

**U.S. DEPARTMENT OF THE INTERIOR  
U.S. GEOLOGICAL SURVEY**

Thermal maturity patterns (CAI and %R<sub>o</sub>) in the Ordovician and Devonian  
rocks of the Appalachian basin in New York State

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Open-File Report 00-496

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.

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## INTRODUCTION

The classic study by Epstein and others (1977), using conodont alteration index (CAI) isograds, is the established standard for evaluating thermal maturity patterns of lower and middle Paleozoic rocks and associated oil and gas accumulation in the Appalachian basin. Maps from the Epstein and others (1977) and Harris and others (1978) studies show basin wide thermal maturity patterns for the Ordovician, Silurian through Middle Devonian, and Upper Devonian through Mississippian. Despite the value of these maps, they have a strong bias toward outcrop samples and, in many parts of the basin, CAI isograds have been extrapolated several hundreds of miles without being constrained by subsurface control points. Wandrey and others (1997) converted the CAI isograds of Harris and others (1978) to vitrinite reflectance equivalents (VTE) for the Ordovician of the central Appalachian basin; however, few new data points were added. Also, several vitrinite reflectance (%R<sub>o</sub>) maps are available for evaluating thermal maturity patterns in the Appalachian basin but they are limited to smaller areas than the CAI-based maps. Among the best examples of these vitrinite reflectance maps are those of Upper Devonian black shale units by Streib (1981) and Boswell (1996) and of Pennsylvanian coal beds by Chyi and others (1987) and Zhang and Davis (1993).

The objective of this study is to enhance existing thermal maturity maps in New York State by establishing: 1) new subsurface CAI data points for the Ordovician and Devonian and 2) new %R<sub>o</sub> and Rock Eval subsurface data points for Middle and Upper Devonian black shale units. The thermal maturity of the Ordovician and Devonian rocks is of major interest because they contain the source for most of the unconventional natural gas resources in the basin. Thermal maturity patterns of the Middle Ordovician

Trenton Group are evaluated here because they closely approximate those of the overlying Ordovician Utica Shale that is believed to be the source rock for the regional oil and gas accumulation in Lower Silurian sandstones (Jenden and others, 1993; Ryder and others, 1998). Improved CAI-based thermal maturity maps of the Ordovician are important to identify areas of optimum gas generation from the Utica Shale and to provide constraints for interpreting the origin of oil and gas in the Lower Silurian regional accumulation, in particular, its basin-centered part (Ryder, 1998). Thermal maturity maps of the Devonian will better constrain burial history-petroleum generation models of the Utica Shale, as well as place limitations on the origin of regional oil and gas accumulation in Upper Devonian sandstone and Middle to Upper Devonian black shale.

New York State is the first area in the Appalachian basin where collecting, processing, and analysis of subsurface drill-hole cuttings and core samples have been completed on a large-scale to recover conodont elements and assign CAI values to them. This investigation was a cooperative effort between the U.S. Geological Survey (USGS) and the New York State Geological Survey. Additional cooperative investigations in Pennsylvania (USGS–Pennsylvania Topographic and Geologic Survey), West Virginia (USGS–West Virginia Geological Survey) and Ohio (USGS–Ohio Division of Geological Survey), are at various stages of completion.

## **METHODOLOGY**

Drill-hole cuttings (n=106) and selected cores (n=3) were collected by one of us (R.N.) at the New York State Geological Survey's sample storage facility in Albany.

Sixty drill holes in 24 counties were sampled. Locations of the wells sampled are shown on figure 1. Where possible, Ordovician and Devonian intervals were collected from the

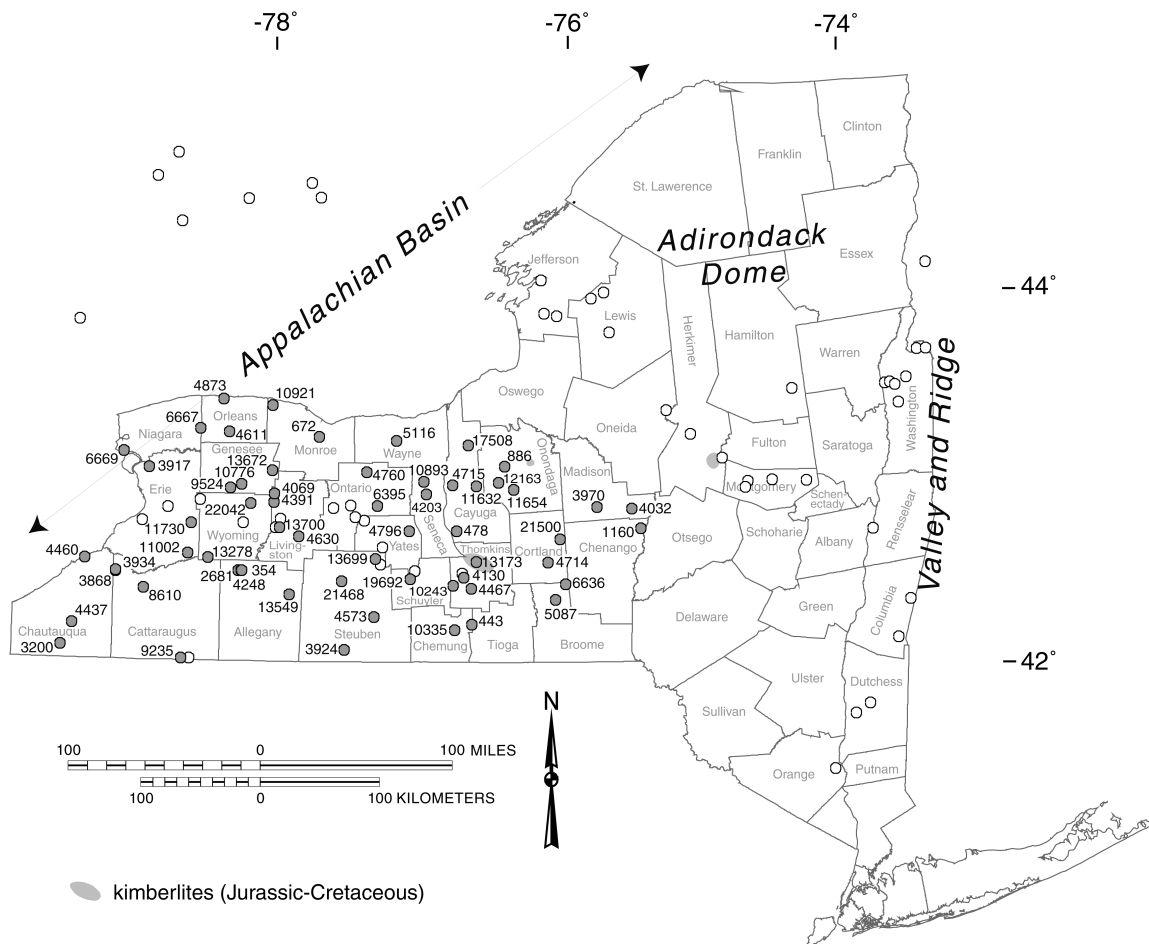


Figure 1. Map of New York showing location of wells (●) and surface localities sampled (○) in this study. Wells labeled with American Petroleum Institute (API) suffix numbers. Surface sample data from Harris and others (1978). Location of kimberlites shown because they are discussed later.

same drill hole (well). The total collection (n=109) consists of: 1) carbonate (limestone) samples from the Middle Ordovician Trenton Group (n=43), 2) carbonate (chiefly limestone and calcareous shale) samples from selected Devonian units (n=44), and 3) black shale samples primarily from the Middle Devonian Marcellus Shale (n=22). Each sample weighed about 100 g and consisted of rock fragments >20 mesh. Most samples were composites from 50 to 200 ft of stratigraphic section. The carbonate samples were sent to the USGS in Reston, Virginia, where they were processed and analyzed for conodonts. Devonian black shale samples were sent to Humble Geochemical Services<sup>1</sup>, Humble, Texas where they were processed and analyzed for total organic carbon (TOC), Rock Eval parameters, and vitrinite reflectance.

Conodonts recovered were visually compared with a set of conodont color standards provided by A.G. Harris of the U.S. Geological Survey and assigned a CAI value. Samples exhibiting a range of CAI values were assigned a minimum and maximum value. Since variations in CAI within a sample can be caused by very local hydrothermal alteration, the CAI minimum value was assumed to most accurately reflect regional thermal effects, as per Epstein and others (1977) and Rejebian and others (1987), and was the value used for the succeeding maps (figs. 4-7). The conodont samples are repositied in the collections of the U.S. Geological Survey and filed under Cambrian-Ordovician (CO) or Silurian-Devonian (SD) collection numbers (see tables 1 and 2).

The maps, figs. 1 and 4-8, were constructed by plotting points in ARC/INFO over a digital base map, using latitude/longitude coordinates from the New York State

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<sup>1</sup> Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

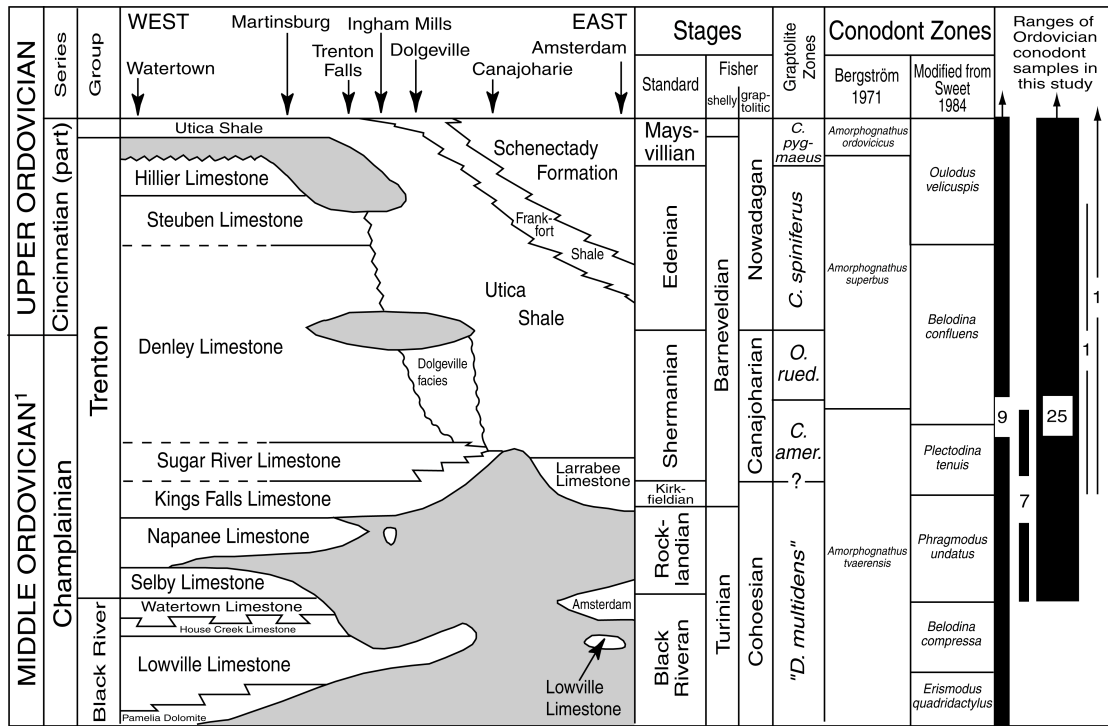
Geological Survey well database. The points were then attributed with American Petroleum Institute (API) numbers and minimum and maximum CAI values. Data points and CAI isograd contours from Harris and others (1978) were captured by scanning and georegistering the maps, then tracing and attributing the points and lines in ARC/INFO. The coverages were then projected to State Plane Projection and exported to ARCVIEW version 3.1 for ease of manipulation and graphic display.

