GEOLOGIC INVESTIGATION OF THE GAS POTENTIAL
in the
OTSEGO COUNTY REGION, EASTERN NEW YORK STATE

FINAL PHASE ONE REPORT
to
MILLENNIUM NATURAL RESOURCES DEVELOPMENT, L.L.C.

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PART I
CORE AND CUTTING ANALYSES, SURFACE STRUCTURE, FAULTS AND LINEAMENTS, AND STRATIGRAPHIC CROSS-SECTIONS BASED ON PREVIOUS INVESTIGATIONS

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PART II
SEISMIC REFLECTION ANALYSES OF EXISTING DATA

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PART III
STRUCTURE CONTOURS, STRATIGRAPHIC CROSS-SECTIONS, AND OIL AND GAS PROSPECTS

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NOTICE

ABSTRACT

In Part I, Jacobi and Smith show that Silurian and Devonian rocks in outcrop provide evidence for at least three intersecting fault systems that trend NNE, NE and WNW. The NNE-striking faults and associated monoclines are reactivated Ordovician faults that are coincident with Earthsat and topographic lineaments. The WNW-trending faults and monoclines are related to Iapetan opening faults that were reactivated in the Paleozoic. The reactivation of the fault systems indicates that fracture porosity probably exists throughout much of the section along these fault traces. Carbonates in core held by the NYSGS did not display secondary porosity (dissolution), unlike what is suspected to occur along the fault systems. Thin sections of the Gilboa (a suspected target) did not reveal good porosity. Although well cutting fragments were generally too small to determine accurate porosity, we estimate that the Herkimer has low porosity where the cuttings were sampled, whereas the Oneida and Oriskany have relatively high porosity.

In Part II, Cruz interprets the available seismic data and suggests that faults are observed on all the seismic lines. Combined with magnetics, several of the faults are thought to trend WNW, especially in the area of the Butternut Prospect in western Otsego County. Other fault systems are thought to trend NE and NNE (N), based on integration with lineaments. Of the several potential gas reservoirs recognized in the seismic data, three are recommended for further study: the Butternut, Pittsfield, and Lead 9a prospects.

In Part III, Billman reviews the potential hydrocarbon sources and hydrocarbon migration pathways. Hydrocarbon sources include the Utica and Marcellus formations. Billman characterize the Genegantslet, Stagecoach, Lebanon gas fields and Trenton/Black River exploration. Billman's new isopach and structural contour maps confirm the Butternut Prospect. Stratigraphic cross sections based on well logs demonstrate a basin deepening and stratigraphic thickening to the south-southwest. The Silurian section thins markedly from west to east across Otsego County. Billman describes nearby analog fields, the Butternut Creek Prospect, and provides a "Butternut Creek Prospect Summary".

KEY WORDS

Otsego County, hydrocarbon prospects, faults, seismic, well logs, sedimentary petrography

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SUMMARY

This report consists of three parts: Part I deals with a) investigations of surface geology in the northern Otsego County region, with a focus on defining faults at the surface and groundtruthing lineaments, b) examination of cores and well cuttings in the Otsego County region that are held by the New York State Geological Survey, and c) geological cross sections constructed from existing stratigraphic cross sections, with a focus on identifying growth fault geometries as well as present day offset. Part II centers on existing seismic reflection profiles that were reprocessed for this project. The focus in Part II is threefold: a) defining the reflector horizons, b) identifying possible stratigraphic traps, and c) defining faults and related potential structural traps. Part III summarizes possible analog fields, provides isopach (thickness of units) maps, structural contour maps, and prospect descriptions and summaries.

In Part I, Jacobi and Smith show that the surface Silurian and Devonian rocks provide evidence for at least three intersecting fault systems that trend NNE, NE and WNW. The NNE-striking faults and associated monoclines are reactivated Ordovician faults that are coincident with Earthsat and topographic lineaments. The WNW-trending faults and monoclines are related to Iapetan opening faults that were reactivated in the Paleozoic. The reactivation of the fault systems indicates that fracture porosity probably occurs throughout much of the section along these fault traces. Carbonates in core held by the NYSGS were dense and did not display secondary porosity (dissolution), unlike what is suspected to occur along the fault systems. Fractures in intact core were also minimal. Thin sections of the Gilboa (a suspected target) did not reveal good porosity. Although well cutting fragments were generally too small to determine accurate porosity, our estimates are that the Herkimer has low porosity where the cuttings were sampled, whereas the Oneida and Oriskany have relatively high porosity. The Queenston, upper Grimsby and Saquoit may also have zones of sufficient porosity.

In Part II, Cruz found evidence for faults on all the seismic lines. Combined with magnetics, several of the faults are thought to trend WNW, especially in the area of the Butternut Prospect. Other fault systems are thought to trend NE and NNE (N), based on integration with lineaments. Of the several potential gas reservoirs recognized in the seismic data, three are recommended for further study: the Butternut, Pittsfield, and Lead 9a prospects.

In Part III, Billman reviews the potential hydrocarbon sources and hydrocarbon migration pathways. He interprets new isopach and structural contour maps, as well as stratigraphic cross sections. Billman describes nearby analog fields, provides a "Butternut Creek Prospect Summary" , and describes the Butternut Creek Prospect.

PART I
CORE AND WELL CUTTING ANALYSES, SURFACE STRUCTURE, FAULTS AND LINEAMENTS, AND STRATIGRAPHIC CROSS-SECTIONS BASED ON PREVIOUS INVESTIGATIONS

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INTRODUCTION AND HISTORY OF PRESENT INVESTIGATION

The attendees at the first Millennium meeting in Cooperstown on May 18, 1999, included:
Mr. Bruce Hargrove and Mr. Ted Hargrove, Millennium Natural Resources Development
Dr. John Martin, NYSERDA
Dr. Robert Fakundiny, NYSGS
Mr. Rich Niahay, NYSGS
Mr. Dan Billman, Billman Geologic Consultants, Inc.
Dr. Robert Jacobi, SUNY at Buffalo
Dr. Gerald Smith, SUNY at Buffalo
A technical oversight committee formed by Dr. Martin included Mr. Stuart Loewenstein, Mr. Oliver Mohar, Mr. Art Pyron and Mr. Lyman Rudolph.

At this meeting, participants reviewed the known geology and developed a research plan to determine optimum areas for hydrocarbon exploration in the Otsego County area. At the end of the first meeting, all agreed that stacked reservoirs would be the primary targets. At the end of the second day of the second meeting (which was held at Buffalo), Jacobi proposed that the investigators integrate all the information from lineaments, seismics, magnetics, structure, and stratigraphy/sedimentology to construct a map that showed fault trends as a base map, over which layers portraying various sedimentological/stratigraphical aspects could be added. The intersection of fault systems with, for example, beach facies would pinpoint areas where the best opportunities for stacked structural and sed/stratigraphic targets might occur.

RESEARCH PLAN

At the second meeting, the research plan for the various investigators was refined: Fagan would procure high resolution aeromagnetics and digitize NYSGS facies maps that included the area, Cruz would procure and analyze seismic, Billman would construct stratigraphic cross sections, structure contour maps, and isopach maps, and Jacobi/Smith would
1) continue an abbreviated petrographic study of the original plan developed by Friedman; this study would include inspection of thin sections that Friedman had made.
2) inspect core held in Albany by NYSGS
3) determine whether faulting/folding extended to the surface in the region of Cherry Valley, Otsego County
4) provide GIS-based shot point maps for Kevin Cruz, and
5) integrate data on GIS-based maps.
Later discussion led to Jacobi/Smith also constructing an E-W cross-section across Otsego County and excerpting cross-sections from older reports.

PREVIOUS INVESTIGATIONS

Detailed geological studies in Otsego County began in the late 1940's and continued into the mid-1950's. Stevenson's (1948, 1949) research on the lithology and structure of Middle Devonian strata of Otsego County allowed him to construct a structural contour map on the top of the Tully Formation for Otsego County. Stevenson's (1948, 1949) work documented the presence of six NNE to NE-trending folds that are relatively narrow and are located along prominent valleys in the county.

Geologic maps were generated for northern Otsego County (Rickard and Zenger, 1964) based on field mapping of the Richfield Springs 15' quadrangle by Rickard from 1953 to 1955, and of the Cooperstown 15' quadrangle by Zenger in 1958. The Richfield Springs map shows that the Silurian Sauquoit/Otsquago/Oneida (undifferentiated) units pinch-out east of Salt Springville (NNE of East Springfield), and that a pinch-out (to the east) of the overlying Silurian Herkimer Sandstone occurs west of Van Hornesville. Rickard and Zenger (1964) also provided detailed descriptions of the lithological and paleontological characteristics of the stratigraphic units from the Middle Ordovician Canajoharie-Dolgeville shales to the Upper Devonian Oneonta Formation.

In 1980, Fisher published his bedrock geology map of the central Mohawk Valley area; the southern extent of his map covers the northernmost part of the study area of Otsego County. Fisher's (1980) map and report described outcrops along Rt. 20 in Cherry Valley and outcrops at Judd's Falls. The description of the stratigraphic units provided age data from ash beds in the Kalkberg Formation. Fisher's (1980) map also provided limited structural data for the area of northern Otsego County. Fisher (1980) showed SSW-plunging anticlines aligned along the major ravines of the Helderberg Escarpment.

Rickard's correlations among well logs in New York State included several of the deep wells in Otsego County. Unpublished drafts of stratigraphic cross-sections made by Rickard (held by the NYS Geological Survey) included such wells as API #10138, 10834, 3993 and 4055. These cross-sections correlated Cambrian to Devonian strata. A published example of Rickard's stratigraphic cross-sections is found in his "Stratigraphy and Structure of the Subsurface Cambrian and Ordovician Carbonates of New York" (1973; Plate 11, Cross Section 2). Rickard (1973) also suggested that the generally N-striking faults observed in the Mohawk Valley extended south into Otsego County in the subsurface. These faults were assumed to be Taconic-aged, with no motion on them since Ordovician times.

Subsurface work also was performed by Beinkafner (1981, 1983), who analyzed and correlated the Silurian Herkimer Formation throughout central New York State. Beinkafner's (1981) cross-sections of the Herkimer Formation used wells in and adjacent to Otsego County (API# 1160,4040, 3993, 4055, 4245, 4429, 4547, 4455, 4073 and 4364). From the well log data Beinkafner (1981, 1983) generated isopach, structural contour, and lithofacies maps for the Herkimer Formation in much of Otsego County. The isopach map for the lower Herkimer Formation displays dominantly N-striking contours, whereas the upper Herkimer Formation shows both N-striking and E-striking isopach trends. The N-striking trends are located in the western part of Beinkafner's (1981) study area and along the outcrop band. The E-striking contours occur in the south-central and southeastern parts Beinkafner's (1981) study area. The western contact between the Herkimer and the Rochester trends generally north, as does the contact to the east between the Joslin Hill and Jordanville members of the Herkimer Formation (this contact is regarded as the shoreline in the lower Herkimer). In contrast, lithofacies trends within the Herkimer present a more complicated picture. The lower Herkimer has strong east-west and north-south lithofacies trends, whereas the upper Herkimer has NW trends.

Saroff's (1987) study of the Auburn gas field in Cayuga County included well log analyses, annual production data, and petrography of the Queenston sandstone. Saroff (1987) concluded that the highest producing wells in the Queenston Formation lay along a NE-striking trends that are parallel to lineaments in Bouguer gravity and aeromagnetic anomalies. He suggested that the geophysical anomalies marked faults in the Precambrian basement that were apparently reactivated in post Silurian times, resulting in fracture porosity that promoted increased hydrocarbon production.

Earthsat (1997) inspected Landsat images of the Appalachian Basin in NYS and constructed maps displaying lineaments identified in the images of the NYS Appalachian basin, as well as potential oil and gas fairways based on the lineament map. Jacobi et al. (2000) integrated Earthsat's lineament data base with gravity, magnetics, available seismic, and the Geological Map of NYS (Rickard and Fisher, 1970) to determine potential fault trends in the Appalachian Basin in NYS. These data suggested that faults in the Precambrian basement extend farther up-section than previously suspected. For example, on the NYS Geological Map (Rickard and Fisher, 1970), NNE-striking faults observed in the Mohawk Valley were assumed to "die out" below Upper Ordovician shales (the Utica Formation). However, lineaments that are coincident with the assumed pre-Upper Ordovician faults (as defined by Rickard, 1973) extend into regions where Devonian sediments outcrop at the surface. This observation strongly suggested that the "pre-Upper Ordovician" faults actually affected the entire stratigraphic section in the Otsego County region. Furthermore, Silurian sediments which are continuous to the west of Otsego County, underwent rapid facies changes (including rapid thinning to 0 thickness) in regions on strike with the "pre-Upper Ordovician" faults. This observation suggested that the faults had been active during deposition in the Silurian units, and had controlled the depositional facies. Jacobi et al. (2000) proposed that Earthsat's (1997) ENE-striking lineaments may reflect the rift faults of the northern extension of the Rome Trough. To the west in the Finger Lakes region, these faults were pathways for fluid migration, which resulted in dissolution of the carbonate and partial replacement with dolostone. This combination of fault and fluid migration effects resulted in high porosity zones that are the targets of CNR exploration. Wells drilled along these faults have estimated yields of natural gas of as high as 2-3 bcf. On seismic, these zones are recognized by a subtle sag in the Trenton/Black River reflectors.

The existence of the lineaments, coincident with deep fault systems, had two important implications for this project:

1) the lineaments, which crossed the entire area of focus, imply that deep faults could be located throughout the area, and

2) the faults probably extended up though the entire section, so that fracture porosity and secondary dissolution porosity could be expected in units above the Ordovician limestones as

well. Furthermore, the facies changes associated with the faults could lead to stratigraphic traps along the fault trends.

JACOBI AND SMITH RESEARCH RESULTS

The lithologic stratigraphic column for outcrop in the northern Otsego County area is shown in Figure 1a and the general columns for the Appalachian Basin in New York State are shown in Figure 1b. The location of gas franchises, gaslines, major power lines, and wells are shown in Appendix A.

1) Thin Section Studies

A) Brannagan Well (API # 3970), Madison County. (For location, see Appendix A, Figure 7). We examined 53 thin sections consisting of cuttings from the Brannagan Well. Forty-three thin sections were made in Dr. Friedman's lab. Rich Nyahay of NYSGS had 10 additional thin sections made for intervals where Friedman did not make any thin sections. The depths and units from which these cuttings came are shown in the stratigraphic column of Figure 2. Table 1 provides a petrographic description of the examined thin sections. Organic laminae and bitumen were observed in several thin sections, as indicated on Figure 2 and Table 1. Because these thin sections are all from cuttings, accurate assessments of the porosity is generally not possible. In fact, some units are represented by single grains, such as the Oriskany. Based on the Oriskany grains, the Oriskany here may be a moderately clean sand, comprised of angular to subangular, silt to fine sand-sized, highly fractured quartz grains, although some seriticized feldspar was noted.

B) Jefferson Site #1 (Texas Eastern API # 21006), Schoharie County. (For location, see Appendix A, Figure 6). Three oversized thin sections were made by Rich Nyahay of the NYS Geological Survey for the Gilboa (broadly, a Tully-age equivalent) from intervals 823.33' and 867' and 867'. The thin sections were not stained for porosity. All three thin sections consist of fine-grained siltstone with quartz grains. The groundmass is fairly uniform, except for faint shalier laminae. All the thin sections contain rip-up clasts of dark gray shale with scattered silt-size quartz grains. The few fossil fragments occur near the rip-up clasts, and are generally brachiopod shells. Dark shale similar to the rip-up clasts occurs within the more complete shell fragments. No mica, calcite or plagioclase grains were observed.

Porosity of the Gilboa Fm. was estimated by performing 300-point count analyses of thin section 823.33. A total of 302 sites were counted at intervals of 0.5 mm; of the 302 points, only 4 points were likely to be voids. However, the sizes of these voids are approximately 0.05 mm to 0.001 mm in diameter, and appear isolated from one another. The estimated porosity is 1.325%, and the effective porosity is assumed to be much lower. The error in a petrographic 300-point count analysis was determined by Van der Plas and Tobi (1965) to be +/-1%.

2) Core Inspections

A) Holdridge #1 (API #10096), Delaware County. (For location, see Appendix A, Figure 6). With the help of Rich Nyahay, Jacobi and Smith logged the Holdridge #1 (API #10096) core from Delaware County that is held at the NYSGS. The depth of the three core runs for Holdridge #1 are shown on the drilling rate and mud logs in Figure 3, and on the gamma ray and sonic logs in Figure 4. Core #1 sampled the Manlius, the lowermost unit in the Helderberg

Group. Core #2 sampled the Cobleskill, the lower unit in the Rondout, and core #3 sampled the Brayman. The values used for rock quality designation (RQD) calculations are shown in Table 2. For RQD calculations, we used the percent of intact core over 0.1 m long (about 4").

The Manlius core (Core #1) consists of about 3 ft of limestone rubble (Figure 5) over a 6 ft cored interval, making core recovery less than 50%. The RQD is 0 for this core. The mud log noted that shale was an important constituent in this interval, although none was boxed in the rubble. The actual clasts that remain exhibit no porosity.

The Cobleskill carbonate core (Core #2; Figure 6) had much higher recovery rates, and its RQD is similarly higher than the Manlius core (Table 2). Styolitic fractures are common in the lower part of the core, and two vertical fractures occur in core from boxes 5 and 6. Boxes 4, 5, and 6 display a high number of horizontal, coring-induced/accentuated fractures. Anhydrite occurs at three horizons in the upper part of the core, and one horizon in the lower part of the core. Soft sediment deformation is encountered in box 9. Other than the fractures, the unit does not exhibit visible significant primary or secondary porosity.

The Brayman carbonate and anhydrite core (Core #3; Figure 7) had good core recovery, but the RQD is comparable to the Cobleskill core (Table 2). Anhydrite is interbedded with carbonate throughout Core #3. Chicken wire texture is common in the lower part of the core. Dipping/deformed layering occurs in boxes 3 and 10. Styolitic fractures are not common, but dipping fractures, both filled and open, are moderately abundant (especially compared to the other cores). No primary or secondary significant porosity, other than the fracture porosity, is observed.

B) Jefferson Site #1 (Texas Eastern API # 21006), Schoharie County. (For location, see Appendix A, Figure 6). Jacobi and Smith logged core boxes 49-55 (810 ft to 907 ft) of the Jefferson Site #1 (API #10096) core from Schoharie County. This core is also held at the NYSGS. These basal cores penetrated the Gilboa, which here consists of interbedded shales, siltstones and fine sandstones (Figure 8). Core recovery was nearly 100% and RQD values are all above 90%, some at 100% (Table 2). The RQD values are consistent with the lack of fracturing evident in these cores. No vertical or dipping fractures were encountered in the cores, but one slump fault dipping at 42^{o} at 893' ft., and two intervals of dipping beds at 887 ft. and 906 ft. were observed. These cores exhibit several intervals with siltstones and fine sandstones over 1 foot thick, including between 822 ft. and 824.5 ft., 837 ft. and 838 ft., 861 ft. and ~868 ft., 871 ft. and 873.5 ft., 877 ft. and 881.5 ft., for a total of 17 ft. of siltstone and sandstone in units thicker than 1 foot thick. Additional intervals of thinner interbedded siltstone and sandstone beds occur between 813 ft. and 817.5 ft., 819.5 ft. and 822 ft., 837 ft. and 845 ft., 855 ft. and 860 ft., 868 ft. and 872.5 ft., 885.5 ft. and 896.5 ft., and 903.5 ft. and 907 ft.. Several of the sandstone intervals are noticeably porous. The sandstone and siltstone intervals correlate very well with gamma ray lows (Figure 9), such as at 815 ft., 822 ft., ~837 ft.-843 ft.,~858 ft.-867 ft. and 880 ft.. The conclusion is that the Gilboa here has porosity. Three oversized thin sections were made by Rich Nyahay of the NYS Geological Survey for the intervals 823.33 ft. and 867 ft.. The thin sections were not stained for porosity (see description of thin sections above).

C) Delaney A (API # 13645), (Miller Brewing) Cayuga County. (For location, see Appendix A, Figure 6). Jacobi and Smith logged core box 4 (1536 ft to 1545 ft) of the Delaney A (API #13645) core from Cayuga County. This core is also held at the NYSGS. These cores penetrated the Queenston Formation, which here consists of interbedded red siltstones and sandstones (Figure 10a). Core recovery was nearly 100% and RQD values are all at 100%. The RQD values are consistent with the lack of fracturing evident in these cores. No vertical or dipping fractures were encountered in the cores. These sandstones exhibit visible porosity. We collected one sample for a thin section to be made by NYS Geological Survey, but we have not received the section for observation. Saroff (1977) studied two thin sections from the 1543 ft level in this same core. Saroff (1977) found that the unit consisted of "moderately well sorted, fine-grained, subrounded to rounded grains...[that are a]... mixture of quartz, metamorphic rock fragments, and clay and shale" (p. 50). About 50% of the grains are subrounded to rounded quartz. From a third thin section taken from the 1540 ft level, Saroff (1977) determined that the overall porosity is 13%, although the porosity is highly variable. From the decline rate curves of average daily production, Saroff (1977) concluded that the highly productive wells in the Auburn Field were influenced primarily by fracture porosity in the first 4 years of production, and then by primarily intergranular porosity.

3) Well Cuttings Inspections

Jacobi and Smith examined 57 well cutting samples representing 451 feet of the Grimsby to Herkimer stratigraphic section encountered in the Elliott (API # 4050) well. For location, see Appendix A, Figure 6. This well is also located on cross section "Figure 14" in Part I of this report and in cross section N-S of Billman's Part III of this report. The well is located on the north side of the Butternut prospect. Figure 10b displays a log of the major lithologies observed in the cuttings, and Table 3 is a compilation of the details concerning the lithologies observed in the cuttings. Three lithologies dominate over the intervals inspected: gray shaly silt to silty shale, "white" clasts and grains of clear to cloudy sand sized quartz, and "redbeds" consisting of hematite stained quartz grains and composite clasts with silt to sand-sized quartz grains. The Herkimer is predominately gray silt to silty shale, with a 15 ft. interval (3235 ft. to 3250 ft.) of redbed material and quartz sands. Overall, the Herkimer does not appear to be an optimum target at this location. The underlying Willowvale consists of gray silt to silty shale and redbed material. This unit is also a weak target. The underlying Saquoit is predominately a redbed in the upper 110 ft. of the unit. The lower 54 ft. are more variable, with quartz sands at the base grading up into gray silt to silty shale. The underlying Wolcott consists primarily of equal proportions of gray silt to silty shale and "white" quartz sands. The underlying Sodus consists of "white" quartz sands and lesser amounts of redbed material and gray silt to silty shale. The underlying Oneida consists predominately of "white" quartz sands with minor amounts of gray silt to silty shale except in a 12 ft. interval near the base. Overall, this unit presents the best target of the units examined. The upper 23 ft. of the Grimsby is similar to the Oneida, and might suggest that these 23 ft. should more properly be assigned to the Oneida. However, the small amount of redbed material at 3610 to 3613 supports the present terminology that the upper 23 ft. of sands being Grimsby, with a strong component similar to the Oneida. This upper part of the Grimsby is also a suitable target. The lower part of the Grimsby that we examined consists of 50% gray silt to silty shale and 50% "white" quartz sands.

Well-rounded, frosted, sand size quartz grains indicative of an aeolian source were observed in several samples, including the Herkimer between 3235 ft. and 3244 ft., 3247 ft. and 3250 ft., the Saquoit between 3406 ft. and 3421 ft., 3433 ft. and 3458 ft., the Wolcott between 3496 ft. and 3500 ft., the Wolcott and Sodus between 3519 ft. and 3543 ft., the Oneida between 3567 ft. and 3589 ft., and the Grimsby between 3601 ft. and 3613 ft. The relative percentage of these grains is generally small (on the order of 1 to a few percent), so the actual cuttings generally did not sample an aeolian environment; rather, the cuttings sampled a sediment which had, as one of its sources, an aeolian environment. Only in the Saquoit between 3451 ft. and 3458 ft., the Wolcott/Sodus between 3523 ft. and 3536 ft., and especially at the top of the Oneida between 3557 ft. and 3567 ft. are significant amounts of rounded, frosted quartz grains encountered. Even here, the high proportion of other components in the samples suggests either that an aeolian environment source simply provided more grains for the sediments encountered in the well than for the other samples with rounded grains, or that an aeolian environment played a minor role in the depositional environment of these samples. Rounded grains as a major constituent were observed in redbeds of the Sauquoit between 3359 ft. and 3388 ft. and may indicate an aeolian environment of deposition for this sediment.

We observed phosphatic nodules in the Sodus between 3543 ft. and 3548 ft. and in the Oneida between 3567 ft. and 3574 ft., and between 3593 ft. and 3596 ft. Phosphate nodules are indicative of unconformities. We also observed extremely clear (angular) quartz crystals in the Herkimer between 3244 ft. to 3250 ft., the Saquoit between 3460 ft. and 3463 ft., 3469 ft. to 3475 ft., the Sodus between 3530 ft. and 3548 ft., the Wolcott between 3516 ft. and 3519 ft., and the Oneida between 3567 ft. and 3593 ft.. The clear quartz grains, especially in the Saquoit and Sodus, are similar to the "Herkimer diamonds" found in the Cambrian Little Falls Dolomite. If the "Herkimer diamonds" did provide a source for these units, then the implication is that the Cambrian Little Falls Dolomite was exposed to erosive processes at these times.

4) Cross Sections

We constructed geologic cross sections from Rickard's (unpub) and Beinkafner's (unpub) stratigraphic cross sections that cross Otsego County (for location of cross sections, see Figure 11). Three NW-SE trending geologic cross sections in the northern part of the county were the result (Figures 12, 13, 14). We also constructed E-W and N-S cross sections across Otsego County based on tops information from wells in Otsego County (Figures 15 and 16, respectively)

A) #3993-#4065 Geologic Cross Section (Eastern-most Section, Figures 11A, 11B, 11C, 12A, 12B). In the Siluro-Devonian geologic cross section (Figure 12a), we excerpted the stratigraphic columnar sections, and the associated stratigraphic correlations from Rickard's Michigan-NYS stratigraphic cross section, and constructed a geologic cross section. The wells are spaced too far apart to determine the existence and location of faults, but the regional (apparent) dip, based on two closely spaced wells (#4245 an #4547) in the central part of the county, agrees closely with the dip between these two wells (Figure 12a). This agreement could be interpreted to imply that no major fault, active in Silurian or younger times, lies between the two wells. However, the units do not maintain consistent thickness relationships between the two wells. The thickness of the Tristates section increases 8 fold to the SE, whereas the Manlius and Syracuse thin to the SE. The 8-fold increase in both clastic and nonclastic components suggests that a short-lived basin lay to the SE of the northern well, #3993. Because along-strike, southward extensions of the Mother's Creek and Ephrata faults would cross the geologic cross section (Figure11a, b, c), this basin was probably fault-controlled. (A branch of the West Stone Arabia Fault also may pass the southeastern end of the cross section.) If these faults do cross the line of section, then these faults were active in Siluro-Devonian times.

In the Cambro-Ordovician geologic cross section between the same two wells (Figure 12b), we excerpted the stratigraphic columnar sections, and the associated stratigraphic correlations, from Rickard's (1973) Lake Ontario-Bash Bish Falls stratigraphic cross section, and constructed the geologic cross section in Figure 12b. The calculated regional apparent dip is not consistent with this deeper part of the section. Rather, the dip between wells for the Cambro-Ordovician section is shallower than the calculated regional apparent dip. This inconsistency between the dip of the deeper units and the dip of the Siluro-Devonian section could indicate that fault activity affected the basin before the Siluro-Devonian, i.e., during the Ordovician Taconic Orogeny. Because the radical Cambro-Ordovician thickness variations between the two wells occur primarily in the Chuctanunda (or broadly "Black River") interval, the faulting was probably active primarily at this time. This is the same general time period as the fault activity in the Finger Lakes region that resulted in the Trenton-Black River porosity. The same faults as discussed above, the Mother's Creek and Ephrata faults, are possible candidates for the proposed fault motion.

The Earthsat lineaments (Landsat data) indicate fracturing in the surface rocks, which are Devonian aged in much of Otsego County. That the Earthsat lineaments are coincident with the Ordovician-aged faults (Figure 11a) supports the contention that the Ordovician faults were reactivated in Siluro-Devonian (Acadian times).

B) #10138-#10834 Geologic Cross Section (Central Northern Cross Section, Figure 13). In this Silurian geologic cross section, we excerpted the stratigraphic columnar sections, and the associated stratigraphic correlations from Rickard's E-W cross section #5, and constructed the geologic cross section in Figure 13. The regional (apparent) dip, based on two closely spaced wells (#4245 an #4547) in the central part of the county, is approximately the same as the dip between these two wells (Figure 13). The general agreement could be interpreted to mean that no major fault, active in Silurian or younger times, lies between the two wells. The generally constant thickness of units between Rickard's correlation lines also supports the suggestion that no significant growth fault activity occurred between these two wells during the Silurian times represented by the units. However, well logs indicate that the Oneida, which has a high proportion of sandstones in the northwestern well, becomes much shalier in the southeastern well (#10834). Other units show a similar pattern; the Otsquago is also much shalier in the southeast well. Although the correlation lines indicate a constant thickness for the Herkimer across the cross-section, the part of the sandy section in the Herkimer decreases by about 1/2 in the southeastern well. These facies change could be the result of a basinal warp, or could be an indication of fault controlled deposition. The latter case would suggest that the Little Falls Fault, which crosses the geological cross section (Figure 11b), was active in Silurian times, and that the motion was down-to-the east at that time. The present sense of offset on the Little Falls Fault to the north is also down-to-the-east, and is consistent with the slightly steeper correlation lines compared to the regional dip (Figure 13).

The Little Falls Fault, as delineated by Rickard (1973), crosses seismic line 5PN-7 on Figure 11b at about shot point 105. Although a probable fault is imaged at about shot point 108, neither the lineaments nor the magnetics of Fagan (Phase 2 research effort) support this placement of the Little Falls fault. Figure 11 shows that the lineaments associated with the Little Falls Fault form an inverted “Y” in northern Otsego County. The more easterly branch of lineaments crosses seismic line 5PN-7 at about shot point 65, 48, and at 35, where the easternmost lineament intersects, and then parallels, the seismic line to the first shot point. The more westerly branch of lineaments crosses the seismic line at its northern end between shot points 115 and 155. The high resolution magnetics flown and analyzed by PRJ (year 2 research effort) are not consistent with Rickard’s (1973) central location of the Little Falls Fault; rather, the magnetics are more consistent with significant basement offset along the eastern lineament branch of the Little Falls Fault. South of 42^{o} 44’, the western branch of lineaments intersects a prominent west-northwest trending magnetic “low”, adjacent to, and north of, the west-northwest trending high associated with the Butternut Prospect. The trend of the magnetic low suggests that the dominant basement faults south of 42^{o} 44’ in the area of the western lineaments are west-northwest trending Iapetan rift faults. That no Earthsat lineaments are coincident with the west-northwest trend in this area suggests that the faults do not significantly affect the upper section. Seismic line 5PN-7 supports this contention, in that prominent offsets that occur in the Trenton and basement reflectors from shot point 85 northward are generally not observed in the uppermost digitized reflector--the Onondaga. (In contrast, offsets in the Onondaga are observed between shot points 60 and 85.). Thus, the model of the Little Falls Fault as a single NNE-trending fault that extends southward from the Mohawk Valley through Otsego County (and affects the section shown in Figure 13) is too simplistic. In Otsego County the Little Falls Fault consists of at least three parallel faults, two of which face east and one faces west. However, much of the faulting observed in the seismic line that parallels the geologic cross section probably trends WNW, based on the magnetic anomalies. Intersecting fault trends thus typify the region of cross section 13, and so the anomalous slope of stratigraphic units between wells cannot be ascribed to any one fault.

C) #1160-#4050 Geologic Cross Section (Westernmost Northern Cross Section, Figure 14). In this Silurian geologic cross section, we excerpted the stratigraphic columnar sections, and the associated stratigraphic correlations from Beinkafner’s (1981) stratigraphic cross section, and constructed the geologic cross section displayed in Figure 14. The regional (apparent) dip, based on two closely spaced wells (#4245 an #4547) in the central part of the county, is steeper than the apparent dip between the wells #1160 and #4050 in Figure 14, based on a correlation line drawn between the base of the limestones, and the lines between tops and bases of the Herkimer. However, because neither section in Figure 14 displays the true top or base of the Herkimer Formation, the actual dip between wells is conjecture. The facies change from the northwestern well, where limestones are present in the upper part of the section, to the southwestern well, where limestone is much thinner and sandstone more prevalent.

No fault has been mapped previously in this area. However, NNE-trending lineaments that intersect the cross section may be related to a south-southwest extension of the Herkimer Fault, or faults parallel to the Herkimer Fault. These lineaments cross seismic line 5PN-8 between shot points ~0 and 55 (Figure 11b). Southeast-facing faults, which are displayed along the seismic line in this shot point interval, are consistent with the offset on the Herkimer Fault to the north. However, these faults are only observed high in the section, and have little effect on the basement reflector, except for a possible southeastern most fault at about shot point 58. If this lack of basement offset is correct, then most of the faults in the fault zone (the possible extension of the Herkimer Fault) may be splays in units above basement, such as listric faults. These faults would root in the southeastern fault, which may have basement offset associated with it. Such faults, that do not affect basement, would not be expected to give rise to a magnetic anomaly, and the high resolution magnetics flown and analyzed by Fagan (Phase 2 research effort) do not indicate a NNE trend in the area of the seismic line. Rather, north and west-northwest trends predominate in this area. The Earthsat lineaments cross both trends at a significant angle. Although the lack of magnetic signature is consistent with the faults not significantly affecting basement, the alternative view is that the major faults here trend WNW and N-S, and the NNE-trending lineaments are a minor feature compared to the WNW trends.

D) E-W Geologic Cross Section (Figure 15). This geologic cross section is based on stratigraphic tops information from the NYSGS compilation entitled "Eastern New York Gas Potential, Preliminary Data", compiled by Nyahay and Fakundiny. We calculated the southward component of regional dip on the top of the Onondaga between two closely-spaced wells, #4245 an #4547, that exhibited generally constant thickness of units between them (i.e., no significant growth fault apparently existed between the wells during the Siluro-Devonian). The southward slope calculated on the tops of the Ludlowville, Cherry Valley, and Oneida units has an average of about 100 ft/mile (down-to-the-south). Based on this calculated dip, we corrected the depths of units in other wells which are not located directly on the line-of-section. The resulting geologic cross section displays two regions where faults may exist, although the wide spacing of most of the wells easily could hide additional small local fault effects.

The sharp changes in depth of units between wells #4429 and #4547 in the east, and between #2612 and #10725 in the west suggest faults pass between these well sets. The change in thickness of the units, especially the Syracuse and the Rondout, between the eastern pair of wells supports a growth fault interpretation The units have similar thicknesses in wells #4245 and #4547, but these thicknesses contrast with the thicknesses of units in well #4429. Thus, a NE-SW-striking growth fault probably passes between the eastern well, #4429, and the two other wells, #4245 and #4547. The relative positions of the three wells make other orientations of the growth fault less likely, although a strong set of NE-striking lineaments passes just north of well # 4547 (see further discussion below in the "N-S Geologic Cross Section").

The sharp change in elevations of units between the western set of wells (#2612, #10725, and #4050) suggests a fault passes between the wells with a present down-on-the-east sense of offset. Lineaments in the area can be traced to the north-northeast where they merge with lineaments of the Little Falls Fault, and therefore may indicate a splay of the Little Falls Fault. The observed sense of offset is consistent with the offset on the Little Falls Fault. Growth fault geometries suggest that the fault was active in Tristates and Onondaga times (both units thin to the west), with the same sense of motion as observed on the main branch of the Little Falls Fault, down-to-the-east. Other faults that pass through the area are probably oriented WNW, based on magnetics. These faults, which are located on the south flank of the Butternut Prospect, also would have a sense-of-motion consistent with the cross section (i.e., down-on-the-south).

The Syracuse thickens rapidly to the west, similar to the observations from the eastern cross section (#3993-#4065) above. This significant thickening of the Syracuse, in contrast to the relatively constant thickness of the underlying Herkimer and Oneida, as well as the Helderberg above, suggests that basin development and basin-bounding fault activity were most active in Syracuse time.

E) N-S Geologic Cross Section. This geologic cross section (Figure 16) is also based on stratigraphic tops information from the NYSGS compilation entitled "Eastern New York Gas Potential, Preliminary Data", compiled by Nyahay and Fakundiny. The rapid thickness variations between wells #4245 and #4547 (only 1.5 miles apart) suggest that a growth fault may pass between the two wells. A zone of continuous NE-striking lineaments passes between the two wells, and the zone extends NE to Ordovician-aged, southeast-facing normal faults in the Mohawk Valley region (Figure 11a). Southeast-facing faults are consistent with the growth fault geometry for the Silurian Rondout southward thickening that ocurs between the two wells (Figure 16). This zone of lineaments intersects the southern end of seismic line 5PN-1, so the seismic line cannot reveal the nature of these faults. However, the high resolution magnetics show a narrow NNE-trending high in the region of the three wells. A much weaker lineament trend with a NNE-strike passes through the area of these three wells; this weaker lineament may be associated with the magnetic anomaly feature, since the lineaments occur along the flanks of the anomaly. It is difficult, however, to imagine that these possible faults resulted in the thickened section to the south, since 1) the faults essentially parallel the magnetic anomaly and the line of cross section on which the three wells are drilled, and 2) the southern well is actually on the highest part of the culmination of the magnetic anomaly.

5) Field Work

We performed reconnaissance field geology and detailed field work in the East Springfield area (Figures 17, 18) in order to determine
1) what the character of the fractures is,
2) whether faults affect the Siluro-Devonian section, and if they do,
3) what is the orientation of the faults.

The rationale for the field work was to
1) groundtruth the lineaments that were identified by Earthsat in the Landsat data, and
2) use the lineaments in other areas as potential indicators of fault locations, if the lineaments were associated with significant structure in the East Springfield area.

In order to accomplish these tasks, we measured fractures and faults, and documented the elevations and apparent dips of units in the area of concentration from Springfield Four Corners to Cherry Valley. We measured sections, primarily in the Onondaga, in order to ascertain exact correlations among outcrops.

A) Structure. Site locations are shown on Figure 18 and modified rose diagrams for fractures (Figure 19) are shown in Figure 20. These modified rose diagrams show the relative number of fractures oriented within each 10^{o} arc on the upper half of the rose diagram (the red petals), and show the abutting relationships of fractures oriented in the direction of the petals in the lower half of the rose diagram (the yellow petals). The longest petal in the lower half designates a master fracture orientation, whereas the next shorter petal in the lower half signifies the orientation of fractures that abut the master ("1st abut"); similarly, the shortest petal in the lower half signifies the orientation of fractures that abut the 1st abutting fractures ("2nd abut").

Inspection of Figure 20 reveals that there are, regionally, two common orientations of fractures, NNE and WNW. In Figure 21 we grouped sites with similar fractures. In Domain #1 master fractures strike NNE, and the first abut fractures have varying orientations, including WNW, E-W, N-S, ENE, and NNW. The common factor is that the master fractures, and in most cases the most closely-spaced fractures, strike NNE. In the four valley regions labeled on the map (Cherry Valley area, East Springfield, Springfield Four Corners, and Van Hornesville), the strike of the master fractures is colinear with the trend of the valley. Near site 7 (along Rt. 20 east of Cherry Valley and west of the abandoned railroad track, Figure 18), a prominent sag in the carbonate units appears to strike colinearly with the NNE-striking master fractures at the same location. At Van Hornesville stratigraphic mismatches across a narrow ravine (sites 13 and 14) suggest that a NE-striking fault, with about 2 m stratigraphic offset, strikes along the stream. Three Fracture Intensification Domains (FIDs) were observed, at sites 5, 33, and 37. All three strike NNE. The combination of 1) NNE-striking FIDs, 2) NNE-striking sag, 3) NE-striking fault at Van Hornesville, and 4) long lineaments suggests that the NNE-striking fractures are related to adjustments caused by NNE-striking faults at depth. These faults (see discussion below) are on strike, and colinear with, faults exposed in the Mohawk Valley that were assumed to have "died out" in the Upper Ordovician.

Other fracture domains are characterized by WNW and NW-striking master fractures (domains 2 and 3, respectively). Domain 2 (Figure 21) is located along the Helderberg Escarpment. Although the closely-spaced WNW-striking fractures could be interpreted as valley wall effect fractures, that they are masters to the NNE-striking fractures at site 5 suggests that these WNW-striking fractures predate the present position of the escarpment. Additional WNW fractures which are not masters could have developed in response to valley wall effect (such as those at site 1). An anomalously high southward dip in the region of Domain 2 and the northeastern part of domain 1 in the Cherry Valley area suggests that the Domain 1 fractures are related to a WNW-striking, southward-dipping upwarp that follows the approximate escarpment in the Cherry Valley area. Although this upwarp is positioned so that it could be interpreted as solely caused by valley effect (the unloading to the north of the escarpment essentially allowing the Mohawk Valley Lowlands to rebound), that the fractures are early, and the fact that a prominent magnetic lineament also trends WNW in this region, suggest to us that the WNW-striking Domain 2 is related to a WNW-striking fault at depth that was periodically reactivated. The reactivations caused the present upwarping we observed along the escarpment, as well as Domain 2.

Domain 3 is located in Cox's Ravine, west of Cherry Valley (Figure 21). Here WNW to NW-striking fractures are the masters and are the most-closely spaced fractures. This Domain is complicated because NNE-striking features are also found in the ravine, suggesting that the Domain is actually an intersection of WNW striking fractures with more localized NNE-striking features, such as the thrusts in the Cherry Valley Limestone and Union Springs Shale (Figure 22) and the monoclines in the overlying Marcellus Shale (Figure 22). The trend of Domain 3 is approximately the same as Domain 2, but more importantly, it is colinear with streams southwest of Cherry Valley (Lineament Domain 4, Figure 21) that parallel a prominent swing in the magnetics. Thus, it is probable that another WNW-striking fault occurs in this area in basement, and that later faulting along the basement fault has resulted in the fracturing along Domain 2.

To summarize, in the local study area, two primary fracture trends define structural domains: NNE and WNW. We suggest that the NNE-striking valleys mark fault systems at depth, and that some of these faults do extend to the surface bedrock, as demonstrated at Van Hornesville. These NNE-striking faults are the faults exposed in the Mohawk Valley, where they are thought to have been active as extensional faults during Iapetan opening, and then ramped back during Taconic closure. The WNW-striking fracture domains were unexpected, but do agree with magnetic lineaments, suggesting that the WNW-striking trends also mark basement faults. We know that the WNW-striking faults at depth caused warping of the exposed section. We have no direct evidence to suggest whether the warping was accompanied by faulting; however, the number of fractures at Cox's Ravine suggests that a WNW-trending FID is located here. FIDs commonly are associated with faults. The steep aeromagnetic anomalies (J. P. Fagan, year 2 report) also support the WNW-trending fault interpretation.

B) Stratigraphy and Cross Section. An approximately E-W geologic cross section is shown in Figure 23, and its location is shown on Figure 18. The cross section displays sharp offsets in the Onondaga across the region. The eastern low is located in the Cherry Valley region, and the western low is located in the East Springfield area. In the Cherry Valley low, the inferred eastern dip (down-to-the-west) is consistent with the observed dips along the Rt. 20 outcrops (the observed dip is shown by the triangles); i.e., there is no need for a fault to accomplish the offset. On the western side of the Cherry Valley structural low, the down-to-the-east dip cannot be accounted for by the measured easterly dip along Rt. 20 (Figure 23). However, a strong southward dip also affects the Rt. 20 outcrop west of Cherry Valley. This dip, combined with the easterly dip, is sufficient to account for most of the offset observed on the west side of Cherry Valley. We propose that the relatively high southward dip is a result of warps across the WNW-striking basement faults, and the NNE-striking lows are the result of sags over zones of dissolution along faults and highly fractured zones. Minor NNE-striking faulting does extend to the surface, as exemplified at Van Hornesville. The sag (or partial collapse) may be an observable analog for the Trenton-Black River plays in the Finger Lakes.

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PART II
SEISMIC REFLECTION ANALYSES OF EXISTING DATA
OTSEGO COUNTY, NEW YORK

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SEISMIC DATA ACQUISITION AND PROCESSING

Five seismic lines, totaling 67.3 miles (Figure 11a), were purchased from Amoco Production Company in August, 1999 as part of a county wide study to assess the economic potential of gas exploration in Otsego County, New York. The lines, which are oriented north-south with a line spacing of 6-8 miles, are Vibroseis multifold CDP lines shot at 12 and 24 fold. A breakdown of the line mileage, source interval, group interval, number of channels and the fold is as follows:

Line Number	Miles	Source Interval	Group Interval	# of Channels	Fold
5PN-1	9.6	250’	500’	24	12
5PN-2	11.9	250’	500’	24	12
5PN-7	15.9	250’	500’	24	12
5PN-8	10.4	250’	250’	48	24
5PN-9	19.5	250’	250’	48	24

A split spread geometry was used with a far offset of 6500 ft.

Sterling Seismic Services, Ltd. (Littleton, CO) were chosen to reprocess the seismic data set using the latest state-of-the-art software and processing sequence. Compared to the original processing by Amoco in 1973, the data benefit from refraction statics, closely spaced velocity analysis (every 1 mile), interactive velocity analysis/automatic statics, post stack migration and zero phase correction to a nearby synthetic. The Amoco #1 Wahlberg, 5.8 miles due west of line 9, was used to phase correct and correlate formation tops. Data quality after reprocessing shows dramatic improvement in signal to noise, reflection continuity, frequency bandwidth and sequence character (Figures 24-28). This translates into increased resolution of thin beds and small scale faulting with a higher degree of structural interpretation confidence from improvement in shallow and deep reflection data.

SEISMIC INTERPRETATION METHODOLOGY

Nine horizons from the Middle Devonian to the Precambrian were correlated to line 9 (SP 200) using a synthetic seismogram generated from the Amoco #1 Wahlberg. A jump character correlation was made to line 8 and then subsequent lines to the east (Figures 29-33). A detailed structural interpretation was made on each line to assess the potential of structural trapping of hydrocarbons. Following fault interpretation, a stratigraphic interpretation was performed at potential target horizons (i.e. Onondaga and Oriskany) in order to delineate stratigraphic anomalies such as limestone reef or channel sandstone development.

As the seismic coverage spans the central and southern extent of Otsego County a regional evaluation was made in conjunction with other data sets such as gravity, aeromagnetic, land-sat lineament and regional well control. Through the synthesis and integration of all data a structural model was developed with implications for the accumulation of natural gas based on nearby analogous production and gas show information. A play concept for each potential horizon is summarized defining the reservoir and trap type. Seismic leads were delineated and defined with at least two or more vertically stacked objectives. Wells which intersect a line are posted on the seismic with the projected depths estimated from seismic horizon correlation. A seismic lead map was generated to show the location of each of the leads. Finally seismic leads were high graded and recommendations made for prospect confirmation through additional seismic acquisition and mapping.

REGIONAL INTERPRETATION

An east-west Middle Devonian shelf margin runs through Otsego County. On three seismic lines (lines 8,7 and 2) the shelf break occurs on the northern end of each line as a change in slope at the Onondaga reflection. Expansion of the overlying Catskill Deltaic sequence occurs down dip of the margin. The shelf margin appears to be result of synthetic (down to the south) basement faulting at a hinge zone roughly parallel to the axis of the basin. The alignment of gravity and magnetic anomalies along the interpreted margin compliment this interpretation.

Overall divergence or expansion of section from the Upper Devonian to Precambrian Basement occurs in a southerly and westerly direction indicating basin thinning to the east and north. This agrees with regional well control and subsurface mapping done by Rickard. Progressive erosional truncation of the uppermost Catskill Deltaic sequence can be readily seen on lines 1 and 2 in eastern Otsego County.

Seismic fault interpretation indicates much more intensity and complexity in the western half of the county. Land-sat lineament data support this observation with a higher density of lineaments towards the western part of the county.

STRUCTURAL MODEL

Seismic fault geometry, the orientation/position of gravity and magnetic anomalies and dominant lineament orientations suggest repeated episodes of extensional and compressional wrench tectonics. Not surprising, since the study area lies in close proximity to the Adirondack uplift to the northeast, the collision zone between North America and Europe to the east and the Rome Trough to the south. Of particular interest is the NE-SW tight groupings of lineaments in the western part of Otsego County which form pronounced parallel bands. Numerous gravity and magnetic anomalies lie adjacent to the NE-SW trend at the intersection of other lineament orientations. An overlay of lineament data on gravity and magnetic data shows gravity minima and magnetic maxima anomalies where the dominant NE-SW trend intersects N-S and NW-SE lineament trends. Seismic lines 7, 8 and 9 in western Otsego County exhibit intense synthetic (down to the south) and antithetic (down to the north) fault configurations at the Basement and Trenton reflections. En echelon faulting, accompanied with roll and apparent fault block rotation, gives the appearance of normal and reverse flower structures indicative of wrench tectonics. The result is the formation of basement horst and graben structures. A subsequent compressional/extensional episode appears to have occurred during Upper Silurian or Lower Devonian time. The reactivation of faults formed collapse features through the propagation of antithetic and secondary synthetic faults. This structural overprinting can give rise to half horst and horst structures which overlie Trenton/Basement grabens.

POTENTIAL GAS RESERVOIRS

Based on nearby production, show information and log data a listing of potential objectives summarizes the play concept, reservoir type and production analog for each target formation.

- **Lower Marcellus Shale.** Middle Devonian fractured shale reservoir on structural highs and along fault shear zones. An analog is the Genegantslet Field in Smithville Township, Chenango County, New York: Genegantslet Gas and Oil #2 W. Decker; 1650 MCF/D natural flow.

- **Onondaga Limestone.** Middle Devonian patch reefs or shoals with preferential development on paleo structural highs. Analogs are 1) seven reef fields located in Steuben County, New York with recoverable reserves of 28 BCF from 13 wells; and 2) reef debris/oolitic shoal type reservoirs in Warren County, Pennsylvania.

- **Oriskany Sandstone.** Lower Devonian offshore sandbar deposition occurring on paleohighs and faultbound incised valley fill channel sandstone created during sea level fluctuation. An analog is the Stagecoach Field Tioga County, New York with estimated reserves of 20-30 BCF from channelized sandstone reservoir.

- **Herkimer/Oneida Sandstone.** Silurian age fractured regressive/transgressive shoreline sands structurally trapped in horst and half horst upthrown fault blocks. Analogs are three fields (Lebanon, Hamilton, Sangerfield) in southern Madison County, New York Renewed activity and success in Lebanon field; fifteen year production of 4.72 BCF. Six new discovery wells since 1995.

  Gross sand thickness mapping of the Herkimer and Oneida indicates a roughly E-W depositional thickening (Herkimer) and a N-S trending thickening (Oneida) in western Otsego County. A large cross-shaped magnetic minima anomaly, coinciding with the sand thickening, suggests the formation of intraslope depocenters along a N-S (Oneida) followed by an E-W (Herkimer) extensional structural event.

- **Trenton/Black River Dolomite.** Ordovician fracture dolomite reservoirs on structural highs and along fault shear zones within collapse grabens. Analogs are recent discoveries and production in Steuben County, New York with initial open flows of well over 10 MMCF/D.

- **Potsdam/Theresa Sandstone.** Upper Cambrian fractured quartzitic sands structurally trapped in Basement horst block structures. There is no analog. Log data from the Amoco #1 Hoose well in central Otsego County indicate a porous zone in the Potsdam Formation.

FRACTURE RESERVOIRS

Reservoirs in Eastern New York are generally tight and require fracture enhancement and/or diagenetic alteration to improve porosity and permeability. The productive range of porosity for limestone is 5-10% (Onondaga) whereas sandstone (Herkimer, Oneida, Oriskany) is 7-14%.

Given the structural model as indicated by gravity, magnetic, lineament and seismic data the likelihood of encountering fracture enhanced reservoirs seems very good.
The Utica and Lower Marcellus shales are the hydrocarbon source rocks for the area and may also pose as significant fracture reservoirs given the optimum stress, strain and geopressured conditions.

SEISMIC LEADS

A total of 13 leads have been identified on the reprocessed seismic lines. A lead is defined as at least two or more vertically stacked objectives which can be tested with a single drill location. Horst and half horst upthrown structures are the primary traps with antithetic down to the north faults providing the critical trapping mechanism. Of the three wells drilled on seismic lines (10725 on line 9, 4050 on line 8 and 10138 on line 7), none have tested an upthrown fault trap. Leads are assigned a letter designation corresponding to a line number starting from the northern end of each line (i.e. lead 9a, 9b, 9c etc.) On the top of each seismic section a colored bar corresponds to a formation objective (red - Trenton/Black River, purple - Herkimer/Oneida, green - Oriskany, blue - Onondaga). The length of the bar represents the north-south limits of the possible trap. The Seismic Lead Map shows the total limit of the combined stacked objectives. A lead is elevated to prospect status given additional evidence for three dimensional closure from gravity, magnetic or well show data. A brief description of each lead/prospect for every line from west to east is as follows:

<u>Line 9 (4 leads)</u>

<u>Lead 9a</u>. A major graben can be seen at the Trenton/Basement level. Within the main graben smaller horst features occur from the interplay of synthetic and antithetic faults. A large magnetic minima anomaly coincides with the seismic graben indicating localized collapse adjacent to a NE-SW lineament wrench zone. Up section in the Silurian and Lower Devonian, various horst blocks are formed from reactivation of basement faults. At the Oriskany reflector a fault bound depression shows an expansion/thickening of the Oriskany section. The NE-SW lineament wrench zone may have provided a fairway for Oriskany channel sand deposition with preservation of sands in the graben. Potential targets include the Potsdam, Trenton, Herkimer/Oneida and the Oriskany.

<u>Lead 9b.</u> A basement, Trenton and Herkimer/Oneida horst block is overlain by an Onondaga mounded reef anomaly.

<u>Lead 9c.</u> A horst block feature at the Trenton and Herkimer/Oneida is overlain by a drape anticline at the Oriskany.

<u>Lead 9d.</u> An upthrown half-horst at the Herkimer/Oneida and Oriskany datums.

<u>Line 8 (1 lead, 2 prospects)</u>

Lead 8a. A horst and graben at the Trenton level is overlain by a horst at both the Herkimer/Oneida and Oriskany reflections. A decrease in amplitude at the Trenton (peak) pick is accompanied by Basement to Trenton interval thinning. The change in reflection amplitude may represent a change in lithology or porosity (dolomitization).

Thinning just below the Trenton peak suggests an eroded positive feature which subsequently collapsed.

Pittsfield Prospect. Situated updip of the Prensett #1 Elliott, the Pittsfield Prospect is a horst structure at the Potsdam, Trenton and Herkimer/Oneida with half horst upthrown fault traps in the Oriskany. A shallow collapse flower structure north of the prospect indicates rejuvenation of basement faulting along a transtensional wrench fault. The Elliott well had a significant show in the Herkimer - 20 MCF down to 5 MCF before it watered out after a frac completion.

Butternut Prospect. Butternut Prospect is a large horst block at the Potsdam and Trenton with a drape anticline at the Herkimer/Oneida and Oriskany. Gravity minima and magnetic maxima anomalies correlate with the seismic basement horst on line 8. A possible closure of 8700 acres is shown by the 1430 gamma contour on the Total Magnetic Intensity (Reduced to Pole) Map. Occurring at an intersection of a major NE-SW lineament trend and other lineament orientations, the prospect appears to be a wrench related pop up structure. At basement, numerous antithetic faults indicate apparent fault block rotation from strike slip movement. The potential for reservoir fracture enhancement is very good at this location.

Line 7 (3 leads, 1 prospect)

Of all the seismic lines, line 7 displays the most structural complexity. Lineament density is high and the line parallels a prominent N-S magnetic minima.

Lead 7a. A Trenton horst and graben is overlain by an upthrown fault trap in the Herkimer/Oneida and Oriskany. The fault configuration suggests at least two major episodes of deformation.

Lead 7b. Located within the collapse zone, the complex faulted section provides fracture reservoir potential in horst structures at the Trenton, Herkimer/Oneida and Oriskany levels.

Lead 7c. A Trenton collapse graben is overlain by Herkimer/Oneida horst and an Oriskany half horst upthrown traps.

Butternut Prospect. On the eastern flank of the 8700 acre magnetic anomaly, the southern portion of line 7 shows strong down to the south synthetic faulting which gives rise to down to the north antithetic trapping faults in the Trenton, Herkimer/Oneida and Oriskany.

Line 2 (1 lead)

A collapse flower structure (SP 20-60) shows localized thinning in the Herkimer/Oneida as well as the Trenton/Basement interval. This may indicate a once emergent high which collapsed by the end of the Silurian. A series of Herkimer/Oneida upthrown half horsts with an overlying Oriskany horst define Lead 2a.

Line 1 (1 lead)
At the southern end of line 1, Trenton and Herkimer/Oneida upthrown antithetic fault blocks have resulted from a synthetic down to the south fault displacement.

High Graded Leads
Seismic leads in the western half of Otsego County appear to have the best potential for encountering hydrocarbon reserves given the expanded stratigraphic column, structural complexity and fracture potential of the area. Lines 9, 8 and 7 clearly show this when compared to Lines 1 and 2. An exploration template starts to emerge when lineament, gravity and magnetic data are incorporated into the picture. Basement related wrench faulted structures can be identified where prominent NE-SW lineament bands occur. At the Butternut Prospect, a seismic basement horst correlates to a closed magnetic maxima and a gravity minima anomaly at the intersection of major lineament trends. Butternut ranks high because of its size, proximity to established production at Lebanon field and the complimentary evidence from the various data sets. The prospect also lies within a Herkimer and Oneida gross sand thick.

North of Butternut, the Pittsfield Prospect has been high graded from lead status because of the Prensett #1 Elliott Herkimer sand gas show and its relationship to the updip fault closure on line 8. Perhaps the well watered out due to its low structural position at a possible gas/water contact. Lead 9a, which appears to be a transtensional wrench graben, provides exploration opportunity in Oriskany stratigraphic channel sands, Trenton fractured dolomite and fractured Herkimer/Oneida structural traps. The magnetic data show an areally restricted minima which may represent the limits of the wrench graben. Preservation potential for Oriskany channel sands at this downdip location appears good given the anomalous thickening of the Oriskany on Line 9.

The three leads represent three distinct concepts which remain untested. All other leads would fall into one of the three types. Butternut is a transcompressional wrench horst, lead 9a a transtensional wrench graben and Pittsfield an antithetic upthrown fault closure created by reactivation of basement synthetic faults forming Silurian and Lower Devonian collapse features. All three prospects/leads lie in a Silurian Herkimer/Oneida sand fairway.

