218	42.8231	-76.7807
31099213570000	**21357-00-00**	Ch of Jesus Christ 1229	Columbia Natural Resources LLC	Fayette	Seneca	2070	42.8668	-76.8755
31099213580000	**21358-00-00**	Jensen 1216	Columbia Natural Resources LLC	Fayette	Seneca	2089	42.8787	-76.8965
31099213590000	**21359-00-00**	Stein 1214	Columbia Natural Resources LLC	Fayette	Seneca	2155	42.8565	-76.8932
31099213630000	**21363-00-00**	Rasmussen 1225	Columbia Natural Resources LLC	Fayette	Seneca	2358	42.8267	-76.8678
31099213720000	**21372-00-00**	Waelz 1224	Columbia Natural Resources LLC	Fayette	Seneca	2061	42.8775	-76.8906
31099213820000	**21382-00-00**	Wright 1238	Meridian Exploration Corp.	Waterloo	Seneca	1919	42.9106	-76.8934
31099213840000	**21384-00-00**	Ch of Jesus Christ 1248	Columbia Natural Resources LLC	Fayette	Seneca	2068	42.8706	-76.871
31099213920000	**21392-00-00**	Jarman 1204	Columbia Natural Resources LLC	Fayette	Seneca	2170	42.8528	-76.8419
31011213930000	**21393-00-00**	Bowen 1261	Columbia Natural Resources LLC	Springport	Cayuga	2349	42.8187	-76.6823
31099214070000	**21407-00-00**	Wagner 1292	A.D.C.O. Well Services	Fayette	Seneca	2049	42.8749	-76.9074
31101214680000	**21468-00-00**	Mitchell 1	Semgas Storage L.L.C.	Avoca	Steuben	9887	42.4197	-77.4532
31011214690000	**21469-00-00**	Asdgt 2	Auburn Enlarged Central School District		Cayuga	5106	42.9467	-76.5413
31097214950000	**21495-00-00**	Bale 1	JMC Cayuta Inc.	Cayuta	Schuyler	11823	42.27	-76.7136
31101214960000	**21496-00-00**	Hubbard No. 1	Semgas Storage L.L.C.	Avoca	Steuben	10051	42.4053	-77.4632
31101215510000	**21551-00-00**	BPSI 8	Bath Petroleum Storage Inc.	Bath	Steuben	6000	42.3117	-77.2564
31101215920000	**21592-00-00**	Gray 21625	Columbia Natural Resources LLC	Pulteney	Steuben	7176	42.5406	-77.2366
31101216010000	**21601-00-00**	Mitchell 2	Semgas Storage L.L.C.	Avoca	Steuben	9786	42.4334	-77.4534
31101216240000	**21624-00-00**	Avoca 4	Semgas Storage L.L.C.	Avoca	Steuben	9202	42.4201	-77.4672
31101216330000	**21633-00-00**	Mitchell 3	Semgas Storage L.L.C.	Avoca	Steuben	9950	42.4279	-77.4456
31101216360000	**21636-00-00**	Fee 6	Semgas Storage L.L.C.	Avoca	Steuben	9939	42.429	-77.4657
31101216880000	**21688-00-00**	Levandowski 623088	Columbia Natural Resources LLC	Prattsburg	Steuben	7313	42.5344	-77.2519
31101216890000	**21689-00-00**	Covert 622302	Columbia Natural Resources LLC	Prattsburg	Steuben	7499	42.5388	-77.275
31099216900000	**21690-00-00**	Freir 1235-1	Meridian Exploration Corp.	Fayette	Seneca	0	42.841	-76.8981
31101216920000	**21692-00-00**	Pizura 623143	Columbia Natural Resources LLC	Pulteney	Steuben	7091	42.5399	-77.1822
31101217030000	**21703-00-00**	Radigan 623267	Columbia Natural Resources LLC	Pulteney	Steuben		42.5435	-77.1674
31101217040000	**21704-00-00**	Fimlaid 1	Columbia Natural Resources LLC	Wayne	Steuben	8028	42.4394	-77.1112
31101217050000	**21705-00-00**	Smith 1	Columbia Natural Resources LLC	Pulteney	Steuben	7110	42.5435	-77.198
31101217060000	**21706-00-00**	Fox 1 (623217)	Columbia Natural Resources LLC	Pulteney	Steuben	7048	42.5387	-77.2031
31101217100000	**21710-00-00**	Bergstresser 1	Columbia Natural Resources LLC	Pulteney	Steuben	6691	42.5472	-77.1723
31101217150000	**21715-00-00**	Grace 1	Columbia Natural Resources LLC	Prattsburg	Steuben	7879	42.5237	-77.3412
31109217160000	**21716-00-00**	Stairs 1	Columbia Natural Resources LLC	Dryden	Tompkins	7468	42.5111	-76.3007
31101217180000	**21718-00-00**	Demun 1	True Oil Co.	Troupsburg	Steuben	11166	42.0956	-77.594
31097217250000	**21725-00-00**	Forte 1	Columbia Natural Resources LLC	Tyrone	Schuyler	8275	42.4713	-77.0039
31097217260000	**21726-00-00**	Mast 1	Columbia Natural Resources LLC	Tyrone	Schuyler	8174	42.4761	-77.0028
31101227410000	**22741-00-00**	Von Rhedey 623519	Columbia Natural Resources LLC	Pulteney	Steuben	7500	42.4939	-77.2055
31101227450000	**22745-00-00**	Faber 1	Columbia Natural Resources LLC	Prattsburg	Steuben	7371	42.5003	-77.2418
31123227460000	**22746-00-00**	Dewitt 623333	Columbia Natural Resources LLC	Barrington	Yates		42.5173	-77.0609
31101227470000	**22747-00-00**	Smith 1	Columbia Natural Resources LLC	Pulteney	Steuben	7442	42.5103	-77.209
31101227480000	**22748-00-00**	McAllister 1	Columbia Natural Resources LLC	Pulteney	Steuben	7232	42.5107	-77.1918

API #	SAPINO	WELL NAME	OPERATOR	TOWN	COUNTY	Total Depth	Lat	Lon
31123227500000	**22750-00-00**	Weitz 1	Columbia Natural Resources LLC	Barrington	Yates	7555	42.4933	-77.0873
31123227520000	**22752-00-00**	Knapp 1	Columbia Natural Resources LLC	Barrington	Yates	7543	42.5285	-77.0824
31109227530000	**22753-00-00**	Koskinen 623513	Columbia Natural Resources LLC	Ulysses	Tompkins	7462	42.4904	-76.673
31097227540000	**22754-00-00**	Gunning 1	Columbia Natural Resources LLC	Hector	Schuyler	7999	42.4602	-76.7318
31101227550000	**22755-00-00**	Snyder 1	Columbia Natural Resources LLC	Pulteney	Steuben	6816	42.5188	-77.1658
31101227560000	**22756-00-00**	Grand View 1	Columbia Natural Resources LLC	Pulteney	Steuben	7848	42.4823	-77.2037
31123227570000	**22757-00-00**	NYS Reforestation Area 1	Belden & Blake Corporation	Italy	Yates	7287	42.6457	-77.2463
31101227580000	**22758-00-00**	S & D Farms 623504	Columbia Natural Resources LLC	Cohocton	Steuben	7416	42.5494	-77.4539
31101227590000	**22759-00-00**	S & D Farms 623144	Columbia Natural Resources LLC	Cohocton	Steuben		42.5334	-77.4002
31101227600000	**22760-00-00**	Wolcott 623284	Columbia Natural Resources LLC	Cohocton	Steuben		42.5423	-77.4184
31099227610000	**22761-00-00**	Poorman 2586-01	Meridian Exploration Corp.	Fayette	Seneca	5431	42.8393	-76.8367
31099227620000	**22762-00-00**	Schaffer 2584-03	Columbia Natural Resources LLC	Fayette	Seneca	5002	42.8601	-76.8517
31099227630000	**22763-00-00**	Murray 2587-01	Meridian Exploration Corp.	Fayette	Seneca	5452	42.8284	-76.8375
31123227640000	**22764-00-00**	Costanza 1	Belden & Blake Corporation	Italy	Yates	6473	42.632	-77.2785
31101227650000	**22765-00-00**	Wise 1 (623520)	Columbia Natural Resources LLC	Pulteney	Steuben		42.4932	-77.2345
31101227660000	**22766-00-00**	Peck 1 (623516)	Columbia Natural Resources LLC	Cohocton	Steuben	7644	42.5458	-77.441
31109227670000	**22767-00-00**	Duddleston 623514	Columbia Natural Resources LLC	Ulysses	Tompkins	7454	42.512	-76.6358
31101227710000	**22771-00-00**	Jimerson 1240	Fortuna Energy Inc.	Hornby	Steuben	9710	42.2148	-77.0145
31101227720000	**22772-00-00**	Egresi 1	Columbia Natural Resources LLC	Pulteney	Steuben	7152	42.5353	-77.1718
31123227730000	**22773-00-00**	Knapp 2	Columbia Natural Resources LLC	Barrington	Yates	7598	42.5241	-77.0817
31123227740000	**22774-00-00**	Knapp 3	Columbia Natural Resources LLC	Barrington	Yates	7101	42.5308	-77.0826
31123227750000	**22775-00-00**	Walters 623641	Columbia Natural Resources LLC	Jerusalem	Yates		42.6141	-77.1519
31109227890000	**22789-00-00**	Rehebein/Call 1	Columbia Natural Resources LLC	Dryden	Tompkins	0	42.5429	-76.2799
31123227900000	**22790-00-00**	Agliata 1 (623780)	Columbia Natural Resources LLC	Milo	Yates	7417	42.582	-77.0622
31123227910000	**22791-00-00**	Bauer 1 (623781)	Columbia Natural Resources LLC	Barrington	Yates	7086	42.5764	-77.0579
31123227950000	**22795-00-00**	Martin-Repacki 1	Columbia Natural Resources LLC	Barrington	Yates	7333	42.5345	-77.0466
31123227960000	**22796-00-00**	Zimmerman 623825	Columbia Natural Resources LLC	Barrington	Yates	7482	42.5481	-77.0398
31097227990000	**22799-00-00**	Rumsey 1 (623838)	Columbia Natural Resources LLC	Tyrone	Schuyler	8037	42.4452	-77.0582
31101228140000	**22814-00-00**	Howe 1300	Pennsylvania General Energy	Hornby	Steuben	10285	42.2049	-77.0542
31101228250000	**22825-00-00**	Rice 1301	Fortuna Energy Inc.	Hornby	Steuben	9322	42.2127	-77.0354
31015228260000	**22826-00-00**	Broz Unit 1	Fortuna Energy Inc.	Veteran	Chemung	9362	42.2728	-76.7738
31015228270000	**22827-00-00**	Bennett Family 1	Fortuna Energy Inc.	Veteran	Chemung	9442	42.2841	-76.7747
31123228280000	**22828-00-00**	Martin 623864	Columbia Natural Resources LLC	Benton	Yates	6652	42.6724	-77.1042
31097228300000	**22830-00-00**	Grand Prix 2 (624066)	Fortuna Energy Inc.	Orange	Schuyler	9745	42.3061	-77.0805
31015228310000	**22831-00-00**	Lovell 1323	Fortuna Energy Inc.	Big Flats	Chemung	9386	42.1868	-76.9582
31015228380000	**22838-00-00**	Monahan 624115	Columbia Natural Resources LLC	Erin	Chemung	10017	42.1754	-76.6513
31123228400000	**22840-00-00**	Dick 623970	Columbia Natural Resources LLC	Jerusalem	Yates	6061	42.598	-77.1677
31097228410000	**22841-00-00**	SRA 2 1	Fortuna Energy Inc.	Orange	Schuyler	8675	42.3403	-77.0204
31101228450000	**22845-00-00**	Medrek 624126	Columbia Natural Resources LLC	Pulteney	Steuben		42.509	-77.1727
31123228500000	**22850-00-00**	Watson 1	Belden & Blake Corporation	Italy	Yates	7136	42.618	-77.3167
31101228520000	**22852-00-00**	Van Vleet 1355	Fortuna Energy Inc.	Hornby	Steuben	10514	42.2013	-77.0863

API #	SAPINO	WELL NAME	OPERATOR	TOWN	COUNTY	Total Depth	Lat	Lon
31015228530000	**22853-00-00**	Rhodes 1322	Fortuna Energy Inc.	Big Flats	Chemung	9682	42.1953	-76.9209
31015228570000	**22857-00-00**	Kimball 1	Fortuna Energy Inc.	Veteran	Chemung	9166	42.2727	-76.7913
31123228580000	**22858-00-00**	Mulligan 1	Belden & Blake Corporation	Italy	Yates	6102	42.6391	-77.2771
31101228590000	**22859-00-00**	Huber 1	Belden & Blake Corporation	Wayland	Steuben	7535	42.5357	-77.592
31101228610000	**22861-00-00**	NYS GMA 2	Fairman Drilling Co.	Erwin	Steuben	10524	42.1576	-77.1646
31099228640000	**22864-00-00**	DJ Farms 624312	Columbia Natural Resources LLC	Fayette	Seneca	2193	42.8562	-76.8498
31099228660000	**22866-00-00**	DJ Farms 624311	Columbia Natural Resources LLC	Fayette	Seneca	2196	42.8534	-76.8536
31011228790000	**22879-00-00**	Cuff A123-4	OI Auburn Inc.	Aurelius	Cayuga	1896	42.9129	-76.7087
31097228810000	**22881-00-00**	Learn 1	Fortuna Energy Inc.	Montour	Schuyler	9061	42.3083	-76.8158
31101228850000	**22885-00-00**	Corning Game Club 624460	Fortuna Energy Inc.	Corning	Steuben	10050	42.1799	-77.0662
31097228930000	**22893-00-00**	Purvis 1	Fortuna Energy Inc.	Dix	Schuyler	9095	42.2952	-76.8597
31015228990000	**22899-00-00**	Trimber 624536	Columbia Natural Resources LLC	Erin	Chemung	10530	42.1604	-76.6868
31015229020000	**22902-00-00**	Lederer 1412	Pennsylvania General Energy	Catlin	Chemung	9602	42.2525	-76.8691
31099229090000	**22909-00-00**	Campion 1	EOG Resources Inc	Lodi	Seneca	7673	42.553	-76.819
31015229110000	**22911-00-00**	Schmidt 624537	Columbia Natural Resources LLC	Erin	Chemung	10366	42.1468	-76.6927
31015229180000	**22918-00-00**	Gregory 1446	Pennsylvania General Energy	Catlin	Chemung	9402	42.2073	-76.8844
31015229190000	**22919-00-00**	Hardy 1447	Pennsylvania General Energy	Catlin	Chemung	9859	42.2374	-76.9201
31015229240000	**22924-00-00**	Johnson 1	Fairman Drilling Co.	Veteran	Chemung	9803	42.269	-76.7509
31107229340000	**22934-00-00**	Manwaring 624470	Columbia Natural Resources LLC	Tioga	Tioga	11552	42.0578	-76.4098
31097229350000	**22935-00-00**	Wonderview Farms 1	Fortuna Energy Inc.	Catharine	Schuyler	8762	42.3304	-76.7468
31123229410000	**22941-00-00**	Boudinot 623968	Columbia Natural Resources LLC	Starkey	Yates	7181	42.5239	-76.9567
31097229420000	**22942-00-00**	Bonham 1	Fortuna Energy Inc.	Orange	Schuyler	10069	42.296	-76.9891
31069229430000	**22943-00-00**	Stoddard 624633	Columbia Natural Resources LLC	Hopewell	Ontario	4965	42.8889	-77.1914
31099229440000	**22944-00-00**	Lott 624600	Columbia Natural Resources LLC	Fayette	Seneca		42.8797	-76.8123
31099229460000	**22946-00-00**	Nolt 624595	Columbia Natural Resources LLC	Fayette	Seneca		42.863	-76.8485
31099229470000	**22947-00-00**	Hartman 624594	Columbia Natural Resources LLC	Fayette	Seneca		42.8302	-76.8846
31099229500000	**22950-00-00**	Ziefle 1	Eastern American Energy Corp.	Covert	Seneca	7497	42.5642	-76.702
31007229840000	**22984-00-00**	Merrill 1	Belden & Blake Corporation	Colesville	Broome	9874	42.1782	-75.6703
31007229950000	**22995-00-00**	Beagell 2	Belden & Blake Corporation	Kirkwood	Broome	10260	42.1373	-75.8335
31101230540000	**23054-00-00**	Hakes 1	Fortuna Energy Inc.	Corning	Steuben	10107	42.1786	-77.0169
31007230560000	**23056-00-00**	Butkowsky 1	Belden & Blake Corporation	Kirkwood	Broome	10105	42.1428	-75.8249
31101230850000	**23085-00-00**	Erwin WMA 1	Fortuna Energy Inc.	Erwin	Steuben	9797	42.1644	-77.1496
31121233890000	**23389-00-00**	Krolick 2	Stedman Energy Inc.	Arcade	Wyoming	6200	42.5648	-78.4439
31009234560000	**23456-00-00**	Braymiller-Rauch 1454	Pennsylvania General Energy	Yorkshire	Cattaraugus	6565	42.4976	-78.5228

Appendix B - Table 2 - Formation Tops

API	SAPINO		**LOCKPORT** (ESOGIS*)	**CLINTON** (ESOGIS*)	**MEDINA** (ESOGIS*)	**QUEENSTON** (NYGS*)	**OSWEGO** (NYGS*)	**OSWEGO** (NYGS*)	**LORRAINE** (ESOGIS*)	**TRENTON** (NYGS*)
31011004780000	**00478-00-00**					3099	4050	4050		
31121006150000	**00615-00-00**					3358			4524	
31017011600000	**01160-00-00**					3075			3132	
31003039560000	**03956-00-00**					4110			5312	
31109039730000	**03973-00-00**					5635	6230	6230	6984	
31109040070000	**04007-00-00**					5688	6390	6390	7000	
31011040380000	**04038-00-00**					1465				
31099040640000	**04064-00-00**					1800				
31011040680000	**04068-00-00**					1810				
31099040820000	**04082-00-00**					1676				
31121040920000	**04092-00-00**					3366			4600	
31099041110000	**04111-00-00**					1796				
31011041120000	**04112-00-00**					1884				
31109041300000	**04130-00-00**					5185	5861	5861	6555	
31099041580000	**04158-00-00**					1577				
31099042030000	**04203-00-00**					1754	2790	2790	3050	3479
31099042440000	**04244-00-00**					2035				
31011043890000	**04389-00-00**					1542				
31099044080000	**04408-00-00**					1522				
31011044480000	**04448-00-00**					1504				
31109044670000	**04467-00-00**		4425	4548	5040	5199	5800	5800	6555	7348
31011044910000	**04491-00-00**					1510				
31011044930000	**04493-00-00**					1519				
31011044970000	**04497-00-00**					1550				
31011045120000	**04512-00-00**					1556				
31011045180000	**04518-00-00**					1530				
31011045190000	**04519-00-00**					1575				
31011045210000	**04521-00-00**					1550				
31011045400000	**04540-00-00**					1675				
31099045440000	**04544-00-00**					1980				

API	SAPINO		LOCKPORT (ESOGIS*)	CLINTON (ESOGIS*)	MEDINA (ESOGIS*)	QUEENSTON (NYGS*)	OSWEGO (NYGS*)	OSWEGO (NYGS*)	LORRAINE (ESOGIS*)	TRENTON (NYGS*)
31051045670000	**04567-00-00**					1437			2548	
31011045710000	**04571-00-00**					1584				
31099046000000	**04600-00-00**					1736				
31011046240000	**04624-00-00**					226	1020	1020	1270	
31011046280000	**04628-00-00**					1700				
31011046520000	**04652-00-00**					1520				
31011047150000	**04715-00-00**					1494	2220	2220	2665	
31099047680000	**04768-00-00**					1560				
31123047950000	**04795-00-00**					2685				
31123047960000	**04796-00-00**					2865				
31123047970000	**04797-00-00**					2520				
31099048140000	**04814-00-00**					1554				
31011049990000	**04999-00-00**					1409			2466	
31011050000000	**05000-00-00**					918	1919	1919	1950	
31011050110000	**05011-00-00**					690	1679	1679	1852	
31011050310000	**05031-00-00**					606			1699	
31117050320000	**05032-00-00**					996			2080	
31073050690000	**05069-00-00**					100			730	
31099050950000	**05095-00-00**		568	720	1028	1105	1770	1770	2410	2850
31011054670000	**05467-00-00**					946	1950	1950	2118	
31011057940000	**05794-00-00**					1610				
31011060600000	**06060-00-00**					1780				
31011067790000	**06779-00-00**					929			2004	
31011067800000	**06780-00-00**					904			1984	
31123098460000	**09846-00-00**					2751				
31011107010000	**10701-00-00**					1525				
31011107020000	**10702-00-00**					1543				
31037107760000	**10776-00-00**					1588			2702	
31099108930000	**10893-00-00**					1434	1951	1951	2755	3153
31029110020000	**11002-00-00**					3308			4420	0
31029111140000	**11114-00-00**		1547	1746	1846	1969	2569	2569	2988	3816
31011111290000	**11129-00-00**					824			2000	

API	SAPINO		LOCKPORT (ESOGIS*)	CLINTON (ESOGIS*)	MEDINA (ESOGIS*)	QUEENSTON (NYGS*)	OSWEGO (NYGS*)	OSWEGO (NYGS*)	LORRAINE (ESOGIS*)	TRENTON (NYGS*)
31011114320000	**11432-00-00**					1550				
31011114960000	**11496-00-00**					1554				
31011115460000	**11546-00-00**					1516				
31011115480000	**11548-00-00**					1505				
31011115870000	**11587-00-00**					1526				
31011116000000	**11600-00-00**					1450				
31099116180000	**11618-00-00**					1854				
31011116320000	**11632-00-00**									
31011116330000	**11633-00-00**					1630				
31011116560000	**11656-00-00**					1760				
31099116660000	**11666-00-00**					1940				
31099117080000	**11708-00-00**					1860				
31099120510000	**12051-00-00**					1774				
31099120520000	**12052-00-00**					1802				
31099120530000	**12053-00-00**					1780				
31101124020000	**12402-00-00**					5760				
31011135530000	**13553-00-00**					1520				
31011135540000	**13554-00-00**					1500				
31011135620000	**13562-00-00**					1664				
31011135880000	**13588-00-00**					1582				
31011135890000	**13589-00-00**					1525				
31011135980000	**13598-00-00**					1531				
31011135990000	**13599-00-00**					1514				
31011136000000	**13600-00-00**					1568				
31011136010000	**13601-00-00**					1510				
31011136060000	**13606-00-00**					1500				
31011136370000	**13637-00-00**					1500				
31011136390000	**13639-00-00**					1500				
31011136440000	**13644-00-00**					1528				
31011136450000	**13645-00-00**		936	1089	1449	1509	2100	2100	2800	3200
31011136460000	**13646-00-00**					1498				
31011136550000	**13655-00-00**					1505				

API	SAPINO		LOCKPORT (ESOGIS*)	CLINTON (ESOGIS*)	MEDINA (ESOGIS*)	QUEENSTON (NYGS*)	OSWEGO (NYGS*)	OSWEGO (NYGS*)	LORRAINE (ESOGIS*)	TRENTON (NYGS*)
31099136750000	**13675-00-00**					1805				
31099136760000	**13676-00-00**					1782				
31101136990000	**13699-00-00**					5138			6500	
31101137360000	**13736-00-00**					4740				
31011137840000	**13784-00-00**					1543				
31011153770000	**15377-00-00**					1756				
31123154060000	**15406-00-00**					2800				
31101154380000	**15438-00-00**					4445			5838	
31011155000000	**15500-00-00**					1533				
31011155010000	**15501-00-00**					1510				
31011155020000	**15502-00-00**					1500				
31011155290000	**15529-00-00**					2400				
31011156110000	**15611-00-00**					1512				
31011156120000	**15612-00-00**					1509				
31011156430000	**15643-00-00**					1566				
31011156500000	**15650-00-00**					1510				
31011156610000	**15661-00-00**					1490				
31011156620000	**15662-00-00**					1500				
31011156630000	**15663-00-00**					1510				
31011156640000	**15664-00-00**					1458				
31011156650000	**15665-00-00**					1492				
31011157020000	**15702-00-00**					1516				
31011157030000	**15703-00-00**					1505				
31011157040000	**15704-00-00**					1518				
31011157070000	**15707-00-00**					1400				
31011157080000	**15708-00-00**					1522				
31011157090000	**15709-00-00**					1502				
31011157100000	**15710-00-00**					1485				
31011157450000	**15745-00-00**					1480				
31011157560000	**15756-00-00**					1515				
31101158340000	**15834-00-00**					6514				
31011158500000	**15850-00-00**					1496				

API	SAPINO		LOCKPORT (ESOGIS*)	CLINTON (ESOGIS*)	MEDINA (ESOGIS*)	QUEENSTON (NYGS*)	OSWEGO (NYGS*)	OSWEGO (NYGS*)	LORRAINE (ESOGIS*)	TRENTON (NYGS*)
31011159620000	**15962-00-00**					1768				
31011159630000	**15963-00-00**					1830				
31011161200000	**16120-00-00**					3470	4157	4157	4705	
31011161230000	**16123-00-00**					1586				
31011161490000	**16149-00-00**					1488				
31011161510000	**16151-00-00**					1574				
31011169910000	**16991-00-00**					1660				
31011175080000	**17508-00-00**					780			1818	
31011175090000	**17509-00-00**					754				
31011175100000	**17510-00-00**					696			1792	
31011175170000	**17517-00-00**					1510				
31011175550000	**17555-00-00**					1602				
31011175560000	**17556-00-00**					2180				
31011175570000	**17557-00-00**					2340				
31011175580000	**17558-00-00**					1448	2169	2169	2548	
31011175590000	**17559-00-00**					1400	2107	2107	2612	
31099175650000	**17565-00-00**					1658				
31099175670000	**17567-00-00**					1760				
31099175700000	**17570-00-00**					1688				
31099175720000	**17572-00-00**					1954				
31099175730000	**17573-00-00**					1820				
31099175760000	**17576-00-00**					1854				
31099175780000	**17578-00-00**					1774				
31099175790000	**17579-00-00**					1704				
31011175950000	**17595-00-00**					1452				
31011175990000	**17599-00-00**					1467				
31123194030000	**19403-00-00**					3875				
31099194590000	**19459-00-00**					1934				
31099194610000	**19461-00-00**					2116				
31099194620000	**19462-00-00**					1948				
31099194630000	**19463-00-00**					2187				
31099194640000	**19464-00-00**					2072				

API	SAPINO		LOCKPORT (ESOGIS*)	CLINTON (ESOGIS*)	MEDINA (ESOGIS*)	QUEENSTON (NYGS*)	OSWEGO (NYGS*)	OSWEGO (NYGS*)	LORRAINE (ESOGIS*)	TRENTON (NYGS*)
31099194650000	19465-00-00					2000				
31099194670000	19467-00-00					1932				
31099194700000	19470-00-00					2200	2874	2874		
31099194810000	19481-00-00					1940				
31099194820000	19482-00-00					2188				
31023194840000	19484-00-00					4260			5078	
31053194850000	19485-00-00					2840			3422	
31099194900000	19490-00-00					2146				
31099194910000	19491-00-00					2146				
31101194970000	19497-00-00					4430			5822	
31011194980000	19498-00-00					1477				
31011195000000	19500-00-00					1504				
31011195010000	19501-00-00					1466				
31099195030000	19503-00-00					2030				
31099195040000	19504-00-00					2092				
31099195050000	19505-00-00					2151				
31099195060000	19506-00-00					2004				
31099195350000	19535-00-00					1995				
31099195410000	19541-00-00					2110				
31099195420000	19542-00-00					2155				
31099195440000	19544-00-00					2111				
31099195450000	19545-00-00					2125				
31099195480000	19548-00-00					2150				
31099195490000	19549-00-00					1990				
31099195500000	19550-00-00					2150				
31099195510000	19551-00-00					1934				
31099195530000	19553-00-00					2155				
31099195540000	19554-00-00					2050				
31099195550000	19555-00-00					1920				
31099195560000	19556-00-00					2022				
31099195570000	19557-00-00					2085				
31099195580000	19558-00-00					2070				

API	SAPINO		LOCKPORT (ESOGIS*)	CLINTON (ESOGIS*)	MEDINA (ESOGIS*)	QUEENSTON (NYGS*)	OSWEGO (NYGS*)	OSWEGO (NYGS*)	LORRAINE (ESOGIS*)	TRENTON (NYGS*)
31099195620000	19562-00-00					2050				
31099195630000	19563-00-00					1995				
31099195740000	19574-00-00					1905				
31099195790000	19579-00-00					1972				
31099195800000	19580-00-00					1990				
31099195830000	19583-00-00					1800				
31099195840000	19584-00-00					1825				
31099195850000	19585-00-00					1256	1682	1682		
31099195860000	19586-00-00					1490				
31099195870000	19587-00-00					1260				
31099195880000	19588-00-00					2208				
31099195890000	19589-00-00					2362				
31099195970000	19597-00-00					2167				
31099196210000	19621-00-00					2160				
31099196230000	19623-00-00					2139				
31099196310000	19631-00-00					2014				
31011196340000	19634-00-00					1388				
31011196360000	19636-00-00					1502				
31011196370000	19637-00-00					1586				
31011196380000	19638-00-00					1522				
31011196400000	19640-00-00					1473				
31011196410000	19641-00-00					1472				
31011196420000	19642-00-00					1504				
31011196430000	19643-00-00					1490				
31011196440000	19644-00-00					1496				
31011196450000	19645-00-00					1485				
31011196650000	19665-00-00					1466				
31011196660000	19666-00-00					1481				
31099196720000	19672-00-00					2144				
31099196730000	19673-00-00					2180				
31011196740000	19674-00-00					1505				
31099196750000	19675-00-00					1770				

API	SAPINO		LOCKPORT (ESOGIS*)	CLINTON (ESOGIS*)	MEDINA (ESOGIS*)	QUEENSTON (NYGS*)	OSWEGO (NYGS*)	OSWEGO (NYGS*)	LORRAINE (ESOGIS*)	TRENTON (NYGS*)
31099196860000	**19686-00-00**					3762				
31097196920000	**19692-00-00**					5040	6402	6402	6532	
31099204130000	**20413-00-00**					1980				
31099204150000	**20415-00-00**					2042				
31099204160000	**20416-00-00**					2030				
31097204170000	**20417-00-00**					5002	6290	6290	6490	
31011204200000	**20420-00-00**					1746				
31011204210000	**20421-00-00**					1605				
31011204220000	**20422-00-00**					1630				
31099204230000	**20423-00-00**					2132				
31099204240000	**20424-00-00**					2122				
31099204290000	**20429-00-00**					2130				
31099204300000	**20430-00-00**					2137				
31099204310000	**20431-00-00**					2156				
31099204320000	**20432-00-00**					2010				
31011204360000	**20436-00-00**					1530				
31011204370000	**20437-00-00**					1500				
31099204460000	**20446-00-00**		2108	2249	2625	2709	3346	3346	3947	4518
31099204470000	**20447-00-00**					1912				
31099204480000	**20448-00-00**					1890				
31011204510000	**20451-00-00**					1498				
31011204540000	**20454-00-00**					1572				
31011204550000	**20455-00-00**					1525				
31011204560000	**20456-00-00**					1510				
31099204590000	**20459-00-00**					2135				
31011204600000	**20460-00-00**					1525				
31011204610000	**20461-00-00**					1532				
31011204640000	**20464-00-00**					1556				
31011204670000	**20467-00-00**					1562				
31011204880000	**20488-00-00**					1860				
31011204990000	**20499-00-00**					1645				
31011205010000	**20501-00-00**					1594				

API	SAPINO		LOCKPORT (ESOGIS*)	CLINTON (ESOGIS*)	MEDINA (ESOGIS*)	QUEENSTON (NYGS*)	OSWEGO (NYGS*)	OSWEGO (NYGS*)	LORRAINE (ESOGIS*)	TRENTON (NYGS*)
31011205030000	20503-00-00					1714				
31011205060000	20506-00-00					1790				
31011205070000	20507-00-00					1805				
31011205080000	20508-00-00					1810				
31011205110000	20511-00-00					1870				
31011205150000	20515-00-00					1568				
31011205160000	20516-00-00					1491				
31011205170000	20517-00-00					1510				
31099205230000	20523-00-00					1846				
31011205250000	20525-00-00					1906				
31099205260000	20526-00-00					1820				
31123205370000	20537-00-00					2665				
31123205390000	20539-00-00					2712				
31123205440000	20544-00-00					2568				
31123205460000	20546-00-00					2508				
31011205530000	20553-00-00					1565				
31011205540000	20554-00-00					1600				
31011205550000	20555-00-00					1502				
31011205560000	20556-00-00					1515				
31011205600000	20560-00-00					1738				
31011205610000	20561-00-00					1662				
31123205620000	20562-00-00					3105				
31123205700000	20570-00-00					2630				
31123205710000	20571-00-00					2970				
31011206090000	20609-00-00					1880				
31011206140000	20614-00-00					1704				
31011206150000	20615-00-00					1616				
31011206160000	20616-00-00					1584				
31011206170000	20617-00-00					1578				
31011206180000	20618-00-00					1700				
31011206210000	20621-00-00					1495				
31011206240000	20624-00-00					1704				

API	SAPINO		LOCKPORT (ESOGIS*)	CLINTON (ESOGIS*)	MEDINA (ESOGIS*)	QUEENSTON (NYGS*)	OSWEGO (NYGS*)	OSWEGO (NYGS*)	LORRAINE (ESOGIS*)	TRENTON (NYGS*)
31011206250000	20625-00-00					1676				
31011206260000	20626-00-00					1880				
31099206270000	20627-00-00					1840				
31099206290000	20629-00-00					1864				
31011206320000	20632-00-00					1906				
31011206380000	20638-00-00					1680				
31011206390000	20639-00-00					1747				
31011206490000	20649-00-00					1730				
31011206500000	20650-00-00					1546				
31011206510000	20651-00-00					1816				
31011206530000	20653-00-00					1921				
31011206560000	20656-00-00					1736				
31011206630000	20663-00-00					1870				
31011206730000	20673-00-00					1675				
31011206750000	20675-00-00					1936				
31011206810000	20681-00-00					1636				
31099206830000	20683-00-00					1828				
31099206940000	20694-00-00					1875				
31011206950000	20695-00-00					1984				
31099207000000	20700-00-00					2030				
31099207010000	20701-00-00					2135				
31099207020000	20702-00-00					1832				
31099207070000	20707-00-00					2119				
31099207080000	20708-00-00					1834				
31099212330000	21233-00-00					1765				
31099212360000	21236-00-00					2105				
31011212380000	21238-00-00					1705				
31099212480000	21248-00-00					2100				
31099212490000	21249-00-00					1940				
31099212500000	21250-00-00					2010				
31011212530000	21253-00-00					2040				
31099212690000	21269-00-00					2100				

API	SAPINO		LOCKPORT (ESOGIS*)	CLINTON (ESOGIS*)	MEDINA (ESOGIS*)	QUEENSTON (NYGS*)	OSWEGO (NYGS*)	OSWEGO (NYGS*)	LORRAINE (ESOGIS*)	TRENTON (NYGS*)
31099212860000	**21286-00-00**					1772				
31099212930000	**21293-00-00**					1884				
31099212970000	**21297-00-00**					1815				
31099212980000	**21298-00-00**					1830				
31099213150000	**21315-00-00**					1826				
31099213190000	**21319-00-00**					1725				
31099213230000	**21323-00-00**					1896				
31067213350000	**21335-00-00**					1150			2000	
31099213540000	**21354-00-00**					1808				
31099213550000	**21355-00-00**					1910				
31099213570000	**21357-00-00**					1790				
31099213580000	**21358-00-00**					1690				
31099213590000	**21359-00-00**					1796				
31099213630000	**21363-00-00**					2026				
31099213720000	**21372-00-00**					1740				
31099213820000	**21382-00-00**					1550	1790	1790		
31099213840000	**21384-00-00**					1786				
31099213920000	**21392-00-00**					1822				
31011213930000	**21393-00-00**					1992				
31099214070000	**21407-00-00**					1708				
31101214680000	**21468-00-00**					5125			6534	
31011214690000	**21469-00-00**					1804			2865	
31097214950000	**21495-00-00**					6500	6933	6933	8080	
31101214960000	**21496-00-00**					5270			6705	
31101215510000	**21551-00-00**					5170				
31101215920000	**21592-00-00**					4520	5376	5376	5876	
31101216010000	**21601-00-00**					5117			6528	
31101216240000	**21624-00-00**					5112			6544	
31101216330000	**21633-00-00**					5105			6563	
31101216360000	**21636-00-00**					5127	5615	5615	6586	
31101216880000	**21688-00-00**					4454			5858	
31101216890000	**21689-00-00**					4193			5575	

API	SAPINO		LOCKPORT (ESOGIS*)	CLINTON (ESOGIS*)	MEDINA (ESOGIS*)	QUEENSTON (NYGS*)	OSWEGO (NYGS*)	OSWEGO (NYGS*)	LORRAINE (ESOGIS*)	TRENTON (NYGS*)
31099216900000	**21690-00-00**					2420				
31101216920000	**21692-00-00**					4080			5489	
31101217030000	**21703-00-00**					3782	4992	4992	5170	
31101217040000	**21704-00-00**					4555	5872	5872	6088	
31101217050000	**21705-00-00**					4172	4760	4760	5566	
31101217060000	**21706-00-00**					4163			5688	
31101217100000	**21710-00-00**					3837	5011	5011	5224	
31101217150000	**21715-00-00**					4790			6176	
31109217160000	**21716-00-00**					4652	5300	5300	5798	
31101217180000	**21718-00-00**					7340	8119	8119	8902	
31097217250000	**21725-00-00**					4760	6035	6035	6250	
31097217260000	**21726-00-00**					4700			6168	
31101227410000	**22741-00-00**					4532			5991	
31101227450000	**22745-00-00**					4482	5305	5305	5927	
31123227460000	**22746-00-00**					4476	5682	5682	5884	
31101227470000	**22747-00-00**					4498			5968	
31101227480000	**22748-00-00**					4319			5782	
31123227500000	**22750-00-00**					4530			6004	
31123227520000	**22752-00-00**					4122			5554	
31109227530000	**22753-00-00**					4378			5772	
31097227540000	**22754-00-00**		4206	4329	4803	4899	5552	5552	6350	6997
31101227550000	**22755-00-00**					3902			5292	
31101227560000	**22756-00-00**					4600	5265	5265	6026	
31123227570000	**22757-00-00**					3905	4510	4510	5215	
31101227580000	**22758-00-00**					4302			5636	
31101227590000	**22759-00-00**					4862			6218	
31101227600000	**22760-00-00**					4802	5495	5495	6163	
31099227610000	**22761-00-00**					1897			3104	
31099227620000	**22762-00-00**					1802			3000	
31099227630000	**22763-00-00**		1368	1520	1870	1920	2629	2629	3146	3713
31123227640000	**22764-00-00**					3265			4600	
31101227650000	**22765-00-00**					4570	5170	5170	5995	

API	SAPINO		LOCKPORT (ESOGIS*)	CLINTON (ESOGIS*)	MEDINA (ESOGIS*)	QUEENSTON (NYGS*)	OSWEGO (NYGS*)	OSWEGO (NYGS*)	LORRAINE (ESOGIS*)	TRENTON (NYGS*)
31101227660000	**22766-00-00**					4504	5130	5130	5846	
31109227670000	**22767-00-00**					4235			5604	
31101227710000	**22771-00-00**					6570	7140	7140	8200	
31101227720000	**22772-00-00**					3947			5326	
31123227730000	**22773-00-00**					4098			5632	
31123227740000	**22774-00-00**					4085			5480	
31123227750000	**22775-00-00**					3088			4454	
31109227890000	**22789-00-00**					4500			5775	
31123227900000	**22790-00-00**					3580	4220	4220	4892	
31123227910000	**22791-00-00**					3545			4938	
31123227950000	**22795-00-00**					4290			5692	
31123227960000	**22796-00-00**					4108			5488	
31097227990000	**22799-00-00**					4508	5974	5974	6006	
31101228140000	**22814-00-00**					6792			8460	
31101228250000	**22825-00-00**					6594			8226	
31015228260000	**22826-00-00**					6451	7145	7145	7988	8750
31015228270000	**22827-00-00**					6180	6765	6765	7702	
31123228280000	**22828-00-00**					3268	3921	3921	4670	
31097228300000	**22830-00-00**					6170	6682	6682	7799	
31015228310000	**22831-00-00**					6658	7390	7390	8400	
31015228380000	**22838-00-00**					6979	7708	7708	8624	
31123228400000	**22840-00-00**					3446			4810	
31097228410000	**22841-00-00**					5592	6245	6245	7247	
31101228450000	**22845-00-00**		3408	3547	3913	4060	4696	4696	5453	6058
31123228500000	**22850-00-00**					4344			5600	
31101228520000	**22852-00-00**					6795	7372	7372	8505	
31015228530000	**22853-00-00**					6667	7265	7265	8302	
31015228570000	**22857-00-00**					6238	7068	7068	7835	
31123228580000	**22858-00-00**		2618	2764	3061	3209	3801	3801	4510	5180
31101228590000	**22859-00-00**		3508	3683	3909	4054	4687	4687	5394	6038
31101228610000	**22861-00-00**					6790	7406	7406	8472	
31099228640000	**22864-00-00**					1820				

API	SAPINO		LOCKPORT (ESOGIS*)	CLINTON (ESOGIS*)	MEDINA (ESOGIS*)	QUEENSTON (NYGS*)	OSWEGO (NYGS*)	OSWEGO (NYGS*)	LORRAINE (ESOGIS*)	TRENTON (NYGS*)
31099228660000	**22866-00-00**					1822				
31011228790000	**22879-00-00**					1482				
31097228810000	**22881-00-00**					5647	6408	6408	7271	
31101228850000	**22885-00-00**					6393	7080	7080	8121	
31097228930000	**22893-00-00**					5620	6365	6365	7332	
31015228990000	**22899-00-00**		6206	6478	6907	7132	7904	7904	8769	9565
31015229020000	**22902-00-00**					6301	6969	6969	7961	
31099229090000	**22909-00-00**					4359				6392
31015229110000	**22911-00-00**		6115	6377	6843	7029	7805	7805	8702	9565
31015229180000	**22918-00-00**					6305	7048	7048	8000	
31015229190000	**22919-00-00**					6677			8395	
31015229240000	**22924-00-00**					6208			7802	
31107229340000	**22934-00-00**		7152	7400	7925	8169	8854	8854	9710	10597
31097229350000	**22935-00-00**		4718	5005	5381	5563	6219	6219	7105	7924
31123229410000	**22941-00-00**		3288	3443	3869	3995	4627	4627	5433	6020
31097229420000	**22942-00-00**					6488	7140	7140	8152	
31069229430000	**22943-00-00**					2622			3883	
31099229440000	**22944-00-00**					1608				
31099229460000	**22946-00-00**					1795				
31099229470000	**22947-00-00**					1914				
31099229500000	**22950-00-00**		3590	3720	4157	4273	4919	4919	5647	6290
31007229840000	**22984-00-00**					7515			7959	
31007229950000	**22995-00-00**		7010	7087	7741	7958	8397	8397	8729	9574
31101230540000	**23054-00-00**					6935			8681	
31007230560000	**23056-00-00**					7226			8550	
31101230850000	**23085-00-00**					6714			8395	
31121233890000	**23389-00-00**		2925	3106	3201	3316	3893	3893	4372	5232
31009234560000	**23456-00-00**					3620			4720	

* Source Information

NYGS - Tops picked during the current research initiative

ESOGIS - Tops obtained from NYGS online database ESOGIS,

Appendix B - Table 3 - Porosity Estimates from the Delaney A-124-5 Well Thinsections

Depth (ft)	Porosity (%)
1510.8	0
1513.9	0
1518.1	1-5
1523.5	1-5
1525.8	1
1529.0	8-10
1535.4	5-10
1541.1	≤ 1
1542.3	4-7
1546.4	1-5
1552.2	4-7
1553.1	8-10
1559.9	1
1562.1	7-10
1571.6	~1
1577.2	>10
1578.2	7-10
1577.4	~10
1582.2	4-7
1589.2	0
1592.5	0
1602.7	7-12
1613.2	0
1617.2	7-9
1620.8	7-9
1624.2	0
1625.3	≥15
1634.5	≥15
1638.7	1
1641.1	7-10
1645.5	5-8
1647.5	0
1649.0	>10
1653.8	<1
1661.5	0
1663.0	2-5
1670.6	<1
1672.9	2-3
1680.5	1-2
1685.9	1-3
1692.2	<1
1699.3	<1
1705.1	<1
1711.0	5-10
1716.5	5-10
1723.8	0-2
1725.2	1-3
1733.2	1-3
1735.2	1
1737.9	0
1741.5	3-5
1748.4	0
1749.1	0
1753.6	1-3
1758.5	1-3
1764.5	0
1766.3	0
1767.3	10-20
1776.3	5-7
1776.7	1-7
1782.6	7-9
1785.5	0
1790.8	0- >10
1796.6	0
1805.8	0
1808.8	3-7
1810.8	0
1810.9	0
1811.0	1-3
1815.3	0
1816.2	3-5

Appendix B - Table 4 - Sample Injection Data From Bath Petroleum Inc.
(only 2 weeks of multiple month injection)

Date	Chlorides (mg/L)	Time (military)	Annular Pressure	Injection Pressure	pH	SG	Brine Temp.	Meter Reading Barrels	BPM	GPM	Name of Recorder
8/12/2004		1800	200	980				455309			B Moon
	167000	1900	200	980	7.1	1.170	90	455582	~5		B Moon
		1915	200	980				455750			B Moon
		1916									B Moon
		2030									B Moon
		2050	280	980	off for Repairs			455760			B Moon
8/13/2004		930	190					455760			B Moon
		950	offline - to work on oiler								B Moon
		955	online								B Moon
		1040	200	1040				456083	5.1	214.2	B Moon
	180000	1130	300	1060	7.2	1.168	95	456218	5.1	214.2	B Moon
		1230	280	1080				456617	4.9	205.8	B Moon
		1330	290	1090				456914	4.9	205.8	B Moon
		1430	230	1095				457214	5.0	210.0	B Moon
		1530	200	1100				45716	5.0	210.0	B Moon
		1630	200	1095				457805	5.0	210.0	B Moon
		1730	220	1090				458115	5.0	210.0	B Moon
		1830	220	1090				458428	5.0	210.0	B Moon
		1930	220	1090				458718	5.0	210.0	B Moon
		2030	230	1090				459021	5.0	210.0	B Moon
		2130	230	1090				459332	5.0	210.0	B Moon
		2230	220	1090				459623	5.0	210.0	B Moon
		2330	220	1090				459623	5.0	210.0	B Moon
8/14/2004		30	220	1090				459942	5.0	210.0	B Moon
		130	220	1090				460236	5.0	210.0	B Moon
		230	220	1090				460556	5.0	210.0	B Moon
		330	220	1090				460860	5.0	210.0	B Moon
		430	220	1090				461173	5.0	210.0	B Moon
		530	220	1090				461485	5.0	210.0	B Moon
		630	220	1090				461790	5.0	210.0	B Moon
		730						462120	5.0	210.0	B Moon
		830									B Moon

Date	Chlorides (mg/L)	Time (military)	Annular Pressure	Injection Pressure	pH	SG	Brine Temp.	Meter Reading Barrels	BPM	GPM	Name of Recorder
		930									B Moon
		1030									B Moon
		1110		1000				462318			B Moon
		1150	offline for repairs - motor not working					462490			B Moon
		1230		990				462490			B Moon
	17700	1345			13	1.172	97				B Moon
		1337	290	1045				462843	5.0	210.0	B Moon
		1430	335	1075				463111	5.0	210.0	B Moon
		1530	250	1080				463422	5.1	214.2	B Moon
		1630	240	1080				463730	5.1	214.2	S Stahl
		1730	225	1080				464042	5.1	214.2	S Stahl
		1830	270	1080				464347	5.1	214.2	S Stahl
		1930	250	1080				464661	5.1	214.2	S Stahl
		2030	240	1080				464973	5.1	214.2	S Stahl
		2130	250	1080				465276	5.0	210.0	S Stahl
		2230	240	1070				465593	5.0	210.0	S Stahl
		2330	240	1075				465903	5.0	210.0	S Stahl
8/15/2004		30	200	1080				466212	5.0	210.0	J Cardona
		130	220	1070				466527	5.0	210.0	J Cardona
		230	220	1090				466842	5.0	210.0	J Cardona
		330	220	1080				467160	5.1	214.2	J Cardona
		430	220	1070				467466	5.2	218.4	J Cardona
		530	220	1080				467788	5.2	218.4	J Cardona
		630	220	1080				768094	5.2	218.4	J Cardona
		730	220	1080				768403	5.2	218.4	J Cardona
		830	235	1085				468724	5.3	222.6	T Rice
		930	240	1080				469037	5.2	218.4	T Rice
		1030	250	1080				469350	5.2	218.4	T Rice
		1130	280	1080				469668	5.3	222.6	T Rice
	172000	1230	160	1080	7.3	1.170	98	469983	5.2	218.4	T Rice
		1330	205	1080				470299	5.2	218.4	T Rice
		1430	235	1080				470614	5.2	218.4	T Rice
		1530	240	1080				470929	5.2	218.4	T Rice
		1630	235	1080				471236	5.1	214.2	S Stahl