## **RESULTS**

### **STRATIGRAPHY OF SAMPLED INTERVALS**

All Ordovician samples used in this study were identified on well logs by the New York Geological Survey as Trenton Group, with no subdivision. No attempt was made to identify any of the samples to formational level. All 43 carbonate samples from the Trenton Group yielded conodonts, in absolute abundances ranging from 1 element fragment up to 136 elements. Ranges of conodont species recovered indicate that all of the samples are consistent with the age of the Trenton Group, with 36 samples not necessarily restricted to the Trenton, and 7 samples restricted to that range (fig. 2). Table 1 contains detailed species composition, abundance, biostratigraphic position, and other data from the conodont collections recovered.

Devonian samples were selected from various carbonate units, predominantly in the Upper Devonian. Where Upper Devonian samples were not available or were ambiguous, samples were taken in Middle or Lower Devonian carbonates. Twenty-five of the 44 carbonate samples from the Devonian yielded conodonts, in absolute abundances ranging from 1 element fragment up to 262 elements. Recovered conodont species indicate ages ranging from Late Silurian/Early Devonian to late Devonian. A single sample



<sup>1</sup>Due to the recent decision of the International Commission on Stratigraphy (Webby, 1998), the entire Black River and Trenton Groups would now be considered Upper Ordovician. We follow the traditional Series assignments here to be consistent with longtime usage.

Figure 2. Stratigraphic relationships of the Black River and Trenton Groups in New York with ranges of conodont sample collections recovered in this study. Numbers in black bars indicate number of samples representing each range, total = 43. Stratigraphy from Bergström (1986, Fig. 2)

is possibly Late Silurian in age (Table 2, USGS sample number 12703-SD) but was retained in the Devonian sample set, as the CAI value from it is consistent with those from neighboring samples. Figure 3 illustrates the numbers, successful conodont yield, and approximate position within the regional stratigraphy of samples in the Devonian set. Table 2 contains detailed species composition, abundance, biostratigraphic position, and other data from the conodont collections recovered.





## **THERMAL MATURITY RESULTS**

### **Ordovician Data Set**

The new CAI data for the Ordovician samples are plotted in figure 4 and contoured as isograds. For comparison, the CAI isograds from Harris and others (1978) are also shown. The earlier data were chiefly from surface collections along the Adirondack Dome to the north and east, the Valley and Ridge rocks in the eastern part of the state, and central Pennsylvania to the south (figure 1), giving little control over the Appalachian basin in central and western New York. CAI isograds in Harris and others (1978) range from 2 in the west to 5 in the east and trend smoothly in a southwest to northeast direction. Although isograds defined from this study approximate those of Harris and others (1978) in eastern and western New York, they differ in central New York, where they are shifted markedly further west by more than 100 km and are more tightly grouped, particularly in the CAI 3 to 4.5 range. This close grouping of isograds reflects a steeper thermal gradient than previously noted by Harris and others (1978). A similarly abrupt east-to-west increase in thermal maturity across New York was noted by Johnsson (1986) in the Middle Devonian Tioga metabentonite using clay-mineral diagenesis and apatite fission-track age data. Moreover, our data show an adjoining relatively low thermal maturity embayment that protrudes southeastward from Herkimer County.

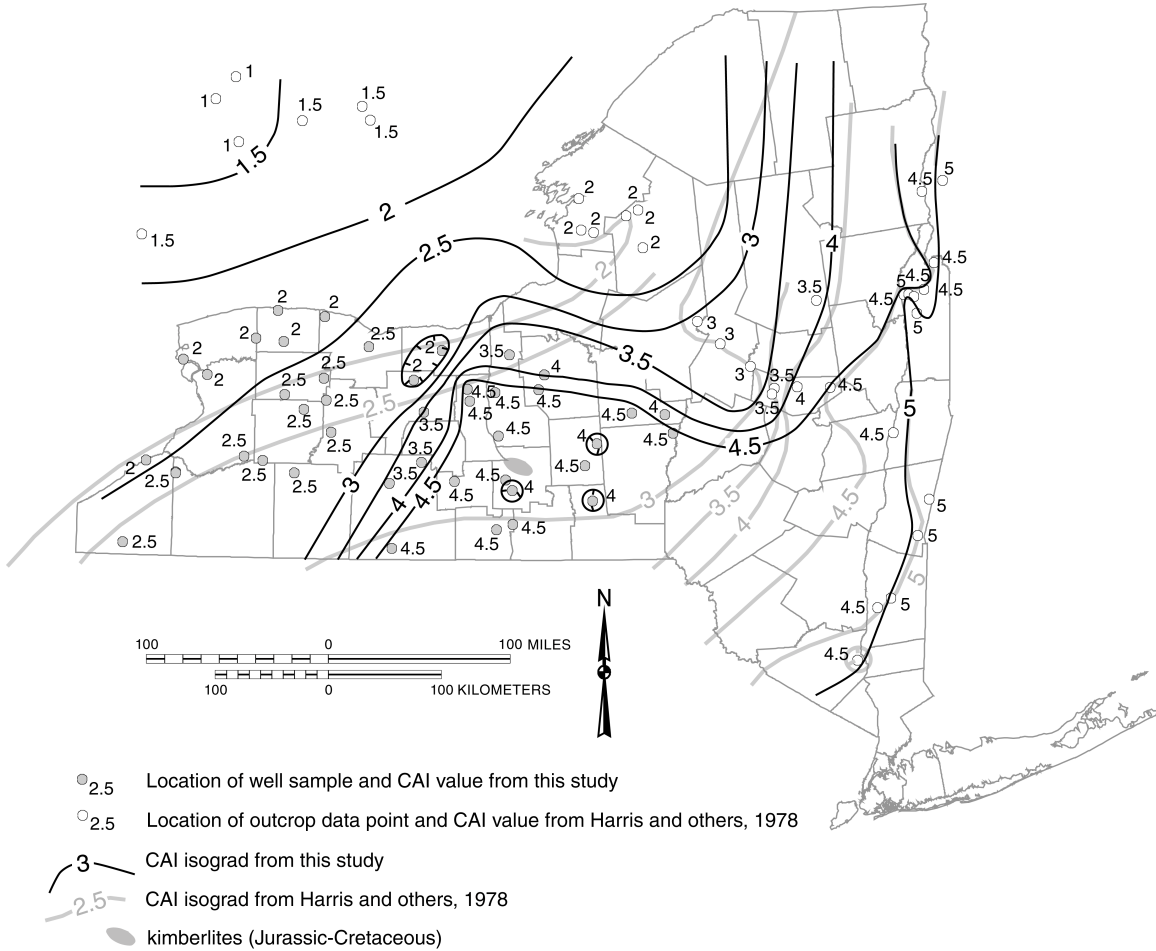


Figure 4. Middle and Upper Ordovician Conodont Alteration Index (CAI) isograds from data used in this study. The CAI isograds are based on data from this study and that of Harris and others (1978)

At first glance this shape in the isograds appears to mimic the isopach contours for Upper and Middle Ordovician clastic rocks, and Silurian carbonate and evaporite rocks in New York (Miller, 1975; de Witt and others, 1975). However, the CAI 3 to 4.5 isograds cut across the isopach at a high angle in west-central New York and CAI 4.5 to 5 isograds are centered over the thinnest isopachs. A better match between isograd and isopach

patterns is achieved with the Middle Ordovician through Permian isopachs (Harris and others, 1978) but even in this situation CAI 3 to 4.5 isograds cut sharply across the isopachs in west-central New York. These comparisons between isograd and isopach patterns in New York are complicated by Paleozoic and post-Paleozoic uplift of the Appalachians and the erosion of parts of the Upper Ordovician and Silurian as well as all pre-existing Carboniferous and Permian strata.

The CAI isograds for the Ordovician samples are plotted on figure 5, along with the locations of Middle and Upper Ordovician and Lower Silurian gas fields. The gas fields are located largely between the 2.5 and 4.5 CAI isograds (%Ro ~1.5 and 4) which is broadly consistent with the range of thermal maturity indices commonly cited for the “window” of dry natural gas generation and preservation (Dow, 1977; Harris and others, 1978; Tissot and Welte, 1984).

#### **Devonian data set**

The CAI data and interpreted isograds for the Devonian samples are plotted in figure 6 along with the CAI isograds from Harris and others (1978) for comparison. The distribution and shape of the isograds in this study change significantly from those of the Harris and others (1978) plot because of additional sample localities, especially in north-central and south-central New York. As noted for the Ordovician data, the CAI 2 to 3 isograds are shifted farther westward about 50 to 75 kilometers than shown in Harris and others (1978) and furthermore, there is a hint that they are more tightly grouped in the same approximate locations as the Ordovician isograds in the 3 to 4.5 range. Again the isograds reflect higher paleotemperatures and a steeper paleotemperature gradient in central New York than was recognizable given the data used by Harris and others (1978).