RECOMMENDATIONS

For prospect confirmation, additional seismic will be needed to adequately map structural closure. Vibroseis data, being the most cost effective, can be acquired where roads are the optimum orientation provided there are no severe bends. Thirty fold CDP coverage should be sufficient for noise cancellation. Otherwise cross-country dynamite data can be shot at $2000 over the cost of Vibroseis data. A confirmation exploration program for each of the three areas is as follows:

Butternut Prospect
A six mile Vibroseis line can be shot on an existing road halfway between lines 7 and 8. This line will verify the relationship between Line 8 and the magnetic maxima anomaly -confirming

the 8700 acre horst feature. With concept confirmation, an additional 10-12 mile east-west seismic line should be shot or purchased to tie the three north-south lines. The data can then be mapped on various horizons in order to delineate an optimal well location. Because of the possible size of the basement structure, a 6000' well should be drilled to test all objectives down to the Cambrian Potsdam sandstone.

Pittsfield Prospect
A four mile dynamite seismic line is needed to prove east-west closure. This line should be shot orthogonal to line 8.

Lead 9a
Using the magnetic minima anomaly to orient the lines, a 20-24 mile, 2-3 seismic line survey would be needed to map the graben. The Trenton/Black River would be the primary objective with secondary potential in overlying Herkimer/Oneida structural traps and stratigraphically trapped Oriskany channel sands.

PART III
STRUCTURE CONTOURS, STRATIGRAPHIC CROSS-SECTIONS,
AND
OIL AND GAS PROSPECTS

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HYDROCARBON SOURCE, MIGRATION AND RESOURCE POTENTIAL

The Ordovician Utica Shale

The Middle Ordovician, Utica Shale lies conformable above the Trenton Limestone. The Utica Shale is typically considered the source rock for the Lower Devonian through Cambrian production and shows. Where the Utica has been faulted into position against lower formations, hydrocarbon migration is postulated (Dykstra and Longman, 1995) to move from the younger, Middle Ordovician Utica Formation to older, Lower Ordovician to Cambrian formations. Upper Ordovician through Lower Devonian formations could be charged with hydrocarbon generated from the Utica Shale through upward "percolation" through fractures, faulting and permeability pathways. The Utica of eastern New York is within the "dry gas window" of the "petroleum kitchen" (Wallace and Roen, 1989, Roen, 1999). The Utica Shale should range from 400 feet to 1,000 feet in the Otsego County, New York area.

Total Organic Content (TOC) has been measured and reaches up to 3% in the Utica Shale and slightly less in the Lorraine Group in southwestern Quebec (Beiers, 1976). The TOC content has been measured up to 2+% in eastern New York (Ryder, et al., 1989, Roen, 1999), although western New York is generally less than 2%. Similar tests also indicate a late stage of maturation, which is evident in the gas analysis from samples from the Canadian Lowlands. These analyses indicate methane concentrations ranging from 88% to 96% (Beiers, 1976).

Log analysis by Aguilera (1978) indicates that the Utica Shale of the Quebec Lowlands may contain 5 BCFG per square mile (640 acres) and the average Utica fractured shale well could produce initially, approximately 500 MCF/D. This estimate is based on daily production rates of approximately 296 MCF/D after 20 years. Milici (1996) suggested that this average is too optimistic and indicates that the 20-year average daily rate would likely be much closer to 50 MCF/D. Therefore, Aguilera (1978) has likely overestimated the total resource potential. Wallace and Roen (1989) calculated the Utica Shale of the northern Appalachian Basin (New York, Ohio, Pennsylvania and portions of West Virginia) to have generated 165 billion barrels of oil or equivalent quantity of natural gas.

Models indicate that gas generation in the eastern New York likely occurred 75-100 million years after deposition, during the Devonian (Dykstra and Longman, 1995). Although varying models could put hydrocarbon generation as young as the Permian portion of the Alleghanian Orogeny (Ryder, et al., 1998). Thermal maturation models for the St. Lawrence Lowlands of New York and Canada indicate that hydrocarbon generation likely occurred during early Taconic Orogeny periods and culminated with the emplacement of the thrust sheets (Dykstra, 1993), likely portions of eastern New York were also generating hydrocarbon at this time. However, the traps in front of the thrust sheets were likely charged in the Devonian, after much of the porosity likely was diagenetically destroyed or altered (Milici, 1996).

The Devonian Marcellus Shale

The Middle Devonian Marcellus Formation is part of the Hamilton Group. The Marcellus shale lies conformable above the Onondaga Limestone and lies unconformable below the Tully Limestone/Gilboa Sandstone. Reservoirs in the Middle and Late Devonian, the Onondaga Limestone and Oriskany Sandstone often show a mixed gas thermogenic signature (Jenden, et al., 1993). Often these reservoirs show gases from both the Devonian Marcellus and deeper units, such as the Utica Shale (Jenden, et al., 1993).

TOC values for Middle and Upper Devonian black shales range from 1% to 20% basin wide, with an average in New York approximately 3% (Jenden, et al., 1993). In western New York the approximate total thickness of the entire Devonian black shale interval (Marcellus, Geneseo, Middlesex, Rhinestreet and Dunkirk) is 300 feet (Van Tyne, 1983, Jenden, et al., 1993). Although eastern New York would not be considered optimum Devonian black shale potential, eastern New York does have projected radioactive Devonian Shale greater than 100' and falls within the optimum stress ratio window (Streib, 1981). Hydrocarbon generation within the Marcellus Shale likely occurred in late Alleghanian Orogeny time, likely Permian and Pennsylvanian.

Field Studies

Genegantslet Field. Genegantslet Field is located in Smithville Township, Chenango County. The field has produced from the Middle Devonian, Marcellus Shale of the Hamilton Group. There has been no reported production to the state since 1983 (when the state began reporting and tracking production) and 5 wells are listed as inactive on New York state's 1996 oil and gas drilling and production statistics.

The W. Decker #2 was drilled by Genegantslet Gas & Oil between May and July, 1964. The well was drilled to a total depth of approximately 2050 feet into the Marcellus Shale. The well had an initial potential of 1650 MCF/D, with between 565# to 650# pressure (possibly conflicting reports). The well blew down to 1000 MCF/D after 54 hours. Peoples Natural Gas Co. sampled gas from the Decker #2, the results follow:

Methane:	96.83%	Calculated Dry Heating Value:	1021 Btu
Ethane:	1.90%	Calculated Wet Heating Value:	1003 Btu
Propane:	0.09%		
IsoButane:	Trace	Calculated Specific Gravity:	0.5614
Hydrogen:	0.85%		
Nitrogen:	0.27%		
Helium:	0.06%		
Oxygen:	Trace		

This gas analysis is consistent with a gas generated within the dry gas/mature "hydrocarbon window".

First reports (driller's log) of the drilling of the Decker #2 were that a 100 feet sand was cut by the driller, and this same zone was cut in the Decker #1 but did not have a natural gas flow. Most likely, the reservoir is not a sand, possibly a silt and since assumed fracturing was likely intense, the zone may have drilled like a porous sandstone. The Decker #2 was drilled 3050 feet south of the Decker #1

After the success of the Decker #2, the Decker #3 was drilled. No show was reported from the Marcellus and the well was drilled to a total depth of 3685' into the Helderberg Limestone. The

Decker #4 was drilled next and initially encountered 250 MCF/D, but after 5 hours gauged 332 MCF/D, with 565# pressure. The Decker #4 reached a total depth of 2002' into the Marcellus Shale.

The Flanigan #1 was drilled to a depth of 2462' through the Marcellus Shale. The encountered a "scum" show and show of water from 1110' to 1130' (which occurred above the Tully Limestone) and a gas show of 25 to 50 MCF/D at 1502' to 1512', within the upper Hamilton Group. Mixed reports include plugging and abandoning and turning the well over to the landowner.

Genegantslet Gas and Oil then drilled the J. Bottle #1. The well reached a total depth of 2015' in the Marcellus Shale. Drilling encountered 25 MCF/D at 1958' and 2000 to 3000 MCF/D at 1975'. Pressure was gauged at 575# after a 5 hour build up, and 560# pressure after approximately 2 months. Genegantslet drilled 4 more wells in Smithville and Greene townships over the next year with only one significant show (7 to 8 MCF/D) from the Marcellus shale. Genegantslet Gas and Oil ran production test on the three significant producers (Decker #2, Decker #4 and Bottle #1) over the period 10/24-25/1965. Initial shut in pressure for each well was 555 psig.

The Black Moshannon Field in central Pennsylvania may be an analog field. Black Moshannon Field also produces from the Upper Devonian shales (likely younger than the Marcellus Shale) and is within a similar structural position as Genegantslet Field. Also, similar to Genegantslet Field, economic production has been difficult to establish. Wells in Black Moshannon range in Estimated Ultimate Recoverable from less than 100 to 300 MMCF. The field continues to produce today, the last well drilled in the field was in the early 1990's by Eastern States Exploration Co.

The Genegantslet Field may also be an analog to Utica Shale production. The Utica would be a possible secondary target when drilling for Trenton Limestone and deeper. In Ohio, the Utica Shale produces in Fairfield and Hocking Counties. Wells in the Fairfield County are reported to initially produce up to 500 Bbl oil/day and 50 MCF/D with rock pressures of 900+ psi at reservoir depths of 2400 feet (Wickstrom, 1999). The Leitnaker #2 (34-045-21209), of Fairfield County, Ohio, has cumulatively produced 44,091 BO and 5,688 MCF in 2.5 years of sporadic production. In Hocking County, Quaker State (now Belden and Blake) drilled the Robinette #1 (34-073-23278) based on seismic imaged series of high angle, basement seated, east-west trending faults. The well was proposed as a Trenton test. The well bore encountered a series of fractures in the Cincinnati Group (roughly the Lorraine Shale of New York) and produced approximately 1200 BO during drilling (Brannock, 1993). The well was nitrogen frac'd and had produced 6395 BO from 1989 until 1993 when the well was shut-in (Brannock, 1993).

Stagecoach Field. The Stagecoach Field is located in Tioga County, New York and Bradford County, Pennsylvania. Approximately 20+ producing wells are located in the two county field. The field was discovered in 1987 when Quaker State (now Belden & Blake) drilled the Fyock #1, and confirmed with the drilling of the Racht #1.

Production recorded through 1996 for the New York wells was only cumulatively 7.88 BCF. The gas produced is “dry” with no associated water production (Pyron, 1997b). It is rumored that the Pennsylvania production is comparable; however, production reporting in Pennsylvania has a longer confidentiality period. Pyron (1997a) believes that the main reservoir for the field is a fractured portion of the upper Helderberg section. Conversation with field operators, however, indicate the reservoir is an Oriskany Sandstone “channel” (approximately 70’ to 100’ below the “true” top of Oriskany) which likely down cut into the underlying Helderberg Limestone. Those who have seen the seismic and operate the field, believe that the Oriskany Sandstone “channel” is fault-bound and was able to down cut into the older Helderberg Limestone section.

Pyron’s (1997b) structure mapping on numerous datum within the field area showed no correlation to cumulative production. Pyron’s work (1997a) included paleogeographic mapping (First Derivative mapping, from the top of the Cherry Valley to the base of the Silurian) which indicated an Oriskany Sandstone “thick”, which likely corresponds to the “channel” facies. Pyron’s (1997a, 1997b) indicated that the top of the Devonian structure map to be “interesting because it apparently shows the location of fault blocks under the field boundaries.” Although Pyron may not believe the reservoir to be “channeled” Oriskany Sandstone, he may have come up with the same conclusion regardless. Also, Pyron (1997b) noted a thinning of the Tully Limestone above the productive Oriskany Sandstone within Stagecoach Field.

A near surface geochemical survey was also conducted, in conjunction with NYSERDA, over the Stagecoach Field, Tioga County. The survey encountered very mixed results and was generally inconclusive, however some geochemical indicators did point to potential infill locations (Fontana and Viellenave, 1999).

Within the last two months, Cabot Oil & Gas drilled the Wicks #1 (007-22807) in Colesville Township, Belden Quadrangle, Broome County looking for an extension of the Stagecoach Field. The well had a planned total depth of 4865’. According to rumor, the well encountered 7’-8’ of Oriskany Sandstone pay and open flows range from 250 to 1000 MCF/D “on the rumor mill”. Cabot did run pipe on the well and plans to treat and test for production.

Lebanon Field. Lebanon Field was first discovered in 1960 with the drilling of the Parteka #N-748, drilled by New York State Natural Gas Corp. The well was drilled to 2794’ to a total depth just beyond the Silurian Herkimer Sandstone of the Upper Clinton Group. Since the discovery of the field, the deeper Oneida Sandstone (of the Lower Clinton Group) also has established production

Recently, Nornew, Inc. in conjunction with Ardent Resources has drilled wells in Lebanon Field. At least three wells have been drilled in 1999, and numerous wells drilled in 1998 (see production data below).

Kearney (1983) shows both the Herkimer Sandstone and the Oneida Sandstone trend from the productive Lebanon Field area in Madison County, southeast into Otsego. Both sandstones are shallow marine in origin however, the Herkimer Sandstone is progressive and the Oneida is transgressive. This progressive/transgressive cycle explains why the two sandstone packages almost coalesce to the easternmost portion of the study area.

Below is the reported production for the Madison county, Lebanon Field wells for the last 15 years, as reported by the state.

Date	Producing Wells	Gas Production (MMCF)
1985	3	34.0
1986	3	28.4
1987	2	30.8
1988	2	25.0
1989	2	34.2
1990	2	32.2
1991	2	33.7
1992	2	31.4
1993	not reported	
1994	2	29.4
1995	3	43.7
1996	3	31.7
1997	5	30.9
1998	8	86.6
TOTAL:		472.0

The Parteka #N-748 is still a major contributor to the above production. Remembering the Parteka #N-748 was drilled in 1960, the production has sustained almost 40 years (assuming production began almost immediately after discovery).

Trenton/Black River Exploration. Before the mid-1990's Trenton/Black River production was predominately from central Ohio and central Kentucky, at the edges of the Appalachian Basin. The play was exploited in central Ohio, predominately in the late 1800's and early 1900's. Data is sparse from that era, however GIP was calculated for numerous fields and ranged from 1.2 to 8.1 BCF. Data is sparse in Kentucky, but it is known that approximately 50 Trenton/Black River wells were drilled in central Kentucky in the 1980's.

More recently, Columbia Natural Resources has drilled in Roane County, WV and discovered a new Trenton/Black River Field. Rumors have the natural open flow over 20 MMCF/D. A group seismic shot has recently been proposed for the area.

Columbia Natural Resources has also discovered a new Trenton/Black River field in Steuben County, NY, and surrounding area. Due to New York regulations (as compared to WV), more is know of this area. Columbia Natural Resources has drilled numerous wells in northeastern Steuben County and rumor has initial open flows well over 10 MMCF/D. In southeastern Steuben County, Pennsylvania General Energy also drilled a Trenton/Black River well with similar reported success.

Prior to recent exploration efforts Trenton drilling was often based on surface mapping and not on geophysical prospecting (Robinson, 1985), however, rumor has CNR and PGE using numerous geophysical methods (i.e. seismic, aeromagnetics, gravity and/or remote sensing studies). It appears that companies are exploring for Albion-Scipio “type” reservoirs. Albion-Scipio is a 150 million-barrel oil and 205 BCF gas field. Albion-Scipio is a fractured dolomite play, in which, fluid migration has allowed for diagenetic alteration of the original calcite/carbonate material and a “hard” cap dolomite forms the seal. The Utica Shale, occurring above the Trenton Limestone would also serve as a sealing formation.

The Steuben County play is in an east-west trending graben “fairway”. Nine wells have had production (1996 – 1998) turned into the NY-DEC and first year production ranges from 100 – 300 MMCF on the better six wells. Three wells averaged well less than 100 MMCF their first year.

Seismic data across “similar but undrilled” features else where in Steuben County indicates (Berg, 1999):

- Variations (increase or decrease) of the top of Trenton reflection amplitude.
- Decrease of reflection continuity at the top and within the Trenton-Black River section
- Vertically distributed zones of seismic noise above, below and within the Trenton
- A sag in the top of Trenton reflection accompanied by isochronal thickening in the Queenston-Utica section.

Locations coincident with E-W linear features visible on detailed aeromagnetics data (this E-W trend is also parallel to CNR’s recent Trenton-Black River activity.

Regional Subsurface Mapping

Logs for available wells (approx. 20) were analyzed and sand thickness and formation tops were collected. For all sand zones (Oriskany, Herkimer and Oneida sandstones) the 50% clean sand was determined by summing the footage of sand mid-way between the “clean shale” baseline and “clean sand” baseline (refer to Figures 34 - 36). Below is a summary of the zones mapped.

Oriskany Sandstone Gross Sand Isopach. The Oriskany Sandstone (Figure 34) has a relatively consistent sand thickness (9-15 feet) throughout Otsego County. The sand thickens to the southeast to 27 feet in Delaware County. The Oriskany Sandstone has a wide extent throughout the Appalachian Basin. Basin-wide, the Oriskany Sandstone is interpreted as shallow water, near shore/shoreface sandstone deposit (Isachsen et al., 1991). The mapped pattern is consistent with that interpretation.

Herkimer Sandstone Gross Sand Isopach. The Herkimer Sandstone interval (Figure 35) was also mapped using a 50% “clean sand” cut-off. Fourteen wells with logs penetrated the Herkimer interval.

A “no-sand” line was inferred from two wells as an approximate pinch-out line of the Herkimer interval. This line runs roughly north-south in east-central Otsego County. Sand thickness contours, as mapped with the available data, trend roughly east-west. The Herkimer Sandstone has been interpreted as a beach and shallow water deposit (Isachsen et al, 1991), which trends regionally northeast-southwest (Kearney, 1983). As the Otsego County area is near the shelf edge and in the bend around the northeast corner of the Appalachian Basin, the local sand patterns could be slightly shifted from the regional trends. One could expect 30 to 50 feet of gross Herkimer Sandstone through the Butternut Creek Prospect area.

Oneida Sandstone Gross Sand Isopach. The Oneida Sandstone interval (Figure 36) also was mapped using a 50% clean sand cut-off. Thirteen wells with logs had penetrated the Oneida interval in the mapped area.

The 50% clean sand gross interval of the Oneida Sandstone has a roughly north-south trend. The Oneida Sandstone has been interpreted as a beach sand (Isachsen, et al., 1991) with a north-south trend (Kearney, 1983). The mapped sand fits current interpretations very well. Within the Butternut Creek Prospect area, one could expect <30 to >50 feet of Oneida Sandstone gross interval.

Structure Mapping. Tops from logs were collected for the Onondaga Formation, Herkimer Sandstone, Lorraine Shale and Trenton Formation. These zones were mapped to determine general structures on these surfaces (Figures 37-40). As discussed previously, minimal log data is available for Otsego County and surrounding area.

Two NNE-SSW trending faults, previously mapped by Rickard and verified in the field by Jacobi and Smith for this project, were assumed for purposes of these maps. Maps were constructed with the faults in place as interpreted. The Butternut Creek Prospect area, delineated by aeromagnetics, gravity and seismic was also overlain on the maps and the structure was interpreted with that data incorporated.

All the zones mapped depict a southward slope (down-to-basin) geometry. The Herkimer Sandstone and Lorraine Shale structure maps show some structural complexity on the Otsego/Delaware County line. The actual structure is definitely more complex than depicted. The lack of subsurface data lends itself to an oversimplified interpretation.

Type Log. The Amoco, Hoose #1 (Ots-10834) was chosen as a type log. The well was drilled in the middle of Otsego County, and drilled to Precambrian basement. The type log is included as Figure 41.

Cross Sections. Seven cross sections were constructed that cross the study area (Figures 42-49). Four sections are east-west (A, B, C, and D), and three sections are north-south (E, F, and N-S). All cross sections were stratigraphically hung on the Middle Onondaga limestone and are as deep as the available log data, with some logs reaching the Precambrian.

The cross sections show a basic basin geometry of deepening and stratigraphic thickening to the south-southwest. The Silurian section thins markedly from west to east across Otsego County. This is important as the Silurian sandstones are one of the projected reservoirs throughout the study area and therefore the Silurian reservoirs will be limited to the western portion of Otsego County.

The Trenton Formation is thin (100 feet and less) throughout much of the study area. However, the Cambrian to Ordovician carbonates (undifferentiated) are 1500+ feet thick through most of the study area. Potential for dolomitization reservoirs along the numerous fractures and faults exhibited by the seismic and fracture studies suggest that these carbonates are good potential reservoirs.

BUTTERNUT CREEK PROSPECT SUMMARY

Prospect:	Butternut
Location:	Laurens Township, Otsego County, New York
Drilling Depth:	6000 ft. through Cambrian Basement
Expected Pay and Well Spacing:	Dry Gas; 160 ac.

I. Play Concept/Type

A. Herkimer/Oneida Sandstones

Silurian fractured regressive/transgressive shoreline sands structurally trapped in horst and half horst/upthrown fault blocks.

B. Trenton/Black River Limestone

Ordovician fractured dolomite on structural highs, along fault shear zone and within collapse graben structures.

C. Theresa/Potsdam Quartzitic Sandstone

Upper Cambrian fractured sandstone occurring on basement structural highs.

2. Geologic Setting

Regional:

Downdip of the Middle Devonian Shelf Margin on a basin margin platform/ramp.

Local:

Strike-slip wrench faulting along E-W and N-S fault trends resulting in tensional and compressional fault bound basement structural highs.

3. Nearby Production/Analogs:

Herkimer/Oneida:

3 fields (Lebanon, Hamilton, Sangerfield) in southern Madison County, New York. Renewed activity and success in Lebanon field, fifteen-year production of 472 MMCF. Six new discovery wells since 1995.

Trenton/Black River:

Recent discoveries and production in Steuben County, New York with initial open flows of well over 10 MMCF/D

4. Prospect Definition (Herkimer/Oneida)

Structural:

Horst block structure bound by down to the north and south E-W basement faults

References:

a) Seismic line 5PN-8 (SP 162-200)
150 ft., 20 ms. N-S closure on western flank of structure
Seismic Line 5PN-7 (SP 10-30)
75 ft., 10 ms. N-S upthrown closure against down to the north antithetic fault on eastern flank of structure

b) Aeromagnetic Total Intensity (reduced to pole) Map
Inferred basement closure defined by 1430 gamma contour with 110 gamma relief situated between lines 5PN-7 and 5PN-8

c) Bouguer Gravity Map
Gravity minima anomaly coincident with aeromag feature

A. Source Rock
Utica Shale

B. Trap
Four-way fault/dip closure

C. Primary Reservoir
Herkimer/Oneida
Sandstone with 7-14% porosity

D. Areal Extent of Prospect (acres)
Herkimer/Oneida:
8700 acres
Ref.: area within 1430 gamma contour, Total Magnetic Intensity Map

E. Net Effective Pay (NEP)

Low Case: 20 ft.
Middle Case: 30 ft.
High Case: 50 ft.
Ref.: near-by well control

F. Recovery Factor (RF)
Herkimer/Oneida:
150 MCF/ac. ft.

G. Reserves: Recoverable Reserves = (NEP)(Acres)(RF)
Herkimer/Oneida

Low Case: (20 ft.)(8700 ac.)(150 MCF/ac. ft.) = 26 BCF

Middle Case: (30 ft.)(8700 ac.)(150 MCF/ac. ft.) = 39 BCF

High Case: (50 ft.)(8700 ac.)(150 MCF/ac. ft.) = 65 BCF

H. Offset Well Review

a. OTS-02612

- WELL NAME: E. Matteson #1
- OPERATOR: Blue Rock Drilling Co.
- COMPLETION DATE: 12/15/1952
- STATUS: Drilled & Abandoned w/ no shows
- TOTAL DEPTH: 2450'
- FORMATION @ TD: Oriskany/Helderberg

- FORMATION TOPS (REPORTED BY DRILLERS)

TULLY LIMESTONE: 125' – 200'
ONONDAGA LIMESTONE: 2283' – 2374'
ORISKANY SANDSTONE: 2426' – 2436'

- LOG DATA

No Log Data Available

b. OTS-04050

- WELL NAME: W. Elliott #1
- OPERATOR: Prensett Corp.
- COMPLETION DATE: 12/5/1960
- STATUS: Plugged & Abandoned after fracture treatment
- TOTAL DEPTH: 3697'
- FORMATION @ TD: Lorraine Shale

- FORMATION TOPS (REPORTED BY DRILLERS)

Onondaga Limestone: 2070'

- LOG DATA

  Marcellus Shale: 1435’
  Onondaga Limestone 2060’
  Oriskany Sandstone: 2210’ (9’ gross sand)
  Helderberg Limestone:2219’
  Herkimer Sandstone: 3228’ (40’ gross sand)
  Oneida Sandstone: 3612’ (32’ gross sand)
  Lorraine Shale: 3644’

c. OTS-10725

- WELL NAME: C.R. Bellows #1
- OPERATOR: Amoco Production Co.
- COMPLETION DATE: 5/20/1974
- STATUS: Drilled & Abandoned
- TOTAL DEPTH: 3980’
- FORMATION @ TD: Lorraine Shale

- FORMATION TOPS (REPORTED BY DRILLERS)

  No report

- LOG DATA

  Marcellus Shale 1526’
  Onondaga Limestone 2166’
  Oriskany Sandstone: 2320’ (11’ gross sand)
  Helderberg Limestone:2331’
  Herkimer Sandstone: 3432’ (24’ gross sand)
  Oneida Sandstone: 3802’ (58’ gross sand)
  Lorraine Shale: 3872’

d. OTS-10834

- WELL NAME: H. S. Hoose #1
- OPERATOR: Amoco Production Co.
- COMPLETION DATE: 6/15/1974
- STATUS: Drilled & Abandoned

- TOTAL DEPTH: 5824’
- FORMATION @ TD: Precambrian Basement

- FORMATION TOPS (REPORTED BY DRILLERS)

  Granite Wash (Potsdam Equiv.?): 5768’ – 5788’
  Basement/Granite: 5788’

- LOG DATA

  Marcellus Shale: 1217’
  Onondaga Limestone 1898’
  Oriskany Sandstone: 2056’ (9’ gross sand?)
  Helderberg Limestone:2065’
  Herkimer Sandstone: 2898’ (54’ gross sand)
  Oneida Sandstone: 3250’ (35’ gross sand)
  Lorraine Shale: 3298’
  Trenton Limestone: 4170’
  (Cambro-Ord Carbonates undifferentiated to 5770’)
  Precambrian Basement/Granite: 5792’

BUTTERNUT CREEK PROSPECT

PROSPECT SUMMARY

The Butternut Creek Prospect is predominately located in Laurens Township, Otsego County, New York (please review attached map). The primary exploration objectives are the Silurian-aged Herkimer and Oneida Sandstone. The prospect is an upthrown horst block, bound by sub-parallel East-West normal faults. The prospect has been delineated by both re-interpretation of existing seismic and interpretation of a proprietary aeromagnetic survey.

Recently, activity in Lebanon Field, Madison County, New York, has further expanded the Herkimer/Oneida Silurian Sandstone play. This play is looked at as the analog of the Butternut Creek Prospect. Approximately 9 new wells have been drilled since 1995. From 1985 to 1998, approximately 0.5 BCF gas was produced from predominately 2 wells.

PROSPECT DISCUSSION

Geophysics

The Butternut Creek Prospect is delineated by interpretation of an aeromagnetic survey, two seismic lines (5PN-7 and 5PN-8) and a regional Bouguer gravity survey. The geophysical interpretation indicates two sub-parallel East-West trending normal faults forming a horst block within the basement. This basement feature forms a structural high in the Silurian Herkimer and Oneida Sandstones. The seismic indicates approximately 150 feet of closure on the western flank of the structure and 75 feet of closure on the eastern flank of the structure. The Butternut Creek Prospect area has been defined as the area between the two sub-parallel faults (as seen on seismic), and approximately delineated by the reduced to pole aeromagnetic image. A gravity minima anomaly coincides with the aeromagnetic feature described above.

Geology

The Herkimer Sandstone is Upper Silurian in age and was deposited as a nearshore, shallow marine and beach depositional environment. The eastern, beach sand facies tends to be an orthoquartzite while the western offshore facies tends to be a “dirty” sandstone and often interbedded with carbonate and shales. Regionally, the Herkimer sands trend roughly northwest – southeast through eastern New York.

The Oneida Sandstone is Lower Silurian in age and was deposited as a transgressive clastic shoreline. Depositional fabric and grain characteristics indicate a high-energy environment. The Oneida can be coarse-grained sandstone to conglomerate. Regionally, the Oneida Sandstone trends roughly north – south through eastern New York.

Given the proximity to the structural front, it is safe to assume these sandstones have undergone the effects of the Appalachian orogenic events. Most likely any primary porosity has now been removed by diagenetic processes, either compassion or segmentation. Most porosity would be secondary, either fracture porosity or secondary dissolution of "weaker" grains or rock fragments.

Analog -- Lebanon Field

Lebanon Field was first discovered in 1960 with the drilling of the Parteka #N-748, drilled by New York State Natural Gas Corp. The well was drilled to 2794 feet to a total depth just below the Silurian Herkimer Sandstone of the Upper Clinton Group. Since the discovery of the field, the deeper Onieda Sandstone (of the Lower Clinton Group) also has established production. Recently, Nornew, Inc. in conjunction with Ardent Resources has drilled wells in Lebanon Field. At least three wells have been drilled in 1999, and numerous wells drilled in 1998. Both the Herkimer Sandstone and the Oneida Sandstone trend from the productive Lebanon Field area in Madison County, southeast into Otsego County.

Below is the reported production for the Madison county, Lebanon Field wells for the last 15 years, as reported by the state.

Date	Producing Wells	Gas production (MMCF)
1985	3	34.0
1986	3	28.4
1987	2	30.8
1988	2	25.0
1989	2	34.2
1990	2	32.2
1991	2	33.7
1992	2	31.4
1993	not reported	
1994	2	29.4
1995	3	43.7
1996	3	31.7
1997	5	30.9
1998	8	86.6
TOTAL:		472.0

The Parteka #N-748 is still a major contributor to the above production. Remembering the Parteka #N-748 was drilled in 1960, the production has sustained almost 40 years (assuming production began almost immediately after discovery).

Source rocks and migration mechanisms

The Middle Ordovician, Utica Shale lies unconformable above the Trenton Limestone. The Utica Shale is typically considered the source rock for the Lower Devonian through Cambrian production and shows. Where the Utica has been faulted into position against lower formations, hydrocarbon migration is postulated (Dykstra and Longman, 1995) to move from the younger, Middle Ordovician Utica Formation to older, Lower Ordovician to Cambrian formations. Upper Ordovician through Lower Devonian formations could be charged with hydrocarbon generated from the Utica Shale through upward "percolation" through fractures, faulting and permeability pathways. The Utica of eastern New York is within the "dry gas window" of the "petroleum kitchen". (Wallace and Roen, 1989, Roen, 1999). The Utica Shale should range from 400 feet to 600 feet in the Otsego County, New York area. The TOC content has been measured up to 2+% in eastern New York (Ryder, et al, 1989, Roen, 1999), although western New York is generally less than 2%.

Log analysis by Aguilera (1978) indicates that the Utica Shale of the Quebec Lowlands may contain 5 BCFG per square mile (640 acres) and the average fractured Utica Formation well could produce initially, approximately 500 MCF/D. This estimate is based on daily production rates of approximately 296 MCF/D after 20 years. Milici (1996) suggests that this average is too optimistic and indicates that the 20-year average daily rate would likely be much closer to 50 MCF/D. Therefore, Aguilera (1978) has likely overestimated the total resource potential. Wallace and Roen (1989) calculated the Utica Shale of the northern Appalachian Basin (New York, Ohio, Pennsylvania and portions of West Virginia) to have generated 165 Billion Barrels of oil or equivalent quantity of natural gas.

Models indicate that gas generation in the eastern New York likely occurred 75-100 million years after deposition, during the Devonian (Dykstra and Longman, 1995). Although varying models could put hydrocarbon generation as young as the Permian portion of the Alleghanian Orogeny (Ryder, et al, 1998). However, the traps in front of the thrust sheets were likely charged in the Devonian, after much of the primary porosity likely was diagenetically destroyed or altered (Milici, 1996).

<u>Off Structure Wells</u>
The following is a discussion of wells proximal to the Butternut Creek Prospect.

- Permit # -- OTS-02612:
  The E. Matterson #1 was drilled by Blue Rock Drilling Company in 1952. The well reached a total depth of 2450 feet in the Middle Devonian Oriskany/Helderberg section. The well was drilled and abandoned with no shows or treatment. No electric logs are available.

- Permit # -- OTS-04050:
  The W. Elliott #1 was drilled by Prensett Corporation in 1960. The well reached a total depth of 3697 feet in the Silurian Lorraine Shale. The well was plugged and abandoned after treatment. The Herkimer Sandstone was treated from 3247 to 3258 feet. The zone initially produced 20 MCF/D, blowing down to 5 MCF/D. After treatment, the well produced 250 MCF/D but soon watered out and was plugged and abandoned. A Gamma Ray log is available.

- Permit # -- OTS-10725:
  The C.R. Bellows #1 was drilled by Amoco Production Company in 1974. The well reached a total depth of 3980 feet in the Silurian Lorraine Shale. The well was drilled and abandoned with no treatment. A full set of electric logs is available.

- Permit # -- OTS-10834:
  The H. S. Hoose #1 was drilled by Amoco Production Company in 1974. The well reached a total depth of 5824 feet in the Precambrian Igneous Basement. The well was drilled and abandoned with no treatment. A full set of electric logs is available.

Secondary Targets in Butternut Creek Prospect Area

- Lower Marcellus Shale/Utica Shale:
  A Middle Devonian fractured shale reservoir thought to be found on structural highs and/or along fault shear zones. Genegantslet Field in Chenango County, NY would be a potential analog. The W. Decker #2 had a natural open flow of 1650 MCF/D.

- Onondaga Limestone:
  Reservoirs within the Middle Devonian Onondaga tend to be patch reefs and shoals situated along paleo highs. Seven reef fields with Steuben County, NY have reported recoverable reserves of 28 BCF from 13 wells.

- Oriskany Sandstone:
  The Oriskany Sandstone can occur as either offshore sandbar deposits or faultbound channels. Stagecoach Field in Tioga County, NY has an estimated 20-30 BCF of reserves from a channel sand reservoir.

- Trenton/Black River Limestones:
  The Ordovician fractured dolomite occurs on structural highs, along fault, shear zones and within collapse graben structures. Recent discoveries in Steuben County, NY report initial open flows of over 10 MMCF/D.

Reserve Potential

Log calculations of the Amoco Hoose and Bellows wells indicate porosities in the 5% to 11% range. These porosity values are typical of Appalachian Basin clastic reservoirs. Water saturations range from 20% to 45%. Again, very typical for Appalachian Basin reservoirs. A "sandy-shale" log analysis of the zones indicates potential per well Gas in Place (GIP) of 400 to 600 MMCF. Assuming 75% recovery factor, a per well Estimated Ultimate Recoverable (EUR) would be roughly 300 to 400 MMCF. Assuming an 8700 acre prospect (defined by aeromagnetic and seismic interpretation) and assuming 160 acre spacing, the field could yield approximately 25 BCF. That number is based on the log analysis of two off-structure wells though. Assuming these two wells on structure with slightly better porosity (average of approximately 12%) on the high/prospect and slightly less water saturations (average of approximately 20%), the number could increase significantly to a best case scenario of 650 to 900 MMCF EUR. Again, assuming an 8700 acre prospect (defined by aeromagnetic and seismic interpretation) and assuming 160 acre spacing, the field could yield approximately 50 BCF.

The off-structure wells do not contain significantly porous Oriskany Sandstone or Onondaga Limestone. If encountered in the prospect area, porosities should range from 7-14% for the Oriskany and 5-10% for the Onondaga (potentially higher porosities in the reefal facies). If the Oriskany Sandstone were encountered in the prospect area, the 20-30 BCF, Stagecoach Field

(Tioga County, NY) could be an analog. Onondaga Limestone fields in New York tend to be reefal features and may only be 1-3 well fields, yielding up to 7 BCF.

The Hoose #1 is the only off-structure well to penetrate the Trenton Limestone. Recent drilling activity in Stueben County has operators encountering Trenton wells with large (rumored up to 10 MMCF/D) natural open flows. Reserve estimates are difficult. It has been rumored that these wells could average 1+ BCF per well, but duration of production could be a major concern as these wells are, in part, fracture reservoirs and the extent of the fracture system and connectivity has yet to be determined.

Reserve calculations for the Trenton/Black River potential in the area is much less easy to quantify. To date, all wells drilled in the area appear to be very tight through the Trenton/Black River and therefore do not appear to be reservoir quality. Assuming similar reservoir quality/quantity to CNR's Steuben County production, one might expect 100 – 300 MMCF for the first year of production. Depending on reservoir size (aerial extent), type (fracture or matrix dominated) and relative permeability, one could expect over 1 BCF wells from this formation.

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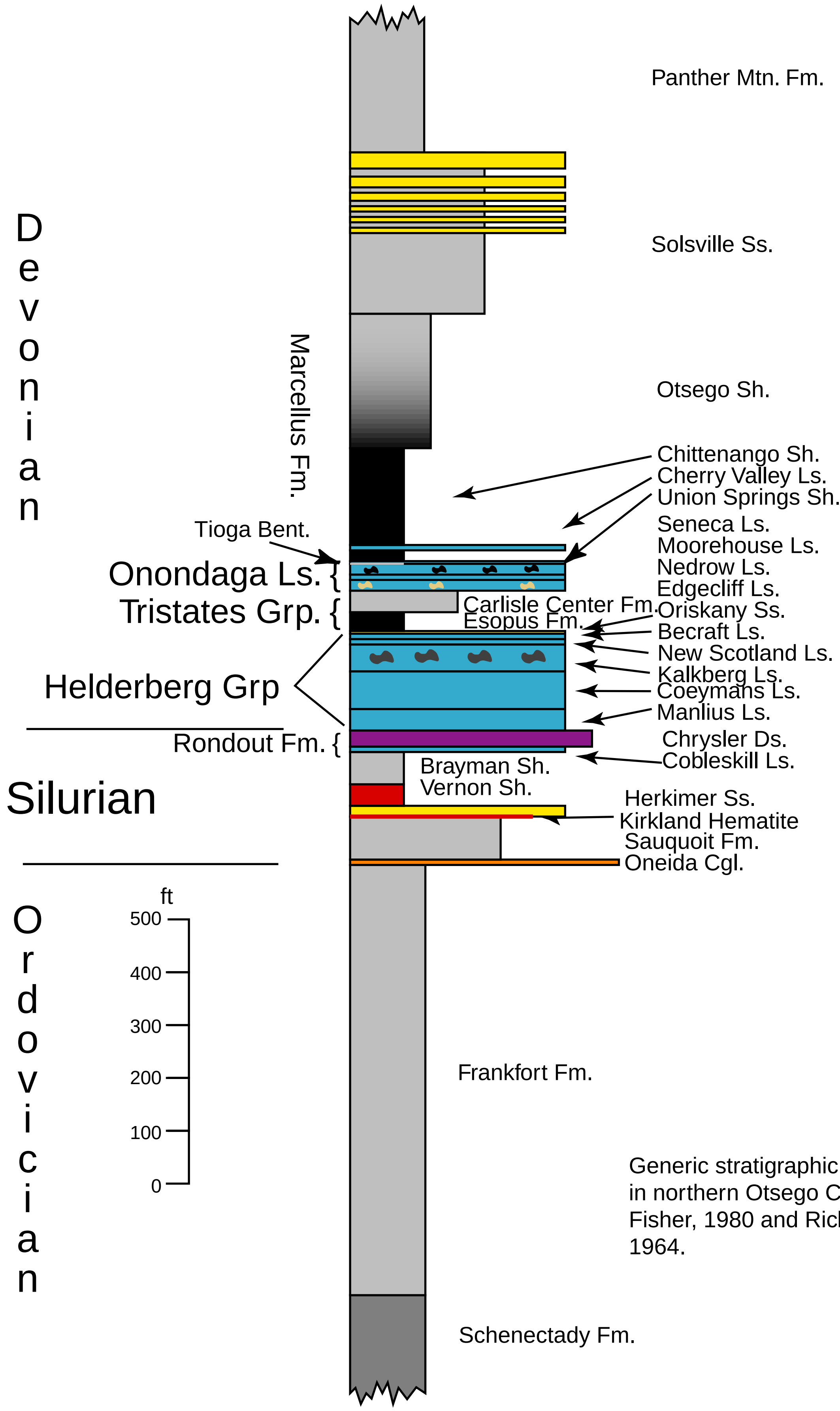
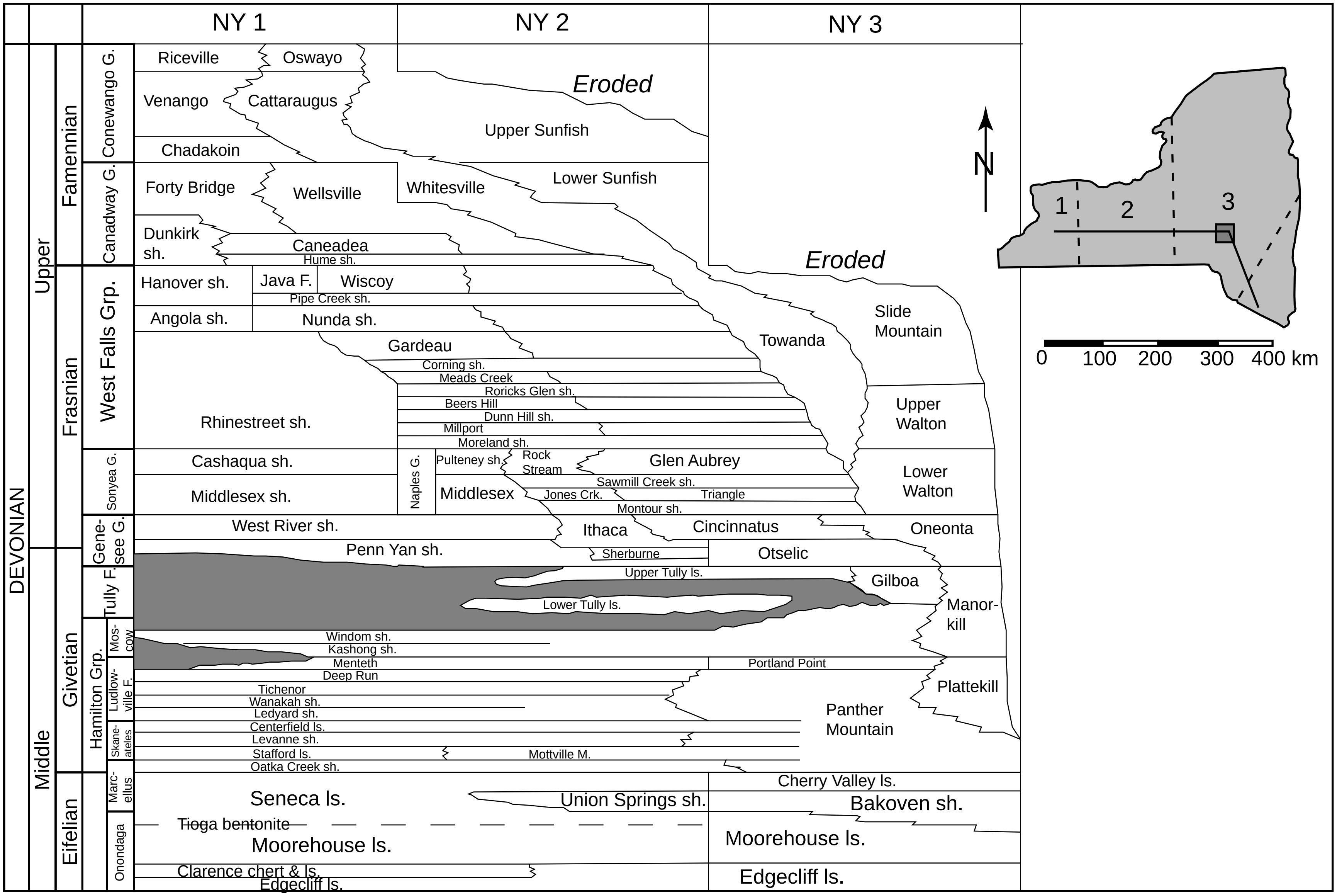


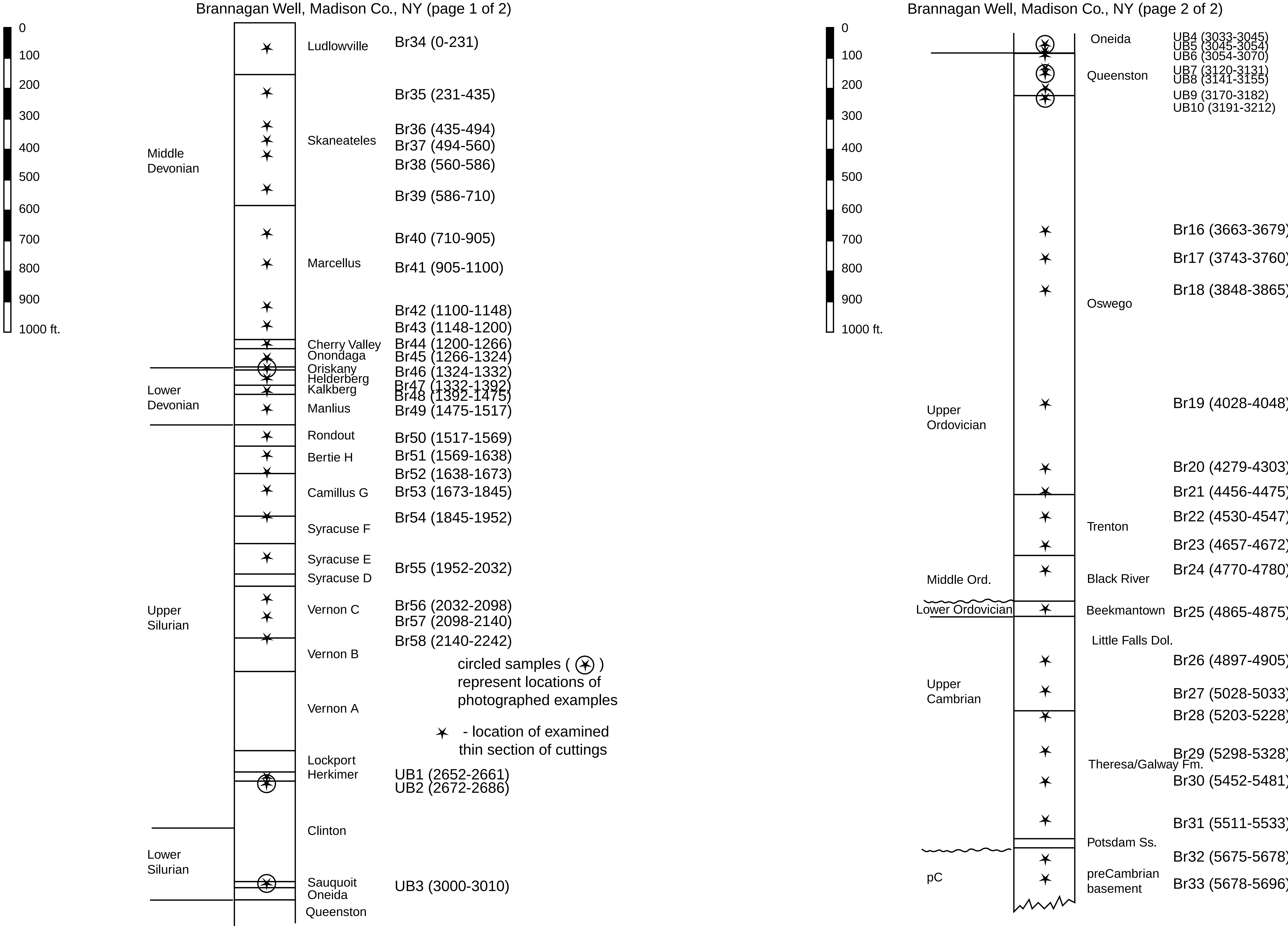
Generic stratigraphic column for outcrop in northern Otsego County, from Fisher, 1980 and Rickard and Zenger, 1964.

Figure 1a

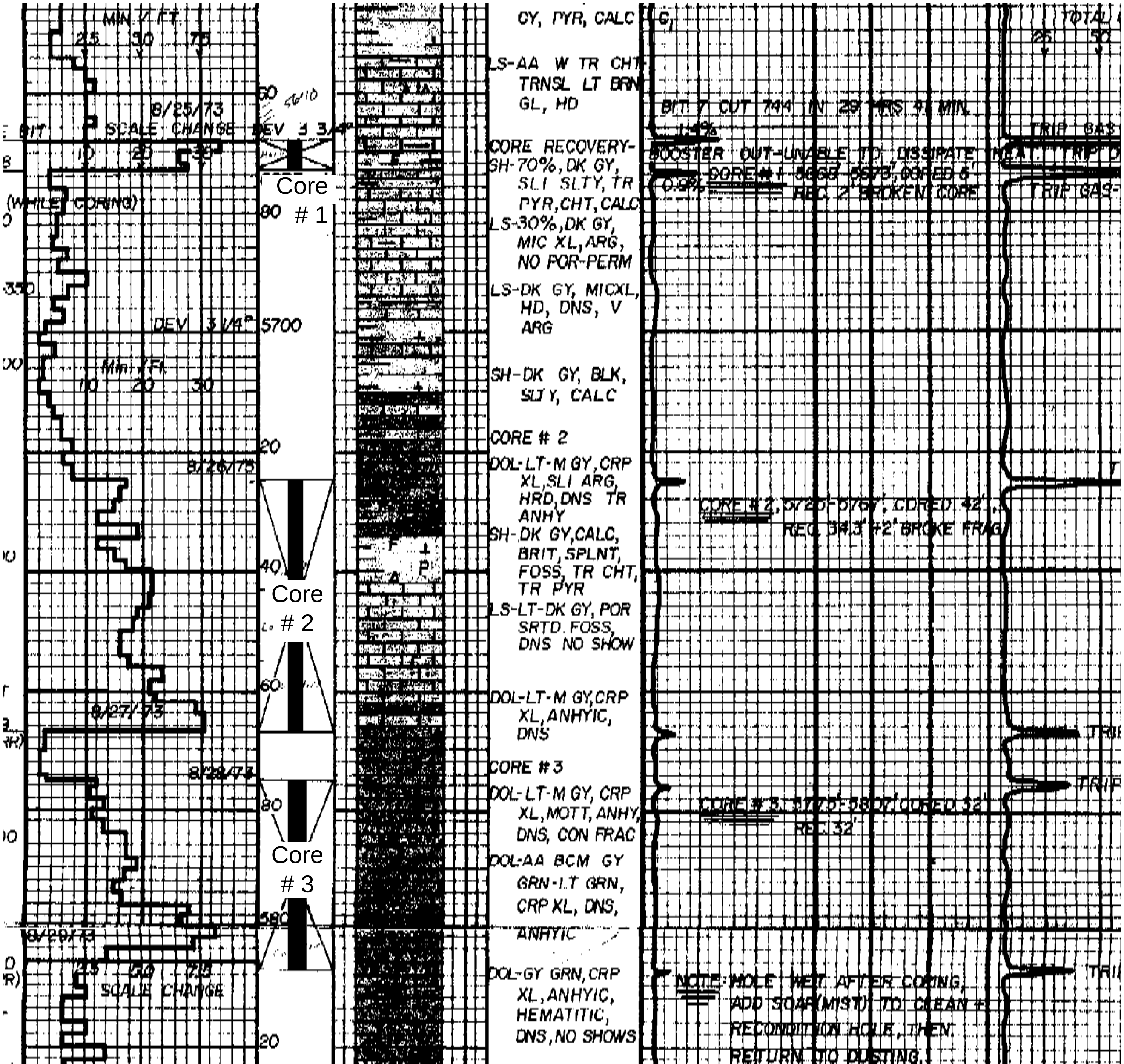


Middle and Upper Devonian stratigraphy of the Appalachian Basin in New York State after Woodrow and Sevon, 1985.