Date	Chlorides (mg/L)	Time (military)	Annular Pressure	Injection Pressure	pH	SG	Brine Temp.	Meter Reading Barrels	BPM	GPM	Name of Recorder
		1730	250	1080				471562	5.1	214.2	S Stahl
		1830	240	1080				471885	5.1	214.2	S Stahl
		1930	250	1080				472178	5.1	214.2	S Stahl
		2030	250	1080				472498	5.1	214.2	S Stahl
		2130	230	1075				472802	5.1	214.2	S Stahl
		2230	240	1075				473109	5.1	214.2	S Stahl
		2330	240	1075				473436	5.1	214.2	S Stahl
8/16/2004		30	220	1080				473744	5.1	214.2	J Cardona
		130	220	1080				474064	5.1	214.2	J Cardona
		230	220	1080				474380	5.1	214.2	J Cardona
		330	210	1080				474692	5.1	214.2	J Cardona
		430	220	1080				474996	5.1	214.2	J Cardona
		530	210	1080				475305	5.1	214.2	J Cardona
		630	210	1080				475636	5.1	214.2	J Cardona
		730	220	1080				475937	5.1	214.2	J Cardona
		830	220	1100				476254	5.2	218.4	T Rice
		930	240	1090				476563	5.1	214.2	T Rice
		1030	250	1090				476876	5.2	218.4	T Rice
		1130	280	1080				477180	5.0	210.0	T Rice
	175000	1230	285	1085	7.3	1.170	97	477494	5.2	218.4	T Rice
		1330	180	1080				477805	5.1	214.2	T Rice
		1430	195	1085				478119	5.2	218.4	T Rice
		1530	215	1085				478433	5.2	218.4	T Rice
		1630	240	1080				478752	5.1	214.2	S Stahl
		1730	240	1080				479071	5.1	214.2	S Stahl
		1830	220	1080				479384	5.1	214.2	S Stahl
		1930	230	1080				479688	5.0	210.0	S Stahl
		2030	230	1080				479995	5.1	214.2	S Stahl
		2130	240	1080				480295	5.1	214.2	S Stahl
		2230	240	1080				480612	5.1	214.2	S Stahl
		2330	245	1080				480930	5.1	214.2	S Stahl
8/17/2004		30	220	1050				481256	5.1	214.2	J Cardona
		130	210	1080				481568	5.1	214.2	J Cardona
		230	220	1080				781852	5.1	214.2	J Cardona

Date	Chlorides (mg/L)	Time (military)	Annular Pressure	Injection Pressure	pH	SG	Brine Temp.	Meter Reading Barrels	BPM	GPM	Name of Recorder
		330	210	1080				482156	5.1	214.2	J Cardona
		430	220	1080				482478	5.1	214.2	J Cardona
		530	210	1080				482796	5.1	214.2	J Cardona
		630	210	1080				483096	5.1	214.2	J Cardona
		730	220	1080				483399	5.1	214.2	J Cardona
		815	for repairs - pump					483656			T Rice
		930									
		1030									
		1130									
		1230									
	on	1350	60	990	Started pump after repairs			483656			B Moon
	175000	1430	250	1060	7.4	1.117	98	485848	5.1	214.2	B Moon
		1530	300	1070				484140	5.1	214.2	S Stahl
		1630	240	1075				484450	5.0	210.0	S Stahl
		1730	270	1075				484752	5.0	210.0	S Stahl
		1830	240	1075				485064	5.1	214.2	S Stahl
		1930	250	1075				485373	5.1	214.2	S Stahl
		2030	250	1075				485688	5.1	214.2	S Stahl
		2130	240	1075				485997	5.1	214.2	S Stahl
		2230	240	1075				486298	5.1	214.2	S Stahl
		2330	245	1075				486618	5.1	214.2	S Stahl
8/18/2004		30	220	1075				486942	5.1	214.2	J Cardona
		130	220	1075				487248	5.1	214.2	J Cardona
		230	210	1080				487548	5.1	214.2	J Cardona
		330	210	1080				487860	5.1	214.2	J Cardona
		430	210	1080				488161	5.1	214.2	J Cardona
		530	210	1080				488486	5.1	214.2	J Cardona
		630	210	1080				488796	5.1	214.2	J Cardona
		730	210	1080				487094	5.1	214.2	J Cardona
		830	210	1120				489426	5.5	231.0	T Rice
		930	235	1120				489731	5.0	210.0	T Rice
		1030	240	1120				490030	4.9	205.8	T Rice
		1130	250	1115				490337	5.1	214.2	T Rice
	173000	1230	280	1115	7.4	1.168	97	490647	5.1	214.2	T Rice

Date	Chlorides (mg/L)	Time (military)	Annular Pressure	Injection Pressure	pH	SG	Brine Temp.	Meter Reading Barrels	BPM	GPM	Name of Recorder
		1350	300	1120				490975	5.2	218.4	B Moon
		1430	320	1120				491261	4.7	197.4	T Rice
		1530	325	1115				491549	4.8	201.6	T Rice
		1630	310	1125				491820	4.6	193.2	S Stahl
		1730	260	1125				492125	5.1	214.2	S Stahl
		1830	270	1125				492446	5.1	214.2	S Stahl
		1930	250	1125				492730	4.9	205.8	S Stahl
		2030	250	1125				493041	4.7	197.4	S Stahl
		2130	255	1125				493330	4.9	205.8	S Stahl
		2230	260	1125				493615	4.8	201.6	S Stahl
		2330	260	1125				493908	4.8	201.6	S Stahl
8/19/2004		30	230	1125				494184	4.8	201.6	J Cardona
		130	240	1125				494509	4.8	201.6	J Cardona
		230	240	1125				494750	4.8	201.6	J Cardona
		330	240	1125				495044	4.8	201.6	J Cardona
		430	240	1125				495338	4.8	201.6	J Cardona
		530	240	1125				495630	4.8	201.6	J Cardona
		630	240	1125				495922	4.8	201.6	J Cardona
		730	240	1125				496215	4.8	201.6	J Cardona
		830	245	1125				496499	4.7	197.4	T Rice
		930	250	1120				496785	4.7	197.4	T Rice
		1030	275	1120				497068	4.7	197.4	T Rice
		1130	285	1125				497371	5.0	210.0	T Rice
		1230	315	1125				497700	5.4	226.8	T Rice
	172000	1330	325	1125				467984	4.7	197.4	T Rice
		1420	fline for repairs								B Moon
		1430	350	1125				498246	start		S Stahl
		1530	280	1120				498246	5.3	222.6	S Stahl
		1630	250	1125				498551	5.2	218.4	S Stahl
		1730	290	1125				498855	5.2	218.4	S Stahl
		1830	250	1125				449177	5.2	218.4	S Stahl
		1930	260	1125				449482	5.2	218.4	S Stahl
		2030	270	1135				499785	5.2	218.4	S Stahl
		2130	230	1135				500078	5.1	214.2	S Stahl

Date	Chlorides (mg/L)	Time (military)	Annular Pressure	Injection Pressure	pH	SG	Brine Temp.	Meter Reading Barrels	BPM	GPM	Name of Recorder
		2230	240	1135				500384	5.1	214.2	S Stahl
		2330	250	1135				500682	5.0	210.0	S Stahl
8/20/2004		30	240	1135				500964	5.0	210.0	J Cardona
		130	250	1135				501258	5.0	210.0	J Cardona
		230	250	1135				501559	5.0	210.0	J Cardona
		330	250	1135				501860	5.0	210.0	J Cardona
		430	250	1135				502144	5.0	210.0	J Cardona
		530	250	1135				502440	5.0	210.0	J Cardona
		630	250	1135				502750	5.0	210.0	J Cardona
		730	240	1135				503056	5.0	210.0	J Cardona
		830	250	1135				503359	5.0	210.0	T Rice
		930	260	1135				503655	4.9	205.8	T Rice
		1030	275	1140				503954	4.9	205.8	T Rice
		1130	290	1140				504253	5.0	210.0	B Moon
	178000	1230	310	1140	7.4	1.167	98	504558	5.0	210.0	T Rice
		1330	320	1140				504863	5.0	210.0	T Rice
		1430	330	1140				505164	5.0	210.0	T Rice
		1530	340	1140				505467	5.0	210.0	T Rice
		1630	340	1140				505750	4.7	197.4	S Stahl
		1730	350	1140				506060	5.0	210.0	S Stahl
		1830	355	1140				506346	5.0	210.0	S Stahl
		1930	360	1140				506649	5.0	210.0	S Stahl
		2030	350	1140				506950	5.0	210.0	S Stahl
		2130	350	1140				507250	5.0	210.0	S Stahl
		2230	330	1140				507550	5.0	210.0	S Stahl
		2330	330	1140				507850	5.0	210.0	S Stahl
8/21/2004		30	330	1140				508144	5.0	210.0	J Cardona
		130	330	1140				508428	5.0	210.0	J Cardona
		230	330	1140				508756	5.0	210.0	J Cardona
		330	330	1140				509020	5.0	210.0	J Cardona
		430	300	1140				509324	5.0	210.0	J Cardona
		530	310	1140				509618	5.0	210.0	J Cardona
		630	320	1140				509940	5.0	210.0	J Cardona
		730	320	1140				510220	5.0	210.0	J Cardona

Date	Chlorides (mg/L)	Time (military)	Annular Pressure	Injection Pressure	pH	SG	Brine Temp.	Meter Reading Barrels	BPM	GPM	Name of Recorder
		830	320	1160				510524	5.0	210.0	T Rice
		930	325	1155				510822	4.9	205.8	T Rice
		1030	345	1155				511120	4.9	205.8	T Rice
		1130	355	1155				511420	5.0	210.0	T Rice
	167000	1230	360	1155	7.5	1.102	94	511720	5.0	210.0	T Rice
		1330	370	1155				512022	5.0	210.0	T Rice
		1430	375	1155				512327	5.0	210.0	T Rice
		1530	375	1155				512626	4.9	205.8	T Rice
		1630	375	1140				512912	4.7	197.4	S Stahl
		1730	380	1140				513214	5.0	210.0	S Stahl
		1830	380	1140				513519	5.0	210.0	S Stahl
		1930	380	1140				513823	5.0	210.0	S Stahl
		2030	375	1140				514123	5.0	210.0	S Stahl
		2130	370	1140				514423	5.0	210.0	S Stahl
		2230	365	1140				514723	5.0	210.0	S Stahl
		2330	360	1140				515021	5.0	210.0	S Stahl
8/22/2004		30	350	1140				515320	5.0	210.0	J Cardona
		130	350	1140				515640	5.0	210.0	J Cardona
		230	340	1140				515910	5.0	210.0	J Cardona
		330	340	1140				516215	5.0	210.0	J Cardona
		430	340	1140				516519	5.0	210.0	J Cardona
		530	340	1140				516817	5.0	210.0	J Cardona
		630	340	1140				517118	4.9	205.8	J Cardona
		730	320	1140				517422	4.9	205.8	J Cardona
		830	320	1200				517696	4.5	189.0	T Rice
		930	320	1200				517980	4.7	197.4	T Rice
		1030	325	1195				518262	4.7	197.4	T Rice
		1130	355	1190				518548	4.7	197.4	T Rice
	154000	1230	370	1190	7.4	1.150	95	518855	4.7	197.4	T Rice
		1330	380	1200				519162	5.1	214.2	T Rice
		1430	410	1200				519470	5.1	214.2	T Rice
		1530	240	1200				519777	5.1	214.2	T Rice
		1630	260	1200				520084	5.1	214.2	S Stahl
		1730	270	1200				520388	5.0	210.0	S Stahl

Date	Chlorides (mg/L)	Time (military)	Annular Pressure	Injection Pressure	pH	SG	Brine Temp.	Meter Reading Barrels	BPM	GPM	Name of Recorder
		1830	280	1200				520690	5.0	210.0	S Stahl
		1930	280	1200				520992	5.0	210.0	S Stahl
		2030	280	1200				521290	5.0	210.0	S Stahl
		2130	280	1200				521590	5.0	210.0	S Stahl
		2230	290	1190				521890	5.0	210.0	S Stahl
		2330	285	1190				522190	5.0	210.0	S Stahl
8/23/2004		30	280	1190				522478	5.0	210.0	J Cardona
		130	280	1190				522784	5.0	210.0	J Cardona
		230	280	1190				522069	5.0	210.0	J Cardona
		330	280	1190				523389	5.0	210.0	J Cardona
		430	290	1190				523675	5.0	210.0	J Cardona
		530	280	1190				523939	5.0	210.0	J Cardona
		630	290	1190				524274	4.9	205.8	J Cardona
		730	290	1190				524568	4.9	205.8	J Cardona
		830	285	1200				524844	4.6	193.2	T Rice
		847			offline to fix oiler			524929			T Rice
		930			oiler repaired						T Rice
		1030	260	1115	online			524929			T Rice
		1130	315	1200				525199	4.9	205.8	T Rice
	149000	1230	365	1200	7.4	1.144	96	525502	5.0	210.0	T Rice
		1330	235	1200				525806	5.0	210.0	T Rice
		1430	205	1200				526106	5.0	210.0	T Rice
		1530	200	1200				526408	5.0	210.0	T Rice
		1630	200	1200				526710	5.0	210.0	S Stahl
		1730	200	1200				527000	4.8	201.6	S Stahl
		1830	220	1200				527292	4.9	205.8	S Stahl
		1930	230	1210				527596	5.0	210.0	S Stahl
		2030	240	1210				527900	5.0	210.0	S Stahl
		2130	240	1210				528207	5.0	210.0	S Stahl
		2230	240	1200				528514	5.1	214.2	S Stahl
		2330	255	1200				528821	5.1	214.2	S Stahl
8/24/2004		30	260	1210				529120	5.0	210.0	J Cardona
		130	260	1210				529434	5.2	218.4	J Cardona
		230	260	1210				529741	5.1	214.2	J Cardona

Date	Chlorides (mg/L)	Time (military)	Annular Pressure	Injection Pressure	pH	SG	Brine Temp.	Meter Reading Barrels	BPM	GPM	Name of Recorder
		330	260	1210				530050	5.2	218.4	J Cardona
		430	270	1220				530350	5.0	210.0	J Cardona
		530	270	1220				530658	5.1	214.2	J Cardona
		630	270	1220				530960	5.0	210.0	J Cardona
		730	270	1220				531264	5.0	210.0	J Cardona
		830	275	1235				531561	4.9	205.8	T Rice
		930	280	1235				531861	5.0	210.0	T Rice
		1030	290	1235				532161	5.0	210.0	T Rice
		1130	315	1235				532460	4.9	205.8	T Rice
	155000	1230	275	1235	7.4	1.148	95	532762	5.0	210.0	T Rice
		1330	275	1235				533064	5.0	210.0	T Rice
		1430	275	1235				533358	4.9	205.8	T Rice
		1530	280	1235				533963	5.0	210.0	T Rice
		1630	300	1240				534263	5.0	210.0	S Stahl
		1730	310	1235				534561	5.0	210.0	S Stahl
		1830	310	1235				534561	4.9	205.8	S Stahl
		1930	320	1230				534858	4.9	205.8	S Stahl
		2030	320	1220				535151	4.8	201.6	S Stahl
		2130	320	1230				535454	5.0	210.0	S Stahl
		2230	320	1230				535756	5.0	210.0	S Stahl
		2330	320	1230				536059	5.0	210.0	S Stahl
8/25/2004		0005	off - gas valve on motor not working					536208			J Cardona
		130									J Cardona
		300	240	1220	On Line			536208			J Cardona
		330	240	1220				536370	5.4	226.8	J Cardona
		430	320	1240				536667	4.9	205.8	J Cardona
		530	250	1240				536972	5.0	210.0	J Cardona
		630	280	1240				537274	5.0	210.0	J Cardona
		730	280	1240				537578	5.0	210.0	J Cardona
		830	300	1240				537862	4.7	197.4	T Rice
		930	315	1240				538151	4.8	201.6	T Rice
		1030	320	1240				538442	4.8	201.6	T Rice
		1130	280	1235				538733	4.8	201.6	T Rice
	155000	1230	285	1235	7.4	1.146	96	539025	4.8	201.6	T Rice

Appendix C

Trenton-Black River Data

Appendix C - Table 1 - Trenton-Black River General Well Data

UWI (APINum)	Well Label	Well Name	Operator	Township	County	TD	Surf Lat	Surf Lon
31-121-00271-00-00	00271-00	Bigelow Albert 1	Wilson K.E.	ARCADEN	WYOMING	7065	42.5732	-78.4454
31-015-00443-00-00	00443-00	Kesselring 1	Tremblay Gail R. & Alan B.	VA ETTENN	CHEMUNG	11145	42.1986	-76.5381
31-011-00478-00-00	00478-00	Mahaney J C	Reserve Oil Co.	LEDYARDN	CAYUGA	6166	42.6848	-76.6443
31-109-00481-00-00	00481-00	Farkas Joe 1	Reserve Oil Co.	LA SINGN	TOMPKINS	6210	42.5292	-76.5074
31-121-00615-00-00	00615-00	Fee 1	Wilson K.E.	ARCADEN	WYOMING	7144	42.5306	-78.4235
31-037-00650-00-00	00650-00	Martin 1	Pavilion Natural Gas Co.	PAVILION	GENESEE	4082	42.8807	-77.9793
31-037-00651-00-00	00651-00	Gibson	Rice Charles H.	BATAVIAN	GENESEE	3450	43.0412	-78.2858
31-055-00671-00-00	00671-00	Brockport Well	unknown	SWEDEN	MONROE	2000	43.2116	-77.9411
31-055-00672-00-00	00672-00	Rochester Deep Well	unknown	BRIGHTON	MONROE	3100	43.1702	-77.6186
31-065-00680-00-00	00680-00	Williams Elmer 1	Property Shares Inc.	FLORE CEN	ONEIDA	1451	43.3818	-75.7346
31-065-00681-00-00	00681-00	De LA Roche	Property Shares Inc.	CAMDEN	ONEIDA	1300	43.3575	-75.7571
31-065-00682-00-00	00682-00	Rinkle Leigh 1	Cabot G.L.	CAMDEN	ONEIDA	1793	43.3651	-75.7658
31-065-00683-00-00	00683-00	Owens W T 2	Property Shares Inc.	CAMDEN	ONEIDA	1305	43.3616	-75.7707
31-065-00684-00-00	00684-00	Owens 1	Property Shares Inc.	CAMDEN	ONEIDA	973	43.3635	-75.7767
31-065-00685-00-00	00685-00	Meeker Ezra	Cabot G.L.	CAMDEN	ONEIDA	1396	43.3668	-75.741
31-065-00686-00-00	00686-00	Macker Estates Meeker	Knese N.R.	CAMDEN	ONEIDA	1373	43.3695	-75.7413
31-065-00687-00-00	00687-00	Griffin Joseph	Oneida Products	CAMDEN	ONEIDA	1405	43.3772	-75.762
31-065-00689-00-00	00689-00	Dunn 2	Oneida Products	CAMDEN	ONEIDA	1405	43.3692	-75.7481
31-065-00691-00-00	00691-00	Donlon Ed	Cabot G.L.	CAMDEN	ONEIDA	1528	43.3588	-75.7474
31-065-00692-00-00	00692-00	Davies J C 1	unknown	CAMDEN	ONEIDA	1880	43.3383	-75.7413
31-065-00693-00-00	00693-00	Homer Dale	Oneida Products	CAMDEN	ONEIDA	1365	43.3605	-75.7575
31-065-00694-00-00	00694-00	Brewster A 2	Property Shares Inc.	CAMDEN	ONEIDA	1081	43.3687	-75.7609
31-065-00695-00-00	00695-00	Standard Harvester	Standard Harvester	UTICAN	ONEIDA	1370	43.0977	-75.2526
31-065-00696-00-00	00696-00	Globe Woolen Works 1	Globe Woolen Works	UTICAN	ONEIDA	1720	43.1043	-75.2459
31-065-00697-00-00	00697-00	New York Mills Well 1	Campbell	WHITESTOWN	ONEIDA	2250	43.108	-75.2866
31-065-00698-00-00	00698-00	Ainsworth Oneida Valley 1	unknown	VERO AN	ONEIDA	2795	43.1552	-75.7087
31-065-00700-00-00	00700-00	Ft Stanwick Mfg Co	unknown	ROMEN	ONEIDA	820	43.2158	-75.4464
31-065-00701-00-00	00701-00	Murphy Silas	Ontario Syndicate	ROMEN	ONEIDA	748	43.2365	-75.4336
31-065-00704-00-00	00704-00	Hathaway H H	Natural Gas Property	ROMEN	ONEIDA	895	43.2634	-75.4656
31-065-00707-00-00	00707-00	Brass & Copper 1	unknown	ROMEN	ONEIDA	1598	43.2088	-75.454
31-065-00709-00-00	00709-00	Fee	unknown	ROMEN	ONEIDA	1005	43.2081	-75.4546
31-073-00711-00-00	00711-00	Emilkamp Henry	Clark Clyde et al	CLARE DONN	ORLEANS	3030	43.1662	-78.0537
31-075-00712-00-00	00712-00	Stillwater Or Phineas 1	unknown	ORWELLN	OSWEGO	1789	43.5503	-75.9201
31-075-00713-00-00	00713-00	Rice Central Sq 1	unknown	HASTI GSN	OSWEGO	2450	43.2983	-76.1526
31-075-00714-00-00	00714-00	Wilcox 1	unknown	PARI HS	OSWEGO	2080	43.4082	-76.003
31-075-00715-00-00	00715-00	Carley 1	Eastern Oil Co. of Buffalo	PARI HS	OSWEGO	2157	43.3813	-76.0932
31-075-00720-00-00	00720-00	Mexico Well/Earl 1	unknown	MEXICON	OSWEGO	2000	43.4636	-76.2301
31-075-00725-00-00	00725-00			VOL EYN	OSWEGO		0	0
31-075-00726-00-00	00726-00	Vanburen Edward 1	Lewis & Case	VOL EYN	OSWEGO	2050	43.3676	-76.4265

UWI (APINum)	Well Label	Well Name	Operator	Township	County	TD	Surf Lat	Surf Lon
31-075-00727-00-00	00727-00	Vogelsang 1	Lewis & Case	VOL EYN	OSWEGO	2500	43.3152	-76.3828
31-075-00728-00-00	00728-00	Oswego City Well 0	unknown	CRIBAS	OSWEGO	1196	43.468	-76.4955
31-067-00804-00-00	00804-00	Names 1	Onondaga Gas Co.	LYSA DERN	ONONDAGA	2547	43.153	-76.3235
31-067-00805-00-00	00805-00	Monroe 1	Baldwinsville Light & Heat	LYSA DERN	ONONDAGA	2420	43.1656	-76.328
31-067-00807-00-00	00807-00	Binning Hickock Farm 1	Phoenix Gas Co.	LYSA DERN	ONONDAGA	0	43.1764	-76.3121
31-067-00808-00-00	00808-00	Yost Yenny 1	Lupner P.W. & Kline	O ONDAGAN	ONONDAGA	4690	43.0025	-76.1875
31-067-00809-00-00	00809-00	Spaulding 2	Onondaga Gas Co.	VA BURENN	ONONDAGA	0	43.1274	-76.3322
31-067-00810-00-00	00810-00	Waffle 1	Trenton Rock Oil & Gas	VA BURENN	ONONDAGA	2860	43.155	-76.3543
31-049-00824-00-00	00824-00	Steinmaker 1	Tug Hill Natural Gas	HARRI BURGS	LEWIS	1156	43.7837	-75.6136
31-049-00825-00-00	00825-00	Nefsey P 2	Tug Hill Natural Gas	HARRI BURGS	LEWIS	1186	43.7909	-75.5958
31-049-00826-00-00	00826-00	Nefsey 1	Tug Hill Natural Gas	HARRI BURGS	LEWIS	886	43.7906	-75.5909
31-049-00828-00-00	00828-00	Finn William 1	Tug Hill Natural Gas	MARTI SBURGN	LEWIS	1476	43.7744	-75.614
31-029-00837-00-00	00837-00	Bemus Pierce	National Fuel Gas Supply Corp.	BRA TN	ERIE	4560	42.5737	-79.0967
31-029-00839-00-00	00839-00			BUFFALON	ERIE		0	0
31-029-00840-00-00	00840-00	City Hospital Grounds 1	Buffalo City of	BUFFALON	ERIE	3420	42.9277	-78.8326
31-045-00844-00-00	00844-00	White 1	White Rufus	ADAMS	JEFFERSON	921	43.8154	-76.0434
31-065-00883-00-00	00883-00	Grimm William	Utical Natural Gas Drilling	WESTERN	ONEIDA	900	43.2988	-75.4498
31-067-00884-00-00	00884-00	Sherwood 1	Empire Portland Cement	CAMILLUS	ONONDAGA	3600	43.0756	-76.3483
31-067-00885-00-00	00885-00	Warner Plant Well 1	Empire Portland Cement	CAMILLUS	ONONDAGA	3600	43.0756	-76.3279
31-067-00886-00-00	00886-00	Monroe E K 1	Cunningham Natural Gas Corp.	CAMILLUS	ONONDAGA	4427	43.0189	-76.3039
31-067-00887-00-00	00887-00	Ashby H 2	Meridian Gas Co.	ELBRIDGEN	ONONDAGA	3631	43.0729	-76.4597
31-067-00888-00-00	00888-00	Kendall	Onondaga Gas Co.	LYSA DERN	ONONDAGA	0	43.1708	-76.3213
31-073-00911-00-00	00911-00	Hobby 1	unknown	MURRAYN	ORLEANS	0	43.2686	-78.1937
31-075-00912-00-00	00912-00	Parker F 0	Shannon L.B.	CO STANTIAN	OSWEGO	2385	43.2807	-76.0038
31-075-00913-00-00	00913-00	Grey Leo 0	Underwood	GRA BYN	OSWEGO	2375	43.2879	-76.4656
31-075-00914-00-00	00914-00	Sallie Giaccio 0	Hungiville Development Corp.	REDFIELDN	OSWEGO	1810	43.4879	-75.7583
31-099-00920-00-00	00920-00	Bump 2	Syracuse Alliance Co.	JU IUSN	SENECA	3930	42.98	-76.9339
31-029-00988-00-00	00988-00	Elma Deep Well	Stearns J.W.	ELMAN	ERIE	3986	42.8496	-78.6392
31-029-00989-00-00	00989-00	Depew Deep Well 2	Iroquois Gas Corp.	LA CASTERN	ERIE	3685	42.9354	-78.688
31-011-01003-00-00	01003-00	Slayton H 2	Duchscherer William J.	CO QUESTN	CAYUGA	3912	43.1211	-76.5935
31-043-01005-00-00	01005-00	Ilion 1	Remington Standard Typewriter	GERMA FLATTSN	HERKIMER	1135	43.0153	-75.0356
31-075-01008-00-00	01008-00	Beckwith Martin 1	Lovell Tower et al	SA DY CREEKN	OSWEGO	2335	43.4339	-76.4653
31-117-01009-00-00	01009-00	Wolcott Well	unknown	WOLCOTTN	WAYNE	2700	43.2228	-76.8134
31-067-01010-00-00	01010-00	Empire Port Cement Co 2	Empire Portland Cement	VA BURENN	ONONDAGA	3526	43.0884	-76.3476
31-073-01013-00-00	01013-00	Holley Dr Allen	Stearns J.W.	MURRAYN	ORLEANS	2025	43.2785	-78.009
31-013-01017-00-00	01017-00	Thomas	Frost Gas	DU KIRK CITYN	CHAUTAUQUA	4035	42.4816	-79.3088
31-029-01018-00-00	01018-00	Fee 1 1	Linde Air Products	TO AWANDAN	ERIE	3275	42.9738	-78.8907
31-029-01019-00-00	01019-00	Button George	Reservation Gas	COLLI SN	ERIE	4602	42.5462	-78.9959

UWI (APINum)	Well Label	Well Name	Operator	Township	County	TD	Surf Lat	Surf Lon
31-029-01020-00-00	01020-00	Well In South Park	Buffalo City of	BUFFALON	ERIE	3288	42.8366	-78.8023
31-065-01027-00-00	01027-00	Rome Brass & Copper 2	Rome Brass & Copper	ROMEN	ONEIDA	1632	43.2067	-75.4478
31-065-01028-00-00	01028-00	Dean-Garry (Vernon Well)	unknown	VER ONN	ONEIDA	1968	43.0809	-75.5392
31-065-01029-00-00	01029-00	Dodge Or Verona Well	unknown	VERO AN	ONEIDA	0	43.1364	-75.5632
31-065-01033-00-00	01033-00	Morgan E D 1	unknown	TRE TONN	ONEIDA	1000	43.2058	-75.1976
31-045-01034-00-00	01034-00	Unnamed	Black River Gas & Fuel	WATERTOWN	JEFFERSON	530	43.9781	-75.9011
31-073-01047-00-00	01047-00	Lyman/Eagle Harbor	unknown	ALBION	ORLEANS	2300	43.2445	-78.2575
31-001-01071-00-00	01071-00			GUILDERLA DN	ALBANY		0	0
31-013-01157-00-00	01157-00	Schafer #1102	Heintz Gas & Oil Co. Inc.	SHERIDAN	CHAUTAUQUA	0	42.51	-79.2749
31-017-01160-00-00	01160-00	Lobdell 1	Bradley Producing Corp.	COLUMBUS	CHENANGO	5701	42.6933	-75.3451
31-049-01168-00-00	01168-00	Aikens G	Cabot G.L.	LEWIS	LEWIS	1641	43.4339	-75.5907
31-049-01169-00-00	01169-00	Goutremont	Tug Hill Natural Gas	HARRI BURGS	LEWIS	1276	43.7894	-75.615
31-049-01170-00-00	01170-00	Berrus 1	Tug Hill Natural Gas	HARRI BURGS	LEWIS	1170	43.7855	-75.6053
31-053-01173-00-00	01173-00	Letts 1	New York Natural Gas Co.	BROOKFIELDN	MADISON	4170	42.8611	-75.4025
31-065-01176-00-00	01176-00	Roberts M	Cabot G.L.	CAMDEN	ONEIDA	1933	43.3712	-75.7982
31-065-01179-00-00	01179-00	Comins Laura	Cabot G.L.	FLORE CEN	ONEIDA	1745	43.404	-75.7737
31-065-01180-00-00	01180-00	Williams E 2	Property Shares Inc.	FLORE CEN	ONEIDA	1595	43.3845	-75.7379
31-065-01181-00-00	01181-00	Ringdahl Ivar 1	Property Shares Inc.	ROMEN	ONEIDA	900	43.2274	-75.4368
31-065-01182-00-00	01182-00	Ringdahl Ivar 2	Property Shares Inc.	ROMEN	ONEIDA	705	43.2272	-75.4339
31-065-01183-00-00	01183-00	Ringdahl Ivar 3	Boyce et al	ROMEN	ONEIDA	717	43.2303	-75.437
31-065-01184-00-00	01184-00	Ringdahl Ivan 4	Property Shares Inc.	ROMEN	ONEIDA	760	43.2294	-75.4336
31-065-01185-00-00	01185-00	Youskiewies	Seaton J.	ROMEN	ONEIDA	1536	43.2291	-75.5143
31-065-01186-00-00	01186-00	Hooper C & Jones	Property Shares Inc.	ROMEN	ONEIDA	737	43.2407	-75.4343
31-065-01188-00-00	01188-00	Mierek Anton	Utical Natural Gas Drilling	WESTERN	ONEIDA	746	43.3374	-75.3416
31-065-01190-00-00	01190-00	Skinner R 1	Property Shares Inc.	WESTMORELA DN	ONEIDA	1683	43.1187	-75.4798
31-011-01301-00-00	01301-00	Old Auburn 1	Stearns J.W.	THROOPN	CAYUGA	3600	42.9568	-76.5792
31-013-01464-00-00	01464-00	Niehause J.M #2(Lincoln)	Heintz Gas & Oil Co. Inc.	SHERIDAN	CHAUTAUQUA	4517	42.5132	-79.2741
31-029-01690-00-00	01690-00	More E #1	Pan Energy Company Inc.	ELMAN	ERIE	3100	42.8174	-78.6779
31-013-01808-00-00	01808-00	Niehaus Joseph M 2	Heintz Gas & Oil Co. Inc.	SHERIDAN	CHAUTAUQUA	4510	42.5157	-79.2738
31-117-01870-00-00	01870-00	Welch John 2	Hadley & Rogers	GALEN	WAYNE	2770	43.0888	-76.8566
31-117-01871-00-00	01871-00	Arnold Ethel	Boyce et al	GALEN	WAYNE	3000	43.105	-76.8344
31-117-01872-00-00	01872-00	Harper R 1	Boyce et al	GALEN	WAYNE	3400	43.0842	-76.8569
31-117-01873-00-00	01873-00	Harper R 2	Boyce et al	GALEN	WAYNE	2885	43.0836	-76.8592
31-117-01874-00-00	01874-00	Welch J O 1	Hadley & Rogers	GALEN	WAYNE	2740	43.0883	-76.8532
31-067-01876-00-00	01876-00	Bigelow Well 1	unknown	LYSA DERN	ONONDAGA	2795	43.1759	-76.3311
31-067-01877-00-00	01877-00	Talmadge	unknown	VA BURENN	ONONDAGA	0	43.14	-76.3367
31-117-02287-00-00	02287-00	Harper R 3	Boyce et al	GALEN	WAYNE	2770	43.0869	-76.8577
31-045-02289-00-00	02289-00	Dexter Village Water 9	Village of Dexter	BROW VILLEN	JEFFERSON	701	44.0119	-76.042
31-067-02366-00-00	02366-00	Ashby Harvey 1	Meridian Gas Co.	ELBRIDGEN	ONONDAGA	3631	43.0721	-76.4661
31-067-02403-00-00	02403-00				Onondaga		43.1963	-76.3161
31-067-02404-00-00	02404-00						43.2091	-76.2977
31-075-02426-00-00	02426-00	Baldwin 1	Lupher	VOL EYN	OSWEGO	0	43.358	-76.3388

UWI (APINum)	Well Label	Well Name	Operator	Township	County	TD	Surf Lat	Surf Lon
31-075-02432-00-00	02432-00	Briggs E 0	unknown	VOL EYN	OSWEGO	0	43.4014	-76.4687
31-075-02433-00-00	02433-00	Sanford	Sandy Creek Oil & Gas	SA DY CREEKN	OSWEGO	1240	43.6459	-76.0894
31-075-02446-00-00	02446-00	Snyder Ralph Sutton 0	Sandy Creek Oil & Gas	SA DY CREEKN	OSWEGO	900	43.6265	-76.0697
31-075-02448-00-00	02448-00	Nye 0	Sandy Creek Oil & Gas	SA DY CREEKN	OSWEGO	1000	43.6311	-76.0602
31-075-02449-00-00	02449-00	Tuttle Irving Loundb 2	Sandy Creek Oil & Gas	SA DY CREEKN	OSWEGO	0	43.6362	-76.0588
31-075-02456-00-00	02456-00	None Specified	Sandy Creek Oil & Gas	SA DY CREEKN	OSWEGO	0	43.6567	-76.031
31-075-02457-00-00	02457-00	Grey 0	Sandy Creek Oil & Gas	SA DY CREEKN	OSWEGO	0	43.6656	-76.0321
31-075-02459-00-00	02459-00	Hilton 0	Sandy Creek Oil & Gas	SA DY CREEKN	OSWEGO	0	43.6307	-76.1389
31-075-02460-00-00	02460-00	Woodard 1	Sandy Creek Oil & Gas	SA DY CREEKN	OSWEGO	0	43.628	-76.1327
31-075-02461-00-00	02461-00	Woodard 2	Sandy Creek Oil & Gas	SA DY CREEKN	OSWEGO	0	43.6251	-76.134
31-075-02463-00-00	02463-00	Beldrock 0	Sandy Creek Oil & Gas	SA DY CREEKN	OSWEGO	0	43.6343	-76.0839
31-075-02489-00-00	02489-00	Hollis H Robbins 9	Sandy Creek Oil & Gas	SA DY CREEKN	OSWEGO	0	43.653	-76.0525
31-075-02494-00-00	02494-00	Deshane Baldwin S N 0	Sandy Creek Oil & Gas	SA DY CREEKN	OSWEGO	0	43.6604	-76.0412
31-075-02495-00-00	02495-00	Tollner 1	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1400	43.567	-76.1336
31-075-02496-00-00	02496-00	Tollner 2	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1050	43.5685	-76.122
31-075-02497-00-00	02497-00	Tollner 3	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1175	43.5746	-76.1285
31-075-02498-00-00	02498-00	Betts 2/ Tollner 4	Pulaski Gas & Oil	RICHLA DN	OSWEGO	650	43.5725	-76.1376
31-075-02499-00-00	02499-00	Betts 3	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1200	43.5588	-76.1283
31-075-02500-00-00	02500-00	Tylor 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1000	43.5822	-76.1298
31-075-02501-00-00	02501-00	Maltby 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1150	43.592	-76.1304
31-075-02502-00-00	02502-00	Heard 8	Pulaski Gas & Oil	SA DY CREEKN	OSWEGO	1200	43.6034	-76.1302
31-075-02503-00-00	02503-00	Clark 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1100	43.5774	-76.1211
31-075-02504-00-00	02504-00	Twitchell 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1050	43.5883	-76.147
31-075-02505-00-00	02505-00	Lightall Wayne 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1000	43.5733	-76.151
31-075-02506-00-00	02506-00	Tollner 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1425	43.5824	-76.1166
31-075-02507-00-00	02507-00	Bamburg James 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1000	43.5695	-76.1576
31-075-02508-00-00	02508-00	Betts 4	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1200	43.5703	-76.1332
31-075-02509-00-00	02509-00	Smith 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1100	43.5725	-76.1434
31-075-02510-00-00	02510-00	Corbett 2	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1175	43.577	-76.1574
31-075-02511-00-00	02511-00	Crocket Howard Stew 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1200	43.5759	-76.1665
31-075-02512-00-00	02512-00	Brown 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1175	43.5754	-76.177
31-075-02513-00-00	02513-00	Hilliker 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1150	43.5729	-76.1859
31-075-02514-00-00	02514-00	Nelson 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1325	43.574	-76.199
31-075-02515-00-00	02515-00	Gollner 3	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1075	43.5695	-76.1175
31-075-02516-00-00	02516-00	Stewart 2	Pulaski Gas & Oil	RICHLA DN	OSWEGO	780	43.5847	-76.1625
31-075-02517-00-00	02517-00	Stewart 3	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1036	43.5702	-76.1655
31-075-02518-00-00	02518-00	Goodwin S Nelson 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1150	43.5748	-76.1935
31-075-02519-00-00	02519-00	Gollner 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1140	43.5953	-76.181
31-075-02520-00-00	02520-00	Brown 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1075	43.5732	-76.2016
31-075-02522-00-00	02522-00	Russell 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1080	43.5666	-76.1895
31-075-02523-00-00	02523-00	Phillips Wallace 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	890	43.5634	-76.1929
31-075-02524-00-00	02524-00	Letts Fred Price 0	Central Region	RICHLA DN	OSWEGO	1150	43.5602	-76.1822

UWI (APINum)	Well Label	Well Name	Operator	Township	County	TD	Surf Lat	Surf Lon
31-075-02525-00-00	02525-00	Gollner 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1170	43.568	-76.1251
31-075-02526-00-00	02526-00	Banburg 4	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1140	43.5857	-76.1776
31-075-02527-00-00	02527-00	Anderson 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1053	43.5902	-76.1703
31-075-02528-00-00	02528-00	Carr 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1090	43.5932	-76.1788
31-075-02529-00-00	02529-00	Robinson 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1055	43.5975	-76.1599
31-075-02530-00-00	02530-00	Robinson 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1060	43.6017	-76.1685
31-075-02531-00-00	02531-00	Mitchell 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1065	43.5603	-76.1512
31-075-02532-00-00	02532-00	Barclay Hugh Moody 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1150	43.5619	-76.1597
31-075-02533-00-00	02533-00	Barclay Hugh Eddy 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1125	43.5718	-76.1791
31-075-02534-00-00	02534-00	Barclay H Jamerson40	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1205	43.5559	-76.1459
31-075-02535-00-00	02535-00	Austin 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1180	43.5596	-76.1718
31-075-02536-00-00	02536-00	Stewart 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1328	43.5457	-76.1274
31-075-02537-00-00	02537-00	Loomis Mrs J B 1	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1240	43.5511	-76.1487
31-075-02538-00-00	02538-00	Richardson D R Hiltn 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	895	43.5544	-76.1608
31-075-02539-00-00	02539-00	Loomis Mrs J B 2	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1238	43.549	-76.1427
31-075-02540-00-00	02540-00	NY Defense Reloc Corp	Pulaski Gas & Oil	RICHLA DN	OSWEGO	908	43.5406	-76.1524
31-075-02541-00-00	02541-00	Decater	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1230	43.5426	-76.158
31-075-02542-00-00	02542-00	Jamison 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1206	43.5422	-76.1629
31-075-02543-00-00	02543-00	Robert Cates 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1225	43.5508	-76.1827
31-075-02544-00-00	02544-00	Davis/Perry	Central Region	RICHLA DN	OSWEGO	1175	43.5515	-76.1946
31-075-02545-00-00	02545-00	Manwaring/Givens 51	Central Region	RICHLA DN	OSWEGO	1232	43.5538	-76.2046
31-075-02546-00-00	02546-00	Stewart/Mitchell 52	Central Region	RICHLA DN	OSWEGO	1165	43.5625	-76.2029
31-075-02547-00-00	02547-00	Hardie 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1250	43.5453	-76.1921
31-075-02548-00-00	02548-00	Cole 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1250	43.5374	-76.1959
31-075-02549-00-00	02549-00	Patrick Charles D 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1218	43.5438	-76.2003
31-075-02550-00-00	02550-00	Calkens 2	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1251	43.5448	-76.2163
31-075-02554-00-00	02554-00	Cates Rob Gallagher 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1225	43.5541	-76.1776
31-075-02555-00-00	02555-00	Barclay Hugh Sanders 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1200	43.5547	-76.172
31-075-02556-00-00	02556-00	Sanders 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	900	43.564	-76.1465
31-075-02557-00-00	02557-00	Calkins 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1210	43.5377	-76.1869
31-075-02558-00-00	02558-00	Loomis Mrs J B 3	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1240	43.5542	-76.1402
31-075-02559-00-00	02559-00	Letts Fred 0	Central Region	RICHLA DN	OSWEGO	1236	43.5551	-76.1835
31-075-02560-00-00	02560-00	Letts 0	Central Region	RICHLA DN	OSWEGO	1238	43.556	-76.194
31-075-02561-00-00	02561-00	Baird Curtis Hawlett 1	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1205	43.5526	-76.1553
31-075-02562-00-00	02562-00	Davis 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	0	43.551	-76.1899
31-075-02563-00-00	02563-00	Baird C K 0	Pulaski Gas & Oil	RICHLA DN	OSWEGO	1255	43.5467	-76.1565
31-045-02671-00-00	02671-00	Smith Dr H L	Springstein	WATERTOWN	JEFFERSON	870	43.9675	-75.9357
31-029-02959-00-00	02959-00	Union Garage 1	Livingston Mrs (Ira)	CHEEKTOWAGAN	ERIE	3660	42.8848	-78.756
31-013-03200-00-00	03200-00	Morse Kyle #1	Universal Delta Drilling	HARMO YN	CHAUTAUQUA	7100	42.0682	-79.4156
31-065-03304-00-00	03304-00	Randall 1	Crandall Oil Company	TRE TONN	ONEIDA	330	43.3029	-75.2067
31-009-03868-00-00	03868-00	Ellis I-1710	National Fuel Gas Supply Corp.	PERRY BURGS	CATTARAUGUS	3925	42.4551	-79.0399

UWI (APINum)	Well Label	Well Name	Operator	Township	County	TD	Surf Lat	Surf Lon
31-055-03879-00-00	03879-00	Fee 0	Sargent & Greenleaf	IRO DEQUOITN	MONROE	3362	43.1875	-77.6085
31-039-03904-00-00	03904-00	Maurice Gans 1	United Productions	WI DHAMN	GREENE	7185	42.3335	-74.2307
31-029-03917-00-00	03917-00	Weinheimer J F Fee 2 2	Weinheimer Plumbing Supply	TO AWANDAN	ERIE	3168	43.0044	-78.8246
31-101-03924-00-00	03924-00	Olin [n650s]	Dominion Transmission Inc.	WOODHULLN	STEUBEN	13500	42.063	-77.4307
31-065-03928-00-00	03928-00	Homer A Keith 1	Keith Homer A.	SA GERFIELDN	ONEIDA	4366	42.868	-75.4266
31-009-03934-00-00	03934-00	Conger I-1748	National Fuel Gas Supply Corp.	PERRY BURGS	CATTARAUGUS	5807	42.4598	-79.0391
31-003-03956-00-00	03956-00	Cook G M 2	Parsons Bros	HUMEN	ALLEGANY	7337	42.453	-78.1743
31-053-03970-00-00	03970-00	Branangan Donald 1	New York Natural Gas Co.	LEBA ONN	MADISON	5703	42.8048	-75.6505
31-109-03973-00-00	03973-00	Shepard 1	CNG Transmission Corp.	DA BYN	TOMPKINS	10438	42.3702	-76.5063
31-043-03993-00-00	03993-00	Skranko 1	New York Natural Gas Co.	WARREN	HERKIMER	3581	42.8807	-74.9168
31-109-04007-00-00	04007-00	Smiley Jean H 1	NYS Natural Gas Corp.	DA BYN	TOMPKINS	8555	42.3654	-76.5033
31-053-04032-00-00	04032-00	Danisevich J 1	New York Natural Gas Co.	BROOKFIELDN	MADISON	4889	42.7963	-75.4046
31-043-04034-00-00	04034-00	Puskarenko 1	Devonian Oil & Gas	TARKS	HERKIMER	2717	42.9093	-74.8352
31-077-04055-00-00	04055-00	Lum Paul B et al 1	NYS Natural Gas Corp.	WORCE TERS	OTSEGO	5511	42.6309	-74.7082
31-051-04069-00-00	04069-00	Mc Donald	New York Natural Gas Co.	YORKN	LIVINGSTON	5090	42.8716	-77.9321
31-121-04092-00-00	04092-00	Veith D 1	NYS Natural Gas Corp.	GAI ESVILLEN	WYOMING	7182	42.6173	-78.0802
31-109-04130-00-00	04130-00	Grund GH	NYS Natural Gas Corp.	E FIELDN	TOMPKINS	8900	42.4421	-76.5928
31-121-04133-00-00	04133-00	Strathern Bros 1	Transamerican Petroleum Corp.	MIDDLEBURYN	WYOMING	5386	42.8306	-78.1169
31-049-04150-00-00	04150-00	Gould Paper Co	Humble Oil & Refining Co.	HIGHMARKETN	LEWIS	1789	43.6066	-75.5992
31-013-04154-00-00	04154-00	Shadle S 1	Humble Oil & Refining Co.	CHERRY CREEKN	CHAUTAUQUA	6281	42.342	-79.1319
31-029-04183-00-00	04183-00	Fee	Concrete Delivery	LACKAWA NAN	ERIE	3703	42.8291	-78.8497
31-075-04201-00-00	04201-00	Fee 1	unknown	SA DY CREEKN	OSWEGO	1393	43.6394	-76.1087
31-099-04203-00-00	04203-00	Schaffer #2	United Productions	FAYETTEN	SENECA	1921	42.8762	-76.8585
31-075-04208-00-00	04208-00	House Edson	Humble Oil & Refining Co.	HASTI GSN	OSWEGO	2240	43.3262	-76.1033
31-075-04209-00-00	04209-00	Heaphy	Humble Oil & Refining Co.	PALERMON	OSWEGO	2592	43.3188	-76.3476
31-025-04214-00-00	04214-00	Campbell H A and M W 1	Gulf Oil Corp.	HAMDEN	DELAWARE	10992	42.1828	-74.9218
31-003-04248-00-00	04248-00	Wolfer Duane A 1	NYS Natural Gas Corp.	HUMEN	ALLEGANY	7560	42.4704	-78.1602
31-075-04357-00-00	04357-00	Kellog	Humble Oil & Refining Co.	WILLIAMSTOWN	OSWEGO	1697	43.4438	-75.8769
31-075-04358-00-00	04358-00	Degraff 1	Davey - Joans	WILLIAMSTOWN	OSWEGO	1780	43.4537	-75.9196
31-025-04364-00-00	04364-00	Fowler Finch 1	Gulf Oil Corp.	SID EYN	DELAWARE	7973	42.3168	-75.2341
31-025-04379-00-00	04379-00	Lanzilotta 1	Gulf Oil Corp.	ROXBURYN	DELAWARE	9075	42.2735	-74.6277
31-121-04392-00-00	04392-00	Werner Frank C 1	NYS Natural Gas Co.	ORA GEVILLEN	WYOMING	5722	42.7477	-78.1978
31-121-04436-00-00	04436-00	Wellman L 1	Transamerican Petroleum Corp.	MIDDLEBURYN	WYOMING	5616	42.8182	-78.1386
31-013-04437-00-00	04437-00	Harrington 1	Pennzoil Products Co.	ELLERYN	CHAUTAUQUA	7694	42.1836	-79.3378
31-029-04440-00-00	04440-00	Lascala 1244 (IGC 2075)	Belden & Blake Corporation	SARDI IAN	ERIE	5913	42.5558	-78.5063