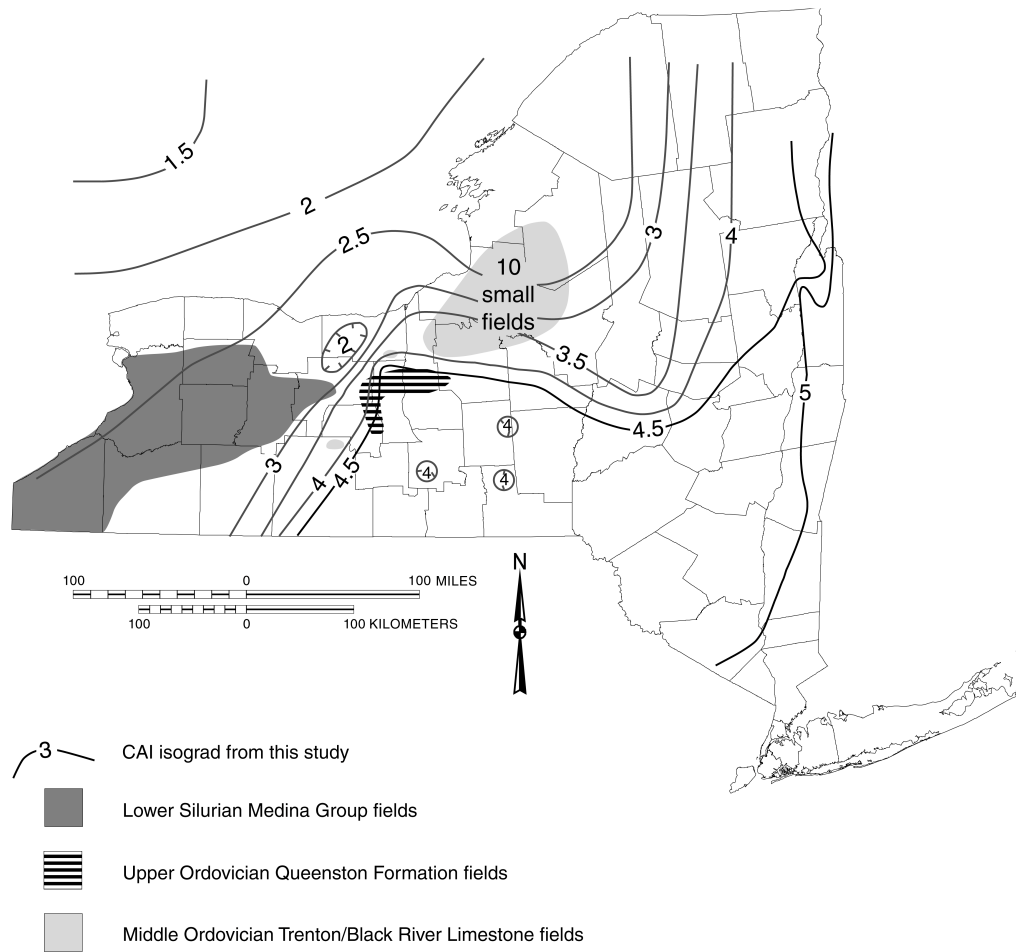


Figure 5. Comparison of locations of Middle/Upper Ordovician and Lower Silurian gas fields in New York with Ordovician Conodont Alteration Index (CAI) isograds from this study. Gas field data from New York State Department of Environmental Conservation (1986).

Although the shapes of the Devonian isograds and overburden isopachs (Devonian through Permian; Harris and others, 1978) are more similar than in the Ordovician example, the isograds still cut sharply across the isopachs in central New York.

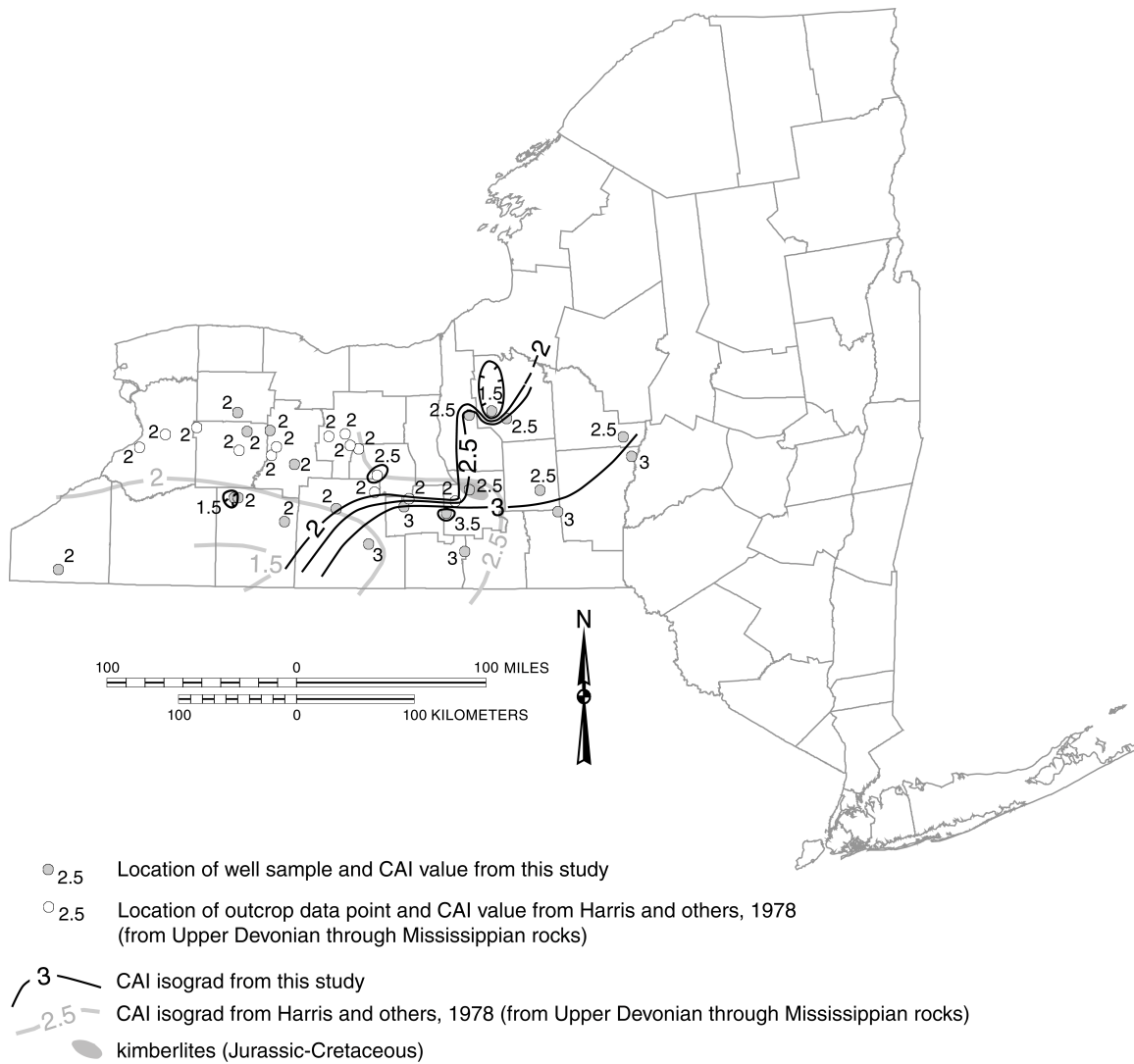


Figure 6. Devonian Conodont Alteration Index (CAI) isograds from data used in this study. The CAI isograds are based on data from this study and that of Harris and others (1978)

The CAI isograds for the Devonian samples are plotted on figure 7 along with locations of Upper Silurian and Devonian oil and gas fields. Oil fields are located in the western part of the area where CAI values are 2 or less (%Ro ~1 or less). The eastern limit of oil fields in the western part of Steuben County has a CAI value of 2.5 (%Ro

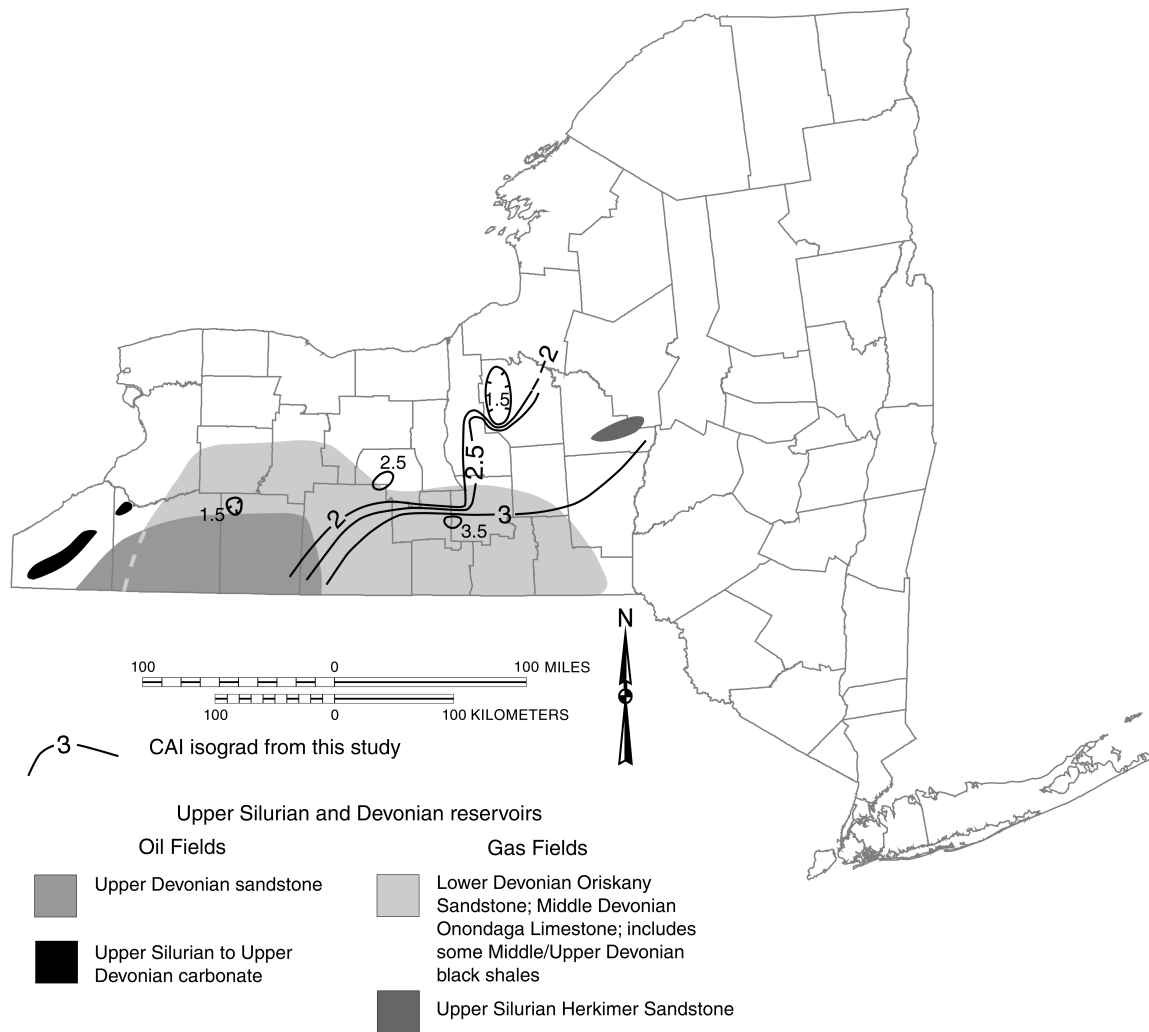


Figure 7. Comparison of locations of Upper Silurian/Devonian oil and gas fields in New York with Devonian Conodont Alteration Index (CAI) isograds from this study. Oil and gas field data from New York State Department of Environmental Conservation (1986).

~1.5). Gas fields are found mainly in south-central and west-central New York where CAI values range from 2 to 3.5 (%Ro ~1 to 2.7). These CAI isograds are broadly consistent with the range of thermal maturity indices commonly cited for the “window” of oil and natural gas generation and preservation (Dow, 1977; Harris and others, 1978; Tissot and Welte, 1984).

Vitrinite reflectance values of black shale samples from the Devonian (mainly Middle Devonian Marcellus Shale) are shown on figure 8. Percent Ro values range from

0.45 in the west (Genesee County) to over 2.12 in the east (Broome County), with a gradual west to east increase. The %Ro contour patterns are roughly compatible with the CAI isograds including the grouping of the contours in central New York.