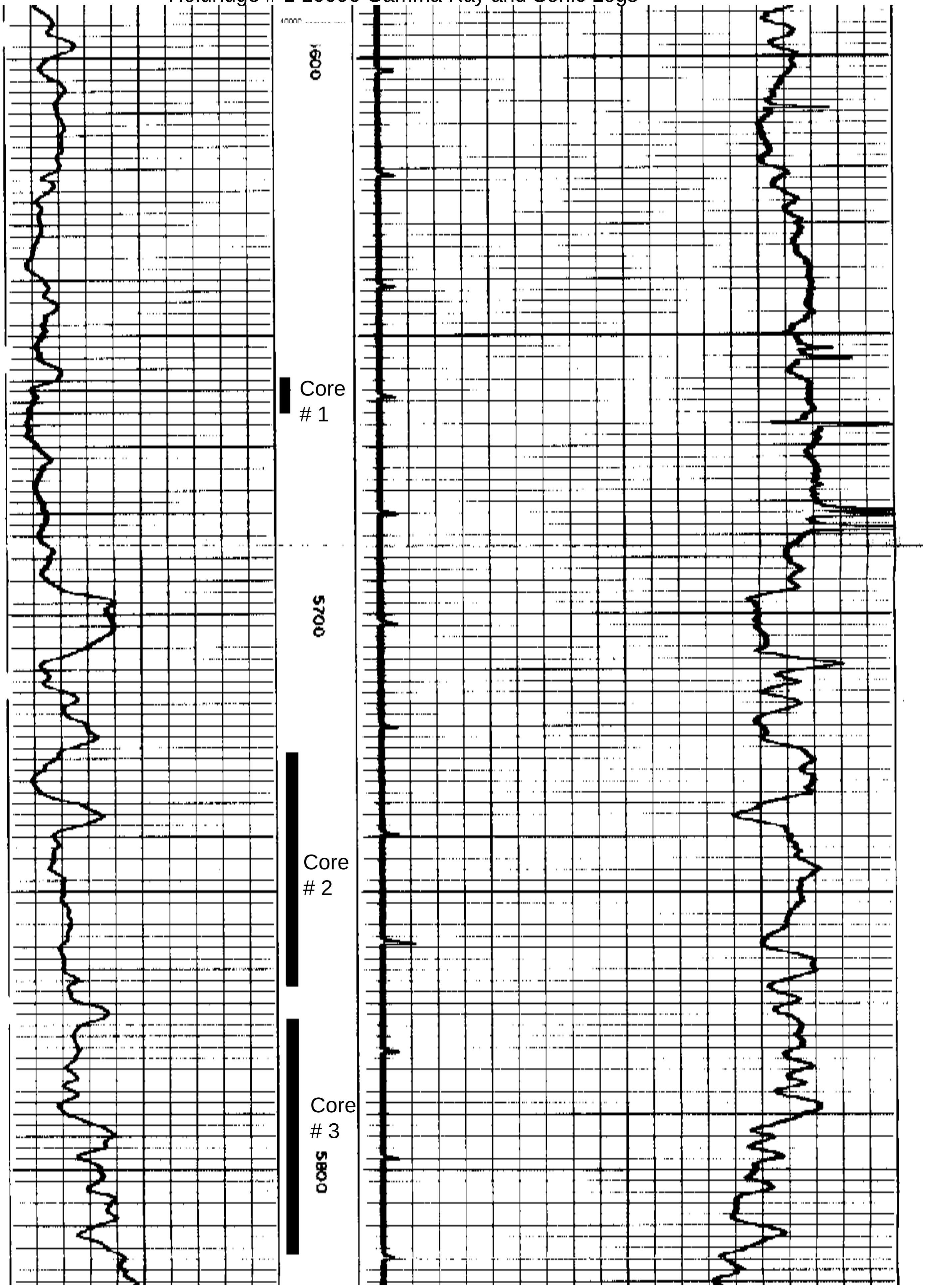
Figure 1b


Brannagan Well, Madison Co., NY (page 1 of 2)
0
100
200
300
400
500
600
700
800
900
1000 ft.
Middle Devonian
Lower Devonian
Upper Silurian
Lower Silurian
Ludlowville
Br34 (0-231)
Br35 (231-435)
Skaneateles
Br36 (435-494)
Br37 (494-560)
Br38 (560-586)
Br39 (586-710)
Marcellus
Br40 (710-905)
Br41 (905-1100)
Br42 (1100-1148)
Br43 (1148-1200)
Cherry Valley
Br44 (1200-1266)
Onondaga
Br45 (1266-1324)
Oriskany
Br46 (1324-1332)
Helderberg
Br47 (1332-1392)
Kalkberg
Br48 (1392-1475)
Manlius
Br49 (1475-1517)
Rondout
Br50 (1517-1569)
Bertie H
Br51 (1569-1638)
Br52 (1638-1673)
Camillus G
Br53 (1673-1845)
Br54 (1845-1952)
Syracuse F
Syracuse E
Br55 (1952-2032)
Syracuse D
Vernon C
Br56 (2032-2098)
Br57 (2098-2140)
Br58 (2140-2242)
Vernon B
circled samples ( ) represent locations of photographed examples
Vernon A
- location of examined thin section of cuttings
Lockport
Herkimer
UB1 (2652-2661)
UB2 (2672-2686)
Clinton
Sauquoit
Oneida
UB3 (3000-3010)
Queenston
Brannagan Well, Madison Co., NY (page 2 of 2)
0
100
200
300
400
500
600
700
800
900
1000 ft.
Oneida
UB4 (3033-3045)
UB5 (3045-3054)
UB6 (3054-3070)
Queenston
UB7 (3120-3131)
UB8 (3141-3155)
UB9 (3170-3182)
UB10 (3191-3212)
Br16 (3663-3679)
Br17 (3743-3760)
Br18 (3848-3865)
Oswego
Upper Ordovician
Br19 (4028-4048)
Br20 (4279-4303)
Br21 (4456-4475)
Trenton
Br22 (4530-4547)
Br23 (4657-4672)
Middle Ord.
Black River
Br24 (4770-4780)
Lower Ordovician
Beekmantown
Br25 (4865-4875)
Little Falls Dol.
Upper Cambrian
Br26 (4897-4905)
Br27 (5028-5033)
Br28 (5203-5228)
Br29 (5298-5328)
Theresa/Galway Fm.
Br30 (5452-5481)
Br31 (5511-5533)
Potsdam Ss.
Br32 (5675-5678)
pC
preCambrian basement
Br33 (5678-5696)

Holdridge #1 10096 Drilling rate and mud-logs

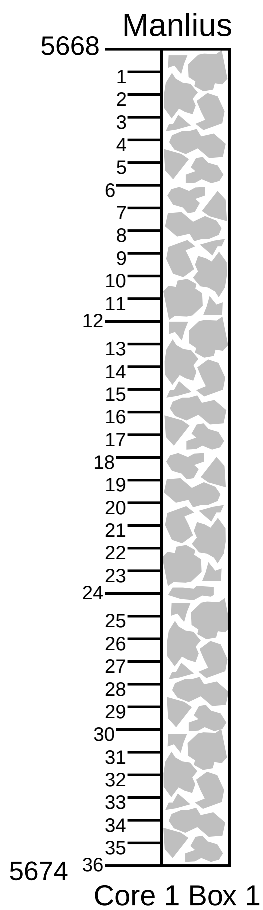


Holdridge # 1 10096 Gamma Ray and Sonic Logs



10096 Holdridge #1
Core 1 5668-5674

Delaware County



Key to Symbols used in core-descriptions

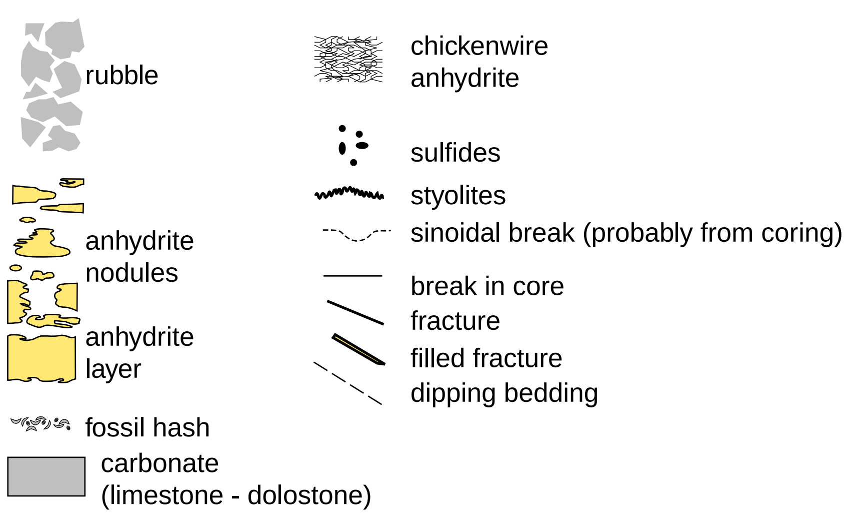
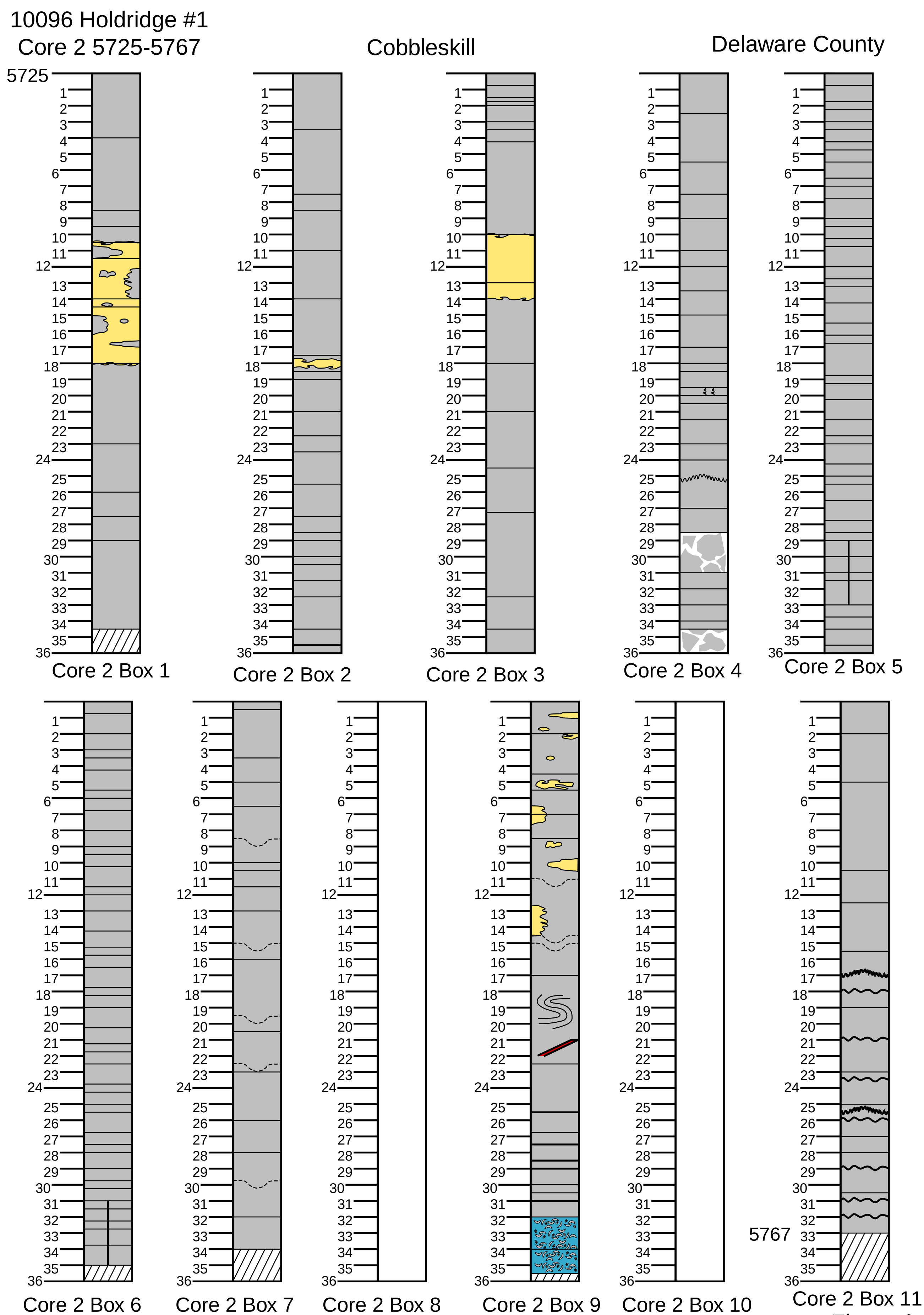


Figure 5


10096 Holdridge #1
Core 2 5725-5767
Cobbleskill
Delaware County
5725
Core 2 Box 1
Core 2 Box 2
Core 2 Box 3
Core 2 Box 4
Core 2 Box 5
Core 2 Box 6
Core 2 Box 7
Core 2 Box 8
Core 2 Box 9
Core 2 Box 10
5767
Core 2 Box 11
Figure 6

10096 Holdridge #1
Core 3 5775-5807

Brayman

Delaware County

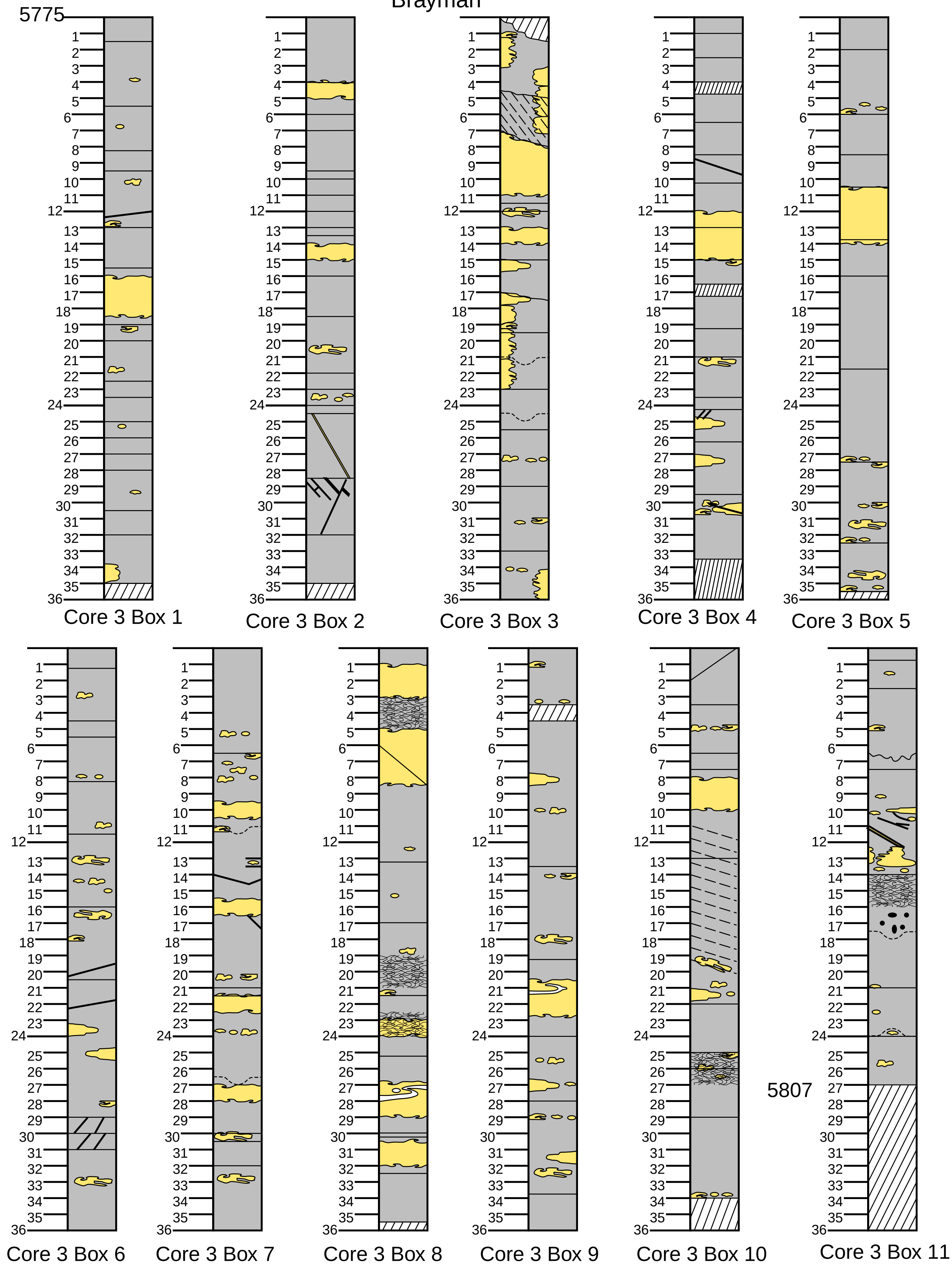


Figure 7

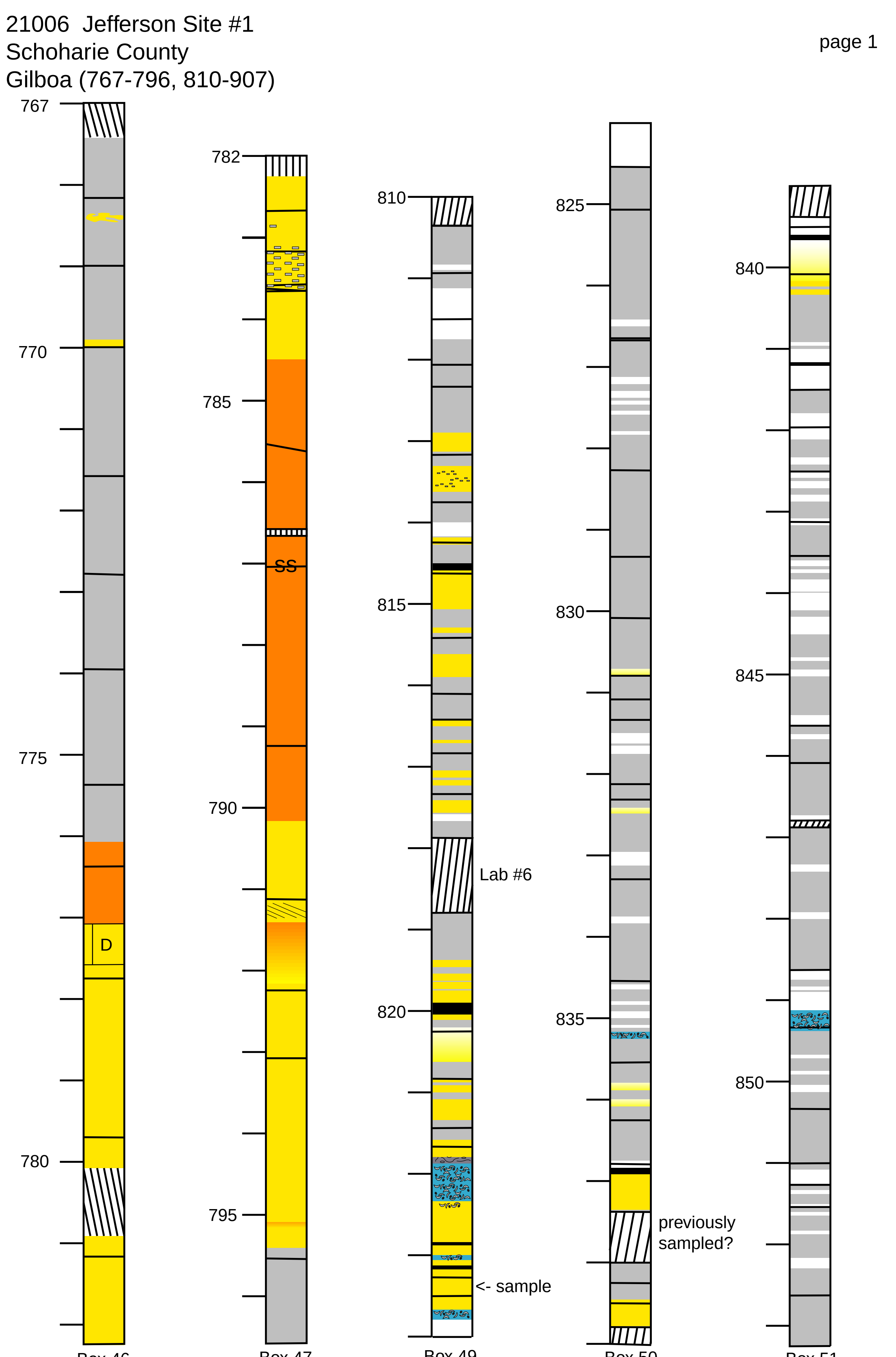


Figure 8

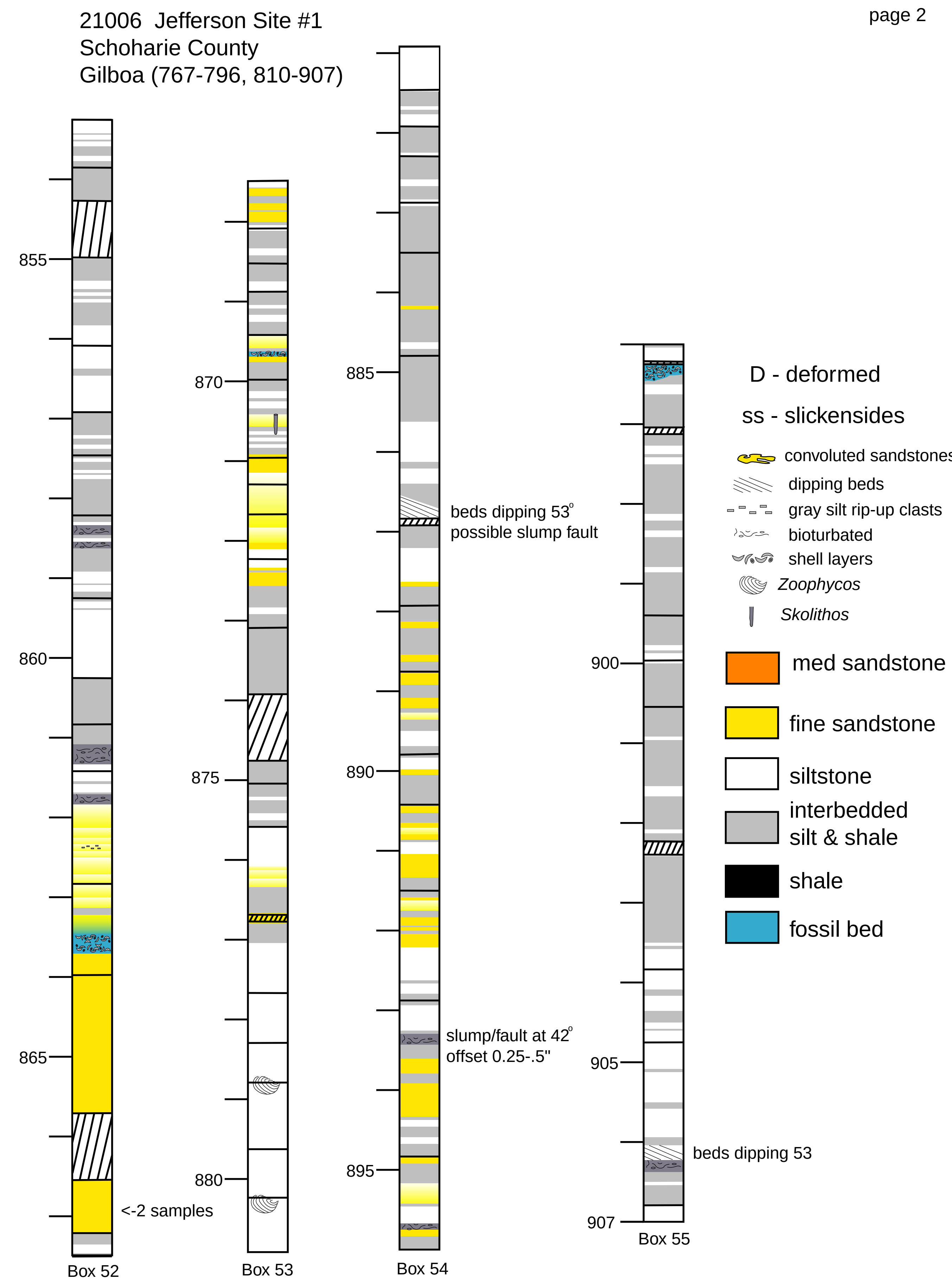


Figure 8

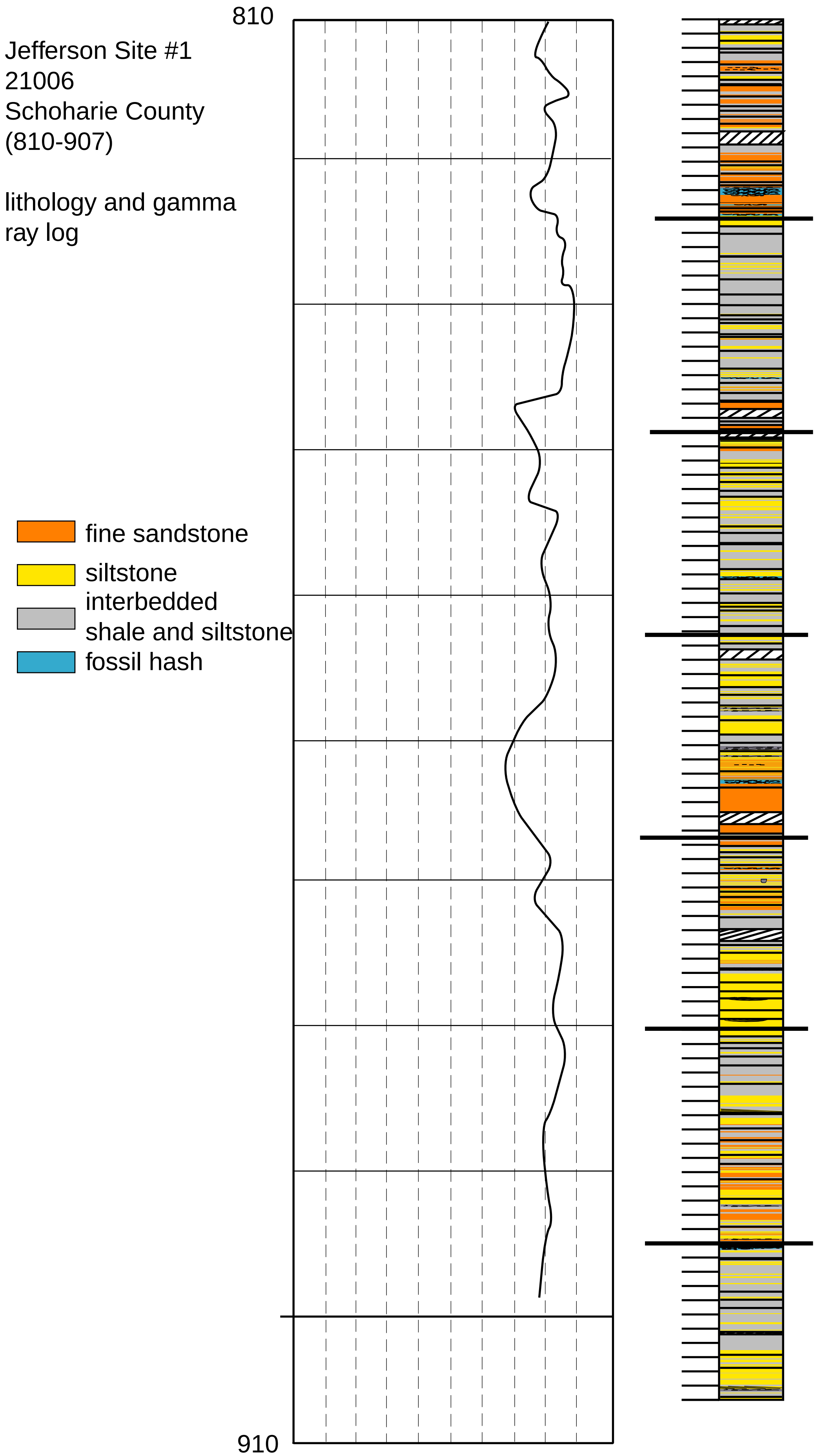

Jefferson Site #1
21006
Schoharie County
(810-907)
lithology and gamma ray log
810
910
fine sandstone
siltstone
interbedded shale and siltstone
fossil hash

Figure 9

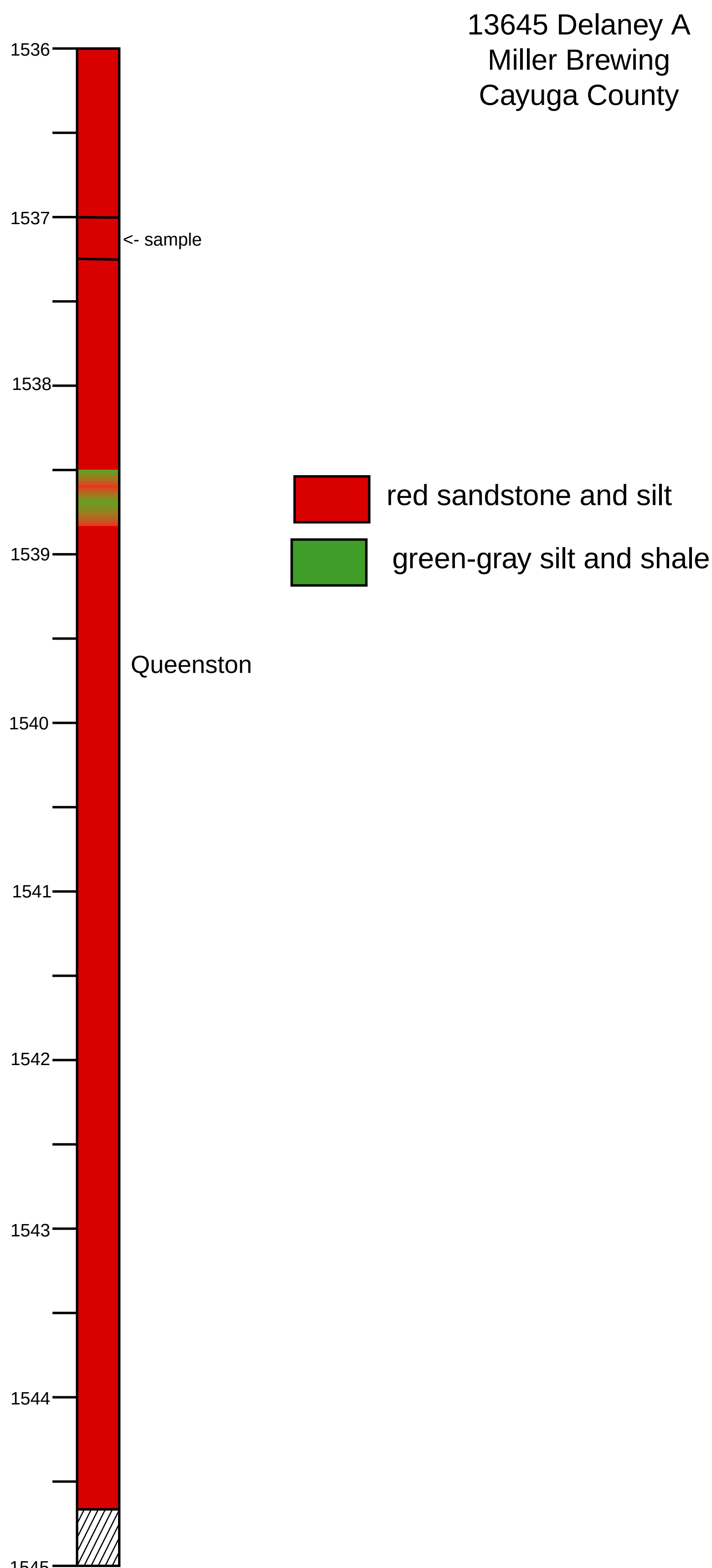

13645 Delaney A
Miller Brewing
Cayuga County
1536
1537
<- sample
1538
1539
1540
1541
1542
1543
1544
1545
Queenston
red sandstone and silt
green-gray silt and shale

Figure 10a

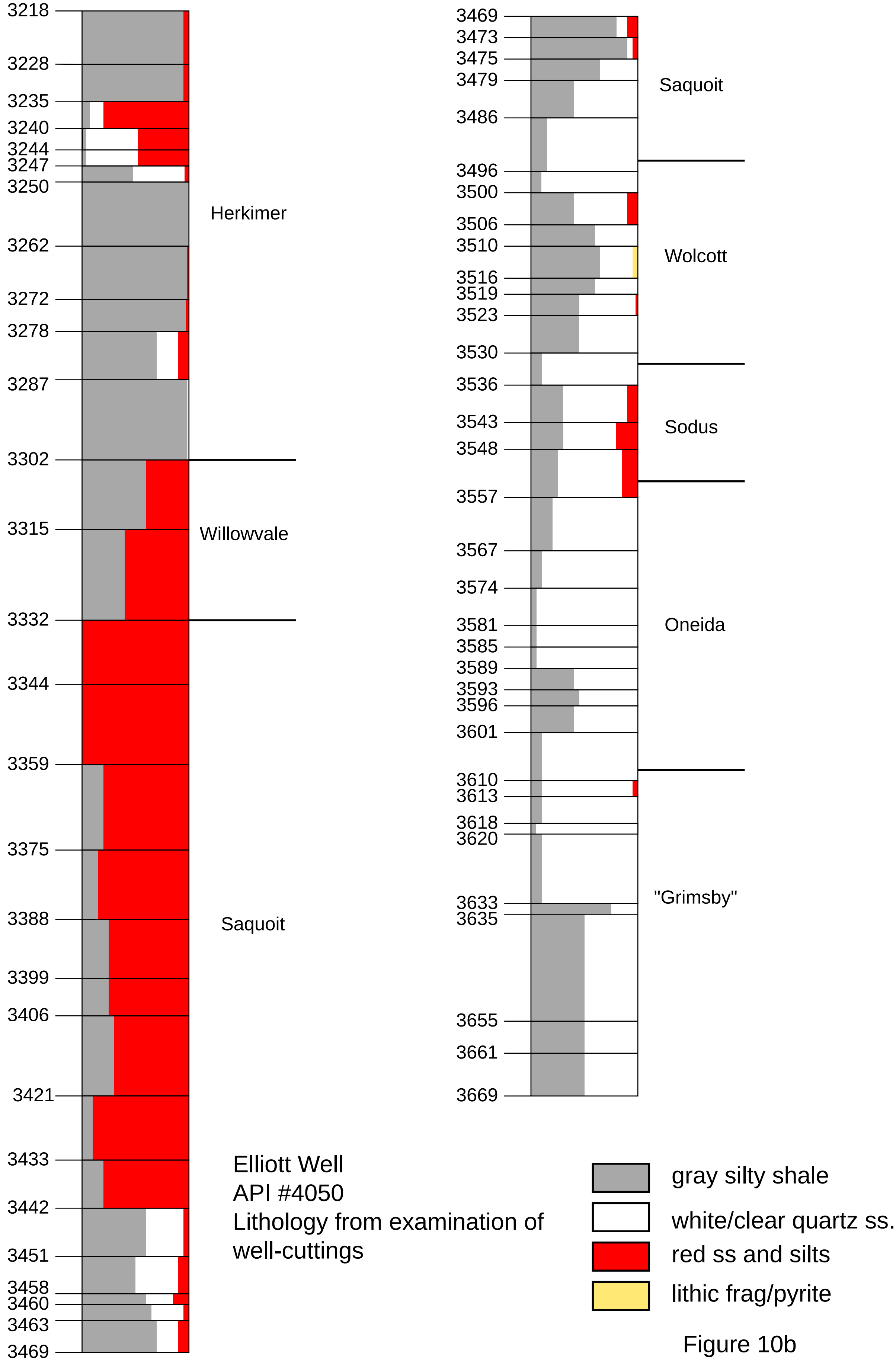

3218
3228
3235
3240
3244
3247
3250
3262
3272
3278
3287
3302
3315
3332
3344
3359
3375
3388
3399
3406
3421
3433
3442
3451
3458
3460
3463
3469
Herkimer
Willowvale
Saquoit
3469
3473
3475
3479
3486
3496
3500
3506
3510
3516
3519
3523
3530
3536
3543
3548
3557
3567
3574
3581
3585
3589
3593
3596
3601
3610
3613
3618
3620
3633
3635
3655
3661
3669
Saquoit
Wolcott
Sodus
Oneida
"Grimsby"
Elliott Well
API #4050
Lithology from examination of
well-cuttings
gray silty shale
white/clear quartz ss.
red ss and silts
lithic frag/pyrite

Figure 10b

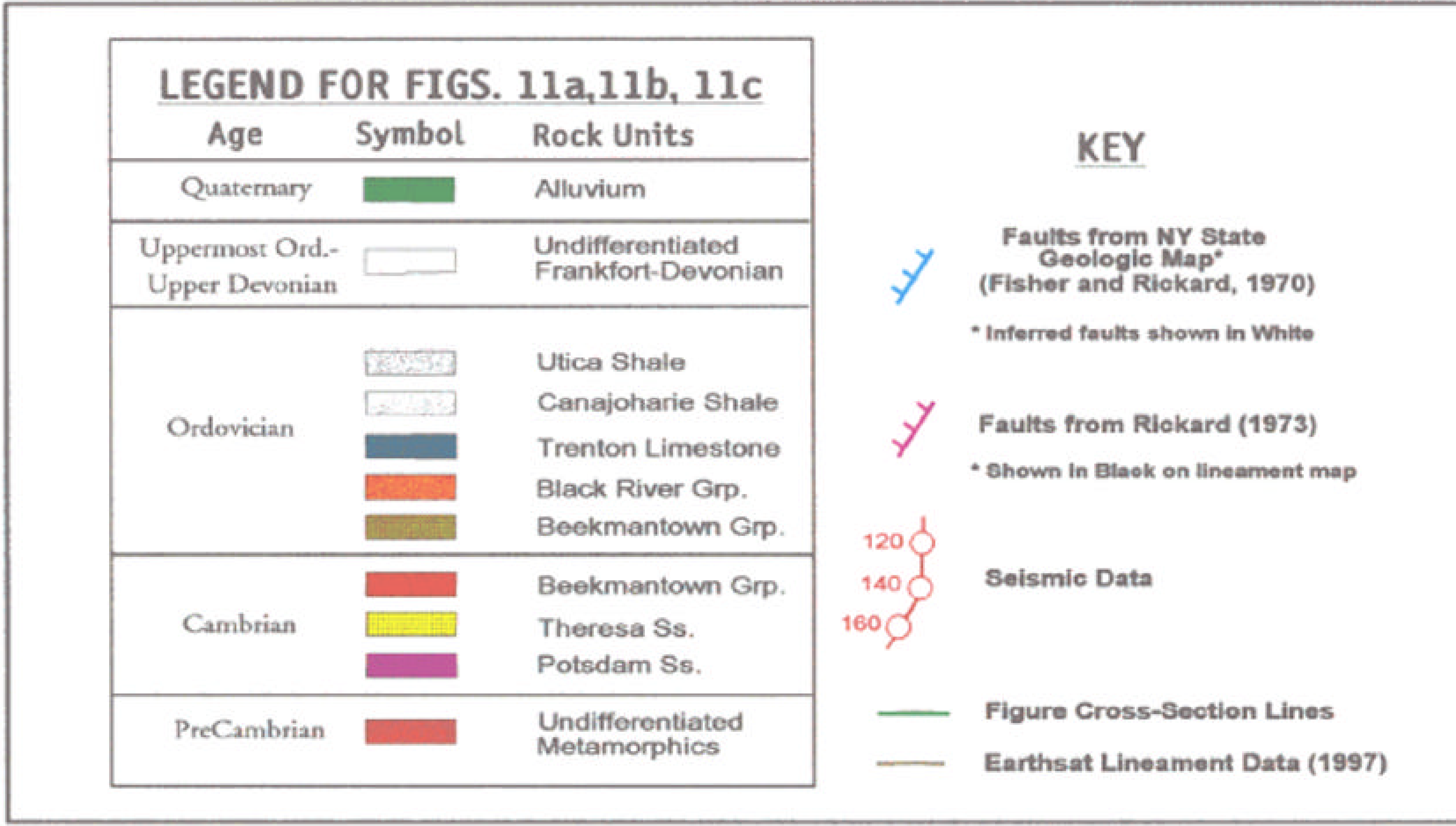
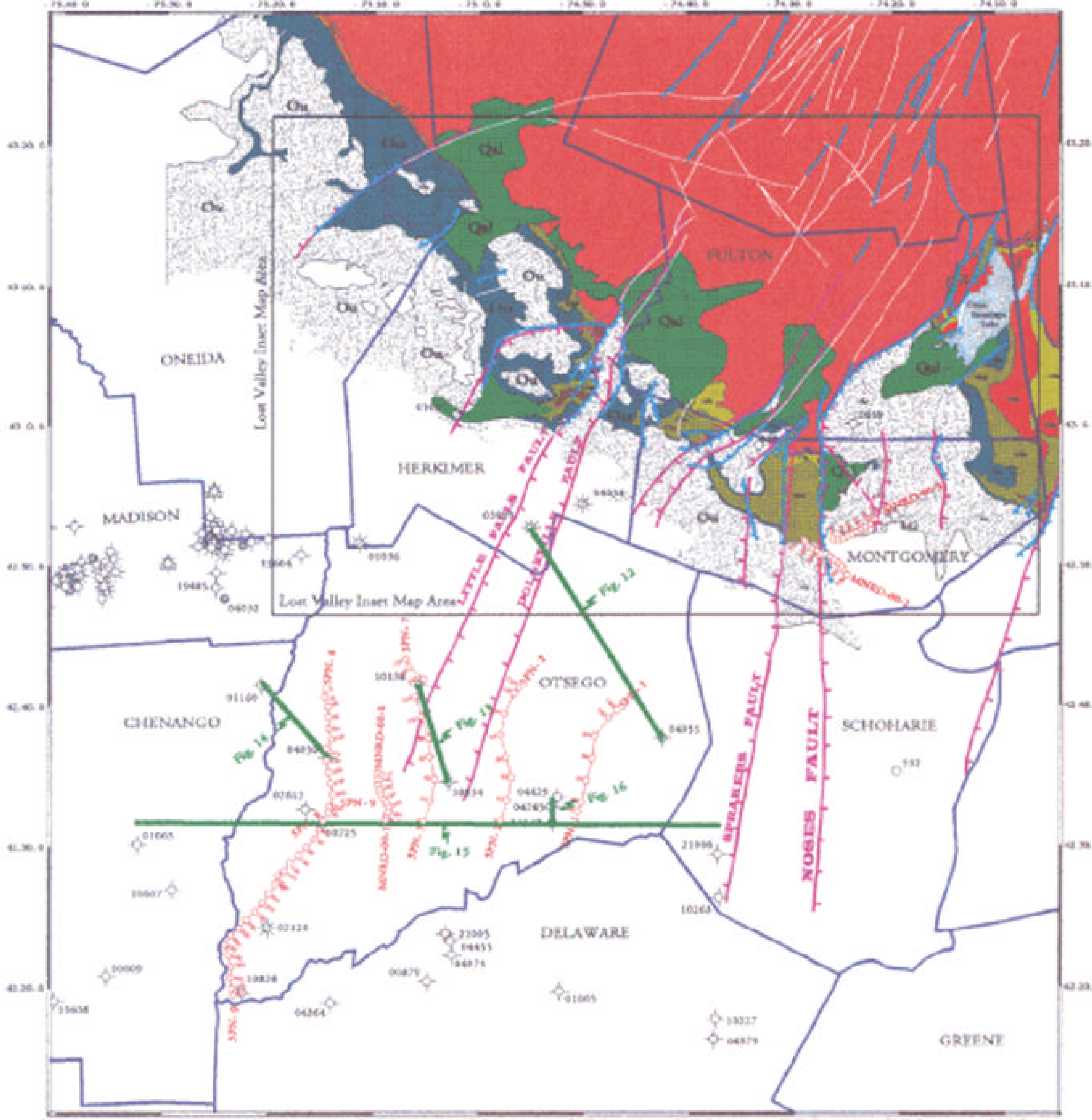


Figure 11a (cont.)

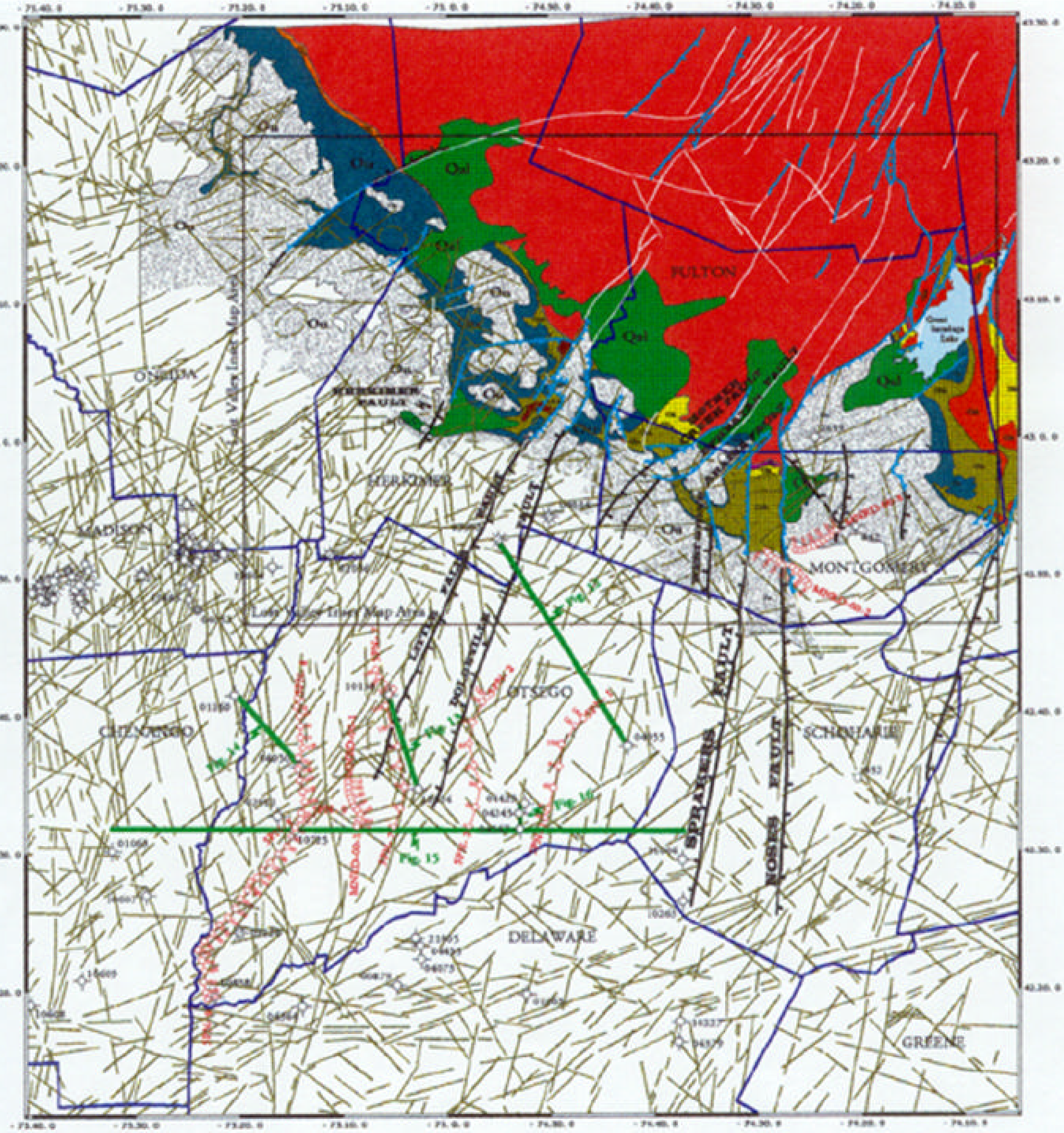


UTM Zone 18
Central Meridian: 75W

Scale 1:800000.

MILLENNIUM NATURAL RESOURCE DEV.	
BUTTERNUT CREEK PROSPECT BASE MAP OTSEGO CO., N.Y.	
otsego.gpf	
Scale 1:800000.	Quest Energy, Inc.

Figure 11a



UTM Zone 18
Central Meridian: 75W

Scale 1:800000.

MILLENNIUM NATURAL RESOURCE DEV.		
BUTTERNUT CREEK PROSPECT BASE MAP OTSEGO CO., N.Y.		
	otbasin.gpf	
	Scale 1:800000.	Quest Energy, Inc.

Figure 11b

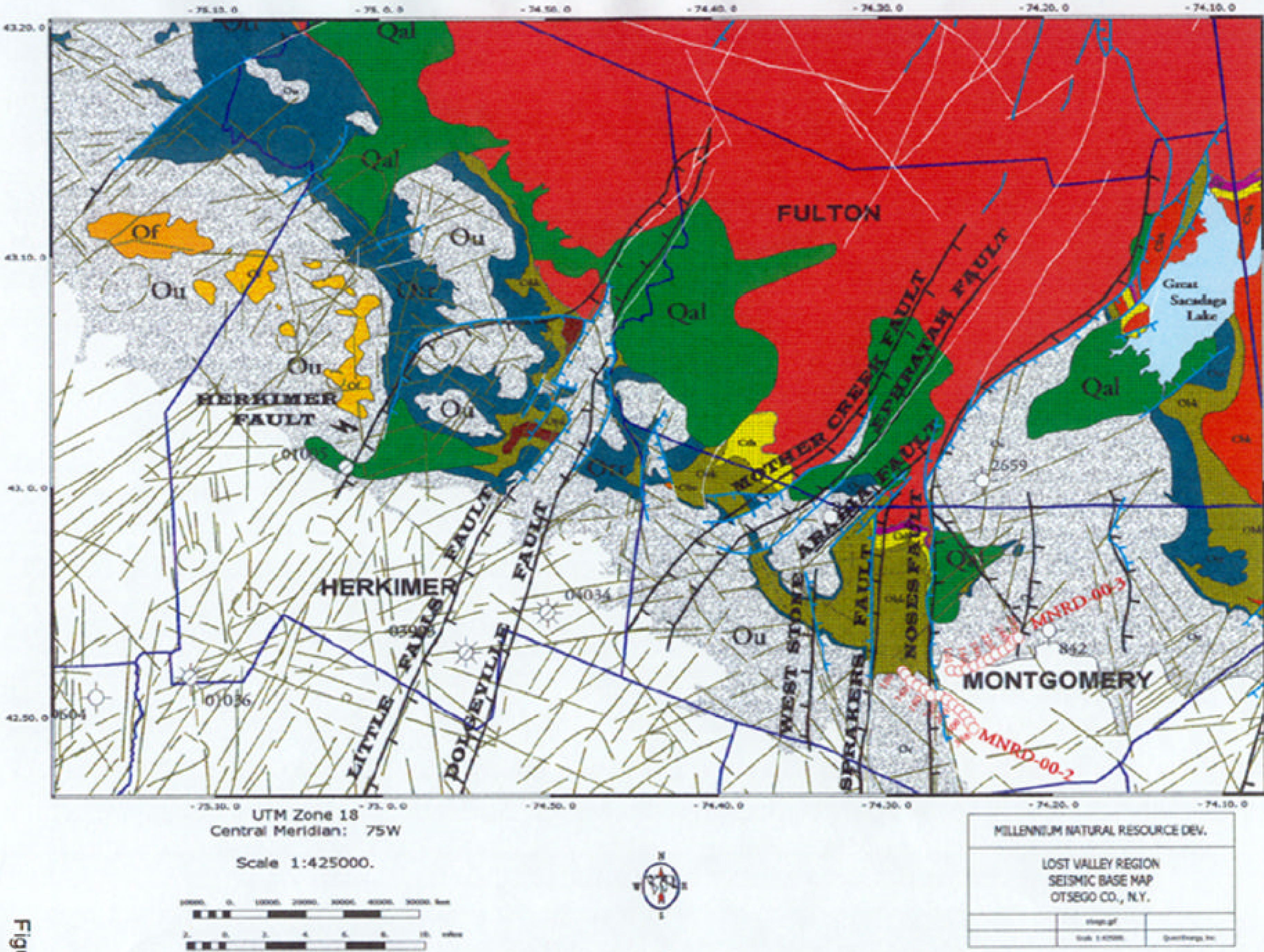
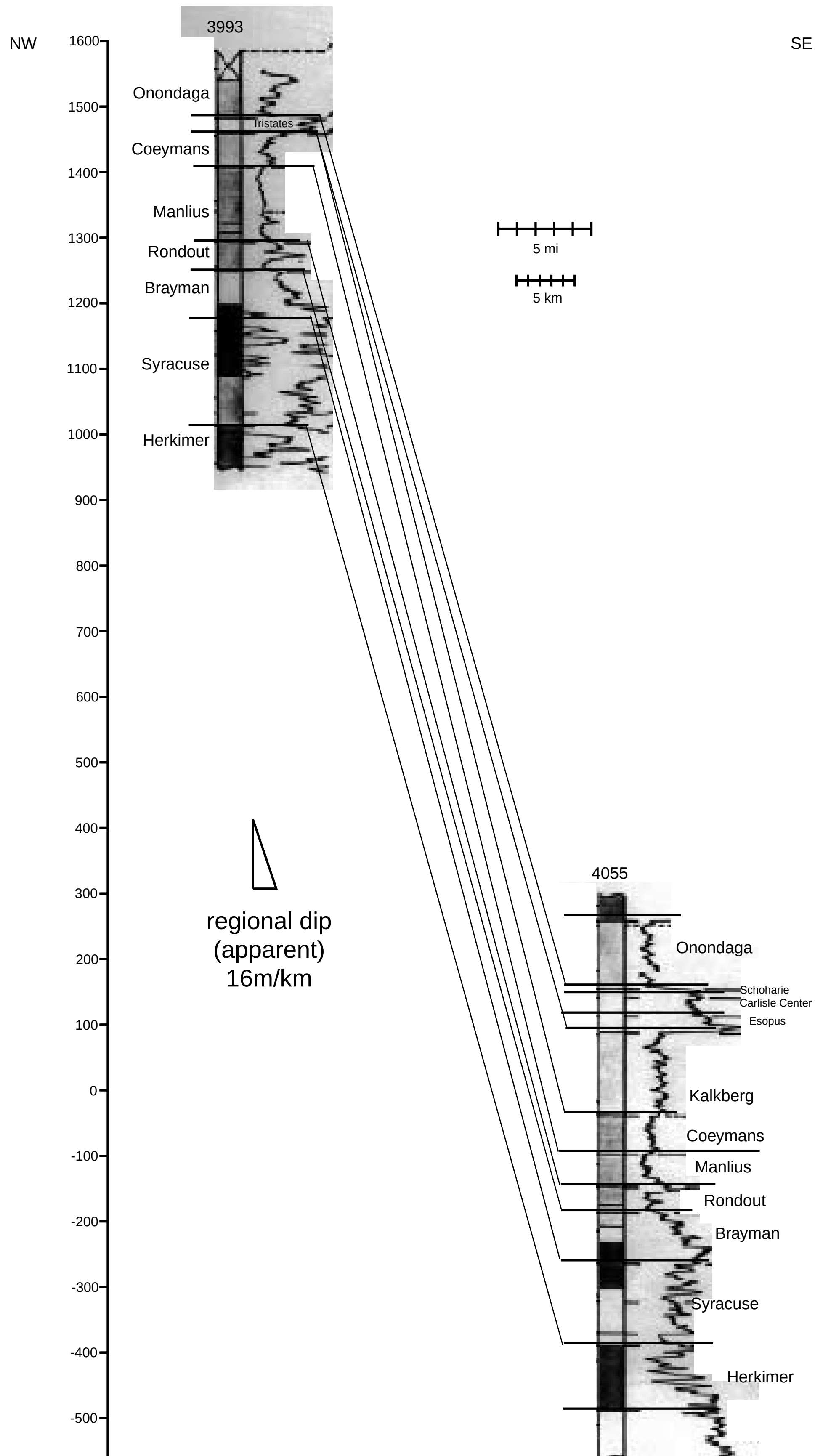
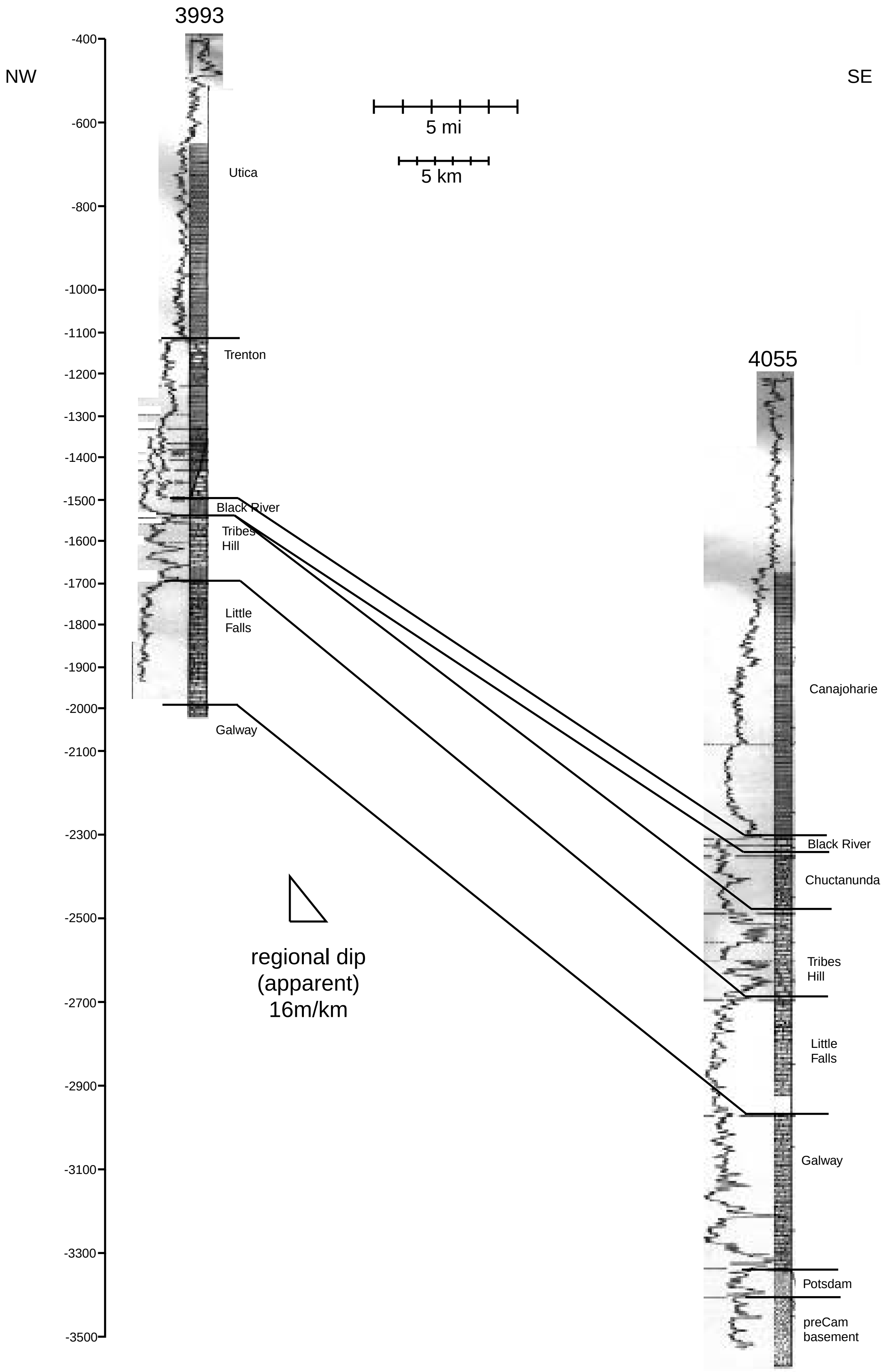

FULTON
HERKIMER
MONTGOMERY
HERKIMER FAULT
LITTLE FALLS FAULT
POLCEVILLE FAULT
WEST SIDE FAULT
SPRAKERS FAULT
NOSES FAULT
HOTHER CREEK FAULT
EPHRATAH FAULT
Great Sacadaga Lake
Qal
Ou
Of
MNRD-00-3
MNRD-00-2
2659
842
UTM Zone 18
Central Meridian: 75W
Scale 1:425000.
MILLENNIUM NATURAL RESOURCE DEV.
LOST VALLEY REGION
SEISMIC BASE MAP
OTSEGO CO., N.Y.