UWI (APINum)	Well Label	Well Name	Operator	Township	County	TD	Surf Lat	Surf Lon
31-121-04447-00-00	04447-00	Warren 1	Transamerican Petroleum Corp.	MIDDLEBURYN	WYOMING	5820	42.8026	-78.1501
31-025-04455-00-00	04455-00	C E Leslie Caroline E 1	Gulf Oil Corp.	FRA KLINN	DELAWARE	7952	42.3904	-75.0445
31-013-04460-00-00	04460-00	Sommers Tuttle 1	Appalachian Basin Oil & Gas Inc.	SHERIDAN	CHAUTAUQUA	4460	42.5211	-79.2623
31-121-04464-00-00	04464-00	Cox George 1	Transamerican Petroleum Corp.	MIDDLEBURYN	WYOMING	5620	42.8383	-78.0967
31-109-04467-00-00	04467-00	Fee Richarson 1	NYS Natural Gas Corp.	EWFIELDN	TOMPKINS	9390	42.3844	-76.5407
31-073-04476-00-00	04476-00	Brakenbury 1	Weaver Exploration	CARLTON	ORLEANS	2234	43.3235	-78.2054
31-073-04489-00-00	04489-00	Foss Harold 1	Weaver Exploration	YATES	ORLEANS	2057	43.3491	-78.3788
31-055-04502-00-00	04502-00	Hazen 1	Colonial Oil & Gas Corp.	HAMLIN	MONROE	2187	43.331	-77.9651
31-075-04520-00-00	04520-00	Nicholson	Scully Leon	RICHLA DN	OSWEGO	1531	43.522	-76.1738
31-013-04535-00-00	04535-00	Martin Alvin 1	Appalachian Basin Oil & Gas Inc.	SHERIDAN	CHAUTAUQUA	4024	42.5114	-79.2632
31-121-04536-00-00	04536-00	Page Henry 1	Transamerican Petroleum Corp.	MIDDLEBURYN	WYOMING	6233	42.8267	-78.1384
31-077-04547-00-00	04547-00	Burkard Ludwig et al 1	NYS Natural Gas Co.	MARYLA DN	OTSEGO	5118	42.5305	-74.8834
31-051-04552-00-00	04552-00	McClurg 1	New York Natural Gas Co.	YORKN	LIVINGSTON	5648	42.8353	-77.937
31-013-04561-00-00	04561-00	Gage C T 1	Belden & Blake Corporation	ELLERYN	CHAUTAUQUA	6292	42.24	-79.4142
31-051-04567-00-00	04567-00	Johnson 1	Stein Paul E. & Sons	CALEDO IAN	LIVINGSTON	4839	42.9323	-77.8841
31-037-04593-00-00	04593-00	Tyler 1	Weaver Oil and Gas Cor.	BYRON	GENESEE	4000	43.0429	-78.0773
31-073-04611-00-00	04611-00	Kelly F E 1	Humble Oil & Refining Co.	BARREN	ORLEANS	3044	43.1909	-78.2583
31-011-04624-00-00	04624-00	Wasielewski 1	Humble Oil & Refining Co.	IRAN	CAYUGA	3055	43.2525	-76.491
31-051-04630-00-00	04630-00	Kennedy 1	Mt. Morris Drilling Inc.	PARTAS	LIVINGSTON	6388	42.6502	-77.756
31-029-04663-00-00	04663-00	Victor 1	JFS Limited Partnership	HAMBURGN	ERIE	4543	42.7232	-78.9451
31-023-04714-00-00	04714-00	Clough K & O 1	Delta Drilling Co.	FREETOWN	CORTLAND	8272	42.5185	-76.0009
31-011-04715-00-00	04715-00	Alnutt R 1	Midwest Oil Corp.	AURELIUS	CAYUGA	4853	42.9217	-76.6716
31-063-04719-00-00	04719-00	Wolf Raymond 1	Duchscherer William J.	OMERSETS	NIAGARA	2159	43.3359	-78.5128
31-073-04722-00-00	04722-00	Cook D R 1	Duchscherer William J.	HELBYS	ORLEANS	2989	43.1858	-78.4418
31-055-04724-00-00	04724-00	Yantz 1	Duchscherer William J.	SWEDEN	MONROE	3274	43.1509	-77.9752
31-073-04730-00-00	04730-00	Daum Reid L 1	Duchscherer William J.	BARREN	ORLEANS	3174	43.1803	-78.1527
31-073-04752-00-00	04752-00	Searles Clayton 1	Duchscherer William J.	YATES	ORLEANS	2218	43.3067	-78.4529
31-073-04753-00-00	04753-00	Weil Bernard 1	Duchscherer William J.	YATES	ORLEANS	2048	43.3485	-78.4447
31-117-04754-00-00	04754-00	Smith Frank 1	Duchscherer William J.	MACEDON	WAYNE	3648	43.0824	-77.2696
31-069-04760-00-00	04760-00	Wyman 1	Hammerstone Oil	FARMI GTONN	ONTARIO	4305	42.9894	-77.2798
31-073-04764-00-00	04764-00	Morrison Manley 1	Duchscherer William J.	YATES	ORLEANS	2750	43.3259	-78.3319
31-037-04806-00-00	04806-00	Naylor 1	Ashland Oil & Refining	BYRON	GENESEE	3410	43.1154	-78.0916
31-069-04871-00-00	04871-00	Bowerman Ralph 1	Duchscherer William J.	FARMI GTONN	ONTARIO	4353	43.0216	-77.3354
31-073-04873-00-00	04873-00	Green Howard 1	Duchscherer William J.	CARLTON	ORLEANS	2025	43.3627	-78.305
31-073-04912-00-00	04912-00	Malone 1	Duchscherer William J.	GAI ESN	ORLEANS	2556	43.2823	-78.1742
31-073-04994-00-00	04994-00	Herman 1	Duchscherer William J.	KE DALLN	ORLEANS	2559	43.3482	-78.0387

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31-011-04999-00-00	04999-00	Parker Robert A 1	Duchscherer William J.	BRUTUS	CAYUGA	3600	43.026	-76.5288
31-011-05000-00-00	05000-00	Ripley 1	Urban Snow Gas Co. Inc.	CATON	CAYUGA	3756	43.1051	-76.5527
31-073-05007-00-00	05007-00	Helfer W G 1	Duchscherer William J.	CARLTON	ORLEANS	2218	43.3578	-78.1487
31-073-05008-00-00	05008-00	Thaxter 1	Duchscherer William J.	RIDGEWAYN	ORLEANS	2664	43.2442	-78.3292
31-011-05011-00-00	05011-00	O'Neil 1	Duchscherer William J.	CATON	CAYUGA	3573	43.1041	-76.5535
31-075-05012-00-00	05012-00	Hall 1	Duchscherer William J.	O WEGOS	OSWEGO	2559	43.3693	-76.6016
31-011-05031-00-00	05031-00	Smith L W 1	Duchscherer William J.	VICTORYN	CAYUGA	3415	43.2015	-76.61
31-117-05032-00-00	05032-00	Kaiser W 1	Duchscherer William J.	GALEN	WAYNE	3915	43.0592	-76.8961
31-117-05041-00-00	05041-00	Reed 1	Norris Robert E. III	BUTLERN	WAYNE	3681	43.1458	-76.7616
31-073-05069-00-00	05069-00	Nowak 1	Duchscherer William J.	KE DALLN	ORLEANS	2325	43.3191	-78.0824
31-073-05086-00-00	05086-00	Stevens F 1	Duchscherer William J.	KE DALLN	ORLEANS	2445	43.308	-78.0339
31-007-05087-00-00	05087-00	Richards 1	Joyce Western Corp.	TRIA GLEN	BROOME	9640	42.3235	-75.9479
31-073-05091-00-00	05091-00	Woolston G E 1	Duchscherer William J.	GAI ESN	ORLEANS	2345	43.306	-78.2245
31-099-05095-00-00	05095-00	Reed 1	Duchscherer William J.	JU IUSN	SENECA	4149	43.0067	-76.9403
31-073-05096-00-00	05096-00	Domoy F 1	Duchscherer William J.	HELBYS	ORLEANS	3119	43.1621	-78.3732
31-117-05114-00-00	05114-00	Olson H V 1	Duchscherer William J.	LYO SN	WAYNE	3744	43.1115	-77.0206
31-037-05115-00-00	05115-00	Brundage 1	Duchscherer William J.	ALABAMAN	GENESEE	3600	43.0906	-78.3135
31-117-05116-00-00	05116-00	Hammond F W 1	Duchscherer William J.	ARCADIAN	WAYNE	3750	43.152	-77.0698
31-037-05117-00-00	05117-00	Klotzbach #1	United States Gypsum Co.	ALABAMAN	GENESEE	3950	43.0403	-78.3902
31-029-05402-00-00	05402-00			TO AWANDAN	ERIE		0	0
31-011-05467-00-00	05467-00	House Louis and Mary 1	Hodges Michael W.	CATON	CAYUGA	3368	43.1007	-76.5127
31-121-06073-00-00	06073-00	Fisher Frank et al 1	Flanigan Brothers	WAR AWS	WYOMING	5712	42.7552	-78.0976
31-069-06395-00-00	06395-00	Frankish George C 1	Hoover Moble C.	GORHAMN	ONTARIO	6012	42.8126	-77.2029
31-063-06667-00-00	06667-00	FMC Corp Niag Chem Div 1	Niagara Chemical Division FMC	ROYALTON	NIAGARA	3189	43.2076	-78.4651
31-029-06668-00-00	06668-00	Fee 1	Bethlehem Steel Corp.	HAMBURGN	ERIE	4310	42.8032	-78.8444
31-063-06669-00-00	06669-00	Fee (Hooker Chemical) 1a	Occidental(Formerly Hooker)	IAGARAN	NIAGARA	3063	43.0799	-79.0067
31-117-06719-00-00	06719-00	Martin 1	Union Oil Company of California	GALEN	WAYNE	4050	43.029	-76.9438
31-011-06779-00-00	06779-00	Karim 1	Karim Raja Abdul	CATON	CAYUGA	3128	43.1093	-76.5615
31-011-06780-00-00	06780-00	Cole 1	Urban Snow Gas Co. Inc.	CATON	CAYUGA	3096	43.1091	-76.5469
31-121-07234-00-00	07234-00	Farrell Robert 1	Lenape Resources Corp. The	MIDDLEBURYN	WYOMING	4944	42.7845	-78.1114
31-121-07278-00-00	07278-00	Texas Brine #18	Texas Brine Company LLC	MIDDLEBURYN	WYOMING	4980	42.7974	-78.0912
31-013-07649-00-00	07649-00	Langworthy #1	Cotton Well Drilling Co. Inc.	VILLE OVAN	CHAUTAUQUA	5940	42.4071	-79.1665
31-009-08581-00-00	08581-00	Thomasett (IGC 2379) 1	Iroquois Gas Corp.	PERRY BURGS	CATTARAUGUS	5701	42.4563	-79.033
31-009-08610-00-00	08610-00	Manning (IGC 2380) 1	Iroquois Gas Corp.	OTTON	CATTARAUGUS	6762	42.3714	-78.8431
31-009-09235-00-00	09235-00	Enterprise Transit St 1	Pennzoil Products Co.	ALLEGA YN	CATTARAUGUS	11680	42.0087	-78.5687
31-013-09355-00-00	09355-00	Newman James 1	Meridian Exploration Corp.	POMFRETN	CHAUTAUQUA	4780	42.4372	-79.4071

UWI (APINum)	Well Label	Well Name	Operator	Township	County	TD	Surf Lat	Surf Lon
31-037-09524-00-00	09524-00	Buckenmeyer 1	CNG Transmission Corp.	ALEXA DERN	GENESEE	4095	42.9	-78.2442
31-073-09540-00-00	09540-00	Maxon Roger 1	Consolidated Gas Supply Corp.	CLARE DONN	ORLEANS	2873	43.1885	-78.0376
31-037-09563-00-00	09563-00	Uebelhoer 1	CNG Transmission Corp.	BYRON	GENESEE	3379	43.0793	-78.1099
31-053-09578-00-00	09578-00	Shepard Helen 1	CNG Transmission Corp.	FE NERN	MADISON	4927	42.9511	-75.8078
31-013-09939-00-00	09939-00	Lesch #1110	Lenape Resources Inc.	POMFRETN	CHAUTAUQUA	5013	42.4158	-79.3787
31-025-10227-00-00	10227-00	Weickert F 1	Anschutz Corp.	ROXBURYN	DELAWARE	6740	42.2976	-74.625
31-015-10335-00-00	10335-00	Matejka 1	Shell Oil Co.	ERIN	CHEMUNG	10614	42.169	-76.659
31-037-10776-00-00	10776-00	Belt 1	Flint Oil & Gas Inc.	BETHA YN	GENESEE	4340	42.9204	-78.1673
31-077-10834-00-00	10834-00	Hoose 1	Amoco Production Co.	LAURE SN	OTSEGO	5824	42.5803	-75.0481
31-099-10893-00-00	10893-00	Kinney 1	Hoover Moble C.	WATERLOON	SENECA	4741	42.9411	-76.8767
31-055-10921-00-00	10921-00	Kerberle 1	Colonial Oil & Gas Corp.	HAMLIN	MONROE	2200	43.3334	-77.9529
31-121-10936-00-00	10936-00	Wagenblass Daniel 1	CNG Transmission Corp.	WAR AWS	WYOMING	5573	42.7442	-78.1855
31-121-10939-00-00	10939-00	Metz 1	Flint Oil & Gas Inc.	SHELDON	WYOMING	5420	42.7668	-78.4179
31-029-11002-00-00	11002-00	Brown Ralph H 1	Belden & Blake Corporation	SARDI IAN	ERIE	6293	42.5575	-78.5357
31-029-11114-00-00	11114-00	Lietz 2	Perkins Cooper & Gondree	BRA TN	ERIE	4822	42.598	-78.9844
31-011-11129-00-00	11129-00	Joshanski 1	Urban Snow Gas Co. Inc.	CATON	CAYUGA	3057	43.1206	-76.548
31-013-11387-00-00	11387-00	Emling 373	Belden & Blake Corporation	RIPLEYN	CHAUTAUQUA	6182	42.2191	-79.6635
31-029-11730-00-00	11730-00	Foss 1241	Lenape Resources Inc.	WALES	ERIE	5550	42.7138	-78.5173
31-067-12163-00-00	12163-00	Harrison	Pominex Inc.	MARCELLUS	ONONDAGA	4176	42.9369	-76.3459
31-121-12178-00-00	12178-00	Meeder Wn-1533	Meeder William H	MIDDLEBURYN	WYOMING	5325	42.7908	-78.1751
31-075-12398-00-00	12398-00	Nicholson	Kirby Exploration Co.	MEXICON	OSWEGO	1860	43.4868	-76.1889
31-075-12399-00-00	12399-00	Yager	Yager Eileen R.	RICHLA DN	OSWEGO	1785	43.5087	-76.1957
31-075-12406-00-00	12406-00	Crane	Kirby Exploration Co.	RICHLA DN	OSWEGO	1795	43.5018	-76.2001
31-075-12447-00-00	12447-00	Manwaring 1	Kirby Exploration Co.	RICHLA DN	OSWEGO	1677	43.5188	-76.1908
31-029-12745-00-00	12745-00	Heary C. N1617	Ardent Resources Inc.	CO CORDN	ERIE	5515	42.5792	-78.7203
31-029-12910-00-00	12910-00	Darling #1	NYS Natural Gas Co.	COLLI SN	ERIE	5826	42.4664	-78.8035
31-121-13278-00-00	13278-00	Romain George 1	Stedman Energy Inc.	ARCADEN	WYOMING	6708	42.5346	-78.3947
31-037-13672-00-00	13672-00	Fee 1	General Crushed Stone Co.	LE ROYN	GENESEE	4203	42.9935	-77.9519
31-101-13699-00-00	13699-00	NYS Reforestation 6	Columbia Gas Trans. Corp.	WHEELERN	STEUBEN	9794	42.4662	-77.2654
31-051-13700-00-00	13700-00	Hilts 20617-T	Columbia Gas Trans. Corp.	MOU T MORRISN	LIVINGSTON	6403	42.6972	-77.892
31-101-15438-00-00	15438-00	Kassow 1	Minter Lee E.	PULTE EYN	STEUBEN	7956	42.5393	-77.2161
31-053-15467-00-00	15467-00	H.J. Becker Et Ux 1	Elcoex Inc.	DE RUYTERN	MADISON	4746	42.8155	-75.7866
31-067-15584-00-00	15584-00	Cox R	Cox Family Farm	LYSA DERN	ONONDAGA	3533	43.1548	-76.4715
31-075-15613-00-00	15613-00	Nicholson	Taber Grover E. Jr.	WEST MO ROEN	OSWEGO	2240	43.3513	-76.0894
31-075-15628-00-00	15628-00	Marquisee	Marquisee Joseph A.	WILLIAMSTOWN	OSWEGO	1725	43.4884	-75.9359
31-011-16120-00-00	16120-00	Venice View Dairy 1-11	Devonian Energy Corp.	VE ICEN	CAYUGA	7346	42.7202	-76.5683

UWI (APINum)	Well Label	Well Name	Operator	Township	County	TD	Surf Lat	Surf Lon
31-075-16814-00-00	16814-00	Atkinson 1	Atkinson James W. & Patricia	RICHLA DN	OSWEGO	800	43.53	-76.1708
31-075-16818-00-00	16818-00	Stowell 1	Kirby Exploration Co.	RICHMO DN	OSWEGO	865	43.5187	-76.214
31-011-17508-00-00	17508-00	Hunter A&B 1	Urban Snow Gas Co. Inc.	CATON	CAYUGA	3658	43.129	-76.5617
31-011-17509-00-00	17509-00	Hunter C 1	Urban Snow Gas Co. Inc.	CATON	CAYUGA	2866	43.1305	-76.5471
31-011-17510-00-00	17510-00	Keysor K 1	Urban Snow Gas Co. Inc.	CATON	CAYUGA	3649	43.1383	-76.5522
31-011-17558-00-00	17558-00	Provo 7271	Meridian Exploration Corp.	SE NETTN	CAYUGA	4555	43.0111	-76.5215
31-011-17559-00-00	17559-00	Quill 7251	Columbia Natural Resources Inc.	AURELIUS	CAYUGA	5038	42.9243	-76.6998
31-053-19485-00-00	19485-00	Larkin 1	F. L. Stead & Associates Inc.	BROOKFIELDN	MADISON	5083	42.8088	-75.4189
31-101-19497-00-00	19497-00	Evangelos 21436-T	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	7961	42.5407	-77.2162
31-023-19540-00-00	19540-00	Vander Ploeg 1	Berea Oil & Gas Corp.	FREETOWN	CORTLAND	7820	42.5543	-76.0209
31-097-19692-00-00	19692-00	Perigo 21578 Tpi	Columbia Natural Resources Inc.	READI GN	SCHUYLER	8384	42.4325	-76.9704
31-121-19937-00-00	19937-00	Phillips J #1	U S Energy Development Corp.	WAR AWS	WYOMING	5670	42.6977	-78.1892
31-053-20411-00-00	20411-00	Gapski 1	N. Y. Keelex Corp.	ELSONN	MADISON	5240	42.8574	-75.7295
31-097-20417-00-00	20417-00	Epstein 21624-Pi	Columbia Natural Resources Inc.	READI GN	SCHUYLER	8520	42.4371	-76.9561
31-099-20446-00-00	20446-00	Compton 1 (4177)	Equitable Resources Exploraration	ROMULUS	SENECA	6366	42.7086	-76.8085
31-037-20687-00-00	20687-00	U S Gypsum Co #2	United States Gypsum Co.	OAKFIELDN	GENESEE	4620	43.0521	-78.2373
31-057-21033-00-00	21033-00	Montanye Lawrence MNRD 1-A	Millennium Natural Resource Development	ROOTN	MONTGOMERY		42.8483	-74.4576
31-067-21335-00-00	21335-00	Halloran 1	Eastern States Exploration Co.	CAMILLUS	ONONDAGA	4159	43.066	-76.3529
31-067-21336-00-00	21336-00	Stell 1	Eastern States Exploration Co.	VA BURENN	ONONDAGA	3923	43.1228	-76.4008
31-101-21468-00-00	21468-00	Mitchell 1	New Avoca Gas Storage LLC	AVOCAN	STEUBEN	9887	42.4196	-77.4535
31-011-21469-00-00	21469-00	Auburn Geothermal Well #2				5122	42.9466	-76.5417
31-097-21495-00-00	21495-00	Bale 1	JMC Cayuta Inc.	CAYUTAN	SCHUYLER	11823	42.2699	-76.7139
31-101-21496-00-00	21496-00	Hubbard No. 1	New Avoca Gas Storage LLC	AVOCAN	STEUBEN	10051	42.4053	-77.4635
31-023-21500-00-00	21500-00	NYS REF 6 Well 01	Quaker State Corp.	TAYLORN	CORTLAND	6886	42.639	-75.9136
31-101-21592-00-00	21592-00	Gray 21625	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	7493	42.5406	-77.237
31-101-21601-00-00	21601-00	Mitchell 2	New Avoca Gas Storage LLC	AVOCAN	STEUBEN	11894	42.4333	-77.4537

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31-101-21624-00-00	21624-00	Avoca 4	New Avoca Gas Storage LLC	AVOCAN	STEUBEN	9224	42.42	-77.4675
31-101-21633-00-00	21633-00	Mitchell 3	New Avoca Gas Storage LLC	AVOCAN	STEUBEN	11415	42.4278	-77.4459
31-101-21636-00-00	21636-00	Fee 6	New Avoca Gas Storage LLC	AVOCAN	STEUBEN	11030	42.429	-77.466
31-101-21688-00-00	21688-00	Levandowski 623088	Columbia Natural Resources Inc.	PRATT BURGS	STEUBEN	7313	42.5343	-77.2522
31-101-21689-00-00	21689-00	Covert 622302	Columbia Natural Resources Inc.	PRATT BURGS	STEUBEN	7136	42.5387	-77.2753
31-101-21689-01-00	21689-01	Covert 622302-A	Columbia Natural Resources Inc.	PRATT BURGS	STEUBEN	7131	42.5387	-77.2753
31-101-21692-00-00	21692-00	Pizura 623143	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	7091	42.5398	-77.1825
31-053-21699-00-00	21699-00	Beers 1	Nornew Inc.	LEBA ONN	MADISON	4734	42.81	-75.5967
31-101-21703-00-00	21703-00	Radigan 623267	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	7266	42.5434	-77.1677
31-101-21704-00-00	21704-00	Fimlaid 1	Columbia Natural Resources Inc.	WAY EN	STEUBEN	8028	42.4393	-77.1115
31-101-21705-00-00	21705-00	Smith 1	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	7110	42.5434	-77.1982
31-101-21706-00-00	21706-00	Fox 1 (623217)	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	7048	42.5386	-77.2035
31-101-21707-00-00	21707-00	Prattsburg Town Farm 1	Columbia Natural Resources Inc.	PRATT BURGS	STEUBEN	7718	42.5377	-77.3033
31-101-21707-02-00	21707-02	Prattsburg Town Farm 623220-B	Columbia Natural Resources Inc.	PRATT BURGS	STEUBEN	7505	42.5377	-77.3033
31-101-21710-00-00	21710-00	Bergstresser 1	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	6691	42.5472	-77.1726
31-101-21712-00-00	21712-00	Kozak 1	Columbia Natural Resources Inc.	PRATT BURGS	STEUBEN	7690	42.5392	-77.2601
31-101-21715-00-00	21715-00	Grace 1	Columbia Natural Resources Inc.	PRATT BURGS	STEUBEN	7879	42.5236	-77.3415
31-109-21716-00-00	21716-00	Stairs 1	Columbia Natural Resources Inc.	DRYDEN	TOMPKINS	7468	42.511	-76.301
31-101-21718-00-00	21718-00	Demun 1	True Oil Co.	TROUP BURGS	STEUBEN	11166	42.0956	-77.5943
31-097-21725-00-00	21725-00	Forte 1	Columbia Natural Resources Inc.	TYRO EN	SCHUYLER	8275	42.4713	-77.0042
31-097-21726-00-00	21726-00	Mast 1	Columbia Natural Resources Inc.	TYRO EN	SCHUYLER	8174	42.476	-77.0032
31-009-21809-00-00	21809-00	Hebdon #1	Hebdon Charles & Cherryl	A HFORDS	CATTARAUGUS	7502	42.3954	-78.6722
31-121-21840-00-00	21840-00	Howes A #1	Miller Gas Corp.	MIDDLEBURYN	WYOMING	5320	42.8172	-78.1104

UWI (APINum)	Well Label	Well Name	Operator	Township	County	TD	Surf Lat	Surf Lon
31-009-21860-00-00	21860-00	Schwerkert-Scharf #1	Schweikert William K.	A HFORDS	CATTARAUGUS	6166	42.4905	-78.6043
31-009-21869-00-00	21869-00	Worden #1	Thompson Timothy G.	YORK HIRES	CATTARAUGUS	6166	42.5003	-78.5085
31-121-21900-00-00	21900-00	Leaton G #1	Miller Gas Corp.	COVI GTONN	WYOMING	5079	42.8307	-78.0549
31-121-21907-00-00	21907-00	Chamberlain D #2	Miller Gas Corp.	MIDDLEBURYN	WYOMING	5373	42.8178	-78.1167
31-121-21908-00-00	21908-00	Howes A #3	Miller Gas Corp.	MIDDLEBURYN	WYOMING	5148	42.8199	-78.1061
31-121-21909-00-00	21909-00	Howes A #2	Miller Gas Corp.	MIDDLEBURYN	WYOMING	5350	42.8216	-78.1111
31-121-21920-00-00	21920-00	Titus Brothers #1	Miller Gas Corp.	MIDDLEBURYN	WYOMING	5260	42.8273	-78.1012
31-121-21945-00-00	21945-00	Howes A #4	Miller Gas Corp.	MIDDLEBURYN	WYOMING	5272	42.816	-78.1048
31-121-21946-00-00	21946-00	Chamberlain B #1	Miller Gas Corp.	MIDDLEBURYN	WYOMING	5201	42.8128	-78.1073
31-121-21962-00-00	21962-00	Lacey R #1	Miller Gas Corp.	COVI GTONN	WYOMING	5140	42.8314	-78.0488
31-121-21963-00-00	21963-00	Tillotson D #1	Miller Gas Corp.	COVI GTONN	WYOMING	5000	42.8271	-78.0504
31-121-21964-00-00	21964-00	Johannes E #1	GFS Energy Inc.	COVI GTONN	WYOMING	5300	42.8213	-78.0685
31-121-22042-00-00	22042-00	Titus Brothers #4	Miller Gas Corp.	MIDDLEBURYN	WYOMING	5211	42.8219	-78.0996
31-121-22046-00-00	22046-00	Titus Brothers #3	Miller Gas Corp.	MIDDLEBURYN	WYOMING	5050	42.8177	-78.099
31-121-22053-00-00	22053-00	Chamberlain P #2	Miller Gas Corp.	MIDDLEBURYN	WYOMING	5340	42.8138	-78.1134
31-013-22497-00-00	22497-00	Kaluza 1	New York Gas & Oil Co Inc.	ELLERYN	CHAUTAUQUA	7288	42.2028	-79.4009
31-013-22498-00-00	22498-00	Butts 1-B	Cei 1992-93 Joint Venture	ORTH HARMONYN	CHAUTAUQUA	7620	42.1438	-79.4174
31-121-22520-00-00	22520-00	Matusik J #1	Belden & Blake Corporation	ARCADEN	WYOMING	6321	42.5535	-78.4388
31-013-22531-00-00	22531-00	Liddell #1	New York Gas & Oil Co Inc.	ELLERYN	CHAUTAUQUA	7330	42.1979	-79.3921
31-013-22588-00-00	22588-00	Gorczyca #1	New York Gas & Oil Co Inc.	ELLERYN	CHAUTAUQUA	7136	42.2298	-79.3904
31-013-22596-00-00	22596-00	Schofield S.P. 127 #1	Schreiner Oil & Gas Inc.	WE TFIELDS	CHAUTAUQUA	5935	42.3382	-79.5319
31-013-22616-00-00	22616-00	Crowe #3	New York Gas & Oil Co Inc.	POMFRETN	CHAUTAUQUA	6174	42.3665	-79.4091
31-121-22655-00-00	22655-00	Stahl #1	Belden & Blake Corporation	ARCADEN	WYOMING	6021	42.577	-78.4587
31-101-22741-00-00	22741-00	Von Rhedey 623519	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	7494	42.4938	-77.2058
31-101-22741-01-00	22741-01	Von Rhedey 623519-A	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	7783	42.4938	-77.2058
31-123-22743-00-00	22743-00	Sensenig 1	Columbia Natural Resources Inc.	TARKEYS	YATES	7241	42.5073	-76.9726
31-101-22745-00-00	22745-00	Faber 1	Columbia Natural Resources Inc.	PRATT BURGS	STEUBEN	7371	42.5002	-77.2421
31-123-22746-00-00	22746-00	Dewitt 623333	Columbia Natural Resources Inc.	BARRI GTONN	YATES	7925	42.5173	-77.0612
31-101-22747-00-00	22747-00	Smith 1	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	7442	42.5102	-77.2093

UWI (APINum)	Well Label	Well Name	Operator	Township	County	TD	Surf Lat	Surf Lon
31-101-22748-00-00	22748-00	McAllister 1	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	7232	42.5106	-77.1921
31-123-22750-00-00	22750-00	Weitz 1	Columbia Natural Resources Inc.	BARRI GTONN	YATES	7555	42.4933	-77.0876
31-123-22752-00-00	22752-00	Knapp 1	Columbia Natural Resources Inc.	BARRI GTONN	YATES	7543	42.5285	-77.0827
31-109-22753-00-00	22753-00	Koskinen 623513	Columbia Natural Resources Inc.	ULY SESS	TOMPKINS	7462	42.4903	-76.6733
31-097-22754-00-00	22754-00	Gunning 1	Columbia Natural Resources Inc.	HECTORN	SCHUYLER	7999	42.4601	-76.7321
31-101-22755-00-00	22755-00	Snyder 1	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	6816	42.5188	-77.1661
31-101-22756-00-00	22756-00	Grand View 1	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	7848	42.4823	-77.204
31-123-22757-00-00	22757-00	NYS Reforestation Area 1	Belden & Blake Corporation	ITALYN	YATES	0	42.6456	-77.2466
31-123-22757-01-00	22757-01	NYS Reforestation Area 1	Belden & Blake Corporation	ITALYN	YATES	7146	42.6456	-77.2466
31-101-22758-00-00	22758-00	S & D Farms 623504	Columbia Natural Resources Inc.	COHOCTON	STEUBEN	7416	42.5494	-77.4542
31-101-22758-01-00	22758-01	S & D Farms 624504-B	Columbia Natural Resources Inc.	COHOCTON	STEUBEN	7468	42.5494	-77.4542
31-101-22759-00-00	22759-00	S & D Farms 623144	Columbia Natural Resources Inc.	COHOCTON	STEUBEN	7892	42.5334	-77.4005
31-101-22759-01-00	22759-01	S & D Farms 623144-A	Columbia Natural Resources Inc.	COHOCTON	STEUBEN	7963	42.5334	-77.4005
31-101-22759-02-00	22759-02	S & D Farms 623144-B	Columbia Natural Resources Inc.	COHOCTON	STEUBEN	8212	42.5334	-77.4005
31-101-22760-00-00	22760-00	Wolcott 623284	Columbia Natural Resources Inc.	COHOCTON	STEUBEN	7832	42.5422	-77.4187
31-101-22760-01-00	22760-01	Wolcott 623284-A	Columbia Natural Resources Inc.	COHOCTON	STEUBEN	7916	42.5422	-77.4187
31-099-22761-00-00	22761-00	Poorman 2586-01	Meridian Exploration Corp.	FAYETTEN	SENECA	5431	42.8393	-76.837
31-099-22762-00-00	22762-00	Schaffer 2584-03	Columbia Natural Resources Inc.	FAYETTEN	SENECA	5002	42.86	-76.852
31-099-22763-00-00	22763-00	Murray 2587-01	Meridian Exploration Corp.	FAYETTEN	SENECA	5452	42.8284	-76.8378
31-123-22764-00-00	22764-00	Costanza 1	Belden & Blake Corporation	ITALYN	YATES	6580	42.6319	-77.2788
31-123-22764-01-00	22764-01	Costanza 1-A	Belden & Blake Corporation	ITALYN	YATES	6188	42.6319	-77.2788
31-123-22764-02-00	22764-02	Costanza 1-B	Belden & Blake Corporation	ITALYN	YATES	6258	42.6319	-77.2788

UWI (APINum)	Well Label	Well Name	Operator	Township	County	TD	Surf Lat	Surf Lon
31-101-22765-00-00	22765-00	Wise 1 (623520)	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	7853	42.4931	-77.2348
31-101-22765-01-00	22765-01	Wise 623520-A	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	7641	42.4931	-77.2348
31-101-22766-00-00	22766-00	Peck 1 (623516)	Columbia Natural Resources Inc.	COHOCTON	STEUBEN	7644	42.5457	-77.4413
31-109-22767-00-00	22767-00	Duddleston 623514	Columbia Natural Resources Inc.	ULY SESS	TOMPKINS	7454	42.512	-76.6361
31-101-22768-00-00	22768-00	Covert 623222	Columbia Natural Resources Inc.	PRATT BURGS	STEUBEN	7386	42.5335	-77.2719
31-101-22769-00-00	22769-00	Ballam-Carter 1	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	7581	42.5367	-77.228
31-101-22771-00-00	22771-00	Jimerson 1240	Pennsylvania General Energy	HOR BYN	STEUBEN	9710	42.2147	-77.0148
31-101-22772-00-00	22772-00	Egresi 1	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	7152	42.5353	-77.1721
31-123-22773-00-00	22773-00	Knapp 2	Columbia Natural Resources Inc.	BARRI GTONN	YATES	7598	42.524	-77.082
31-123-22773-01-00	22773-01	Knapp 2	Columbia Natural Resources Inc.	BARRI GTONN	YATES		42.524	-77.082
31-123-22774-00-00	22774-00	Knapp 3	Columbia Natural Resources Inc.	BARRI GTONN	YATES	7101	42.5307	-77.0829
31-123-22775-00-00	22775-00	Walters 623641	Columbia Natural Resources Inc.	JERU ALEMS	YATES	6849	42.6141	-77.1522
31-123-22775-01-00	22775-01	Walters 623641-A	Columbia Natural Resources Inc.	JERU ALEMS	YATES		42.6141	-77.1522
31-123-22776-00-00	22776-00	Silk 1 (623638)	Columbia Natural Resources Inc.	BARRI GTONN	YATES	7179	42.5513	-77.0733
31-109-22789-00-00	22789-00	Rehebein/Call 1	Columbia Natural Resources Inc.	DRYDEN	TOMPKINS	7634	42.5428	-76.2803
31-109-22789-01-00	22789-01	Rehebein/Call 1-A	Columbia Natural Resources Inc.	DRYDEN	TOMPKINS		42.5428	-76.2803
31-123-22790-01-00	22790-01	Agliata 1 (623780-A)	Columbia Natural Resources Inc.	MILON	YATES		42.582	-77.0625
31-123-22791-00-00	22791-00	Bauer 1 (623781)	Columbia Natural Resources Inc.	BARRI GTONN	YATES	7086	42.5763	-77.0582
31-123-22791-01-00	22791-01	Bauer 623781-A	Columbia Natural Resources Inc.	BARRI GTONN	YATES	7132	42.5763	-77.0582
31-097-22793-00-00	22793-00	Cook 1	Columbia Natural Resources Inc.	HECTORN	SCHUYLER	7587	42.5355	-76.7359
31-097-22794-00-00	22794-00	Dell-Stilwell 1 (623749)	Columbia Natural Resources Inc.	HECTORN	SCHUYLER	7650	42.4733	-76.705

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31-097-22794-01-00	22794-01	Dell-Stilwell 1 (623749-A)	Columbia Natural Resources Inc.	HECTORN	SCHUYLER		42.4733	-76.705
31-123-22795-00-00	22795-00	Martin-Repacki 1	Columbia Natural Resources Inc.	BARRI GTONN	YATES	7333	42.5345	-77.0469
31-123-22795-01-00	22795-01	Martin-Repacki 1 A	Columbia Natural Resources Inc.	BARRI GTONN	YATES		42.5345	-77.0469
31-123-22796-00-00	22796-00	Zimmerman 623825	Columbia Natural Resources Inc.	BARRI GTONN	YATES	7482	42.548	-77.0401
31-123-22796-01-00	22796-01	Zimmerman 623825-A	Columbia Natural Resources Inc.	BARRI GTONN	YATES	7624	42.548	-77.0401
31-123-22797-00-00	22797-00	Bedient 1 (623788)	Columbia Natural Resources Inc.	JERU ALEMS	YATES	6887	42.5834	-77.1663
31-023-22798-00-00	22798-00	Underwood 1 (623835)	Columbia Natural Resources Inc.	SOLON	CORTLAND	7250	42.6073	-76.0419
31-023-22798-01-00	22798-01	Underwood 1 (623835-A)	Columbia Natural Resources Inc.	SOLON	CORTLAND	7076	42.6073	-76.0419
31-097-22799-00-00	22799-00	Rumsey 1 (623838)	Columbia Natural Resources Inc.	TYRO EN	SCHUYLER	8037	42.4451	-77.0585
31-097-22799-01-00	22799-01	Rumsey 1 (623838-A)	Columbia Natural Resources Inc.	TYRO EN	SCHUYLER	7926	42.4446	-77.0592
31-023-22805-00-00	22805-00	Bilodeau 1 (623836)	Columbia Natural Resources Inc.	CORTLA DVILLEN	CORTLAND	7263	42.5828	-76.109
31-023-22805-01-00	22805-01	Bilodeau 1 (623836-A)	Columbia Natural Resources Inc.	CORTLA DVILLEN	CORTLAND		42.5828	-76.109
31-067-22809-00-00	22809-00	Bartoszewski 1-14	RSE Partners-I L.P.	LYSA DERN	ONONDAGA	3096	43.1651	-76.467
31-101-22814-00-00	22814-00	Howe 1300	Pennsylvania General Energy	HOR BYN	STEUBEN	10355	42.2048	-77.0545
31-101-22814-01-00	22814-01	Howe 1300-A	Pennsylvania General Energy	HOR BYN	STEUBEN	10125	42.2048	-77.0545
31-011-22822-00-00	22822-00	Ziemba 1	Peninsular Oil & Gas Co.	CATON	CAYUGA	3588	43.0944	-76.5083
31-101-22825-00-00	22825-00	Rice 1301	Pennsylvania General Energy	HOR BYN	STEUBEN	9818	42.2126	-77.0357
31-015-22826-00-00	22826-00	Broz Unit 1	Fortuna Energy Inc.	VETERAN	CHEMUNG	9362	42.2727	-76.7741
31-015-22827-00-00	22827-00	Bennett Family 1	Fortuna Energy Inc.	VETERAN	CHEMUNG	9455	42.2841	-76.775
31-123-22828-00-00	22828-00	Martin 623864	Columbia Natural Resources Inc.	BE TONN	YATES	6652	42.6723	-77.1046
31-097-22829-00-00	22829-00	Grand Prix 624065	Columbia Natural Resources Inc.	ORA GEN	SCHUYLER	9497	42.3236	-77.0605
31-097-22830-00-00	22830-00	Grand Prix 624066	Columbia Natural Resources Inc.	ORA GEN	SCHUYLER	9745	42.306	-77.0808
31-015-22831-00-00	22831-00	Lovell 1323	Pennsylvania General Energy	BIG FLATS	CHEMUNG	9824	42.1867	-76.9585

UWI (APINum)	Well Label	Well Name	Operator	Township	County	TD	Surf Lat	Surf Lon
31-015-22838-00-00	22838-00	Monahan 624115	Columbia Natural Resources Inc.	ERIN	CHEMUNG	10380	42.1753	-76.6516
31-015-22839-00-00	22839-00	Whiteman 1	Fortuna Energy Inc.	CATLIN	CHEMUNG	9511	42.2852	-76.9165
31-123-22840-00-00	22840-00	Dick 623970	Columbia Natural Resources Inc.	JERU ALEMS	YATES	6695	42.5979	-77.168
31-097-22841-00-00	22841-00	SRA 2 #1	Fortuna Energy Inc.	ORA GEN	SCHUYLER	8770	42.3403	-77.0207
31-101-22844-00-00	22844-00	Doyle 624125	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	7335	42.4959	-77.1758
31-101-22844-01-00	22844-01	Doyle 624125-A	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	7195	42.4959	-77.1758
31-101-22844-02-00	22844-02	Doyle 624125-B	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	7117	42.4959	-77.1758
31-101-22845-00-00	22845-00	Medrek 624126	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	7335	42.5089	-77.173
31-101-22845-01-00	22845-01	Medrek 624126-A	Columbia Natural Resources Inc.	PULTE EYN	STEUBEN	7365	42.5089	-77.173
31-123-22850-00-00	22850-00	Watson 1	Belden & Blake Corporation	ITALYN	YATES	7136	42.6179	-77.317
31-101-22852-00-00	22852-00	Van Vleet 1355	Pennsylvania General Energy	HOR BYN	STEUBEN	10458	42.2012	-77.0867
31-015-22853-00-00	22853-00	Rhodes 1322	Pennsylvania General Energy	BIG FLATS	CHEMUNG	9682	42.1953	-76.9212
31-015-22857-00-00	22857-00	Kimball 1	Fortuna Energy Inc.	VETERAN	CHEMUNG	9166	42.2727	-76.7917
31-123-22858-00-00	22858-00	Mulligan 1	Belden & Blake Corporation	ITALYN	YATES	6254	42.639	-77.2774
31-123-22858-01-00	22858-01	Mulligan 1-A	Belden & Blake Corporation	ITALYN	YATES	5812	42.6378	-77.2775
31-101-22859-00-00	22859-00	Huber 1	Belden & Blake Corporation	WAYLA DN	STEUBEN	7526	42.5356	-77.5922
31-101-22861-00-00	22861-00	NYS GMA 2	Fairman Drilling Co.	ERWIN	STEUBEN	10526	42.1575	-77.1649
31-101-22861-01-00	22861-01	NYS GMA 2-A	Fairman Drilling Co.	ERWIN	STEUBEN		42.1575	-77.1649
31-015-22862-00-00	22862-00	Lant 1	Fortuna Energy Inc.	VETERAN	CHEMUNG	9361	42.2682	-76.8135
31-101-22871-00-00	22871-00	Henkel 1359	Pennsylvania General Energy	COR INGN	STEUBEN	0	42.1671	-76.9727
31-015-22880-00-00	22880-00	Kienzle 1	Fortuna Energy Inc.	VETERAN	CHEMUNG	9121	42.2789	-76.8142
31-015-22880-01-00	22880-01	Kienzle 1-A	Fortuna Energy Inc.	VETERAN	CHEMUNG	9041	42.2789	-76.8142
31-097-22881-00-00	22881-00	Learn 1	Fortuna Energy Inc.	MO TOURN	SCHUYLER	9060	42.3082	-76.8161
31-101-22884-00-00	22884-00	Fratarcangelo 1371	Pennsylvania General Energy	HOR BYN	STEUBEN	9830	42.2345	-76.977
31-101-22884-01-00	22884-01	Fratarcangelo 1371-A	Pennsylvania General Energy	HOR BYN	STEUBEN	9818	42.2345	-76.977

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31-101-22885-00-00	22885-00	Corning Game Club 624460	Pennsylvania General Energy	COR INGN	STEUBEN	10183	42.1799	-77.0665
31-097-22886-00-00	22886-00	Ganung 1	Fortuna Energy Inc.	DIXN	SCHUYLER	9362	42.3091	-76.8961
31-097-22886-01-00	22886-01	Ganung 1-A	Fortuna Energy Inc.	DIXN	SCHUYLER	8902	42.3091	-76.8961
31-097-22886-02-00	22886-02	Ganung 1-B	Fortuna Energy Inc.	DIXN	SCHUYLER	8964	42.3091	-76.8961
31-015-22889-00-00	22889-00	Clauss Jr 1	Fortuna Energy Inc.	VETERAN	CHEMUNG	9513	42.2831	-76.7941
31-015-22889-01-00	22889-01	Clauss Jr 1-A	Fortuna Energy Inc.	VETERAN	CHEMUNG	9115	42.2831	-76.7941
31-015-22890-00-00	22890-00	Peterson 1	Fortuna Energy Inc.	CATLIN	CHEMUNG	9576	42.2864	-76.8923
31-015-22891-00-00	22891-00	Parker 1401	Pennsylvania General Energy	CATLIN	CHEMUNG	10323	42.2379	-76.9389
31-101-22892-00-00	22892-00	Hartman 624546	Pennsylvania General Energy	COR INGN	STEUBEN	10280	42.1775	-77.0002
31-101-22892-01-00	22892-01	Hartman 624546-A	Pennsylvania General Energy	COR INGN	STEUBEN	10214	42.1775	-77.0002
31-097-22893-00-00	22893-00	Purvis 1	Fortuna Energy Inc.	DIXN	SCHUYLER	9162	42.2951	-76.8601
31-015-22899-00-00	22899-00	Trimber 624536	Columbia Natural Resources Inc.	ERIN	CHEMUNG	10530	42.1603	-76.6871
31-015-22899-01-00	22899-01	Trimber 624536-A	Columbia Natural Resources Inc.	ERIN	CHEMUNG	10364	42.1603	-76.6871
31-015-22901-00-00	22901-00	Roy 1	Fortuna Energy Inc.	CATLIN	CHEMUNG	9487	42.2713	-76.957
31-015-22902-00-00	22902-00	Lederer 1412	Pennsylvania General Energy	CATLIN	CHEMUNG	9602	42.2525	-76.8694
31-015-22902-01-00	22902-01	Lederer 1412-A	Pennsylvania General Energy	CATLIN	CHEMUNG		42.2525	-76.8694
31-123-22903-00-00	22903-00	Zimmerman 624466	Columbia Natural Resources Inc.	POTTERN	YATES	5812	42.705	-77.1335
31-123-22903-01-00	22903-01	Zimmerman 624466-A	Columbia Natural Resources Inc.	POTTERN	YATES	5831	42.705	-77.1335
31-101-22908-00-00	22908-00	Hemly 1445	Pennsylvania General Energy	HOR BYN	STEUBEN	9652	42.2541	-77.0967
31-099-22909-00-00	22909-00	Campion 1	EOG Resources Inc	LODIN	SENECA	7973	42.5529	-76.8194
31-099-22909-01-00	22909-01	Campion 1-A	Eastern American Energy Corp.	LODIN	SENECA	7602	42.5529	-76.8194
31-015-22910-00-00	22910-00	Gublo 1	Fortuna Energy Inc.	CATLIN	CHEMUNG	9322	42.2785	-76.8587
31-015-22911-00-00	22911-00	Schmidt 624537	Columbia Natural Resources Inc.	ERIN	CHEMUNG	10561	42.1467	-76.6931
31-015-22918-00-00	22918-00	Gregory 1446	Pennsylvania General Energy	CATLIN	CHEMUNG	9404	42.2072	-76.8847
31-015-22918-01-00	22918-01	Gregory 1446-A	Pennsylvania General Energy	CATLIN	CHEMUNG	7602	42.2072	-76.8847
31-015-22919-00-00	22919-00	Hardy 1447	Pennsylvania General Energy	CATLIN	CHEMUNG	10039	42.2374	-76.9205

UWI (APINum)	Well Label	Well Name	Operator	Township	County	TD	Surf Lat	Surf Lon
31-015-22919-01-00	22919-01	Hardy 1447-A	Pennsylvania General Energy	CATLIN	CHEMUNG	10398	42.2374	-76.9205
31-015-22924-00-00	22924-00	Johnson 1	Fairman Drilling Co.	VETERAN	CHEMUNG	9965	42.2689	-76.7512
31-015-22924-01-00	22924-01	Johnson 1-A	Fairman Drilling Co.	VETERAN	CHEMUNG	9495	42.2689	-76.7512
31-015-22933-00-00	22933-00	Usack 624684	Columbia Natural Resources Inc.	ERIN	CHEMUNG	10555	42.1586	-76.6625
31-107-22934-00-00	22934-00	Manwaring 624470	Columbia Natural Resources Inc.	TIOGAN	TIOGA	11651	42.0578	-76.4101
31-107-22934-01-00	22934-01	Manwaring 624470-A	Columbia Natural Resources Inc.	TIOGAN	TIOGA	11535	42.0578	-76.4101
31-097-22935-00-00	22935-00	Wonderview Farms 1	Fortuna Energy Inc.	CATHARI EN	SCHUYLER	8880	42.3303	-76.7472
31-097-22935-01-00	22935-01	Wonderview Farms 1-A	Fortuna Energy Inc.	CATHARI EN	SCHUYLER		42.3303	-76.7472
31-123-22939-00-00	22939-00	Button 624469	Columbia Natural Resources Inc.	MIDDLE EXS	YATES	5581	42.7464	-77.623
31-123-22939-01-00	22939-01	Button 624469-A	Columbia Natural Resources Inc.	MIDDLE EXS	YATES	5520	42.7464	-77.2875
31-123-22939-02-00	22939-02	Button 624469-B	Columbia Natural Resources Inc.	MIDDLE EXS	YATES	5550	42.7464	-77.2875
31-123-22940-00-00	22940-00	Folts 624464	Columbia Natural Resources Inc.	JERU ALEMS	YATES	6470	42.6275	-77.1116
31-123-22941-00-00	22941-00	Boudinot 623968	Columbia Natural Resources Inc.	TARKEYS	YATES	7181	42.5238	-76.957
31-097-22942-00-00	22942-00	Bonham 1	Fortuna Energy Inc.	ORA GEN	SCHUYLER	10098	42.2959	-76.9894
31-069-22943-00-00	22943-00	Stoddard 624633	Columbia Natural Resources Inc.	HOPEWELLN	ONTARIO	4965	42.8888	-77.1917
31-101-22949-00-00	22949-00	Gray 624468	Columbia Natural Resources Inc.	PRATT BURGS	STEUBEN	0	42.4971	-77.3168
31-099-22950-00-00	22950-00	Ziefle 1	Eastern American Energy Corp.	COVERTN	SENECA	7489	42.5641	-76.7023
31-099-22950-01-00	22950-01	Ziefle 1-A	Eastern American Energy Corp.	COVERTN	SENECA		42.5641	-76.7023
31-015-22960-00-00	22960-00	Chemung SRA 1 Parcel A 1459	Pennsylvania General Energy	CATLIN	CHEMUNG		42.2445	-76.9068
31-101-22963-01-00	22963-01	Maxwell 1-A	East Resources Inc.	CATON	STEUBEN	11502	42.0503	-77.0369
31-067-22965-00-00	22965-00	Leubner 1	Triana Energy Inc.	MARCELLUS	ONONDAGA	5300	42.8994	-76.3421
31-067-22965-01-00	22965-01	Leubner 1--A	Columbia Natural Resources LLC	O ONDAGAN	ONONDAGA	5200	42.8994	-76.3421
31-067-22971-00-00	22971-00	Short 1	Triana Energy Inc.	MARCELLUS	ONONDAGA	5139	42.9203	-76.3473
31-067-22971-01-00	22971-01	Short 1-A	Triana Energy Inc.	MARCELLUS	ONONDAGA	5412	42.9203	-76.3473
31-015-22975-00-00	22975-00	Root 1514	Pennsylvania General Energy	CATLIN	CHEMUNG		42.2385	-76.8903