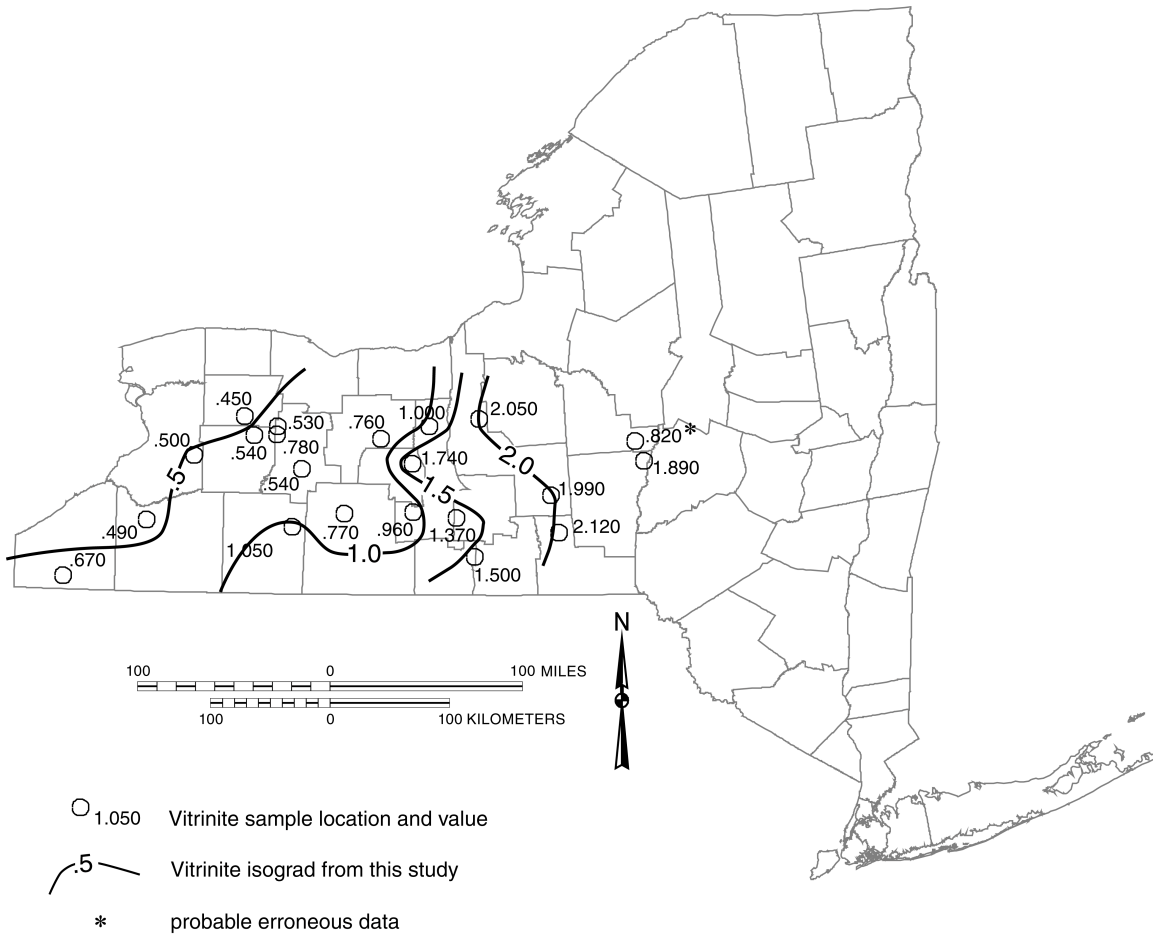


Figure 8. Devonian vitrinite reflectance value (%Ro) contours based on data collected in this study.

In

most localities where both %Ro and CAI measurements are available, the %Ro values indicate a slightly higher level of thermal maturity than the CAI values. Overall, the %Ro contours agree with the oil and gas field locations about as well as the CAI isograds.

## CONCLUSIONS



Assuming a geothermal gradient in the 20° to 30° C/km range that is typical of foreland basin settings, Ordovician CAI isograds in New York (figure 4) imply much higher paleotemperatures than can be explained by the 10,000 to 12,000 ft (3 to 3.7 km) of existing overburden. Moreover, the gradual thickness changes in overburden cannot account for the steep thermal maturity gradient in central New York as indicated by the tight grouping of CAI isograds. Thus, burial by the Taconic clastic wedge could not have been a controlling factor in the distribution of observed CAI isograds. The same is true for the Devonian CAI isograds and %Ro contours (figures 6, 8) which indicate much higher paleotemperatures than expected from the 6000 to 8,000 ft (1.8 to 2.4 km) of existing overburden. Thermal maturity indices measured and interpreted by Friedman and Sanders (1982), Lakatos and Miller (1983), and Johnsson (1986) lead to similar conclusions.

Several explanations for the high thermal maturity are possible: 1) burial beneath thick Carboniferous and Permian overburden that has since been eroded, 2) igneous activity, and 3) regional fluid flow. Johnsson (1986) favors burial heating by 4 km of Carboniferous overburden as the cause of the higher-than-expected paleotemperatures. Although discounted by Johnsson (1986), we suggest that an elevated geothermal flux associated with emplacement of Cretaceous-age ultramafic intrusions in central and eastern New York (Kay and others, 1983) (figures 1,4,6) may be a contributing factor. The intrusions are small, but they could broaden with depth into pluton-sized bodies. Also, the expected high temperatures of emplacement (~900° to 1000° C at 80 to 90 km; Kay and others, 1983) may be sufficient to elevate the regional geothermal gradient. Regional fluid flow is probably not the cause of the high thermal maturity because

estimated rates of flow of basin-derived fluids appear to be too high to leave a thermal imprint on CAI values (Dorobek, 1989).

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TABLE 1. Conodont data from Ordovician samples from the subsurface of New York.

COUNTY API number <sup>1</sup> USGS Collection Number	WELL NAME; FOOTAGE  (Latitude North/ Longitude West)	STRATIGRAPHIC UNIT (Based on picks provided by the New York State Geological Survey)	CORE? OR CUTTINGS	CONODONT FAUNA	AGE RANGE OF CONODONTS	CAI	REMARKS
<b>Allegany Co.</b> <b>003-04248</b> <b>11681-CO</b>	Wolfer No. 1 5930'-6040'  42.47043 -78.16017	Trenton Group	cuttings	1 <i>Drepanoistodus suberectus</i> (Branson & Mehl) element <i>Phragmodus</i> sp. indet. 1 Sb, 3 Sc elements <b>UNASSIGNED ELEMENTS:</b> 1 M (oistodont) 2 indet. bar, blade, and platform fragments	<i>C. friendsvillensis</i> - end of Ordovician (=late Whiterockian-latest Gamachian; = late middle -Late Ordovician)	2.5	151 g of rock processed (44 g +20 and 5 g 20-200 mesh insoluble residue).
<b>Broome Co.</b> <b>007-05087</b> <b>11682-CO</b>	Richards No. 1 7815'-7850'  42.32346 -75.94786	Trenton Group	cuttings	<i>Phragmodus</i> sp. indet. 1 Sa, 2 Sb, 1 Sc elements 4 indet. bar, blade, and platform fragments	Middle or Late Ordovician	4	167 g of rock processed (48 g +20 and 11 g 20-200 mesh insoluble residue).
<b>Cattaraugus Co.</b> <b>009-03868</b> <b>11683-CO</b>	Ellis No. 1 4996'-5061'  42.45509 -79.03989	Trenton Group	cuttings	1 <i>Drepanoistodus suberectus</i> (Branson & Mehl) elements 1 unassigned drepanodontiform <i>Phragmodus undatus</i> Branson & Mehl 2 Sb, 3 Sc & two S fragments	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late Middle -Late Ordovician)	2.5	119 g of rock processed (36 g +20 and 13 g 20-200 mesh insoluble residue).
Cattaraugus Co. 009-03934 11684-CO	Conger No. 1 4837'-4932'  42.45998 -79.04021	Trenton Group	cuttings	<i>Amorphognathus</i> sp. indet. 1 Pa, 1 Pb, 1 Sb, 1 Sc & 1 bar fragment element (all elements incomplete) 1 <i>Belodina compressa</i> (Branson & Mehl) element 1 Sb element <i>Icriodella</i> sp. indet. 5 <i>Panderodus gracilis</i> (Branson & Mehl) elements <i>Phragmodus undatus</i> Branson & Mehl 5 P, 5 M, 3 Sb, 5 Sc & 5 S fragment elements 1 <i>Pseudooneotodus mitratus</i> (Moskalenko) element 1 incomplete P element <i>Rhodesognathus elegans</i> (Rhodes)? 5 indet. bar, blade, and platform fragments	<i>Ph. undatus</i> Zone-lowest <i>B. confluens</i> Zone (=latest Blackriveran-middle Shermanian; =late, but not latest, Middle Ordovician)	2.5	114 g of rock processed (21 g +20 and 12 g 20-200 mesh insoluble residue).
Cayuga Co. 011-00478 11685-CO	Mahaney No. 1 5344'-5603'  42.68477 -76.64431	Trenton Group	cuttings	1 <i>Panderodus gracilis</i> (Branson & Mehl) element <i>Phragmodus undatus</i> Branson & Mehl 5 P, 2 M, 1 Sa, 2 Sb, 8 Sc & 5 S element fragments 1 <i>Plectodina</i> sp. indet. Sb element	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	4.5	107 g of rock processed (19 g +20 and 8 g 20-200 mesh insoluble residue).

<sup>1</sup>Since all samples are from New York, the state API prefix: 31 was omitted for brevity.