Figure 11c



From Rickard's Michigan - NYS cross-section (unpublished data)

Figure 12a



From Rickard's (1973) Lake Ontario - Bash Bish Falls cross-section

Figure 12b

From Rickard E-W cross-section #5 (unpublished data)

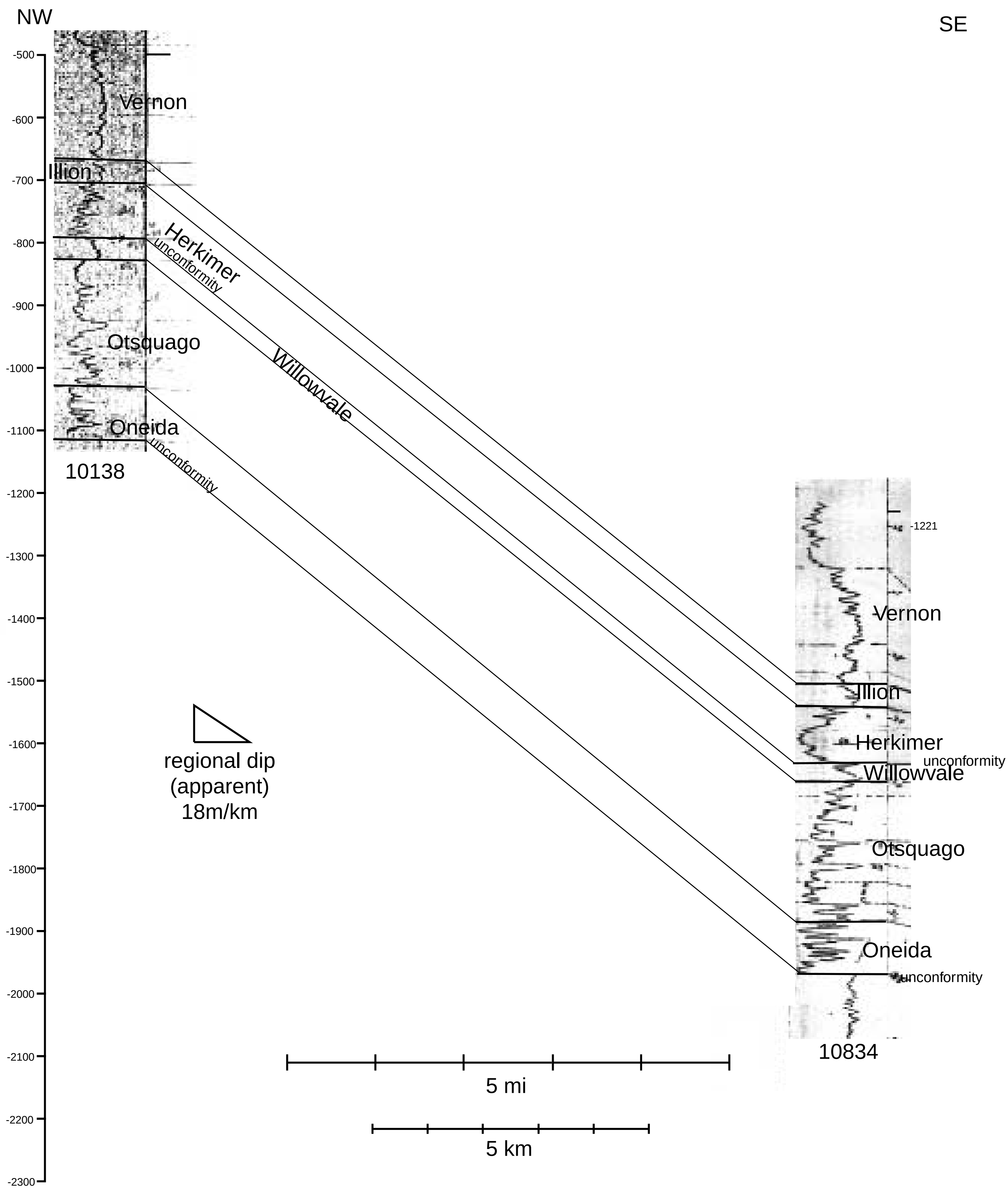


Figure 13

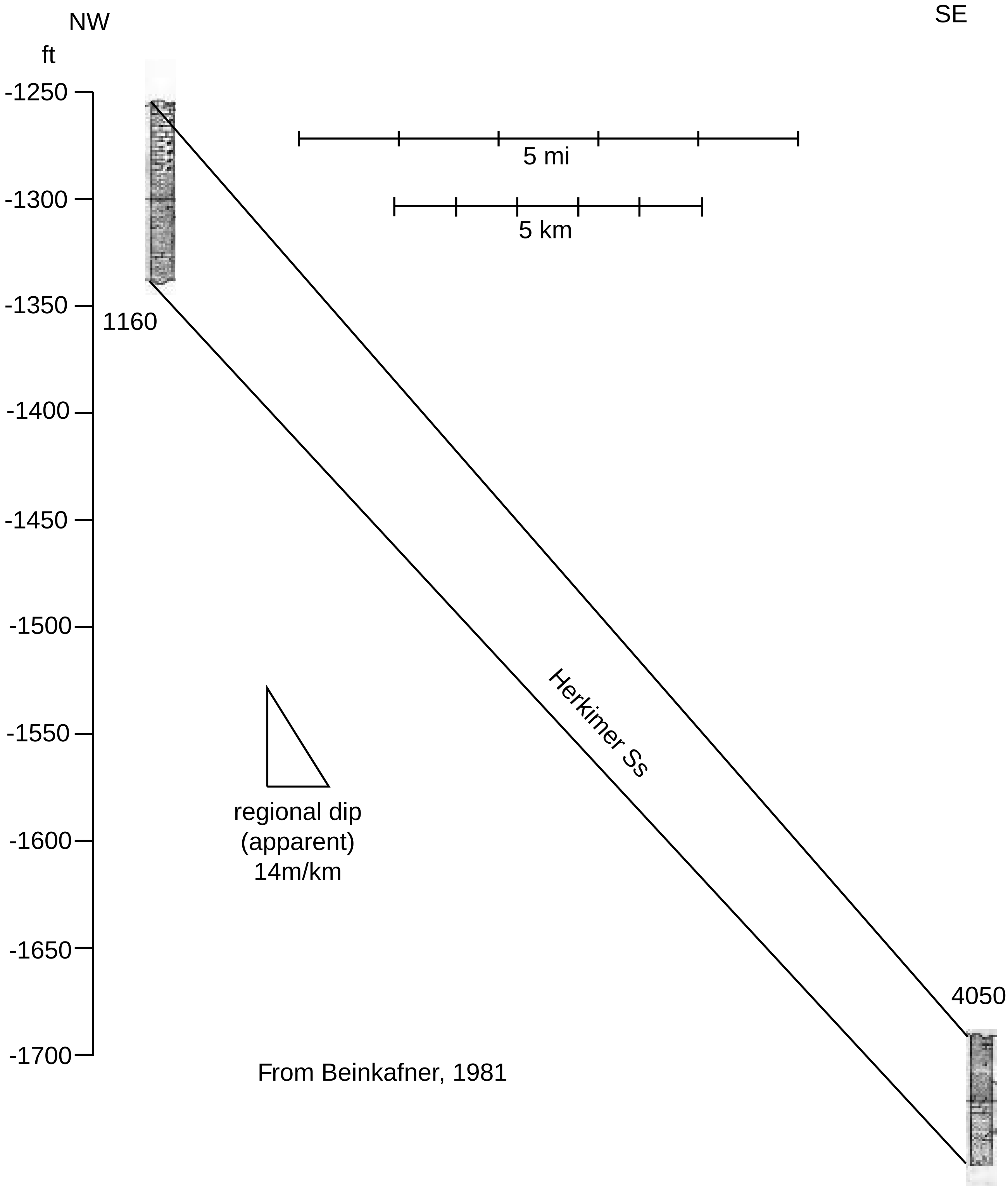

NW
SE
ft
-1250
-1300
-1350
-1400
-1450
-1500
-1550
-1600
-1650
-1700
1160
4050
5 mi
5 km
Herkimer Ss
regional dip
(apparent)
14m/km
From Beinkafner, 1981

Figure 14

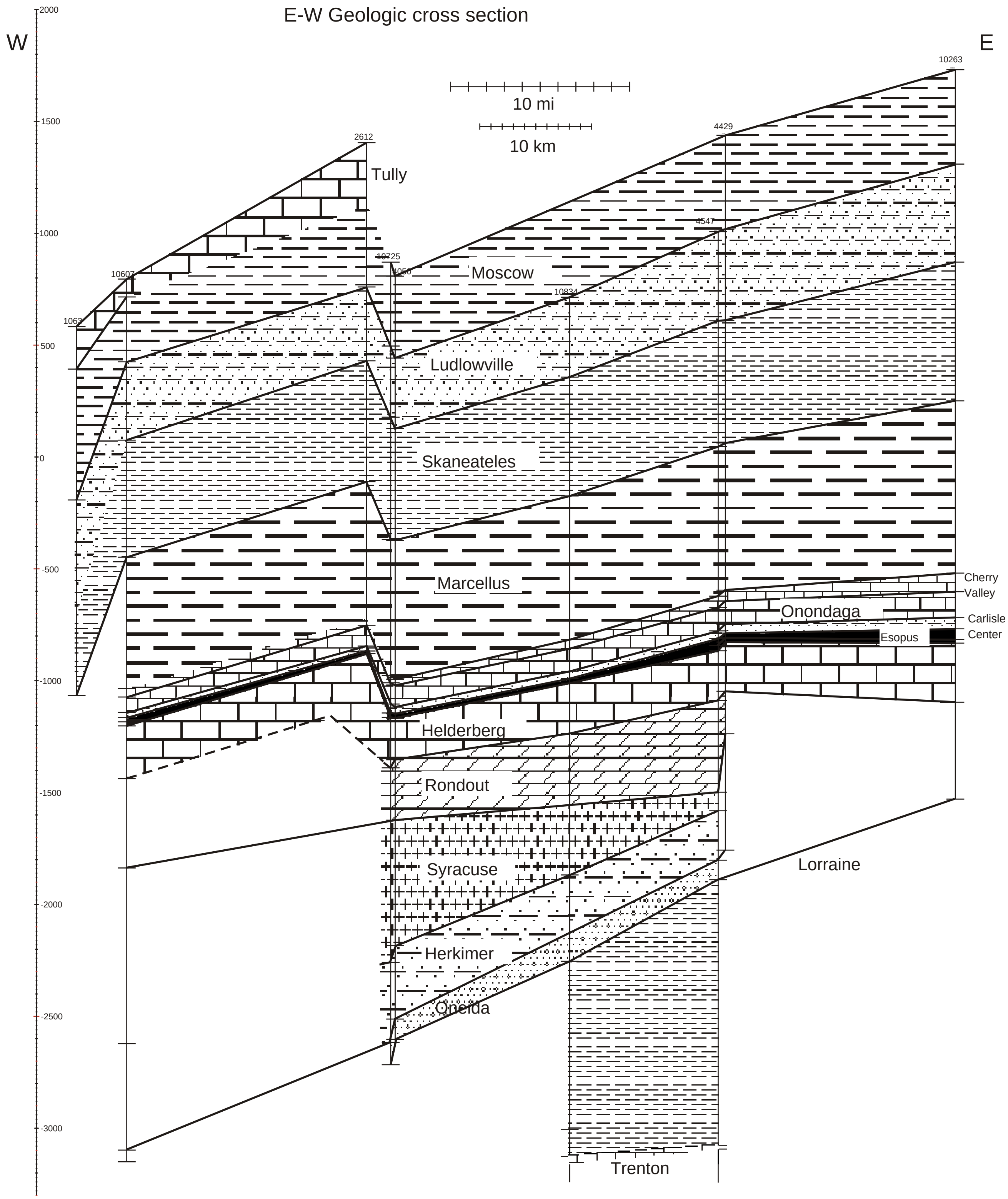
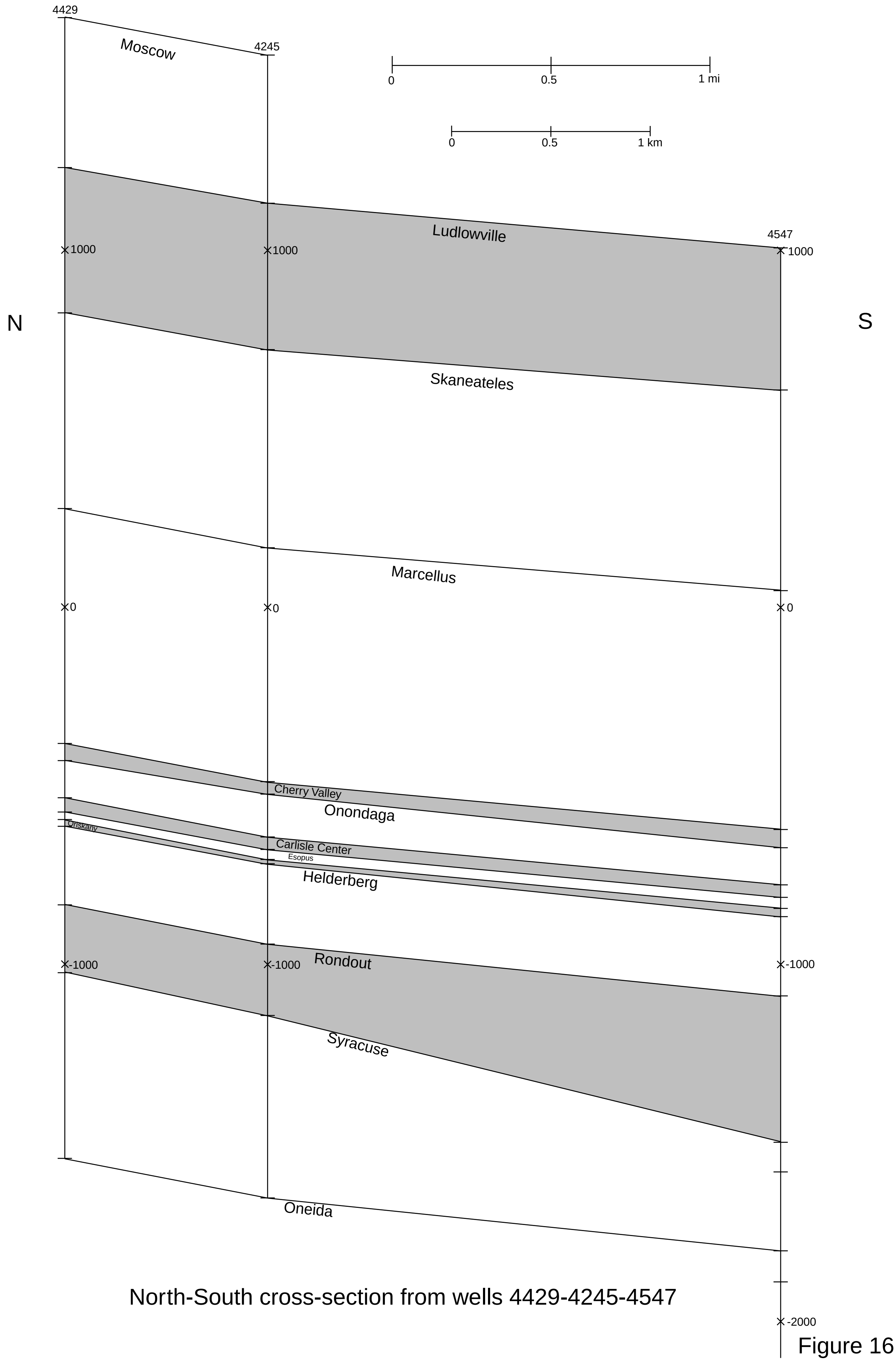

E-W Geologic cross section
W
E
10 mi
10 km
2000
1500
1000
500
0
-500
-1000
-1500
-2000
-2500
-3000
2612
10263
4429
4547
10725
10607
1062
10834
Tully
Moscow
Ludlowville
Skaneateles
Marcellus
Cherry
Valley
Onondaga
Carlisle
Center
Esopus
Helderberg
Rondout
Syracuse
Lorraine
Herkimer
Oneida
Trenton

Figure 15



North-South cross-section from wells 4429-4245-4547

Figure 16

INDEX MAP

(TOPOGRAPHIC 7.5' QUADRANGLE BASE MAPS)

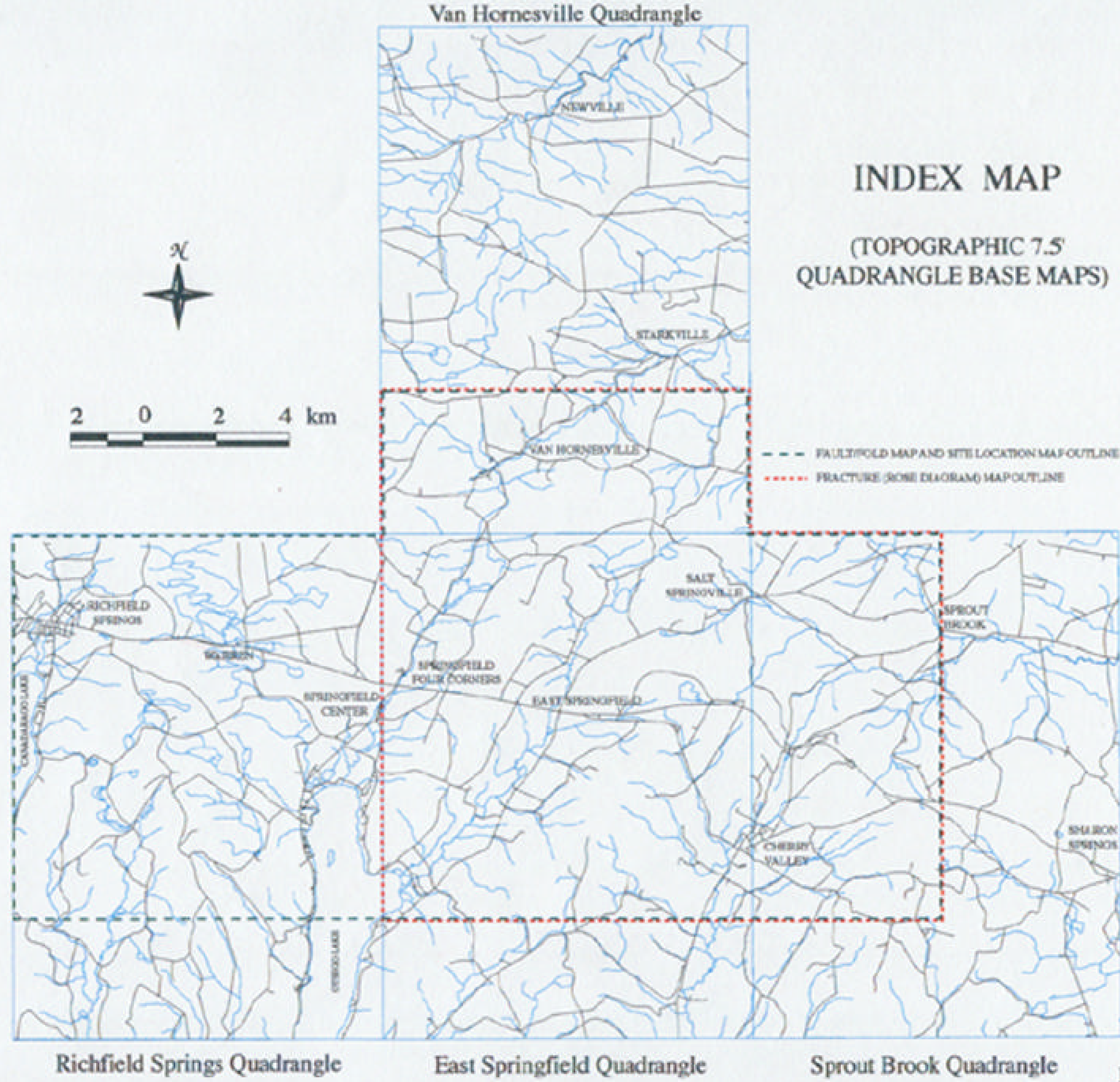


FIGURE 17

SITE LOCATIONS

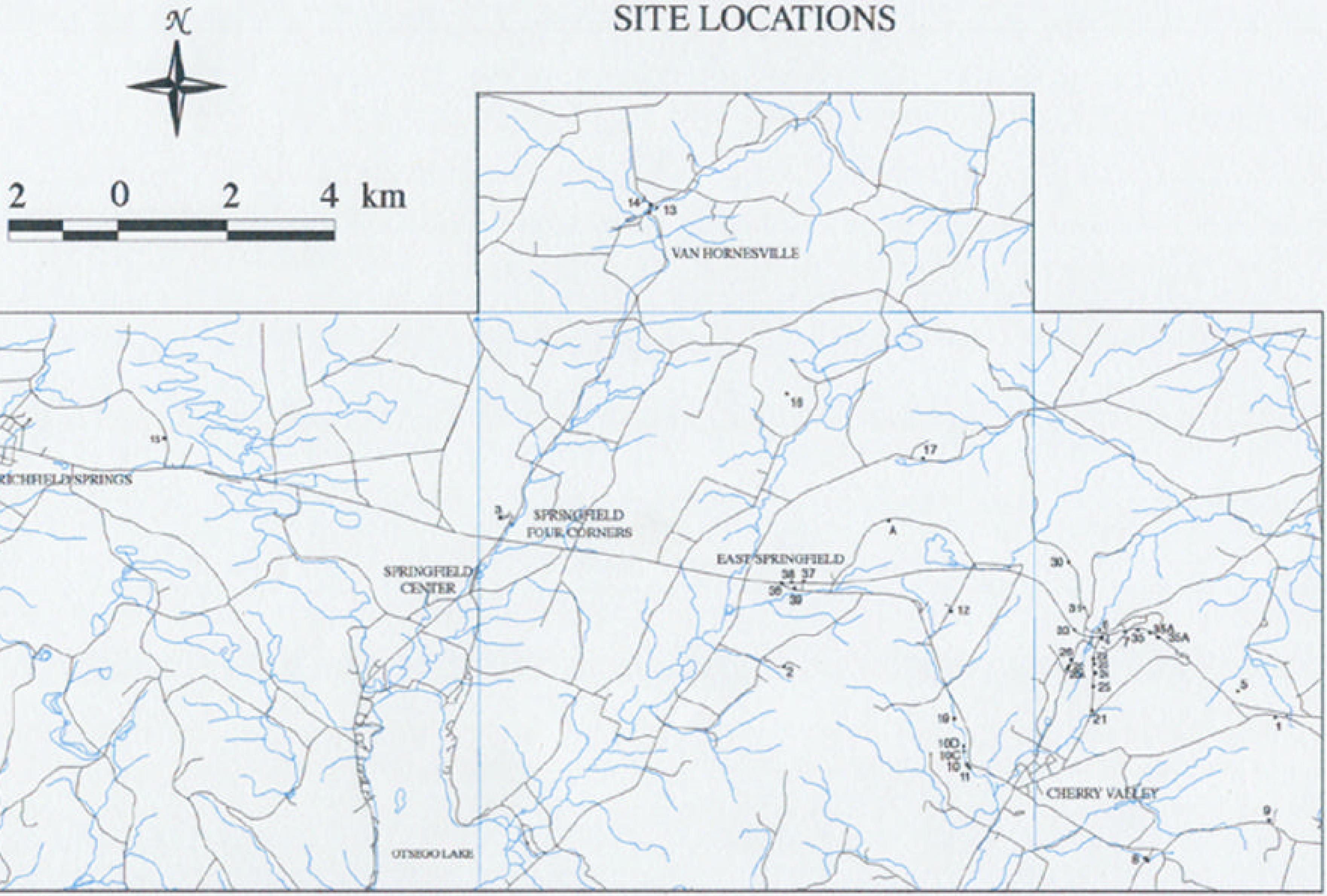


FIGURE 18

EXPLANATION FOR
MODIFIED ROSE DIAGRAMS

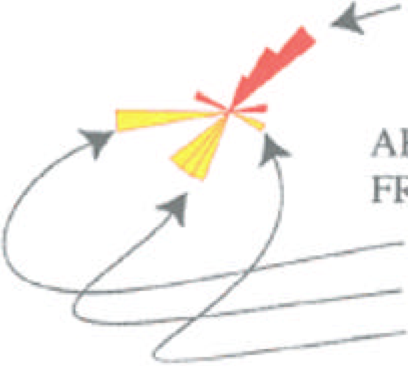


FIGURE 19

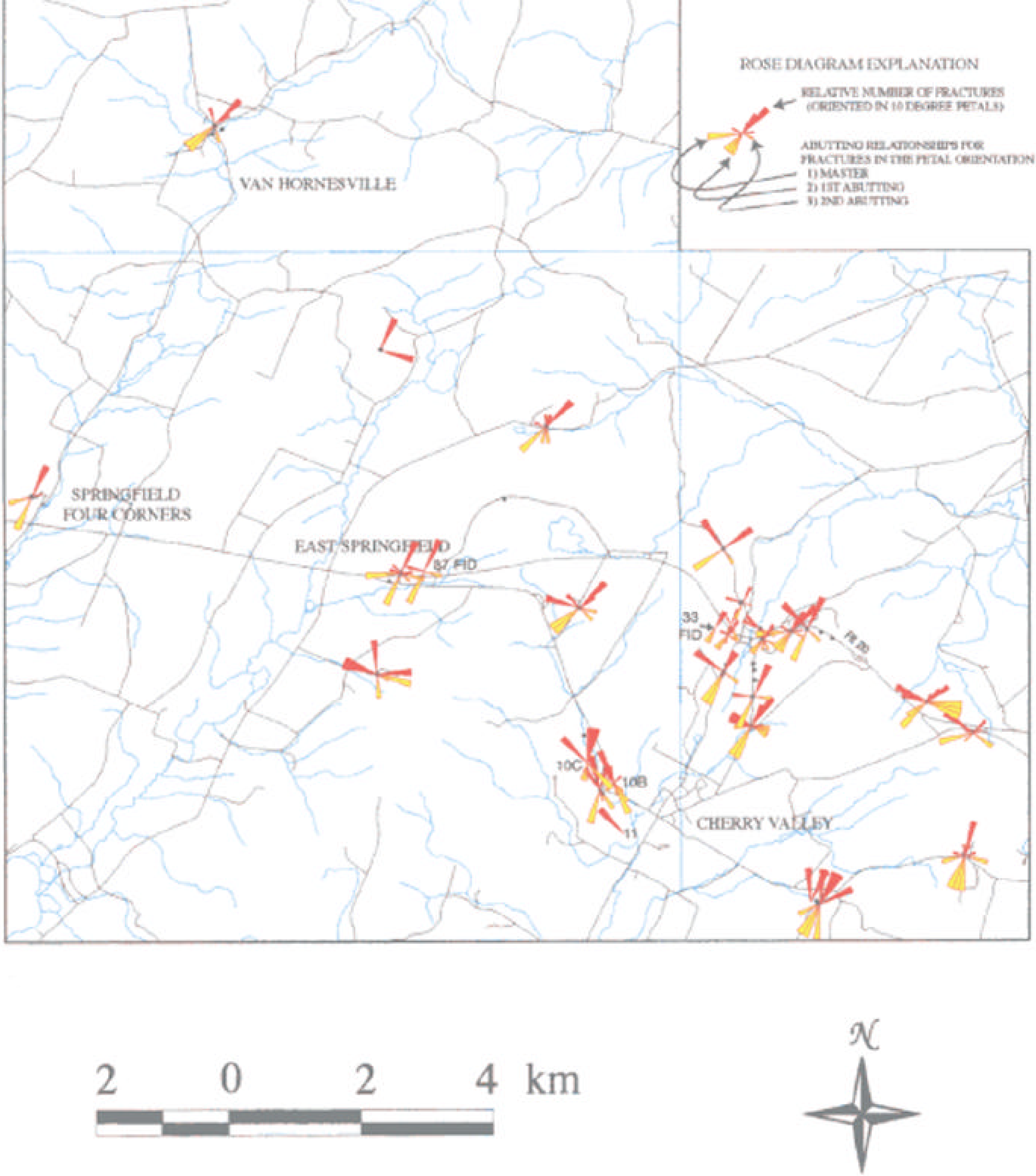

ROSE DIAGRAM EXPLANATION
RELATIVE NUMBER OF FRACTURES (ORIENTED IN 10 DEGREE PETALS)
ABUTTING RELATIONSHIPS FOR FRACTURES IN THE PETAL ORIENTATION
1) MASTER
2) 1ST ABUTTING
3) 2ND ABUTTING
VAN HORNESVILLE
SPRINGFIELD FOUR CORNERS
EAST SPRINGFIELD
87 FID
33 FID
10C
10B
11
CHERRY VALLEY
2 0 2 4 km
N

FIGURE 20

STRUCTURAL DOMAINS BASED ON FRACTURES

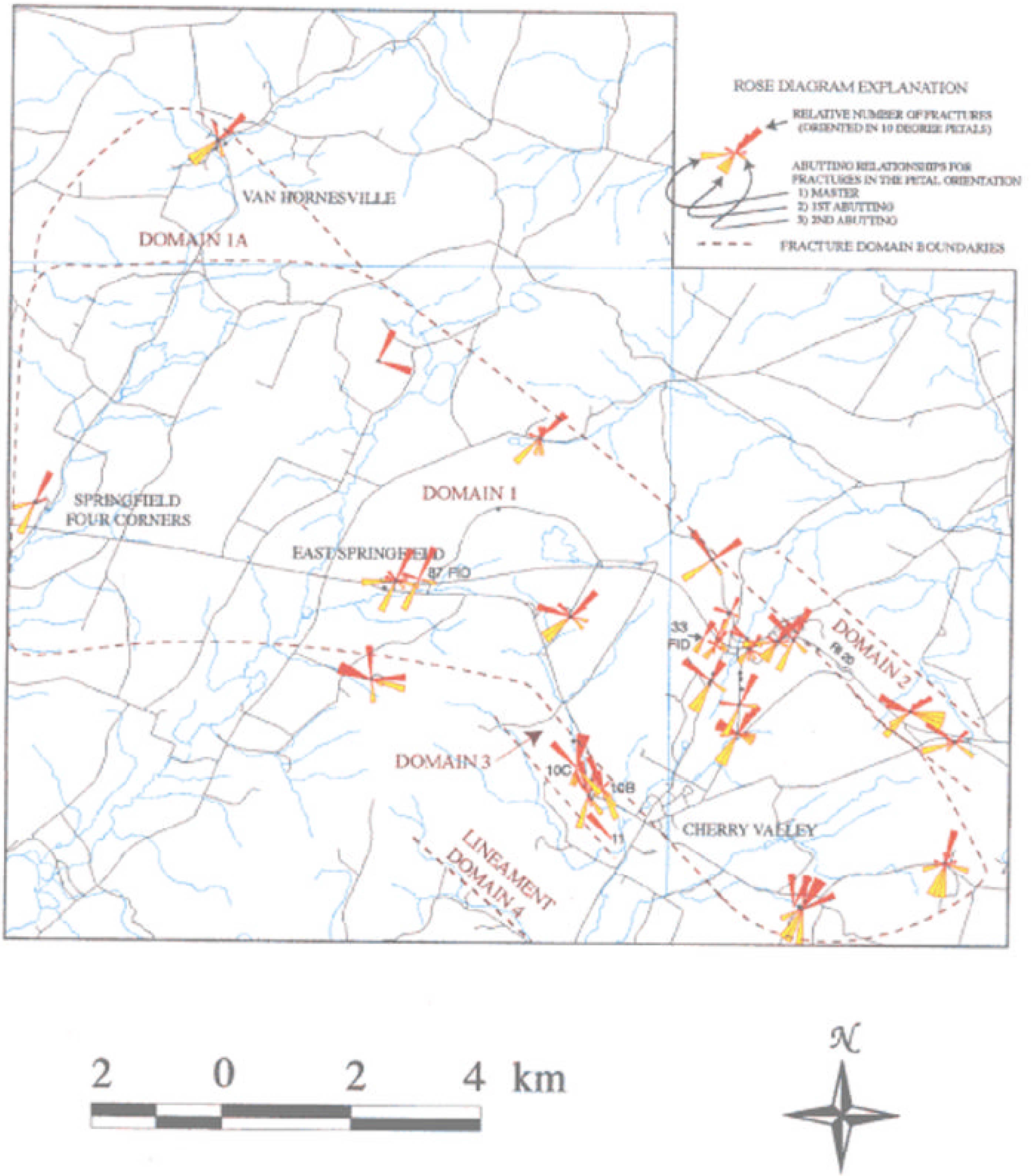


FIGURE 21

FOLDS AND FAULTS IN OUTCROP

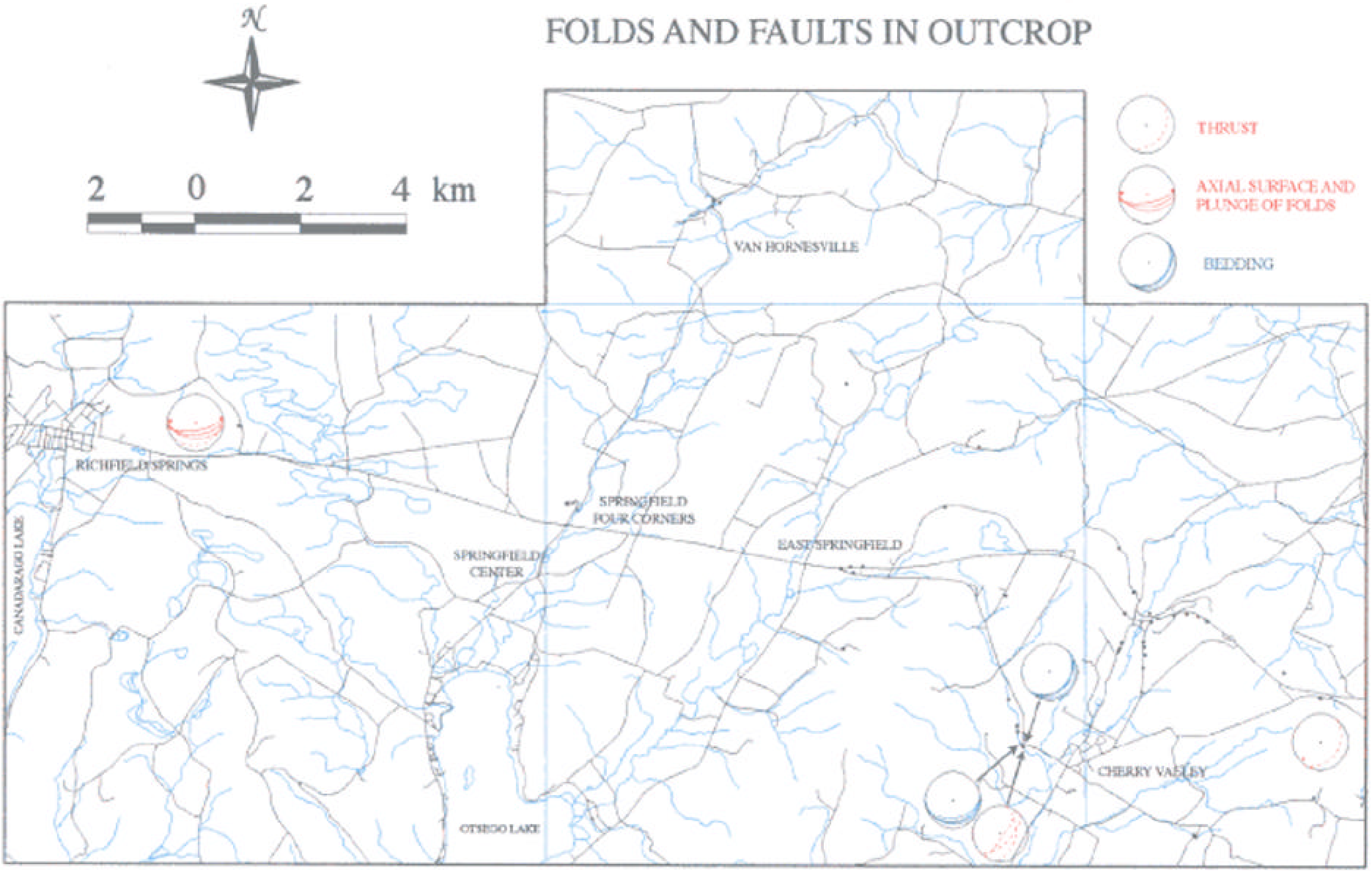


FIGURE 22

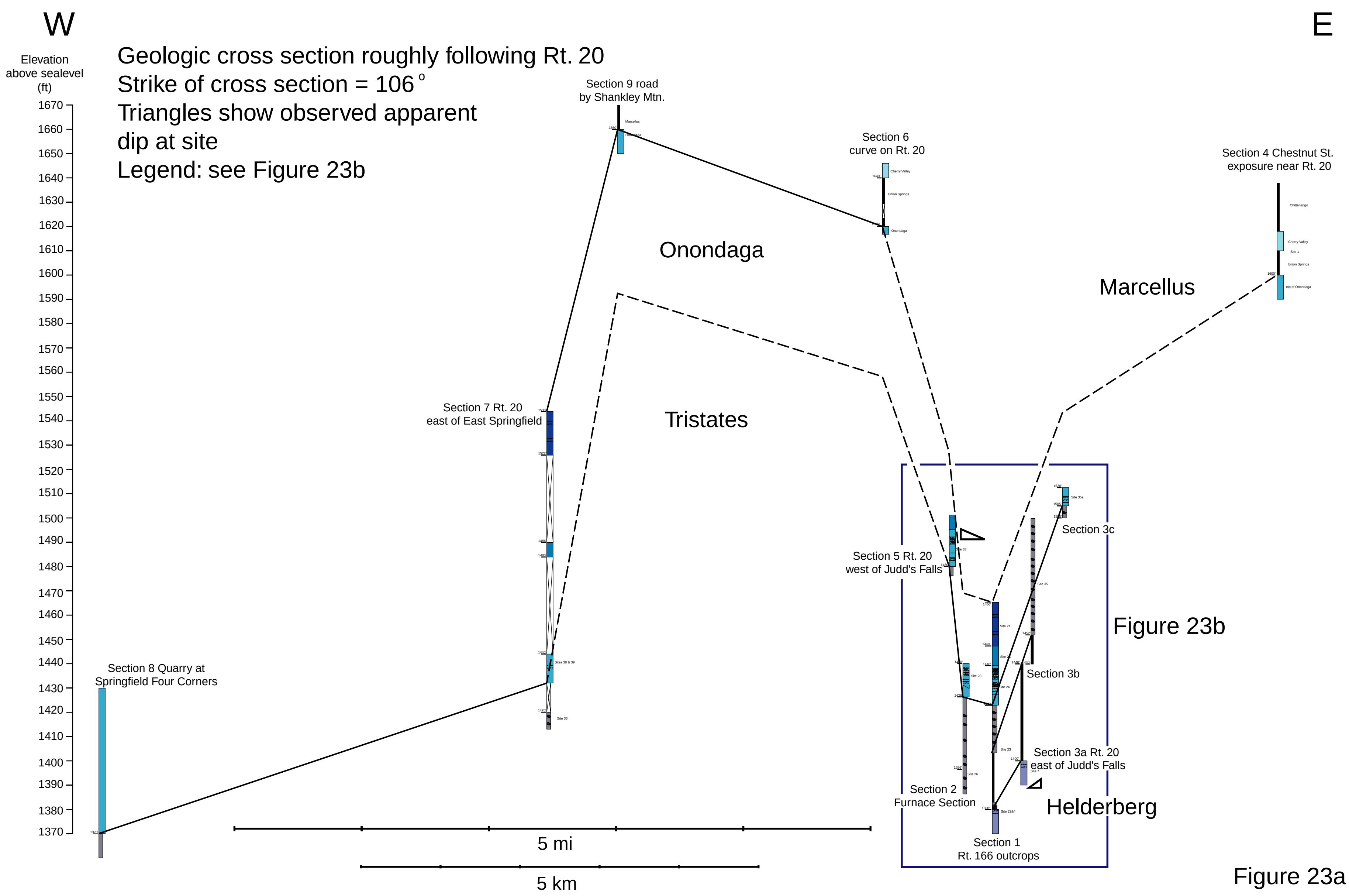

W
E
Elevation above sealevel (ft)
1670
1660
1650
1640
1630
1620
1610
1600
1590
1580
1570
1560
1550
1540
1530
1520
1510
1500
1490
1480
1470
1460
1450
1440
1430
1420
1410
1400
1390
1380
1370
Geologic cross section roughly following Rt. 20
Strike of cross section = 106 °
Triangles show observed apparent dip at site
Legend: see Figure 23b
Section 9 road by Shankley Mtn.
Section 6 curve on Rt. 20
Section 4 Chestnut St. exposure near Rt. 20
Onondaga
Marcellus
Tristates
Section 7 Rt. 20 east of East Springfield
Section 8 Quarry at Springfield Four Corners
Section 5 Rt. 20 west of Judd's Falls
Section 3c
Figure 23b
Section 3b
Section 3a Rt. 20 east of Judd's Falls
Section 2 Furnace Section
Helderberg
Section 1 Rt. 166 outcrops
5 mi
5 km

Figure 23a

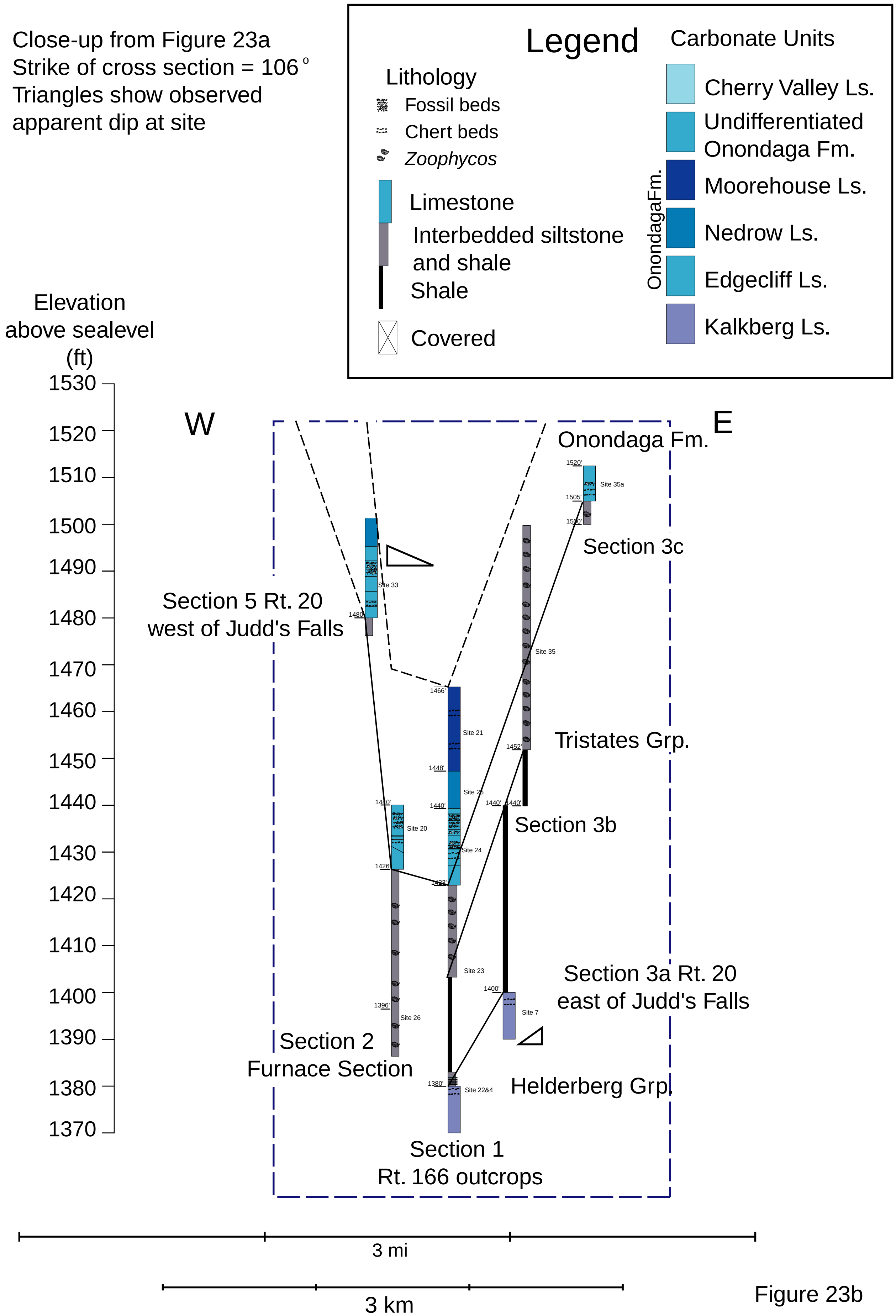

Close-up from Figure 23a
Strike of cross section = 106 °
Triangles show observed apparent dip at site
Legend
Lithology
Fossil beds
Chert beds
Zoophycos
Limestone
Interbedded siltstone and shale
Shale
Covered
Carbonate Units
Cherry Valley Ls.
Undifferentiated Onondaga Fm.
Moorehouse Ls.
Nedrow Ls.
Edgecliff Ls.
Kalkberg Ls.
OnondagaFm.
Elevation above sealevel (ft)
1530
1520
1510
1500
1490
1480
1470
1460
1450
1440
1430
1420
1410
1400
1390
1380
1370
W
E
Onondaga Fm.
Section 3c
Section 5 Rt. 20 west of Judd's Falls
Tristates Grp.
Section 3b
Section 3a Rt. 20 east of Judd's Falls
Section 2 Furnace Section
Helderberg Grp.
Section 1 Rt. 166 outcrops
3 mi
3 km

Figure 23b

MILLENIUM

FF' - SHELL-5PN-01-Sterling
FIELD POLARITY +90 DEG. 36TPI

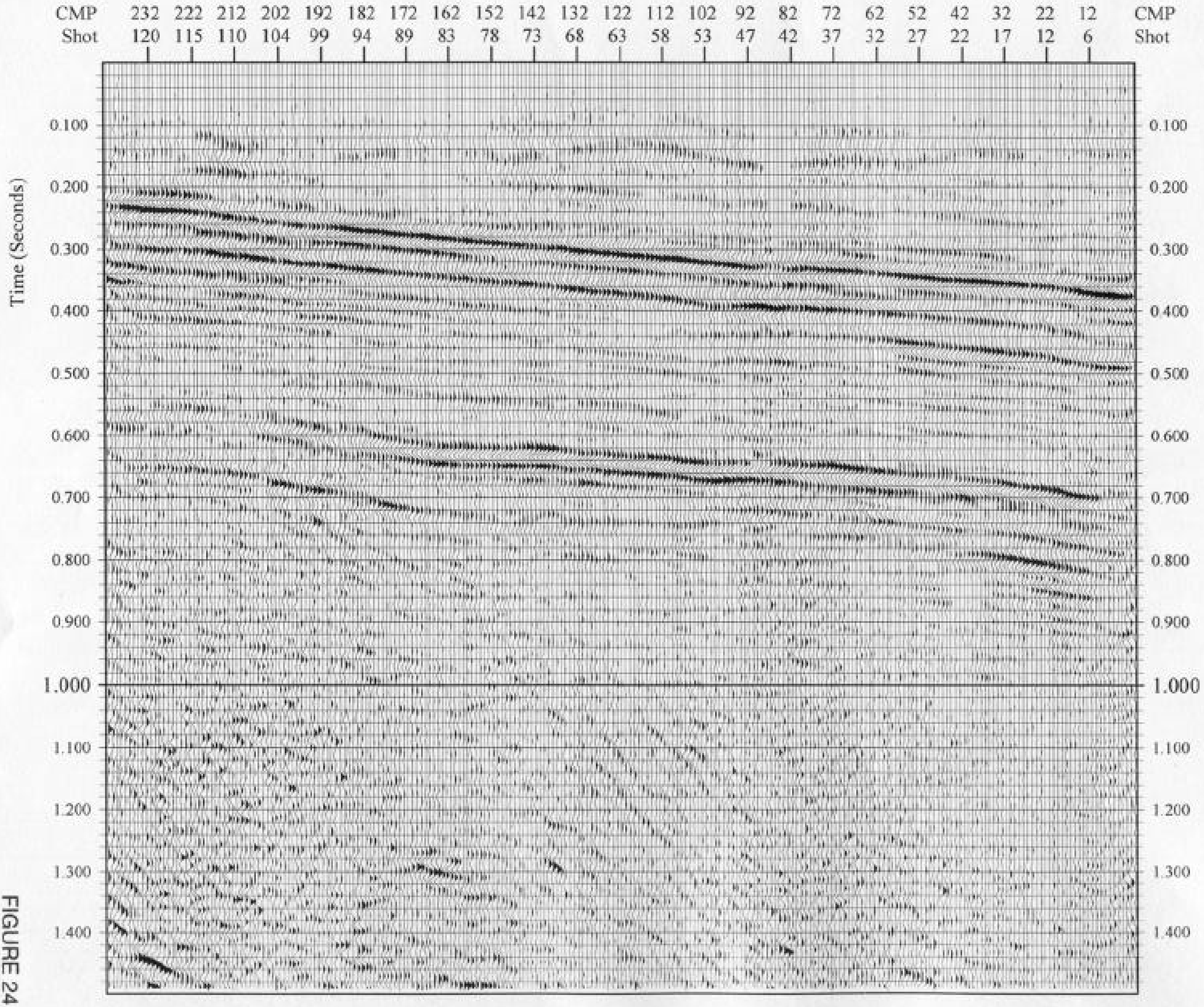


FIGURE 24

MILLENIUM

GG' - SHELL-5PN-02-Sterling
FIELD POLARITY +90 DEG. 36TPI

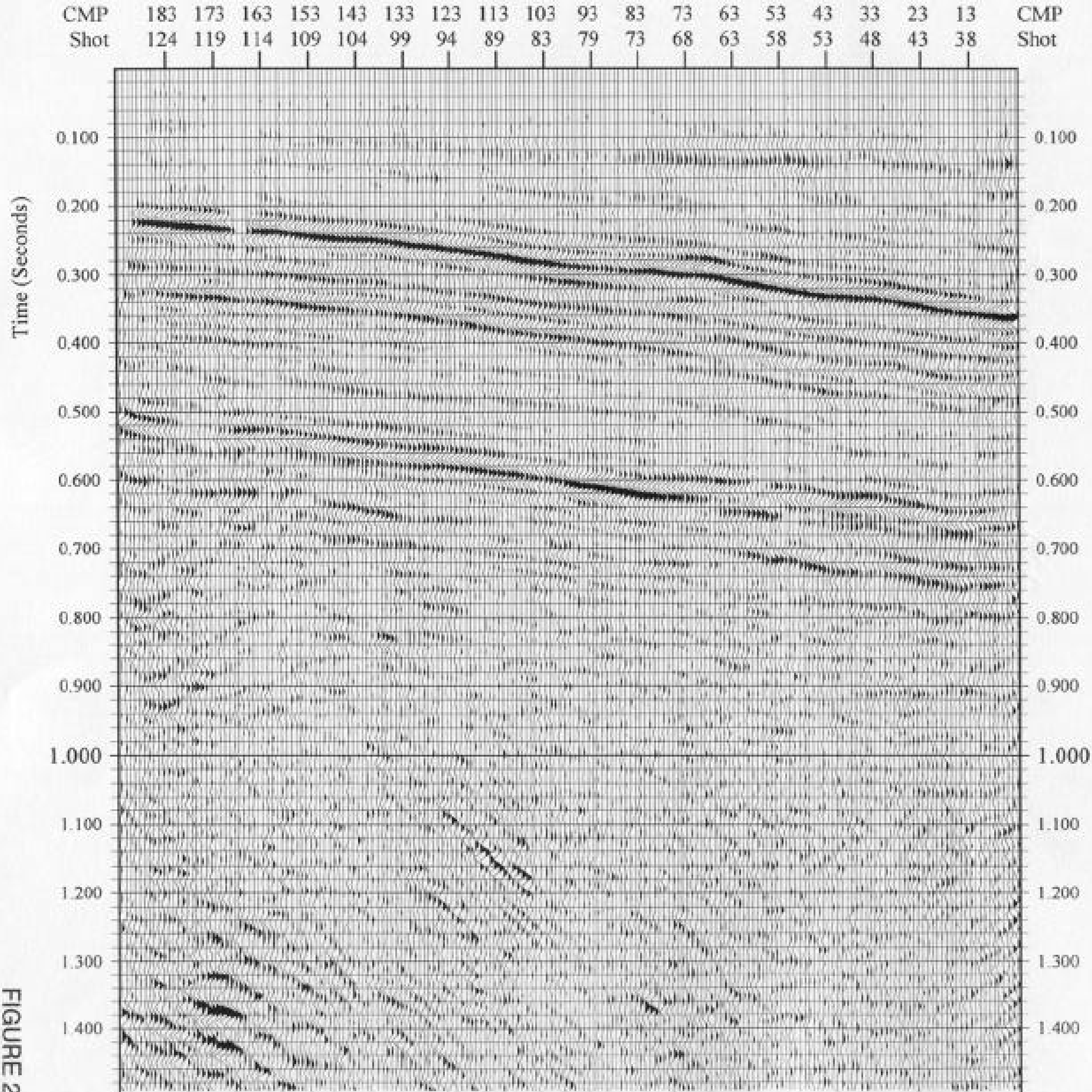


FIGURE 25

MILLENIUM

HH' - SHELL-5PN-07-Sterling

FIELD POLARITY +90 DEG. 36TPI

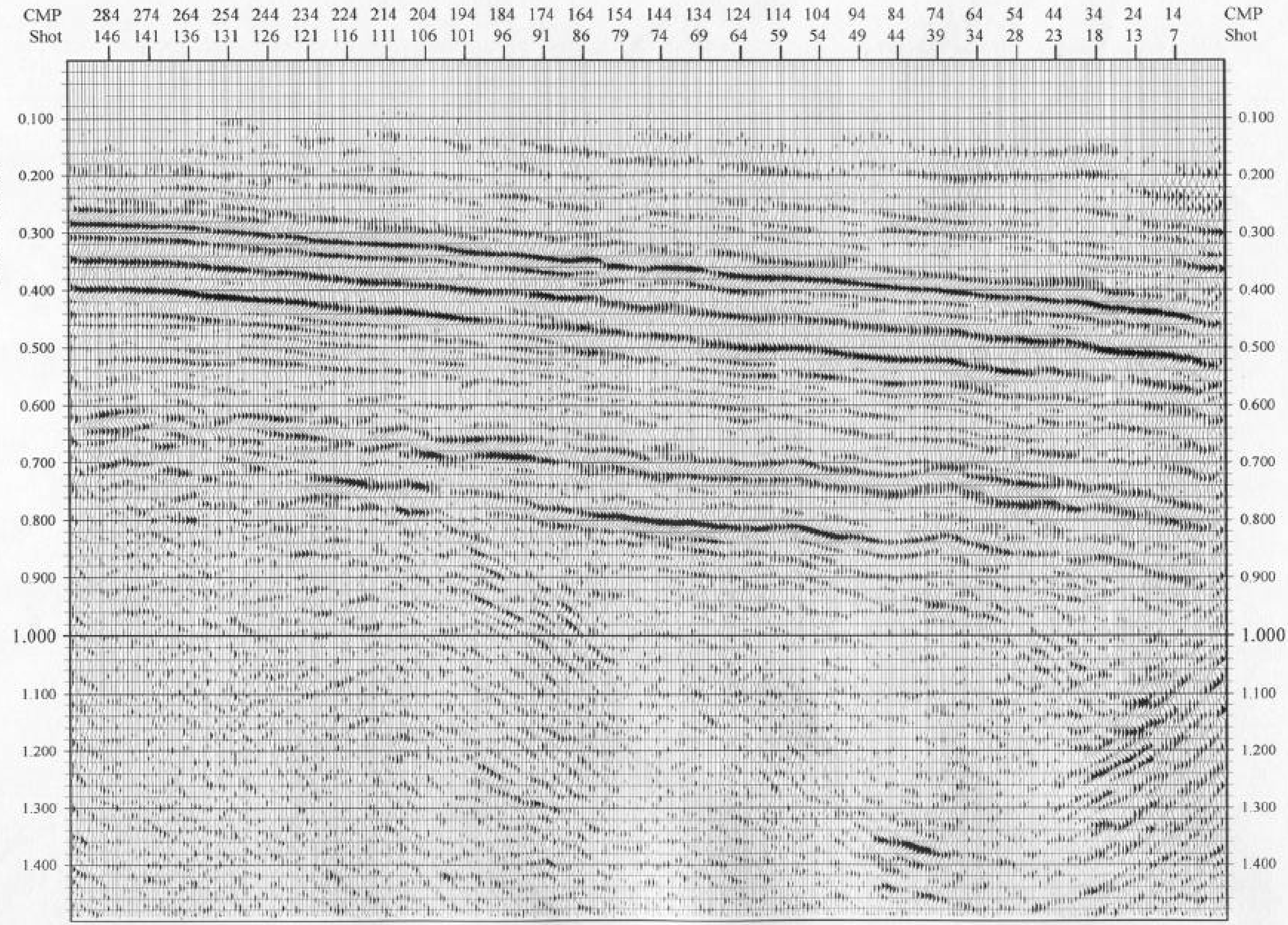
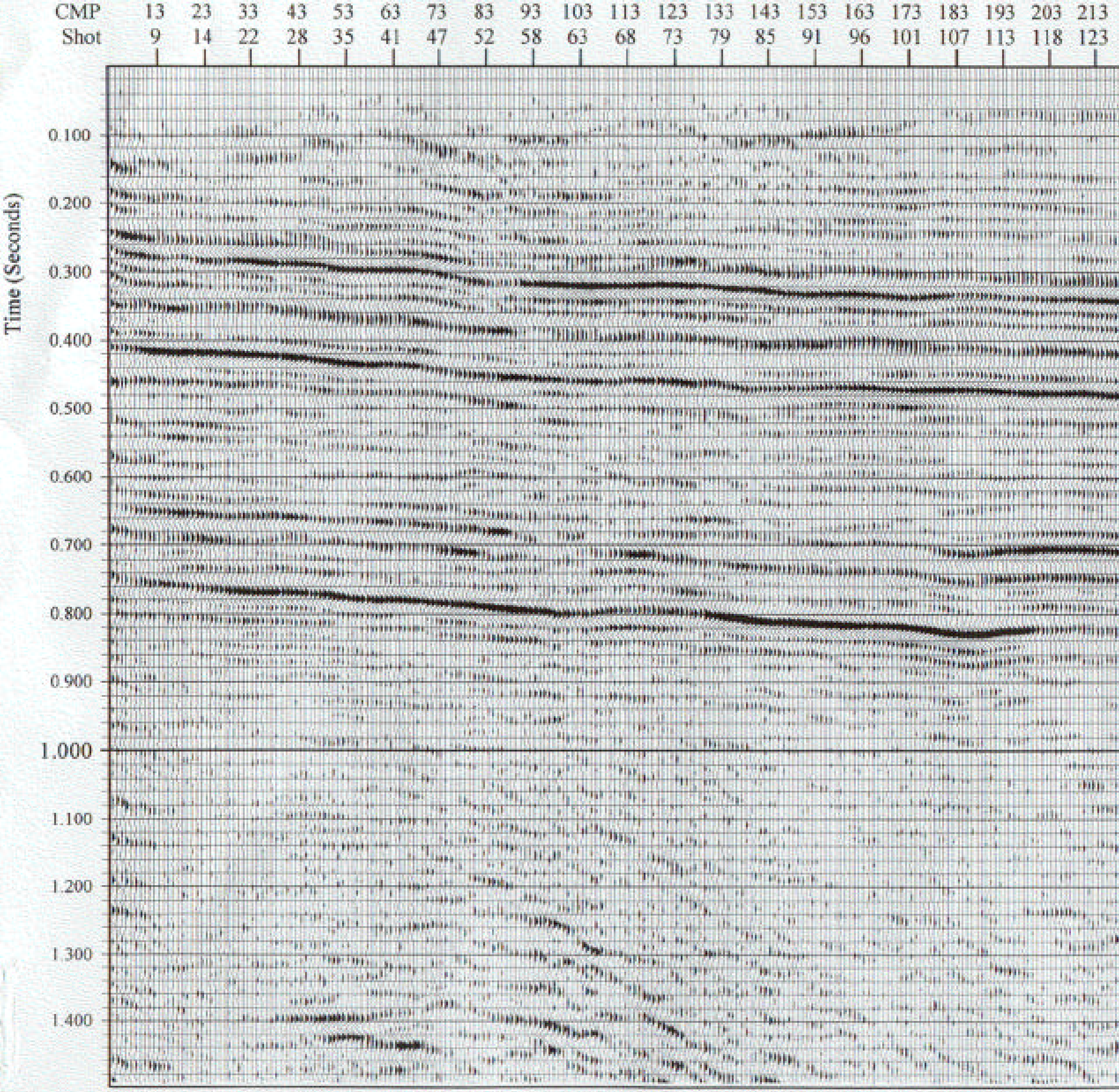
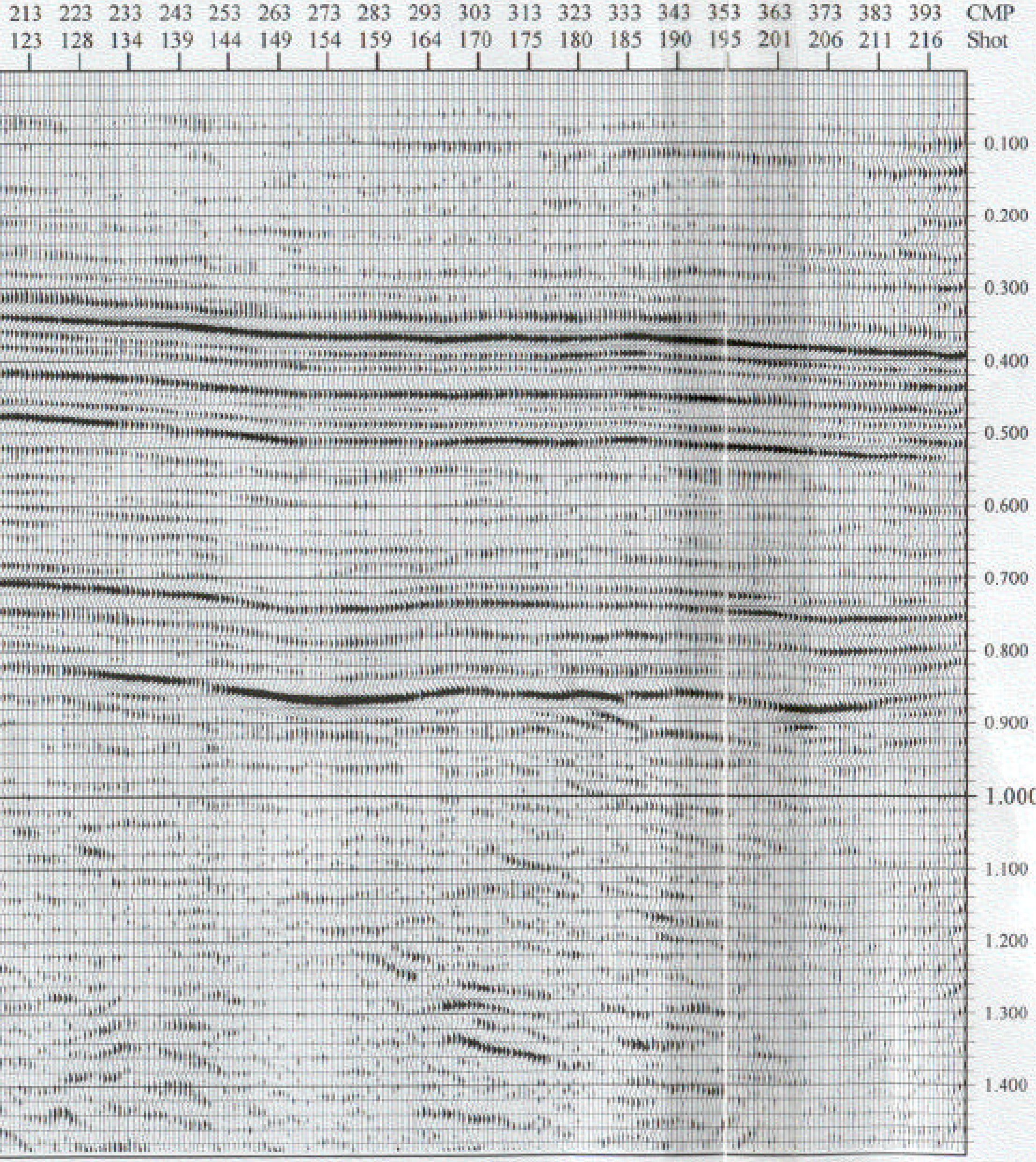