UWI (APINum)	Well Label	Well Name	Operator	Township	County	TD	Surf Lat	Surf Lon
31-101-22976-00-00	22976-00	Youmans 1511	Pennsylvania General Energy	HOR BYN	STEUBEN		42.2613	-76.9964
31-101-22978-00-00	22978-00	Ballymoney 1	Fortuna (U.S.) Inc.	WEST U IONN	STEUBEN	10660	42.0321	-77.6776
31-015-22979-00-00	22979-00	Strope 1516	Pennsylvania General Energy	ERIN	CHEMUNG	9787	42.1986	-76.7242
31-007-22984-00-00	22984-00	Merrill 1	Belden & Blake Corporation	COLE VILLES	BROOME	9800	42.1781	-75.6707
31-007-22984-01-00	22984-01	Merrill 1A	Belden & Blake		Broome		42.1781	-75.6707
31-069-22985-00-00	22985-00	Bay 1	Belden & Blake Corporation	GORHAMN	ONTARIO	5796	42.7908	-77.2136
31-069-22985-01-00	22985-01	Bay 1-A	Belden & Blake Corporation	GORHAMN	ONTARIO	12764	42.7908	-77.2136
31-069-22985-02-00	22985-02	Bay 1B	Belden & Blake Corp.		Ontario	5480	42.7908	-77.2136
31-007-22995-00-00	22995-00	Beagell 2	Belden & Blake Corporation	KIRKWOODN	BROOME	11632	42.1372	-75.8339
31-007-22995-01-00	22995-01	Beagell 2-A	Belden & Blake Corporation	KIRKWOODN	BROOME		42.1372	-75.8339
31-109-22997-00-00	22997-00	Albanese 1	Phillips Production Co.	EWFIELDN	TOMPKINS	8940	42.3272	-76.5504
31-109-22997-01-00	22997-01	Albanese 1A			Tompkins		42.3272	-76.5504
31-109-22998-00-00	22998-00	Stevenson 1	Phillips Production Co.	E FIELDN	TOMPKINS	11965	42.4245	-76.6387
31-109-22998-01-00	22998-01	Stevenson 1-A	Phillips Production Co.	E FIELDN	TOMPKINS	12900	42.4245	-76.6387
31-051-23003-00-00	23003-00	Simpson 3	Lenape Resources Inc.	YORKN	LIVINGSTON	10600	42.8861	-77.8818
31-117-23015-00-00	23015-00	High 1	Lenape Resources Corp., The	ButlerN	Wayne	3960	43.1563	-76.7676
31-007-23032-00-00	23032-00	Pond 1	Phillips Production Co.		BROOME	8990	42.2437	-76.0445
31-117-23037-00-00	23037-00	Harper 1	Triana Energy, Inc.	GalenN		0	43.0871	-76.836
31-101-23039-00-00	23039-00	Miller 1	Triana Energy, Inc.				42.383	-77.5452
31-097-23053-00-00	23053-00	WGI 1	EOG Resources, Inc.				42.3353	-76.9472
31-097-23053-01-00	23053-01	WGI 1-A	EOG Resources Inc.		SCHUYLER	9797	42.3353	-76.9472
31-101-23054-00-00	23054-00	Hakes 1	Fortuna Energy Inc.				42.1785	-77.0172
31-007-23056-00-00	23056-00	Butkowsky #1	Belden & Blake Corp		BROOME		42.1427	-75.8253
31-007-23056-01-00	23056-01				BROOME		42.1427	-75.8253
31-101-23059-00-00	23059-00	Apenowich 1	Fortuna Energy Inc.		Steubrn	12620	42.1977	-77.1237
31-075-23070-00-00	23070-00	Loomis #1	Seneca Resources Corp.		Oswego		43.3648	-76.274
31-075-23071-00-00	23071-00	Huntley #1	Seneca Resources Corp.				43.2939	-76.2981
31-101-23085-00-00	23085-00	Erwin WMA 1		ErwinN	STEUBEN	0	42.1643	-77.1499
31-097-23086-00-00	23086-00					8841	42.3034	-77.045
31-065-23090-00-00	23090-00	Wagner 1		VernonN	ONEIDA	2660	43.0362	-75.538
31-053-23091-00-00	23091-00	Green 1	Ardent Reources Inc	StockbridgeN	MADISON	0	43.0282	-75.6428
31-015-23134-00-00	23134-00	Soderblom 1		Big FlatsN	CHEMUNG	0	42.1927	-76.8829
31-013-23247-00-00	23247-00	Hayner #2	Belden & Blake Corporation	WE TFIELDS	CHAUTAUQUA	5953	42.2736	-79.6413

UWI (APINum)	Well Label	Well Name	Operator	Township	County	TD	Surf Lat	Surf Lon
31-121-23389-00-00	23389-00	Krolick #2	Stedman Energy Inc.	ARCADEN	WYOMING	6200	42.5647	-78.4442
31-009-23435-00-00	23435-00	Geiger Hollow #1	Vertical Resources Inc.	ALLEGA YN	CATTARAUGUS	9346	42.0284	-78.5116
31-121-23449-00-00	23449-00	Jachim #3	Stedman Energy Inc.	ARCADEN	WYOMING	6590	42.5568	-78.3501
31-009-23456-00-00	23456-00	Braymiller-Rauch #1454	Pennsylvania General Energy	YORK HIRES	CATTARAUGUS	6500	42.4975	-78.523
31-009-23456-01-00	23456-01	Braymiller-Rauch #1454a	Pennsylvania General Energy	YORK HIRES	CATTARAUGUS	9185	42.4975	-78.523
31-029-23533-00-00	23533-00	Bockhahn Wm Unit 1	Ardent Resources, Inc.		Erie	5945	42.5978	-78.5978
31-011-90001-00-00	90001-00	Auburn Geothermal	Auburn Enlarged Central School District	AUBUR CITYN	CAYUGA	5260	42.9447	-76.5447

Date	Chlorides (mg/L)	Time (military)	Annular Pressure	Injection Pressure	pH	SG	Brine Temp.	Meter Reading Barrels	BPM	GPM	Name of Recorder
		1330	320	1235				539315	4.8	201.6	T Rice
		1430	240	1235				539606	4.8	201.6	T Rice
		1530	230	1235				539893	4.7	197.4	T Rice
		1600	off for repairs					540018			T Rice
		1630	1710	Restart							S Stahl
		1730	180	1235				540109	5.0	210.0	S Stahl
		1830	250	1240				540408	5.0	210.0	S Stahl
		1930	280	1240				540704	4.9	205.8	S Stahl
		2030	280	1240				541000	4.9	205.8	S Stahl
		2130	290	1240				541296	4.9	205.8	S Stahl
		2230	290	1240				541591	4.9	205.8	S Stahl
		2330	300	1240				541887	4.9	205.8	S Stahl

Appendix C - Table 2 - Treton-Black River Formaton Tops

API #	Well Label	LORRAINE	UTICA	TRENTON	BLACK RIVER	BLACK RIVER BOTTOM
31-121-00271-00-00	**00271-00**			5265		
31-015-00443-00-00	**00443-00**	8123	8668	8899	9342	9810
31-011-00478-00-00	**00478-00**		4897	5054	5635	6045
31-109-00481-00-00	**00481-00**	5395	5700	6116		
31-121-00615-00-00	**00615-00**	4524	5080	5340	5860	6195
31-037-00650-00-00	**00650-00**			3702		
31-037-00651-00-00	**00651-00**			2750		
31-055-00671-00-00	**00671-00**			600		
31-055-00672-00-00	**00672-00**	1409	1850	2006		
31-065-00680-00-00	**00680-00**			956		
31-065-00681-00-00	**00681-00**			885		
31-065-00682-00-00	**00682-00**			928		
31-065-00683-00-00	**00683-00**			896		
31-065-00684-00-00	**00684-00**			901		
31-065-00685-00-00	**00685-00**			965		
31-065-00686-00-00	**00686-00**			987		
31-065-00687-00-00	**00687-00**			994		
31-065-00689-00-00	**00689-00**			1021		
31-065-00691-00-00	**00691-00**			935		
31-065-00692-00-00	**00692-00**			846		
31-065-00693-00-00	**00693-00**			980		
31-065-00694-00-00	**00694-00**			942		
31-065-00695-00-00	**00695-00**		63	562		
31-065-00696-00-00	**00696-00**			570		
31-065-00697-00-00	**00697-00**			800		
31-065-00698-00-00	**00698-00**			1507	1976	
31-065-00700-00-00	**00700-00**			612		
31-065-00701-00-00	**00701-00**	20	150	430		
31-065-00704-00-00	**00704-00**		21	548		
31-065-00707-00-00	**00707-00**		505	635	1080	
31-065-00709-00-00	**00709-00**		116	630		
31-073-00711-00-00	**00711-00**			1972	2713	

API #	Well Label	LORRAINE	UTICA	TRENTON	BLACK RIVER	BLACK RIVER BOTTOM
31-075-00712-00-00	**00712-00**	382	912	1025		
31-075-00713-00-00	**00713-00**		1429	1624		
31-075-00714-00-00	**00714-00**			1150		
31-075-00715-00-00	**00715-00**			1445		
31-075-00720-00-00	**00720-00**			1027		
31-075-00725-00-00	**00725-00**			1370		
31-075-00726-00-00	**00726-00**	585	1280	1370		
31-075-00727-00-00	**00727-00**			1645		
31-075-00728-00-00	**00728-00**			1197		
31-067-00804-00-00	**00804-00**	1765	1878	2270		
31-067-00805-00-00	**00805-00**			2240		
31-067-00807-00-00	**00807-00**			2255		
31-067-00808-00-00	**00808-00**	3000	3200	3730		
31-067-00809-00-00	**00809-00**			2404		
31-067-00810-00-00	**00810-00**			2248		
31-049-00824-00-00	**00824-00**			690		
31-049-00825-00-00	**00825-00**			614		
31-049-00826-00-00	**00826-00**			602		
31-049-00828-00-00	**00828-00**			726	1324	
31-029-00837-00-00	**00837-00**			3750		
31-029-00839-00-00	**00839-00**			2665		
31-029-00840-00-00	**00840-00**			2600		
31-045-00844-00-00	**00844-00**			6		
31-065-00883-00-00	**00883-00**			515		
31-067-00884-00-00	**00884-00**			2700		
31-067-00885-00-00	**00885-00**	1960		2696	3370	
31-067-00886-00-00	**00886-00**			3350		
31-067-00887-00-00	**00887-00**		2160	2618		
31-067-00888-00-00	**00888-00**			2250		
31-073-00911-00-00	**00911-00**			1825		
31-075-00912-00-00	**00912-00**			1535		
31-075-00913-00-00	**00913-00**			1700		
31-075-00914-00-00	**00914-00**			1040		
31-099-00920-00-00	**00920-00**			3030		

API #	Well Label	LORRAINE	UTICA	TRENTON	BLACK RIVER	BLACK RIVER BOTTOM
31-029-00988-00-00	**00988-00**			3160		
31-029-00989-00-00	**00989-00**	2225		2855		
31-011-01003-00-00	**01003-00**			2492	3220	3590
31-043-01005-00-00	**01005-00**		195	475	580	
31-075-01008-00-00	**01008-00**			1316	1976	
31-117-01009-00-00	**01009-00**		1950	2700		
31-067-01010-00-00	**01010-00**			2700		
31-073-01013-00-00	**01013-00**			1420		
31-013-01017-00-00	**01017-00**			4010		
31-029-01018-00-00	**01018-00**			2525		
31-029-01019-00-00	**01019-00**		3150	3835		
31-029-01020-00-00	**01020-00**			2960		
31-065-01027-00-00	**01027-00**		350	625	1025	
31-065-01028-00-00	**01028-00**	510		1165		
31-065-01029-00-00	**01029-00**			1400		
31-065-01033-00-00	**01033-00**			320		
31-045-01034-00-00	**01034-00**			275		
31-073-01047-00-00	**01047-00**			1814		
31-001-01071-00-00	**01071-00**			2880		
31-013-01157-00-00	**01157-00**	2225		2855		
31-017-01160-00-00	**01160-00**	3132	4100	4295	4500	4555
31-049-01168-00-00	**01168-00**			1082		
31-049-01169-00-00	**01169-00**			645		
31-049-01170-00-00	**01170-00**			660		
31-053-01173-00-00	**01173-00**	2510	2881	3093	3306	
31-065-01176-00-00	**01176-00**			975		
31-065-01179-00-00	**01179-00**			1164		
31-065-01180-00-00	**01180-00**			945		
31-065-01181-00-00	**01181-00**			525		
31-065-01182-00-00	**01182-00**			500		
31-065-01183-00-00	**01183-00**			464		
31-065-01184-00-00	**01184-00**		150	468		
31-065-01185-00-00	**01185-00**			728		
31-065-01186-00-00	**01186-00**			439		

API #	Well Label	LORRAINE	UTICA	TRENTON	BLACK RIVER	BLACK RIVER BOTTOM
31-065-01188-00-00	**01188-00**			430		
31-065-01190-00-00	**01190-00**			1383		
31-011-01301-00-00	**01301-00**			3300		
31-013-01464-00-00	**01464-00**			3714	4150	
31-029-01690-00-00	**01690-00**			3100		
31-013-01808-00-00	**01808-00**			3714	4144	
31-117-01870-00-00	**01870-00**			2590		
31-117-01871-00-00	**01871-00**			2540		
31-117-01872-00-00	**01872-00**			2582		
31-117-01873-00-00	**01873-00**			2579		
31-117-01874-00-00	**01874-00**			2590		
31-067-01876-00-00	**01876-00**			2205		
31-067-01877-00-00	**01877-00**			2250		
31-117-02287-00-00	**02287-00**			2600		
31-045-02289-00-00	**02289-00**			14		
31-067-02366-00-00	**02366-00**			2618		
31-067-02403-00-00	**02403-00**	1340		2040		
31-067-02404-00-00	**02404-00**	1404	1840	2097		
31-075-02426-00-00	**02426-00**			1819		
31-075-02432-00-00	**02432-00**			1197		
31-075-02433-00-00	**02433-00**			450		1170
31-075-02446-00-00	**02446-00**			600		
31-075-02448-00-00	**02448-00**			400		
31-075-02449-00-00	**02449-00**			385		
31-075-02456-00-00	**02456-00**			650		
31-075-02457-00-00	**02457-00**			600		
31-075-02459-00-00	**02459-00**			380		
31-075-02460-00-00	**02460-00**			600		
31-075-02461-00-00	**02461-00**			410		
31-075-02463-00-00	**02463-00**			520		
31-075-02489-00-00	**02489-00**	250	418	556	1142	
31-075-02494-00-00	**02494-00**			600		
31-075-02495-00-00	**02495-00**			500		
31-075-02496-00-00	**02496-00**			540		

API #	Well Label	LORRAINE	UTICA	TRENTON	BLACK RIVER	BLACK RIVER BOTTOM
31-075-02497-00-00	**02497-00**			555		
31-075-02498-00-00	**02498-00**			566		
31-075-02499-00-00	**02499-00**			620		
31-075-02500-00-00	**02500-00**			560		
31-075-02501-00-00	**02501-00**			515		
31-075-02502-00-00	**02502-00**			500		
31-075-02503-00-00	**02503-00**			560		
31-075-02504-00-00	**02504-00**			484		
31-075-02505-00-00	**02505-00**			565		
31-075-02506-00-00	**02506-00**			525		
31-075-02507-00-00	**02507-00**			568		
31-075-02508-00-00	**02508-00**			567		
31-075-02509-00-00	**02509-00**			580		
31-075-02510-00-00	**02510-00**			587		
31-075-02511-00-00	**02511-00**			585		
31-075-02512-00-00	**02512-00**			560		
31-075-02513-00-00	**02513-00**			578		
31-075-02514-00-00	**02514-00**			551		
31-075-02515-00-00	**02515-00**			550		
31-075-02516-00-00	**02516-00**			490		
31-075-02517-00-00	**02517-00**			525		
31-075-02518-00-00	**02518-00**			542		
31-075-02519-00-00	**02519-00**			540		
31-075-02520-00-00	**02520-00**			510		
31-075-02522-00-00	**02522-00**			555		
31-075-02523-00-00	**02523-00**			560		
31-075-02524-00-00	**02524-00**			555		
31-075-02525-00-00	**02525-00**			555		
31-075-02526-00-00	**02526-00**			575		
31-075-02527-00-00	**02527-00**			475		
31-075-02528-00-00	**02528-00**			482		
31-075-02529-00-00	**02529-00**			450		
31-075-02530-00-00	**02530-00**			440		
31-075-02531-00-00	**02531-00**			560		

API #	Well Label	LORRAINE	UTICA	TRENTON	BLACK RIVER	BLACK RIVER BOTTOM
31-075-02532-00-00	**02532-00**			538		
31-075-02533-00-00	**02533-00**			519		
31-075-02534-00-00	**02534-00**			582		
31-075-02535-00-00	**02535-00**			543		
31-075-02536-00-00	**02536-00**			600		
31-075-02537-00-00	**02537-00**			603		
31-075-02538-00-00	**02538-00**			610		
31-075-02539-00-00	**02539-00**			610		
31-075-02540-00-00	**02540-00**			606		
31-075-02541-00-00	**02541-00**			589		
31-075-02542-00-00	**02542-00**			606		
31-075-02543-00-00	**02543-00**			590		
31-075-02544-00-00	**02544-00**			609		
31-075-02545-00-00	**02545-00**			630		
31-075-02546-00-00	**02546-00**			575		
31-075-02547-00-00	**02547-00**			603		
31-075-02548-00-00	**02548-00**			637		
31-075-02549-00-00	**02549-00**			616		
31-075-02550-00-00	**02550-00**			625		
31-075-02554-00-00	**02554-00**			583		
31-075-02555-00-00	**02555-00**			583		
31-075-02556-00-00	**02556-00**			610		
31-075-02557-00-00	**02557-00**			592		
31-075-02558-00-00	**02558-00**			614		
31-075-02559-00-00	**02559-00**			600		
31-075-02560-00-00	**02560-00**			611		
31-075-02561-00-00	**02561-00**			605		
31-075-02562-00-00	**02562-00**			600		
31-075-02563-00-00	**02563-00**			630		
31-045-02671-00-00	**02671-00**			75		
31-029-02959-00-00	**02959-00**			2824		
31-013-03200-00-00	**03200-00**		5823	6145	6625	6945
31-065-03304-00-00	**03304-00**			199		
31-009-03868-00-00	**03868-00**	4006	4540	4850	5265	5621

API #	Well Label	LORRAINE	UTICA	TRENTON	BLACK RIVER	BLACK RIVER BOTTOM
31-055-03879-00-00	**03879-00**	1387		2410		
31-039-03904-00-00	**03904-00**			6029		
31-029-03917-00-00	**03917-00**			2420	2875	3160
31-101-03924-00-00	**03924-00**			9675	10315	10870
31-065-03928-00-00	**03928-00**	2525	3000	3228	3460	
31-009-03934-00-00	**03934-00**			4778	5220	5540
31-003-03956-00-00	**03956-00**	5312	5960	6110	6610	7103
31-053-03970-00-00	**03970-00**		4130	4455	4685	4847
31-109-03973-00-00	**03973-00**	6984	7697	7767	8223	
31-043-03993-00-00	**03993-00**			2525	3000	3105
31-109-04007-00-00	**04007-00**	7000	7715	7785	8245	8480
31-053-04032-00-00	**04032-00**	2675	3480	3775	4126	
31-043-04034-00-00	**04034-00**		986	1763	2079	2166
31-077-04055-00-00	**04055-00**	2518	3603	4264	4280	4305
31-051-04069-00-00	**04069-00**	2900	3350	3569	4188	
31-121-04092-00-00	**04092-00**	4505	4899	5305	5816	6260
31-109-04130-00-00	**04130-00**	6555	7100	7298	7750	8175
31-121-04133-00-00	**04133-00**			4258	4834	5252
31-049-04150-00-00	**04150-00**	425	690	1055	1550	
31-013-04154-00-00	**04154-00**	4555	5140	5430	5875	6184
31-029-04183-00-00	**04183-00**			2900		
31-075-04201-00-00	**04201-00**			460	1052	1320
31-099-04203-00-00	**04203-00**	2974	3360	3554	4372	4760
31-075-04208-00-00	**04208-00**	700	1075	1482	2008	2200
31-075-04209-00-00	**04209-00**	950	1278	1615	2238	2596
31-025-04214-00-00	**04214-00**	7250	7640	8230	8300	8300
31-003-04248-00-00	**04248-00**	5186	5648	5899	6450	6900
31-075-04357-00-00	**04357-00**	408	698	841	1426	1657
31-075-04358-00-00	**04358-00**			975	1372	
31-025-04364-00-00	**04364-00**			7316	7398	7463
31-025-04379-00-00	**04379-00**	5820		6770	6790	6863
31-121-04392-00-00	**04392-00**			4724	5238	5612
31-121-04436-00-00	**04436-00**	3615	3990	4330	4904	5325
31-013-04437-00-00	**04437-00**	5100	5944	5968	6370	6750

API #	Well Label	LORRAINE	UTICA	TRENTON	BLACK RIVER	BLACK RIVER BOTTOM
31-029-04440-00-00	**04440-00**	4078		5004	5450	5800
31-121-04447-00-00	**04447-00**	3620	4005	4355	4955	5370
31-025-04455-00-00	**04455-00**	5190		6054	6122	6197
31-013-04460-00-00	**04460-00**	3150	3580	3665	4082	4400
31-121-04464-00-00	**04464-00**	3145	3415	3875	4434	4850
31-109-04467-00-00	**04467-00**	6555	7140	7346	7820	
31-073-04476-00-00	**04476-00**	616	1169	1331	1846	2185
31-073-04489-00-00	**04489-00**	529	955	1232	1740	2042
31-055-04502-00-00	**04502-00**	515	884	1152	1780	2140
31-075-04520-00-00	**04520-00**	168	410	632	1248	1512
31-013-04535-00-00	**04535-00**	2878	3578	3714		
31-121-04536-00-00	**04536-00**	3480	3980	4200	4770	5166
31-077-04547-00-00	**04547-00**	3151	3700	4342	4385	
31-051-04552-00-00	**04552-00**	3162	3625	3855	4480	4880
31-013-04561-00-00	**04561-00**	4647	5277	5460	5860	6222
31-051-04567-00-00	**04567-00**	2548	3045	3200	3840	
31-037-04593-00-00	**04593-00**	1828	2216	2460	3050	3520
31-073-04611-00-00	**04611-00**	1323	1720	2007	2542	2880
31-011-04624-00-00	**04624-00**	1270	1670	1922	2594	2798
31-051-04630-00-00	**04630-00**	3820	4280	4480	5065	5530
31-029-04663-00-00	**04663-00**			3234		
31-023-04714-00-00	**04714-00**	5890	6724	6895	7157	7411
31-011-04715-00-00	**04715-00**	2665		3252	4023	4444
31-063-04719-00-00	**04719-00**			1253		
31-073-04722-00-00	**04722-00**	1305	1750	2012	2510	2847
31-055-04724-00-00	**04724-00**	1456	1920	2105	2692	3137
31-073-04730-00-00	**04730-00**	1500	1892	2166	2706	3060
31-073-04752-00-00	**04752-00**	674	1198	1383	1870	2177
31-073-04753-00-00	**04753-00**	496	860	1199	1692	1997
31-117-04754-00-00	**04754-00**			2500	3189	3585
31-069-04760-00-00	**04760-00**	2348	2700	2950	3526	4110
31-073-04764-00-00	**04764-00**	550	1180	1310	1824	2027
31-037-04806-00-00	**04806-00**	1495	1862	2155	2788	3188
31-069-04871-00-00	**04871-00**	2200		2812	3500	

API #	Well Label	LORRAINE	UTICA	TRENTON	BLACK RIVER	BLACK RIVER BOTTOM
31-073-04873-00-00	**04873-00**	455	868	1134	1691	1985
31-073-04912-00-00	**04912-00**	895	1290	1562	2186	2435
31-073-04994-00-00	**04994-00**	618	1118	1261	1830	2150
31-011-04999-00-00	**04999-00**	2466	2790	3110	3790	4120
31-011-05000-00-00	**05000-00**	1950	2278	2556	3247	3572
31-073-05007-00-00	**05007-00**	360	900	1216	1774	2080
31-073-05008-00-00	**05008-00**	1053	1444	1745	2250	2605
31-011-05011-00-00	**05011-00**	1852	2146	2328	3012	3336
31-075-05012-00-00	**05012-00**	970	1068	1430	2108	2452
31-011-05031-00-00	**05031-00**	1699	2057	2254	2926	3296
31-117-05032-00-00	**05032-00**	2080	2290	2746	3496	3905
31-117-05041-00-00	**05041-00**	1730	2194	2348	3057	3442
31-073-05069-00-00	**05069-00**	730	1102	1382	1946	2264
31-073-05086-00-00	**05086-00**	816	1230	1470	2050	2380
31-007-05087-00-00	**05087-00**	6618	7447	7537	7908	8165
31-073-05091-00-00	**05091-00**	720	1190	1388	1940	2260
31-099-05095-00-00	**05095-00**	2410	2608	2858	3618	3978
31-073-05096-00-00	**05096-00**	1410	1830	2120	2642	2965
31-117-05114-00-00	**05114-00**	1874	2200	2485	3204	3615
31-037-05115-00-00	**05115-00**	1742	2315	2460	2960	3324
31-117-05116-00-00	**05116-00**	1819	2245	2434	3166	3564
31-037-05117-00-00	**05117-00**	1935	2368	2713	3200	3555
31-029-05402-00-00	**05402-00**			2504		
31-011-05467-00-00	**05467-00**	2118	2430	2622	3292	
31-121-06073-00-00	**06073-00**	3795	4315	4540	5040	5525
31-069-06395-00-00	**06395-00**	3736	3988	4285	5040	
31-063-06667-00-00	**06667-00**	1506	1746	1844	2340	
31-029-06668-00-00	**06668-00**	2168	2552	2994	3442	3792
31-063-06669-00-00	**06669-00**	1618	1886	2105	2568	
31-117-06719-00-00	**06719-00**	2184	2430	2786	3535	3825
31-011-06779-00-00	**06779-00**	2004	2288	2558	3066	
31-011-06780-00-00	**06780-00**	1984	2332	2552	3034	
31-121-07234-00-00	**07234-00**	3118	3716	3888	3994	4880
31-121-07278-00-00	**07278-00**	3190	3674	3920	4423	4904

API #	Well Label	LORRAINE	UTICA	TRENTON	BLACK RIVER	BLACK RIVER BOTTOM
31-013-07649-00-00	**07649-00**	4689	4946	5134	5542	5892
31-009-08581-00-00	**08581-00**	4042	4630	4889	5300	5655
31-009-08610-00-00	**08610-00**	5020	5510	5818	6229	6620
31-009-09235-00-00	**09235-00**	7514		8422	8834	9326
31-013-09355-00-00	**09355-00**		3618	3835	4240	4605
31-037-09524-00-00	**09524-00**	2562	3087	3277	3732	
31-073-09540-00-00	**09540-00**	1194	1688	1852	2438	2815
31-037-09563-00-00	**09563-00**	1634	2126	2300	2914	3361
31-053-09578-00-00	**09578-00**	2992	3402	3776	4080	
31-013-09939-00-00	**09939-00**		3760	4100	4512	4832
31-025-10227-00-00	**10227-00**	5652	6389	6630	6644	6690
31-015-10335-00-00	**10335-00**	8588	9208	9330	9827	10227
31-037-10776-00-00	**10776-00**	2702	3174	3408	3962	4313
31-077-10834-00-00	**10834-00**	3298	4012	4330	4550	4610
31-099-10893-00-00	**10893-00**	2755	2915	3184	3976	4398
31-055-10921-00-00	**10921-00**	530	890	1161	1794	2155
31-121-10936-00-00	**10936-00**	3710	4220	4605	5190	
31-121-10939-00-00	**10939-00**	3530	3988	4342	4795	5202
31-029-11002-00-00	**11002-00**	4420	4890	5232	5680	6105
31-029-11114-00-00	**11114-00**	2988	3402	3816	4262	4606
31-011-11129-00-00	**11129-00**	2000	2238	2482	3022	
31-013-11387-00-00	**11387-00**	4510		5346	5747	6120
31-029-11730-00-00	**11730-00**	3592	4030	4354	4804	5206
31-067-12163-00-00	**12163-00**	3290	3660	3958		
31-121-12178-00-00	**12178-00**			4300	4840	
31-075-12398-00-00	**12398-00**	270		971	1581	1774
31-075-12399-00-00	**12399-00**	132	318	734	1372	1682
31-075-12406-00-00	**12406-00**		468	758	1386	1700
31-075-12447-00-00	**12447-00**		400	683	1300	1597
31-029-12745-00-00	**12745-00**			4722	5175	5472
31-029-12910-00-00	**12910-00**	4060	4590	4846	5280	5642
31-121-13278-00-00	**13278-00**	4698	5304	5578	6076	6458
31-037-13672-00-00	**13672-00**	2260	2680	2919	3312	
31-101-13699-00-00	**13699-00**	6500	6804	7091	7867	8429

API #	Well Label	LORRAINE	UTICA	TRENTON	BLACK RIVER	BLACK RIVER BOTTOM
31-051-13700-00-00	**13700-00**	3742	4228	4425	5022	5430
31-101-15438-00-00	**15438-00**	5838	6122	6444	7215	7690
31-053-15467-00-00	**15467-00**	3632	4340	4654		
31-067-15584-00-00	**15584-00**	1650	2045	2320	2975	3275
31-075-15613-00-00	**15613-00**		1306	1510	2030	2214
31-075-15628-00-00	**15628-00**			956	1492	1712
31-011-16120-00-00	**16120-00**	4705	4945	5310	5920	6455
31-075-16814-00-00	**16814-00**			625		
31-075-16818-00-00	**16818-00**			745		
31-011-17508-00-00	**17508-00**	1818	2250	2438	3126	3444
31-011-17509-00-00	**17509-00**			2414		
31-011-17510-00-00	**17510-00**	1792	2176	2400	3083	3402
31-011-17558-00-00	**17558-00**	2548	2918	3142	3828	4196
31-011-17559-00-00	**17559-00**	2612	3018	3202	3988	4424
31-053-19485-00-00	**19485-00**	3422	3792	4004	4250	
31-101-19497-00-00	**19497-00**	5822	6102	6424	7188	7690
31-023-19540-00-00	**19540-00**	5758	6410	6645	7023	7313
31-097-19692-00-00	**19692-00**	6532	6830	7162	7944	
31-121-19937-00-00	**19937-00**	4166	4756	4972	5412	
31-053-20411-00-00	**20411-00**	3608	4462	4629	4876	
31-097-20417-00-00	**20417-00**			7132	7916	8414
31-099-20446-00-00	**20446-00**	3947	4264	4535	5367	5865
31-037-20687-00-00	**20687-00**	1962	2302	2665	3186	3550
31-057-21033-00-00	**21033-00**			165	279	
31-067-21335-00-00	**21335-00**	2000	2365	2751	3420	
31-067-21336-00-00	**21336-00**	2000	2250	2680	3404	
31-101-21468-00-00	**21468-00**	6534	6876	7164	7819	8314
31-011-21469-00-00	**21469-00**	2865		3478	4175	
31-097-21495-00-00	**21495-00**	8080	8405	8847	9320	
31-101-21496-00-00	**21496-00**	6705	7208	7330	7986	8528
31-023-21500-00-00	**21500-00**	5100	6028	6179	6487	6670
31-101-21592-00-00	**21592-00**	5876	6197	6472	7245	
31-101-21601-00-00	**21601-00**	7127	7678	7987	8381	
31-101-21624-00-00	**21624-00**	6544	6892	7174	7820	8345

API #	Well Label	LORRAINE	UTICA	TRENTON	BLACK RIVER	BLACK RIVER BOTTOM
31-101-21633-00-00	**21633-00**	6563	6939	7279	8147	8946
31-101-21636-00-00	**21636-00**	6586	6985	7296	8109	8775
31-101-21688-00-00	**21688-00**	5858	6193	6453	7211	
31-101-21689-00-00	**21689-00**	5575	5978	6178	6948	7452
31-101-21689-01-00	**21689-01**	5588	5953	6191	6981	
31-101-21692-00-00	**21692-00**	5489	5797	6089	6882	
31-053-21699-00-00	**21699-00**	3400	4023	4247	4558	
31-101-21703-00-00	**21703-00**	5170	5518	5772	6570	
31-101-21704-00-00	**21704-00**	6088	6435	6695	7556	
31-101-21705-00-00	**21705-00**	5566	5887	6156	6945	
31-101-21706-00-00	**21706-00**	5688	6018	6292	6675	
31-101-21707-00-00	**21707-00**	5978	6578	6575	7342	
31-101-21707-02-00	**21707-02**	6003	6345	6574	7332	
31-101-21710-00-00	**21710-00**	5224	5616	5826	6634	
31-101-21712-00-00	**21712-00**	5880	6208	6484	7255	
31-101-21715-00-00	**21715-00**	6176	6740	6783	7525	
31-109-21716-00-00	**21716-00**	5798	6295	6622	6998	7342
31-101-21718-00-00	**21718-00**	8902	9775	9785	10422	
31-097-21725-00-00	**21725-00**	6056	6546	6828	7652	
31-097-21726-00-00	**21726-00**	6168	6596	6748	7565	
31-009-21809-00-00	**21809-00**	4875	5532	5712	6163	6523
31-121-21840-00-00	**21840-00**	3200	3740	4070	4640	5056
31-009-21860-00-00	**21860-00**	4258		5077	5540	5877
31-009-21869-00-00	**21869-00**	4522	5141	5366	5844	6194
31-121-21900-00-00	**21900-00**	3140	3505	3834	4410	
31-121-21907-00-00	**21907-00**	3330	3726	4189	4755	5182
31-121-21908-00-00	**21908-00**	3300	3780	4017	4586	5015
31-121-21909-00-00	**21909-00**	3400	3800	4120	4628	5115
31-121-21920-00-00	**21920-00**	3234	3608	3958	4518	4918
31-121-21945-00-00	**21945-00**	3534	3820	4000	4576	4990
31-121-21946-00-00	**21946-00**	3120	3760	3994	4568	4994
31-121-21962-00-00	**21962-00**	3100	3448	3818	4402	4816
31-121-21963-00-00	**21963-00**	3188	3589	3884	4458	4875
31-121-21964-00-00	**21964-00**	3390	3590	3856	4422	4838

API #	Well Label	LORRAINE	UTICA	TRENTON	BLACK RIVER	BLACK RIVER BOTTOM
31-121-22042-00-00	**22042-00**	3230	3642	3942	4512	4930
31-121-22046-00-00	**22046-00**		3606	3810	4378	4796
31-121-22053-00-00	**22053-00**	3380	3977	4158	4660	5150
31-013-22497-00-00	**22497-00**	4670	5362	5541	5948	
31-013-22498-00-00	**22498-00**	4945	5490	5818	6206	6600
31-121-22520-00-00	**22520-00**	4402	5030	5264	5690	6088
31-013-22531-00-00	**22531-00**	4768		5639	6054	6462
31-013-22588-00-00	**22588-00**	4797	5448	5668	6106	6379
31-013-22596-00-00	**22596-00**	3448	3998	4250	4668	4990
31-013-22616-00-00	**22616-00**		4348	4698	5116	5538
31-121-22655-00-00	**22655-00**	4220	4880	5115	5600	5932
31-101-22741-00-00	**22741-00**	5991	6310	6543	7371	
31-101-22741-01-00	**22741-01**	5987	6327	6540	7350	
31-123-22743-00-00	**22743-00**	5507	5972	6108	6943	
31-101-22745-00-00	**22745-00**	5927	6506	6496	7272	
31-123-22746-00-00	**22746-00**	5884	6388	6478	7358	
31-101-22747-00-00	**22747-00**	5968	6256	6524	7312	
31-101-22748-00-00	**22748-00**	5782	6139	6336	7126	
31-123-22750-00-00	**22750-00**	6004	6346	6603	7386	
31-123-22752-00-00	**22752-00**	5554	5844	6143	7082	
31-109-22753-00-00	**22753-00**	5772	6122	6410	7063	
31-097-22754-00-00	**22754-00**	6350	6769	7018	7624	
31-101-22755-00-00	**22755-00**	5292	5824	5894	6684	
31-101-22756-00-00	**22756-00**	6026	6408	6609	7396	
31-123-22757-00-00	**22757-00**	5215	5569	5830	6582	
31-123-22757-01-00	**22757-01**	5215	5569	5821	6605	
31-101-22758-00-00	**22758-00**	5636	6163	6263	6977	
31-101-22758-01-00	**22758-01**	5670	6040	6302	7022	
31-101-22759-00-00	**22759-00**	6218	6625	6816	7505	
31-101-22759-01-00	**22759-01**	6217	6615	6834	7506	
31-101-22759-02-00	**22759-02**	6228	6578	6893	7620	8100
31-101-22760-00-00	**22760-00**	6163	6597	6777	7445	
31-101-22760-01-00	**22760-01**	6165	6518	6778	7488	
31-099-22761-00-00	**22761-00**	3104	3478	3680	4518	4910

API #	Well Label	LORRAINE	UTICA	TRENTON	BLACK RIVER	BLACK RIVER BOTTOM
31-099-22762-00-00	**22762-00**	3000	3300	3578	4400	
31-099-22763-00-00	**22763-00**	3146	3520	3736	4588	5023
31-123-22764-00-00	**22764-00**	4600	4993	5238	5996	
31-123-22764-01-00	**22764-01**	4600	5050	5522	6005	
31-123-22764-02-00	**22764-02**	4600	5050	5221	5972	
31-101-22765-00-00	**22765-00**	5995	6388	6602	7387	
31-101-22765-01-00	**22765-01**	5989	6352	6603	7414	
31-101-22766-00-00	**22766-00**	5846	6216	6467	7205	
31-109-22767-00-00	**22767-00**	5604	6117	6296	6939	7328
31-101-22768-00-00	**22768-00**	5568	5872	6175	6946	
31-101-22769-00-00	**22769-00**	5860	6240	6464	7244	
31-101-22771-00-00	**22771-00**	8200	8625	8994	9638	
31-101-22772-00-00	**22772-00**	5326	5621	5930	6725	
31-123-22773-00-00	**22773-00**	5632	5941	6214	7132	
31-123-22773-01-00	**22773-01**	5632	5952	6217	7144	
31-123-22774-00-00	**22774-00**	5480	5780	6058	6980	
31-123-22775-00-00	**22775-00**	4454	4956	5044	5846	
31-123-22775-01-00	**22775-01**	4455	4787	5060	5930	
31-123-22776-00-00	**22776-00**	5196	5454	5754	6676	
31-109-22789-00-00	**22789-00**	5886	6445	6692	7121	7475
31-109-22789-01-00	**22789-01**	5745	6520	6352	6756	
31-123-22790-01-00	**22790-01**	4885	5245	5473	6640	
31-123-22791-00-00	**22791-00**	4938	5390	5580	6500	
31-123-22791-01-00	**22791-01**	5095	5403	5728	6704	
31-097-22793-00-00	**22793-00**	5792	6007	6376	7062	
31-097-22794-00-00	**22794-00**	5910	6336	6583	7189	
31-097-22794-01-00	**22794-01**	5925	6290	6615	7263	
31-123-22795-00-00	**22795-00**	5692	5958	6264	7143	
31-123-22795-01-00	**22795-01**	5675	5982	6270	7234	
31-123-22796-00-00	**22796-00**	5488	5806	6057	6950	
31-123-22796-01-00	**22796-01**	5490	5718	6115	7088	
31-123-22797-00-00	**22797-00**	4868	5215	5463	6260	
31-023-22798-00-00	**22798-00**	5490	6340	6455	6807	7118
31-023-22798-01-00	**22798-01**	5487	6223	6461	6822	

API #	Well Label	LORRAINE	UTICA	TRENTON	BLACK RIVER	BLACK RIVER BOTTOM
31-097-22799-00-00	**22799-00**	6006	6350	6602	7452	
31-097-22799-01-00	**22799-01**	6006	6399	6618	7510	
31-023-22805-00-00	**22805-00**	5590	6282	6524	6872	
31-023-22805-01-00	**22805-01**	5655	6300	6620	6985	7210
31-067-22809-00-00	**22809-00**	1650	2000	2300	2941	
31-101-22814-00-00	**22814-00**	8460	8877	9234	9880	
31-101-22814-01-00	**22814-01**	8465	8878	9274	9962	
31-011-22822-00-00	**22822-00**	1980	2318	2564	3242	3542
31-101-22825-00-00	**22825-00**	8226	8650	9044	9726	
31-015-22826-00-00	**22826-00**	7988	8501	8755	9308	
31-015-22827-00-00	**22827-00**	7702	8153	8445	8978	
31-123-22828-00-00	**22828-00**	4670	5015	5242	6035	
31-097-22829-00-00	**22829-00**			7906	8416	
31-097-22830-00-00	**22830-00**	7799	8309	8479	9178	
31-015-22831-00-00	**22831-00**	8400	8680	9155	9785	
31-015-22838-00-00	**22838-00**	8624	9228	9354	9910	10335
31-015-22839-00-00	**22839-00**	7777	8307	8699	9430	
31-123-22840-00-00	**22840-00**	4810	5098	5404	6208	
31-097-22841-00-00	**22841-00**	7257	7627	7902	8632	
31-101-22844-00-00	**22844-00**	5610	5811	6196	6985	
31-101-22844-01-00	**22844-01**	5828	5945	6194	6986	
31-101-22844-02-00	**22844-02**	5610	5894	6202	7002	
31-101-22845-00-00	**22845-00**	5453	5820	6056	6846	
31-101-22845-01-00	**22845-01**	5455	5890	6060	6890	
31-123-22850-00-00	**22850-00**	5600	6000	6202	6953	
31-101-22852-00-00	**22852-00**	8505	8890	9248	9926	10378
31-015-22853-00-00	**22853-00**	8302	8600	9048	9594	
31-015-22857-00-00	**22857-00**	7835	8240	8592	9114	
31-123-22858-00-00	**22858-00**	4510	4884	5114	5875	
31-123-22858-01-00	**22858-01**	4512	4886	5119	5886	
31-101-22859-00-00	**22859-00**	5394	5931	6039	6665	7144
31-101-22861-00-00	**22861-00**	8472	9078	9220	9916	
31-101-22861-01-00	**22861-01**	8482	8975	9220	9927	
31-015-22862-00-00	**22862-00**	7502	7881	8237	8767	9157

API #	Well Label	LORRAINE	UTICA	TRENTON	BLACK RIVER	BLACK RIVER BOTTOM
31-101-22871-00-00	**22871-00**	8500	8867	9237	9795	
31-015-22880-00-00	**22880-00**	7537	7997	8276	8822	
31-015-22880-01-00	**22880-01**		8038	8265	8790	
31-097-22881-00-00	**22881-00**	7271	7861	7989	8562	
31-101-22884-00-00	**22884-00**	8100	8658	8916	9656	
31-101-22884-01-00	**22884-01**	8078	8610	8906	9668	
31-101-22885-00-00	**22885-00**	8121	8429	8865	9496	
31-097-22886-00-00	**22886-00**	7231	7819	7970	8746	
31-097-22886-01-00	**22886-01**	7196	7686	7913	8579	
31-097-22886-02-00	**22886-02**	7243	7778	8237	8758	
31-015-22889-00-00	**22889-00**	7702	8168	8456	9002	9415
31-015-22889-01-00	**22889-01**	7700	8328	8439	8964	
31-015-22890-00-00	**22890-00**	7448	7776	8219	8875	9308
31-015-22891-00-00	**22891-00**	8462	8850	9206	9886	
31-101-22892-00-00	**22892-00**	8435	9008	9182	9870	
31-101-22892-01-00	**22892-01**	8450	8822	9198	9886	
31-097-22893-00-00	**22893-00**	7332	7763	8043	8616	
31-015-22899-00-00	**22899-00**	8769	9135	9497	9992	
31-015-22899-01-00	**22899-01**	8773	9381	9496	9989	
31-015-22901-00-00	**22901-00**	7612	7900	8359	9026	
31-015-22902-00-00	**22902-00**	7961	8288	8695	9266	
31-015-22902-01-00	**22902-01**	7968	8425	8709	9316	
31-123-22903-00-00	**22903-00**	4335	4720	4921	5700	
31-123-22903-01-00	**22903-01**	4335	4732	4930		
31-101-22908-00-00	**22908-00**	7866		8572	9412	
31-099-22909-00-00	**22909-00**	5772	6230	6391	7082	7502
31-099-22909-01-00	**22909-01**	5772	6115	6388	7267	
31-015-22910-00-00	**22910-00**	7870	8166	8587	9139	
31-015-22911-00-00	**22911-00**	8702	9318	9435	9940	
31-015-22918-00-00	**22918-00**	8076	8418	8788	9343	
31-015-22918-01-00	**22918-01**	8053	8420	8800	9389	
31-015-22919-00-00	**22919-00**	8395	8807	9172	9856	
31-015-22919-01-00	**22919-01**	8388	8870	9175	9950	
31-015-22924-00-00	**22924-00**	7802	8118	8594	9394	9863

API #	Well Label	LORRAINE	UTICA	TRENTON	BLACK RIVER	BLACK RIVER BOTTOM
31-015-22924-01-00	**22924-01**	7802	8438	8598	9306	
31-015-22933-00-00	**22933-00**	8695	9339	9477	10081	
31-107-22934-00-00	**22934-00**	9710	10471	10626	11098	11390
31-107-22934-01-00	**22934-01**		10150	10575	11034	11400
31-097-22935-00-00	**22935-00**	7105	7717	7818	8361	
31-097-22935-01-00	**22935-01**	7114	7509	7844	8400	
31-123-22939-00-00	**22939-00**	4008	4380	4577	5292	
31-123-22939-01-00	**22939-01**		4342	4577	5281	
31-123-22939-02-00	**22939-02**			4658	5400	
31-123-22940-00-00	**22940-00**	4830	5156	5418	6215	
31-123-22941-00-00	**22941-00**	5435	5891	6020	6837	
31-097-22942-00-00	**22942-00**	8194		8857	9580	
31-069-22943-00-00	**22943-00**	3045	3521	3727	4462	4895
31-101-22949-00-00	**22949-00**	6440	6830	7053	7800	
31-099-22950-00-00	**22950-00**	5650	6159	6291	7010	7382
31-099-22950-01-00	**22950-01**	5634	5963	6280	6999	7345
31-015-22960-00-00	**22960-00**	8145	8630	8887	9498	
31-101-22963-01-00	**22963-01**	9904	10517	10642	11158	11408
31-067-22965-00-00	**22965-00**	3439		4365	4924	
31-067-22965-01-00	**22965-01**	3668	4147	4365	4591	
31-067-22971-00-00	**22971-00**	3520	3995	4210	4772	
31-067-22971-01-00	**22971-01**	3533	3980	4285	4866	
31-015-22975-00-00	**22975-00**	7950	8623	8722	9339	
31-101-22976-00-00	**22976-00**	8508	8830	9240	9953	
31-101-22978-00-00	**22978-00**	9197	9943	10000	10470	
31-015-22979-00-00	**22979-00**	6570	8645	8887	9420	
31-007-22984-00-00	**22984-00**	7959	9178	9351	9583	9744
31-007-22984-01-00	**22984-01**	7959	9179	9489	9698	
31-069-22985-00-00	**22985-00**	3883	4300	4435	5192	5592
31-069-22985-01-00	**22985-01**		4235	4435	5221	
31-069-22985-02-00	**22985-02**	4019		4442	4893	
31-007-22995-00-00	**22995-00**	8529	9527	9694	9934	10126
31-007-22995-01-00	**22995-01**	8546		9668	9914	
31-109-22997-00-00	**22997-00**	7453	8144	8234	8728	

API #	Well Label	LORRAINE	UTICA	TRENTON	BLACK RIVER	BLACK RIVER BOTTOM
31-109-22997-01-00	**22997-01**		8026	8259	8754	
31-109-22998-00-00	**22998-00**	6474	6940	7210		
31-109-22998-01-00	**22998-01**	6498	7052	7216	7647	
31-051-23003-00-00	**23003-00**		3240	3439	4064	
31-117-23015-00-00	**23015-00**	1700		2391	3110	
31-007-23032-00-00	**23032-00**	7552	8334	8402	8766	
31-117-23037-00-00	**23037-00**			2600		
31-101-23039-00-00	**23039-00**	6815	7370	7465	8091	8560
31-097-23053-00-00	**23053-00**	7349		8015	8707	
31-097-23053-01-00	**23053-01**	7332		8020	8754	
31-101-23054-00-00	**23054-00**	8681	9250	9412	10989	
31-007-23056-00-00	**23056-00**	8550		9695	9933	
31-007-23056-01-00	**23056-01**			9676	9984	
31-101-23059-00-00	**23059-00**	8124		8854		
31-075-23070-00-00	**23070-00**	774	1334	1490	2100	2400
31-075-23071-00-00	**23071-00**	1057		1747	2353	
31-101-23085-00-00	**23085-00**	8395		9104	9524	
31-097-23086-00-00	**23086-00**	7290		7988	8518	
31-065-23090-00-00	**23090-00**			2144	2366	
31-053-23091-00-00	**23091-00**	1770		2932	3182	
31-015-23134-00-00	**23134-00**		8810	9007	9482	
31-013-23247-00-00	**23247-00**	4322	4733	4895	5296	5636
31-121-23389-00-00	**23389-00**	4372	4972	5232	5684	6102
31-009-23435-00-00	**23435-00**	7400	8107	8340	8765	9240
31-121-23449-00-00	**23449-00**	4630	5248	5552	6050	6406
31-009-23456-00-00	**23456-00**	4720	5411	5589	6060	6460
31-009-23456-01-00	**23456-01**	5175	5370	5604	6065	6480
31-029-23533-00-00	**23533-00**			5035	5604	
31-011-90001-00-00	**90001-00**	2860	3235	3460	4160	4500

Appendix C- Document 1

Calculation of Cavern Gas Storage Volume from Reserve Volume Trenton- Black River

Method 1

1) $\frac{P_R}{P_S} = B_{GP}$

2) $\frac{V_R(1 - S_w)}{B_{PG}} = V_F$

3) $V_{GR} \cdot SG_S \cdot \rho_W = m_B$

4) $m_B \cdot (S_S) = m_S$

5) $\frac{m_S}{\rho_S} = V_C$

6) $\frac{P_C}{P_S} = B_{GS}$

7) $V_C \cdot B_{GS} = V_{CS}$

Where:

P_R = Pressure of gas in reservoir (psi)

P_S = Surface or atmospheric pressure (psi)

B_{GP} = Gas-Fluid Volume Factor of the potential disposal reservoir (unitless)

V_F = Formation Volume (ft^3)

V_R = Volume of gas that was produced from V_F (BCF)

S_w = Water saturation of gas produced from potential disposal reservoir (Fraction)

SG_S = Specific Gravity of Salt (Fraction)

ρ_W = Density of water (pounds/ ft^3)

m_B = Mass of brine with volume V_{GR} (pounds)

S_S = Saturation of salt in brine (Fraction)

m_S = Mass of salt that could be removed based on the mB that is disposed (pounds)

ρ_S = Density of salt (pounds/ ft^3)

P_C = Cavern Operating Pressure (psi)

V_C = Potential cavern volume (ft^3)

B_{GS} = Gas-Fluid Volume Factor of the Cavern Development formation (unitless)

Sample Calculations for Method 1

1) $\dfrac{P_R}{P_S} = B_{GP} \approx 250$ (Estimated for TBR at 9000 ft.)