COUNTY API number <sup>1</sup> USGS Collection Number	WELL NAME; FOOTAGE  (Latitude North/ Longitude West)	STRATIGRAPHIC UNIT (Based on picks provided by the New York State Geological Survey)	CORE? OR CUTTINGS	CONODONT FAUNA	AGE RANGE OF CONODONTS	CAI	REMARKS
Cayuga Co. 011-04715 11686-CO	Alnutt No. 1 3749'-3877'  42.92171 -75.94786	Trenton Group	cuttings	1 <i>Belodina compressa</i> (Branson & Mehl) element 1 <i>Drepanoistodus suberectus</i> (Branson & Mehl) element 5 <i>Panderodus gracilis</i> (Branson & Mehl) elements <i>Phragmodus undatus</i> Branson & Mehl 4 P, 4 M, 1 Sa, 10 Sb, 5 Sc & 6 S fragment elements 10 indet. bar, blade, and platform fragments	<i>Ph. undatus</i> Zone-lowest <i>B.</i> <i>confluens</i> Zone (=latest Blackriveran-middle Shermanian; =late, but not latest, Middle Ordovician)	4.5	149 g of rock processed (30 g +20 and 3 g 20-200 mesh insoluble residue).
Cayuga Co. 011-17508 11687-CO	Hunter No. 1 2850'-2860'  43.12899 -76.56174	Trenton Group	cuttings	<i>Amorphognathus</i> sp. indet. 1 Pb element, 1 Sb element 2 Belodidid sp. indet. elements 1 <i>Curtognathus</i> sp. indet. M element 1 Dapsilodid sp. indet. element 1 <i>Drepanoistodus suberectus</i> (Branson & Mehl) element 2 <i>Icriodella</i> sp. indet. Sa elements 12 <i>Panderodus gracilis</i> (Branson & Mehl) elements <i>Phragmodus undatus</i> Branson & Mehl 5 P, 3 M, 22 undifferentiated S elements & 23 S element fragments 7 Pa elements <i>Polyplacognathus ramosus</i> Stauffer 6 indet. bar, blade, and platform fragments	<i>Ph. undatus</i> Zone-lowest <i>B.</i> <i>confluens</i> Zone (=latest Blackriveran-middle Shermanian; =late, but not latest, Middle Ordovician)	3.5	126 g of rock processed (5 g +20 and 7 g 20-200 mesh insoluble residue).
Chautauqua Co. 013-3200 11688-CO	Morse No. 1 6501'-6433'  42.06821 -79.41556	Trenton Group	cuttings	<i>Phragmodus undatus</i> Branson & Mehl 2 P, 1 M, 2 Sc elements	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	2.5	146 g of rock processed (31 g +20 and 4 g 20-200 mesh insoluble residue).
Chautauqua Co. 013-04460 11689-CO	Sommers- Tuttle No. 1 3760'-3800'  42.52111 -79.26226	Trenton Group	cuttings	1 <i>Amorphognathus</i> sp. indet. Sc element 3 <i>Drepanoistodus suberectus</i> (Branson & Mehl) elements 6 <i>Panderodus gracilis</i> (Branson & Mehl) elements <i>Phragmodus undatus</i> Branson & Mehl 3 P, 1 M, 2 Sb, 6 Sc, 2 undifferentiated S element fragments 2 <i>Staufferella falcata</i> (Stauffer) elements 3 indet. bar, blade, and platform fragments	<i>Ph. undatus</i> Zone-within <i>O.</i> <i>robustus</i> Zone (=latest Blackriveran-middle Maysvillian; = late middle -Late Ordovician)	2	170 g of rock processed ( 51 g +20 and 20 g 20-200 mesh insoluble residue).
Chemung Co. 015-00443 11690-CO	Kesselring No. 1 9091'-9230'  42.19857 -76.53807	Trenton Group	cuttings	1 <i>Panderodus gracilis</i> (Branson & Mehl) element <i>Phragmodus undatus</i> Branson & Mehl 3 M, 1 Sb, 1 Sc, 2 S element fragments 3 indet. bar, blade, and platform fragments	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	4.5	133 g of rock processed (96 g +20 and 4 g 20-200 mesh insoluble residue).

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Chemung Co. 015-10335 11691-CO	Matejika No. 1 9595'-9650'  42.16901 -76.65898	Trenton Group	cuttings	1 belonidid rastrate element 4 <i>Panderodus gracilis</i> (Branson & Mehl) elements 1 <i>Periodon</i> sp. indet. M element <i>Phragmodus undatus</i> Branson & Mehl 6 P, 3 M, 2 Sb, 3 Sc & 23 S element fragments 13 indet. bar, blade, and platform fragments	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	4.5- 5	116 g of rock processed (31 g +20 and 18 g 20-200 mesh insoluble residue).
Chenango Co. 017-01160 11692-CO	Lobdell No. 1 4417'-4511'  42.69328 -75.34506	Trenton Group	cuttings	1 belonidid sp. indet. rastrate element <i>Phragmodus undatus</i> Branson & Mehl 1 P, 1 M, 2 Sb, 1 Sc & 4 S element fragments	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	4.5	107 g of rock processed (14 g +20 and 7 g 20-200 mesh insoluble residue).
Cortland Co. 023-04714 11693-CO	Clough No. 1 6920'-6958'  42.51847 -76.00093	Trenton Group	cuttings	1 indet. coniform element 4 pyritized, phosphatic ostracode steinkerns, 1 phosphatic gastropod steinkern.	Post Cambrian Paleozoic	4.5	217 g of rock processed (73 g +20 and 11 g 20-200 mesh insoluble residue).
Cortland Co. 023-21500 11694-CO	NYSRT No. 6#1 6290'-6450'  42.63903 -75.91361	Trenton Group	cuttings	2 unassigned M elements 1 indet. bar, blade, or platform fragment	Post Cambrian Paleozoic	4- 4.5	26 g of rock processed (5 g +20 and 4 g 20-200 mesh insoluble residue).
Erie Co. 029-03917 11695-CO	Fee No. 2 2492'-2572'  43.00044 -78.82458	Trenton Group	cuttings	3 <i>Drepanoistodus suberectus</i> (Branson & Mehl) elements 6 <i>Panderodus gracilis</i> (Branson & Mehl) elements <i>Phragmodus undatus</i> Branson & Mehl 1 P, 4 M, 1 Sb, 3 Sc & 5 S element fragments <i>Plectodina tenuis</i> (Branson & Mehl) 1 Pa, 1 Pb, 1 M & 1 Sc elements 1 <i>Pseudooneotodus mitratus</i> (Moskalenko) element <u>UNASSIGNED ELEMENTS:</u> 1 M & 1 Sb 5 indet. bar, blade, and platform fragments	<i>Pl. tenuis</i> Zone-A. <i>shatzeri</i> Zone (Kirkfieldian-Gamachian; =very late Middle-Late Ordovician)	2	204 g of rock processed (66 g +20 and 13 g 20-200 mesh insoluble residue).



COUNTY API number <sup>1</sup> USGS Collection Number	WELL NAME; FOOTAGE  (Latitude North/ Longitude West)	STRATIGRAPHIC UNIT (Based on picks provided by the New York State Geological Survey)	CORE? OR CUTTINGS	CONODONT FAUNA	AGE RANGE OF CONODONTS	CAI	REMARKS
Erie Co. 029-11002 11696-CO	Brown No. 1 5340'-5450'  42.55748 -78.53568	Trenton Group	cuttings	<i>Amorphognathus</i> sp. indet. 1 Sa, 1 Sc element 1 <i>Drepanoistodus suberectus</i> (Branson & Mehl) elements 3 <i>Panderodus gracilis</i> (Branson & Mehl) elements 1 <i>Periodon</i> sp. indet. M element <i>Phragmodus undatus</i> Branson & Mehl 4 P, 1 M, 2 Sb, 4 Sc & 4 S element fragments 2 <i>Plectodina</i> sp. indet. Pa elements 1 <i>Yaioxianognathus abruptus</i> (Branson & Mehl) P element 7 indet. bar, blade, and platform fragments	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	2.5	115 g of rock processed (10 g +20 and 19 g 20-200 mesh insoluble residue).
Genesee Co. 037-9524 11697-CO	Buckenmeyer No. 1 3385'-3500'  42.90003 -78.24422	Trenton Group	cuttings	<i>Amorphognathus</i> sp. indet. 1 Pa, 1 Pa fragment, 1 Sc element 1 <i>Drepanoistodus suberectus</i> (Branson & Mehl) elements <u>UNASSIGNED ELEMENTS:</u> 1 M 4 indet. bar, blade, and platform fragments	<i>C. friendsvillensis</i> -end of Ordovician (=late Whiterockian- latest Gamachian; = late middle -Late Ordovician)	2.5	31 g of rock processed (3 g +20 and 3 g 20-200 mesh insoluble residue).
Genesee Co. 037-13672 11698-CO	Fee No. 1 3230'-3300'  42.99354 -77.95185	Trenton Group	cuttings	5 <i>Drepanoistodus suberectus</i> (Branson & Mehl) elements 7 <i>Panderodus gracilis</i> (Branson & Mehl) elements <i>Phragmodus undatus</i> Branson & Mehl 13 P, 3 M, 6 Sb, 4 Sc & 6 S fragment elements 3 Pa elements 1 <i>Rhodesognathus elegans</i> (Rhodes) element 3 <i>Staufferella falcata</i> (Stauffer) elements <u>UNASSIGNED ELEMENTS:</u> 1 M	<i>Ph. undatus</i> Zone-within <i>O.</i> <i>robustus</i> Zone (=latest Blackriveran-middle Maysvillian; = late middle -Late Ordovician)	2.5	138 g of rock processed (31 g +20 and 35 g 20-200 mesh insoluble residue).
Livingston Co. 051-04069 11699-CO	MacDonald No. 1 4031'-4117'  42.87157 -77.93213	Trenton Group	cuttings	3 <i>Belodina compressa</i> (Branson & Mehl) elements 2 panderodid element fragments <i>Phragmodus undatus</i> Branson & Mehl 8 P, 1 M, 3 Sb, 9 Sc & 7 S fragment elements 3 Pa elements <i>Polyplacognathus ramosus</i> Stauffer 4 indet. bar, blade, and platform fragments	<i>Ph. undatus</i> Zone-lowest <i>B.</i> <i>confluens</i> Zone (=latest Blackriveran-middle Shermanian; =late, but not latest, Middle Ordovician)	2.5	140 g of rock processed (40 g +20 and 38 g 20-200 mesh insoluble residue).

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Livingston Co. 051-13700 11700-CO	Hill's No. 1 4710'-4970'  42.69719 -77.89195	Trenton Group	cuttings	1 belodinid sp. indet. M element 2 <i>Drepanoistodus suberectus</i> (Branson & Mehl) elements 3 <i>Panderodus gracilis</i> (Branson & Mehl) elements <i>Phragmodus undatus</i> Branson & Mehl 6 P, 4 M, 2 Sa, 5 Sb, 10 Sc & 15 S fragment elements 11 indet. bar, blade, and platform fragments	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	2.5	156 g of rock processed (15 g +20 and 15 g 20-200 mesh insoluble residue).
Madison Co. 053-03970 11701-CO	Branagan No. 1 4568'-4695'  42.80480 -75.65048	Trenton Group	cuttings	<i>Phragmodus undatus</i> Branson & Mehl 1 P, 2 Sb, 1 S fragment elements 1 indet. fragment	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	4.5	105 g of rock processed (59 g +20 and 6 g 20-200 mesh insoluble residue).
Madison Co. 053-04032 11702-CO	Danisevich No. 1 4042'-4100'  42.79630 -75.40464	Trenton Group	cuttings	belodinid sp. indet. 1 P, 1 M element 1 M element <i>Periodon</i> sp. indet. <i>Phragmodus undatus</i> Branson & Mehl 4 P, 4 M, 5 Sb, 5 Sc & 4 S fragment elements 1 Pa element <i>Polyplacognathus ramosus</i> Stauffer 1 indet. fragment	<i>Ph. undatus</i> Zone-lower <i>B. confluens</i> Zone (=latest Blackriveran-middle Shermanian; = late middle - Late Ordovician)	4	120 g of rock processed (24 g +20 and 11 g 20-200 mesh insoluble residue).
Monroe Co. 055-00672 11703-CO	Rochester Deep Well 2200'-2610'  43.17023 -77.61864	Trenton Group	cuttings	1 <i>Belodina compressa</i> (Branson & Mehl) element 1 <i>Dapsilodus</i> sp. indet. element 5 <i>Drepanoistodus suberectus</i> (Branson & Mehl) elements 6 <i>Panderodus gracilis</i> (Branson & Mehl) elements <i>Phragmodus undatus</i> Branson & Mehl 7 P, 4 M, 6 Sa, 4 Sb, 5 Sc & 7 S fragment elements 1 Pa element <i>Polyplacognathus ramosus</i> Stauffer 2 indet. bar, blade, and platform fragments	<i>Ph. undatus</i> Zone-lowest <i>B. confluens</i> Zone (=latest Blackriveran-middle Shermanian; =late, but not latest, Middle Ordovician)	2.5	121 g of rock processed (21 g +20 and 3 g 20-200 mesh insoluble residue).
Monroe Co. 055-10921 11704-CO	Kerberle No. 1 1240' - 1300'  43.33336 -77.95290	Trenton Group	cuttings	<i>Amorphognathus</i> sp. indet. 3 Pa, 4 Pb, 1 Sa, 1 Sb, 1Sc elements. 1 <i>Coelocerodontus trigonius</i> Ethington element 4 <i>Drepanoistodus suberectus</i> (Branson & Mehl) elements 13 <i>Panderodus gracilis</i> (Branson & Mehl) elements <i>Phragmodus undatus</i> Branson & Mehl 1 P, 1 Sc elements <i>Plectondina tenuis</i> (Branson & Mehl) 2 Pa, 2 Pb, 2 M, 1 Sa, 1 Sc elements 1 <i>Protopanderodus</i> sp. indet. juvenile element 6 indet. bar, blade, and platform fragments	<i>P. tenuis</i> Zone - lower <i>O. velicuspis</i> Zone (=Kirkfieldian-early Maysvillian; =late, but not latest, Middle Ordovician-early Late Ordovician)	2	196 g of rock processed (29 g +20 and 10 g 20-200 mesh insoluble residue).