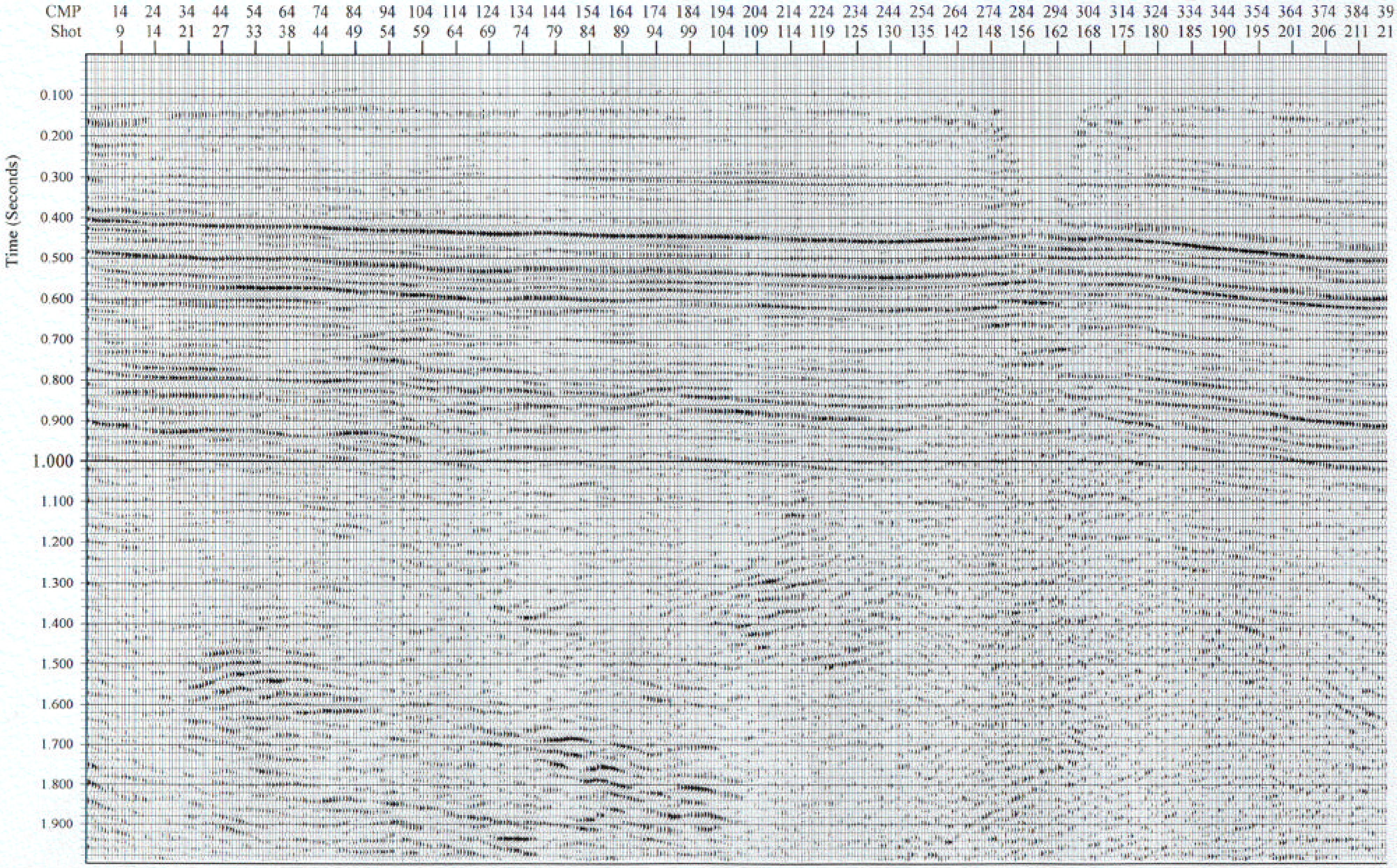
FIGURE 26

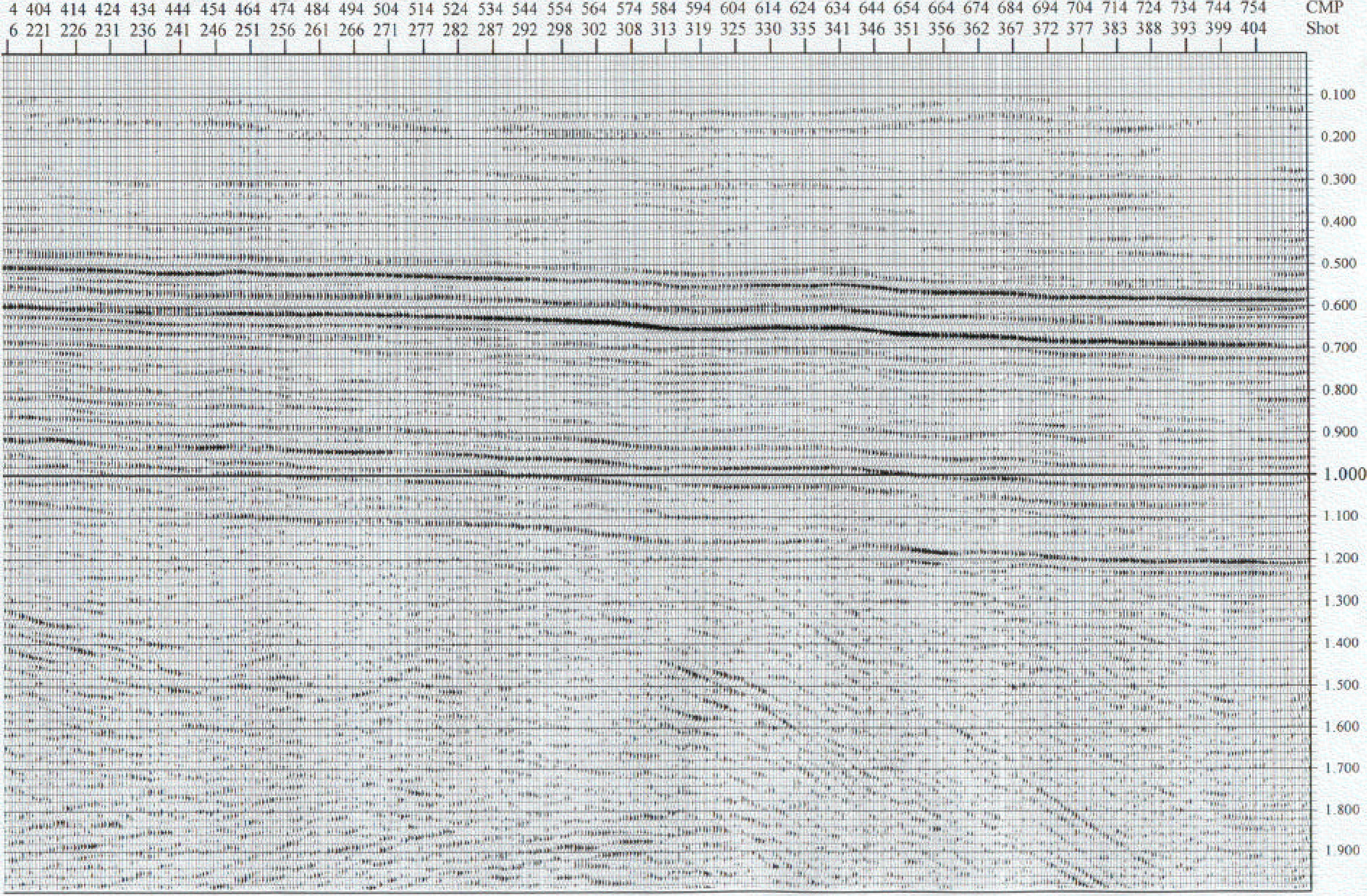
II' - SHELL-5PN-08-Sterling
FIELD POLARITY +90 DEG. 36TPI




213 223 233 243 253 263 273 283 293 303 313 323 333 343 353 363 373 383 393 CMP
123 128 134 139 144 149 154 159 164 170 175 180 185 190 195 201 206 211 216 Shot
0.100
0.200
0.300
0.400
0.500
0.600
0.700
0.800
0.900
1.000
1.100
1.200
1.300
1.400

JJ' - SHELL-5PN-09-Sterling
FIELD POLARITY +90 DEG. 40 TPI




CMP
Shot
4 404 414 424 434 444 454 464 474 484 494 504 514 524 534 544 554 564 574 584 594 604 614 624 634 644 654 664 674 684 694 704 714 724 734 744 754
6 221 226 231 236 241 246 251 256 261 266 271 277 282 287 292 298 302 308 313 319 325 330 335 341 346 351 356 362 367 372 377 383 388 393 399 404
0.100
0.200
0.300
0.400
0.500
0.600
0.700
0.800
0.900
1.000
1.100
1.200
1.300
1.400
1.500
1.600
1.700
1.800
1.900

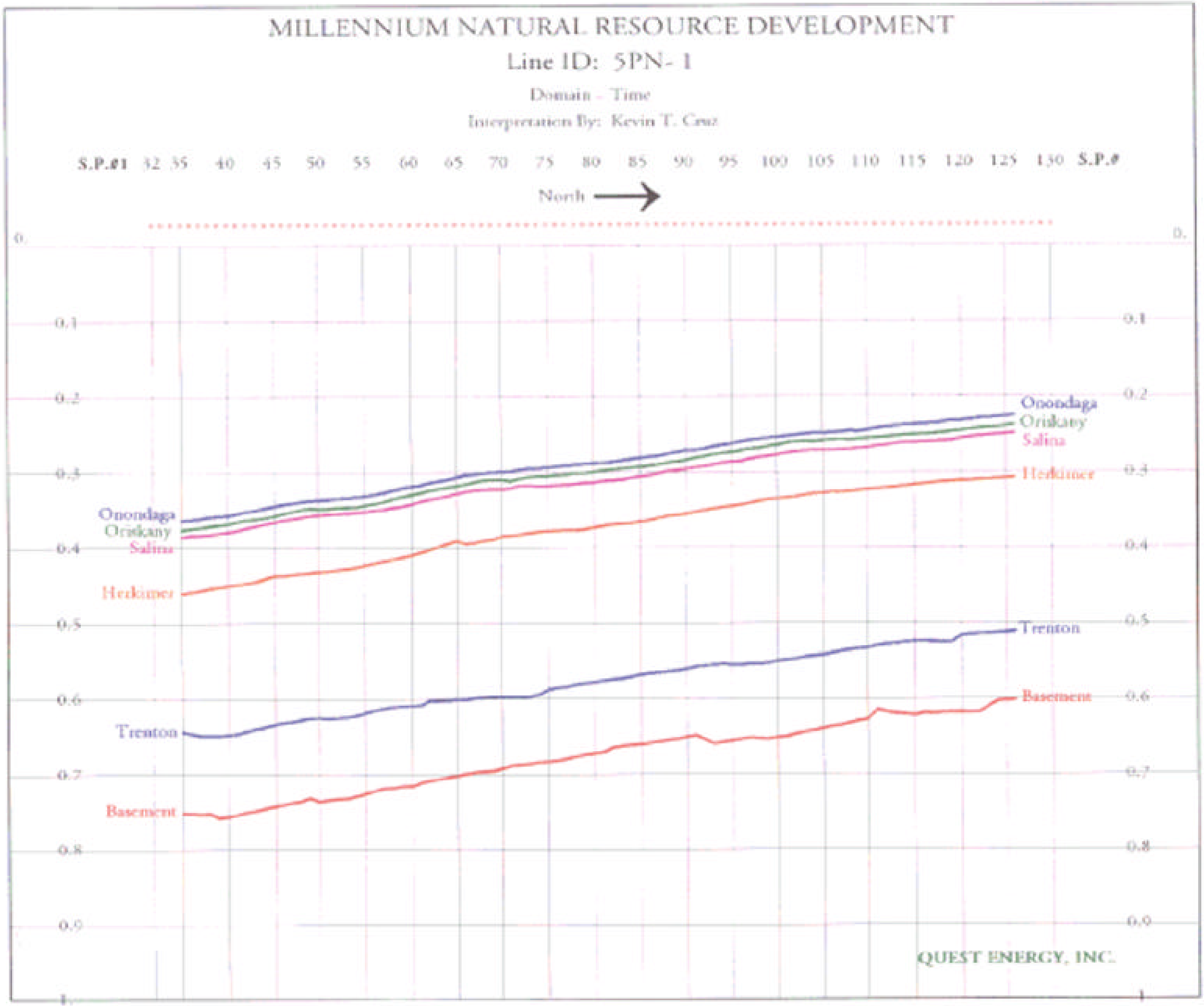

MILLENNIUM NATURAL RESOURCE DEVELOPMENT
Line ID: 5PN- 1
Domain - Time
Interpretation By: Kevin T. Cruz
S.P.#1 32 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 S.P.#
North
Onondaga
Oriskany
Salina
Herkimer
Trenton
Basement
QUEST ENERGY, INC.

Figure 29

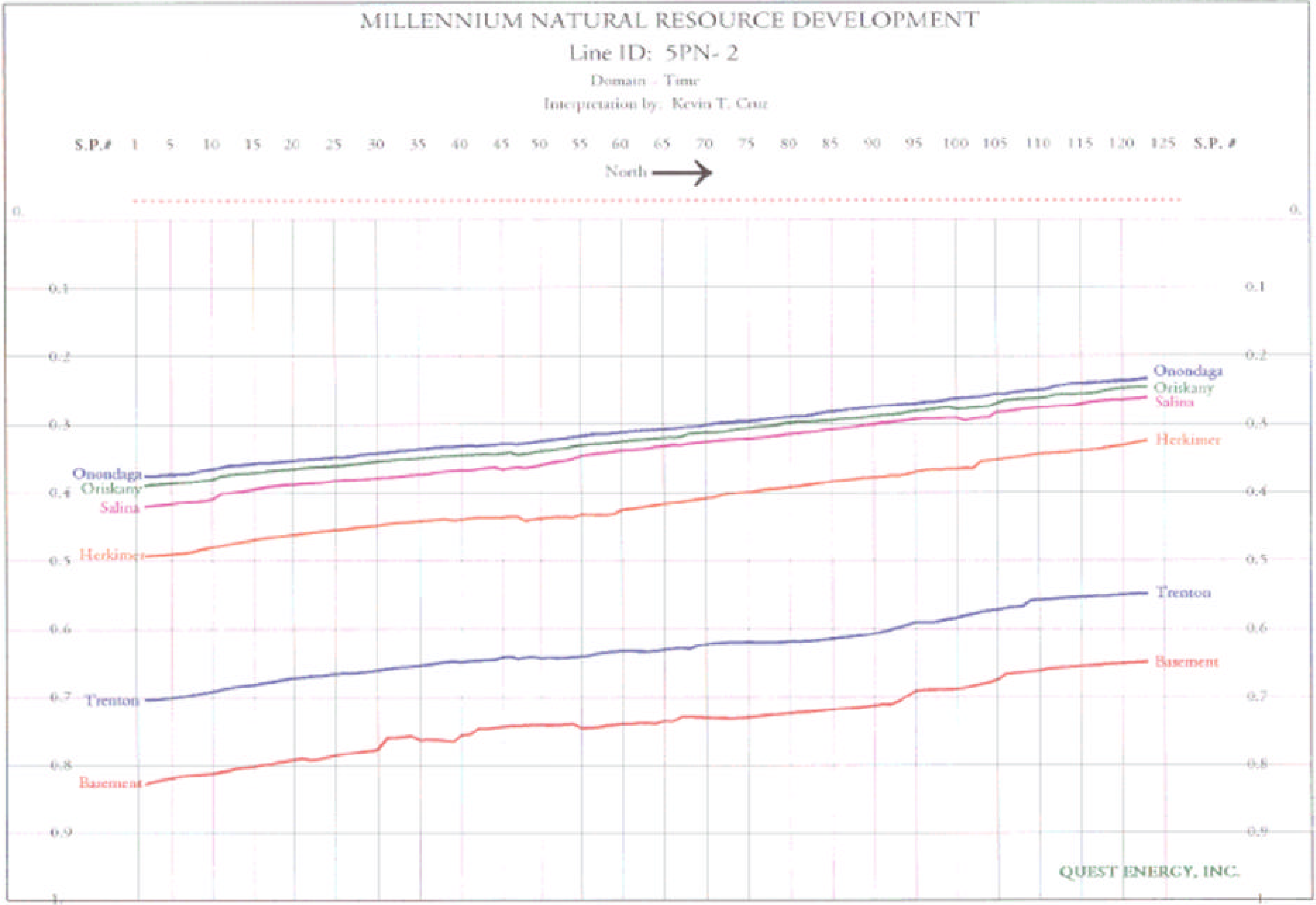

MILLENNIUM NATURAL RESOURCE DEVELOPMENT
Line ID: 5PN- 2
S.P.#
North
Onondaga
Oriskany
Salina
Herkimer
Trenton
Basement
QUEST ENERGY, INC.

Figure 30

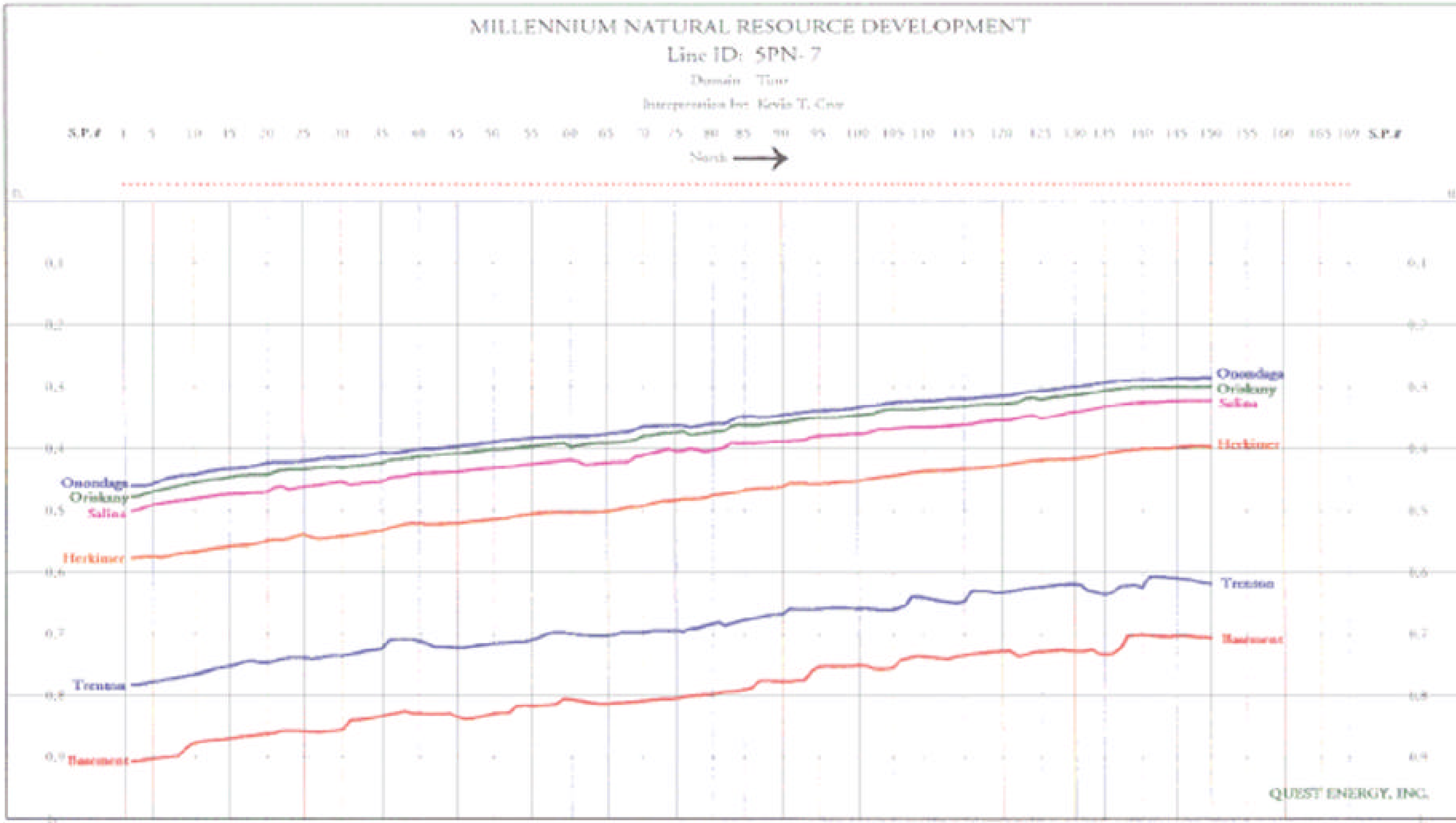

MILLENNIUM NATURAL RESOURCE DEVELOPMENT
Line ID: 5PN- 7
North
Onondaga
Oriskany
Salina
Herkimer
Trenton
Basement
QUEST ENERGY, INC.

Figure 31

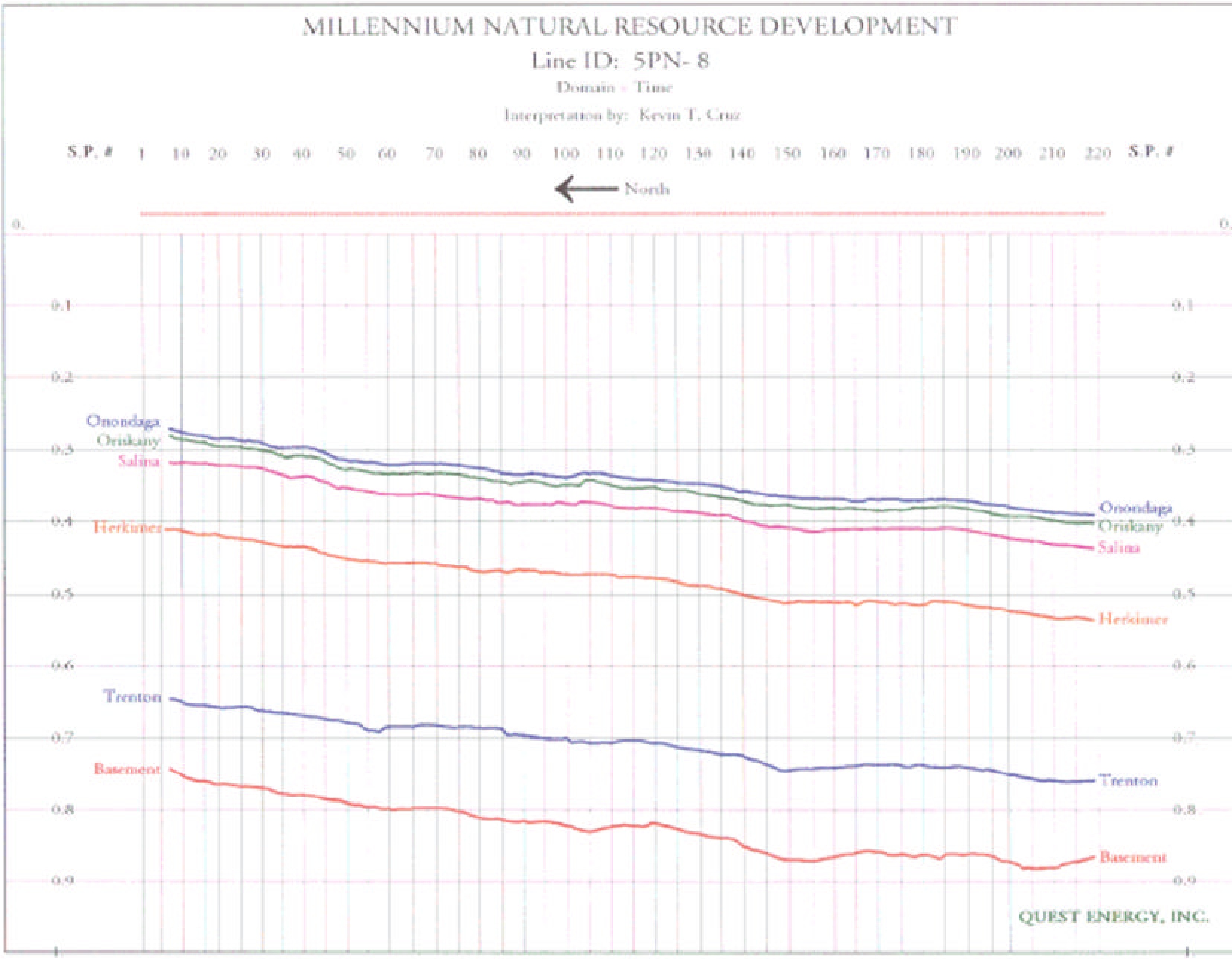

MILLENNIUM NATURAL RESOURCE DEVELOPMENT
Line ID: 5PN- 8
Domain - Time
Interpretation by: Kevin T. Cruz
S.P. # 1 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 S.P. #
North
0.
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Onondaga
Oriskany
Salina
Herkimer
Trenton
Basement
QUEST ENERGY, INC.

Figure 32

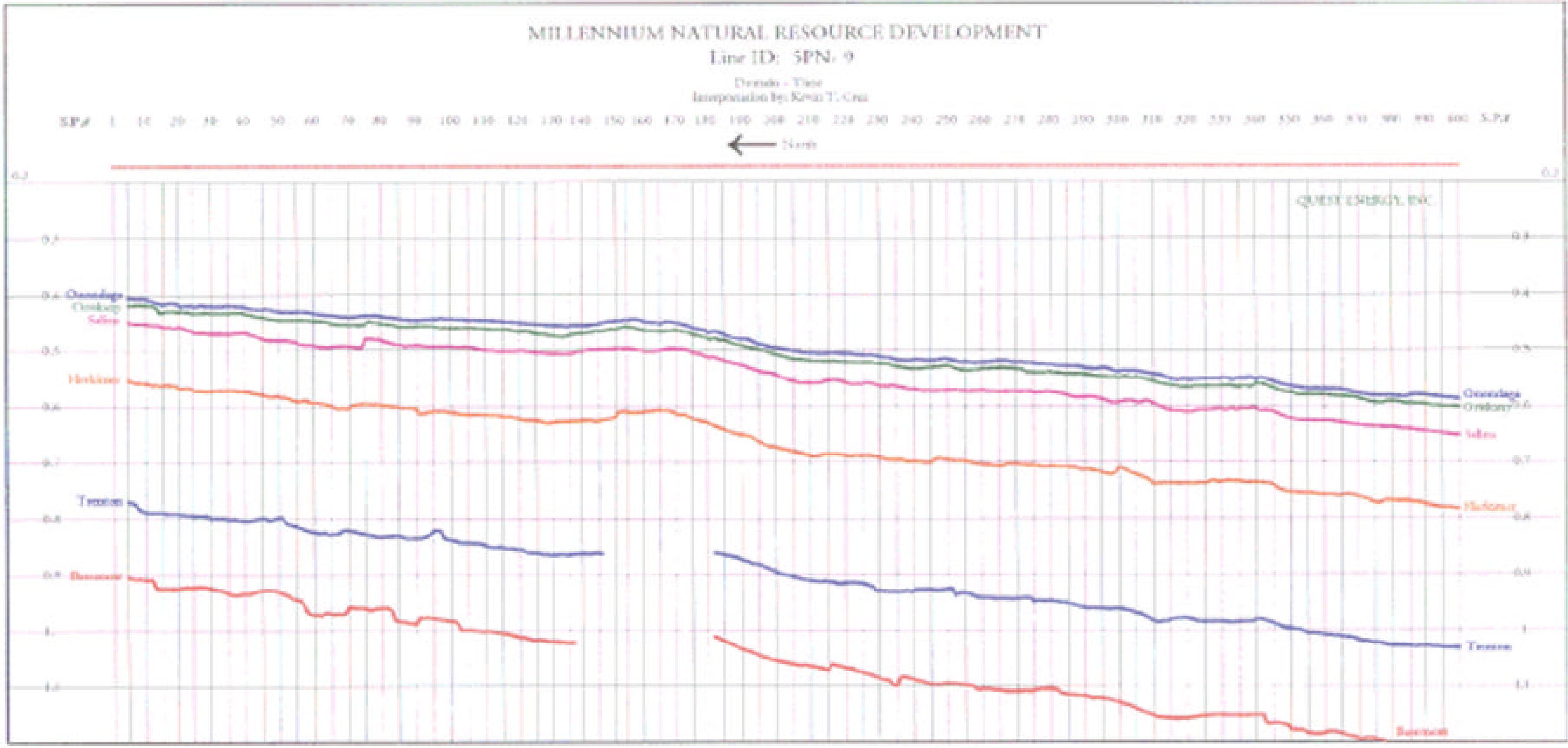
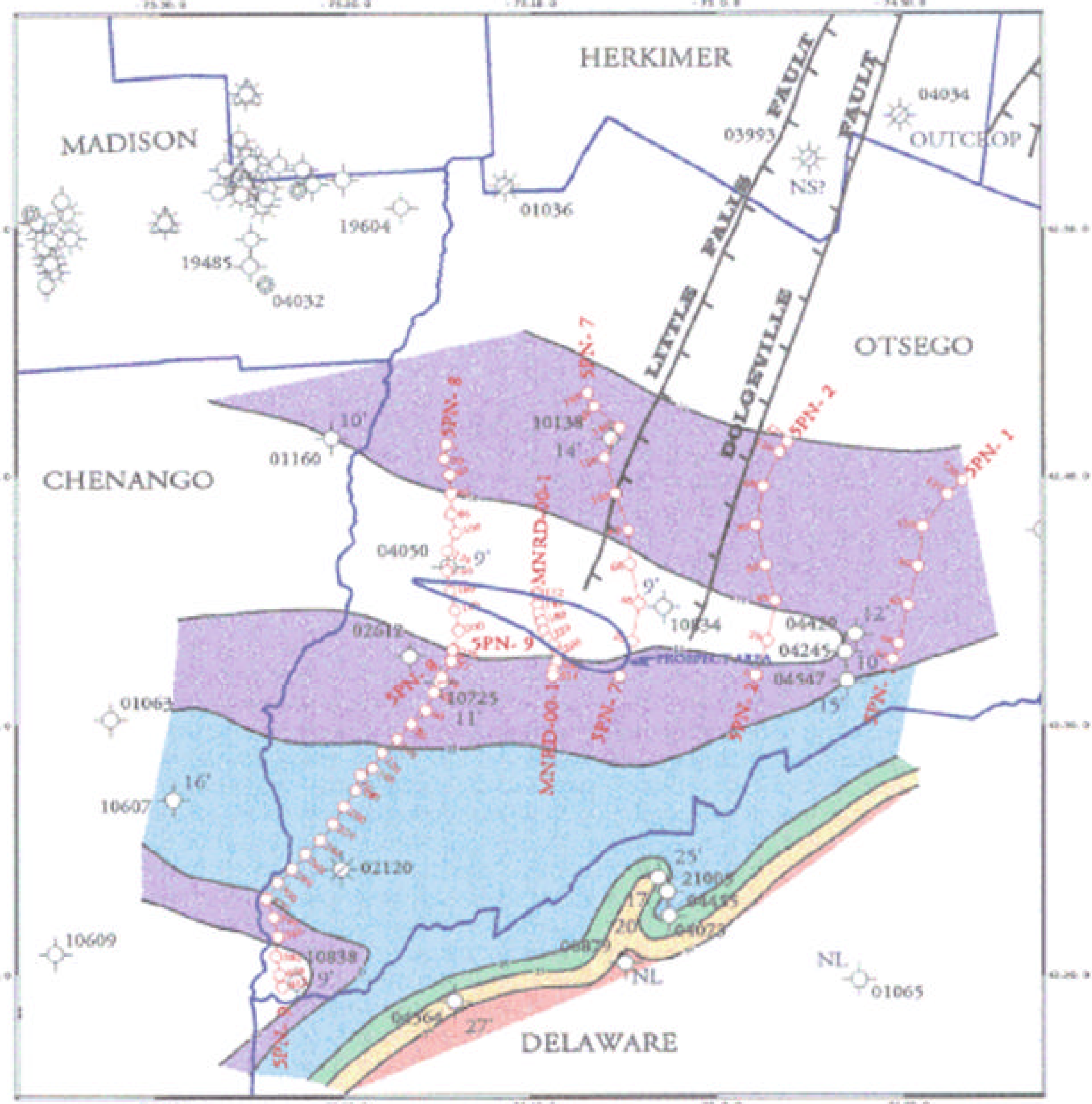

MILLENNIUM NATURAL RESOURCE DEVELOPMENT
Line ID: 5PN- 9
North
QUEST ENERGY, INC.
Onondaga
Oriskany
Salina
Herkimer
Trenton
Basement

Figure 33



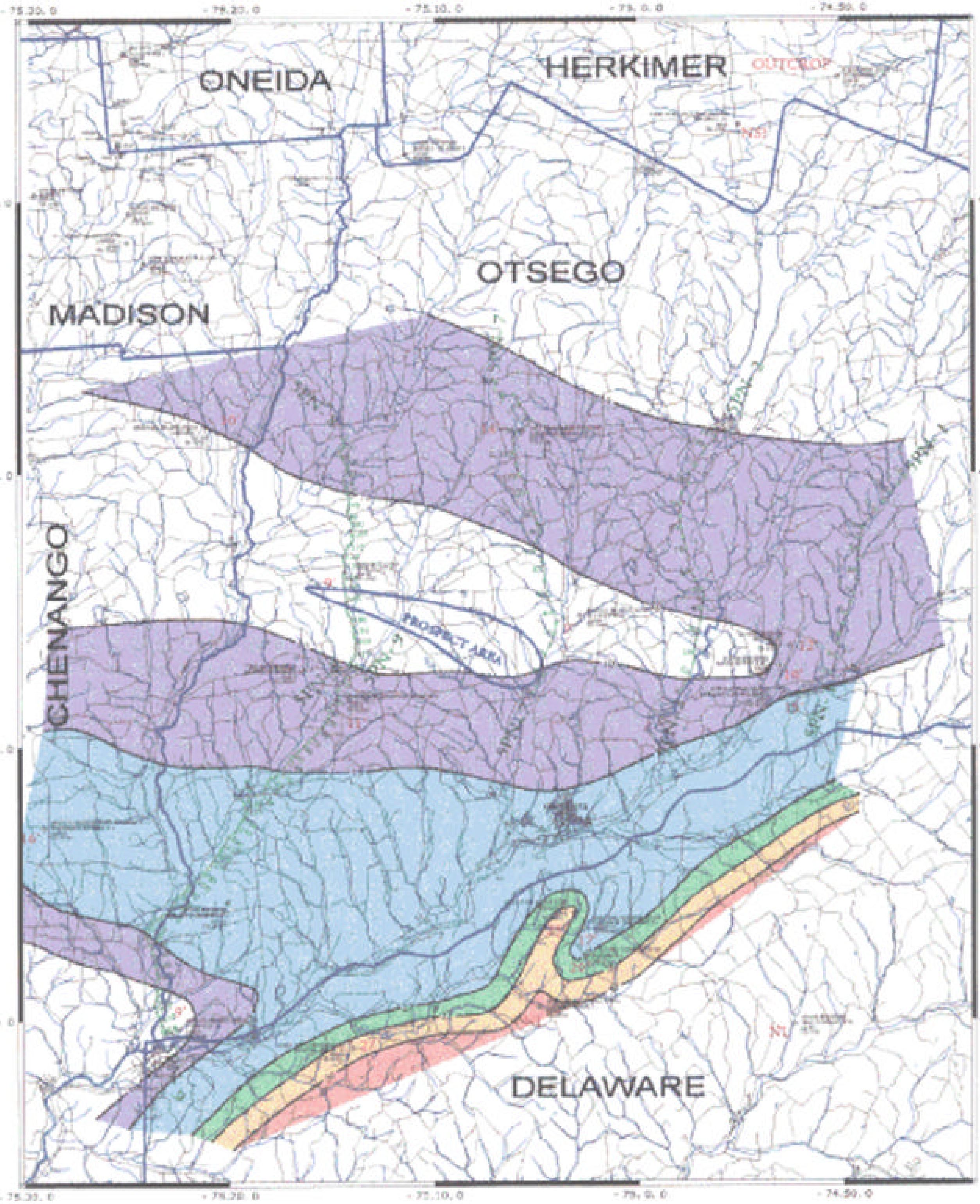
NOTE : Contouring is interpreted from available well data, seismic data, and aeromagnetic interpretation.

UTM Zone 18
Central Meridian: 75W

Scale 1:500000.

MILLENNIUM NATURAL RESOURCE DEV.		
BUTTERNUT CREEK PROSPECT OTSEGO COUNTY, NY ORISKANY THICKNESS CONTOUR		
	otsristh.gpf	
	Scale 1:500000.	Quest Energy, Inc.

Figure 34a

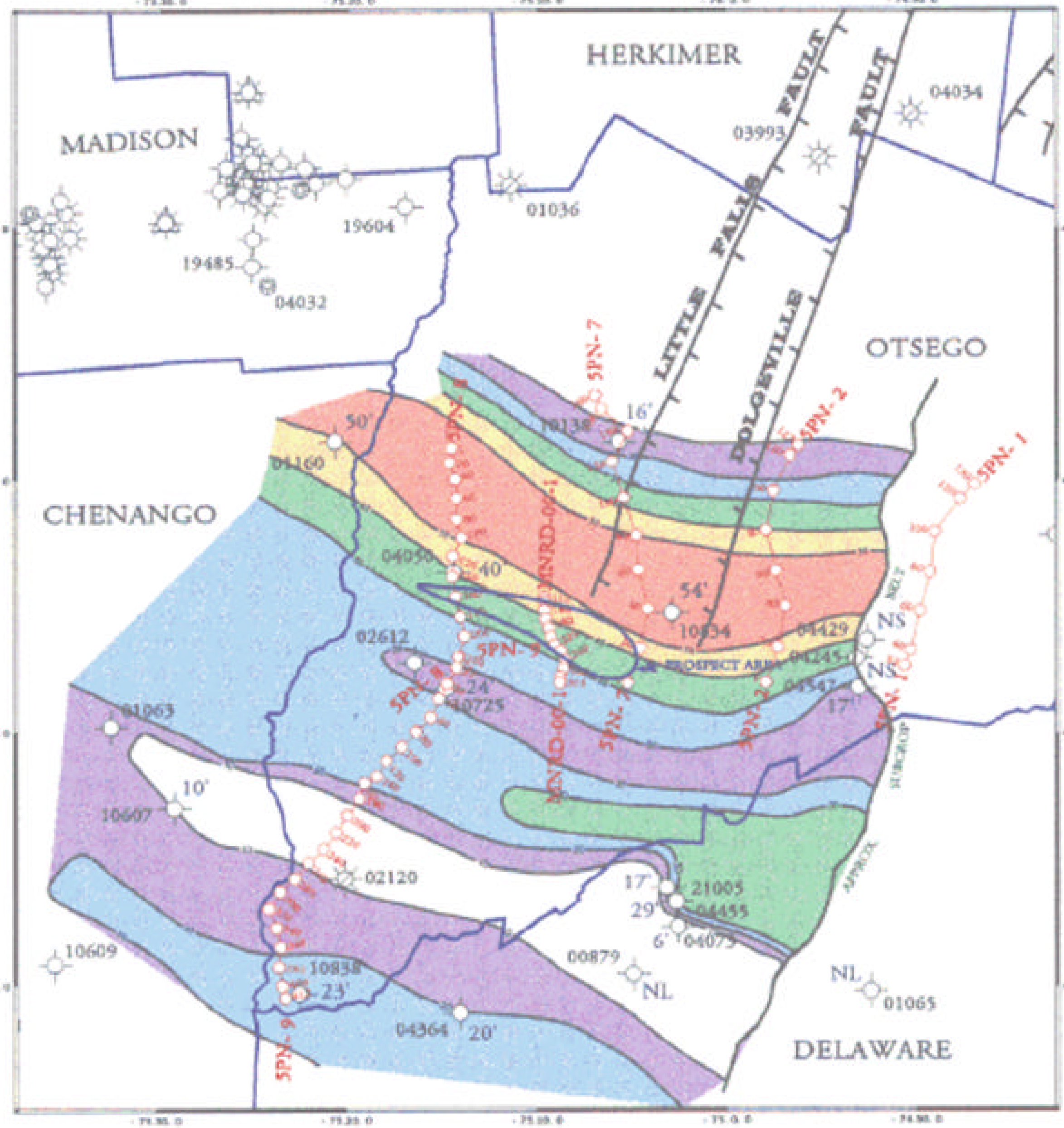


UTM Zone 18
Central Meridian: 75W
Scale 1:400000.

MILLENNIUM NATURAL RESOURCE DEV.

BUTTERNUT CREEK PROSPECT
OTSEGO COUNTY, NEW YORK
ORISKANY GROSS SAND ISOPACH

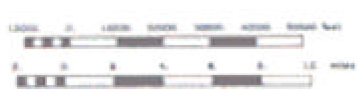
Figure 34b



NOTE : Contouring is interpreted from available well data, seismic data, and aeromagnetic interpretation.

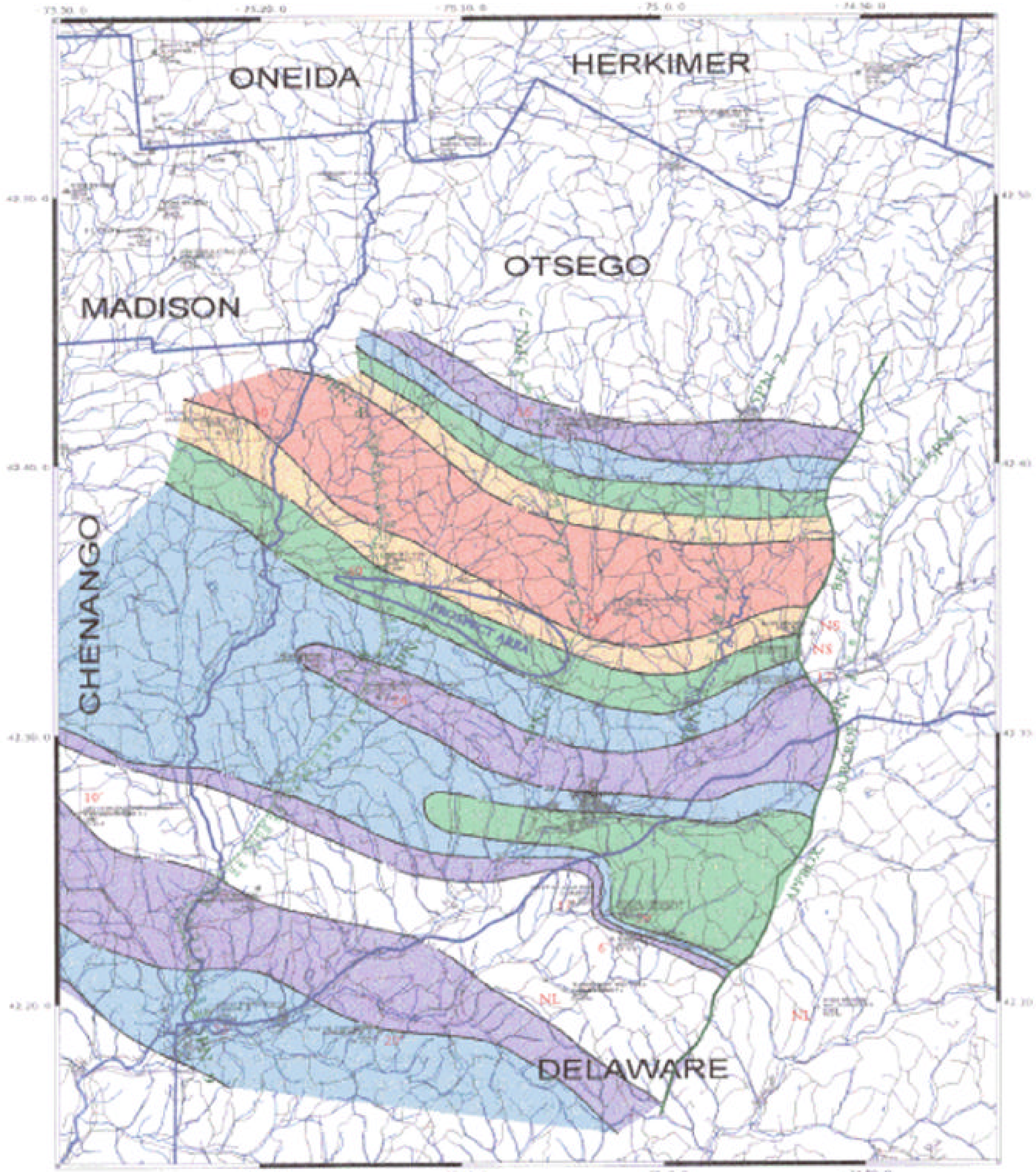
UTM Zone 18
Central Meridian: 75W

Scale 1:500000.



MILLENNIUM NATURAL RESOURCE DEV.		
BUTTERNUT CREEK PROSPECT OTSEGO COUNTY, NY HERKIMER SAND THICKNESS CONTOUR		
	dherth.gpf	
	Scale 1:500000.	Quest Energy, Inc.

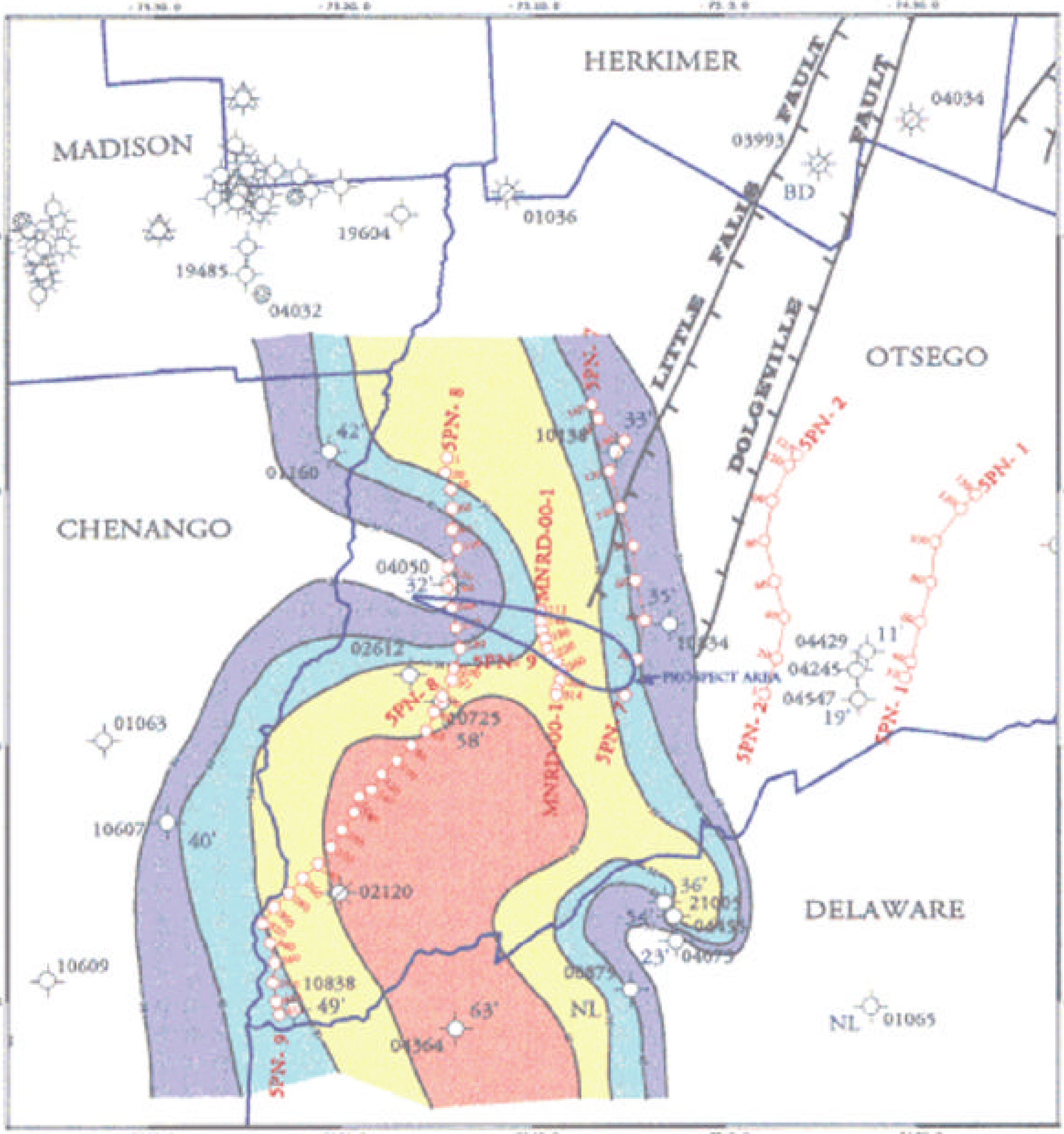
Figure 35a



MILLENNIUM NATURAL RESOURCE DEV.

BUTTERNUT CREEK PROSPECT
OTSEGO COUNTY, NEW YORK
HERKIMER GROSS SAND ISOPACH

Figure 35b



NOTE : Contouring is interpreted from available well data, seismic data, and aeromagnetic interpretation.

UTM Zone 18
Central Meridian: 75W

Scale 1:500000.

MILLENNIUM NATURAL RESOURCE DEV.		
BUTTERNUT CREEK PROSPECT OTSEGO COUNTY, NY ONEIDA GROSS THICKNESS CONTOUR		
	otsnth.gpf	
	Scale 1:500000.	Quest Energy, Inc.

Figure 36a

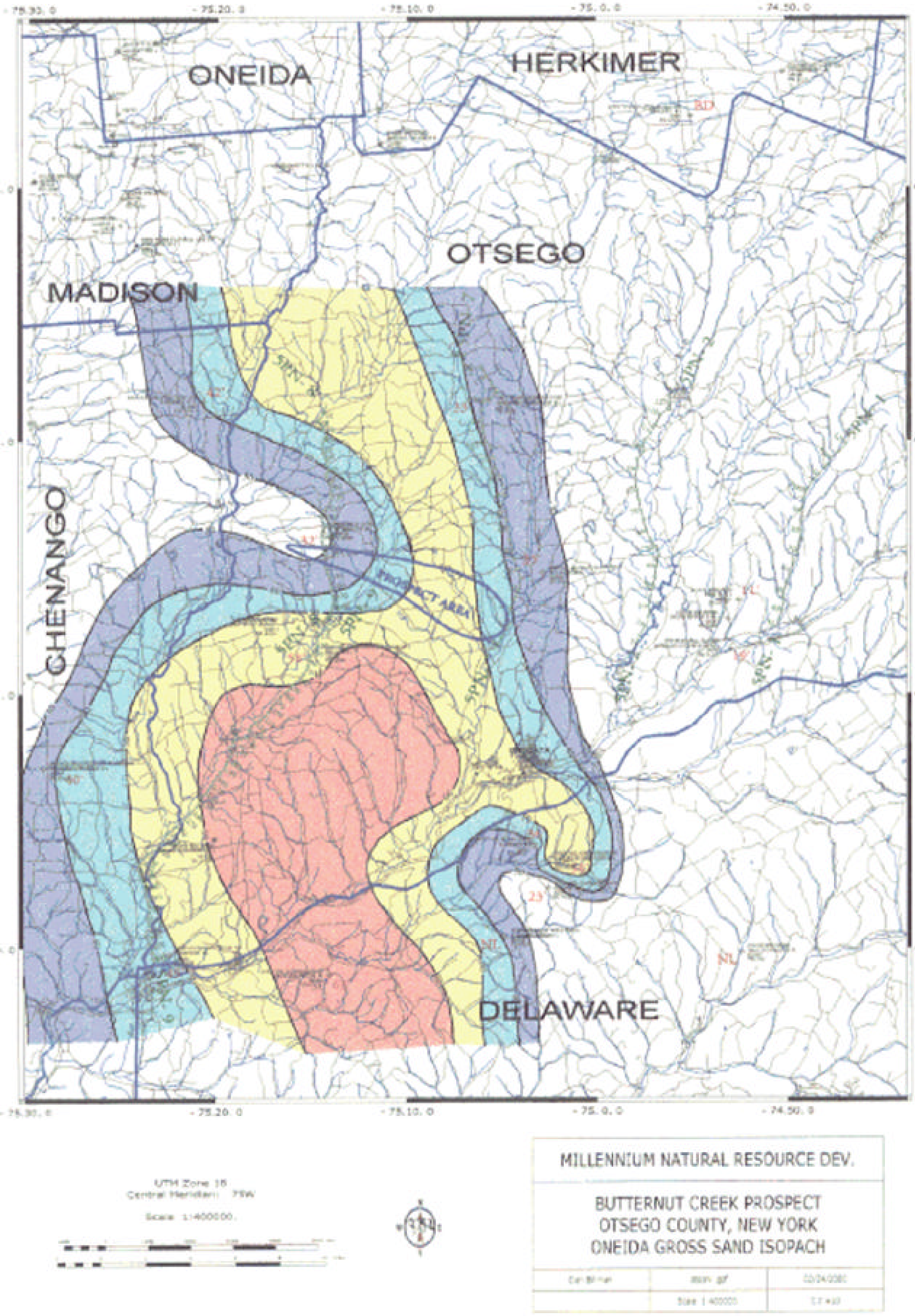
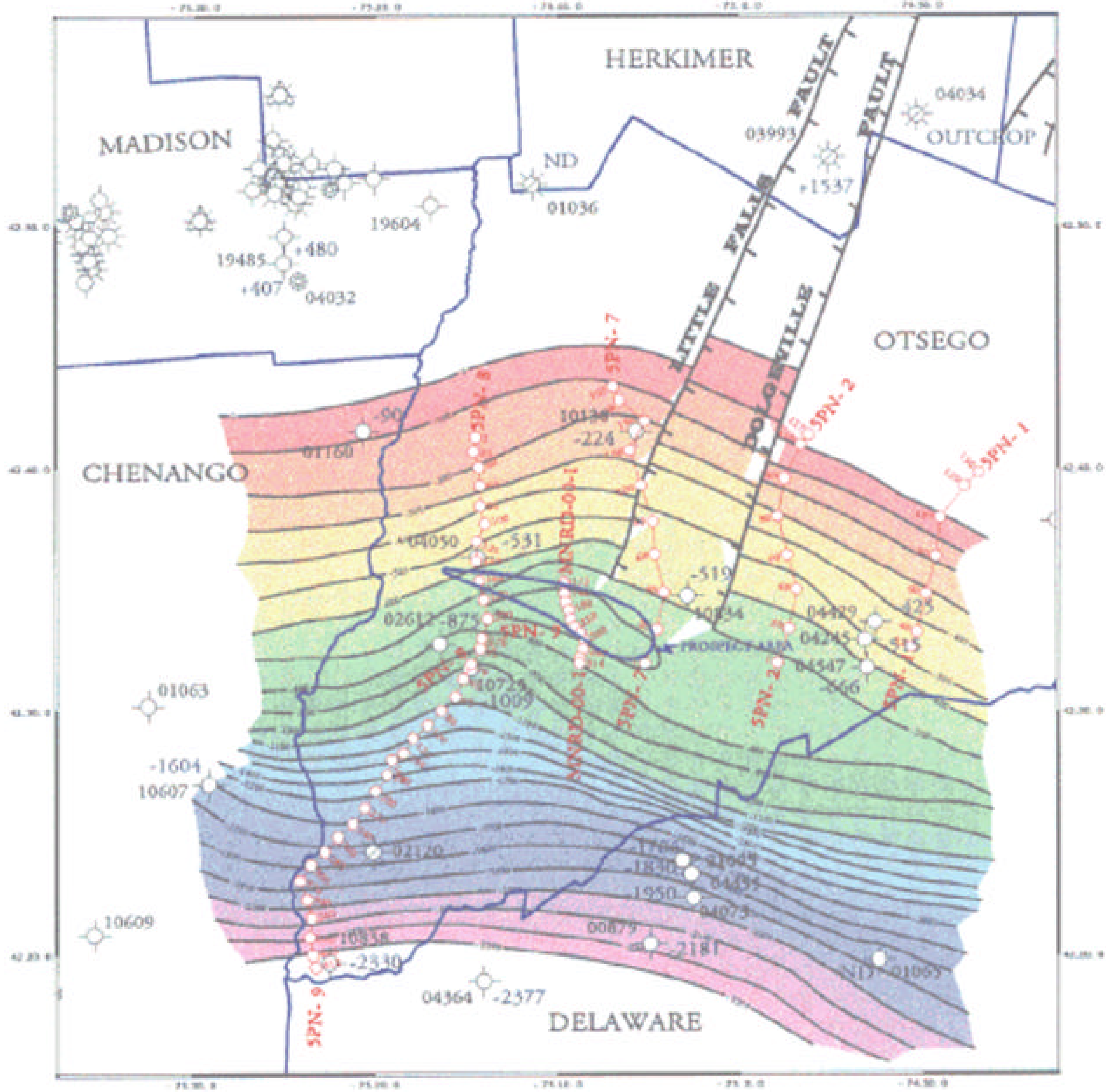
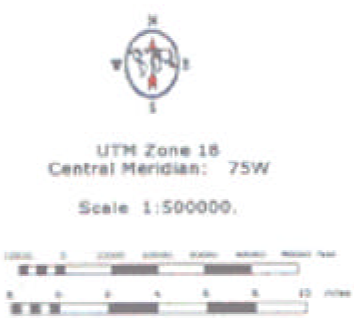

ONEIDA
HERKIMER
OTSEGO
MADISON
CHENANGO
DELAWARE
PROSPECT AREA
MILLENNIUM NATURAL RESOURCE DEV.
BUTTERNUT CREEK PROSPECT
OTSEGO COUNTY, NEW YORK
ONEIDA GROSS SAND ISOPACH

Figure 36b



NOTE : Contouring is interpreted from available well data, seismic data, and aeromagnetic interpretation.