2) $\dfrac{V_R(1-S_w)}{B_{PG}} = V_F = \dfrac{10BCF\cdot(1-0.7)}{250} = 28\text{e}^6\ \text{ft}^3$

3) $V_{GR}\cdot SG_S\cdot\rho_W = m_B = (28\text{e}^6\ \text{ft}^3)\cdot(1.18)\cdot(62.6\ \text{lb/ft}^3) = 2.06e^9 lb$

4) $m_B\cdot(S_S) = m_S = (2.06e^9 lb)\cdot(0.25) = 515e^6 lb$

5) $\dfrac{m_S}{\rho_S} = V_C = \dfrac{515e^6 lb}{134.8lb/ft^3} = 3.8e^6\ ft^3$

6) $\dfrac{P_C}{P_S} = B_{GS} \approx 235$ (Estimated for Salina at 4000 ft.)

(7) $V_C\cdot B_{GS} = V_{CS} = (3.8e^6\ ft^3)\cdot 245 = 0.90$ BCF

Method 2

1) $\frac{P_R}{P_S} = B_{GP}$

2) $\frac{V_R(1-S_w)}{B_{PG}} = V_F$

3) $\frac{V_F}{B_B} = V_C$

5) $\frac{P_C}{P_S} = B_{GS}$

4) $V_C \cdot B_{GS} = V_{CS}$

Where:

P_R = Pressure of gas in reservoir (psi)

P_S = Surface or atmospheric pressure (psi)

B_{GP} = Gas-Fluid Volume Factor of the potential disposal reservoir (unitless)

V_F = Formation Volume (ft^3)

V_R = Volume of gas that was produced from V_F (BCF)

B_B = Brine Volume Factor (unitless)

S_w = Water saturation of gas produced from potential disposal reservoir (Fraction)

V_C = Potential cavern volume (ft^3)

P_C = Cavern Operating Pressure (psi)

B_{GS} =Gas-Fluid Volume Factor of the Cavern Development formation (unitless)

Sample Calculations for Method 2

1) $\frac{P_R}{P_S} = B_{GP} \approx 250$ (Estimated for TBR at 9000 ft.)

2) $\frac{V_R(1-S_w)}{B_{PG}} = V_F = \frac{10BCF \cdot (1-0.7)}{250} = 28e^6\ \mathrm{ft}^3$

3) $\frac{V_F}{B_B} = V_C = \frac{28e^6\, ft^3}{7} = 4e^6\, ft^3$

4) $\frac{P_C}{P_S} = B_{GS} \approx 240$ (Estimated for Salina at 4000ft.)

5) $V_C \cdot B_{GS} = V_{CS} = (4e^6\, ft^3) \cdot (245) = 0.98BCF$

Plate 1 Section A-A''
Silurian Interval

East- West Section -
Western & Central New York

▨ Salt Intervals

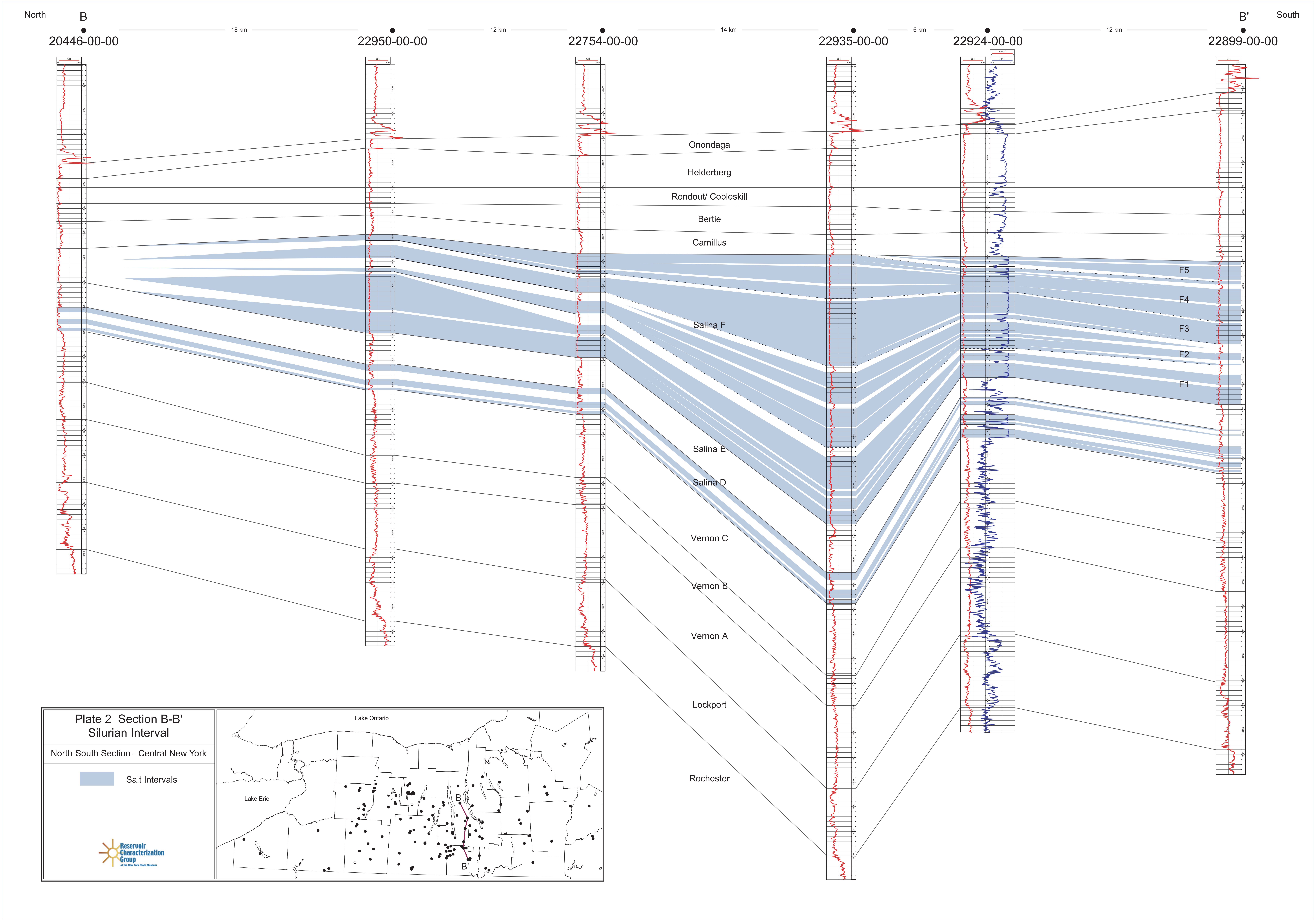
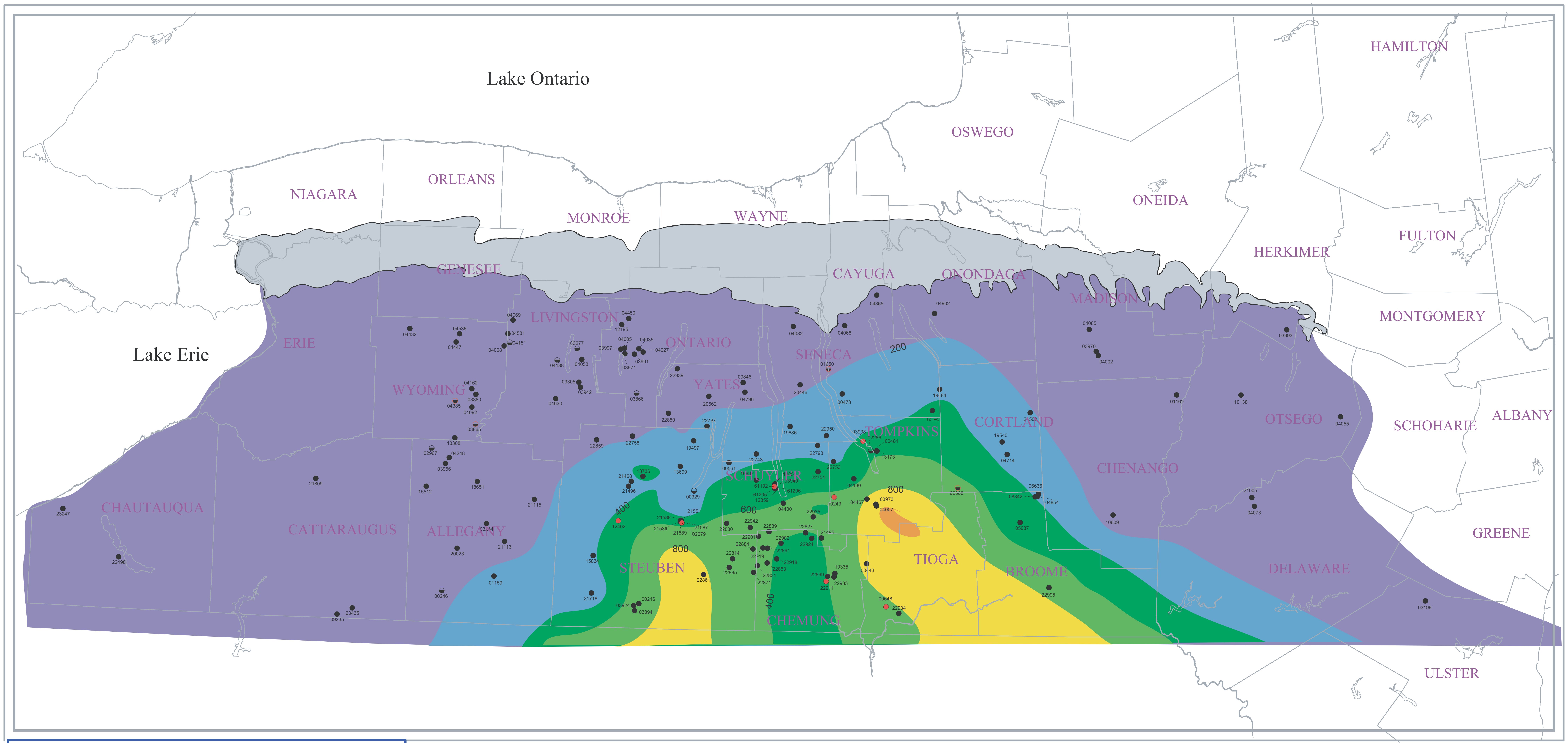


Plate 2 Section B-B'
Silurian Interval

North-South Section - Central New York

🟦 Salt Intervals

Reservoir Characterization Group
at the New York State Museum



Salina F-unit Isopachous Map

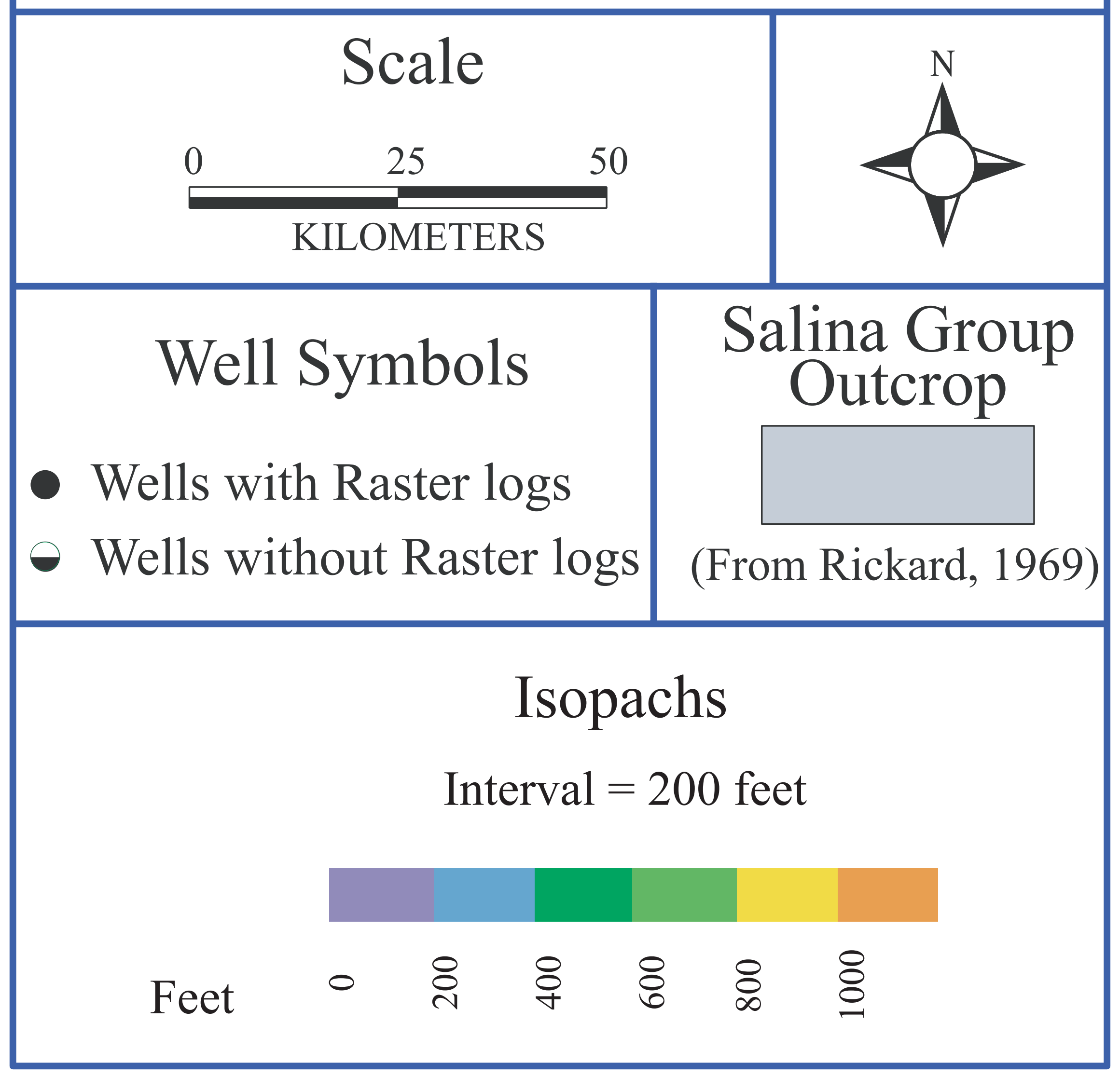


Plate 3 Isopachous map of the entire (aggregate) thickness of the Salina F-unit. This includes both salt and nonsalt beds. South central New York has the greatest thicknesses in the F-unit. The thickening of the F-unit is primarily due to the addition of many thick salt beds, making this area desirable for salt cavern development.

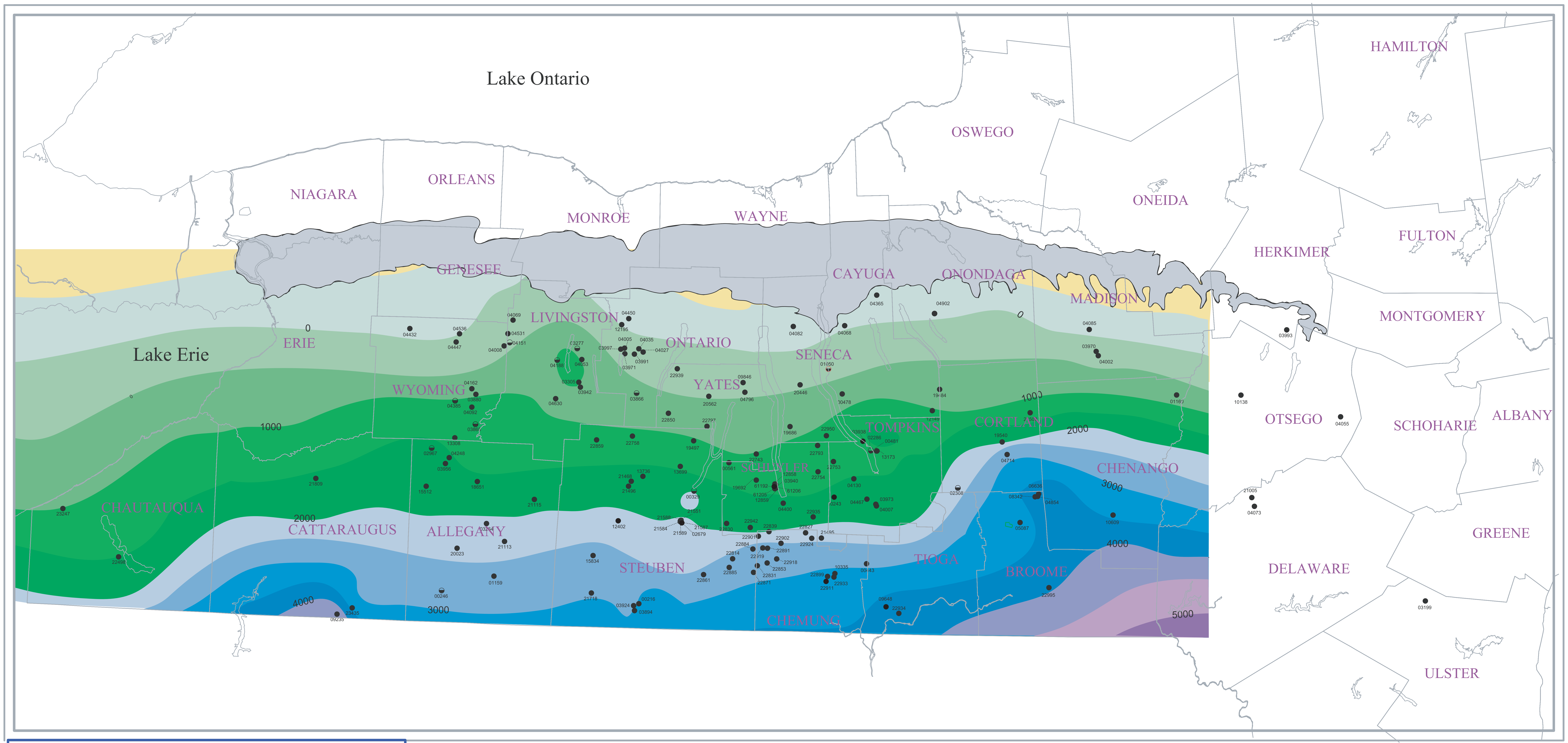


Plate 4 Structure Contour Map of the Salina F-unit. Datum is sea level and the undulations are believed to be variations in the surface of the F-unit. In south-central New York the F-unit reaches depths of 1000- 4000 feet below sea level

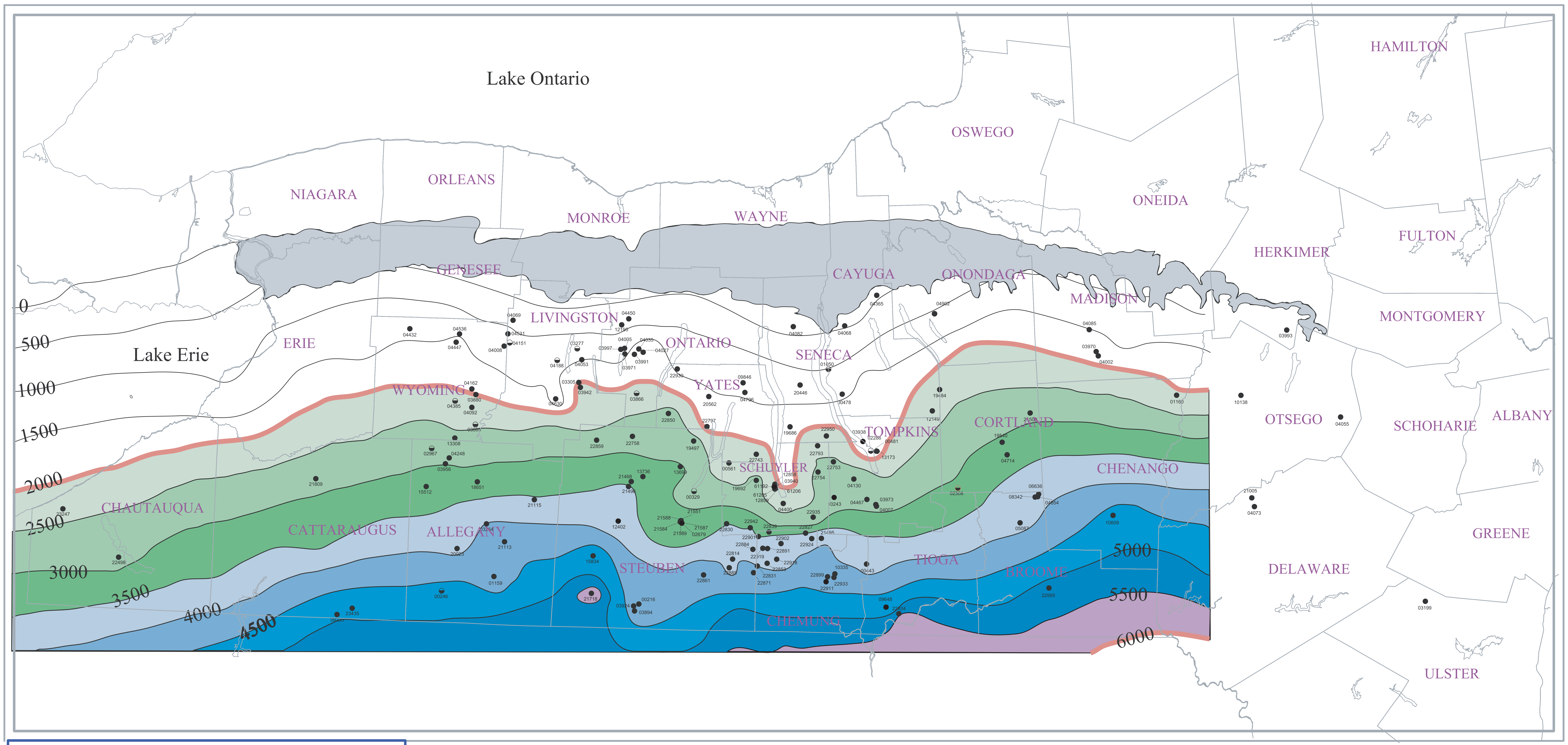


Plate 5 Measured depth to the top of the Salina F-unit in western and central New York State. Contours indicate depth measured from the surface elevation. Measured depth was used to take into account the hilly topography of the region covered by the map. The shaded contours highlight the portion of New York where the Salina F-unit lies at the appropriate depth for cavern development. Cavern development is considered in salt at depths between 2000 and 6000 feet (red).

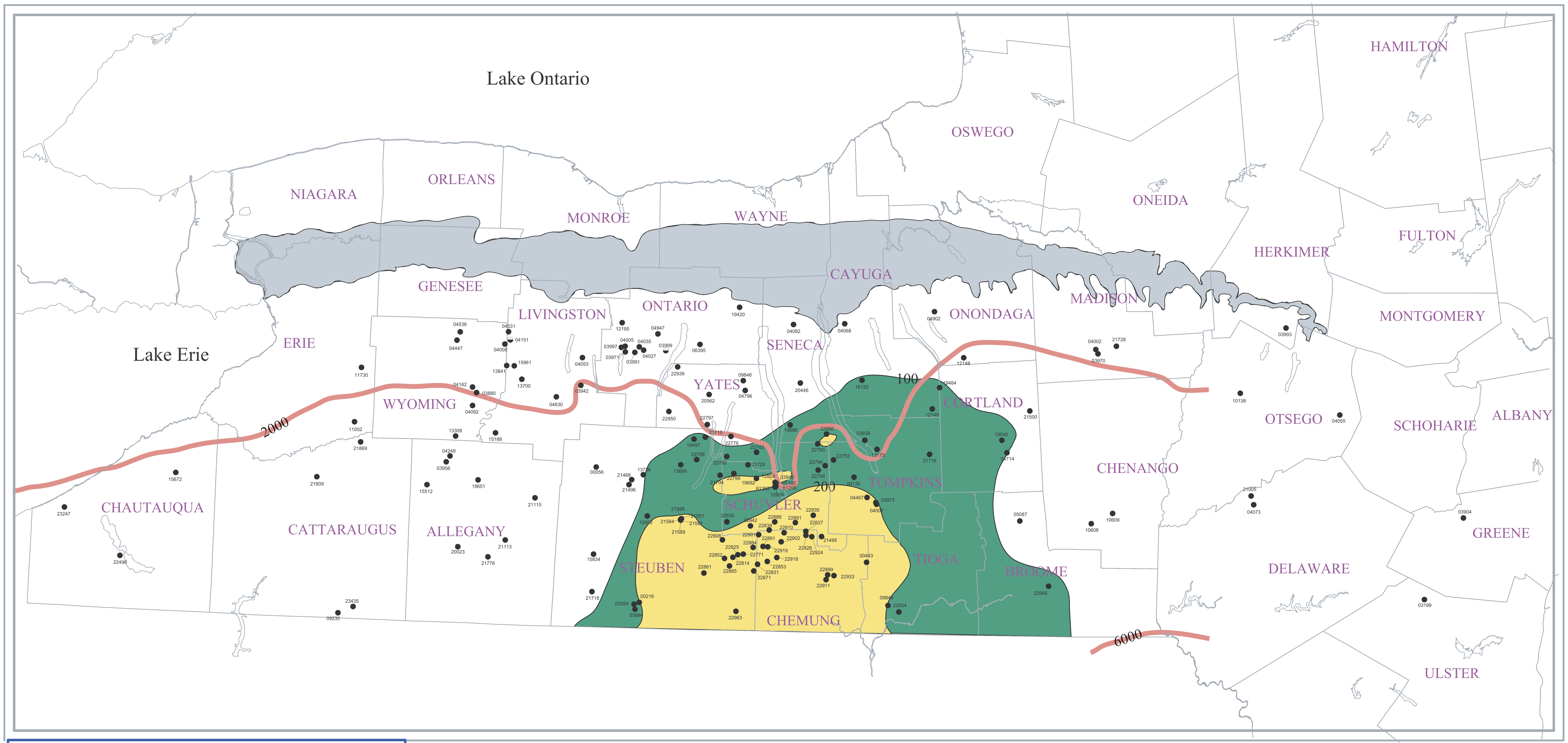


Plate 6 Map of Salt Suitable for Cavern Development. Map of the area underlain by salt that meets Phase I Criteria II, aggregate salt thickness of 100 feet or more with less than 10 feet of non salt breaks. In several wells there was more than one interval of salt in the F-unit that met these criteria, only the interval with the greatest thickness was used to generated the contours display in this map. The red contours are the 2000 and 6000 foot contours. The area between these contours is underlain by F-unit salt that also meets Phase I Criterion I (appropriate depth for cavern development), as shown on Plate 6.

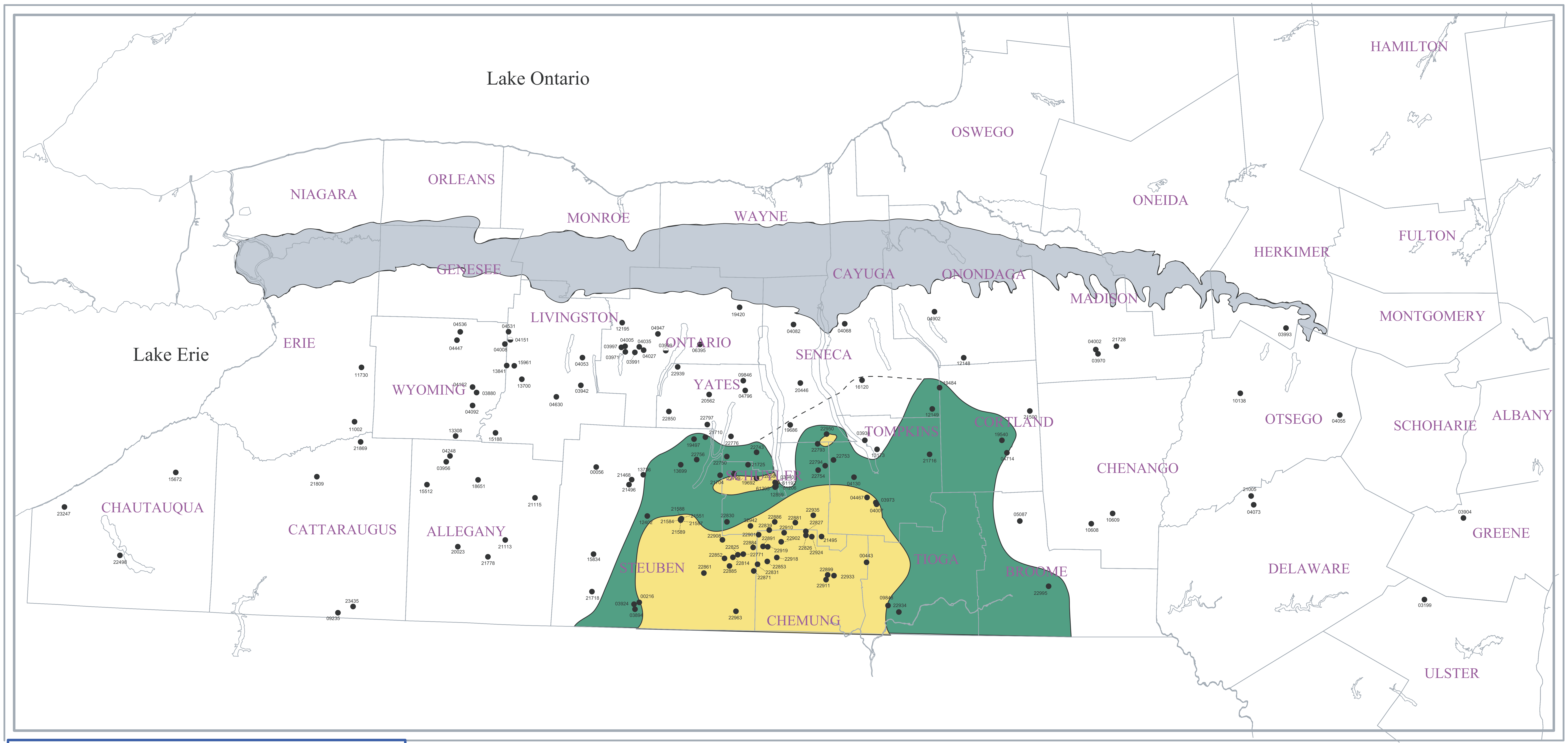


Plate 7 Study area defined in Phase I. The shaded portion of this map represents that area underlain by F-unit salt the meets both criteria for Phase one of this research. The green dashed line represents the area rejected based on Phase I Criterion I. Salt in the rejected portion, while thick enough, is not deep enough for cavern development based on industry standards. A review of the engineering and economics of developing a cavern in the rejected portion may prove that it is viable. Large portions of Stueben, Chemung, Tioga, Broome Cortland, Tompkins, Allegany and Schuyler Counties are underlain by F-unit salt in which a salt cavern storage facility could potentially be created

NEW YORK STATE POTENTIAL DISPOSAL RESERVOIR

PERIOD		GROUP	UNIT	LITHOLOGY	ENVIRONMENT	POROSITY/ PERM.	OIL OR GAS RESERVOIR TYPE	CURRENTLY USED FOR STORAGE	POTENTIAL AS BRINE DISPOSAL RESERVOIR
DEVONIAN	UPPER	GENESEE	WEST RIVER ITHICA RENWICK SHERBURNE PENN YANN GENESEO	SHALE WITH MINOR SILTSTONE AND LIMESTONE	DEEP MARINE BASIN				NO
			TULLY	LIMESTONE WITH MINOR SILTSTONE AND LIMESTONE	LOW ENERGY			YES, 1, GILBERT [7]	MAYBE
	MIDDLE	HAMILTON	MOSCOW LUDLOWVILLE SKANEATELES MARCELLUS	SHALE WITH MINOR SANDSTONE AND CONGLOMERATE	DEEP BASIN, UNDERWATER DELTA CHANNELS, TIDAL FLATS, OFFSHORE BARS DEEP BASIN, POOR CIRCULATION OF OXYGEN		GAS [6]		MAYBE
			ONONDAGA	FOSSILIFEROUS LIMESTONE & REEFS	SHALLOW MARINE, MEDIUM- LOW ENERGY		GAS, REEF AND FAULT GENERATED FRACTURES [6]	YES, 2, FRACTURED LS AND PINNACLE REEF [1]	MAYBE
	LOWER	TRISTATES	ORISKANY	QUARTZ SANDSTONE	NEAR SHORE, SHALLOW MARINE, HIGH ENERGY	-ave. 9% -open fractures, 200-800 md [4,1]	GAS, FORMATION PINCHES OUT LOCALLY FORMING TRAPS, ANY CLOSED STRUCTURALLY HIGHER POSITION [2,6]	YES, AT LEAST 9 [7,6]	MAYBE
		HELDERBERG	MANLIUS RONDOUT	LIMESTONE AND DOLOSTONE	TIDAL, SHALLOW MARINE SHALLOW MARINE, HIGH SALINITY				NO
SIURIAN	UPPER		AKRON-COBLESKILL	DOLOSTONE AND LIMESTONE	SHALLOW MARINE, NORMAL SALINITY	< 5% < 1md [1]	OIL AND GAS, BASS ISLAND TREND, STRUCTURAL TRAPS, FRACTURES [1]	YES [6]	MAYBE
		SALINA	BERTIE CAMILLUS SYRACUSE VERNON	SHALE, DOLOSTONE, ANHYDRITE AND HALITE	SHALLOW SHELF, HIGH SALINITY RESTRICTED MARINE PLAYA OR LAKE COASTAL PLAIN, SHALLOW SHELF			YES, 1- LPG, 1 OPERATIONAL AND SEVERAL PROPOSED NAT. GAS, SOUTH-CENTRAL NY	NO
		LOCKPORT	LOCKPORT	LIMESTONE AND DOLOSTONE STROMATALITE MOUNDS	SHALLOW SHELF TO CARBONATE FLATS		GAS, PINNICALE REEF, NO MAJOR PRODUCTION		NO
	LOWER	CLINTON	ROCHESTER IRONDEQUOIT	SHALE SANDSTONE LIMESTONE	OPEN MARINE SHELF WARM, CLEAR, SHALLOW SHELF		GAS, STRATIGRAPHIC [6]		NO
			WILLOWVALE SAUQUOIT WOLCOTT SODUS BEAR CREEK FURNACEVILLE KODAK	SHALE SANDSTONE AND SHALE LIMESTONE SHALE HEMATITE & IRON ORE SANDSTONE	NEAR SHORE, SUBTIDAL QUIET WATER TO SHALLOW SHELF SHALLOW MARINE IN DEPRESSIONS BETWEEN NEAR SHORE RIDGES OF SAND				
		MEDINA	GRIMSBY WHIRLPOOL	SANDSTONE AND SHALE	DELTAIC - SHALLOW TURBULENT WATER		GAS, SAND DOMINATED CHANNEL DEPOSITS, PRODUCED FROM FRACTURES [1]	10 GAS STORAGE FIELDS IN WESTERN NEW YORK [1]	MAYBE
ORDOVICIAN	UPPER		QUEENSTON	SANDSTONE AND SHALE	DELTAIC, BRAIDED STREAM	AS HIGH AS 15%01md	GAS, UP DIP FACIES CHANGE [3]	POTENTIAL GAS STORAGE RESERVOIR [1]	YES
			OSWEGO LORRAINE UTICA	SHALEY SANDSTONE SHALE WITH SANDSTONE AND SILTSTONE	NEAR SHORE AND BEACH SHALLOW AND MODERATELY DEEP MARINE DEEP BASIN		PORPOSED GAS, GAS SHALE		NO
	MIDDLE	TRENTON-BLACK RIVER	TRENTON BLACK RIVER	FOSSILIFEROUS LIMESTONE DOLOSTONE AND HYDROTHERMAL DOLOMITE	SHALLOW MARINE, TIDAL FLATS AND SLOPE SHALLOW SHELF		GAS, VUGGY HYDROTHERMAL DOLOMITE, FRACTURES-TUG HILL AREA [6]	BECAUSE OF THE HETEROGENEITY OF THE RESERVOIRS, IT IS UNLIKELY THAT MANY OF THESE FEILDS WILL BE UTILIZED FOR TRADITIONAL UNDERGROUND STORAGE	YES
	LOWER	BEEKMAN-TOWN	TRIBES HILL LITTLE FALLS	DOLOSTONE, LIMESTONE AND SILSTONE DOLOSTONE	TROPICAL COASTAL COMPLEX	Numerous porous zones in upper portion of L.F. [4]			YES
			THERESA (GALWAY)	SANDSTONE			GAS, vuggy dolomite, STRUCTURAL CLOSURE OF FRACTURE SYSTEM [5 6]	POTENIAL TRADITIONAL STORAGE RESERVOIR	
CAMB-RIAN	UPPER		POTSDAM	AND SANDY DOLOSTONE QUARTZ SANDSTONE		Basal Potsdam extremely porous and permeable [4]			
PRECAMBRIAN			MARBLE QUARTZITE etc>	METAMORPHIC AND IGNEOUS ROCKS					NO

FROM VANTINE AND COPLEY, 1984 — MODIFIED FROM ISACHSEN ET AL., 2000

1 FREIDMAN ET AL., 2002
2 DEECHIO ET AL., 1984
3 SAROFF, 1987
4 MC CANN ET AL., 1968
5 GOU ET AL., 1996
6 BESTEDO & VAN TYNE, 1990
7 DEC ANNUAL REPORTS

Plate 8 The table above is a compilation of information from several sources. By bringing this information together we were able to identify formations with potential as brine disposal reservoirs. Potential brine disposal reservoirs were chosen based on Lithology, coverage in south central New York and production and storage potential and history. Formations with potential to act as brine disposal reservoirs were designated as YES or MAYBE. Formations that have produced oil or gas were designated YES based on the similar characteristics necessary for both production and disposal. The MAYBE designation was used when a formation is commonly used for storage. This becomes necessary because economically, an operator would probably profit more form getting online quickly with a storage facility that will continually operate rather than the possible slow, one-time disposal that would occur with the brine disposal use.

Plate 9 Section C-C'
Lower Silurian - Upper Ordovician Interval

East-West
Western - Central New York

GeoColumn Shading

Color	Rock Type	GR Range
🟨	Sandstone	0-69
🟧	Sandy Shale	70-79
⬜	Shale	> 80

Reservoir Characterization Group
at the New York State Museum

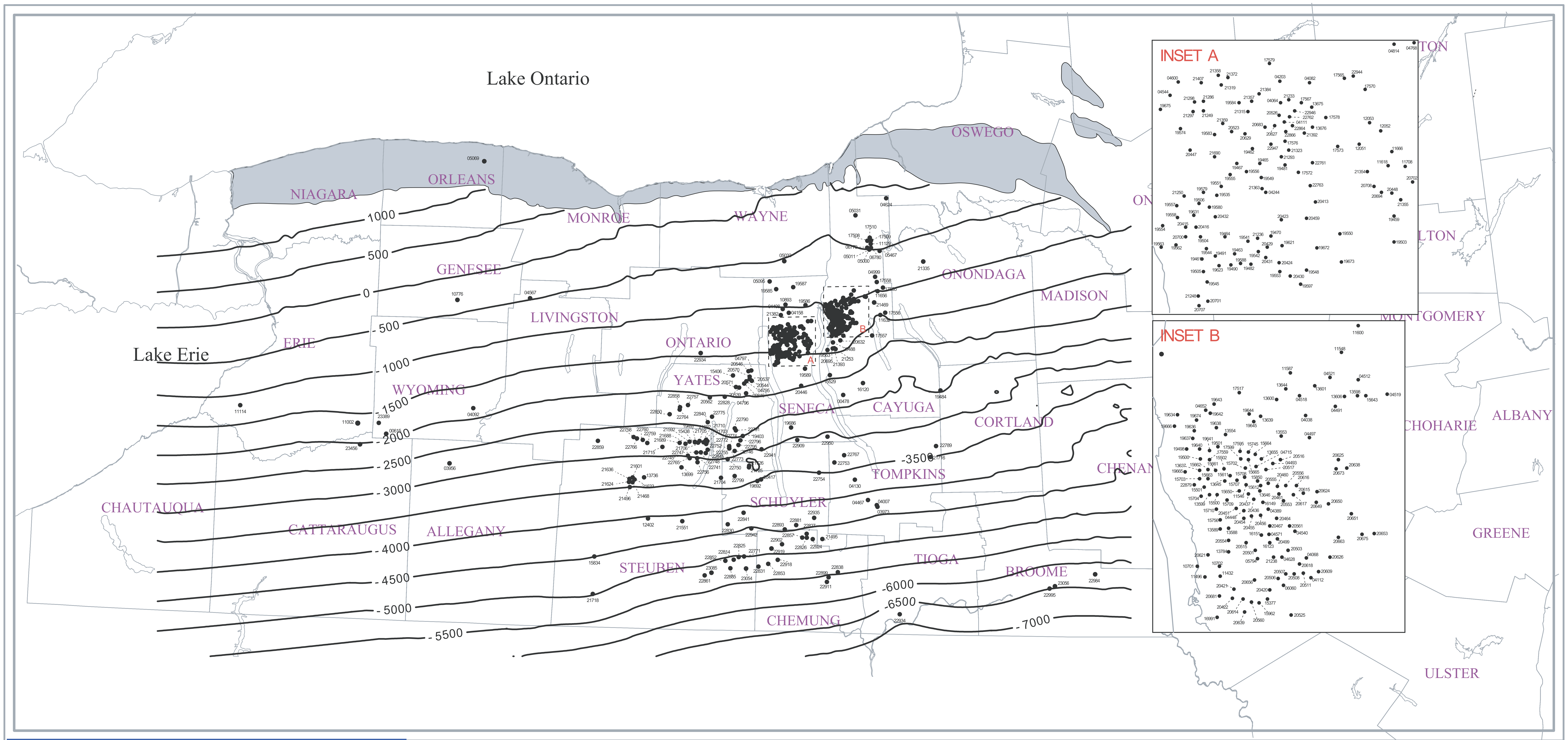
Plate 10 Section D-D"
Lower Silurian - Upper Ordovician Interval

North - South
Central New York

GeoColumn Shading

Color	Rock Type	GR Range
🟨	Sandstone	0-69
🟧	Sandy Shale	70-79
⬜	Shale	> 80

Reservoir Characterization Group at the New York State Museum



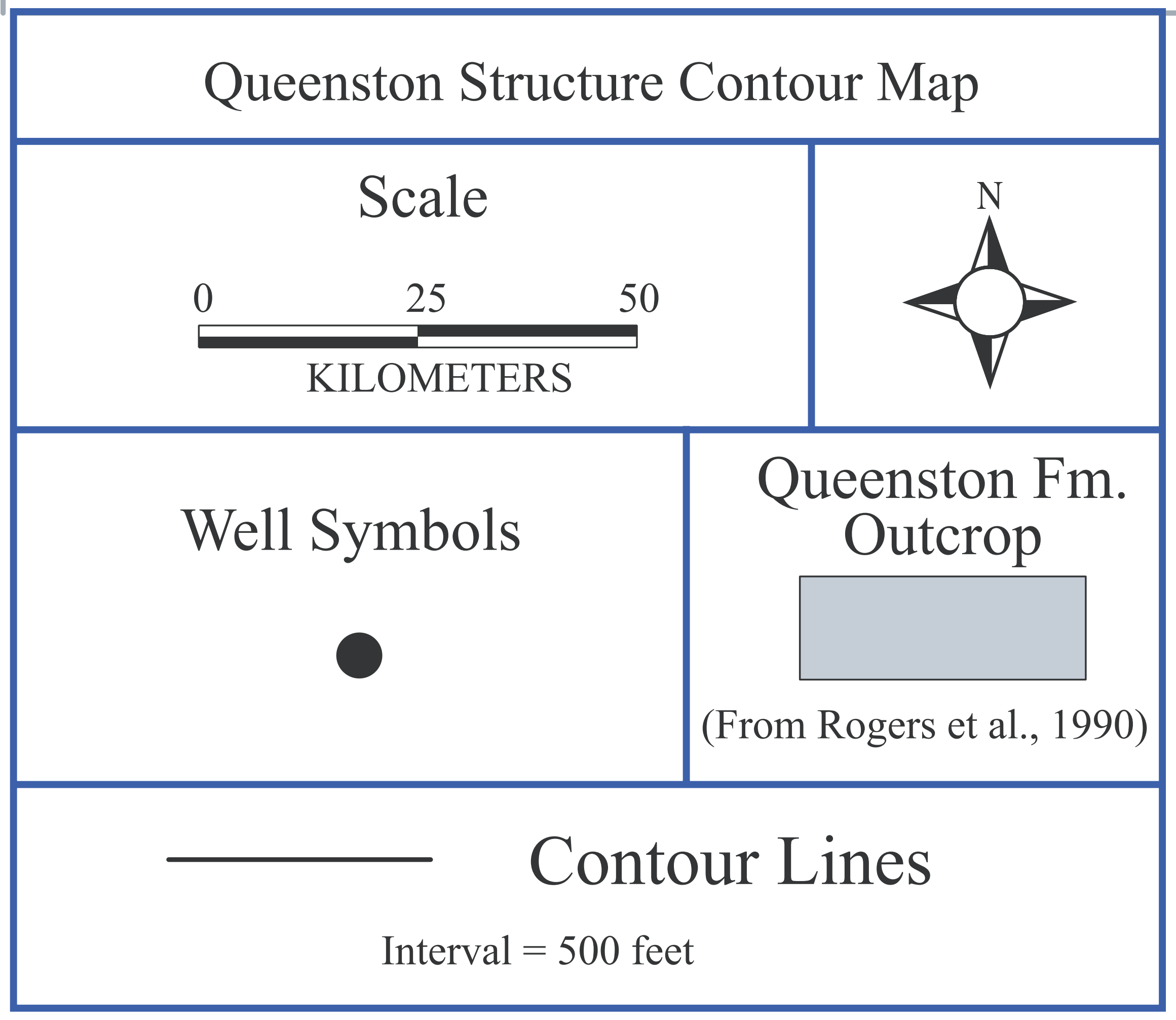
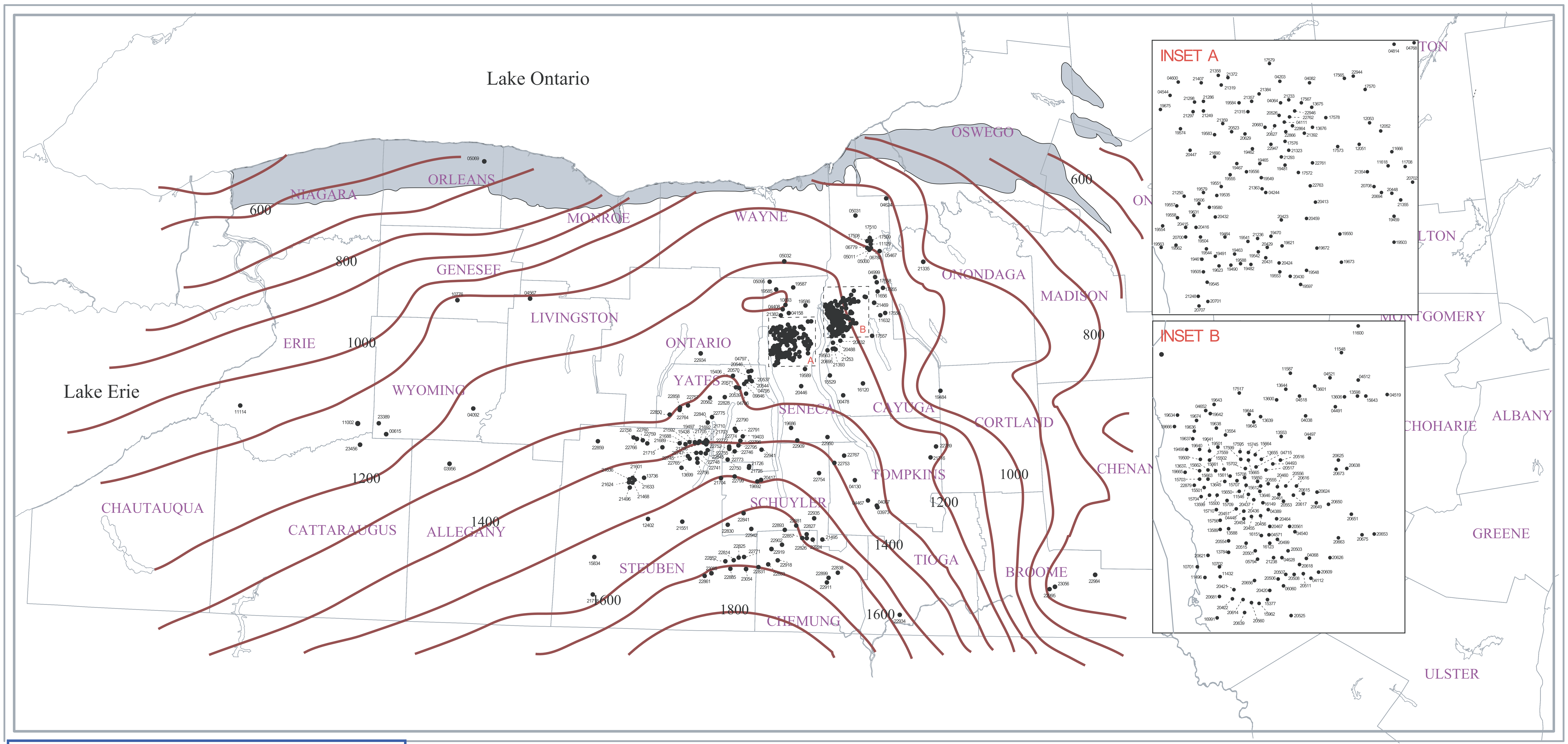


Plate 11 Queenston Formation structure contour map. The top of the Queenston Formation is roughly 1000 to 1800 ft below sea level in the producing area in north-central New York. From the Producing area the formation dips to the south roughly 50 ft/ mile, reaching depths of 6000 ft or more below sea level at the New York - Pennsylvania Border. Within the study area the Queenston is between 2500 and 6500 ft below sea level.