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Niagara Co. 063-06667 11705-CO	FMC Fee No. 1 2020'-2230'  42.20756 -78.46499	Trenton Group	cuttings	1 belonidid sp. indet. rastrate element 5 <i>Drepanoistodus suberectus</i> (Branson & Mehl) elements 3 <i>Panderodus gracilis</i> (Branson & Mehl) elements <i>Phragmodus undatus</i> Branson & Mehl 3 P, 3 M, 3 Sb, 7 Sc & 6 S fragment elements 1 <i>Plectodina</i> sp. indet. Pa element 1 <i>Rhodesagnathus?</i> sp. indet. element 4 indet. bar, blade, and platform fragments	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	2	121 g of rock processed (25 g +20 and 3 g 20-200 mesh insoluble residue).
Niagara Co. 063-06669 11706-CO	Hooker Fee No. 1 2400'-2470'  43.07993 -79.00674	Trenton Group	cuttings	9 <i>Drepanoistodus suberectus</i> (Branson & Mehl) elements 4 <i>Panderodus gracilis</i> (Branson & Mehl) elements 1 <i>Peridon</i> sp. indet. M element <i>Phragmodus undatus</i> Branson & Mehl 32 P, 16 M, 5 Sa, 11 Sb, 24 Sc & 23 S fragment elements 11 indet. bar, blade, and platform fragments  1 phosphatized scolecodont	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	2	129 g of rock processed (13 g +20 and 12 g 20-200 mesh insoluble residue).
Onondaga Co. 067-00886 11707-CO	Munroe No. 1 3376'-3451'  43.01886 -76.30389	Trenton Group	cuttings	1 <i>Phragmodus</i> sp. indet. P element <u>UNASSIGNED ELEMENTS:</u> 1 Pb 3 indet. bar, blade, and platform fragments	Middle or Late Ordovician	4	100 g of rock processed (24 g +20 and 14 g 20-200 mesh insoluble residue).
Onondaga Co. 067-12163 11708-CO	Harrison No. 1 4120'-4180'  42.93688 -76.34586	Trenton Group	cuttings	<i>Phragmodus undatus</i> Branson & Mehl 2 P, 2Sc & 1 S fragment elements	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	4.5	151 g of rock processed (15 g +20 and 13 g 20-200 mesh insoluble residue).
Ontario Co. 069-04760 11709-CO	Wyman No.1 2970'-3640'  42.98944 -77.27984	Trenton Group	cuttings	<i>Phragmodus undatus</i> Branson & Mehl 1 P, 3 Sc, 2 indet S fragment elements 3 indet. bar, blade, and platform fragments	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	2	44 g of rock processed (10 g +20 and 17 g 20-200 mesh insoluble residue).
Ontario Co. 069-06395 11710-CO	Frankish No. 1 4350'-5010'  42.81262 -77.20285	Trenton Group	cuttings	1 <i>Drepanoistodus suberectus</i> (Branson & Mehl) elements 2 <i>Panderodus gracilis</i> (Branson & Mehl) elements <i>Phragmodus undatus</i> Branson & Mehl 3 P, 1 Sa, 1 Sb 1 Sc, 1 indet S fragment elements 4 indet. bar, blade, and platform fragments	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	3.5	77 g of rock processed (11 g +20 and 8 g 20-200 mesh insoluble residue).

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Orleans Co. 073-04611 11711-CO	Kelley No. 1 2321'-2406'  43.19091 -78.25826	Trenton Group	cuttings	2 <i>Drepanoistodus suberectus</i> (Branson & Mehl) elements 4 <i>Panderodus gracilis</i> (Branson & Mehl) elements <i>Phragmodus undatus</i> Branson & Mehl 6 P, 3 M, 1 Sa, 3 Sb, 6 Sc & 10 S fragment elements <i>Plectodina</i> sp. indet. 1 Pa, 1 Pb elements 1 <i>Pseudooneotodus mitratus</i> (Moskalenko) element 4 indet. bar, blade, and platform fragments	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	2	174 g of rock processed (25 g +20 and 21 g 20-200 mesh insoluble residue).
Orleans Co. 073-04873 11712-CO	Green No. 1 1420'-1570'  43.36272 -78.30504	Trenton Group	cuttings	1 Pb element <i>Amorphognathus</i> sp. indet. 5 <i>Panderodus gracilis</i> (Branson & Mehl) elements <i>Phragmodus undatus</i> Branson & Mehl 9 P, 3 M, 1 Sb, 7 Sc & 5 S fragment elements 1 Pa elements <i>Polyplacognathus ramosus</i> Stauffer 5 indet. bar, blade, and platform fragments 1 phosphatic brachiopod valve	<i>Ph. undatus</i> Zone-lowest <i>B. confluens</i> Zone (=latest Blackriveran-middle Shermanian; =late, but not latest, Middle Ordovician)	2	164 g of rock processed (28 g +20 and 21 g 20-200 mesh insoluble residue).
Schuyler Co. 097-19692 11713-CO	Perigo No. 21578 7150'-7440'  42.43251 -76.97039	Trenton Group	cuttings	3 <i>Panderodus gracilis</i> (Branson & Mehl) elements 1 <i>Periodon</i> sp. indet. M element <i>Phragmodus undatus</i> Branson & Mehl 5 P, 1 M, 3 Sb, 4 Sc & 12 S fragment elements <u>UNASSIGNED ELEMENTS:</u> 1 M, 1 Sa 7 indet. bar, blade, and platform fragments	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	4	92 g of rock processed (20 g +20 and 4 g 20-200 mesh insoluble residue).
Seneca Co. 099-04203 11714-CO	Schafer No. 2 4000'-4440'  42.87620 -76.85854	Trenton Group	cuttings	4 <i>Drepanoistodus suberectus</i> (Branson & Mehl) elements 2 <i>Panderodus gracilis</i> (Branson & Mehl) elements <i>Phragmodus undatus</i> Branson & Mehl 6 P, 3 M, 3 Sb, 4 Sc & 8 S fragment elements <u>UNASSIGNED ELEMENTS:</u> 1 Sa, 3 M 7 indet. bar, blade, and platform fragments	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	4.5	76 g of rock processed (15 g +20 and 11 g 20-200 mesh insoluble residue).
Seneca Co. 099-10893 11715-CO	Kinney No. 1 3200'-3700'  42.94114 -76.87669	Trenton Group	cuttings	1 Sb element <i>Phragmodus</i> sp. indet. 3 indet. bar, blade, and platform fragments	Middle or Late Ordovician	4.5	96 g of rock processed (42 g +20 and 12 g 20-200 mesh insoluble residue).
Steuben Co. 101-03924 11716-CO	Olin No. 1 9785'-10300'  43.06303 -77.43067	Trenton Group	cuttings	1 P element <i>Phragmodus</i> sp. indet. 2 indet. bar, blade, and platform fragments	Middle or Late Ordovician	4.5	59 g of rock processed (11 g +20 and 6 g 20-200 mesh insoluble residue).

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Steuben Co. 101-13699 USGS 9732-CO	Columbia NYS Reforestation No. 6 7990'-8100'  42.5372 -77.2157	Black River Group	cuttings	1 drepanodontiform element 1 <i>Panderodus</i> sp. element <u>UNASSIGNED ELEMENTS:</u> 1 trichonodelliform element 6 indet. bar, blade, and platform fragments	Middle or Late Ordovician	3.5- 4	680 g of rock processed (91.2 g +20 and ? g 20-200 mesh insoluble residue) Sample processed and analysed by Anita G. Harris, USGS, Paleontology and Stratigraphy Branch shipment number: 0-80- 77.
Steuben Co. 101-21468 11717-CO	Avoca No. 1 7570'-7620'  42.41958 -77.45354	Trenton Group	cuttings	1 <i>Amorphognathus</i> sp. indet Pa element fragment 1 belodind sp. indet. rastrate element 1 <i>Drepanoistodus suberectus</i> (Branson & Mehl) elements 10 <i>Panderodus gracilis</i> (Branson & Mehl) elements <i>Phragmodus undatus</i> Branson & Mehl 25 P, 10 M, 5 Sa, 8 Sb, 16 Sc elements, 25 S element fragments 1 <i>Polyplacognathus</i> sp. indet. Pa element fragment 23 Indet. bar, blade, and platform fragments	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	3.5	143 g of rock processed (27 g +20 and 29 g 20-200 mesh insoluble residue).
Tompkins Co. 109-04130 11718-CO	Grund No. 1 7400'-7700'  42.44211 -76.59280	Trenton Group	cuttings	2 <i>Panderodus gracilis</i> (Branson & Mehl) elements <i>Phragmodus undatus</i> Branson & Mehl 4 P, 1 M, 1 Sa, 4 Sb, 4 Sc elements 2 Indet. bar, blade, and platform fragments	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	4.5	64 g of rock processed (13 g +20 and 21 g 20-200 mesh insoluble residue).
Tompkins Co. 109-04467 11719-CO	Richardson Fee No. 1 7620'-7770'  42.38417 -76.54083	Trenton Group	cuttings	2 <i>Panderodus gracilis</i> (Branson & Mehl) elements <i>Phragmodus undatus</i> (Branson & Mehl) 2 S element fragments	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	4	24 g of rock processed (4 g +20 and 1 g 20-200 mesh insoluble residue).
Wayne Co. 117-05116 11720-CO	Hammond No. 1 2590'-2630'  43.15198 -77.06980	Trenton Group	cuttings	2 <i>Drepanoistodus suberectus</i> (Branson & Mehl) elements 5 <i>Panderodus gracilis</i> (Branson & Mehl) elements <i>Phragmodus undatus</i> Branson & Mehl 1 P, 2 M, 1 Sb, 1 Sc elements <u>UNASSIGNED ELEMENTS:</u> 1 Sa  10 phosphatic steinkerns of gastropods and miscellania.	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	2	141 g of rock processed (44 g +20 and 8 g 20-200 mesh insoluble residue).
Wyoming Co. 121-13278 11721-CO	George No. 1 5870'-5970'  42.53465 -78.39469	Trenton Group	cuttings	1 <i>Amorphognathus</i> sp. indet Sc element 2 <i>Panderodus gracilis</i> (Branson & Mehl) elements <i>Phragmodus undatus</i> Branson & Mehl 3 P, 3 M, 1 Sb, 4 Sc elements & 1 S element fragment 4 indet. bar, blade, and platform fragments	<i>Ph. undatus</i> Zone-end of Ordovician (=latest Blackriveran-latest Gamachian; = late middle -Late Ordovician)	2.5	166 g of rock processed (16 g +20 and 8 g 20-200 mesh insoluble residue).