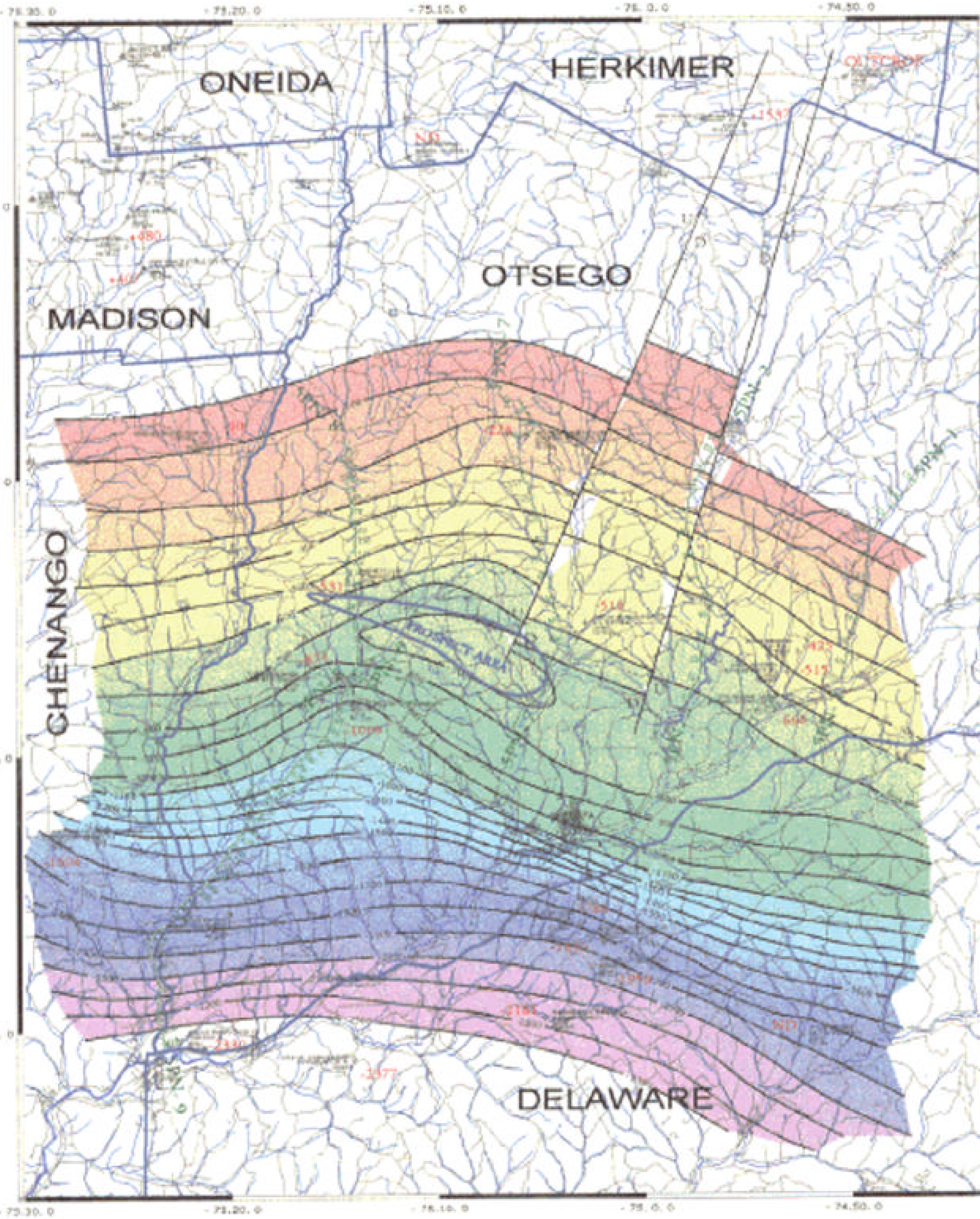


UTM Zone 18
Central Meridian: 75W

Scale 1:500000.

MILLENNIUM NATURAL RESOURCE DEV.		
BUTTERNUT CREEK PROSPECT OTSEGO COUNTY, NY ONONDAGA STRUCTURE CONTOUR		
	Scale 1:500000.	Quest Energy, Inc.

Figure 37a



NOTE: Contouring interpreted from available well data, seismic data, and aeromagnetic interpretations.

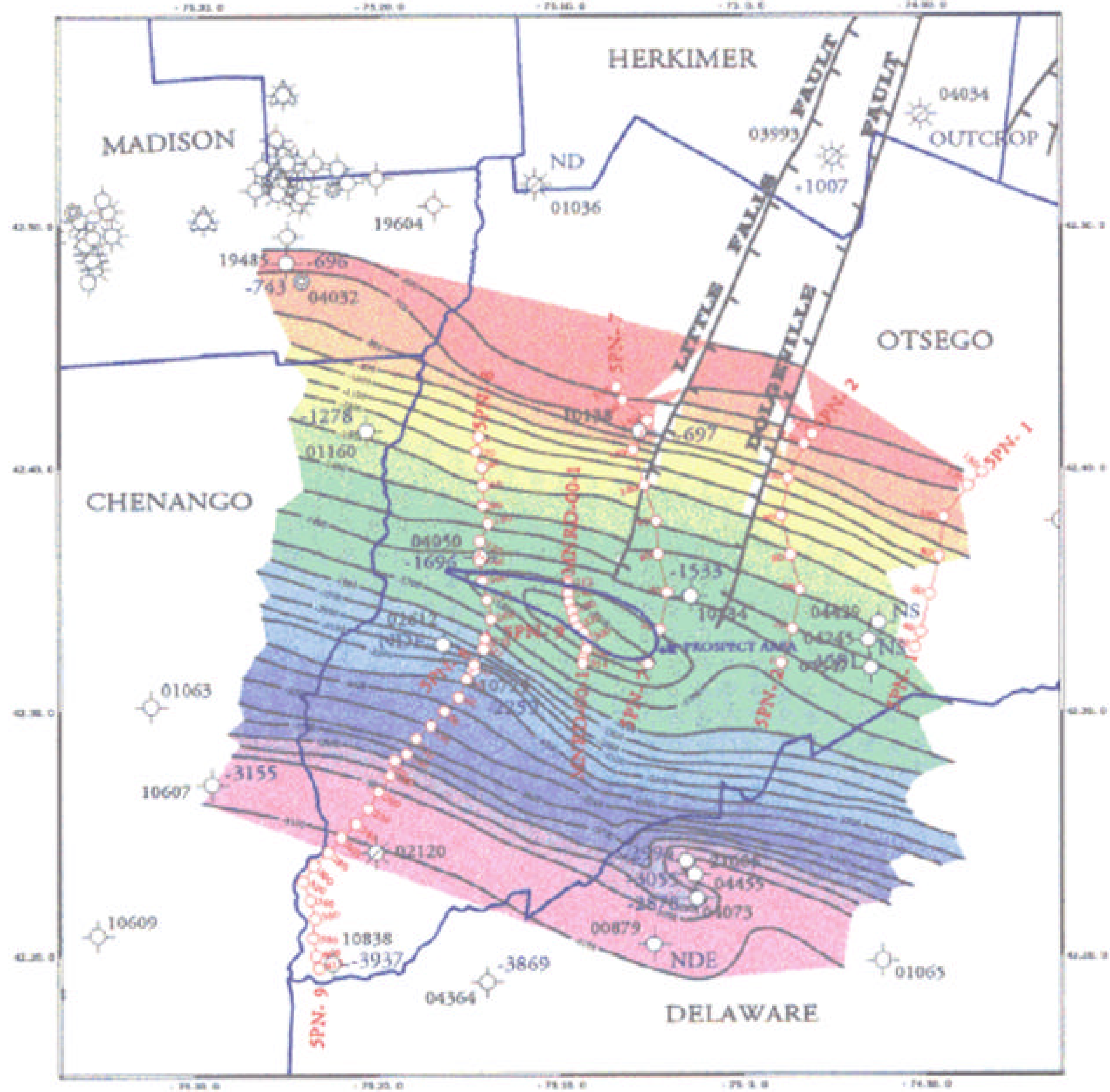
UTM Zone 18
Central Meridian: 75W

Scale 1:400000.

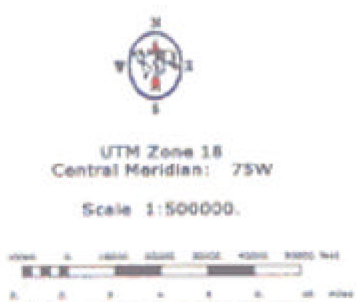
MILLENNIUM NATURAL RESOURCE DEV.

BUTTERNUT CREEK PROSPECT
OTSEGO COUNTY, NEW YORK
ONONDAGA STRUCTURE CONTOUR

Figure 37b

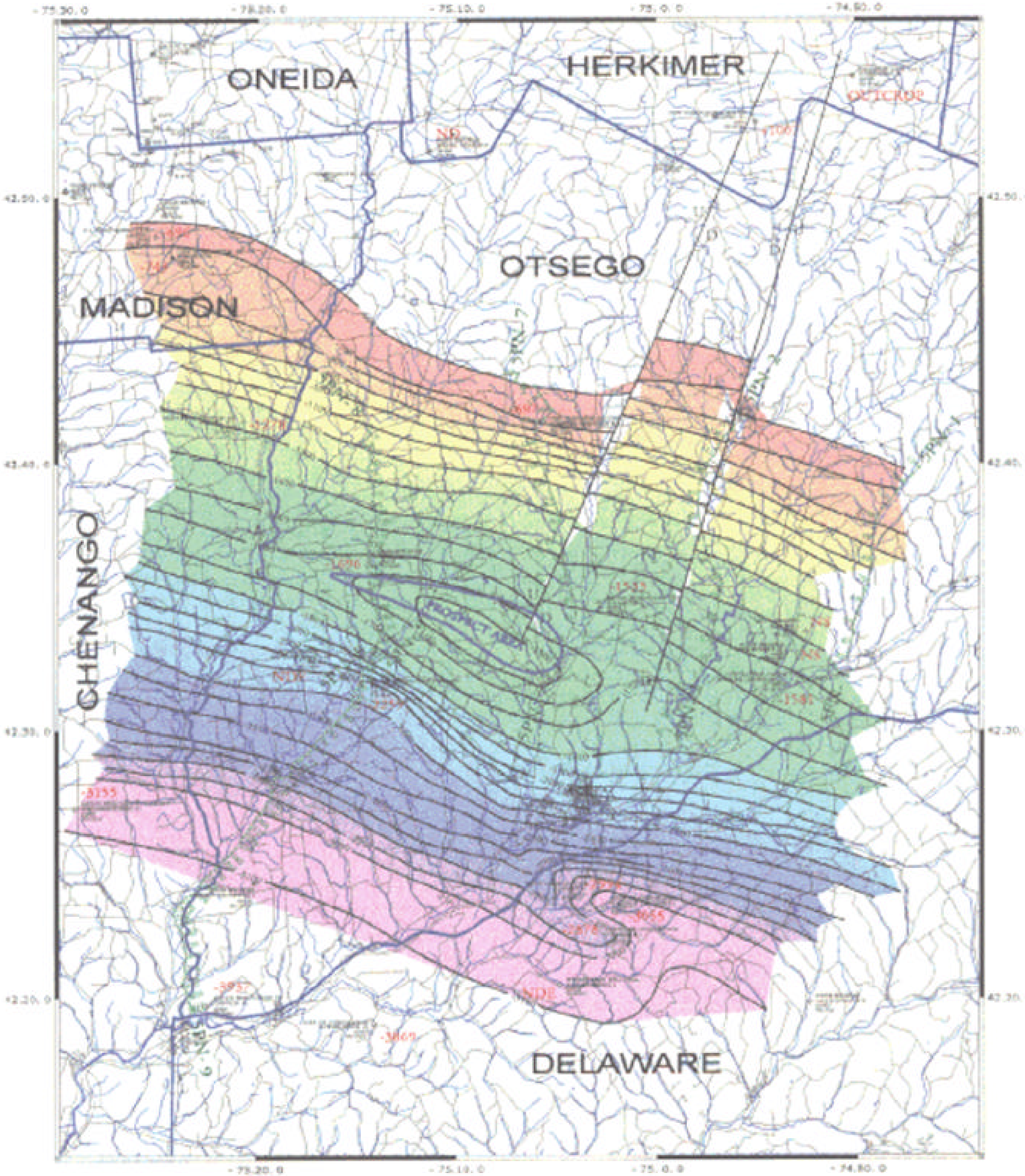


NOTE : Contouring is interpreted from available well data, seismic data, and aeromagnetic interpretation.



MILLENNIUM NATURAL RESOURCE DEV.		
BUTTERNUT CREEK PROSPECT OTSEGO COUNTY, NY HERKIMER STRUCTURE CONTOUR		
	otherstr.gpf	
	Scale 1:500000	Quest Energy, Inc.

Figure 38a



NOTE: Contouring interpreted from available well data, seismic data, and aeromagnetics interpretation.

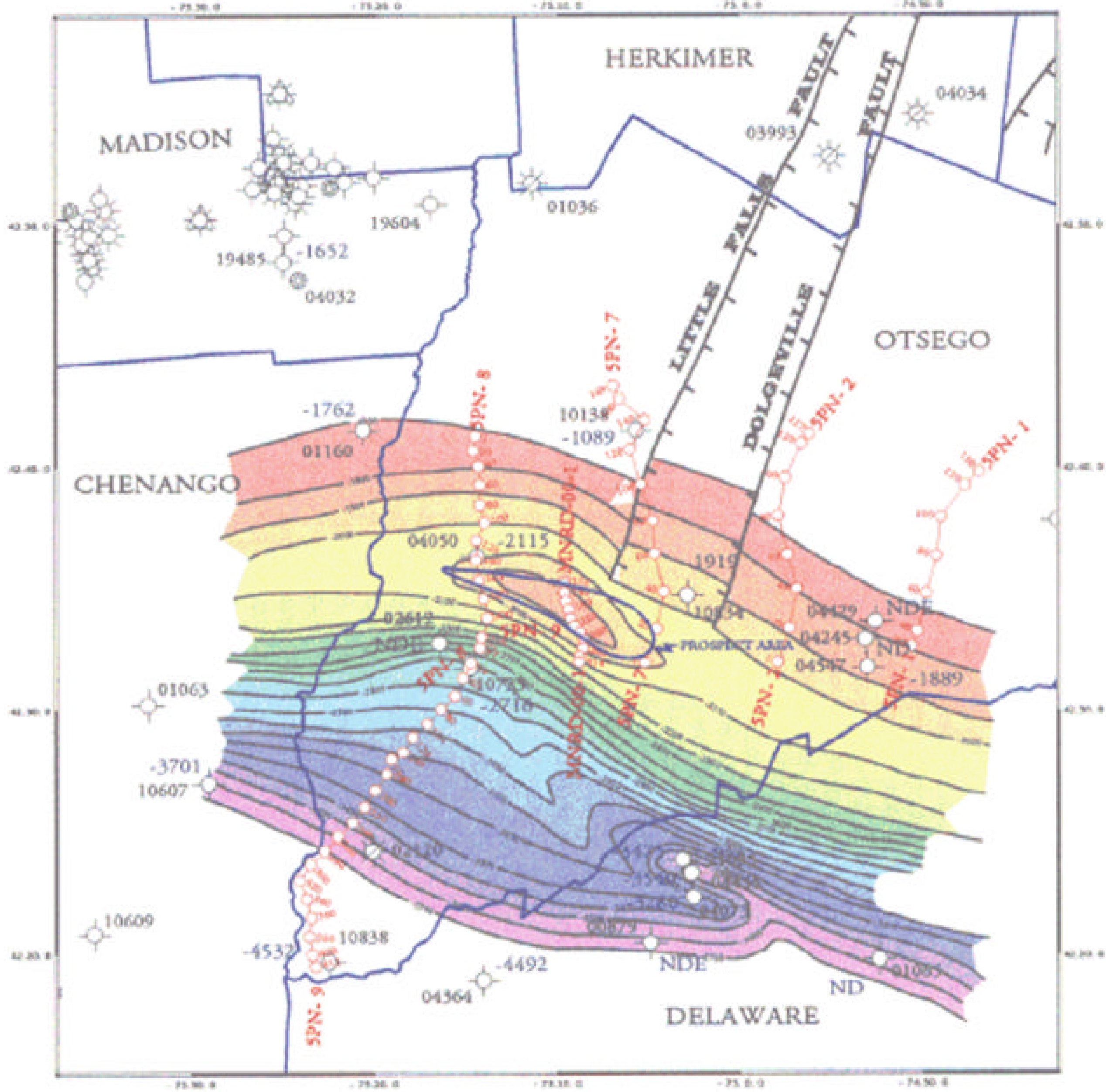
UTM Zone 18
Central Meridian: 75W

Scale 1:400000.

MILLENNIUM NATURAL RESOURCE DEV.

BUTTERNUT CREEK PROSPECT
OTSEGO COUNTY, NEW YORK
HERKIMER SAND STRUCTURE CONTOUR

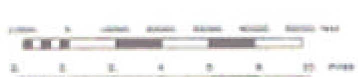
Figure 38b



NOTE : Contouring is interpreted from available well data, seismic data, and aeromagnetic interpretation.

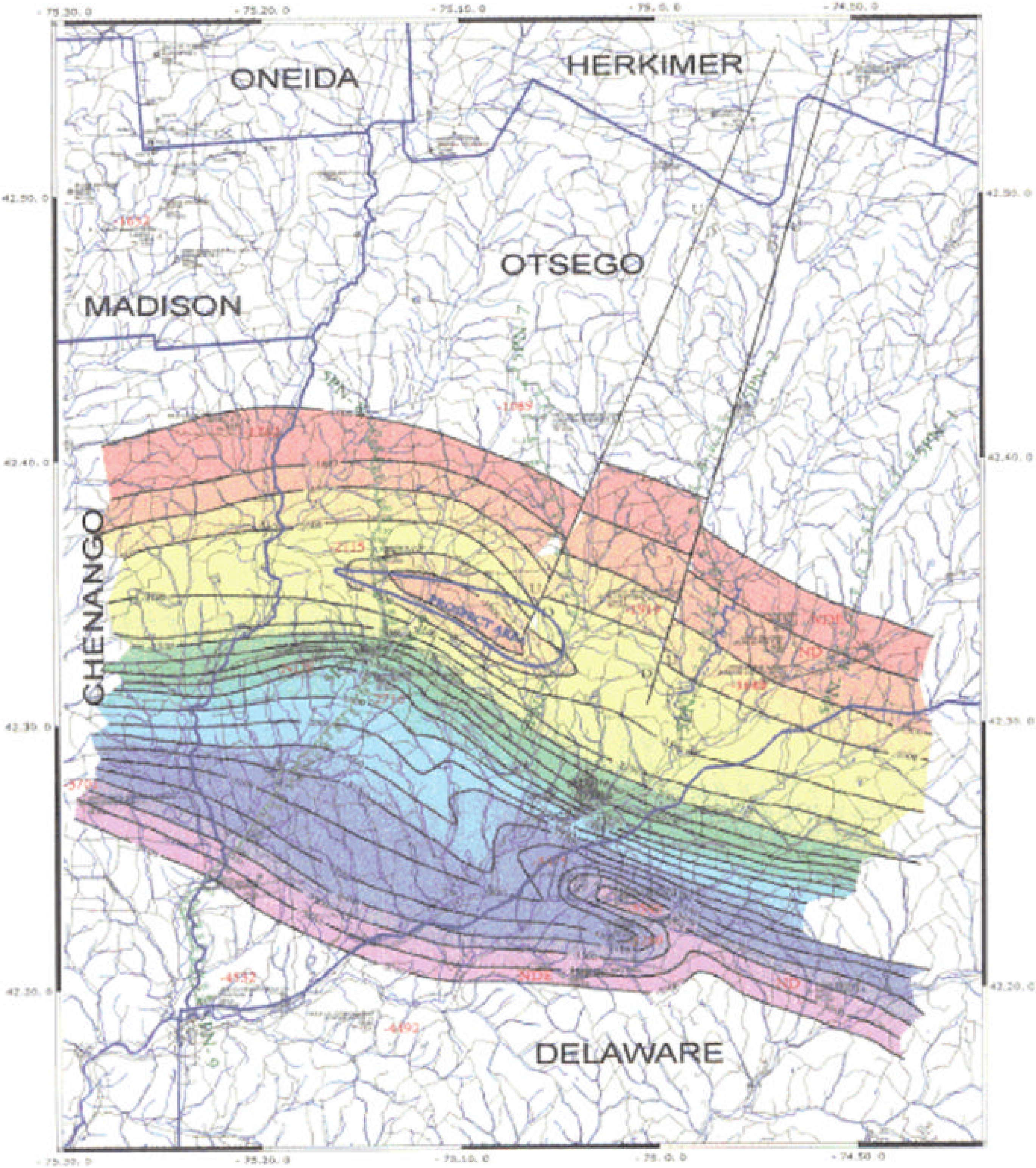
UTM Zone 18
Central Meridian: 75W

Scale 1:500000.



MILLENNIUM NATURAL RESOURCE DEV.		
BUTTERNUT CREEK PROSPECT OTSEGO COUNTY, NY LORRAINE STRUCTURE CONTOUR		
	otbsmtr.gpl	
	Scale 1:500000.	Quest Energy, Inc.

Figure 39a



NOTE: Contouring interpreted from available well data, seismic data, and aeromagnetics interpretation.

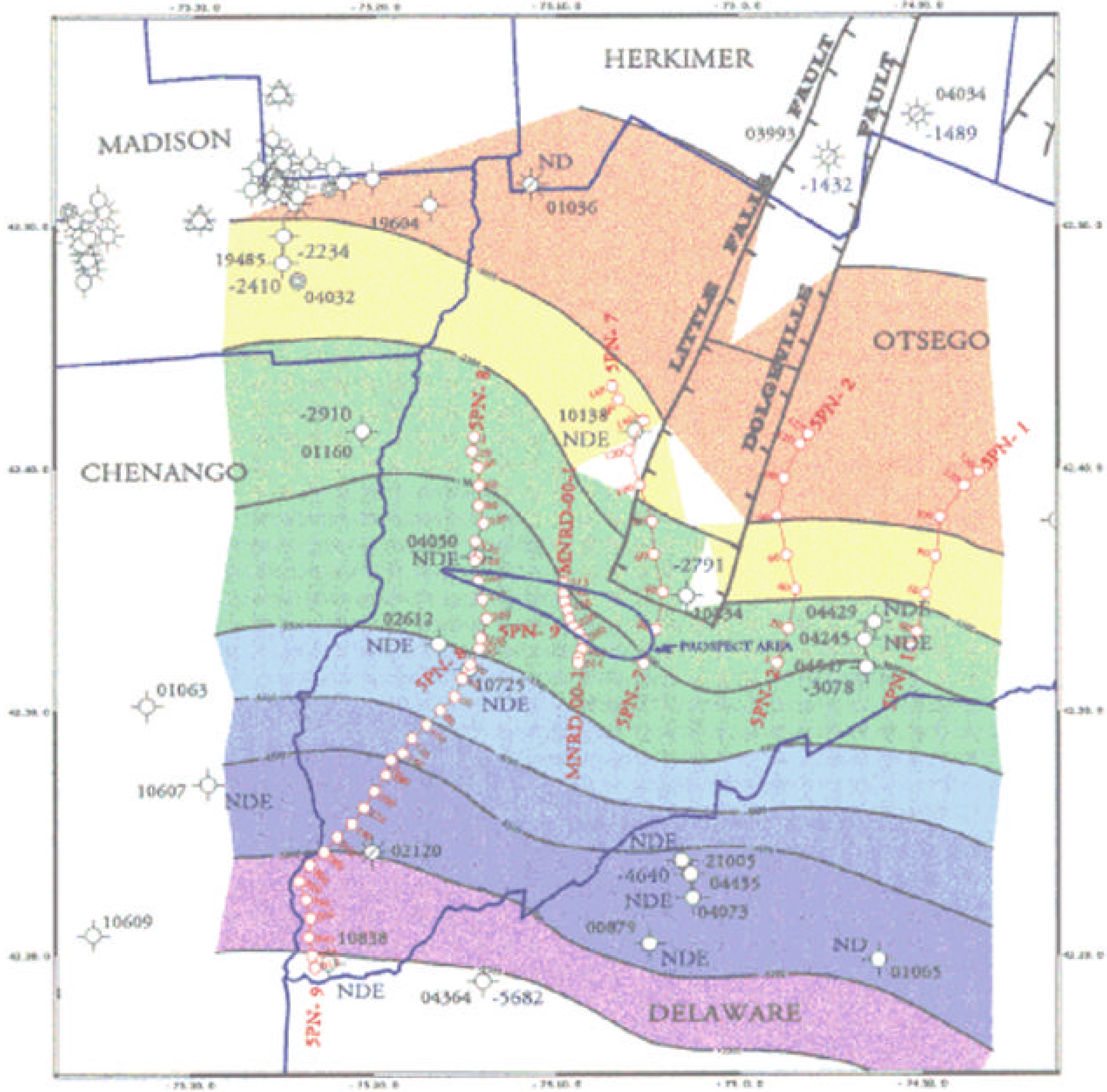
UTM Zone 18
Central Meridian: 75W

Scale 1:400000.

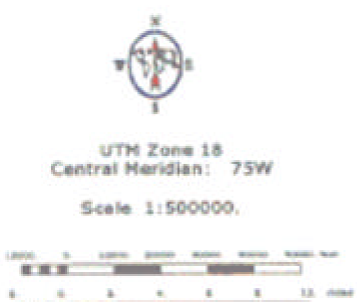
MILLENNIUM NATURAL RESOURCE DEV.

BUTTERNUT CREEK PROSPECT
OTSEGO COUNTY, NEW YORK
LORRAINE STRUCTURE CONTOUR

Figure 39b



NOTE : Contouring is interpreted from available well data, seismic data, and aeromagnetic interpretation.



MILLENNIUM NATURAL RESOURCE DEV.		
BUTTERNUT CREEK PROSPECT OTSEGO COUNTY, NY TRENTON STRUCTURE CONTOUR		
	otrestr.gpf	
	Scale 1:500000.	Quest Energy, Inc.

Figure 40a

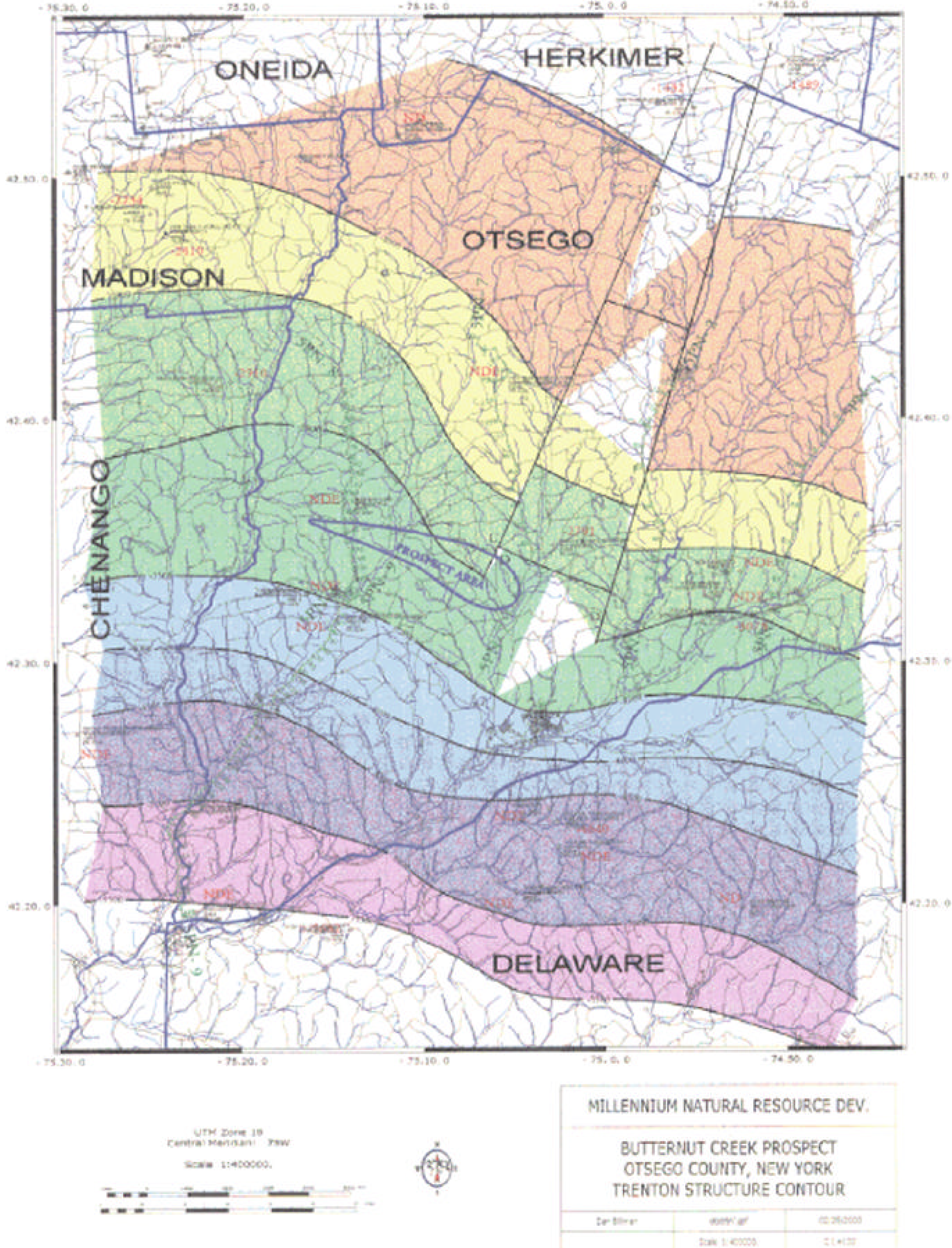

ONEIDA
HERKIMER
OTSEGO
MADISON
CHENANGO
DELAWARE
PROSPECT AREA
MILLENNIUM NATURAL RESOURCE DEV.
BUTTERNUT CREEK PROSPECT
OTSEGO COUNTY, NEW YORK
TRENTON STRUCTURE CONTOUR

Figure 40b

OTSEGO CO., PERMIT 10834
AMOCO PRODUCTION COMPANY
HAROLD S. HOOSE #1

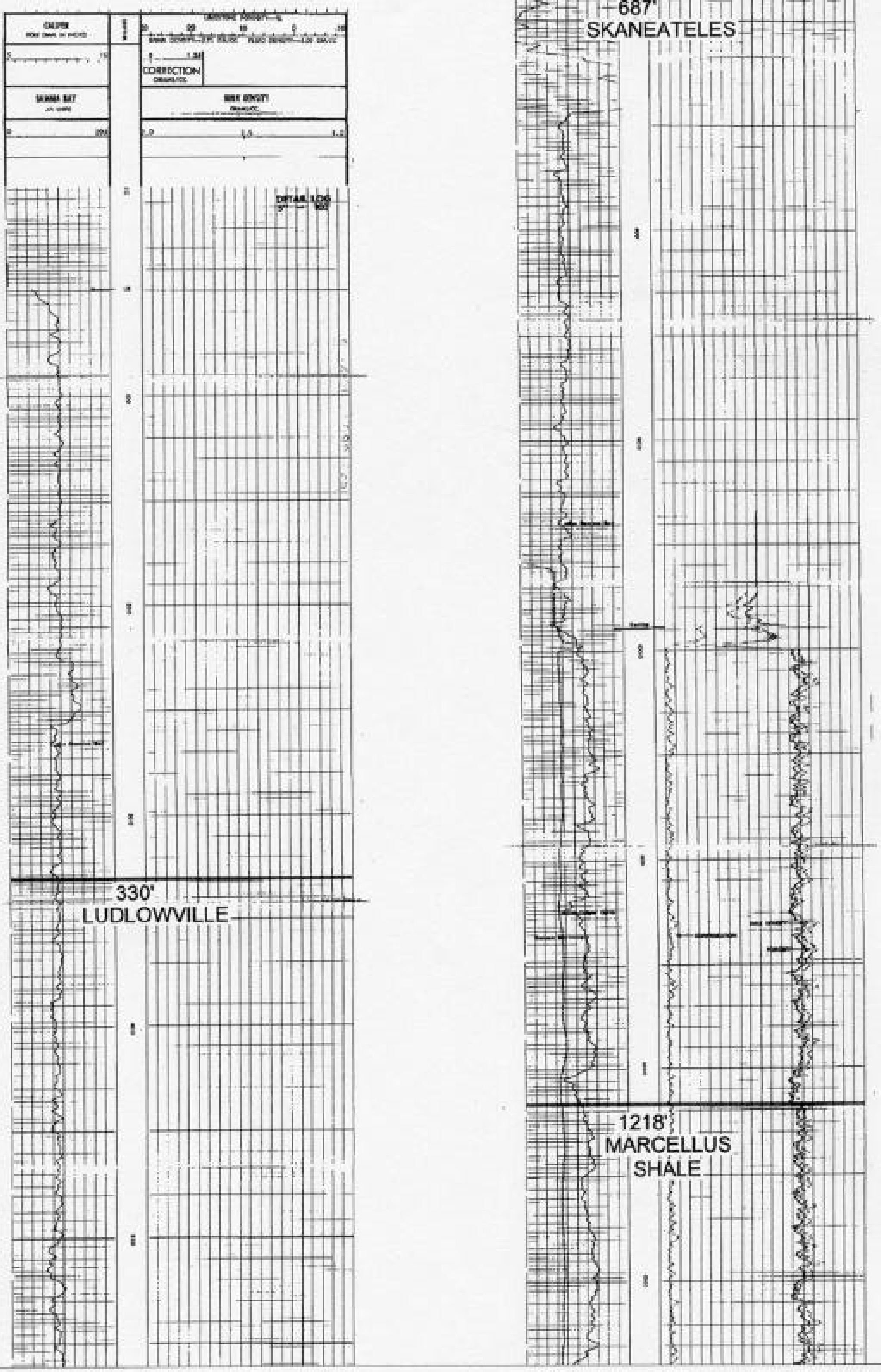


FIGURE 41A

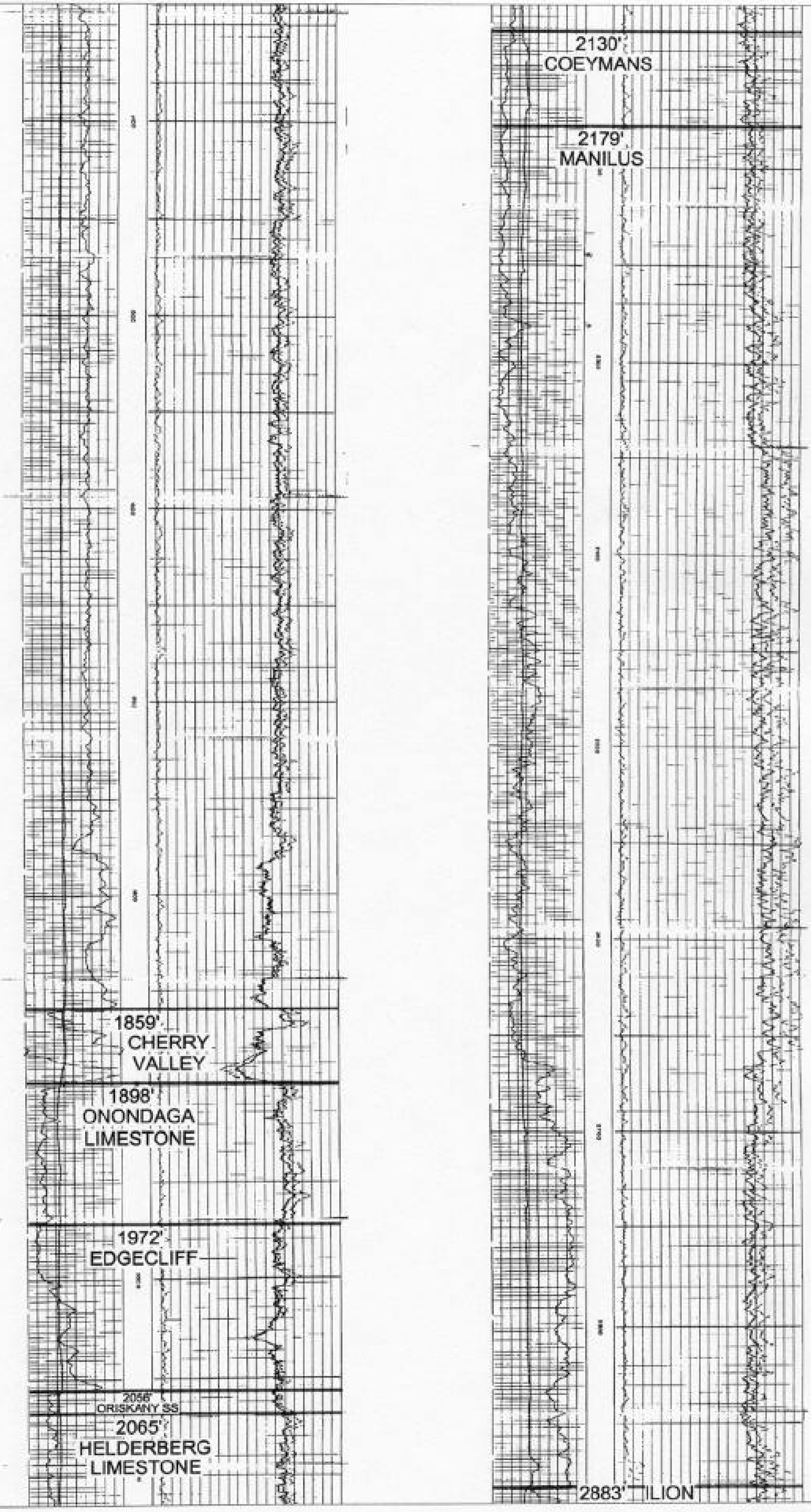
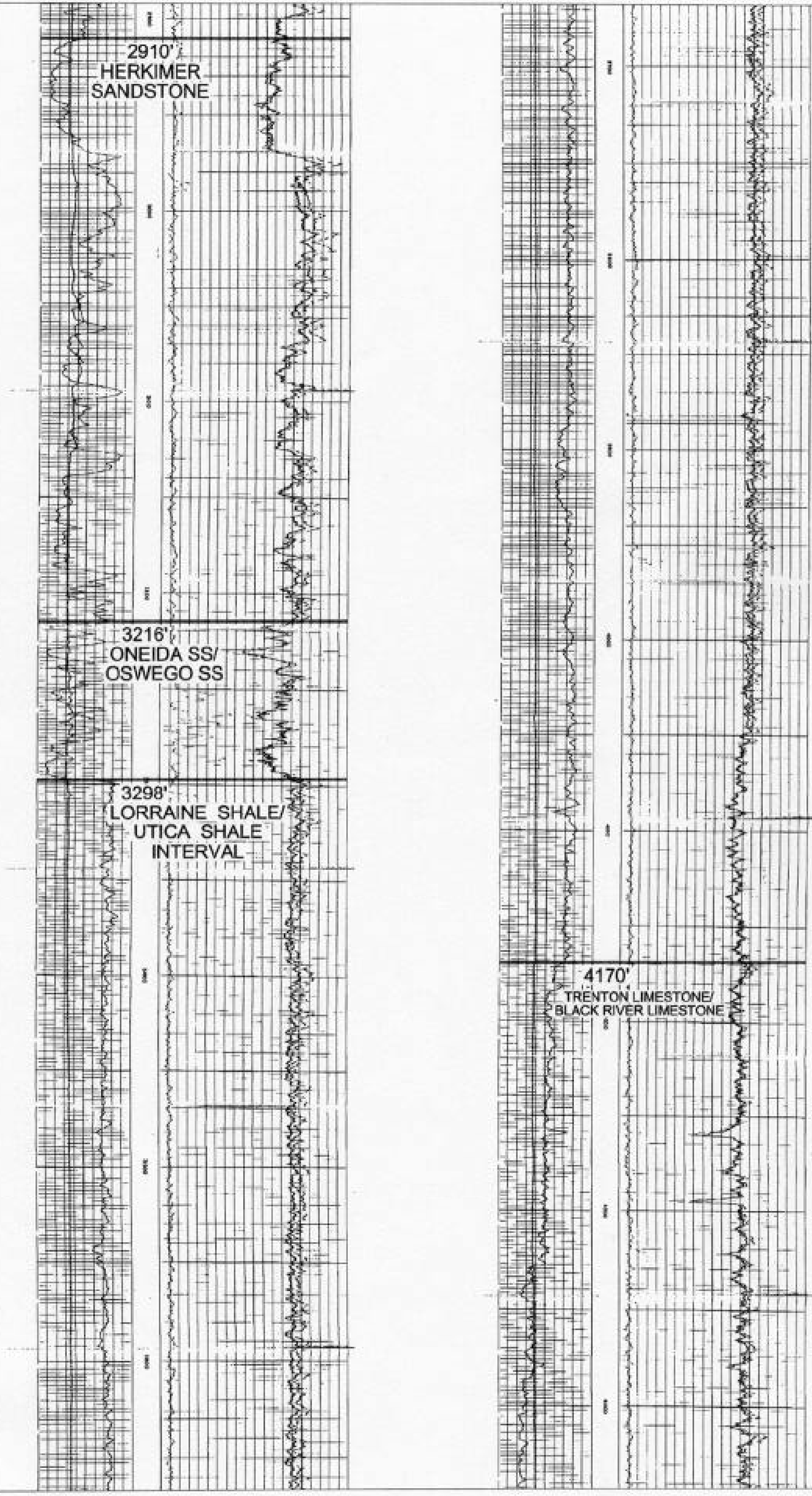

1859' CHERRY VALLEY
1898' ONONDAGA LIMESTONE
1972' EDGECLIFF
2056' ORISKANY SS
2065' HELDERBERG LIMESTONE
2130' COEYMANS
2179' MANILUS
2883' ILION

FIGURE 41B



2910'
HERKIMER SANDSTONE
3216'
ONEIDA SS/ OSWEGO SS
3298'
LORRAINE SHALE/ UTICA SHALE INTERVAL
4170'
TRENTON LIMESTONE/ BLACK RIVER LIMESTONE

FIGURE 41C

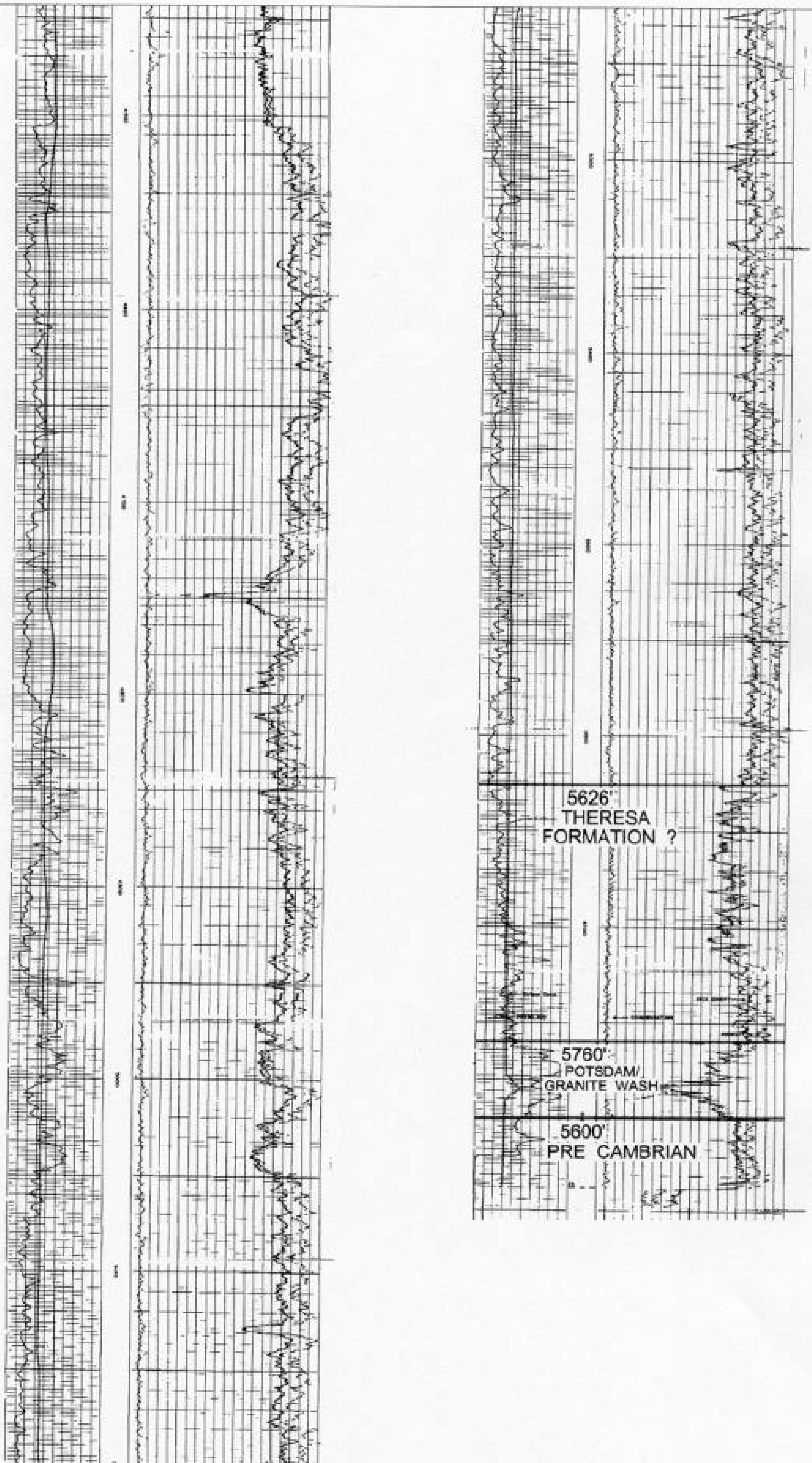

5626'
THERESA
FORMATION ?
5760'
POTSDAM/
GRANITE WASH
5600'
PRE CAMBRIAN

FIGURE 41D

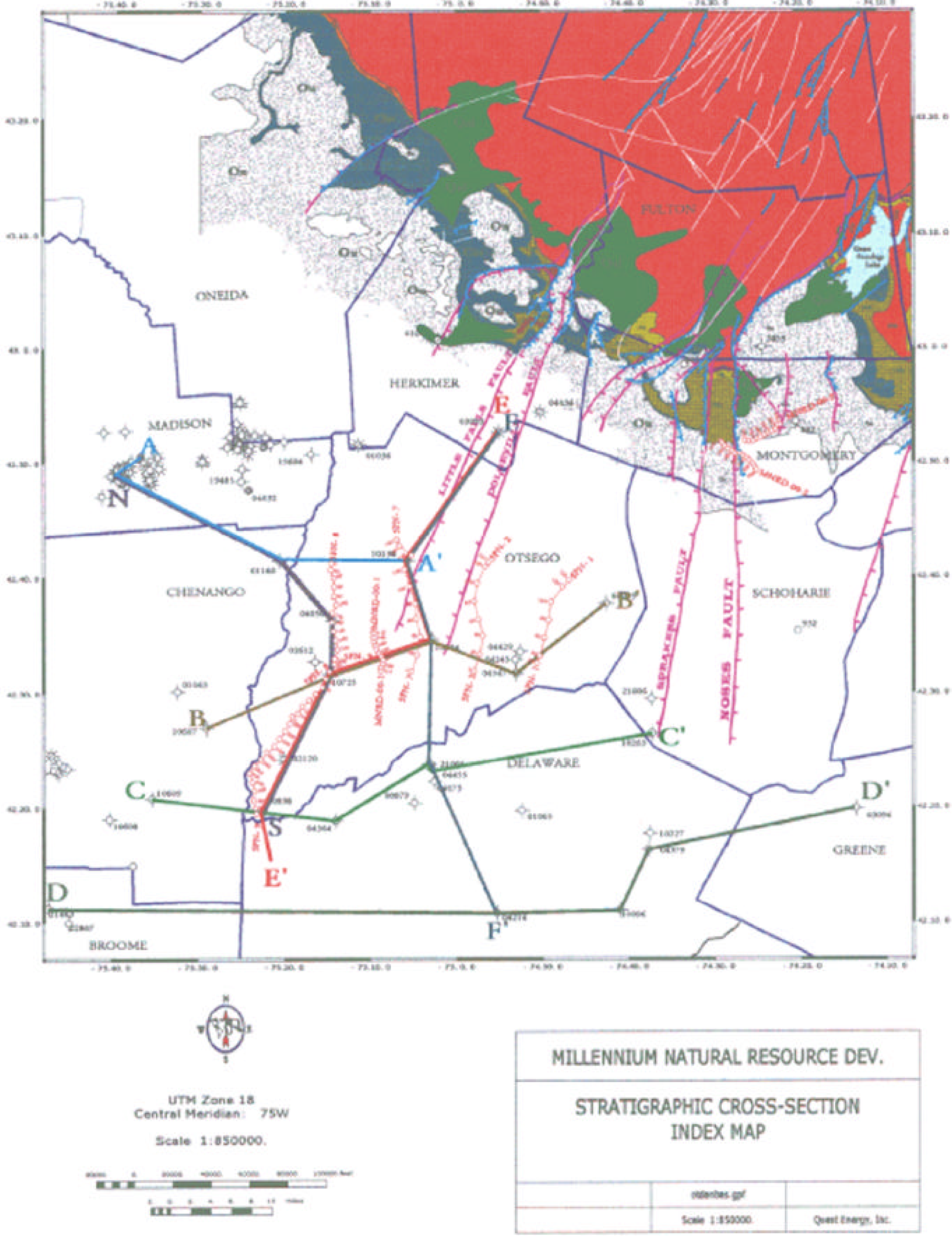
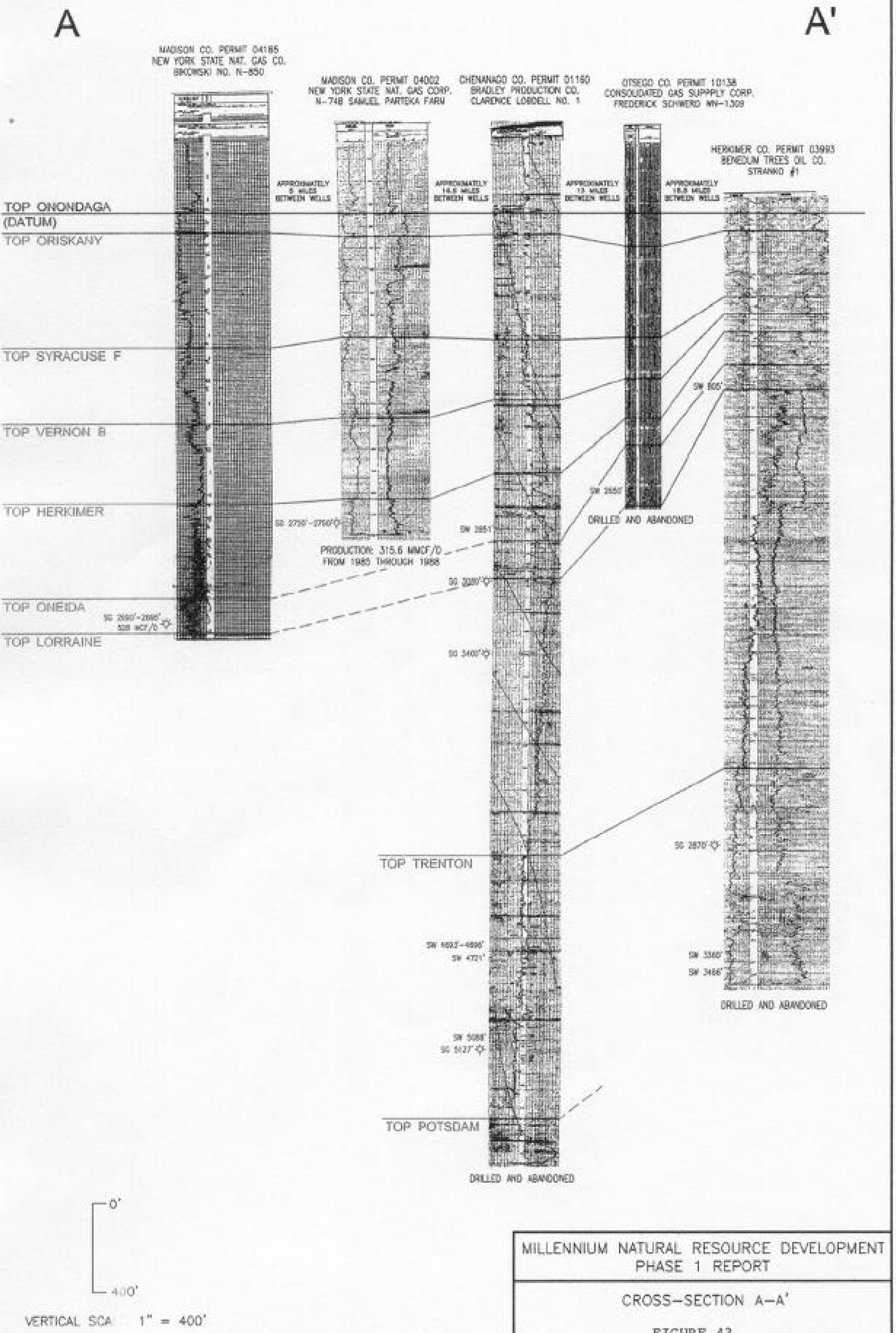

ONEIDA
HERKIMER
FULTON
MADISON
MONTGOMERY
OTSEGO
CHENANGO
SCHOHARIE
DELAWARE
GREENE
BROOME
LITTLE FALLS FAULT
SPRAKERS FAULT
NOSES FAULT
A
A'
B
B'
C
C'
D
D'
E
E'
F
F'
N
S
UTM Zone 18
Central Meridian: 75W
Scale 1:850000.
MILLENNIUM NATURAL RESOURCE DEV.
STRATIGRAPHIC CROSS-SECTION
INDEX MAP
Scale 1:850000.
Quest Energy, Inc.