Queenston - Oswego Isopachous Map

Scale

0 25 50

KILOMETERS

N

Well Symbols

●

Queenston Fm. Outcrop

▨

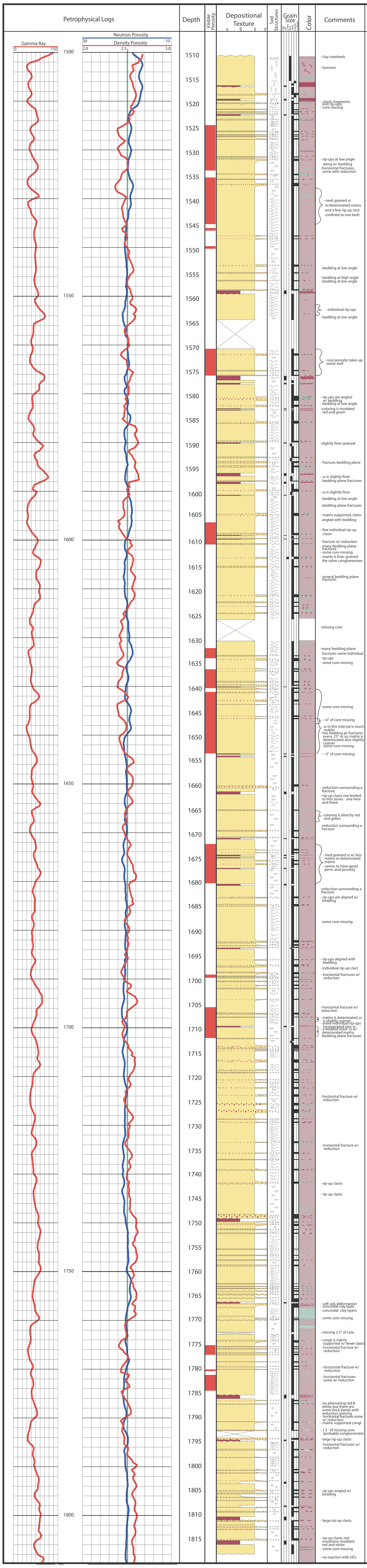
(From Rogers et al., 1990)

Isopachous Lines

Interval = 100 feet

Plate 12 Isopachous map of the Queenston-Oswego interval. This interval is thickest in south-central New York in areas where salt cavern development is a possibility.

Plate 13 - QUEENSTON CORE DESCRIPTION
Delaney A-124-5, Cayuga County , New York



- clay interbeds
- burrows
- clastic fragments (not rip-ups)
- core missing
- rip-ups at low angle along w/ bedding
-horizontal fractures, some with reduction
- med. grained ss w/deteriorated matrix and a few rip-up (not confined to one bed)
- bedding at low angle
- bedding at high angle
- bedding at low angle
- individual rip-ups
- bedding at low angle
- nice porosity takes up water well
- rip-ups are angled w/ bedding
- bedding at low angle
-coloring is modeled red and green
-slightly finer grained
- fracture, bedding plane
- ss is slightly finer
- bedding plane fractures
- ss is slightly finer
- bedding at low angle
- bedding plane fractures
- matrix supported, clasts angled with bedding
- few individual rip-up clasts
- fracture w/ reduction
- many bedding plane fractures
- some core missing
- matrix is finer grained the other conglomerates
- several bedding plane fractures
-missing core
-many bedding plane fractures some individual rip-ups
- some core missing
-some core missing
- ~6" of core missing
- ss in this interval is much redder
-has bedding pl. fractures every .25" or so, matrix is deteriorated, also slightly coarser
- some core missing
- ~3" of core missing
- reduction surrounding a fracture
- rip-up clasts not limited to thin zones - one here and there
-coloring is blotchy red and green
-reduction surrounding a fracture
- med grained ss w/ less matrix or deteriorated matrix
- seems to have good perm. and porosity
-reduction surrounding a fracture
- rip-ups are aligned w/ bedding
-some core missing
- rip-ups aligned with bedding
- individual rip-up clast
- horizontal fractures w/ reduction
- horizontal fracture w/ reduction
- matrix is deteriorated, ss is slightly coarser
- some individual rip-ups incorporated into ss
- x-bedded med/ ss w/ deteriorated matrix, bedding plane fractures
- horizontal fracture w/ reduction
- horizontal fracture w/ reduction
- rip-up clasts
- rip-up clasts
- soft sed. deformation
- concoidal clay layer
- concoidal clay layers
- some core missing
- missing 2.5" of core
- congl. is matrix supported w/ fewer clasts
- horizontal fracture w/ reduction
- horizontal fracture w/ reduction
- horizontal fractures some w/ reduction
- no alternating red & white, but there are some thick bands with reduction staining
- horizontal fractures some w/ reduction
- matrix supported congl.
- 1.5 ' of missing core (probably conglomerate)
- large rip-up clasts
- horizontal fractures w/ reduction
- rip ups angled w/ bedding
- large rip-up clasts
- rip-up clasts, red mudstone modeled red and white
- some core missing
- no reaction with HCL

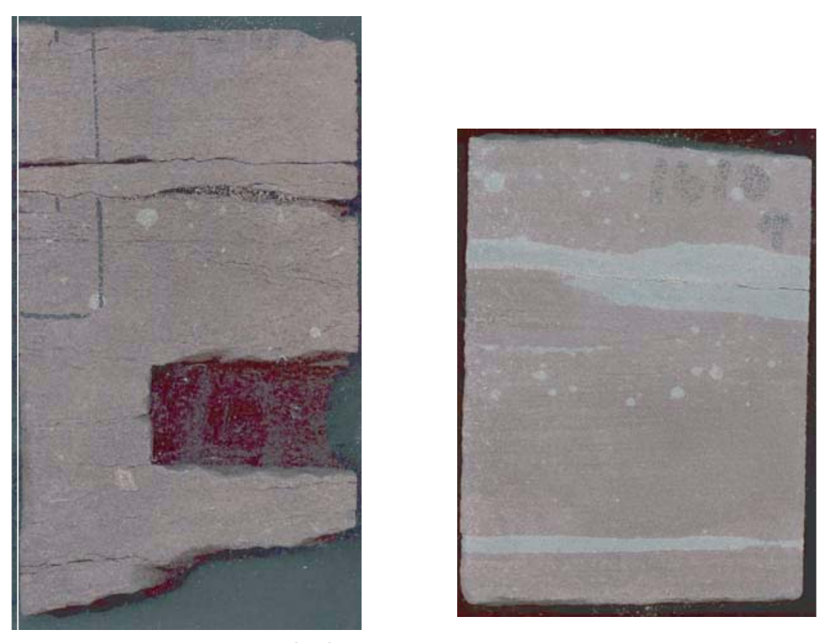
Scanned Core
(all core is four inches in diameter)


1527
med-grained ss in a section of visible porosity, reduction around fracture

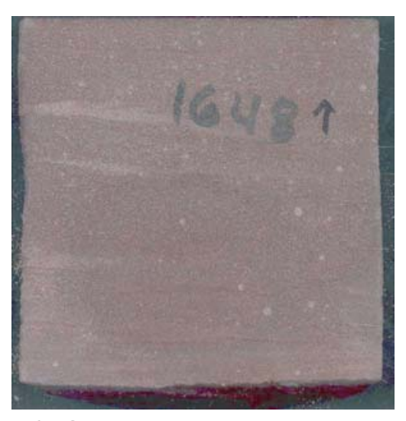

1533
color alteration around a fracture

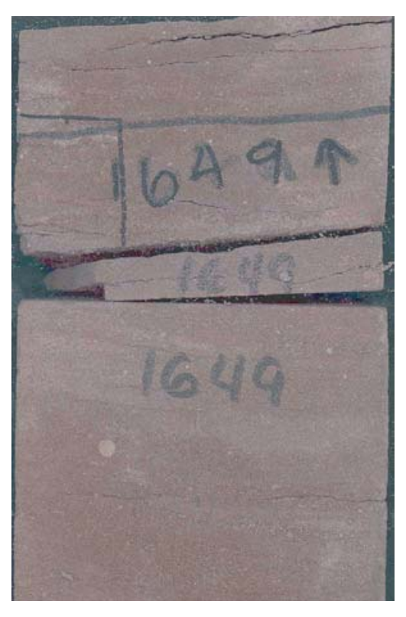

1577
Visible porosity associated with horizontal fractures


1594
Large rip-up clasts in a matrix supported congl,


1610
Visible Porosity in an area with many horizontal fractures, some with reduction


1647
Horizontal zones of visible porosity


1648
Medium grained ss w/ visible porosity


1647
Visible Porosity in an area with many bedding plane fractures


1661
Silt rich section, upper portion is bedded while the lower portion is massive


1676
x-bedded w/ visible porosity


1677
Medium grained ss from a section w/ visible porosity

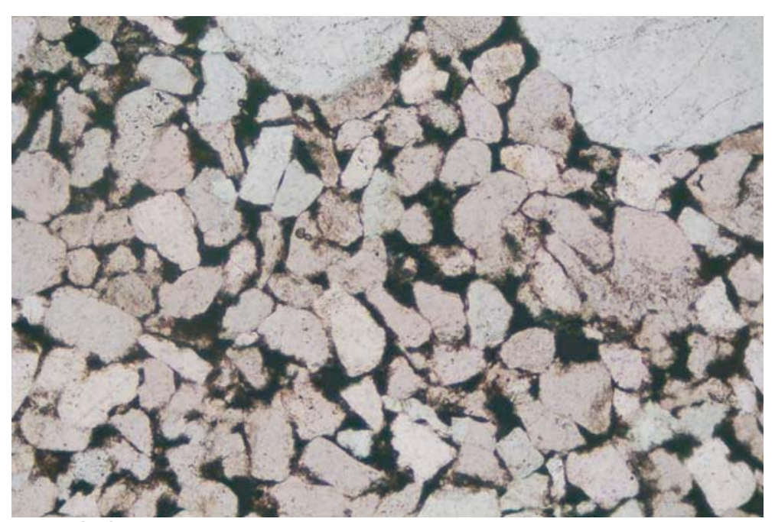

1692
Some clasts and matrix of this conglomerate have been reduced

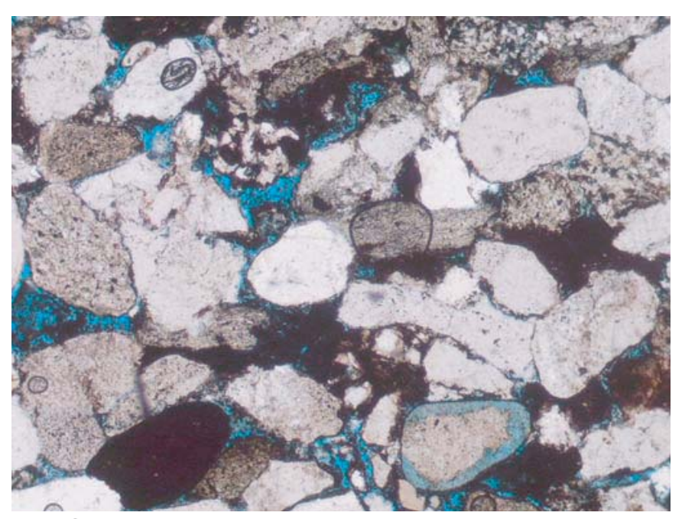

1711
Visible porosity

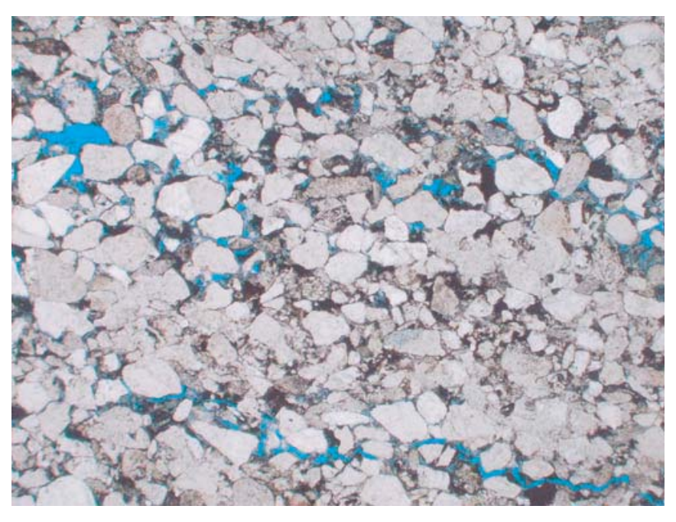

1750
Matrix supported conglomerate

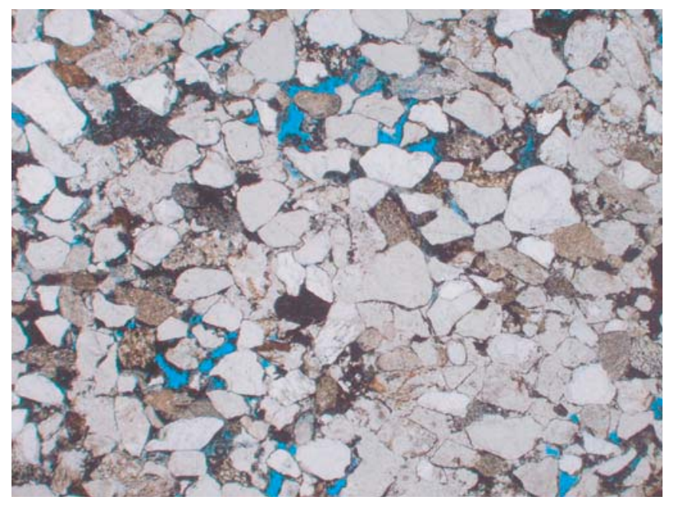

1774
Matrix supported conglomerate consisting of rip-ups

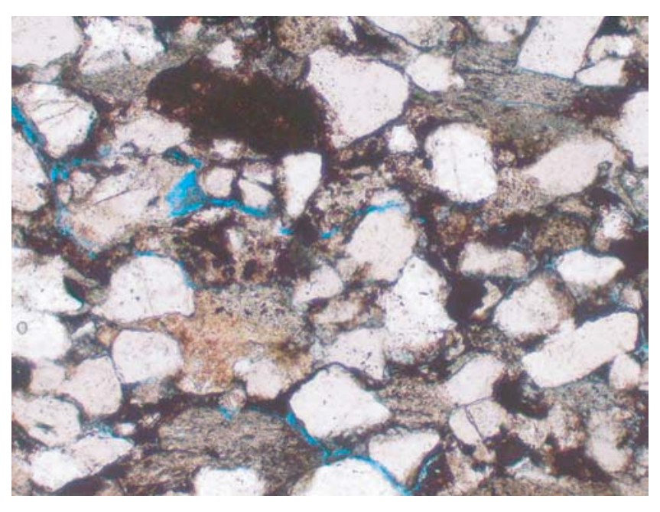
Thin Section Images

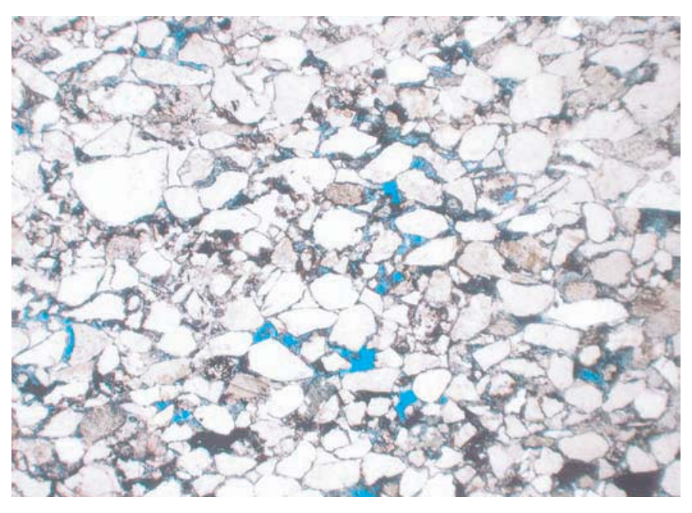

1513.9
Qtz Sandstone w/ black iron oxide cement

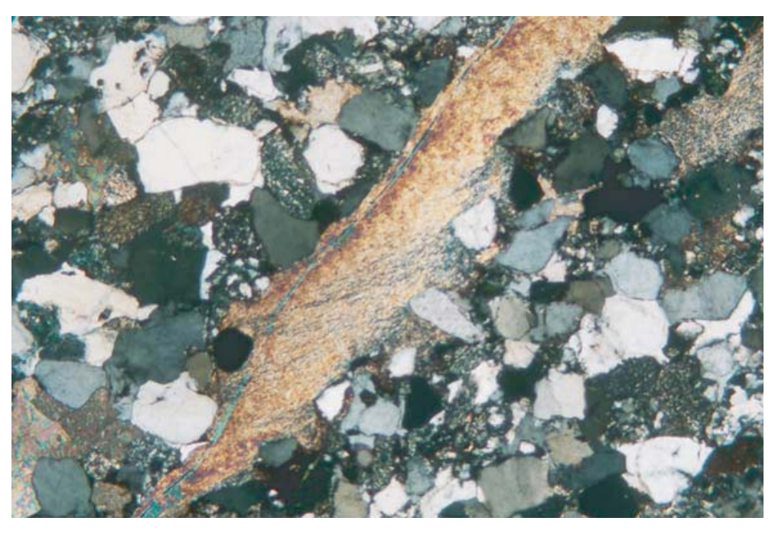

1518.1 5x
Medium grained, qtz ss with small amount of porosity

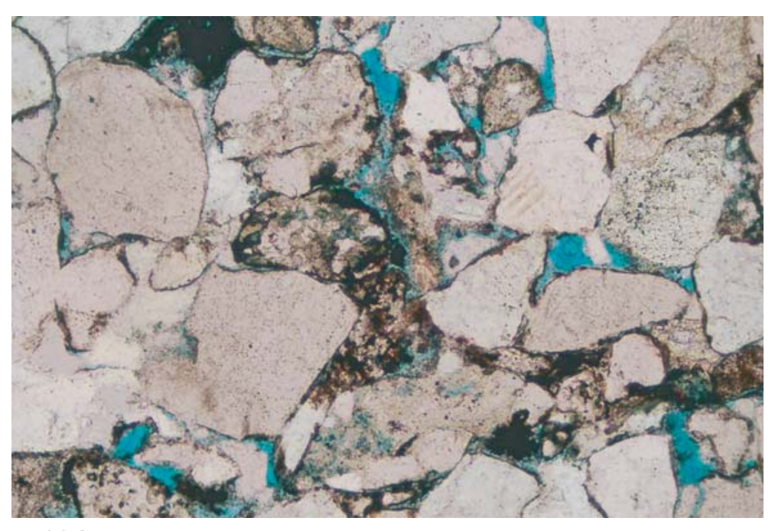

1529
Qtz Sandstone w/ good interparticle porosity

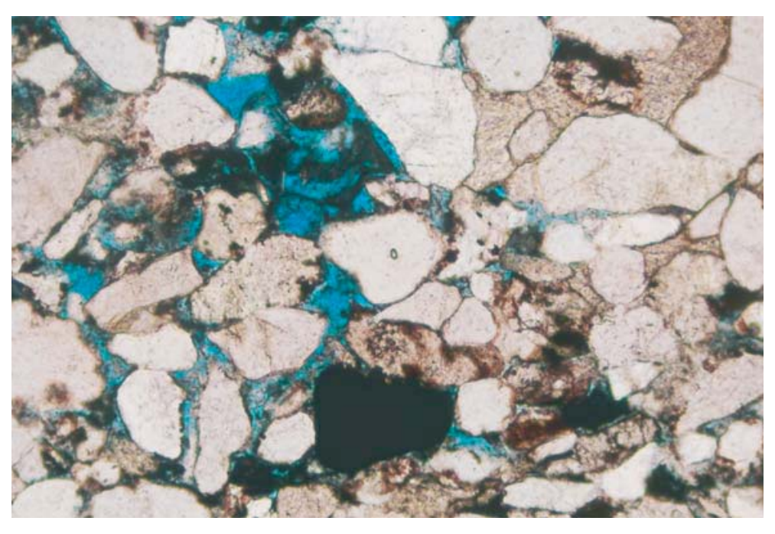

1534.4
Qtz Sandstone w/ patchy interparticle porosity

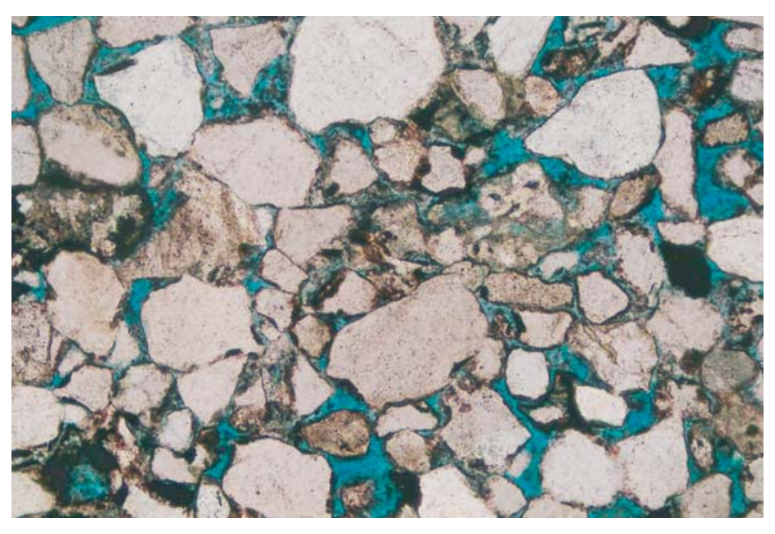

1559.9
Qtz Sandstone w/ good interparticle porosity

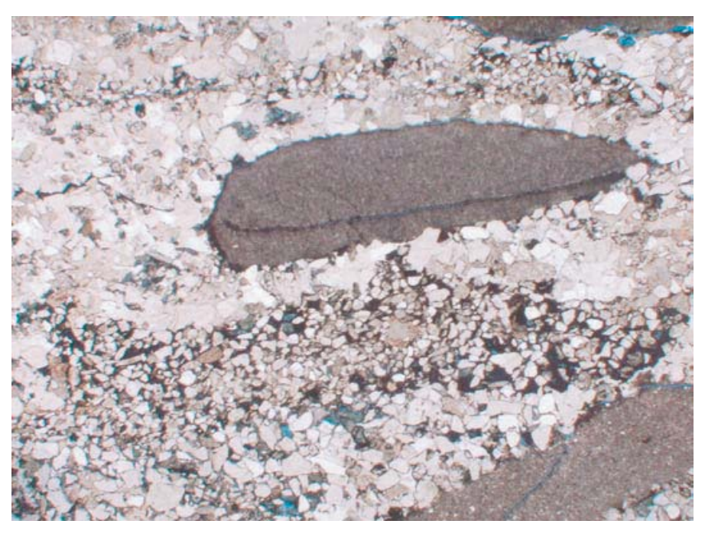

1579.4
Qtz Sandstone w/ good interparticle porosity

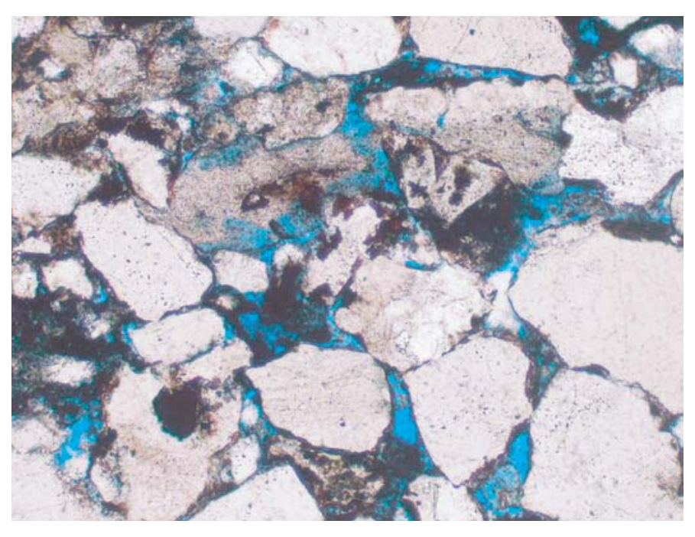

1589.2
Rip-up clast of shale in sandstone matrix


1602.7
Medium grained qtz ss w/ primary porosity

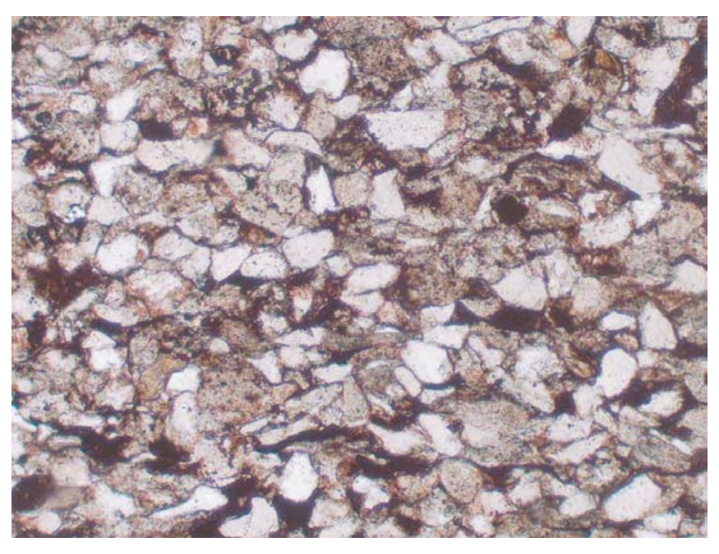

1634.5
Medium grained qtz ss w/ primary porosity


1634.5
Medium grained qtz ss w/ primary porosity

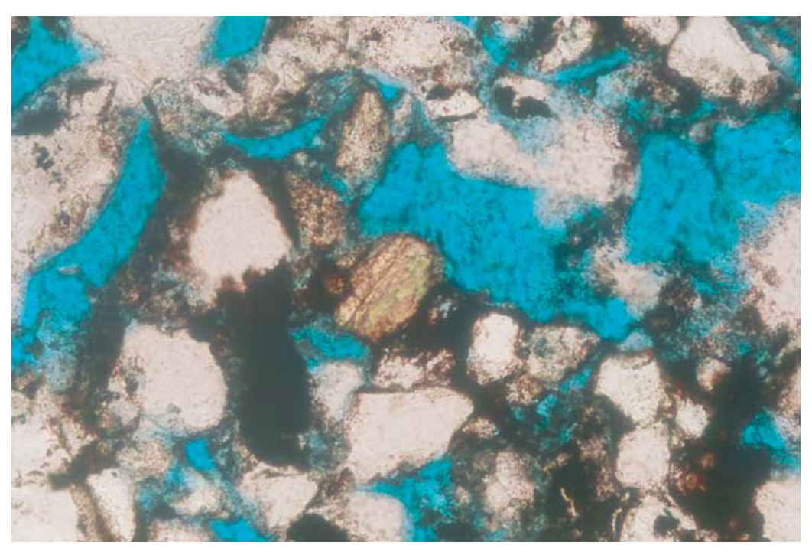

1624.2
Zonation of clay-rich and clay-poor areas in conglomerate.

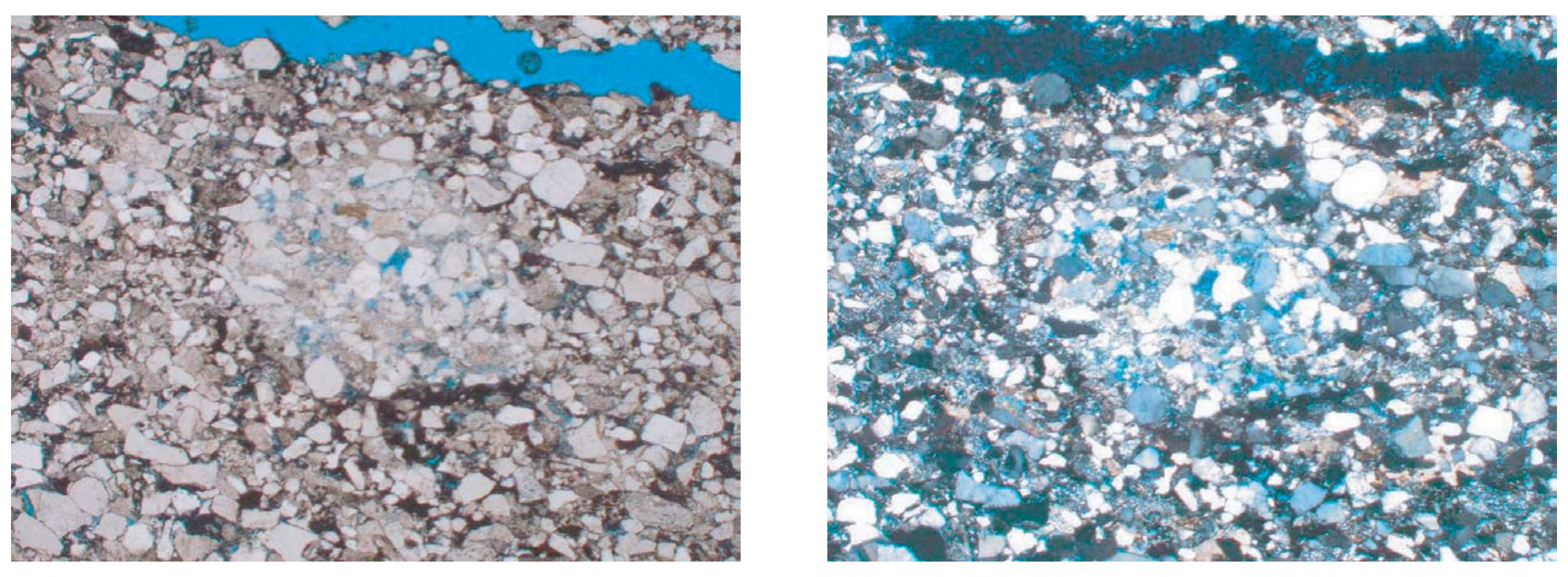

1640
Roughly 10% porosity

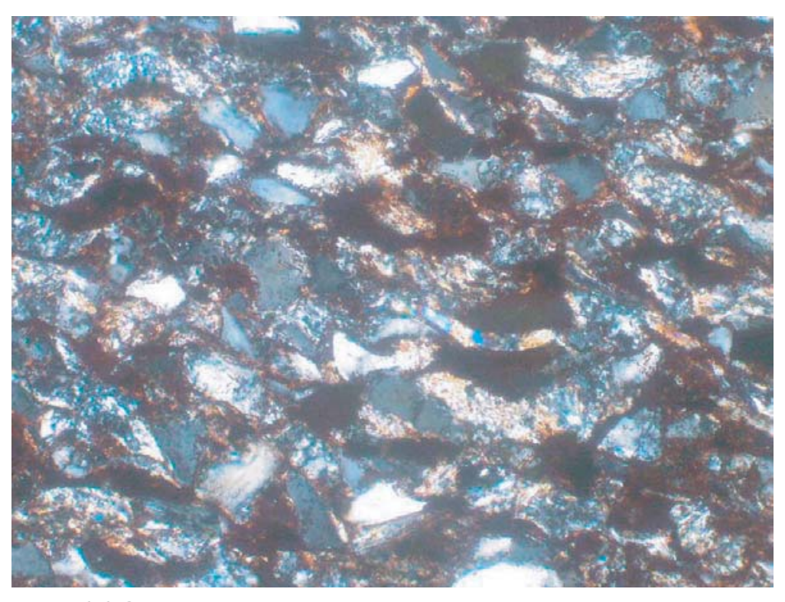

1649
Intergranular porosity in a medium grained qtz ss

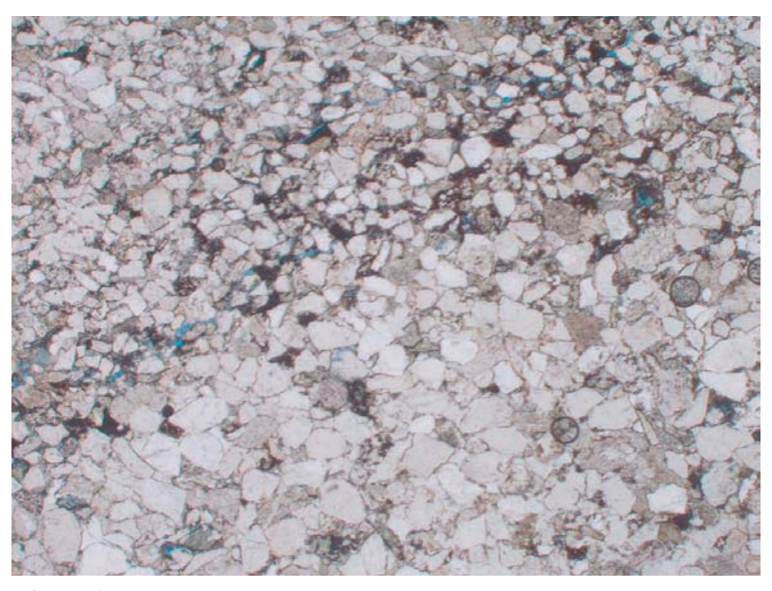

1661.
Siltstone bed


1670.6
Shale lithoclast in very fine sandstone matrix


1680.5
Intergranular porosity in a medium grained qtz ss


1711
Calcite crystal surrounding sand grains. In places porosity has developed, but it is limited to within the crystal.


1766.3
Clay rich non reservoir


1811.0
Transition between fine- and medium-grained ss

Legend

○ ○ ○/● ● ●	Rip-Clast Conglomerate	∼	Planar Bedding	🟨	Sandstone
● ● ●/- - -	Other Lithic Fragments forming a Conglomerate	⫽	Angled Bedding	🟥	Siltstone
≋	Clay interbeds	⊤	Cross Bedded		
ʓ ʓ	Burrows	∿	Fracture		

Reservoir Characterization Group
at the New York State Museum

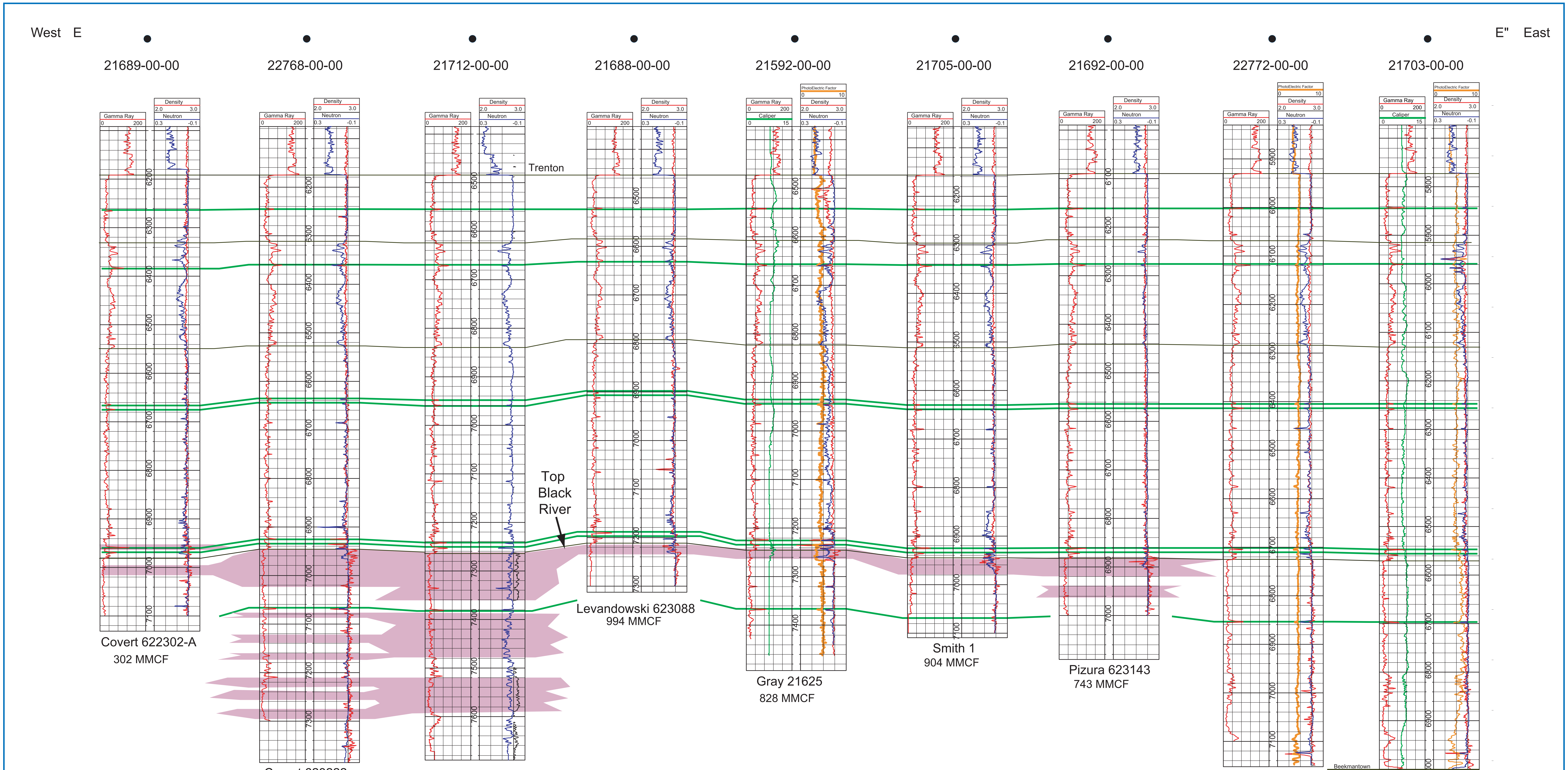


Plate 14 Section E-E'
Trenton - Black River Groups
Glodes Corners Road Field

Log cross section of Glodes Corners Road Field. Note patchy dolomite distribution. Most productive wells in the trend are dolomitized near the top of Black River under argillaceous limestone of basal Trenton.

▨ Dolomite — Bentonite

Reservoir Characterization Group
at the New York State Museum

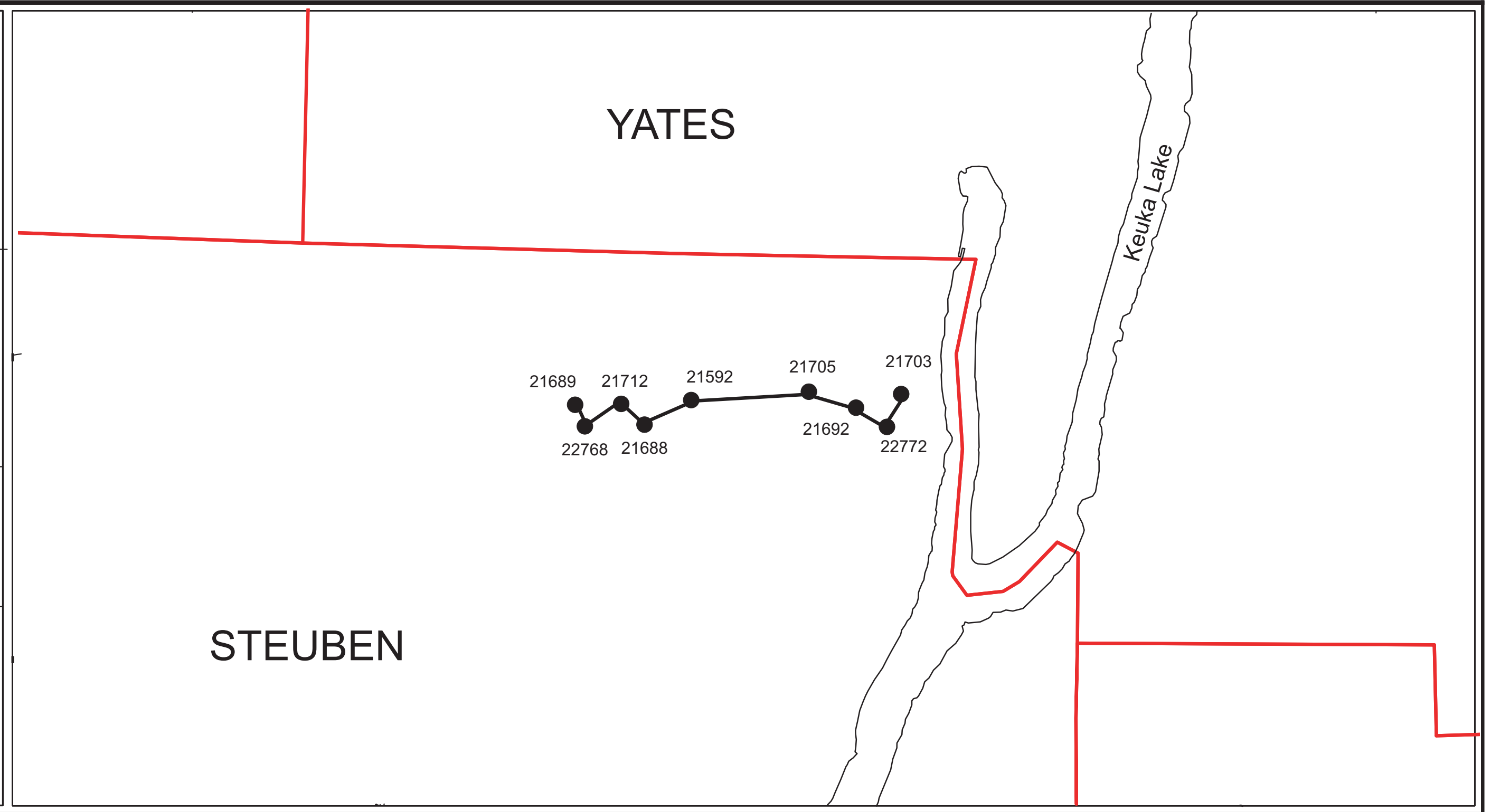
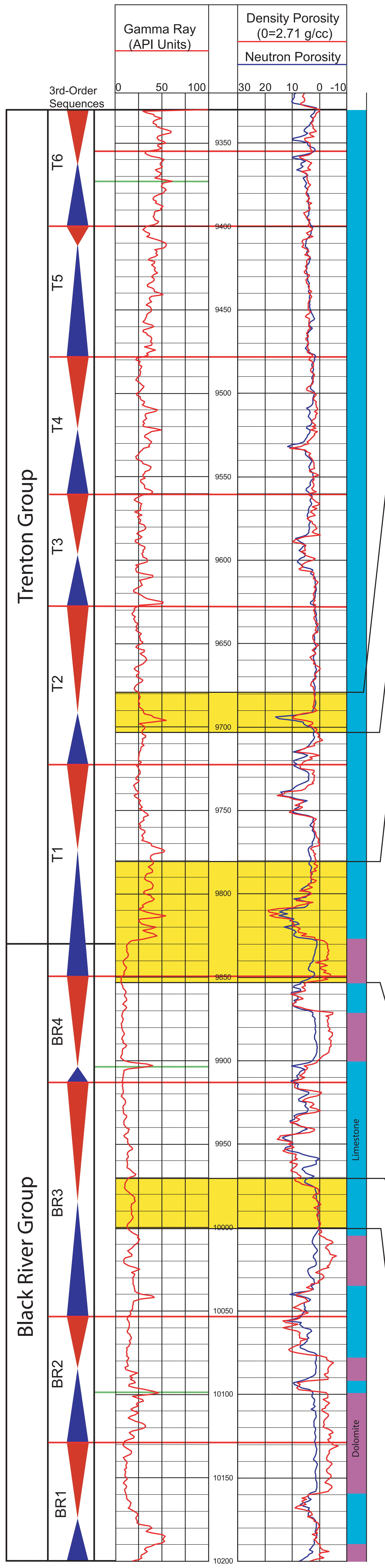
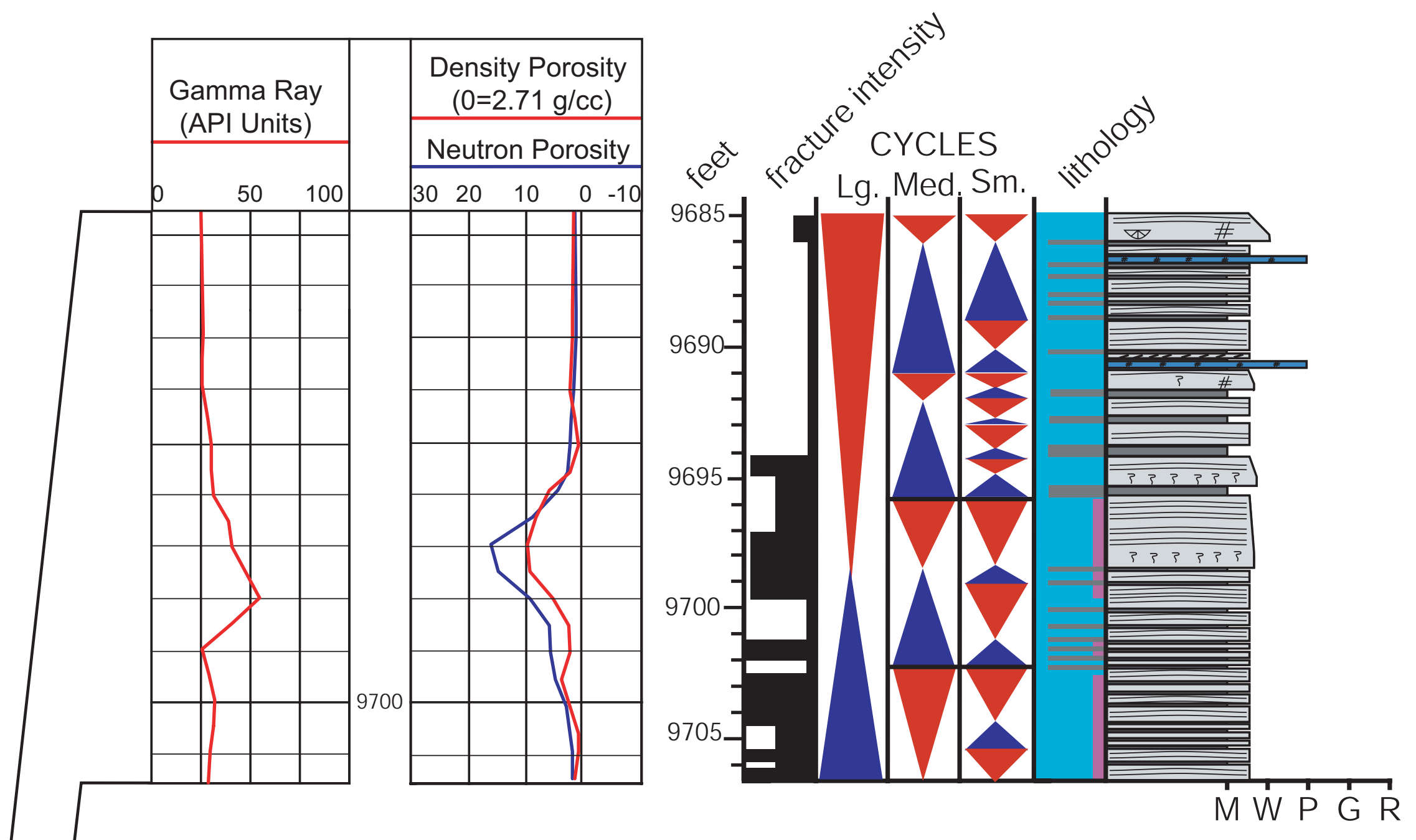


Plate 15 Section F-F''
Trenton-Black River
Interval

Plate 16

Trenton and Black River Cores - Matejka #1, Chemung Co., New York





Comments

-calcite filled fractures with small amount of dolomite

-2"-12" event beds with ripple laminated calcisiltite and fissile, dark gray shale; some hcs and starved ripples in calcisiltite beds; many calcicsiltite beds have bryozoans and brachs at the base
-calcite propped open fracture 9691.1-9691.7 and 9694-9695
-starting from here down, heavily fractured.