COUNTY API number <sup>1</sup> USGS Collection Number	WELL NAME; FOOTAGE  (Latitude North/ Longitude West)	STRATIGRAPHIC UNIT (Based on picks provided by the New York State Geological Survey)	CORE? OR CUTTINGS	CONODONT FAUNA	AGE RANGE OF CONODONTS	CAI	REMARKS
Wyoming Co. 121-22042 11722-CO	Titus Brothers. No. 1 4170'-4210'  42.82192 -78.09957	Trenton Group	cuttings	3 <i>Drepanoistodus suberectus</i> (Branson & Mehl) elements 1 Sa element <i>Icriodella</i> sp. indet. 8 <i>Panderodus gracilis</i> (Branson & Mehl) elements <i>Phragmodus undatus</i> Branson & Mehl 8 P, 3 M, 2 Sb, 3 Sc & 8 S fragment elements <i>Plectodina</i> sp. indet. 2 Pa, 1 Pb, 1 Sa, 1 Sb, 1 Sc elements. 2 <i>Rhodesognathus elegans</i> (Rhodes) elements 4 indet. bar, blade, and platform fragments	<i>A. tvaerensis</i> Zone-A. <i>ordovicicus</i> Zone (=latestBlackriveran-Maysvillian; = late middle -Late Ordovician)	2.5	142 g of rock processed (44 g +20 and 2 g 20-200 mesh insoluble residue).

TABLE 2. Conodont data from Devonian samples from the subsurface of New York.

COUNTY API Number <sup>1</sup> USGS collection number	WELL NAME FOOTAGE  (Latitude North/ Longitude West)	STRATIGRAPHIC UNIT (Based on picks provided by the NY State Geological Survey)	CORE? OR CUTTINGS	CONODONT FAUNA	AGE RANGE OF CONODONTS	CAI	REMARKS
Allegany Co. 003-00354 12691-SD	M. Connor No. 1 1882'-1900'  42.46947 -78.15479	Genundewa Limestone	cuttings	1 <i>Delotaxis</i> (?) sp. indet. Sb element <u>UNASSIGNED ELEMENTS:</u> 2 Sc elements 3 indet. bar, blade, or platform fragments	Post Lower Ordovician Paleozoic	2	18 g of rock processed (14 g +20 and 1 g 20-200 mesh insoluble residue).
Allegany Co. 003-02681 12692-SD	Thomas No. 1 1889'-1936'  42.46920 -78.18133	Penn Yan Shale	cuttings	13 indet. bar, blade, and platform fragments	No older than Devonian (by superposition)	1.5	122 g of rock processed (110 g +20 and 2 g 20-200 mesh insoluble residue).
Allegany Co. 003-02681 12693-SD	Thomas No. 1 1936'-1945'  42.46920 -78.18133	Lodi Limestone	cuttings	1 <i>Polygnathus</i> sp. indet. extremely juvenile Pa element	Devonian or Lower Carboniferous	2	28 g of rock processed (11 g +20 and 1 g 20-200 mesh insoluble residue).
Allegany Co. 003-02681 12694-SD	Thomas No. 1 1945'-1958'  42.46920 -78.18133 <sup>i</sup>	Geneseo Formation	cuttings	1 indet bar or blade fragment.	Post Lower Ordovician Paleozoic	2	39 g of rock processed (34 g +20 and 1 g 20-200 mesh insoluble residue).
Cattaraugus Co. 003-09235	E.T.S. No. 1 4160'-4200'  42.00866 -78.56875	Genundewa Limestone	cuttings	BARREN	indet.		38 g of rock processed (22 g +20 and 1 g 20-200 mesh insoluble residue).

<sup>1</sup> Since all samples are from New York, the state API prefix: 31 was omitted for brevity.

COUNTY API Number <sup>1</sup> USGS collection number	WELL NAME FOOTAGE (Latitude North/ Longitude West)	STRATIGRAPHIC UNIT (Based on picks provided by the NY State Geological Survey)	CORE? OR CUTTINGS	CONODONT FAUNA	AGE RANGE OF CONODONTS	CAI	REMARKS
Allegany Co. 003-13549 12695-SD	National Fuel & NYS Natural Gas No. 3 2730.7'-2731.5'  42.34889 -77.8200	Genundewa Limestone	core	6 <i>Ancyrodella rotundiloba</i> (Bryant) Pa elements 8 <i>Ancyrodella</i> spp. indet Pa fragments and juveniles <i>Delotaxis</i> spp. indet; 3 Pa (2 morphotypes), 1 Pb1, 2 Pb2, 5 M, 2 Sa, 2 Sb, 3 Sc elements <i>Icriodus difficilis</i> Ziegler and Klapper 31 P, 1 coniform elements 13 <i>Polygnathus dengleri</i> (Bischoff & Ziegler) elements 28 <i>Polygnathus dubius</i> Hinde Pa elements 8 <i>Polygnathus pennatus</i> Hinde Pa elements <u>UNASSIGNED ELEMENTS:</u> 15 Pb (4 morphotypes), 13 M (3 morphotypes), 2 Sa (2 morphotypes), 12 Sb (2 morphotypes), 25 Sc (4 morphotypes) 114 indet. bar, blade, and platform fragments  OTHER: 8 pyritized steinkerns of cephalopods, bivalves <sup>1</sup>	Lower <i>falsiovalis</i> Zone to within <i>transitans</i> Zone (= early Frasnian; Late Devonian)	2- 2.5	280 g of rock processed (67 g +20 and 80 g 20-200 mesh insoluble residue).
Allegany Co. 003-13549 12696-SD	National Fuel & NYS Natural Gas No. 3 2732'-2732.3'  42.34889 -77.8200	Genundewa Limestone	core	2 <i>Ancyrodella alata</i> Glenister and Klapper Pa elements 1 <i>Ancyrodella rotundiloba</i> (Bryant) Pa elements 5 <i>Ancyrodella</i> spp. indet Pa fragments and juveniles <i>Delotaxis</i> sp. indet; 1 Pb1, 1 Pb2 elements <i>Icriodus difficilis</i> Ziegler and Klapper 8 P, 1 coniform elements 5 <i>Polygnathus dengleri</i> (Bischoff & Ziegler) elements 7 <i>Polygnathus dubius</i> Hinde Pa elements 5 <i>Polygnathus pennatus</i> Hinde Pa elements <u>UNASSIGNED ELEMENTS:</u> 5 Pb (4 morphotypes), 5 M (3 morphotypes), 1 Sa, 6 Sb (3 morphotypes), 6 Sc (3 morphotypes) 57 indet. bar, blade, and platform fragments  OTHER: 6 pyritized steinkerns of cephalopods, bivalves, and gastropods	Lower <i>falsiovalis</i> Zone to within <i>transitans</i> Zone (= early Frasnian; Late Devonian)	2- 2.5	210 g of rock processed (62 g +20 and 34 g 20-200 mesh insoluble residue).
Allegany Co. 003-13549 12697-SD	National Fuel & NYS Natural Gas No. 3 2867.8'-2868.8'  42.34889 -77.82000	Lodi Limestone	core	21 <i>Polygnathus ovatinodosus</i> Zeigler, Klapper, and Johnson Pa and Pa element fragments  <u>UNASSIGNED ELEMENTS:</u> 2 Pb, 2 M, 1 Sc 23 indet. bar, blade, and platform fragments	Lower <i>varcus</i> Zone through <i>transitans</i> Zone (= Givetian to early Frasnian; Middle to Late Devonian)	2- 2.5	2700 g of rock processed (404 g +20 and 193 g 20-200 mesh insoluble residue).



COUNTY API Number <sup>1</sup> USGS collection number	WELL NAME FOOTAGE (Latitude North/ Longitude West)	STRATIGRAPHIC UNIT (Based on picks provided by the NY State Geological Survey)	CORE? OR CUTTINGS	CONODONT FAUNA	AGE RANGE OF CONODONTS	CAI	REMARKS
Broome Co. 007-06636 12698-SD	C. Smith No. 1 3235'-3460' 42.40618 -75.87740	Helderberg Group	cuttings	1 M element, sp. indet.	post Lower Ordovician Paleozoic	3	71 g of rock processed (13 g +20 and 9 g 20-200 mesh insoluble residue).
Cayuga Co. 011-11632 12699-SD	Steimle No. 9 420'-450' 42.91694 -76.50542	Helderberg Group	cuttings	6 indet. bar, blade, and platform fragments	post Lower Ordovician Paleozoic	2.5- 3.0	68 g of rock processed (1 g +20 and 2 g 20-200 mesh insoluble residue).
Chautauqua Co. 013-03200 12700-SD	Morse No. 1 2600'-2637' 42.06821 -79.41556	Moscow-Ludlowville	cuttings	4 indet. bar, blade, and platform fragments	post Lower Ordovician Paleozoic	2	146 g of rock processed (31 g +20 and 4 g 20-200 mesh insoluble residue).
Chautauqua Co. 013-04437	Harrington No. 1 2340'-2410' 42.18421 -79.33785	Genesee Group	cuttings	BARREN	Indet.		
Chemung Co. 015-00443	Kesselring No. 1 659'-706" 42.19857 -76.53807	Genesee Group	cuttings	BARREN	indet.		103 g of rock processed (68 g +20 and 1 g 20-200 mesh insoluble residue).
Chemung Co. 015-00443 12701-SD	Kesselring No. 1 836'-869' 42.19857 -76.53807	Genesee Group	cuttings	1 <i>Polygnathus alatus</i> Huddle Pa element 4 indet. bar, blade, and platform fragments	Middle <i>varcus</i> subzone into <i>transitans</i> Zone (= Givetian to Frasnian; Middle to Late Devonian)	3	133 g of rock processed (96 g +20 and 4 g 20-200 mesh insoluble residue).
Chenango Co. 017-01160 12702-SD	Lobdell No. 1 338'-353' 42.69328 -75.34506	Skaneateles Formation	cuttings	<i>Icriodus</i> sp. indet.; 4 incomplete P elements of at least two species, 5 lateral process fragments. 1 <i>Polygnathus timorensis</i> ? Klapper, Phillip and Jackson partial Pa element 2 indet. bar, blade, and platform fragments	Probably Givetian (= Middle Devonian)	3	One of the <i>Icriodus</i> species is probably either <i>I. arkonensis</i> Stauffer, or <i>I. n. sp. E</i> of Weddige (1977). The other platforms are possibly <i>I. obliquimarginatus</i> Bischoff and Ziegler or <i>I. expansus</i> Branson and Mehl. The morphotypes of the lateral process fragments are similar to those seen on <i>I. latericrescens</i> <i>latericrescens</i> Branson and Mehl. These are all Givetian forms.  109 g of rock processed (73 g +20 and 6 g 20-200 mesh insoluble residue).