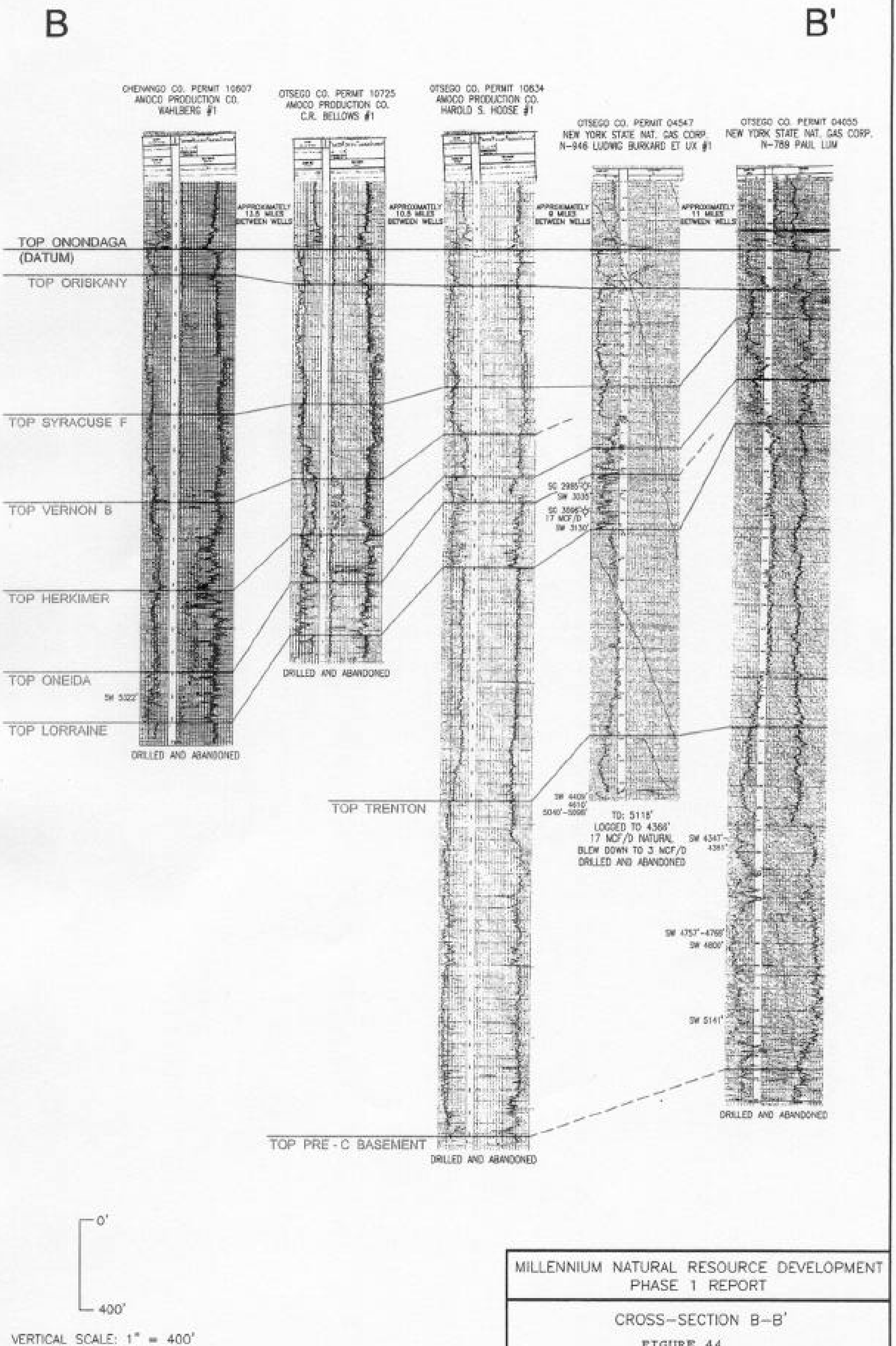
Figure 42



MILLENNIUM NATURAL RESOURCE DEVELOPMENT
PHASE 1 REPORT

CROSS-SECTION A-A'

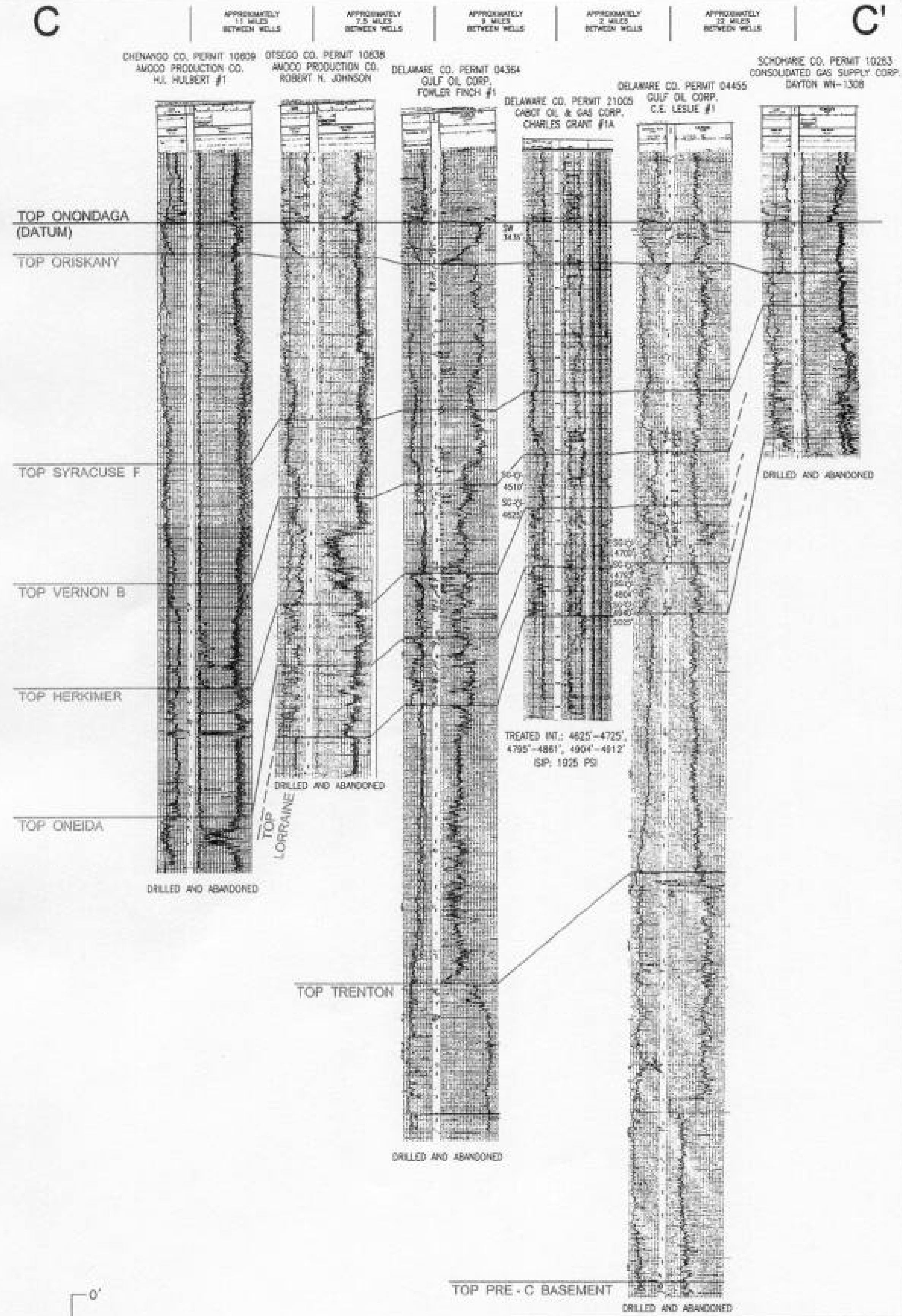
FIGURE 43



MILLENNIUM NATURAL RESOURCE DEVELOPMENT
PHASE 1 REPORT

CROSS-SECTION B-B'

FIGURE 44

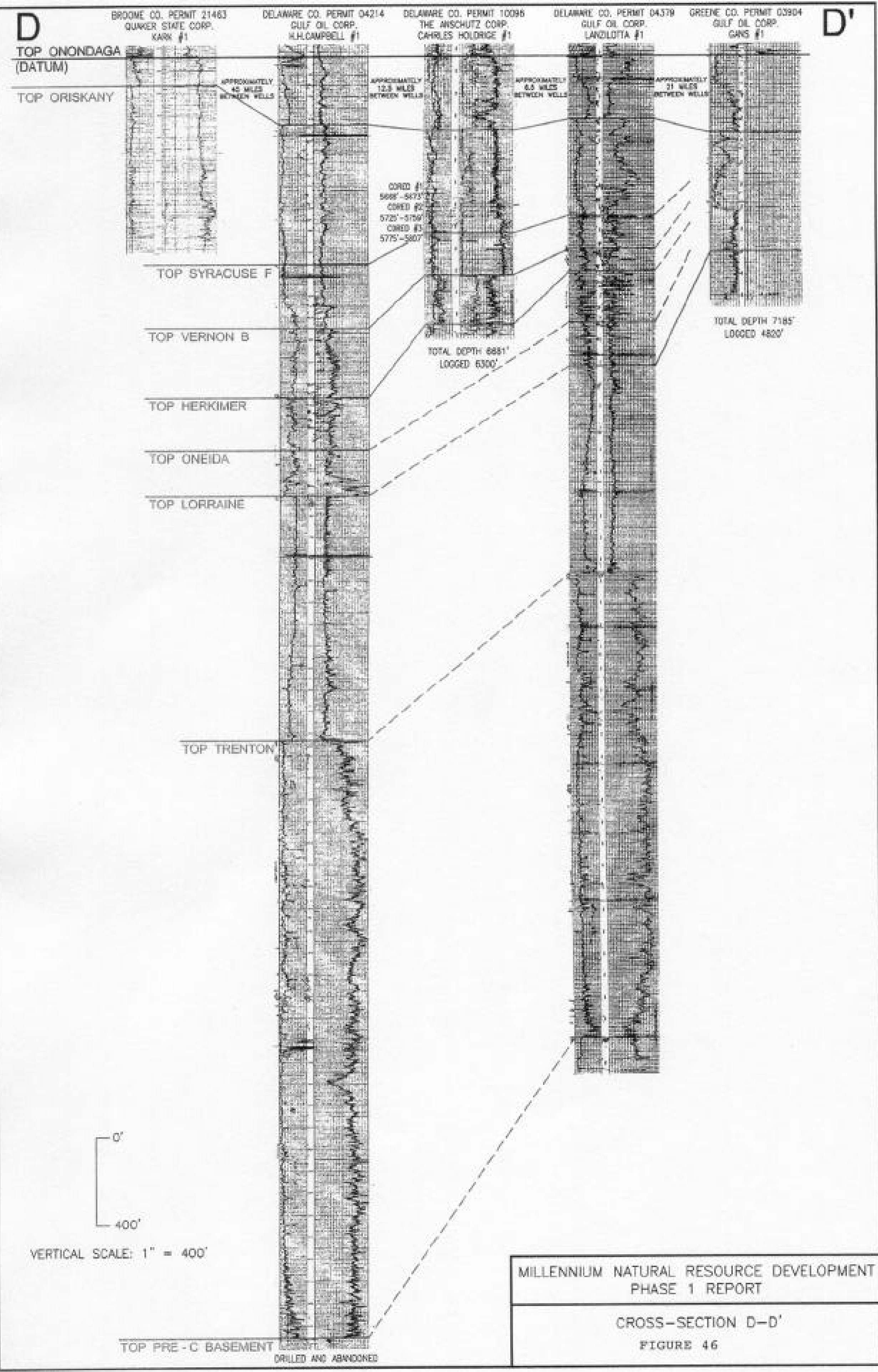


VERTICAL SCALE: 1" = 400'

MILLENNIUM NATURAL RESOURCE DEVELOPMENT
PHASE 1 REPORT

CROSS-SECTION C-C'

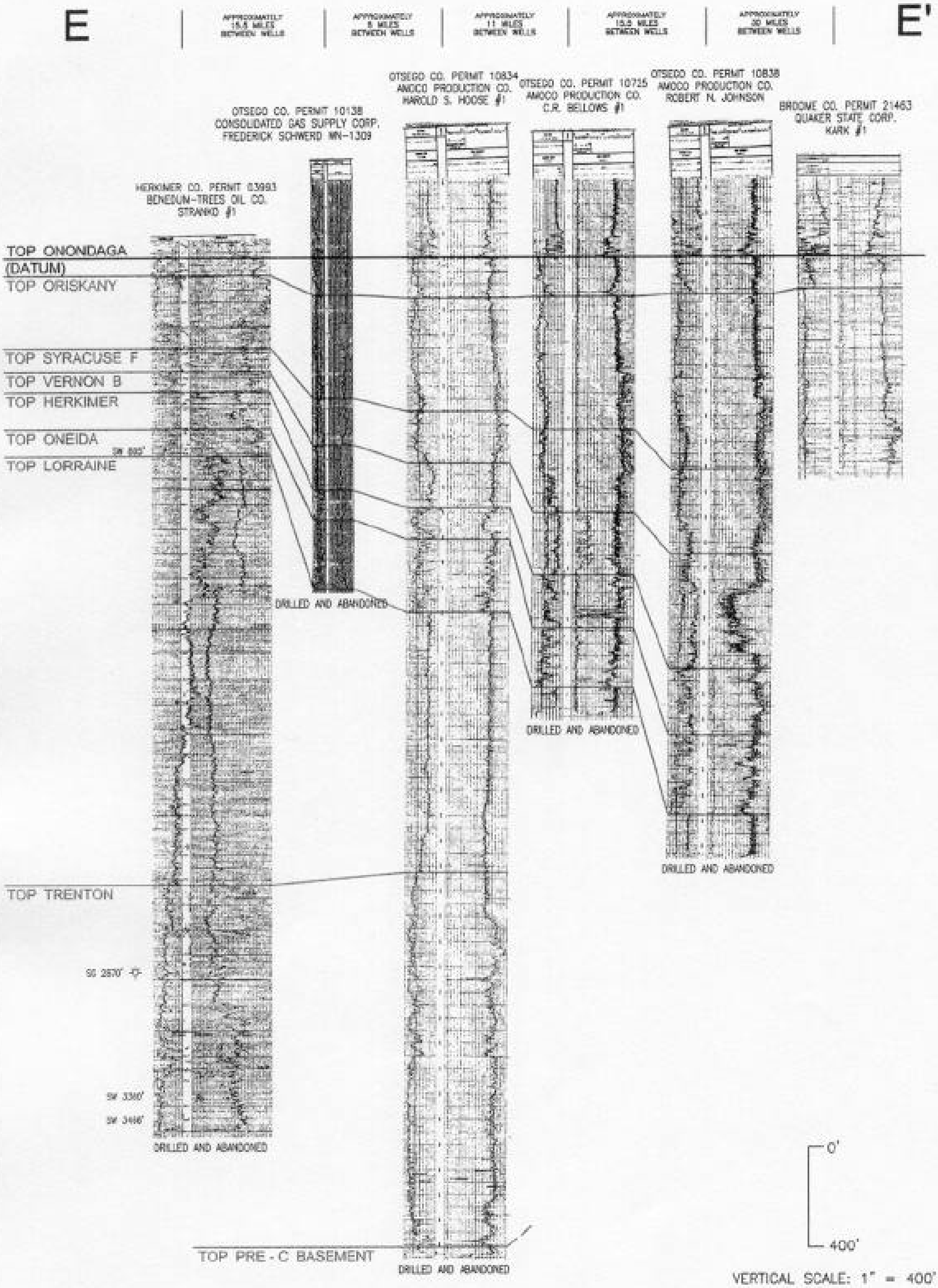
FIGURE 45



MILLENNIUM NATURAL RESOURCE DEVELOPMENT
PHASE 1 REPORT

CROSS-SECTION D-D'

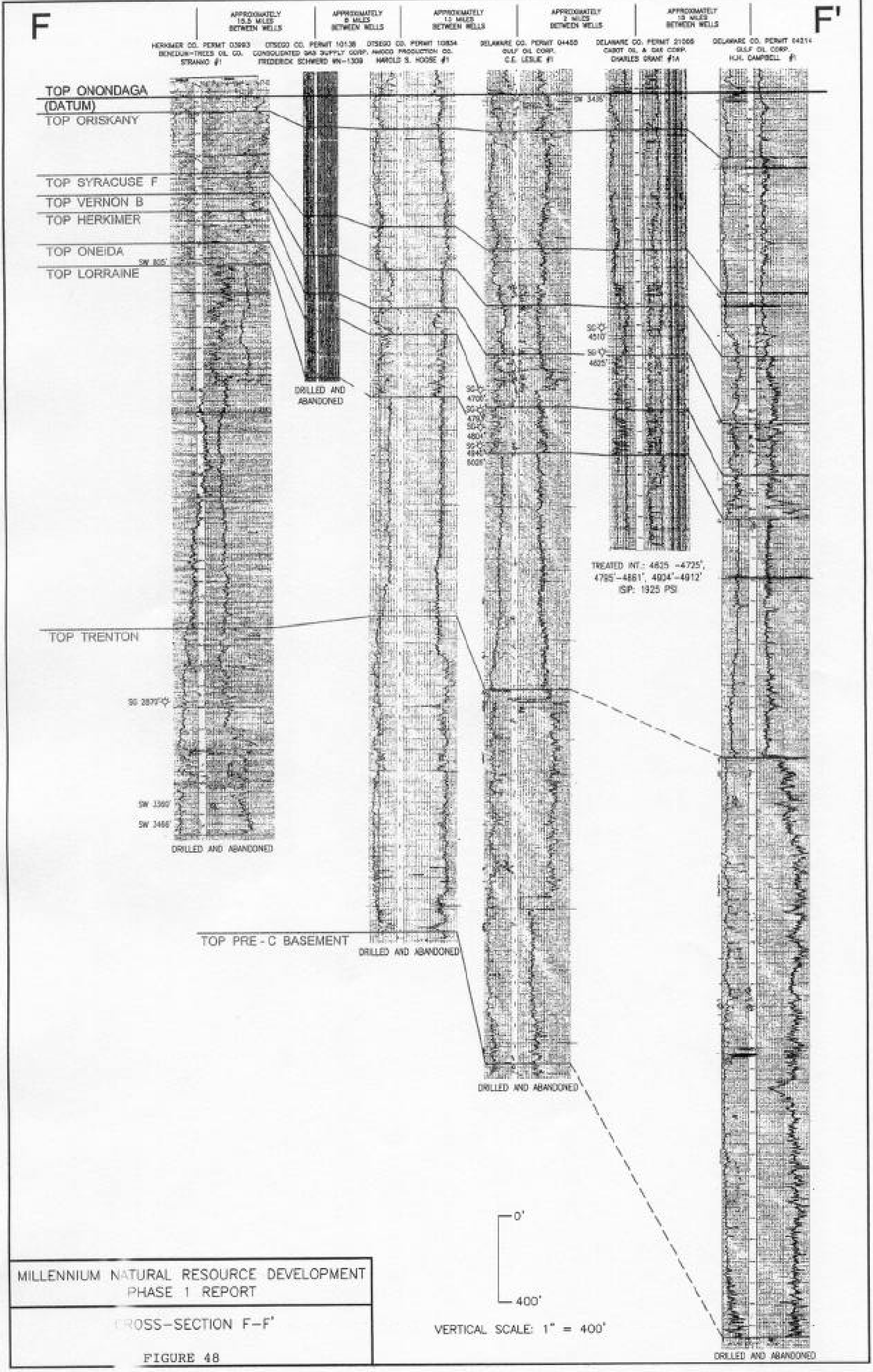
FIGURE 46



MILLENNIUM NATURAL RESOURCE DEVELOPMENT
PHASE 1 REPORT

CROSS-SECTION E-E'

FIGURE 47



MILLENNIUM NATURAL RESOURCE DEVELOPMENT
PHASE 1 REPORT

CROSS-SECTION F-F'

FIGURE 48

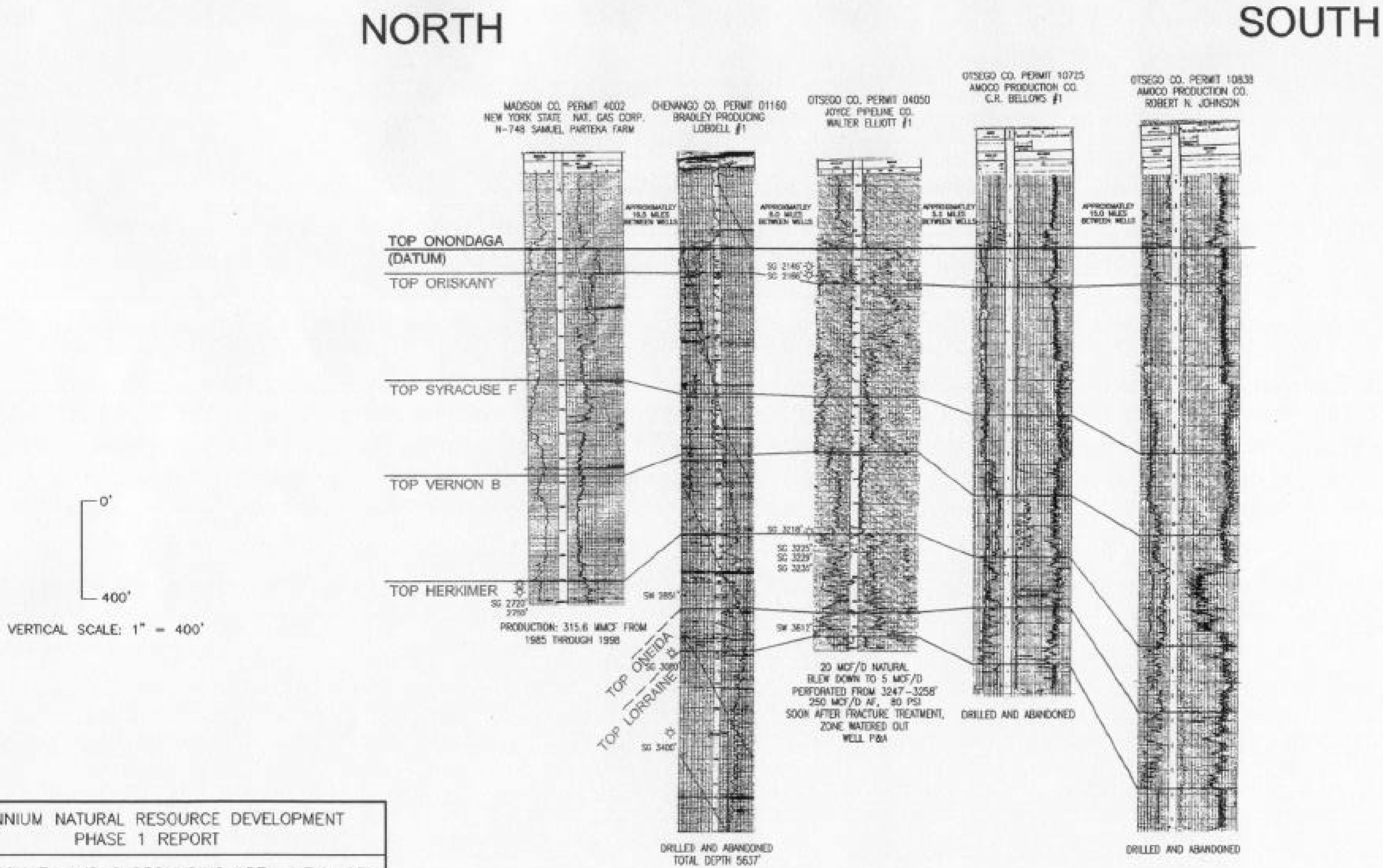


FIGURE 49

MILLENNIUM NATURAL RESOURCE DEVELOPMENT
PHASE 1 REPORT

OTSEGO COUNTY AND SURROUNDING AREA, NEW YORK
NORTH–SOUTH CROSS–SECTION EXTENDING FROM
LEBANON FIELD MADISON COUNTY, NEW YORK

BRANNAGAN WELL				API# 3970			THIN SECTION ANALYSES
Slide	Depth Interval		Formation/Group	Detailed Observations			
Number	top	base	ID	Clast Lithology	major mineralogy	accessory mineralogy	Comments
Br34	0	231	Ludlowville	primarily silt clasts, few biogenic calcite and micrite (pelmicrite) clasts	angular to subangular qtz, and clay; silt grains vary from v. fine to med.	brach shell frags, 1 twinned plagioclase frag, bitumen, scattered mica in silts.	quartz grains are generally unstrained, uniform in size for each clast, probably a graywacke
Br35	231	435	Skaneateles	primarily silt clasts, more biogenic calcite and micrite clasts	angular to subangular qtz, and clay; silt grains vary from v. fine to med coarse silt.	biogenic calc is shell fragments, fibrous anhydrite laminations in the silt clasts; more bitumen	silt grains are more variable in size, probably a fine-grained graywacke
Br36	435	494	Skaneateles	primarily sit clasts, not many micritic clasts.	angular qtz that vary from v. fine to v. coarse, and clay	bitumen is common throughout clasts	visible laminations in the silt clasts, probably a fine-grained graywacke
Br37	494	560	Skaneateles	primarily coarser silt clasts, and some laminated micritic clasts	angular to subangular, strained qtz. that varies from fine to m.coarse silt; and reddish-brown clay	biogenic calc is shell fragments, some qtz grains are surrounded by bitumen	fine-grained graywacke, laminated micrites might be algal mats.
Br38	560	586	Skaneateles	primarily finer grained silts and shales	angular to subangular qtz. and calcite grains that varies from v. fine to med silt; and reddish-brown clay	no observed biogenic calcite	fine-grained graywacke
Br39	586	710	Skaneateles	mostly fine silts, but a few coarser silts and one shell fragments in silt.	angular to subangular, strained qtz. that varies from v. fine to m.coarse silt; no fine clay but carbonate cement	framboids of sulfites	very fine-grained graywacke
Br40	710	905	Marcellus	clasts of shales and fine to coarse silts	angular qtz that vary from v. fine to v. coarse, and dark brown-gray clay	"rings" of bitumen, some biogenic (brach shell) calcite	shale or extremely fine-grained graywacke
Br41	905	1100	Marcellus	laminated clasts of fine to medium silt, with some shale	angular qtz that vary from v. fine to v. coarse, and dark brown-gray clay	many clasts have laminae of bitumen, some carbonate in the clasts	shale or extremely fine-grained graywacke
Br42	1100	1148	Marcellus	clasts of very fine clay	dark reddish-brown to black clay	sporadic silt-sized grains of angular qtz and calcite	first possible black shale
Br43	1148	1200	Marcellus	clasts of very fine clay	dark reddish-brown to black clay	sporadic silt-sized grains of angular qtz and calcite	black shale
Br44	1200	1266	Cherry Valley	black shale clasts that contain convoluted calcite laminations, sporadic biogenic calc, and micritic clasts,	dark reddish-brown to black clay	possible strained oolites, biogenic calcite is in the form of small shell fragments	black shale, with high carbonate input.
Br45	1266	1324	Onondaga	mostly clasts of micritic and biogenic calcite, with sporadic black shale clasts that might be fall-in	micritic calcite and some biogenic calcite	organics occur along fractures in the clasts (possibly styolites?), some schistose pieces?	micritic limestone
Br46	1324	1332	Oriskany	individual grains	angular to subangular quartz grains, highly fractured, grain-size varies from coarse silt to fine sand.	sporadic silt grains of sericitized plagioclase	first sandstone
Br47	1332	1392	Helderberg	large clasts of sparry and micritic calcite	sparry calcite and micritic calcite	some bitumen along fractures, rounded fine silt-size qtz and clay laminations in the micrites	limestone
Br48	1392	1475	Kalkberg	mostly clasts of sparry calcite, fewer micritic and biogenic clasts	sparry calcite and micritic calcite	some bitumen along fractures, rounded fine silt-size qtz and clay laminations in the micrites, sporadic silt-size clasts of sericitized plagioclase	limestone

Br49	1475	1517	Manlius	clasts are primarily sparry and micritic calcite	sparry calcite and micritic calcite	angular and v. fractured quartz grains, single plagioclase grain, sporadic glauconite	limestone
Br50	1517	1569	Rondout	clasts of sparry calcite and laminated micritic calcite	sparry calcite and micritic calcite	laminations of clay and bitumen	limestone
Br51	1569	1638	Bertie	clasts are primarily micritic calcite	micritic calcite and some sparry calcite	fibrous anhydrite, scattered rounded to subrounded silt-sized qtz.	limestone
Br52	1638	1673	Bertie/Camilus	homogeneous micritic clasts	micritic calcite with thin laminations of clay	scattered fibrous anhydrite	limestone
Br53	1673	1845	Camilus	clasts of laminated micritic clasts	micritic calcite with thin laminations of clay	voids in clasts are filled with feathery, fibrous anhydrite, numerous small opaques that are possibly bitumen	limestone
Br54	1845	1952	Camilus/Syracuse F	mix of micritic clasts and anhydrite	micritic calcite and fibrous anhydrite	possibly fine-grained gypsum or anhydrite	limestone/anhydrite
Br55	1952	2032	SyracuseF-D	mostly micritic clasts with anhydrite	micritic calcite and fibrous anhydrite	possibly fine-grained gypsum or anhydrite	limestone/anhydrite
Br56	2032	2098	Vernon C	mostly micritic clasts (stained red) and a few silt graded clasts	micritic calcite, fibrous anhydrite, and subrounded, silt-sized qtz with carbonate cement	possible biogenic calcite laminations in the micritic clasts representing algal mats	limestone
Br57	2098	2140	Vernon C	mostly micritic clasts with anhydrite	micritic calcite and fibrous anhydrite	some clay and possibly biogenic calcite laminations in the micritic clasts representing algal mats	moldic porosity filled with bitumen, limestone
Br58	2140	2242	Vernon C-B	mix of micritic and silt clasts	micritic calcite, fibrous anhydrite, and subrounded, silt-sized qtz with carbonate cement	subangular to subrounded v.fine sand-size qtz grains	limestone
UB1	2652	2661	Herkimer	due to condition of the slide, lithology is difficult to determine	appears to be subangular to subrounded qtz grains	difficult to determine	Sandstone??
UB2	2672	2686	Clinton	mix of micritic, sparry and red-stained silt clasts	micritic and sparry calcite, silt-sized qtz in a calcitic cement.	scattered clasts of black (organic?) shale	Calcareous siltstone
UB3	3000	3010	Sauquoit	mix of sand-size qtz grains, and silt clasts.	Qtz grains are rounded to subrounded and many are embayed. A few of the smaller qtz grains are angular to subangular	Silt clasts have silt-size qtz grains in a black matrix.	silty sandstone
UB4	3033	3045	Oneida	Cuttings are primarily single quartz grains with scattered clasts of fine silt and shale	Qtz grains range from angular to subrounded.	Silt clasts have very small qtz grains, shale clasts are a mixture of clay minerials and groundmass.	sandstone
UB5	3045	3054	Oneida	More of a mix between single qtz grains and silt clasts.	Qtz grains range from angular to subrounded, but most are subangular.	Silt clasts are coasrer than in UB4 occur in greater abundance, there are less shale clasts.	fine sanstone

UB6	3054	3070	Queenston	Mixture of red-stained silt clasts and single qtz clasts.	Qtz clasts include both monocrystaline and polycrystaline. Monocrystaline qtz grains range from angular to subrounded.	Silt clasts are comprised of silt-sized subangular qtz grain in red-stained clays.	silty sandstone
UB7	3120	3131	Queenston	Mixture of moslty red-stained silt clasts and scattered single qtz clasts.	Qtz clasts are mostly monocrystalline grains with fewer polycrystaline grains.	Silt clasts are generally coarser than upsection silt clasts	silty sandstone
UB8	3141	3155	Queenston	Very few cuttings to examine, but the few clasts present are red silts and shales with a few coarse silts	Mixture of true red silts and shales	Coarser silt clasts are similar to those in UB7	red siltstone with red shale
UB9	3170	3182	Queenston	Mixture of mostly single qtz grains and fewer red fine silt clasts and red shale clasts	Qtz grains are subangular to subrounded and are all monocrystaline	Silt and shale clasts are red and the clastic component is very fine grained.	red silty sandstone
UB10	3191	3212	Oswego	Mostly (non-red) silt clasts with some qtz clasts and even fewer red shale clasts	Silt clasts are not red or red-stained, the silt-sized qtz grains are angular to subrounded	Single qtz grains are small (~coarse silt-fine sand) in size and are subrounded. Shale clasts are red	red siltstone
Br16	3663	3679	Oswego	Clasts are a mixture of silt and shales with a few clasts that look calcareous	Clay minerals with grains of quartz and calcite	opaque minerals that are likely to be sulfides or organics	Thin laminations are evident in many of the clasts as coarser or finer layers.
Br17	3743	3760	Oswego	Clasts are a mixture of silt and shales with a few clasts that look calcareous	Clay minerals with grains of quartz and calcite	opaque minerals that are likely to be sulfides or organics	Thin laminations are evident in many of the clasts as coarser or finer layers.
Br18	3848	3865	Oswego	Clasts are a mixture of silt and shales with a few clasts that look calcareous	Clay minerals with grains of quartz and calcite	opaque minerals that are likely to be sulfides or organics	Thin laminations are evident in many of the clasts as coarser or finer layers.
Br19	4028	4048	Oswego	Clasts are a mixture of silt and shales with a few clasts that look calcareous	Clay minerals with higher organic content.	opaque minerals that are likely to be sulfides or organics	Thin laminations are evident in many of the clasts as coarser or finer layers.
Br20	4279	4303	Oswego	Clasts are a mixture of silt and shale with and large number of shales being black shales.	Clay minerals with higher organic content.	opaque minerals that are likely to be sulfides or organics	Thin laminations are evident in many of the clasts as coarser or finer layers.
Br21	4456	4475	Oswego	Clasts are primarily black shales with a few biogenic clasts of fossil fragments.	Clay minerals with higher organic content.	opaque minerals that are likely to be sulfides or organics	Fossiliferous, clast contain and some are comprised of fossil fragments.
Br22	4530	4547	Trenton	Clasts are primarily of micritic limestone	Calcite - typical mitcritic calcite clasts and grains	Scattered, small quartz grains, some clasts have dark staining around calcite grains	Very few fossil fragments

Br23	4657	4672	Trenton	Clasts are primarily of micritic limestone	Calcite - typical mitcritic calcite clasts and grains	Scattered, small quartz grains,	Some calcite grains look recrystalized, other display nice twinning.
Br24	4770	4780	Black River	Clasts of laminated gray shale with clasts of black shale, fewer clasts of micritic limestone.	Clay mineral with few calcite clasts.	Laminations of sulfides and/or organics. Scattered mica grains in the black shales.	Micritic calcite grains have scattered crystals of calcite growing inside.
Br25	4865	4875	Beekmantown	Clasts are primarily shales, a few silts and scattered large calcite grains	Clay minerals with higher organic content.	Scattered large, single calcite grains.	Both black and gray shale clasts are present in ~equal amount.
Br26	4897	4905	Little Falls	Clasts are primarily sparry limestome, with a few clasts of shale.	Sparry calcite with lesser amounts of clay minerals	Clasts present include both black and gray shales.	Very few fossil fragments
Br27	5028	5033	Little Falls	Clasts are a mixture of sparry and micritic limestones with slight clastic imput.	Sparry and micrite calcite with lesser amounts of clay minerals	well-rounded quartz grains.	Very few fossil fragments
Br28	5203	5228	Theresa	Clasts are a mixture sparry and micritic limestone, although the small clast size detracts from analysis	Sparry calcite	scattered well-rounded quartz grains and flecks of organic and/or sulfides.	Very few fossil fragments
Br29	5298	5328	Theresa	Clasts of sparry limestone with slight clastic imput.	Sparry calcite	Large quartz grains that appear well-rounded but some are embayed.	Qtz grains have a strange surface texture that is probably from making the slide and not the qtz itself.
Br30	5452	5481	Theresa	Most clasts are individual grains of primarily calc, and fewer quartz grains.	Sparry calcite	scattered well-rounded quartz grains.	Qtz grains have a strange surface texture that is probably from making the slide and not the qtz itself.
Br31	5511	5533	Theresa	Clasts fairly small but are comprised of aggregations of calcite grains indicating a sparry limestone with slight clastic imput.	Sparry calcite	scattered well-rounded quartz grains, one clast is comprised of sutured quartz grains.	Qtz grains have a strange surface texture that is probably from making the slide and not the qtz itself.
Br32	5675	5678	pC	individual grains	feldspars - both plagioclase and microcline, fractured subangular qtz	sericitized feldspars, glauconite, large opaques	if not an anorthosite then a feldspar-rich granite
Br33	5678	5696	pC	individual grains	feldspars - both plagioclase and microcline, fractured subangular qtz w/some overgrowth	sericitized feldspars	if not an anorthosite then a feldspar-rich granite

RQD CALCULATIONS FOR EXAMINED CORES

Jefferson Site #1 - 21006

	core sections	total		Core Depth (ft)	
Box #	<4"	core length	RQD	top	bottom
49	9.5	158	93.99	810	824
50	18.5	190.5	90.29	824	839
51	6.5	166.5	96.10	839	853.3
52	0	n/a	100.00	853.3	867.5
53	3.5	155.5	97.75	867.5	880.9
54	0	n/a	100.00	880.9	896
55	0	n/a	100.00	896	907

Holdridge #1 - 10096

Core 1	core sections	total		Core Depth (ft)	
Box #	> 4"	core length	RQD	top	bottom
1	n/a	n/a	0.00	5668	5674

Holdridge #1 - 10096

Core 2	core sections	total		Core Depth (ft)	
Box #	> 4"	core length	RQD	top	bottom
1	19	34.5	55.07	5725	
2	4	36	11.11		
3	16	36	44.44		
4	0	n/a	0.00		
5	0	n/a	0.00		
6	0	n/a	0.00		
7	8.5	34	25.00		
8	n/a	n/a	n/a		
9	14	35.5	39.44		
10	n/a	n/a	n/a		
11	11.5	33	34.85		5767

Holdridge #1 - 10096

Core 3	core sections	total		Core Depth (ft)	
Box #	> 4"	core length	RQD	top	bottom
1	4	35	11.43	5775	5777.9
2	8	35	22.86	5777.9	5780.8
3	12	36	33.33	5780.8	5783.8
4	4	33.5	11.94	5783.8	5786.6
5	20.75	35.5	58.45	5786.6	5789.6
6	22.5	36	62.50	5789.6	5792.6
7	33.5	36	93.06	5792.6	5795.6
8	22.5	35.5	63.38	5795.6	5798.5
9	28.75	36	79.86	5798.5	5801.5
10	19.5	34	57.35	5801.5	5804.4
11	13.5	27	50.00	5804.4	5807

Table 2

	Depth (ft)	Depth (ft)		Cuttings	%	%	%	%
Formation	Top	Bottom	Interval	Description	Gray (stsh to shst)	White (qtz)	Red (silt)	Other
Herkimer	3218	3228	10	Mostly gray, silt to shaly silt size composite grains and sporadic red qtz rich silt (<5%).	95	0	5	0
Herkimer	3228	3235	7	Same as above (3218-3228)	95	0	5	0
Herkimer	3235	3240	5	Red composite clasts of both med-well sorted silt size qtz and poorly sorted silt to sand size clear qtz; white grains are both rounded, frosted, css sand size qtz grains and some composite clasts w/ poor to med sorted sand size qtz; all well cemented.	<5	10	80	0
Herkimer	3240	3244	4	Typically angular sand size single grains a small composite clasts and a few rounded qtz grains.	3	48	48	1% black
Herkimer	3244	3247	3	Similar to 3240-44, mostly fine sand size single qtz grains, a few composites; white grains are clear w/cement, mostly angular, very few rounded, but not frosted; fairly well sorted.	4	48	48	0
Herkimer	3247	3250	3	White includes medium sand size rounded and frosted qtz grains (2%), angular medium sand size, clear qtz grains (2%), and composite grains of silt size qtz (44%) that has very low porosity.	48	48	4	0
Herkimer	3250	3262	12	All gray, large composite clasts silt to shaly silt size, well sorted qtz; same as 3218-3228	100	0	0	0
Herkimer	3262	3272	10	Primarily gray composite clasts of well cemented very fine grained silt to shaly silts; red composite clasts are poorly sorted fine-med sand size, same as above	98	0	2	0
Herkimer	3272	3278	6	Gray is same as 3262-3272, red composite clasts with rounded coated sand size grains	96 to 98	0	2 to 4	0
Herkimer	3278	3287	9	All composite clasts; gray are very fine grained silty shale to shaly silt with some pyrite(?); white consists of well sorted, yellow silt size qtz with possible tuffaceous grains.	70	20	10	0
Herkimer	3287	3302	15	Almost all gray, fine grained silt to shaly silt. No red clasts, white grains are possibly crystal lithic tuff	99	0	0	1% lithic
Willowvale	3302	3315	13	Red composite clasts consist of sand size qtz grains and a fine grained matrix. Qtz grains are coated w/ hematite; red composite clasts are poorly sorted. Gray is same as above	60	0	40	0
Willowvale	3315	3332	17	Same as 3302-3315, poorly sorted	40	0	60	0
Saquoit	3332	3344	12	All red clasts, poor to med sorting of med sand size qtz grains in the composite clasts; color is typically purple-red with some terracotta colored grains.	0	0	100	0

Saquoit	3344	3359	15	All red clasts; composite clasts w/coarser grains consist of poorly sorted med sand size qtz; composite grains w/ finer grains consist of well sorted silt to fine sand size qtz; all are well cemented	0	0	100	0
Saquoit	3359	3375	16	Red clasts are composite clasts of very rounded, med sand size qtz grains; about 10% of composites are of fine sand size qtz grains; gray clasts are same as above	20	0	80	0
Saquoit	3375	3388	13	Same as above (3359-3375)	15	0	85	0
Saquoit	3388	3399	11	Red clasts are mostly sand size qtz grains, both rounded discoids and rollers; almost all grains are coated with red hematite, a few lack the red coating. Red is primarily individual grains. Individual grains may imply higher porosity (less cementation) than above.	20 to 30	0	70 to 80	0
Saquoit	3399	3406	7	Same as 3388-3399, many angular, single qtz grains, composite clasts are the same as above, now finer grained sand	20 to 30	0	70 to 80	0
Saquoit	3406	3421	15	Gray clasts are the same as above; red are single grains, not as coated as above, mostly angular, med-fine sand size qtz; many grains are frosted.	30	0	70	0
Saquoit	3421	3433	12	Mostly red fine sand size qtz grains and composites, no med sand size grain, finer than 3406-3421.	5 to 10	0	90	0
Saquoit	3433	3442	9	Red clasts are med-fine sand size qtz grains, some are rose to clear-colored grains. Some med sand size qtz grains are frosted. The rest is fine grained ie. bimodal size distribution.	15 to 20	0	80 to 85	0
Saquoit	3442	3451	9	Gray is same as above; white is composite of angular sand size qtz, a few qtz clasts are clear, rounded, frosted, med sand size quartz grains and a few angular, unfrosted sand size qtz grains. Red grains are generally silt size qtz grains and compsites; a few rounded, frosted, med sand size qtz grains.	60	35	5 to 10	0
Saquoit	3451	3458	7	Gray clasts are very fine grained (silty shale); white grains are 1) clear, angular med sand size qtz (most abundant), 2) frosted, rounded med sand size qtz (less abundant) grains, 3) composte grains of fine silt size qtz; red clasts are same as above	50 to 60	50	10	0
Saquoit	3458	3460	2	White grains are clear, angular med sand size qtz, a few cloudy qtz grains, and a few very rounded grains.	60	25	15	0

Saquoit	3460	3463	3	White grains are clear to yellowish, angular med qtz; clear grains are so clear they look like Herkimer Diamonds, a few rounded frosted med sand grains. Gray is the same as 3458 - 3460	60 to 70	30	5	0
Saquoit	3463	3469	6	Gray is same as above; white qtz is yellowish, no Herkimer Diamonds, some round, mostly angular.	60 to 70	20	10	0
Saquoit	3469	3473	4	Two types of gray clasts, light gray very fine silt to silty shale, fine silt well sorted; darker gray is coarser fine silt same as 3463-3469; white is clear, angular qtz.	90	5	5	0
Saquoit	3473	3475	2	Gray clasts: light gray as above; white: composites w/ clear to milky angular qtz.	90	5	5	0
Saquoit	3475	3479	4	The light gray is muscovite rich, fissile shaly silt to silty shale; some with phacoidal parting; white: silt size, clear qtz composites (35%), (~10%) are fine sand size qtz composites.	55	45	0	0
Saquoit	3479	3486	7	White clasts are composites of clear to cloudy, fine sand size, rounded qtz grains; gray clasts have some fissility.	30 to 40	60	0	0
Saquoit - Wolcott	3486	3496	10	White composite clasts w/ gray to clear rounded fine sand size qtz grains; some very unsorted fine to med sand size, rare rounded, frosted med sand size qtz grains; gray clasts are shaly silts to silts	15	85	0	0
Wolcott	3496	3500	4	White is comprised of: single angular med sand size qtz grains, a few rounded frosted med sand size grains, fine sand size qtz grains (~60%), compostites w/ poorly sorted, clear qtz (10%); gray is the same as above.	10	90	0	0
Wolcott	3500	3506	6	Gray clasts are both fissile shaly silt to silty shale and silt size massive composites; white clasts are clear to yellow composites, with well sorted w/yellow to clear qtz grains; red is poorly sorted sand size qtz.	40	50	10	0
Wolcott	3506	3510	4	Gray clasts are fissile shaly silts to silty shale, white are fine sand size qtz grains	60	40	0	0
Wolcott	3510	3516	6	Gray clasts have phacoidal cleavage and fissility; white clasts are composites of fine sand size qtz grains; <5% limonite/pyrite	65	30	0	5% lithic frags/ pyr
Wolcott	3516	3519	3	Gray clasts show fissility; white clasts are clear to cloudy qtz, clear qtz is med sand size and angular grains, composites clasts w/ well sorted fine sand size qtz grains.	60	40	0	0

Wolcott	3519	3523	4	Gray clasts less fissility than above but still visible fissility; white is clear and cloudy qtz that are the same as above; a few rounded, frosted med sand size grains.	44	54	2	0
Wolcott	3523	3530	7	Gray is fissile; white clasts are clear to cloudy qtz grains, same as above but more rounded frosted grains, two types of composite grains: med size sand that is poorly sorted and fine sand size that is well sorted.	45	55	0	0
Wolcott - Sodus	3530	3536	6	Gray is the same as above; white is: 10% very angular, med sand size clear qtz grains, 10% rounded, med sand size frosted qtz grains, 50% fine sand size, angular qtz grains and 20% composite clasts w/ fine sand size, clear, angular qtz grains.	10	90	0	0
Sodus	3536	3543	7	White is comprised of 5% rounded, frosted aeolian sand grains, 5% Herkimer-like qtz crystals and 50% fine sand size qtz both single grains and composites; red clasts w/ angular sand size qtz grains.	30	60	10	0
Sodus	3543	3548	5	Red clasts are poorly sorted fine sand size qtz grains; white are large composites (25%) w/ poorly sorted fine to med sand size qtz grains and phosphate nodules, and (25%) clear to rose, angular, single qtz crystals.	30	50	20	0
Sodus - Oneida	3548	3557	9	White is clear to milky, mostly angular, fine to med sand size qtz grains; red is poorly sorted, fine sand size qtz composites.	25	65	10	0
Oneida	3557	3567	10	Unwashed sample, many rounded, frosted, med sand size qtz grains.	20	80	0	0
Oneida	3567	3574	7	Fairly well sorted, fine to med sand (mostly single qtz grains); clear to yellow qtz, many prisms. About 1% is rounded, frosted med sand size qtz; some composite clasts with phosphate nodules.	10	90	0	0
Oneida	3574	3581	7	Fairly well sorted, fine to medium sand size angular clear qtz grains; rare rounded, med sand size qtz grains.	5	95	0	0
Oneida	3581	3585	4	Same as 3574 to 3581	5	95	0	0
Oneida	3585	3589	4	Same as 3574 to 3581 and rare rounded, med sand size qtz grains.	5	95	0	0
Oneida	3589	3593	4	White: similar to 3574-3581 but more angular qtz grains and less well sorted.	40	60	0	0

Oneida	3593	3596	3	Gray clasts are fissile; white composite clasts with phosphate nodules (10%) and the remainder (45%) are single qtz grains, more rounded than above.	45	55	0	0
Formation	Top	Bottom	Interval	Description	Gray (stsh to shst)	White (qtz)	Red (silt)	Other
Oneida - Grimsby	3596	3601	5	White Clasts are fairly well sorted, fine sand size qtz, same as 3567-3574; gray clasts are the same as 3593-3596.	40	60	0	0
Grimsby	3601	3610	9	Almost no composite clasts, white grains are mostly fine sand size, clear, angular qtz, some (5%) are rounded, frosted med sand size qtz grains. Sample is well sorted.	10	90	0	0
Grimsby	3610	3613	3	Same as 3601 to 3610, has more of a red component	10	85	5	0
Grimsby	3613	3633	20	White component is fine to med sand size composites and some coarse sand size single grains of cloudy to clear qtz. Qtz grains are poorly sorted and angular to moderately rounded to well rounded.	5	90	0	0
Grimsby	3633	3635	2	The gray is not as fissile as above, the white is angular moderately rounded, light gray fine sand size qtz.	75	25	0	0
Grimsby	3635	3655	20	Same as above (3633-3635)	75	25	0	0
Grimsby	3635	3661	26	Unwashed, fine sands, silts and silty shaes	50	50	0	0
Grimsby	3661	3669	8	Unwashed	50	50	0	0

Oriskany	2138	2146	8	100% light gray, crystalline limestone	0	0	0	100% ls
Oriskany	2146	2156	10	3 types of limestone: 1) light gray, 2) white, and 3) dark gray - black/brown. No qtz except for 1 grain.	0	0	0	100% ls
Oriskany	2156	2168	12	Same as 2146-2156	0	0	0	100% ls

Well Name: Amoco's Bellows #1 | Prepared by: DAB
9-Jan-00

Natural Flow			
	Mcf at		Ft
	Mcf at		Ft
	Mcf at		Ft
	Mcf at		Ft
N A	Mcf at	N A	TD

Grain Density: 2.68
Formation Water Resistivity: 0.07
Type of Fluid in Hole: H_2O

Gamma Ray Environment Correction	
Gamma Ray Shale	160
Gamma Ray Sand	20

Zone	Depth	Total Feet	Gamma Ray	Bulk Density	Resis.	PHIn	T-Kick	PHIe	Sg	GIP (MMcf)	Recoverable Reserves (MMCF)	
Herkimer SS	3,455	7.0	110	2.60	150	7.0%	3	3.6%	57.9%	29	22	Calculated porosity less than 6%!
	3,462	4.0	60	2.55	150	8.0%	3	7.7%	80.9%	52	39	
Total Herkimer:		11.0								81	61	
Onieda SS	3,802	6.0	25	2.52	200	3.0%	3	6.6%	80.7%	74	55	
	3,812	6.0	30	2.54	250	3.0%	3	5.9%	80.8%	67	50	Calculated porosity less than 6%!
	3,838	5.0	40	2.57	80	2.0%	3	4.4%	54.3%	28	21	Calculated porosity less than 6%!
	3,846	3.0	40	2.56	250	2.0%	3	4.7%	75.6%	25	19	Calculated porosity less than 6%!
	3,850	5.0	25	2.48	125	7.0%	3	9.7%	83.6%	95	72	
	3,855	3.0	40	2.55	90	1.0%	3	4.7%	60.1%	20	15	Calculated porosity less than 6%!
	3,865	5.0	30	2.53	125	1.0%	3	5.3%	69.8%	44	33	Calculated porosity less than 6%!
Total Oneida:		33.0								352	264	
Total		37.0								433	325	

Comments and Assumptions: 1. Assumes recovery factor of 75%

TABLE 4
Log Analysis Worksheet
Bellows #1

Well Name: Amoco's Hoose #1

9-Jan-00

Prepared by: DAB

Natural Flow			
	Mcf at		Ft
	Mcf at		Ft
	Mcf at		Ft
	Mcf at		Ft
N A	Mcf at	N A	TD

Grain Density: 2.68

Formation Water Resistivity: 0.07

Type of Fluid in Hole: H2O

Gamma Ray Environment Correction	
Gamma Ray Shale	160
Gamma Ray Sand	20

Zone	Depth	Total Feet	Gamma Ray	Bulk Density	Resis.	PHIn	T-Kick	PHIe	Sg	GIP (MMcf)	Recoverable Reserves (MMCF)	
Herkimer SS	2,923	11.0	30	2.57	45	3.0%	3	5.0%	47.0%	45	33	**Calculated porosity less than 6%!**
	2,934	6.0	25	2.60	300	3.0%	3	4.2%	75.5%	33	25	**Calculated porosity less than 6%!**
	2,940	7.0	35	2.53	250	5.0%	3	7.1%	84.1%	72	54	
	2,950	13.0	45	2.55	70	5.0%	3	6.4%	66.5%	96	72	
	2,963	7.0	45	2.55	20	7.0%	3	7.4%	45.9%	41	31	
Total Herkimer:		44.0								287	215	
Onieda SS	3,227	8.0	20	2.40	65	5.5%	3	11.4%	80.5%	141	106	
	3,279	7.0	30	2.52	50	3.0%	3	6.5%	61.0%	54	41	
	3,286	12.0	20	2.55	300	2.0%	3	5.3%	80.4%	99	75	**Calculated porosity less than 6%!**
Total Oneida:		27.0								294	221	
Total		71.0								581	436	

Comments and Assumptions: 1. Assumes recovery factor of 75%

TABLE 4 (cont.)
Log Analysis Worksheet
Hoose #1

Well Name: best case 2

9-Jan-00

Prepared by: DAB

Natural Flow			
	Mcf at		Ft
	Mcf at		Ft
	Mcf at		Ft
	Mcf at		Ft
N A	Mcf at	N A	TD

Grain Density: 2.68

Formation Water Resistivity: 0.07

Type of Fluid in Hole: H_2O

Gamma Ray Environment Correction	
Gamma Ray Shale	160
Gamma Ray Sand	20

Zone	Depth	Total Feet	Gamma Ray	Bulk Density	Resis.	PHIn	T-Kick	PHIe	Sg	GIP (MMcf)	Recoverable Reserves (MMCF)
Herkimer SS	3,455	7.0	110	2.40	200	7.0%	3	9.3%	86.4%	117	88
	3,462	4.0	60	2.40	200	8.0%	3	12.1%	89.5%	90	67
Total Herkimer:		11.0								207	155
Onieda SS	3,802	6.0	25	2.40	200	3.0%	3	10.1%	87.4%	122	92
	3,812	6.0	30	2.40	200	3.0%	3	10.0%	87.3%	122	91
	3,836	5.0	40	2.40	200	2.0%	3	9.3%	86.5%	95	71
	3,846	3.0	40	2.40	200	2.0%	3	9.3%	86.5%	57	43
	3,850	5.0	25	2.40	200	7.0%	3	12.1%	89.5%	127	95
	3,855	3.0	40	2.40	200	1.0%	3	9.1%	86.1%	55	42
	3,865	5.0	30	2.40	200	1.0%	3	9.1%	86.1%	92	69
Total Oneida:		33.0								670	503
Total		37.0								877	658

Comments and Assumptions:

1. Assumes recovery factor of 75%
2. Assumes 2.4 Bulk Density and 200 Ohms resistivity
3. Otherwise, log data taken from Bellows #1

TABLE 4 (cont.)
Log Analysis Worksheet
Mid-Case Scenario

Well Name: **Best case scenario** **Prepared by:** **DAB**
9-Jan-00

Natural Flow			
	Mcf at		Ft
	Mcf at		Ft
	Mcf at		Ft
	Mcf at		Ft
N A	Mcf at	N A	TD

Grain Density: 2.68
Formation Water Resistivity: 0.07
Type of Fluid in Hole: H2O

Gamma Ray Environment Correction	
Gamma Ray Shale	160
Gamma Ray Sand	20

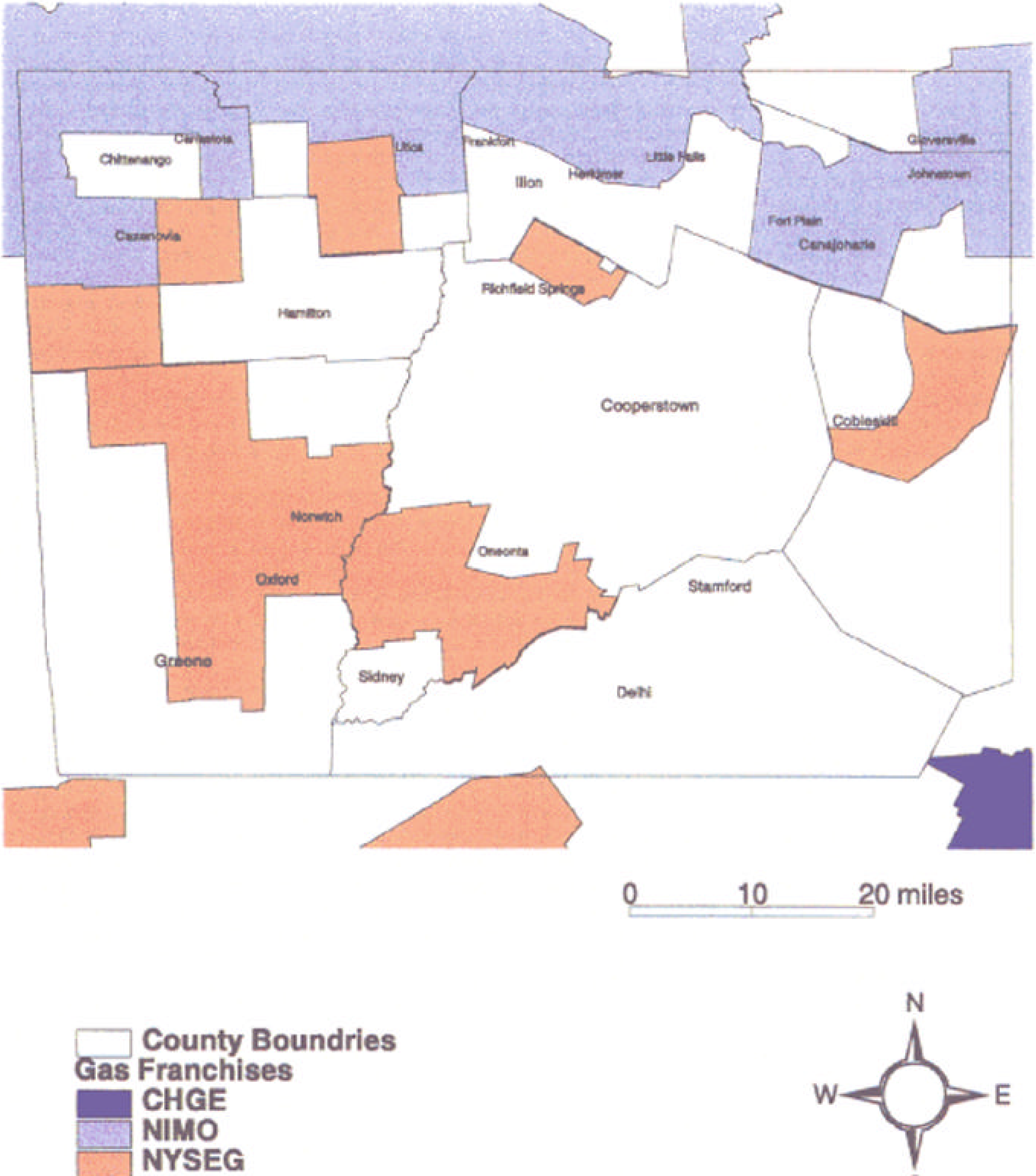
Zone	Depth	Total Feet	Gamma Ray	Bulk Density	Resis	PHIn	T-Kick	PHIe	Sg	GIP (MMcf)	Recoverable Reserves (MMCF)
Herkimer SS	2,923	11.0	30	2.40	200	3.0%	3	10.0%	87.3%	165	124
	2,934	6.0	25	2.40	200	3.0%	3	10.1%	87.4%	91	68
	2,940	7.0	35	2.40	200	5.0%	3	10.9%	88.4%	117	88
	2,950	13.0	45	2.40	200	5.0%	3	10.8%	88.3%	214	161
	2,963	7.0	45	2.40	200	7.0%	3	11.8%	89.3%	128	96
Total Herkimer:		44.0								715	536
Onieda SS	3,227	8.0	20	2.40	200	5.5%	3	11.4%	88.9%	155	117
	3,279	7.0	30	2.40	200	3.0%	3	10.0%	87.3%	119	90
	3,286	12.0	20	2.40	200	2.0%	3	9.6%	86.9%	197	148
Total Oneida:		27.0								472	354
Total		71.0								1,187	890

Comments and Assumptions:

1. Assumes recovery factor of 75%
2. Assumes 2.4 Bulk Density and 200 Ohms Resistivity
3. Otherwise, log data taken from Hoose #1

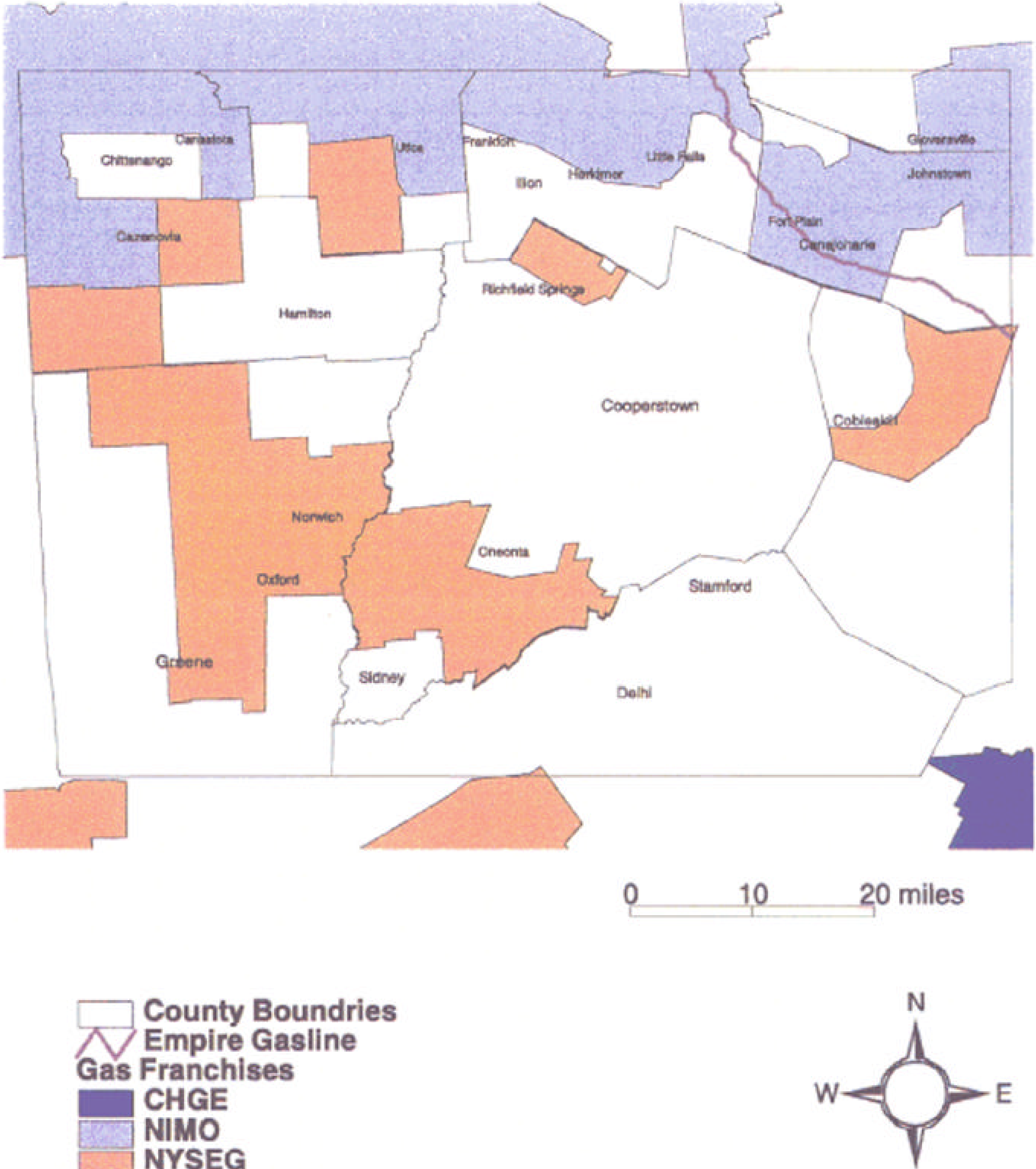
TABLE 4 (cont.)
Log Analysis Worksheet
Best Case Scenario