-Extensional fractures up to 1.5 cm wide, some areas brecciated. Fill is saddle dolomite followed by quartz and calcite.

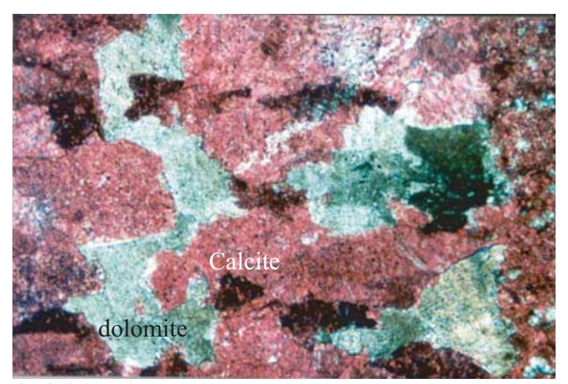
-Major breciation at base, obliterated
This interval logged with G. Davies 12/2001

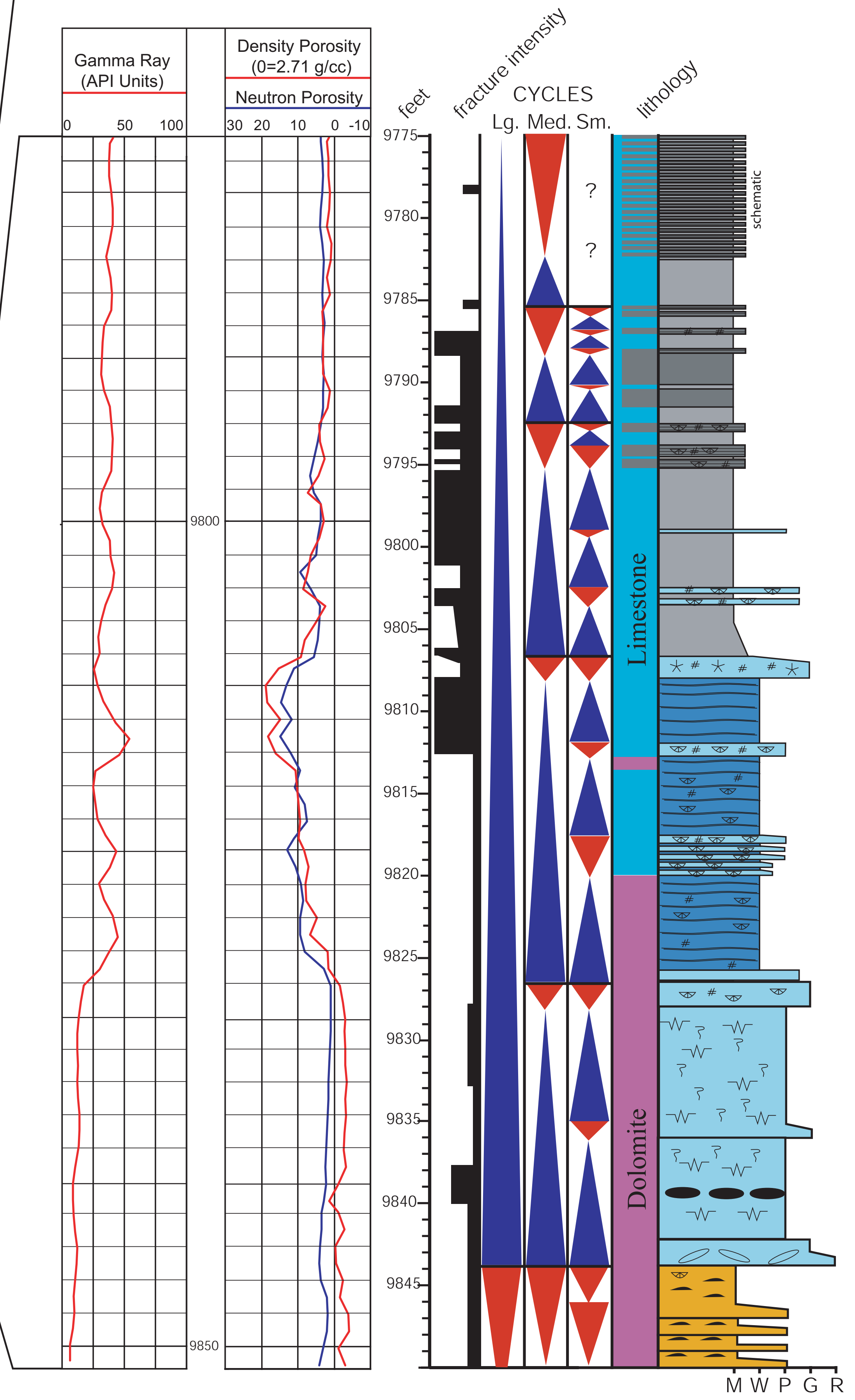

9694: Open fracture in mudstone


9700: Extensional fracture in marl-limestone couplets


9704: Dolomite and calcite-cemented breccia in marl limestone facies


9706 Fracture in lime mudstone filled with calcite and saddle dolomite


9706 Fracture in lime mudstone filled with calcite and saddle dolomite (cross-polarized light)



- A few minor hairline vertical veins throughout this interval

-1 cm wide subvertical veins

-interbedded black fissile marl or wackestone with dark gray mudstone

-dark gray mudstone

-fissile wackestone with crinoids and brachs
-thick, partially filled vertical veins

-intensely veined filled with calcite cement
-fissile mudstone/wackestone with crinoids and brachs
-intensely brecciated, filled with calcite cement

-1/2" bed of packstone
-big fractures filled with calcite
-dark gray mudstone with subtle lams
-intense brecciation at top of pkst bed

-vertical and steeply dipping veins

-whole bryozoans
-intensely brecciated
-a few floating fossils
-20-30% clay
-argillaceous nodular wkst

-whole brachipods

-thin graded beds

-zebra rock calcite/limestone
-argillaceous, hot on gamma ray
-very coarse dolomite, some whole fossils, calcite and dolomite filled fractures

-burrows filled with black, grainy substance

-veins mostly subhorizontal, filled with anhydrite or dolomite
-stylo-nodular dolomite. Hard to tell original fabric, but dolomite is fairly coarse
-stylolites vertical and oblique

-black chert

-zebra calcite filled fractures

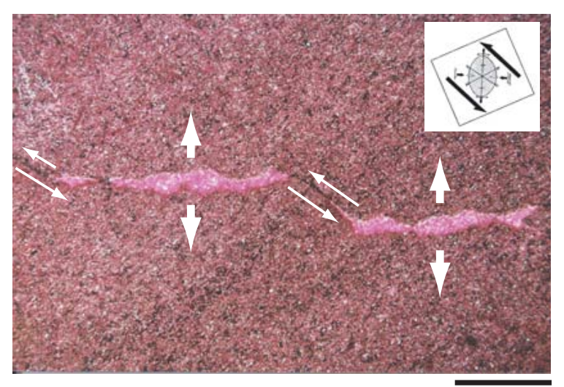
-intraclasts abundant
-Sequence Boundary?
-light gray fenestral mudstone with abundant dolomite cement filling fractures and voids. Coarser packstone beds at base. Peritidal cycles.

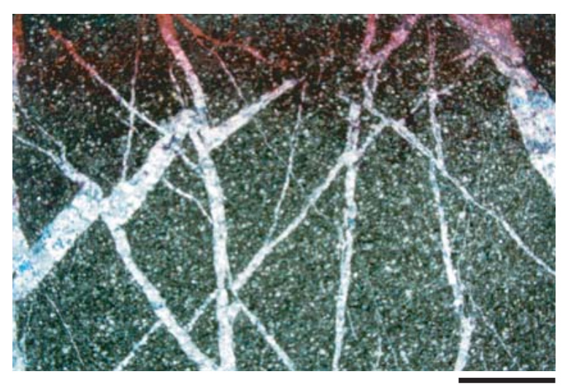
-some open fractures in this unit


9781.5: limestone marl couplets


9787.5: Open vug in fracture fill


9790.5: Fault filled with dolomite and calcite

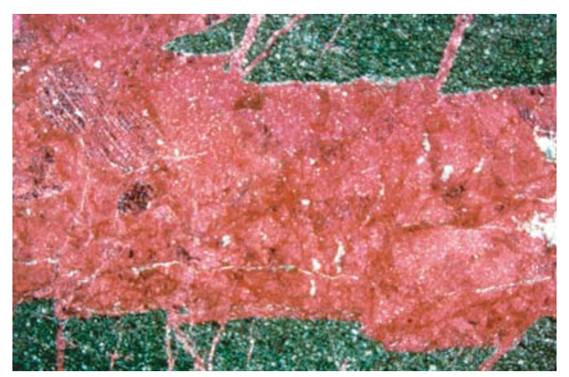

9797.5 Fractal miniature of T/BR Fields produced by Reidel Shear


9797.5 Calcite fills multiple sets of fractures in lime mudstone


9795.5: Fractured lime mudstone


9803: Oriented fracture set filled with calcite


9807.5: Chaotic breccia cemented with dolomite, calcite and quartz

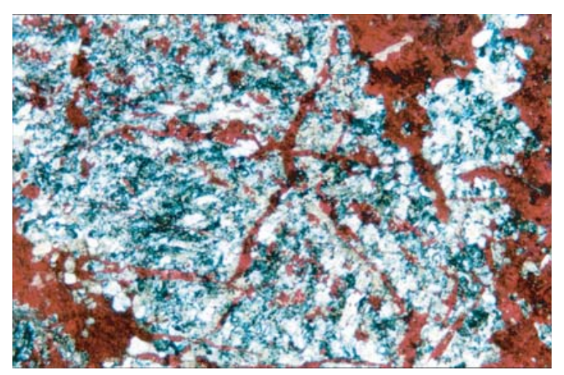

9797.5 2 mm thick calcite vein is offset by imbricate fractures with thinner fills

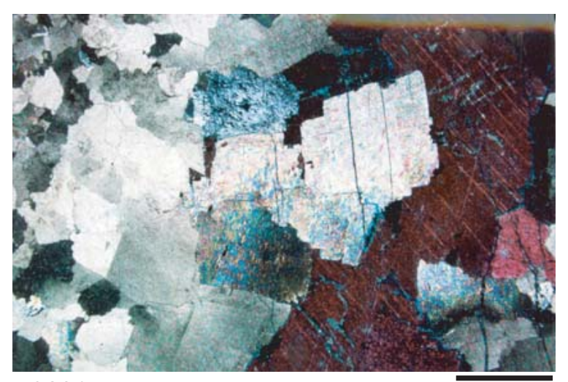

9800.5 Bitumen or organic matter both predates and is interspersed with calcite cement in fractures


9812: Only minor mineralization in marl limestone facies


9816: marl limestone


9821.5: Completely dolomitized packstone

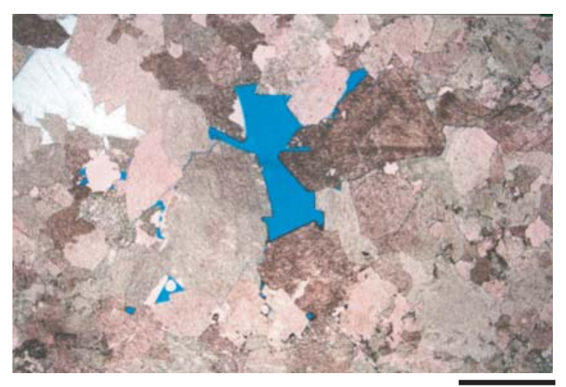

9811 Chert and calcite fill void


9820 Saddle dolomite and calcite fill vein in medium dolomite rock


9830: Matrix dolomite with minor bitumen


9833.5: Matrix dolomite with minor bitumen


9835: Dolomite with minor fractures


9820 Porosity in saddle dolomite filled void

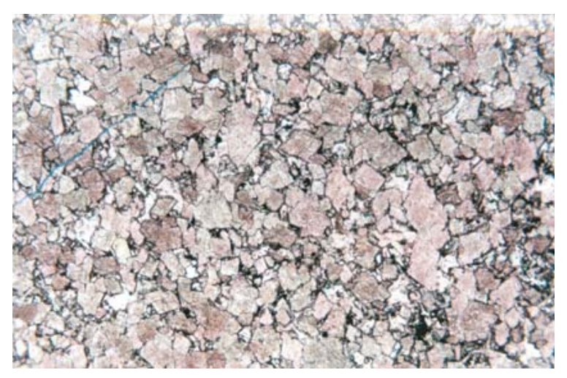

9829 Bitumen in fracture and intercrystalline porosity

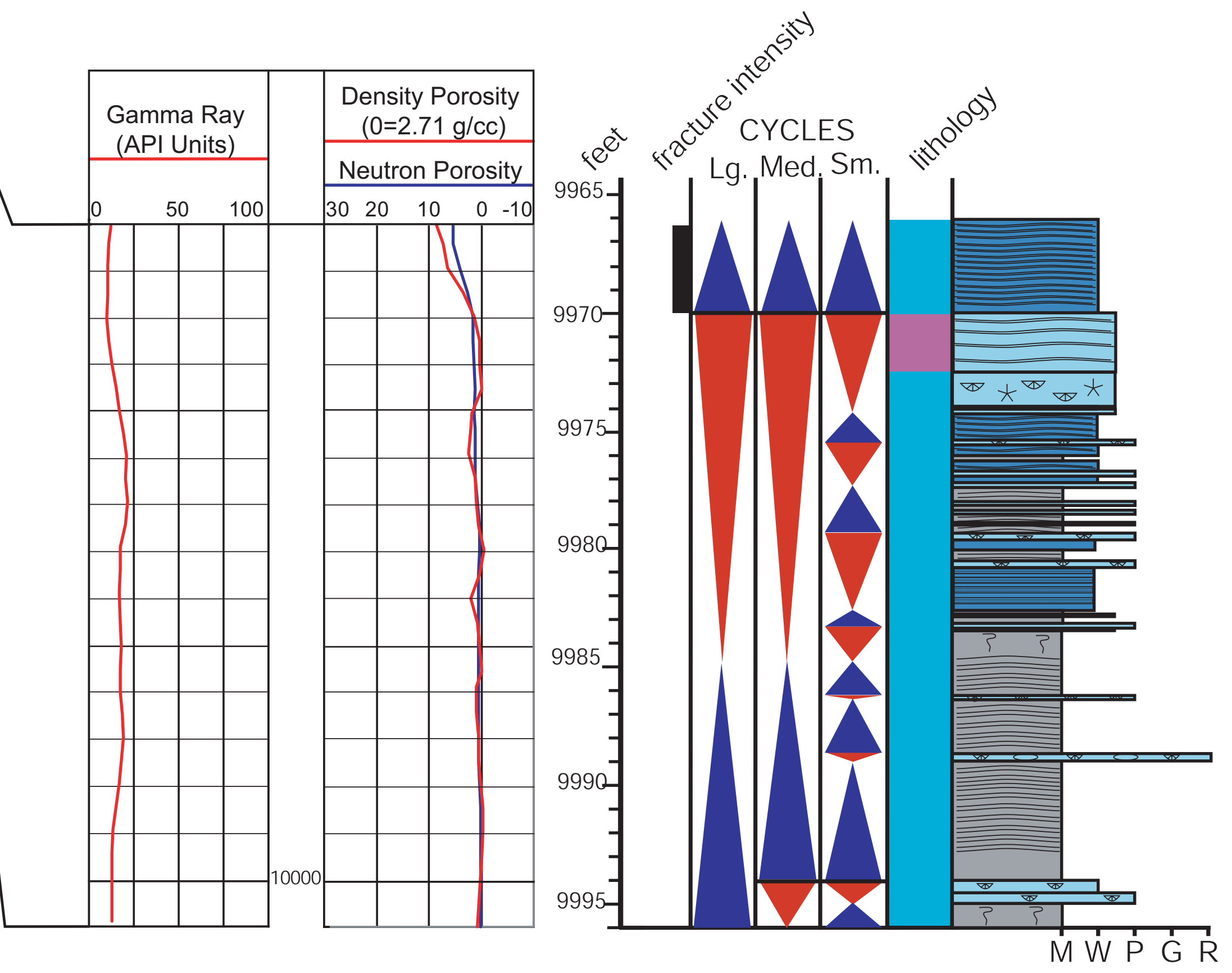

9837.5: Matrix dolomite with a few saddle and chert filled fractures


9842: Matrix dolomite with stylolite


9847: Matrix dolomite with stylolite


9843.5 Dolomite filled fracture crosscuts stylolite suggest some dolomite postdates compaction


9845 Bitumen plugs intercrystalline porosity



-packstone with fine calcisiltite lams

-microfaults and calcite fill vertical fractures
-Dolomite destroys original fabric

-whole brachs, crinoids

-wispy solution seams
-coarse brachs

-closely spaced calcisiltite beds (50-50)

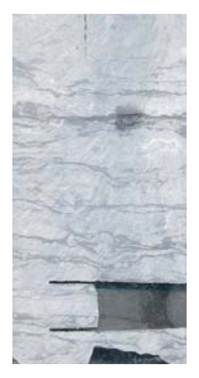
-calcisiltite bands every 6" in pkst/wkst

-calcisiltite beds dip in multiple directions (solution seams?)
thin bed w/brachs

-storm bed with intraclasts and brachs

-wispy lams of shale or calcisiltite in dark mudstone
-hardgrounds at base of calcisiltite lams?
-wispy patches of fine grained grst
-burrows 5 mm across filled w/coarser material.


9966: Lime wackestone with clay wisps


9981: Lime mudstone with clay wisps


9982.7: storm bedded skeletal packstone and arg. mudstone


9873 Odd fracture fill in mudstone


9981 Trilobite and other fossil debris interlaminated skeletal packstone and wackestone


9988: Lime mudstone with clay wisps


9994: Lime mudstone with clay wisps


9995: Lime mudstone with clay wisps


9995 Bitumen in stylolites


9995 Skeletal packstone lamination bounded by stylolites

Sequence and cycle picks are tentative, based only on one core. Further work is necessary before fully establishing a sequence stratigraphic hierarchy.

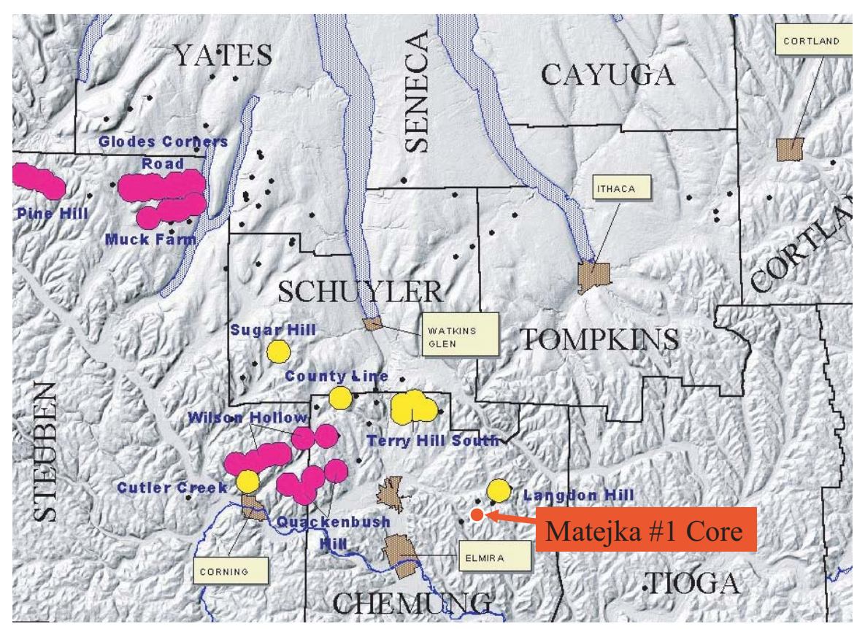
Sequences boundary just below Trenton/Black River boundary occurs at base of transgressive lag conglomerate. Progressive deepening occurs and host rock changes from dolomitized grainstone to packstone, to wackestone to interbedded shale and dark mudstone in maximum flooding interval.

Based on this one core, dolomitized zones occur where the neutron porosity log reads more porosity than the density log. Zones where the density porosity = the neutron porosity are dominantly limestone. The biggest porosity kicks are in brecciated zones that have some open fracture and vuggy porosity in limestone hosts with calcite and less commonly saddle dolomite and quartz cement filling voids.

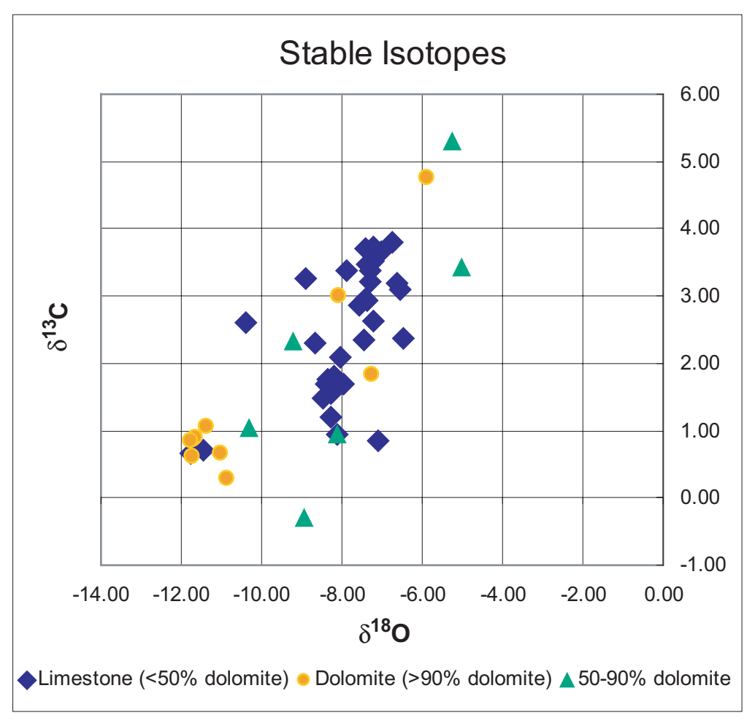
▨ Fenestral lime mudstone (tidal flat)
▨ Grainstone/packstone (high-energy marine)
▨ Skeletal packstone/wackestone (foreshoal)
▨ Calcisiltite (tempestite deposits)
▨ Dark lime mudstone (anaerobic deep shelf)
▨ Fissile fossiliferous black shale (deep shelf)

Bryozoans
Brachiopods
Intraclasts
Chert
Stylolites
Burrows

Wavy Lams
Fenestrae
Boundary
Decreasing Accommodation
MFS
Increasing Accommodation
Boundary



● Producing Well ● Discovery Well Modified from Sanford, 2001

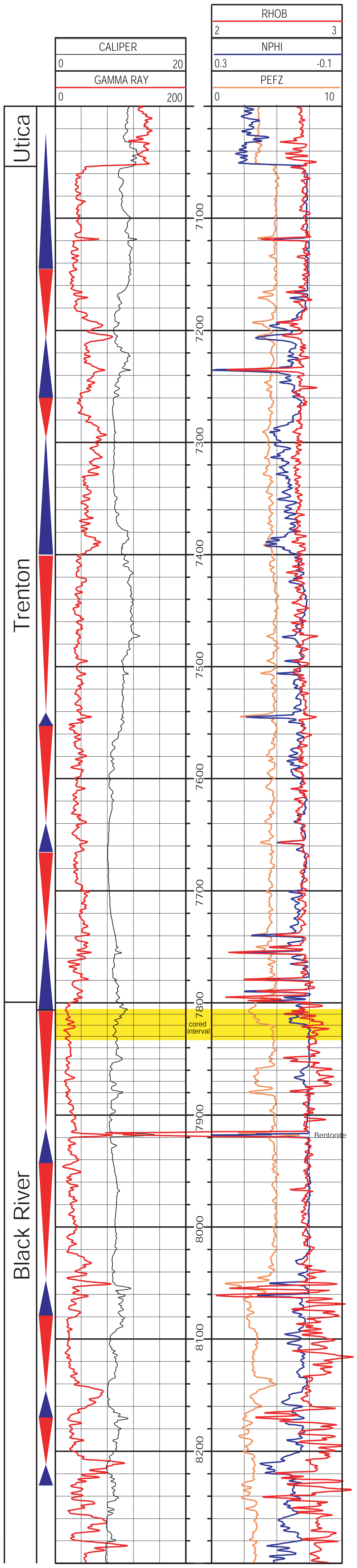


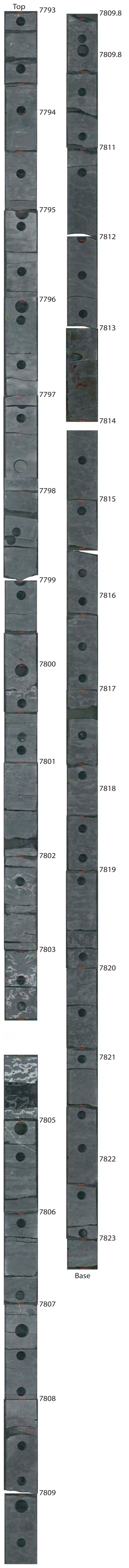
Most dolomite is lighter with respect to carbon and oxygen than limestone. This supports a hydrothermal origin for the dolomite.

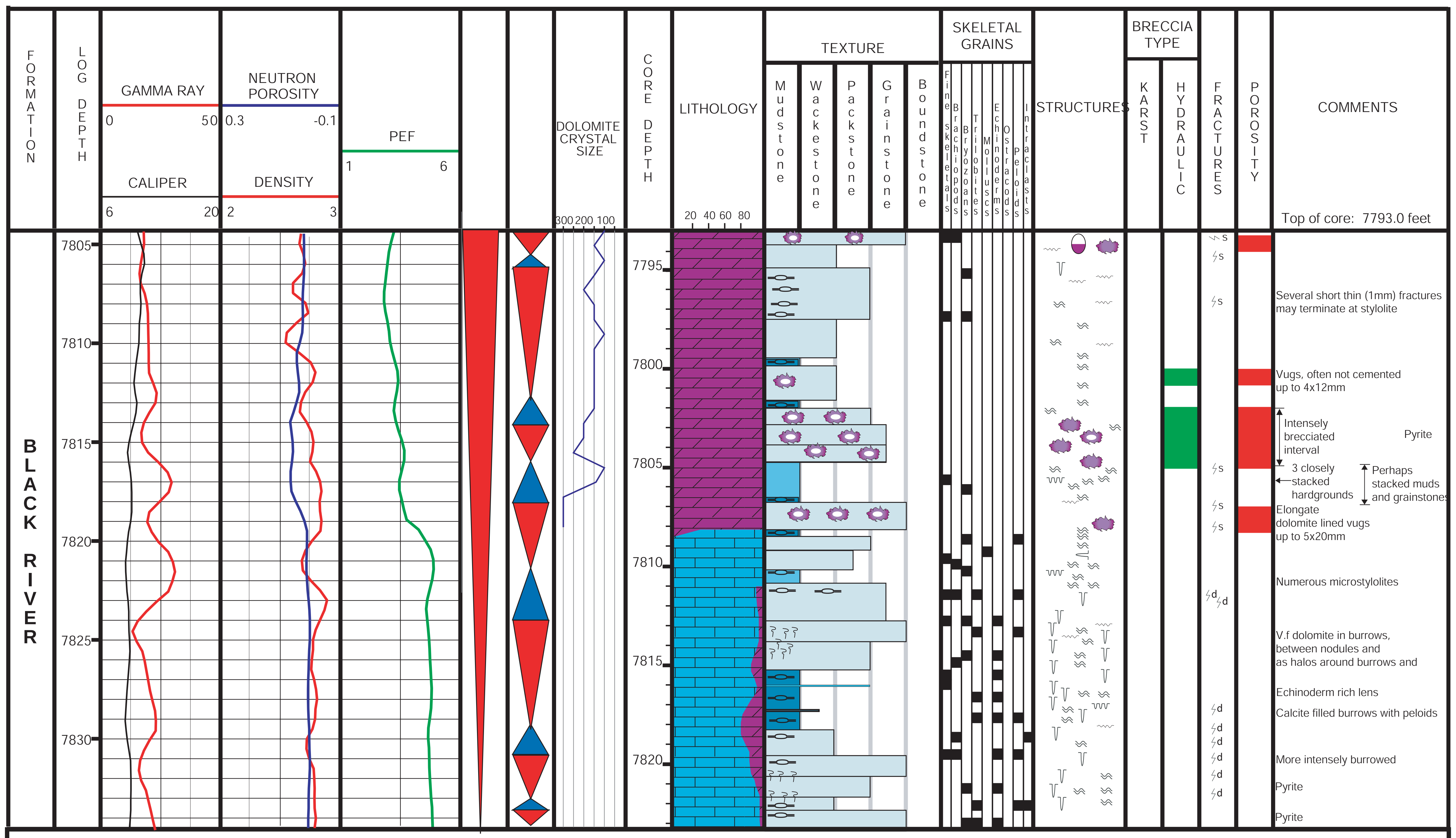
L. B. Smith, 2002, Reservoir Characterization Group, New York State Museum, Room 3140 CEC, Albany, NY 12230 Phone: 518-486-2161 Email: Lsmith@mail.nysed.gov

Plate 17 - Gray # 624468

Steuben County, New York







LITHOLOGY

▦ Limestone

▨ Dolomite

ROCK TYPES

▢ Skeletal peloidal grainstone and packstone

■ Mudstone

■ Mudstone with common clay drapes

STRUCTURES

◒ Dolomite geopetal cement

✹ Saddle dolomite filled vug

⌁s Horizontal, saddle dolomite filled fracture

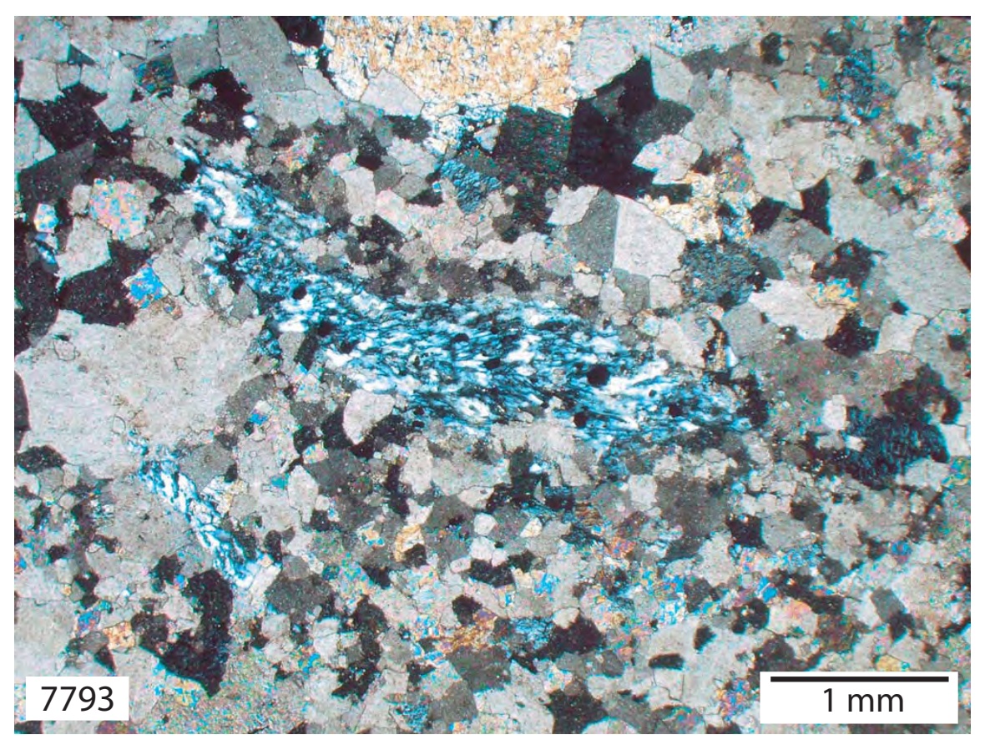
⚡s Vertical, saddle dolomite filled fracture

⚡d Dolomite filled fracture

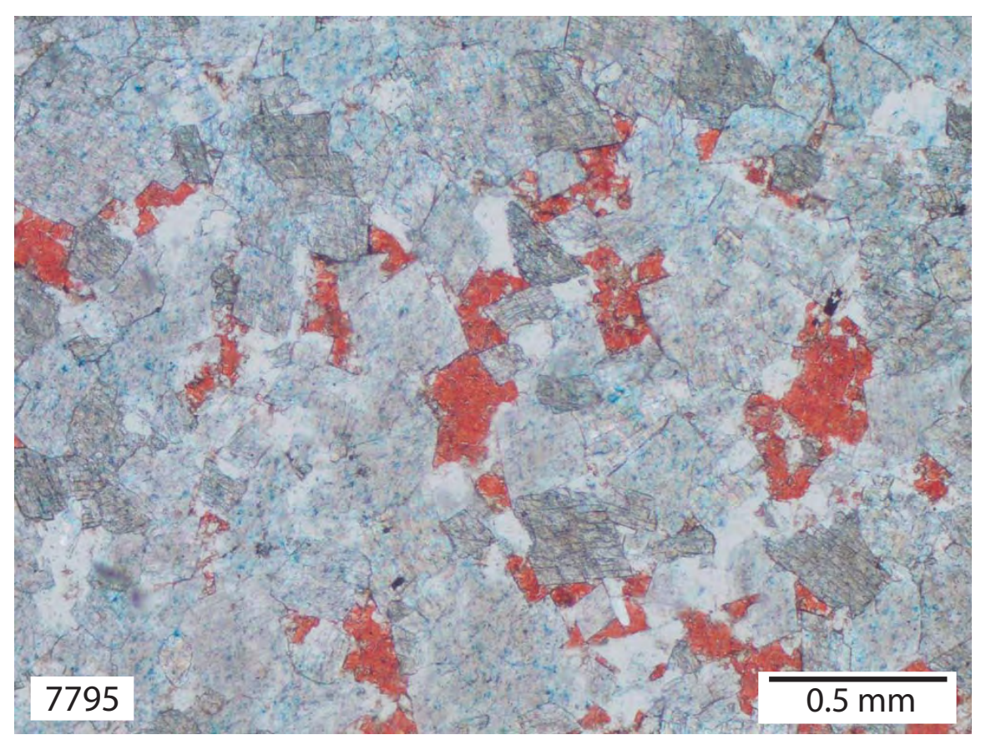
Ɣ Burrow

〰 Stylolite

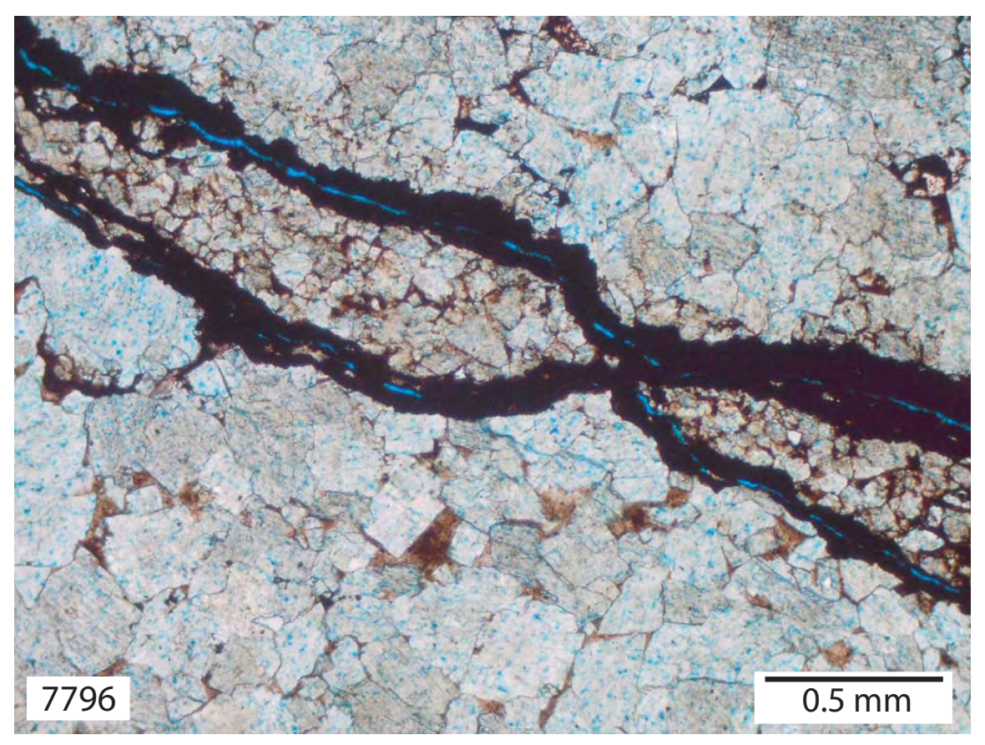
ᴡᴡ Hardground



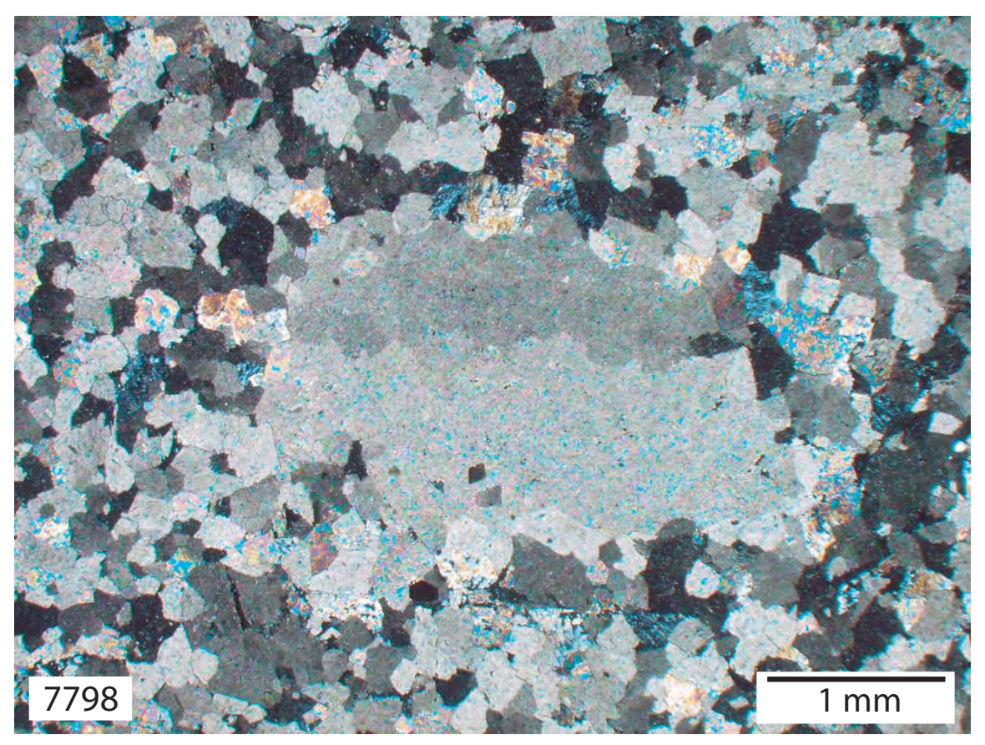
Dolomite with chert plugging elongate pores. Crossed nichols.



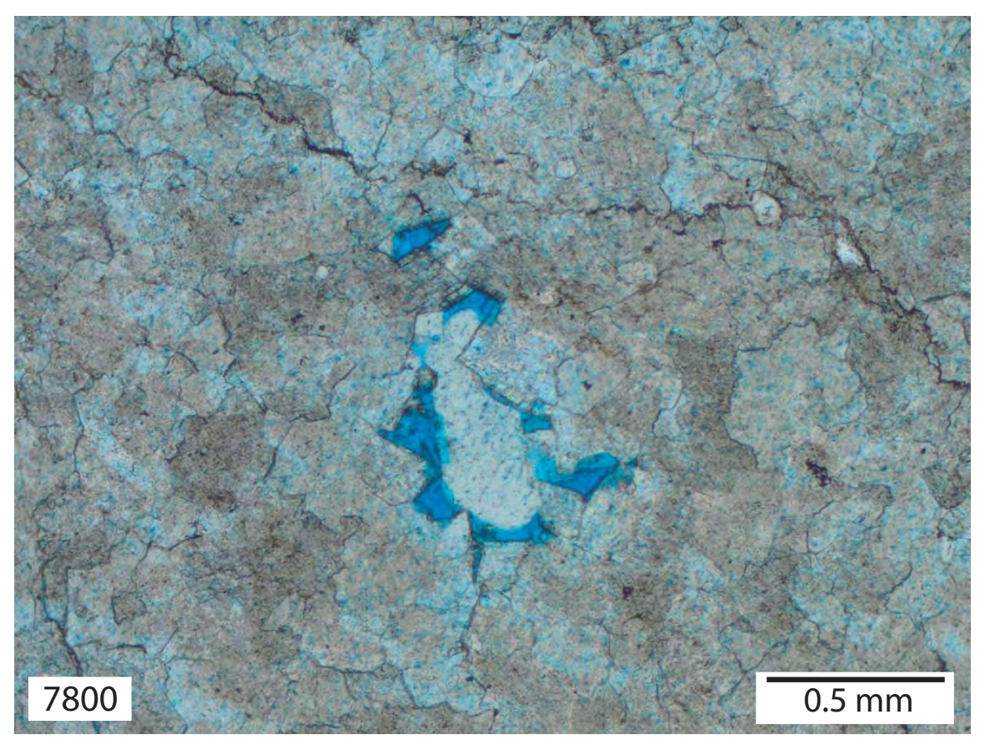
Coarse ferroan dolomite with calcite cement (red) plugging all porosity.



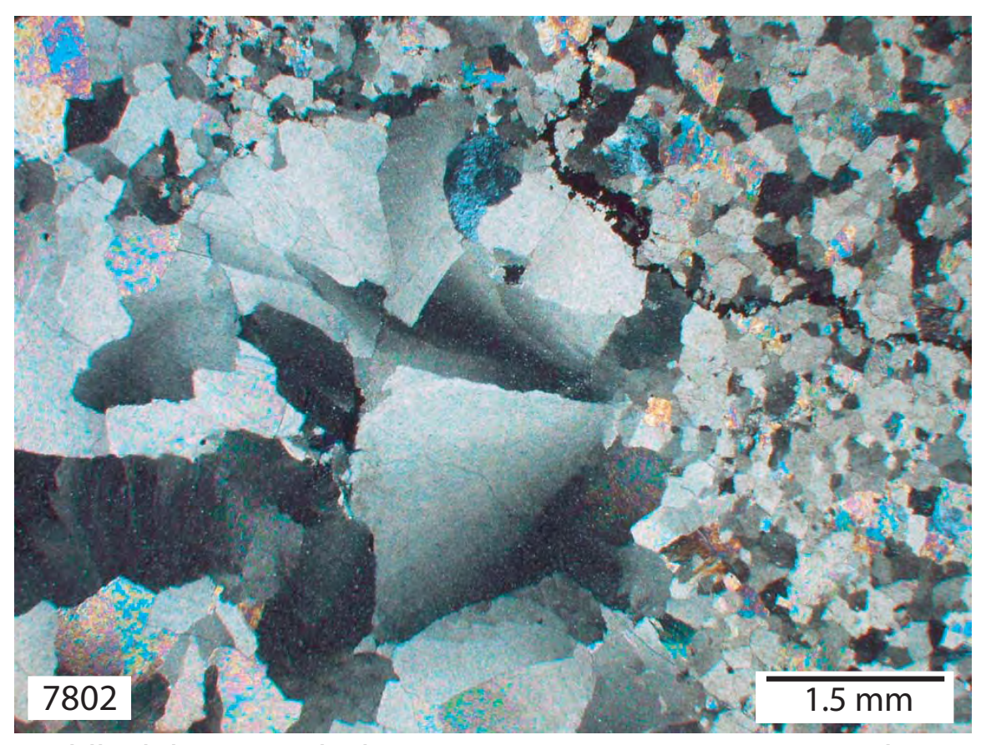
Clay drapes (black) in dolomite are sedimentological features, not stylolites. Minor visible porosity would not be open at depth.



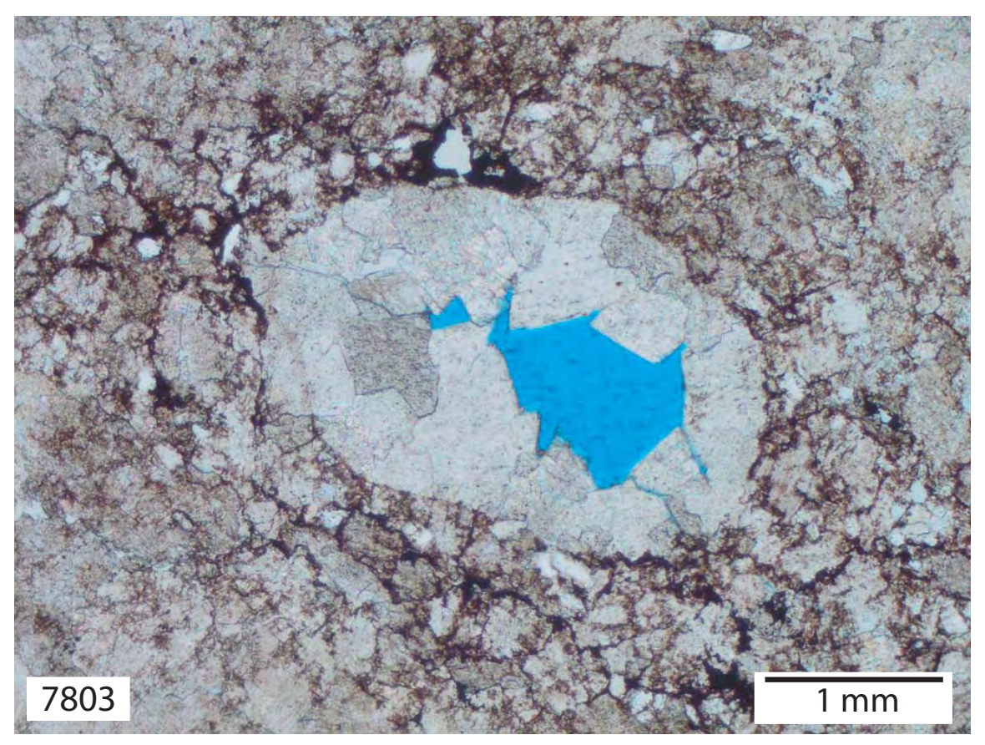
Large crystal of dolomite in center is a replaced echinoderm. This dolomite is completely tight (overdolomitized).



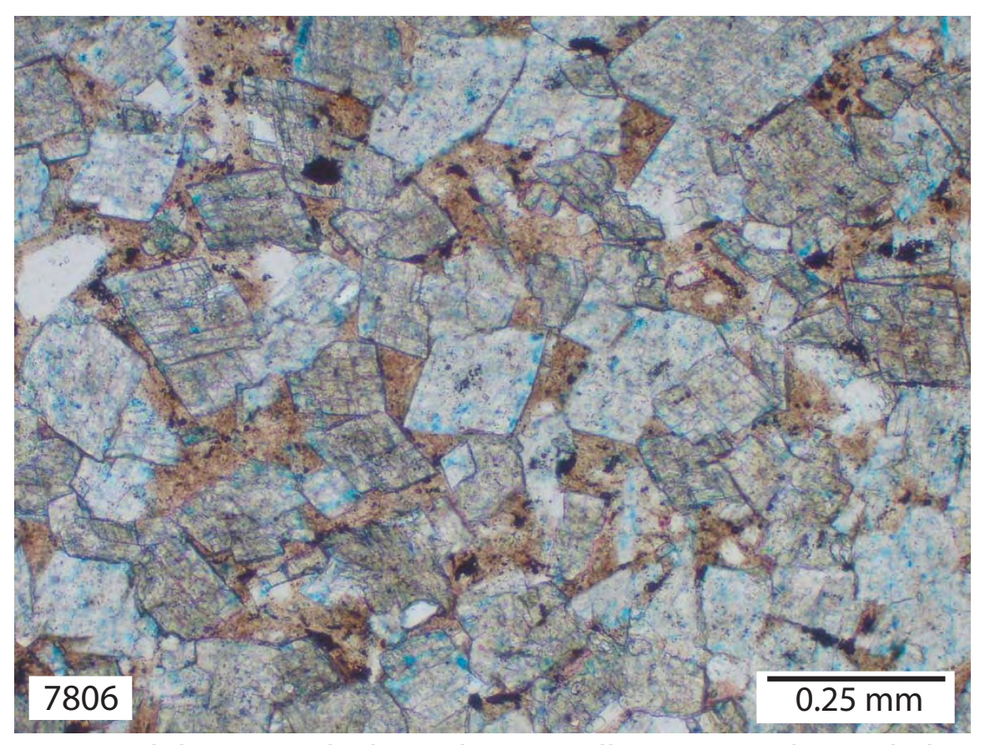
Pore is only partially filled with blue epoxy suggesting that it is not well connected.