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Cortland Co. 023-04714 12703-SD	Clough No. 1 2880'-2910' 42.51847 -76.00093	Helderberg Group	cuttings	<i>Ozarkodina remscheidensis remscheidensis</i> (Ziegler) 3 Pa, 1 Sb elements 2 indet. bar, blade, or platform fragments	Lower <i>O. remscheidensis</i> Subzone-uppermost <i>L.</i> <i>woschmidti</i> Zone (=Pridolian- Lochkovian; Upper Silurian- Lowermost Devonian)	2.5- 3	107 g of rock processed (6 g +20 and 7 g 20-200 mesh insoluble residue).
Genesee Co. 037-10776 12704-SD	Danby Belt No. 1 70'-100' 42.92045 -78.16734	Ludlowville Formation	cuttings	1 indet. bar, blade, or platform fragment	post Lower Ordovician Paleozoic	2	101 g of rock processed (67 g +20 and 21 g 20-200 mesh insoluble residue).
Genesee Co. 037-10776 12705-SD	Danby Belt No. 1 140'-170' 42.92045 -78.16734	Centerfield Limestone Member, Ludlowville Formation	cuttings	1 indet. bar fragment	post Lower Ordovician Paleozoic	1	104 g of rock processed (67 g +20 and 9 g 20-200 mesh insoluble residue). This may be downhole contamination. CAI should not be lower than overlying sample.
Livingston Co. 051-04391 12706-SD	J. Parnell 156'-175' 42.82758 -77.93560	Genesee Group	cuttings	1 <i>Ancyrodella</i> sp. indet. Pa element fragment 1 <i>Icriodus</i> sp. indet. very juvenile P element 1 <i>Polygnathus dubius</i> Hinde Pa element fragment 1 <i>Polygnathus pennatus</i> Hinde Pa element 1 <i>Polygnathus</i> sp. indet. Pa frgment  UNASSIGNED ELEMENTS: 1 Pb, 2 Sb (2 morphotypes), 3 Sc (2 morphotypes).  14 indet. bar, blade, or platform fragments	Lower <i>falsiovalis</i> Zone through <i>transitans</i> Zone (= Frasnian; Upper Devonian)	2	Although the <i>Ancyrodella</i> specimen is not identifiable to species, it is clearly of Upper Devonian morphotype, probably <i>An. rotundiloba</i> (Bryant) or <i>An.</i> <i>alata</i> (Glenister and Klapper).  113 g of rock processed (76 g +20 and 6 g 20-200 mesh insoluble residue).
Livingston Co. 051-04630 12707-SD	Kennedy No. 1 260'-280' 42.65023 -77.75596	Genundewa Limestone	cuttings	4 indet. bar, blade, and platform fragments.	post Lower Ordovician Paleozoic	2	35 g of rock processed (26 g +20 and 1 g 20-200 mesh insoluble residue).
Livingston Co. 051-04630	Kennedy No. 1 280'-300' 42.65023 -77.75596	Lodi Limestone	cuttings	BARREN	indet.		53 g of rock processed (38 g +20 and 1 g 20-200 mesh insoluble residue).
Livingston Co. 051-04630 12708-SD	Kennedy No. 1 330'-370' 42.65023 -77.75596	Genesee Shale	cuttings	1 <i>Polygnathus</i> sp. indet. juvenile Pa element, of Middle Devonian morphotype 11 indet. bar, blade, and platform fragments.	Middle Devonian	2	71 g of rock processed (59 g +20 and 1 g 20-200 mesh insoluble residue).
Madison Co. 053-04032 12709-SD	Danisevich No. 1 140'-157' 42.79630 -75.40464	Skaneateles Group	cuttings	1 <i>Icriodus</i> sp. indet P element fragment	Devonian	2.5	137 g of rock processed (121 g +20 and 1 g 20-200 mesh insoluble residue).

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Onondaga Co. 067-11654 12710-SD	Sears No. 1 110'-160' 42.89831 -76.23852	Moscow Shale	cuttings	2 indet. bar, blade, and platform fragments.	Post Lower Ordovician Paleozoic	2.5- 3	134 g of rock processed (112 g +20 and 8 g 20-200 mesh insoluble residue).
Onondaga Co. 067-11654	Sears No. 1 260'-270' 42.89831 -76.23852	Skaneateles Group	cuttings	BARREN	indet.		124 g of rock processed (101 g +20 and 6 g 20-200 mesh insoluble residue).
Onondaga Co. 067-12163 12711-SD	Harrison No. 1 430'-460' 42.93688 -76.34586	Cherry Valley Limestone	cuttings	3 indet. bar, blade, and platform fragments.	Post Lower Ordovician Paleozoic	1.5	81 g of rock processed 70 g +20 and 1 g 20-200 mesh insoluble residue).
Ontario Co. 069-06395	Frankish No. 1 310'-370' 42.81262 -77.20285	Tichenor Limestone	cuttings	BARREN	indet.		103 g of rock processed (61 g +20 and 2 g 20-200 mesh insoluble residue).
Schulyer Co. 097-19692 12712-SD	L. Perigo No. 1 1240'-1270' 42.43251 -76.97039	Lodi Limestone	cuttings	1 Sa element fragment, sp. indet. 1 indet. bar fragment	Post Lower Ordovician Paleozoic	3	160 g of rock processed (127 g +20 and 1 g 20-200 mesh insoluble residue).
Schuyler Co. 097-19692 12713-SD	L. Perigo No. 1 1290'-1320' 42.43251 -76.97039	Geneseo Shale	cuttings	2 indet. bar, blade, and platform fragments	Post Lower Ordovician Paleozoic	3.5	101 g of rock processed ( 93 g +20 and 1 g 20-200 mesh insoluble residue).
Steuben Co. 101-03924	Olin No. 1 3170'-3190' 43.06303 -77.43067	Genundewa Limestone	cuttings	BARREN	indet.		6 g of rock processed (1g +20 and 1g 20-200 mesh insoluble residue).
Steuben Co. 101-03924	Olin No. 1 3190'-3220' 43.06303 -77.43067	Geneseo Shale	cuttings	BARREN	indet.		21 g of rock processed (17 g +20 and 1 g 20-200 mesh insoluble residue).
Steuben Co. 101-04573	Scudder No. 1 2082'-2101' 42.23546 -77.22256	Genundewa Limestone	cuttings	BARREN	indet.		66 g of rock processed (58 g +20 and 1 g 20-200 mesh insoluble residue).

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Steuben Co. 101-04573 12714-SD	Scudder No. 1 2319'-2344' 42.23546 -77.22256	Lodi Limestone	cuttings	1 indet. bar fragment.	Post Lower Ordovician Paleozoic	3.0	66 g of rock processed (31 g +20 and 8 g 20-200 mesh insoluble residue).
Steuben Co. 101-04573	Scudder No. 1 2344'-2389' 42.23546 -77.22256	Geneseo Shale	cuttings	BARREN	indet.		104 g of rock processed (97 g +20 and 1 g 20-200 mesh insoluble residue).
Steuben Co. 101-21468	Avoca No. 1 2380'-2410' 42.41958 -77.45354	Lodi Limestone	cuttings	BARREN	indet.		122 g of rock processed (104 g +20 and 1 g 20-200 mesh insoluble residue).
Steuben Co. 101-21468 12715-SD	Avoca No. 1 2410'-2430' 42.41958 -77.45354	Geneseo Shale	cuttings	1 indet. denticulate bar, blade, or platform fragment	Post Lower Ordovician Paleozoic	2-3?	106 g of rock processed (88 g +20 and 1 g 20-200 mesh insoluble residue).
Tompkins Co. 109-10243	R. Place No. 1 2980'-3020' 42.40099 -76.66854	Cherry Valley Limestone	cuttings	BARREN	indet.		57g of rock processed (34 g +20 and 4 g 20-200 mesh insoluble residue).
Tompkins Co. 109-10243 12716-SD	R. Place No. 1 3240'-3290' 42.40099 -76.66854	Manlius Limestone	cuttings	1 indet. denticle fragment  1 scolecodont? fragment	Paleozoic	3.5- 4	74 g of rock processed (2 g +20 and 11 g 20-200 mesh insoluble residue).
Tompkins Co. 109-13173 12717-SD	Cargill Cove Test No. 17 33'-34' 42.52296 -76.5052	Lodi Limestone	core	1 indet. denticulate bar, blade, or platform fragment	Post Lower Ordovician Paleozoic	2.5- 3.0	1007g of rock processed (710 g +20 and 42 g 20-200 mesh insoluble residue).
Wyoming Co. 121-22042	Titus Bros. No. 1 430'-460' 42.82192 -78.09957	Genundewa Limestone	cuttings	BARREN	indet.		106 g of rock processed (67 g +20 and 20 g 20-200 mesh insoluble residue).
Wyoming Co. 121-22042 12718-SD	Titus Bros. No. 1 560'-600' 42.82192 -78.09957	Lodi Limestone	cuttings	1 <i>Icridous</i> sp. indet. P element fragment	Devonian	2	92 g of rock processed (49 g +20 and 18 g 20-200 mesh insoluble residue).

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Wyoming Co. 121-22042	Titus Bros. No. 1 810'-840' 42.82192 -78.09957	Marcellus Shale	cuttings	BARREN	indet.		<b>g of rock processed ( g +20 and g 20-200 mesh insoluble residue).</b>
Yates Co. 123-04796	Borglum No. 1 137'-175' 42.68333 -76.9779	Genundewa Limestone	cuttings	BARREN	indet.		73 g of rock processed (65 g +20 and 1 g 20-200 mesh insoluble residue).
Yates Co. 123-04796	Borglum No. 1 243'-264' 42.68333 -76.9779	Lodi Limestone	cuttings	BARREN	indet.		87 g of rock processed (77 g +20 and 1 g 20-200 mesh insoluble residue).
Yates Co. 123-04796	Borglum No. 1 271'-308' 42.68333 -76.9779	Geneseo Shale	cuttings	BARREN	indet.		121 g of rock processed (113 g +20 and 1 g 20-200 mesh insoluble residue).