Gas Franchises



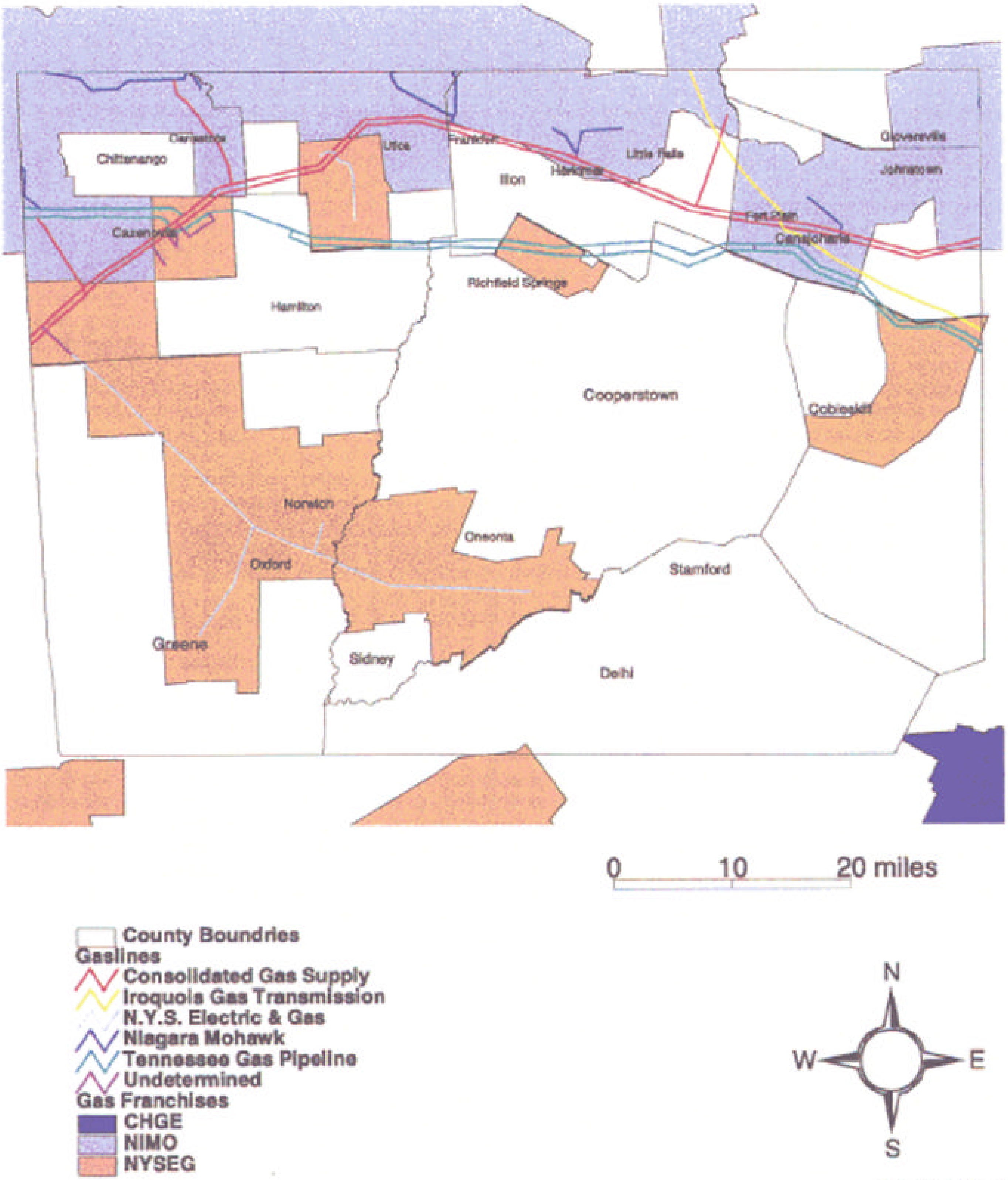
APPENDIX A
Figure 1

Empire Gasline & Gas Franchises



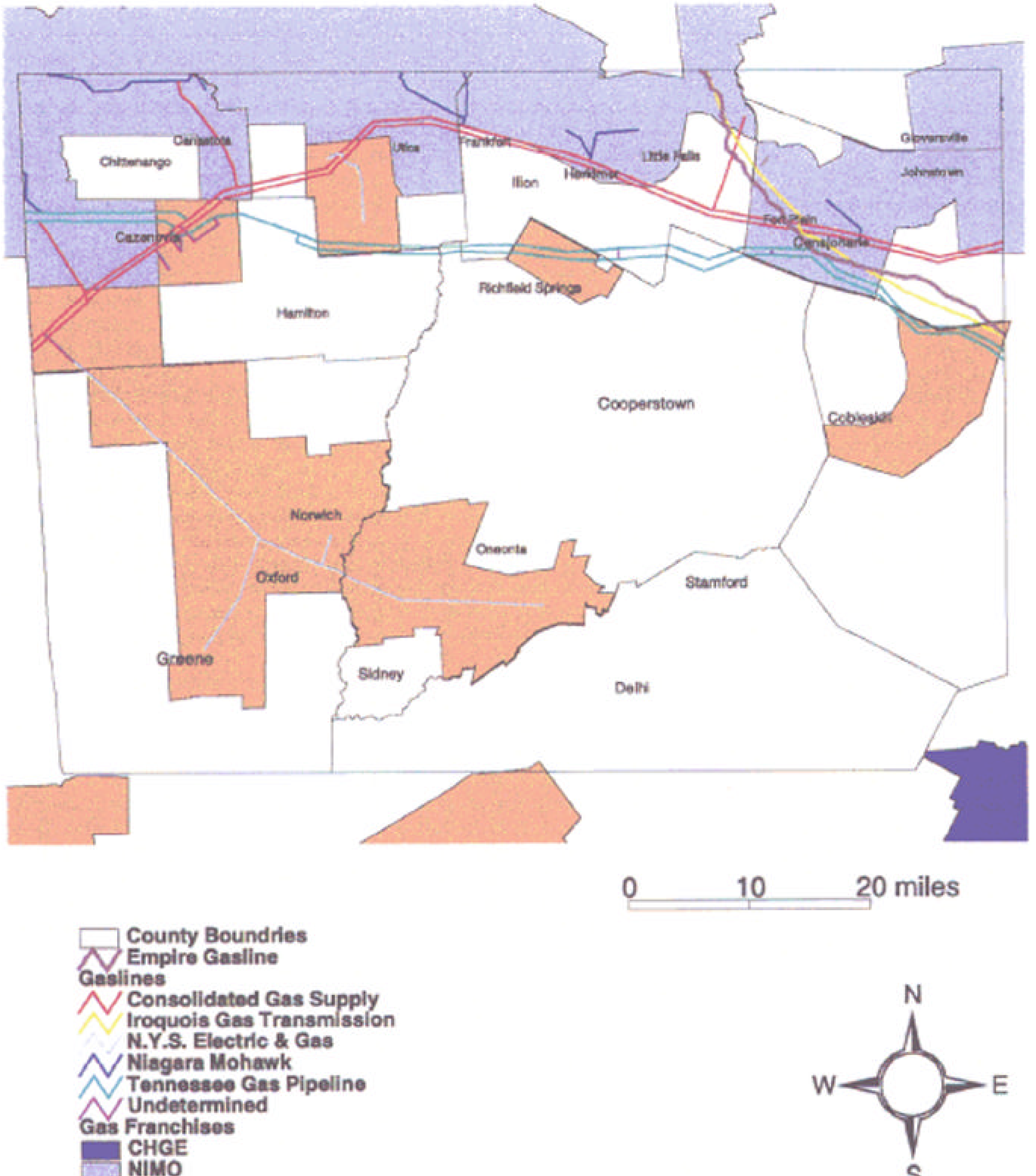
APPENDIX A
Figure 2

Gaslines & Gas Franchises



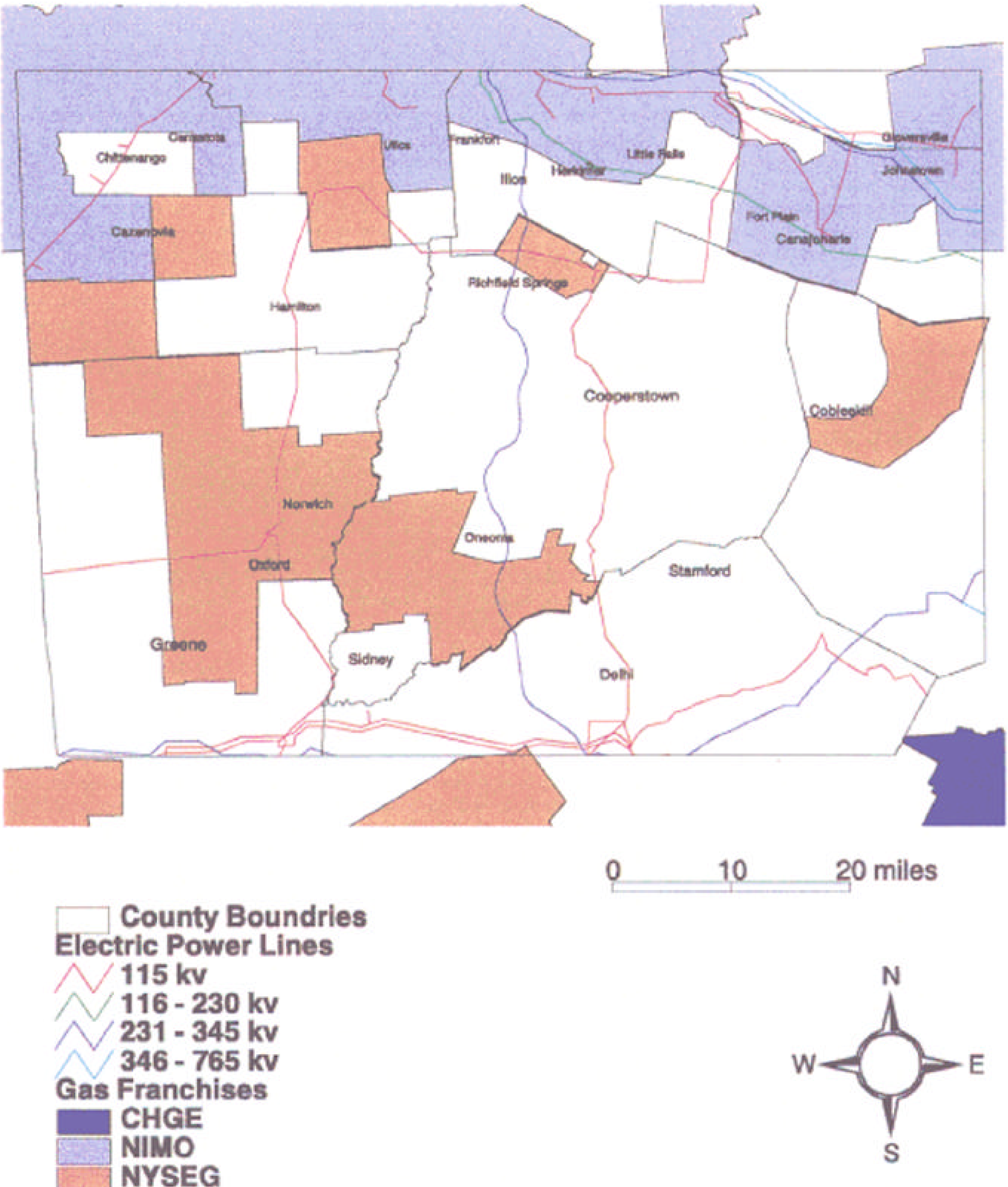
APPENDIX A
Figure 3

Empire Gasline, Gaslines & Gas Franchises



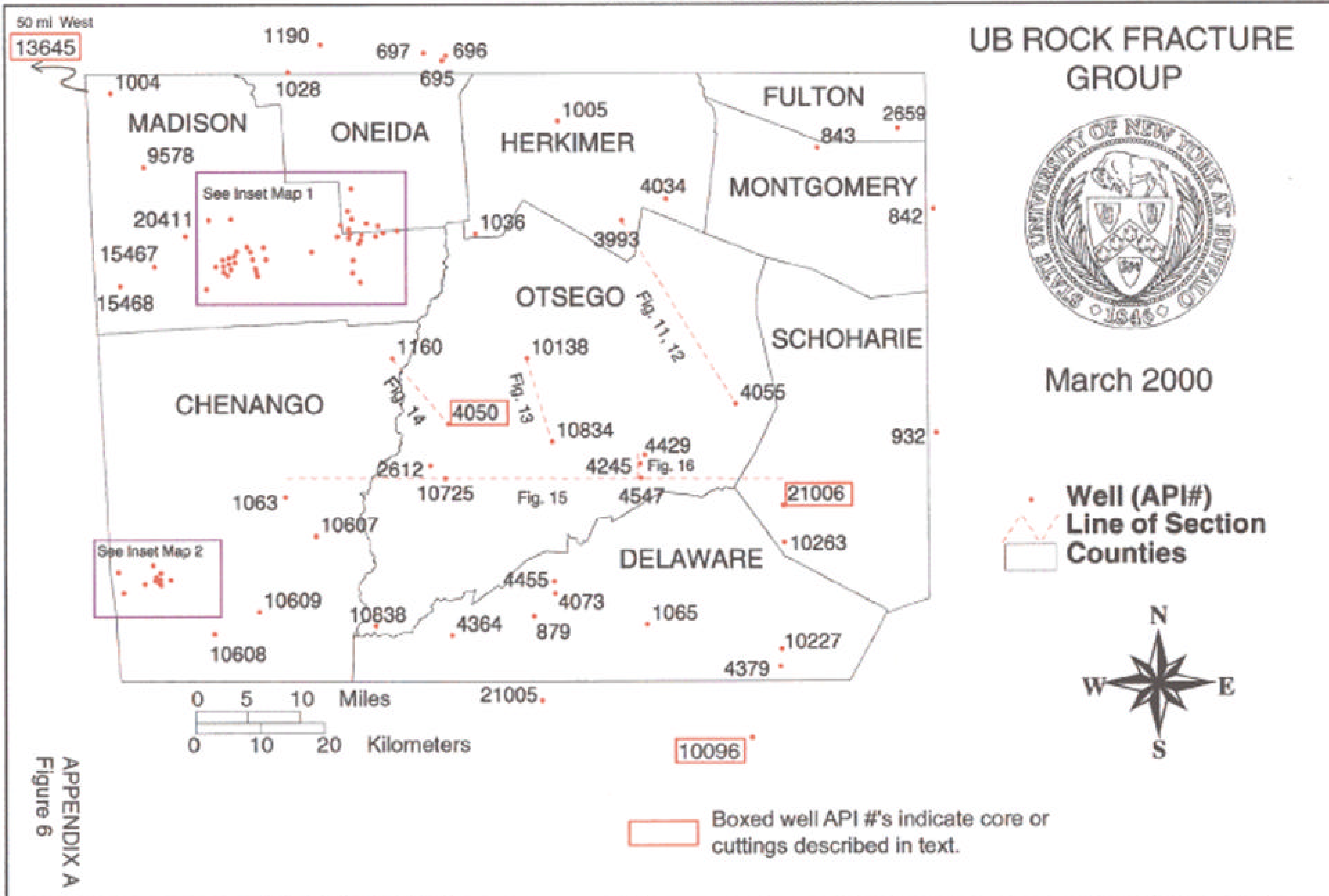
APPENDIX A
Figure 4

Electric Power Lines & Gas Franchises



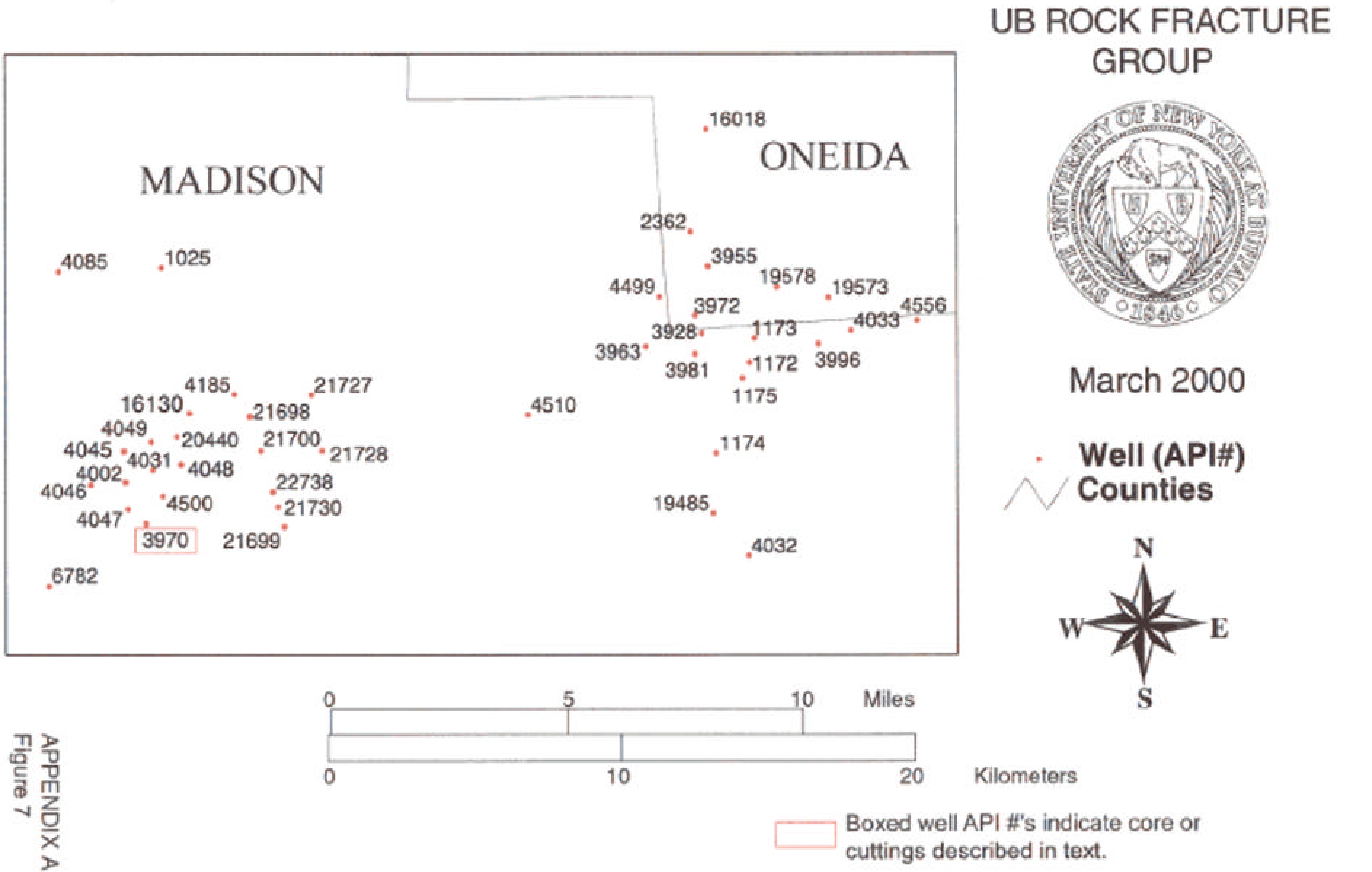
APPENDIX A
Figure 5

WELL LOCATIONS



APPENDIX A
Figure 6

INSET 1

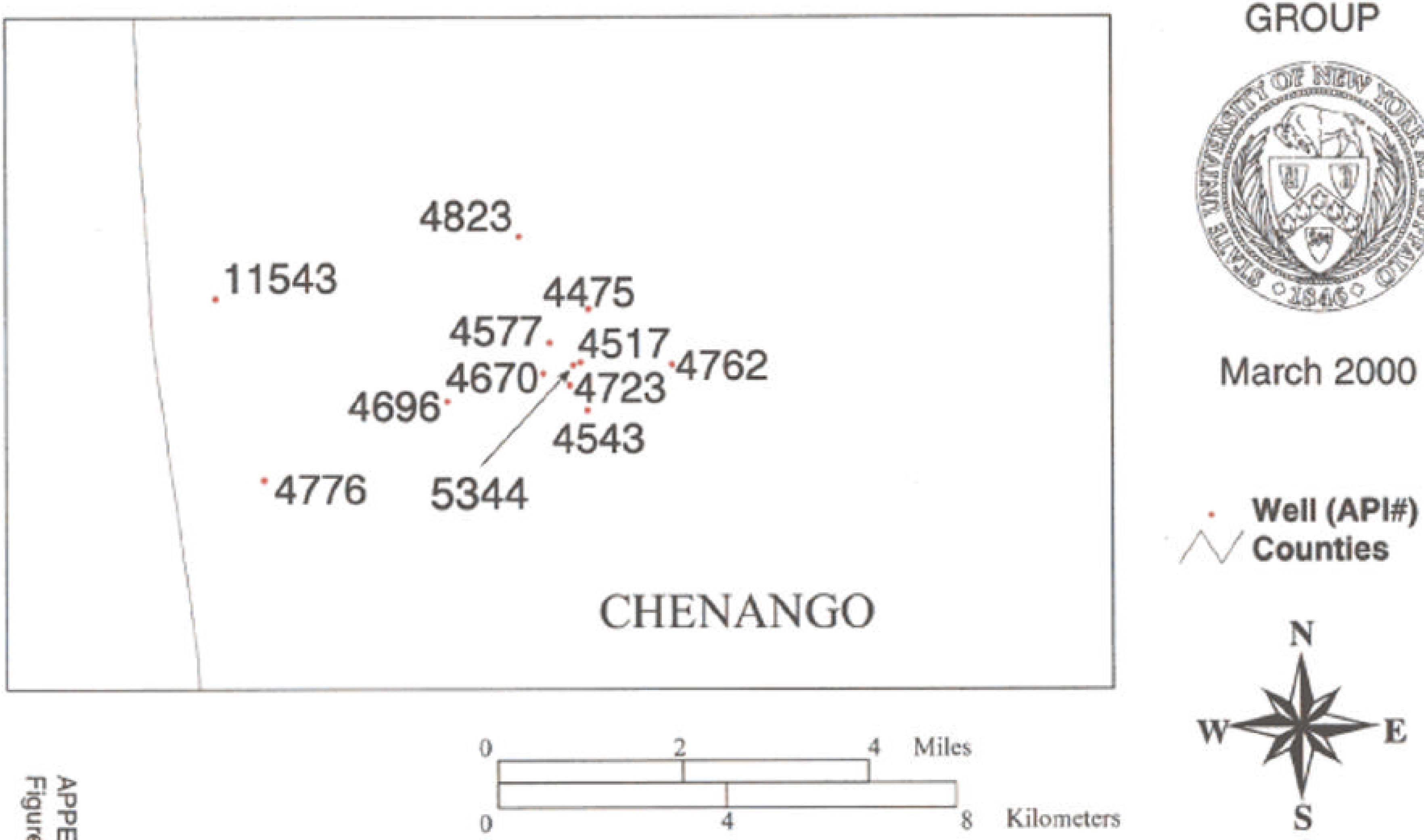


APPENDIX A
Figure 7

INSET 2

UB ROCK FRACTURE GROUP

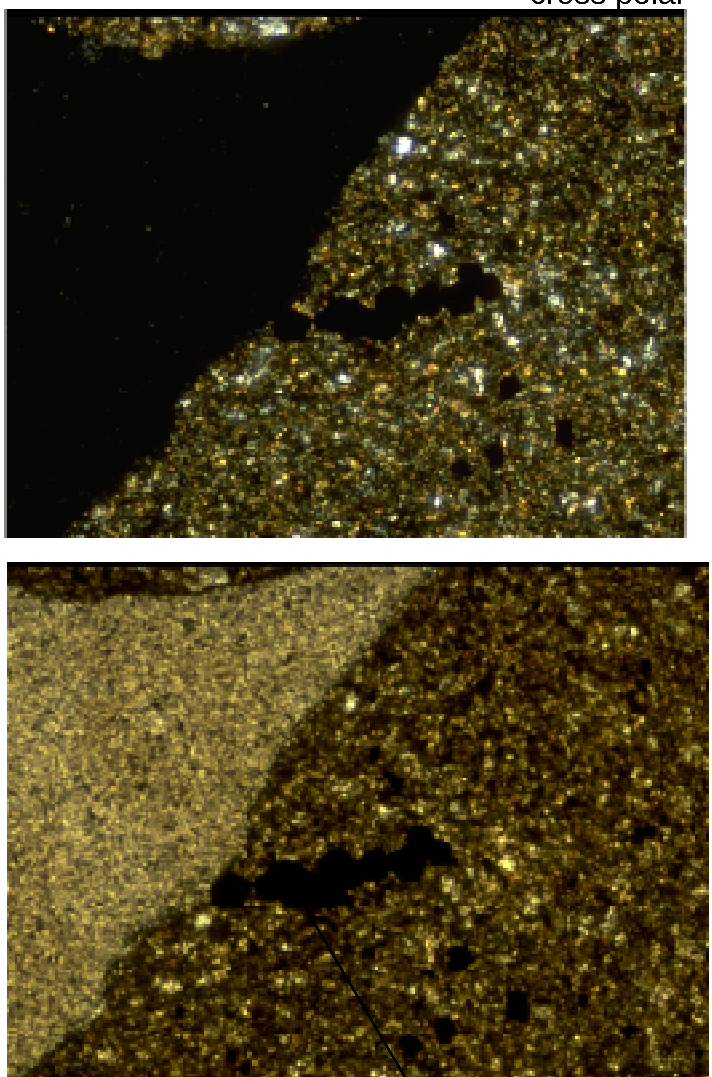
March 2000



APPENDIX A
Figure 8

Well # 3970
Br39 (586 - 710)
Skaneateles Fm.
Middle Devonian

cross polar



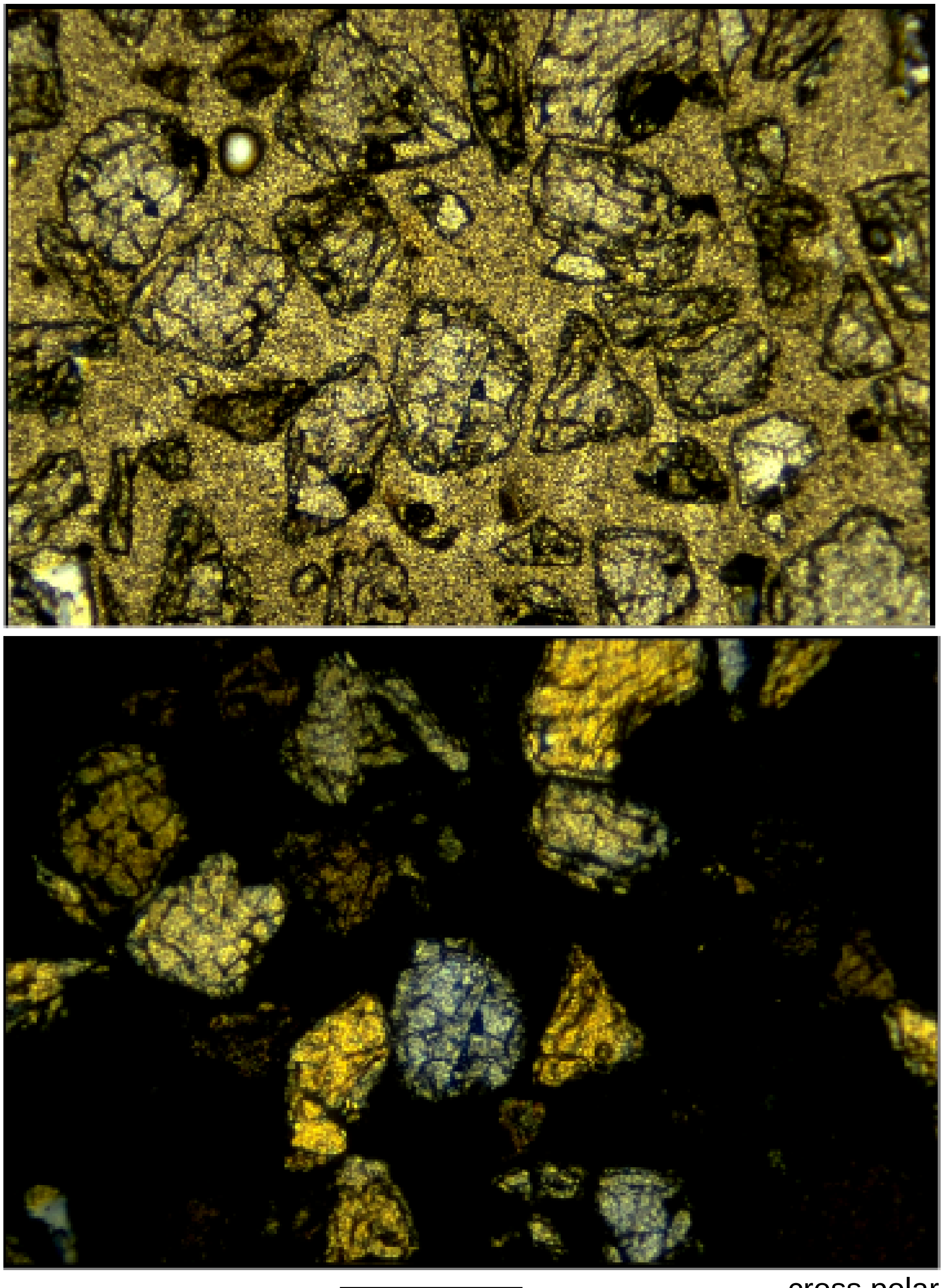
plain light

framboids of pyrite

0.5 mm

Well # 3970
Br46 (1324 - 1332)
Oriskany Fm.
Lower Devonian

plain light

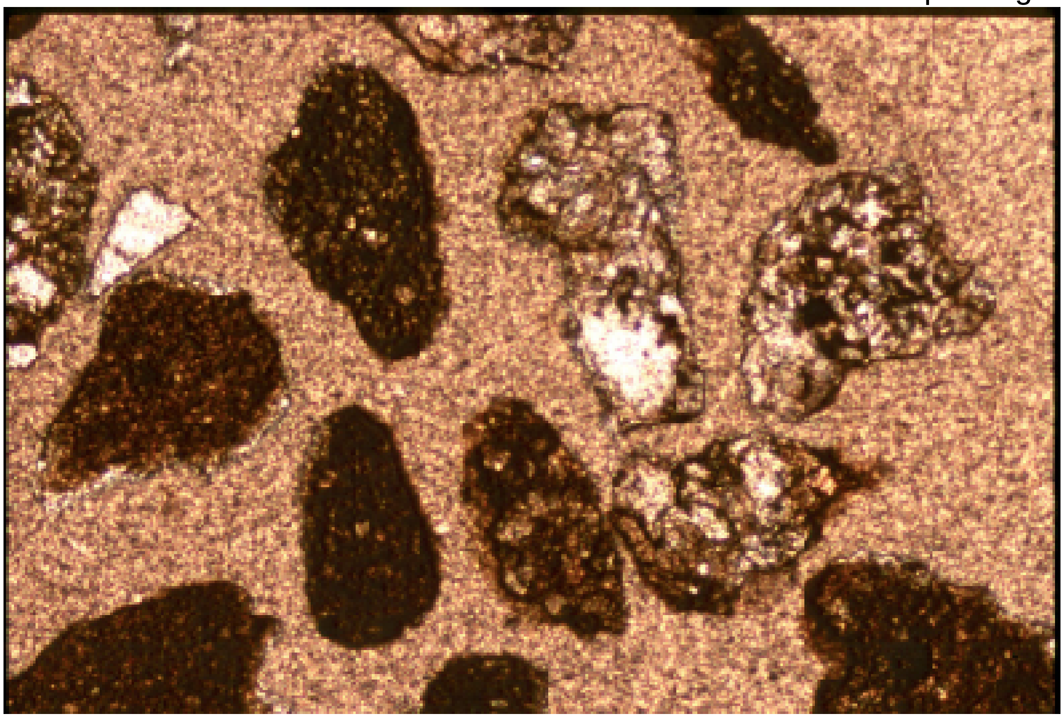


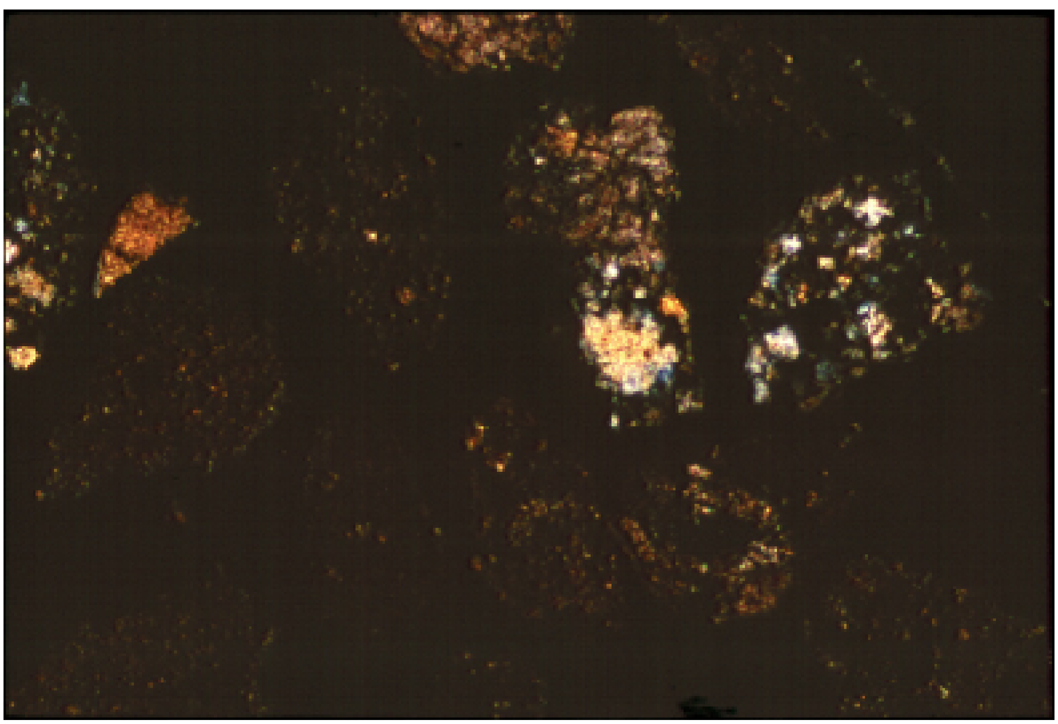
0.5 mm

cross polar

Well # 3970
UB2 (2672 - 2686)
Clinton Group
Upper Silurian

plain light



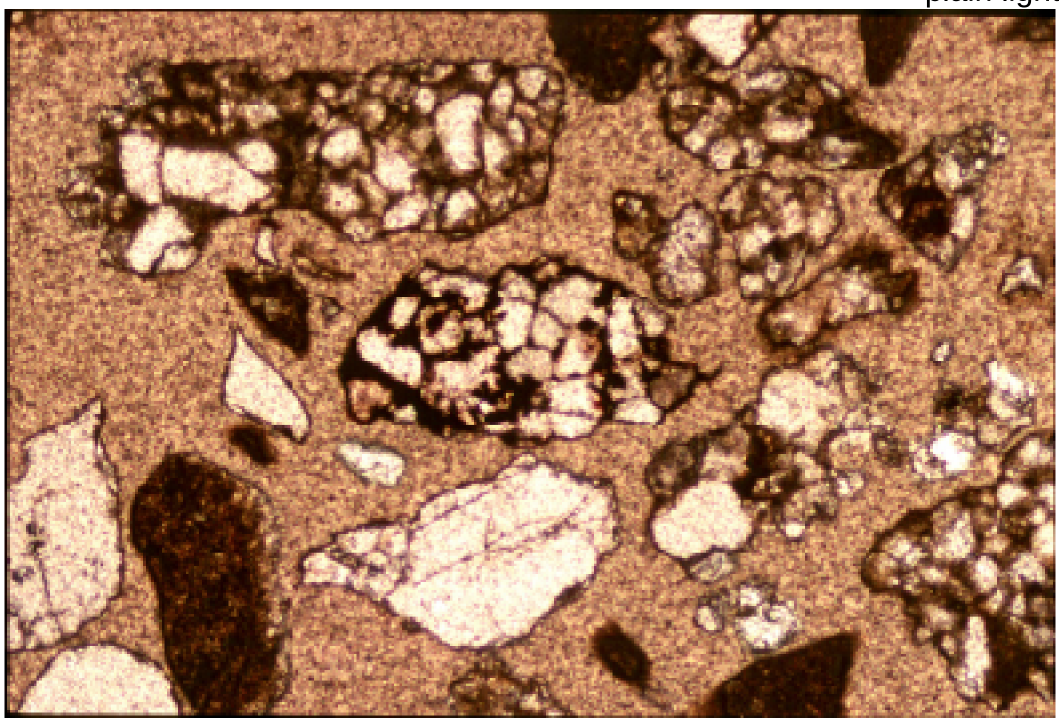


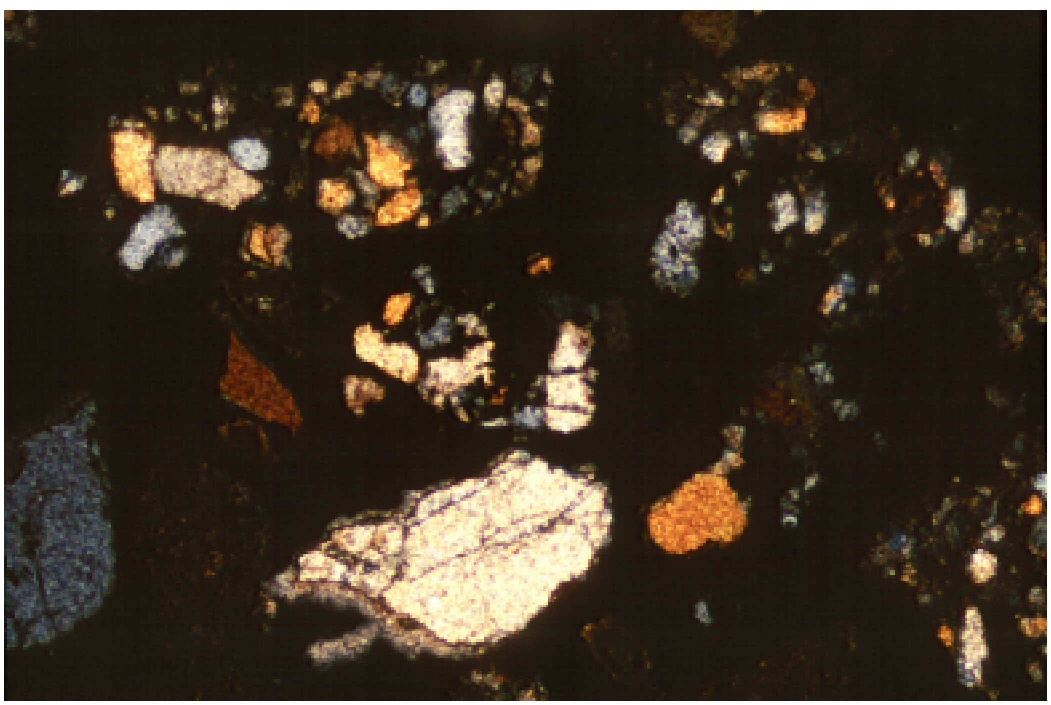
cross polar

0.5 mm

Well # 3970
UB3 (3000 - 3010)
Sauquoit Fm.
Lower Silurian

plain light



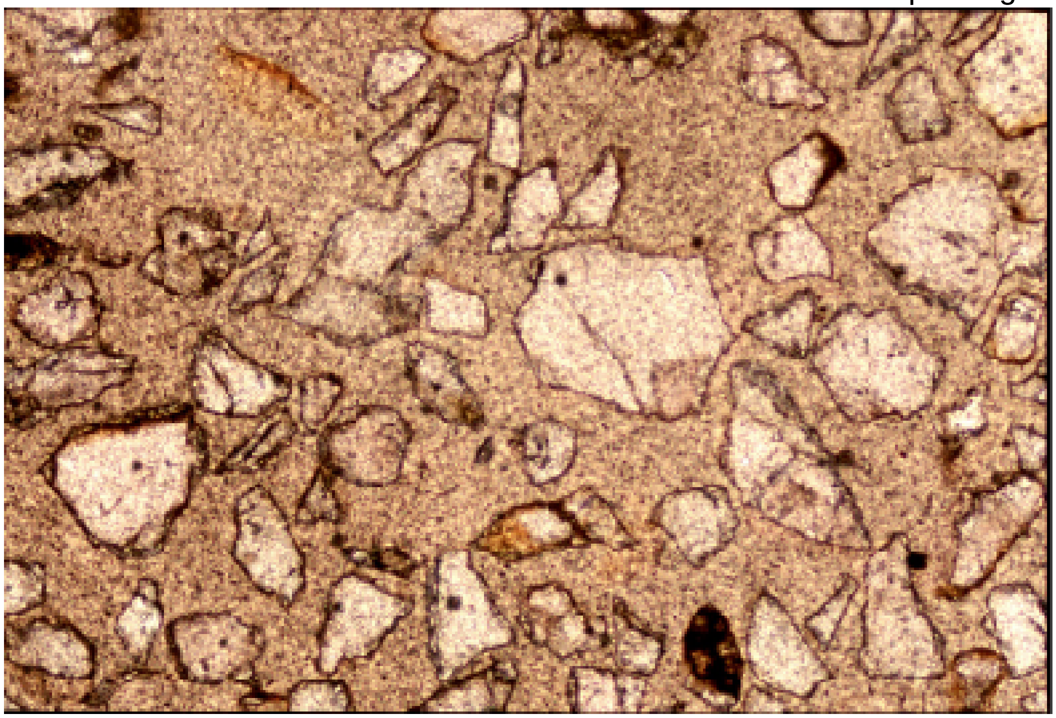


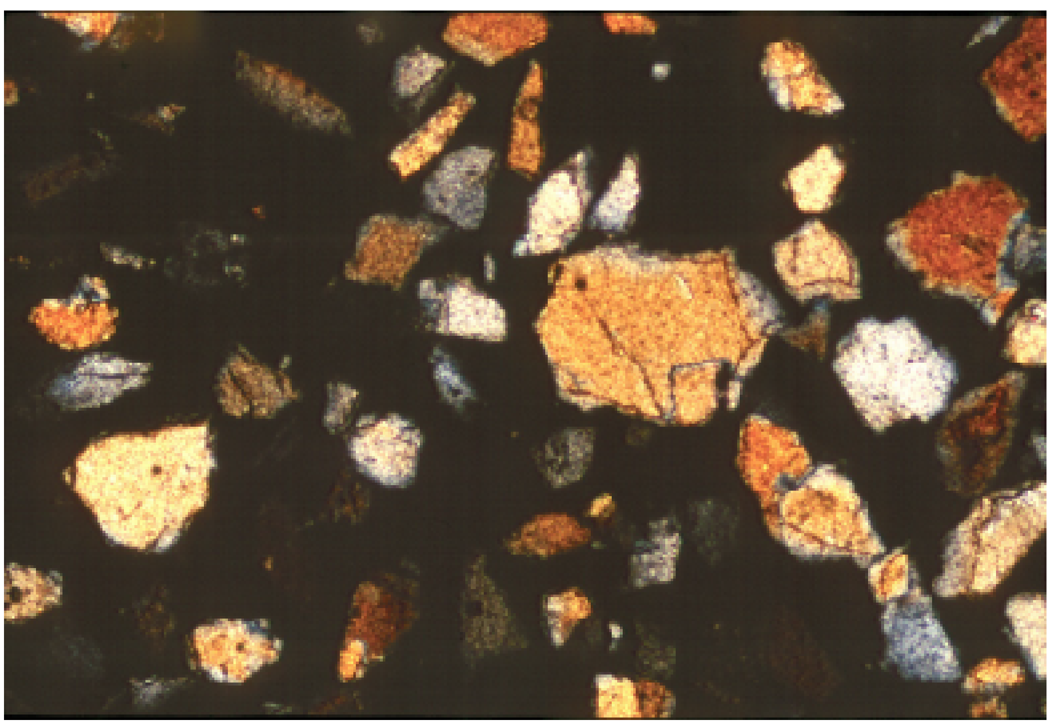
cross polar

0.5 mm

Well # 3970
UB4 (3033 - 3045)
Oneida Fm.
Lower Silurian

plain light



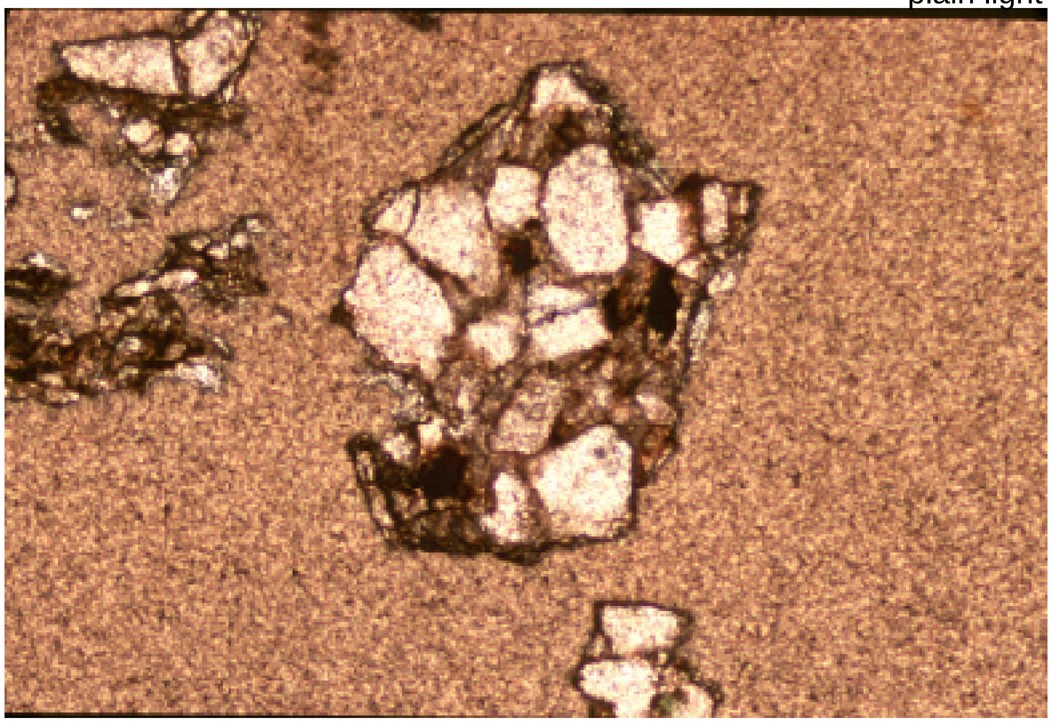


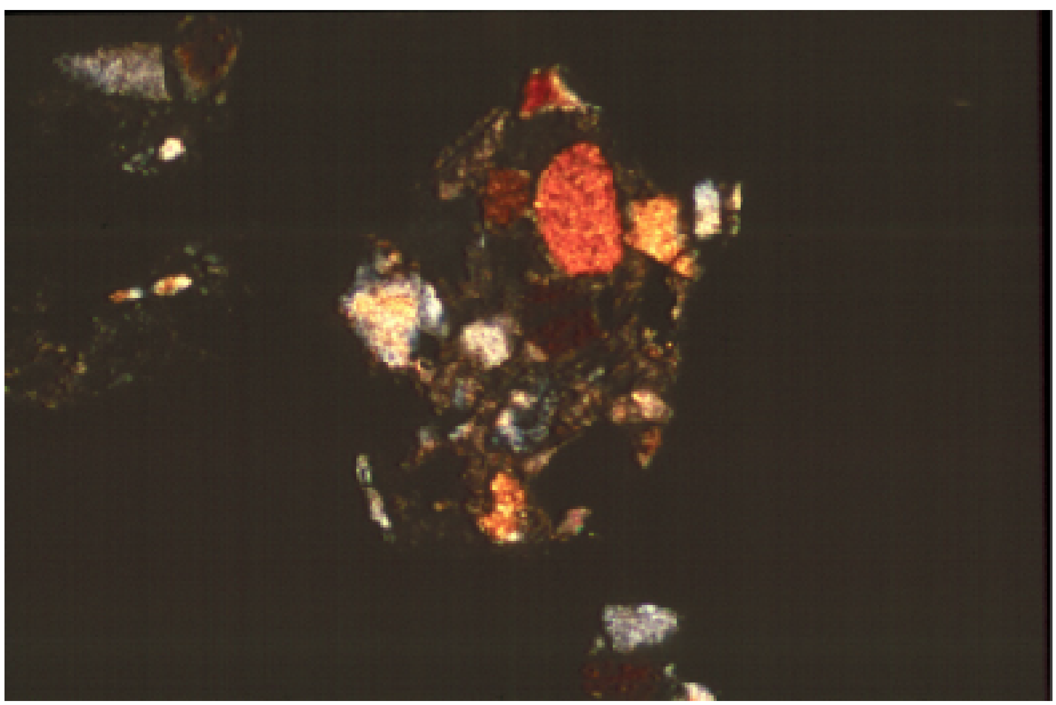
cross polar

0.5 mm

Well # 3970
UB8 (3141 - 3155)
Queenston Fm.
Upper Ordovician

plain light



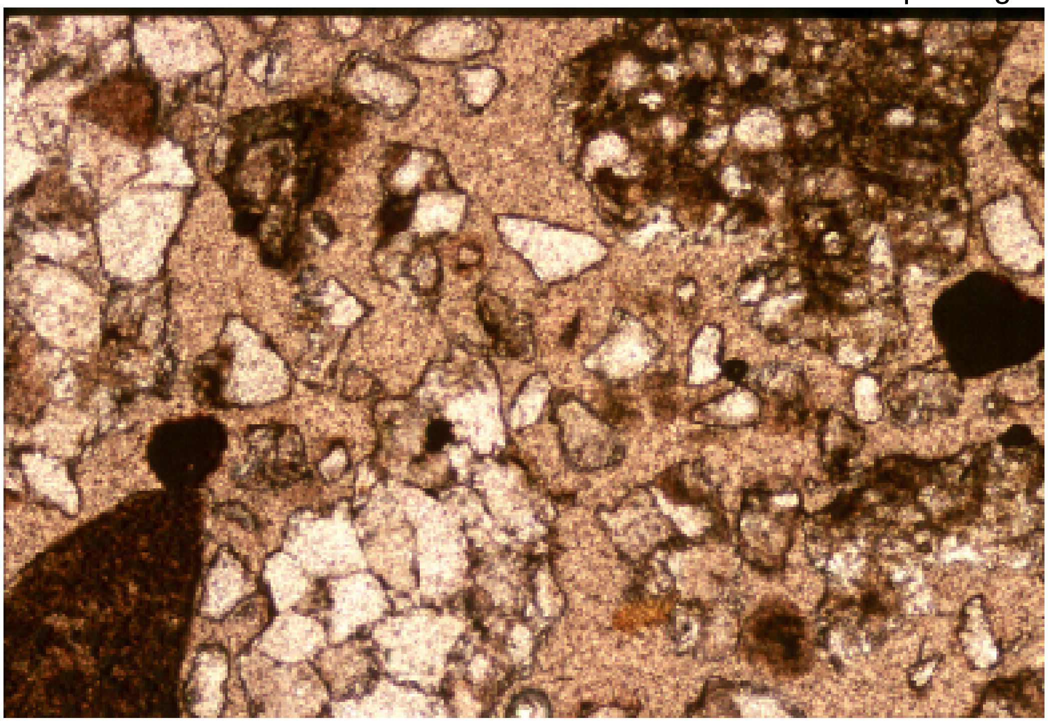


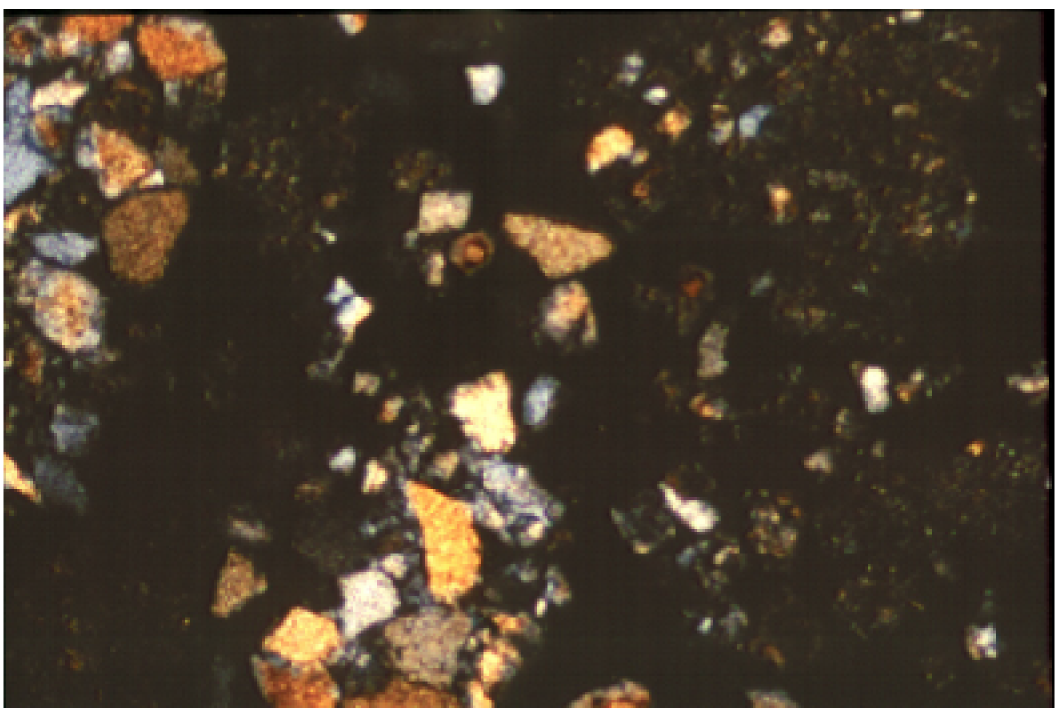
cross polar

0.5 mm

Well # 3970
UB10 (3191 - 3212)
Oswego Fm.
Upper Ordovician

plain light



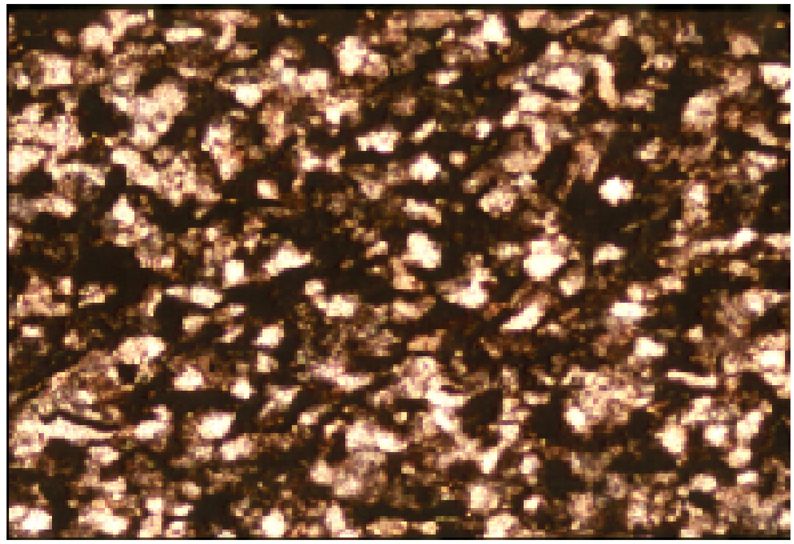


cross polar

0.5 mm

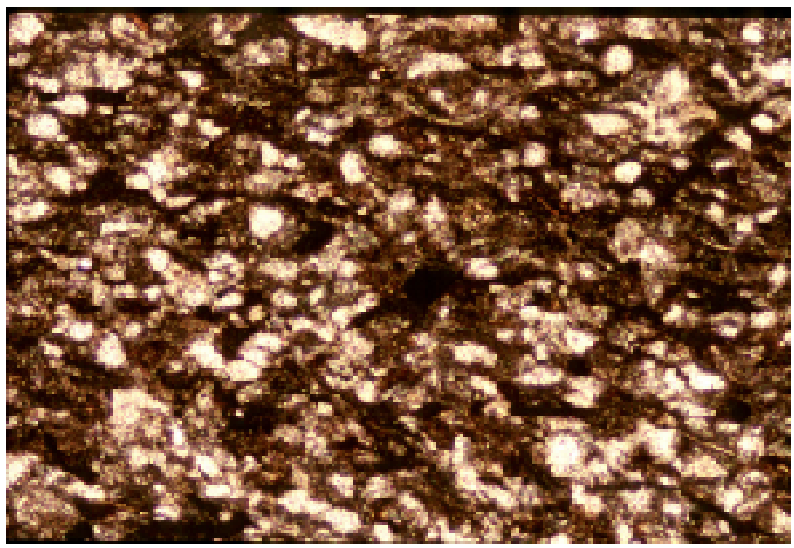
Well # 21006
Gilboa Fm.
Middle Devonian

867 (1)

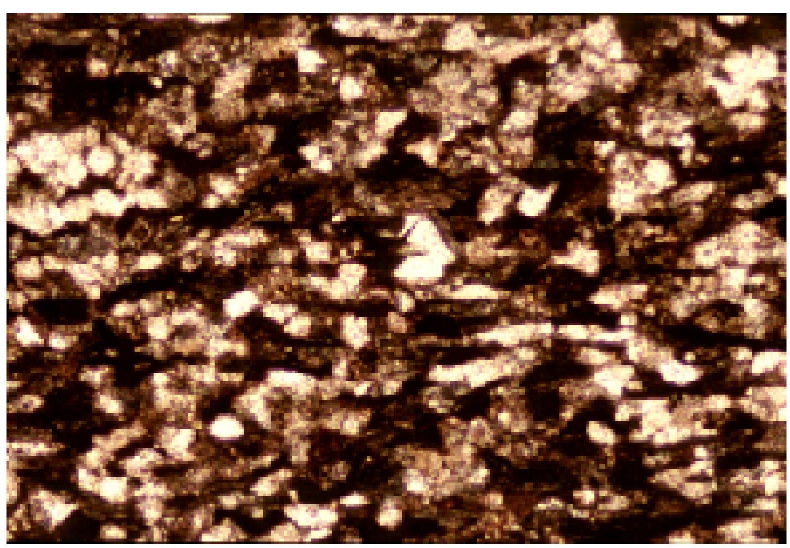


0.5 mm

823.33
photo 1



823.33
photo 2



all photos are plain light exposures