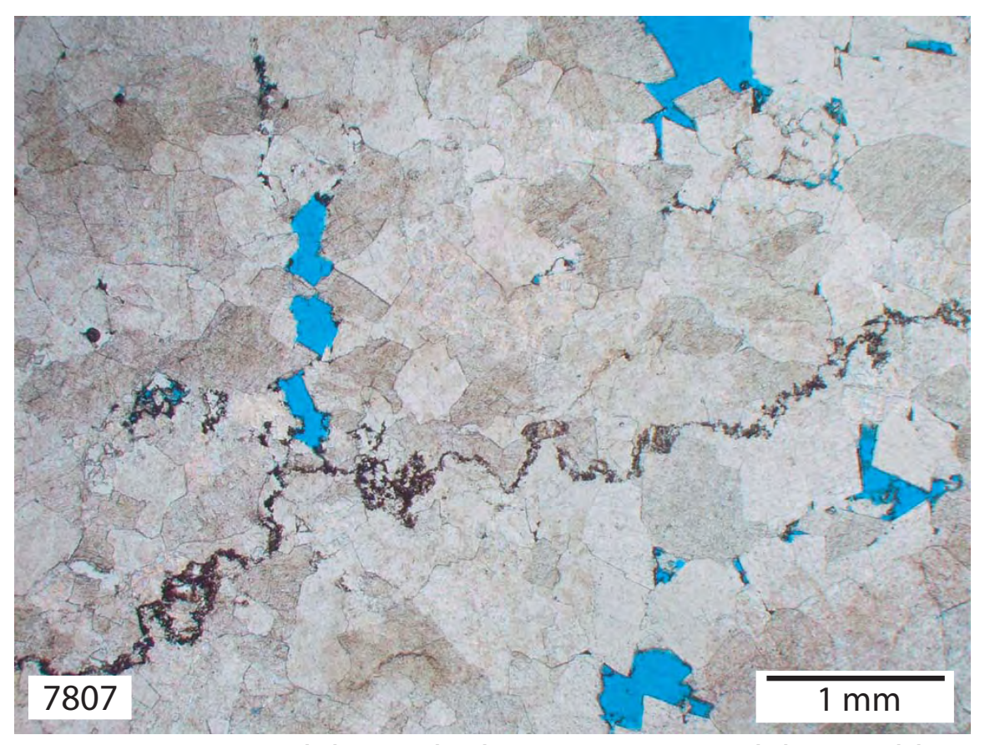
Saddle dolomite with characteristic sweeping extinction where one side of crystal is dark and the other side is light. Saddle dolomite is common in vugs and fractures.



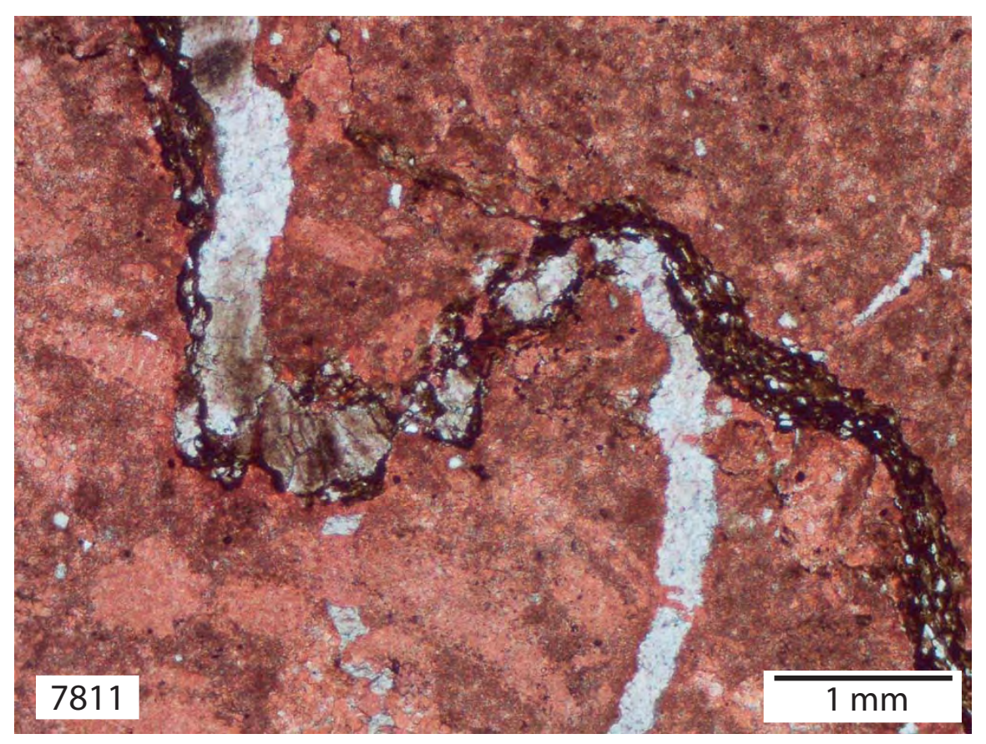
Coarse dolomite partially fills burrow. This porosity is isolated and probably would not flow gas.



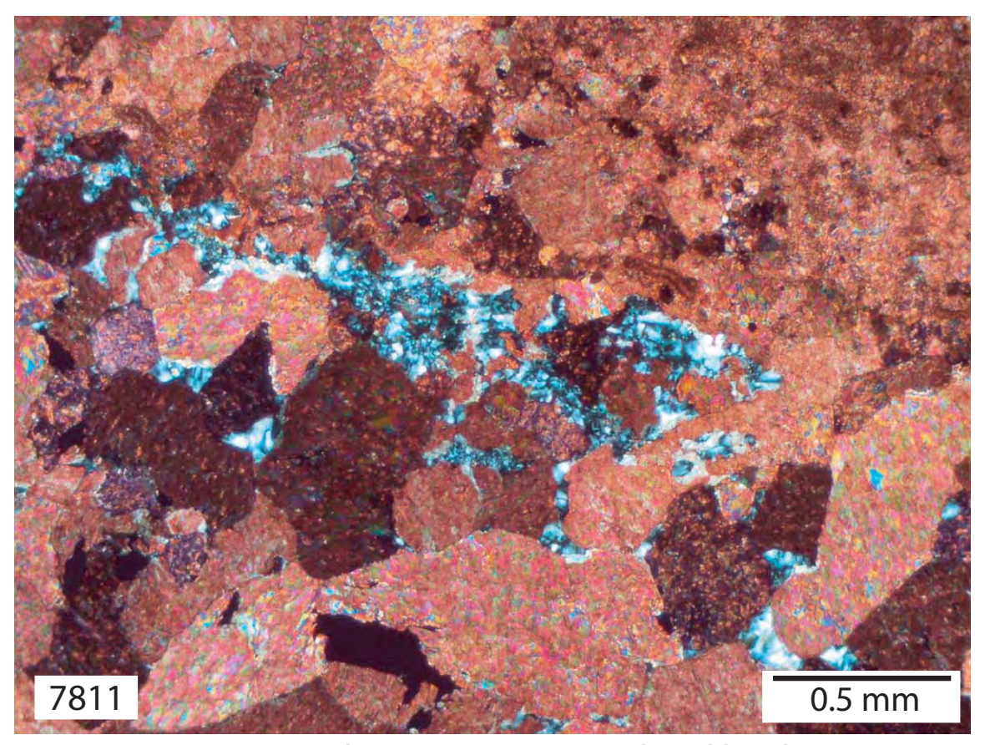
Ferroan dolomite with chert plugging all porosity. Chert is light brown in color. Abundant chert could cause density shift toward less dense values.



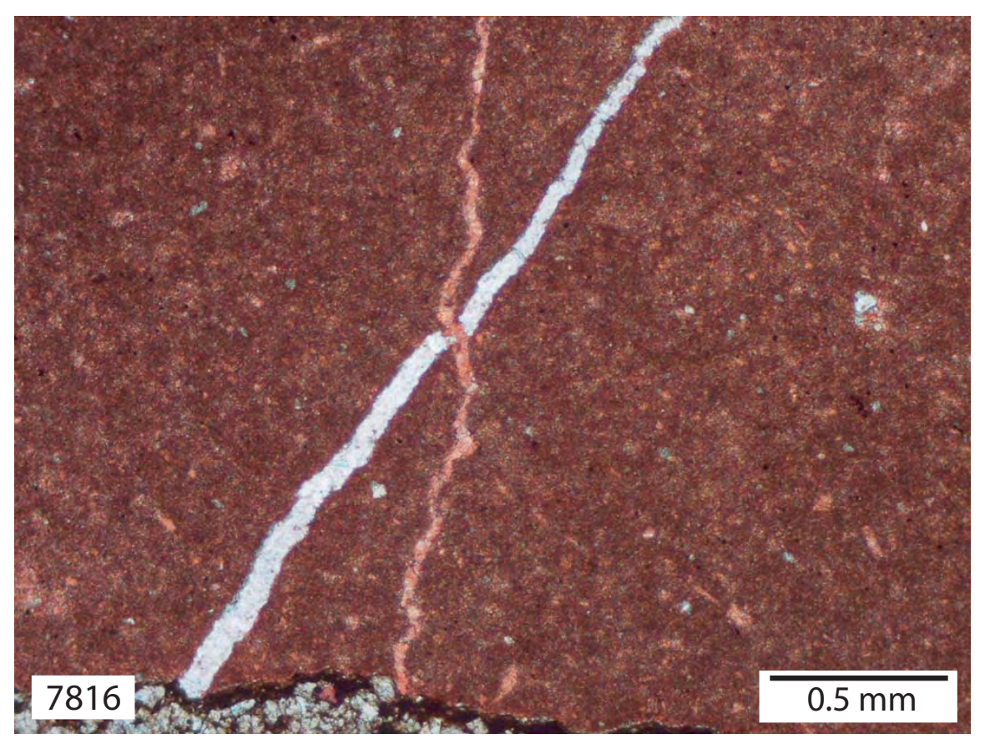
Porosity in coarse dolomite looks more connected than moldic porosity above, but still may be mostly isolated.



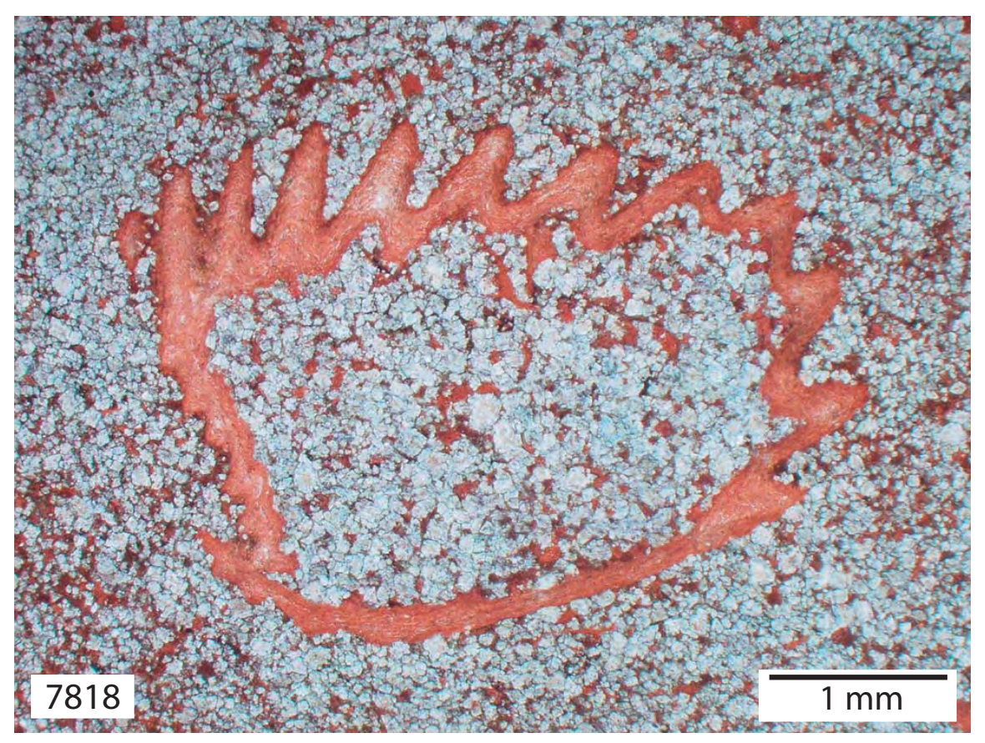
Dolomite-filled fracture in limestone appears to be offset at stylolite. Stylolite appears to have formed at clay drape.



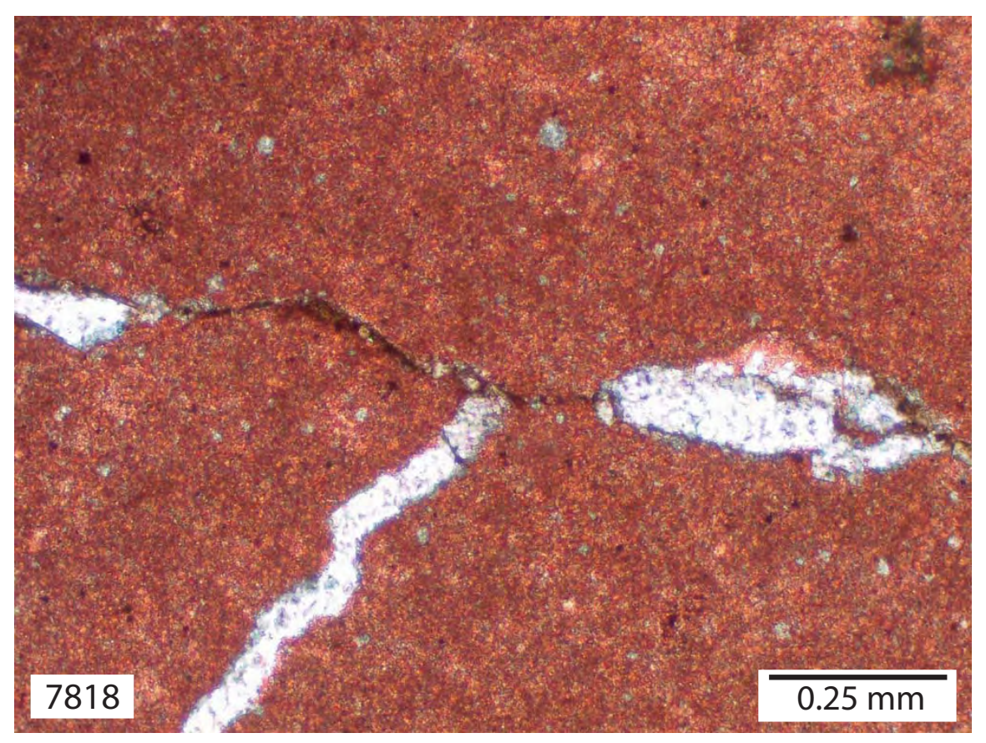
Very coarse calcite cement is postdated by chert.



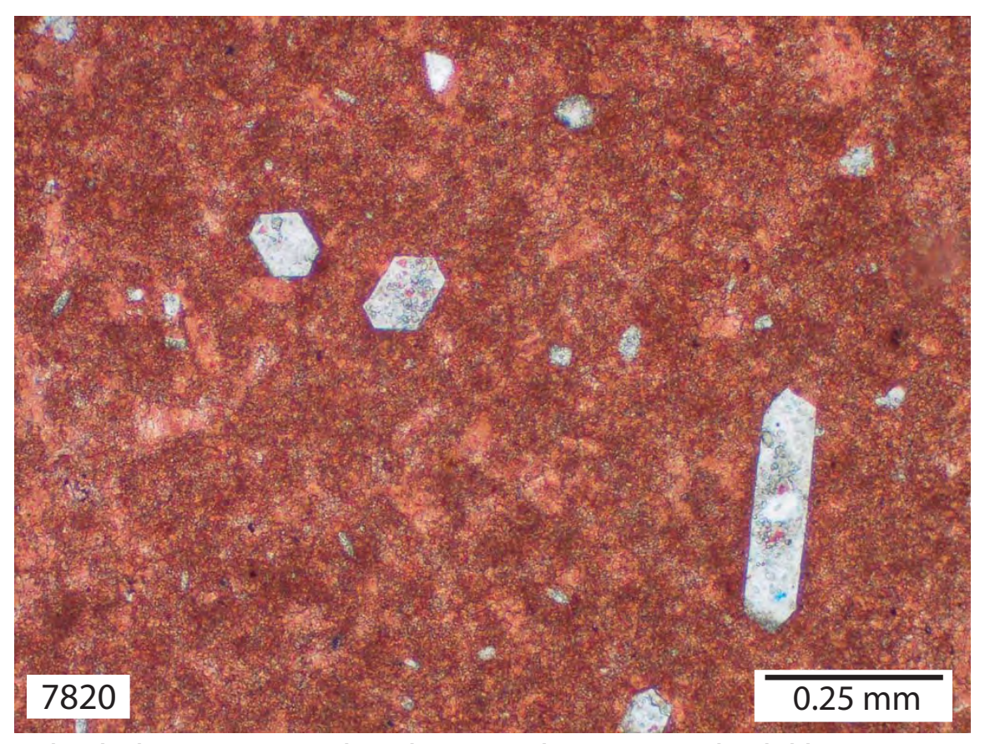
Dolomite filled fracture is clearly offset and postdated by calcite filled fracture. Both terminate against stylolite.



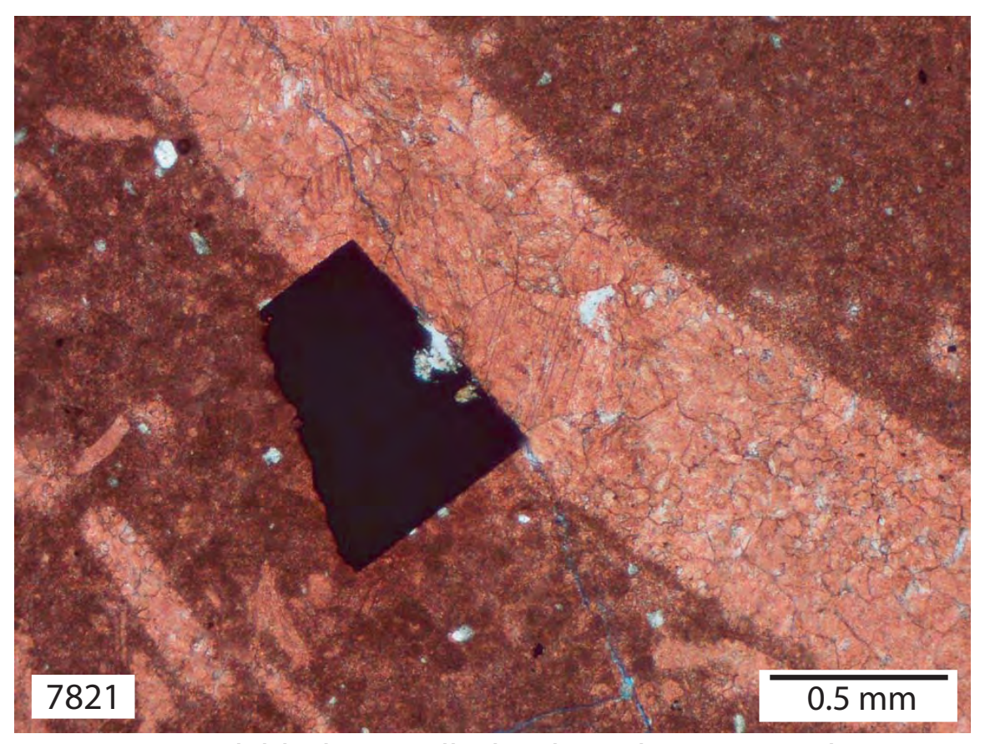
Fossil fragment composed of low-mg calcite remains after rock has been mostly dolomitized.



Dolomite fills fractures and pores in lime mudstone.



Euhedral quartz crystals in lime mudstone or peloidal limestone. These crystals formed during burial and are not detrital.



Pyrite crystal (black) in mollusk rich wackestone/mudstone. Mollusks are lighter colored and made of calcite spar.

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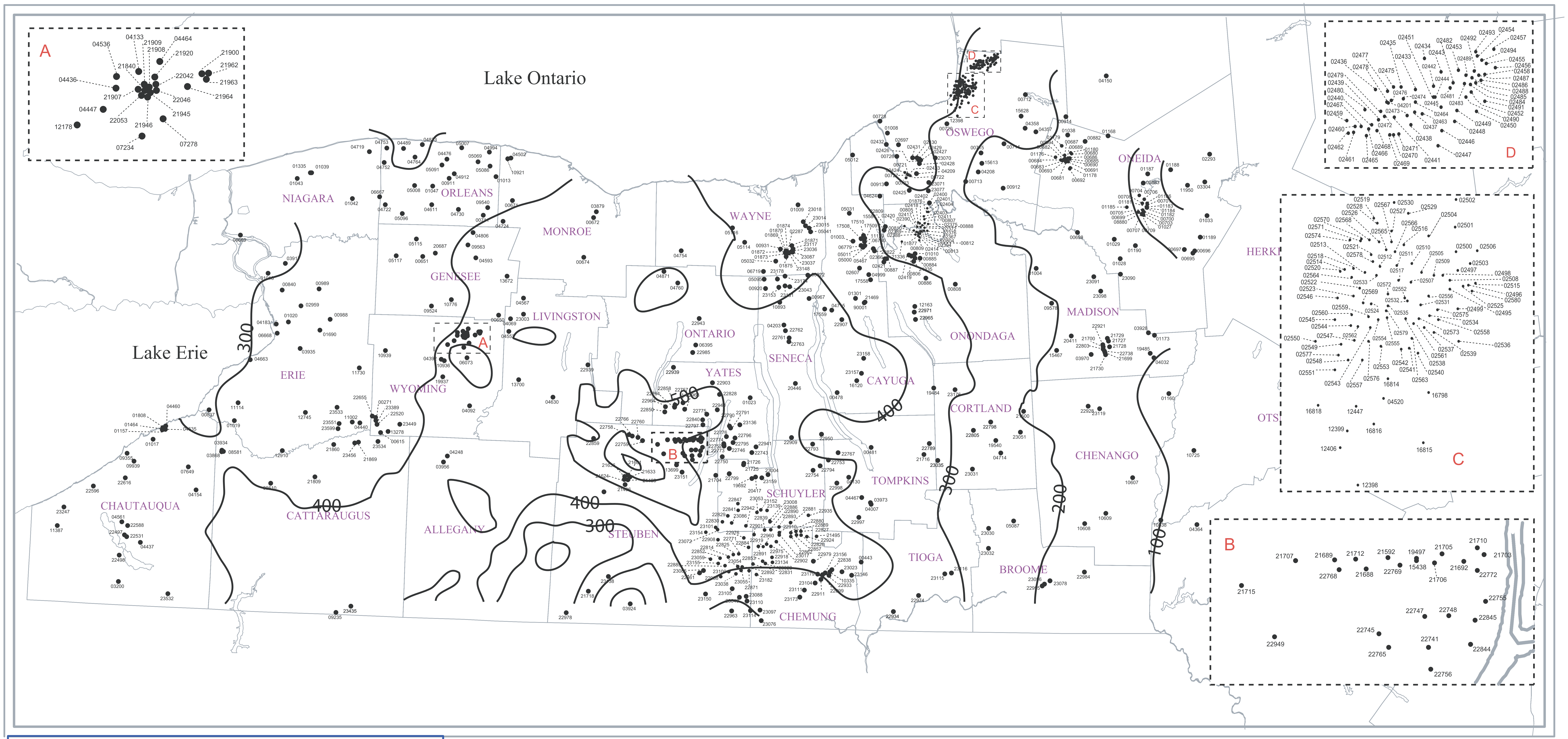


Plate 18 Black River Isopachous Map.

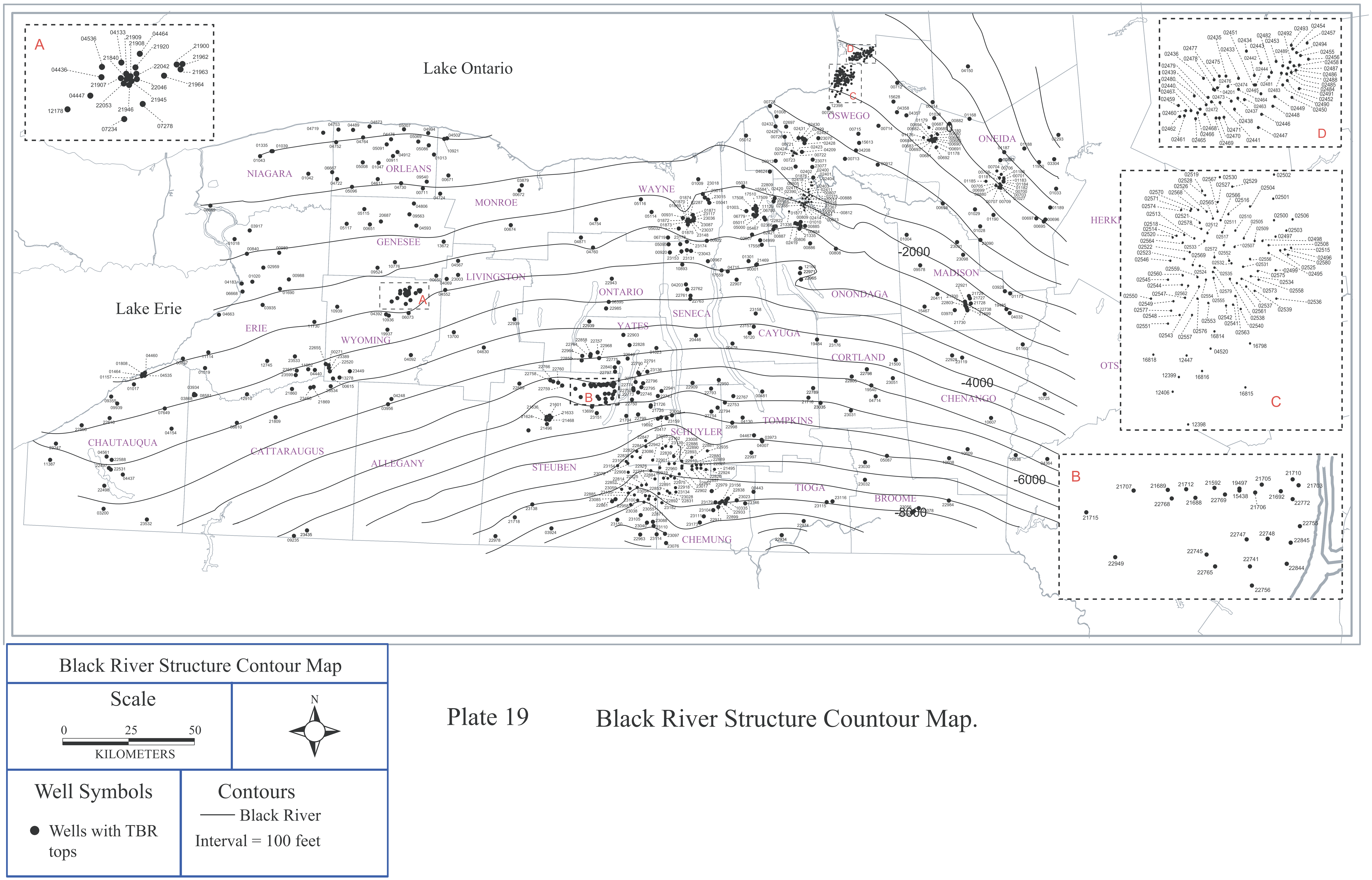


Plate 19 Black River Structure Countour Map.

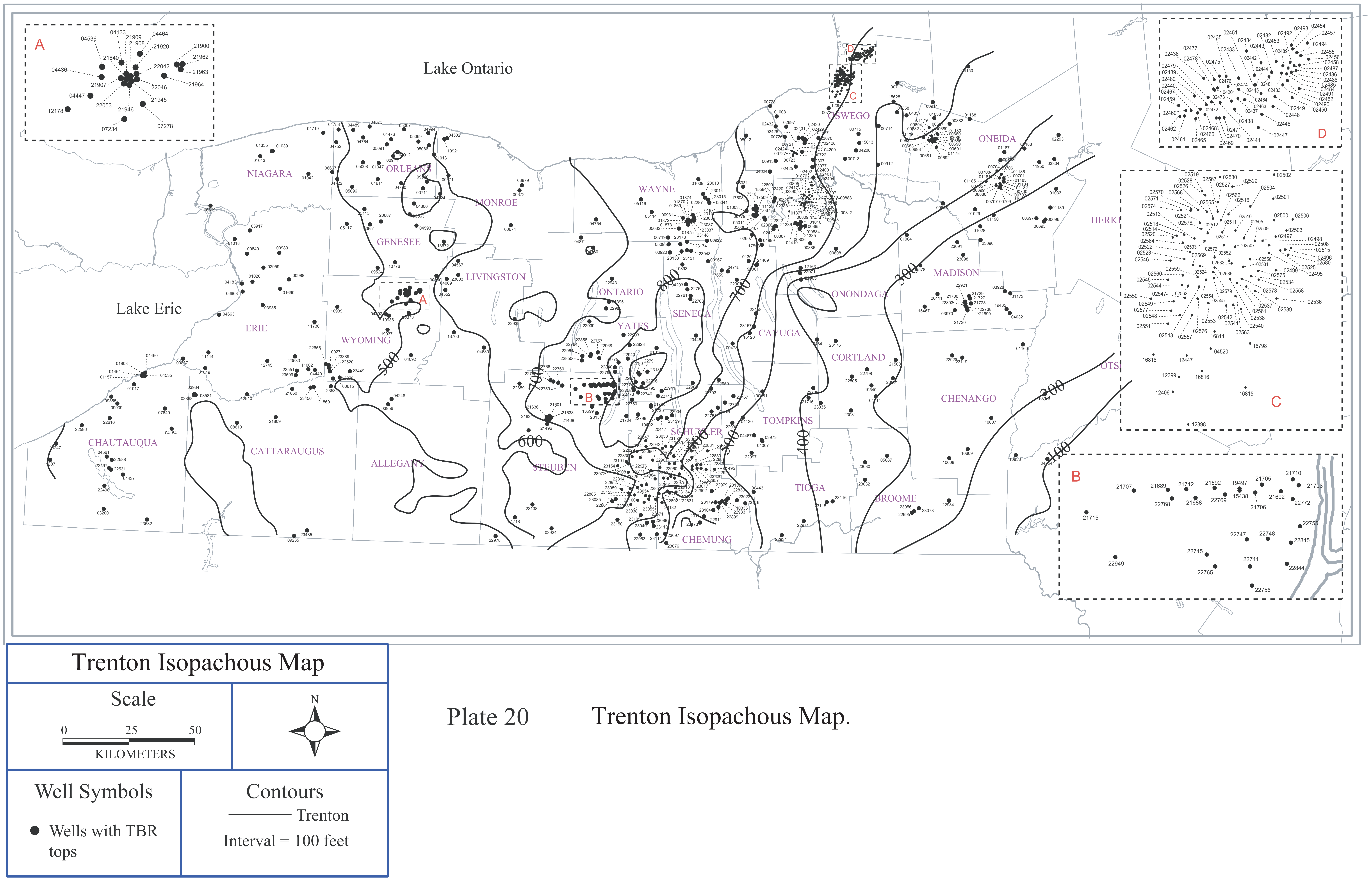
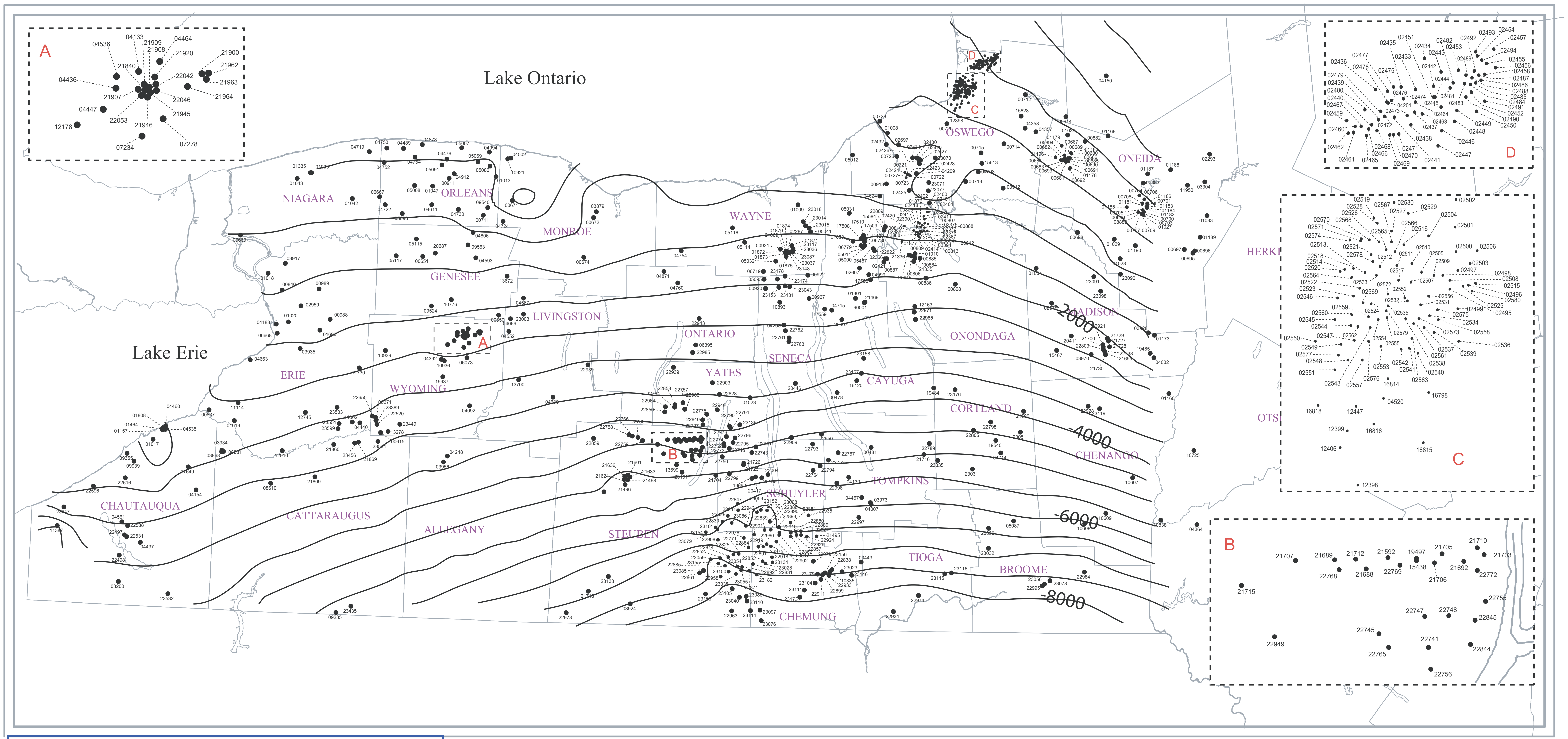


Plate 20 Trenton Isopachous Map.



Trenton Structure Contour Map

Scale

0 25 50

KILOMETERS

N

Well Symbols

● Wells with TBR tops

Contours

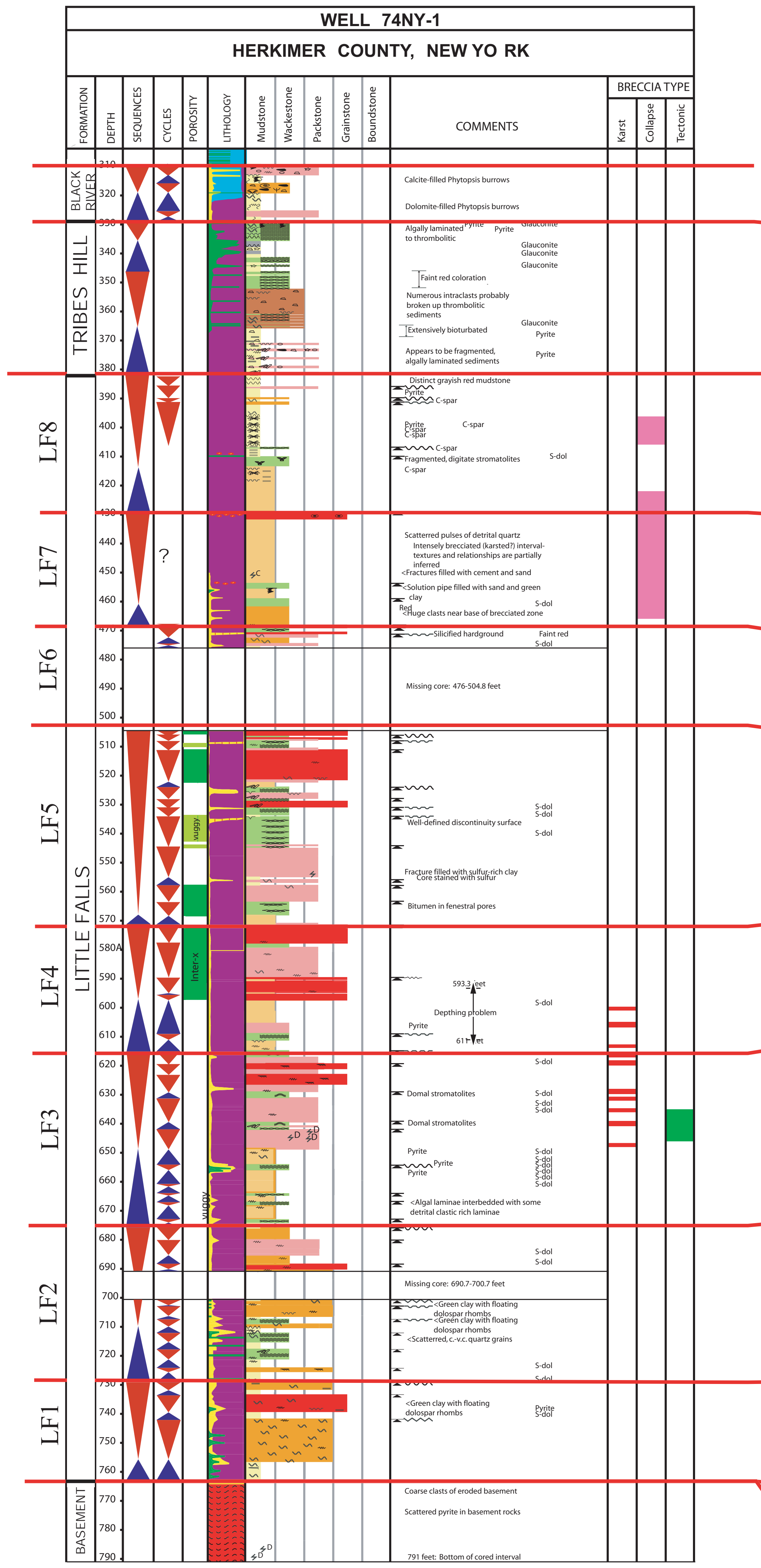
—— Trenton

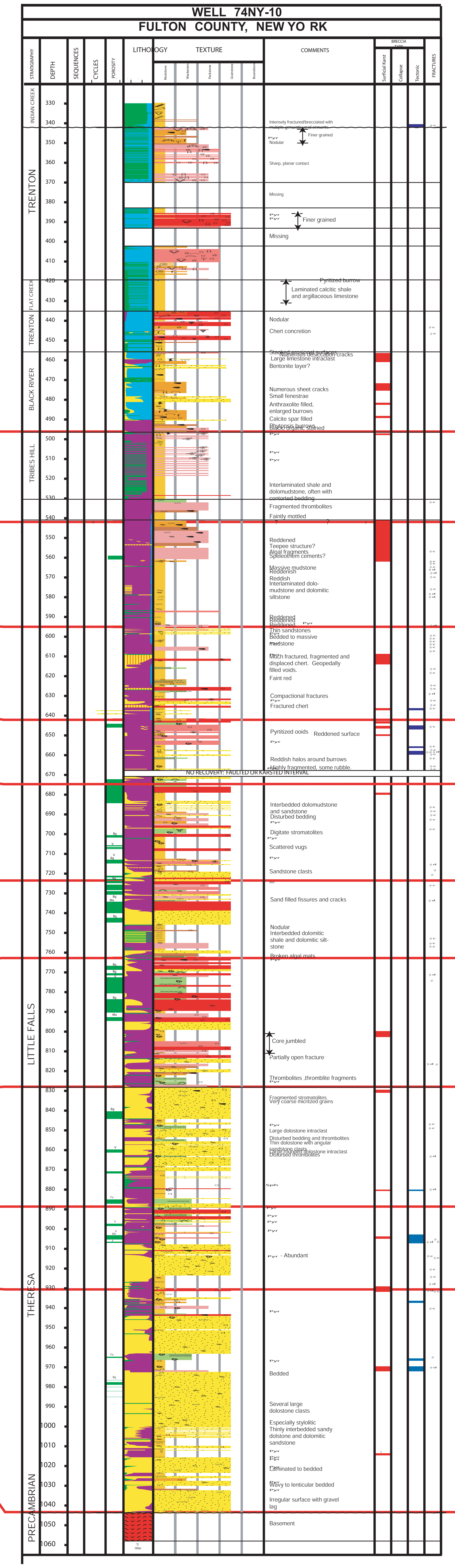
Interval = 500 feet

Plate 21 Trenton Structure Countour Map.

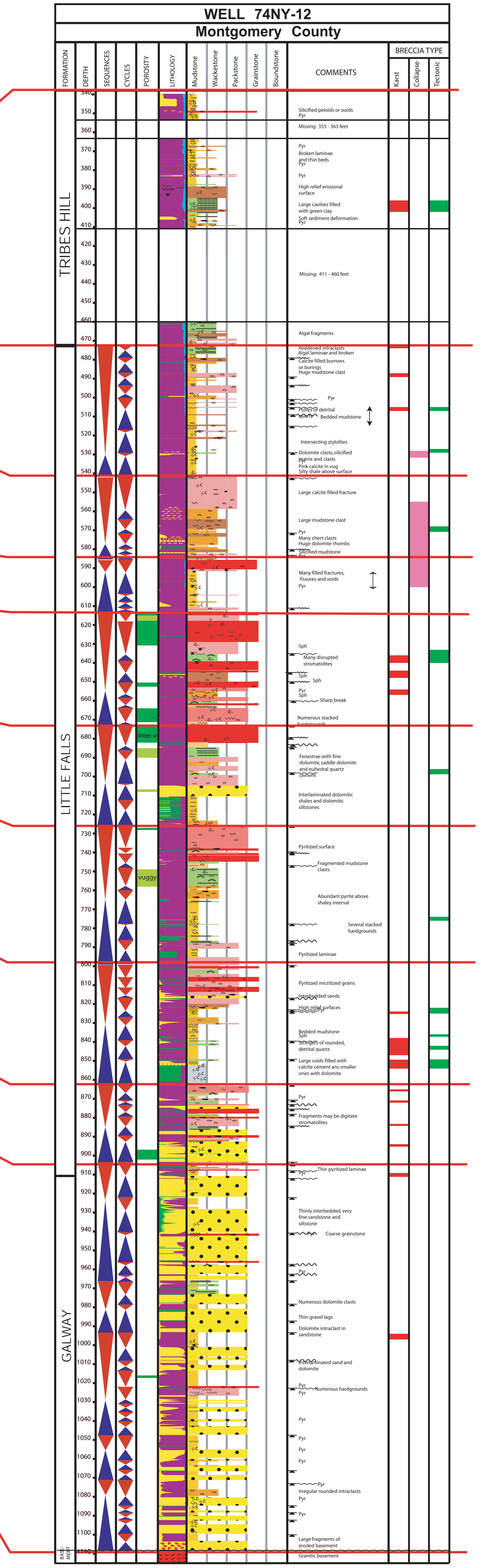
Beekmantown Sequence Stratigraphic Correlation, Mohawk Valley, New York State

WEST





EAST



Legend

🟦	Limestone		Laminated stromatolites
🟪	Dolostone		Fenestral fabric
🟨	Sandstone/sand		Thrombolitic fabric
🟩	Shale/clay		Domal stromatolites
▨	Chert		Digitate stromatolites
▼	SB		Edgewise conglomerates
	Regressive	⊙	Ooids
	MFS	△	Intraclasts
▲	Transgressive		Hardground
	SB		Undulatory surface
			Cross bedding
			Mud cracks
			Stylolites
			Microstylolites
			Laminae
			Fracture
			Solution pipe
			"Crackle" breccia
			Horizontal burrow
			Vertical burrow
		C-spar	Calcite spar
		S-dol	Saddle dolomite

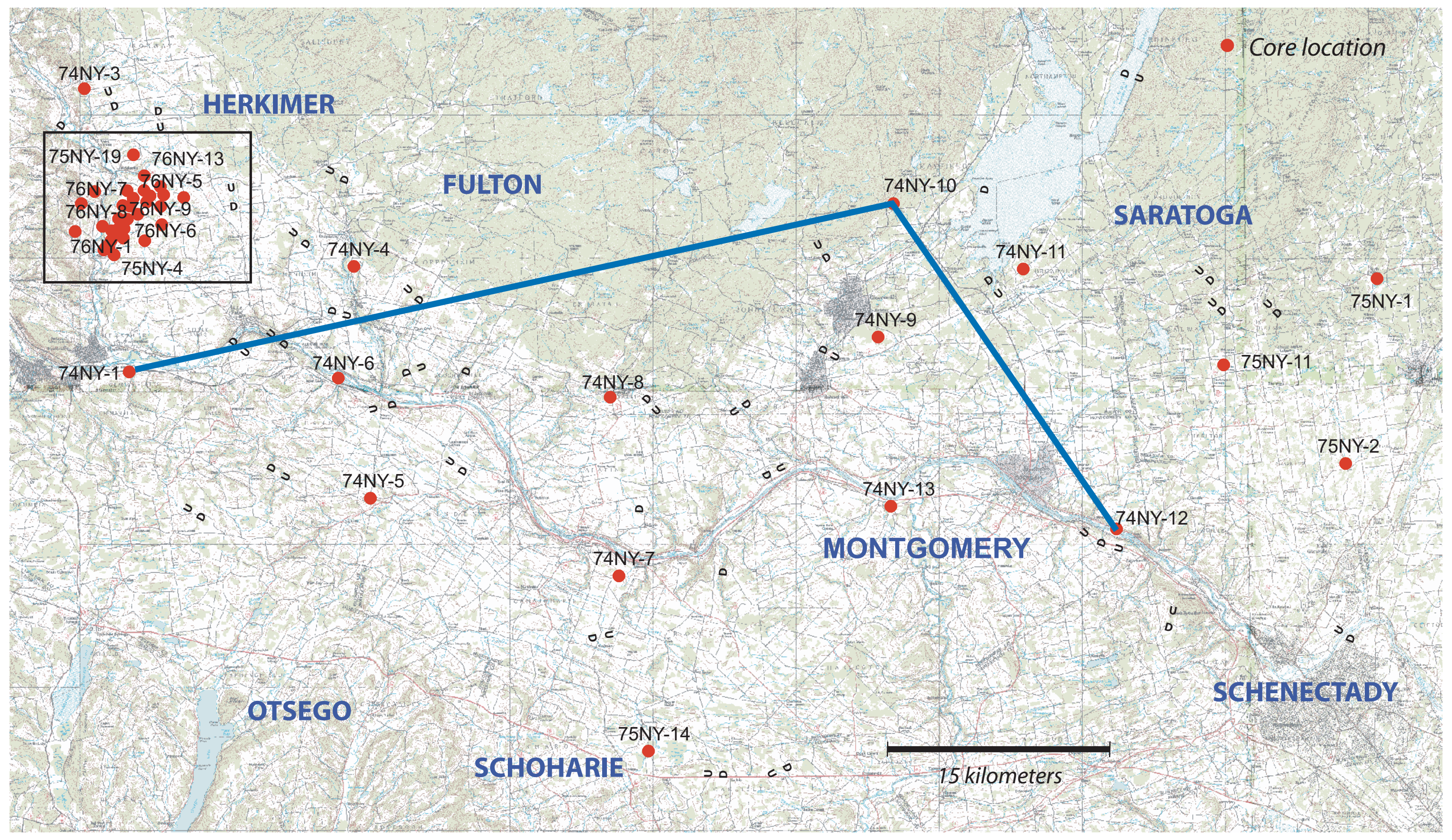


Plate 22

Correlation figure for the Beekmantown Sequence in the Mohawk Valley of New York State. The best porosity zones occur in sequences LF 4 and LF 5 at both sections which strongly suggests good lateral extent to reservoir facies.

Plate 23 Section G-G"
Beekmantown Group

East-West Mohawk Valley - Central New York

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