SUBSURFACE EXPRESSION AND GAS PRODUCTION OF DEVONIAN BLACK SHALES IN WESTERN NEW YORK

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INTRODUCTION

Recent work attempting to refine our understanding of the Middle and Upper Devonian black shales of the Appalachian Basin has been undertaken by a number of agencies and individuals in several eastern states as part of the U. S. Department of Energy's Eastern Gas Shales Project. The EGSP was initiated in 1976 as part of the U. S. Department of Energy's Unconventional Gas Recovery Program. This multi-year project was designed to study the Devonian black shales of the eastern United States, to develop new and improved methods of exploiting their indigenous gas reserves, and to promote commercial development of this gas resource. The project is part of a long-range plan to increase the ultimate recovery of gas from these shales in an attempt to supplement local supplies and to lessen United States dependency on foreign energy sources.

The New York portion of this study was accomplished by a team under the direction of the author at the Alfred Oil and Gas Office of the Geological Survey, New York State Museum. Dr. L. Rickard of the Albany office of the survey was associated with this group during the early phases of the project. Approximately 18,000 square miles of the State are underlain by one or more Devonian black shale formations.

STRATIGRAPHY

The Devonian black shales of New York are included in the Middle Devonian Hamilton Group and the Genesee, Sonyea, West Falls and Canadaway Groups of the Upper Devonian (See fig. 1). The following discussion of these groups and their black shales summarizes the pertinent subsurface stratigraphy that we found from studies of gamma ray well logs and drill cuttings samples. It appears that the black shale tongues are a reasonable approximation of time planes. The tongues probably represent a single episode of deposition and make it possible to reconstruct the depositional history of this complex section. Sutton (1963) has previously suggested that the Upper Devonian black shale tongues, "appear to be the closest approach to time planes".

MIDDLE AND UPPER DEVONIAN STRATIGRAPHY OF WESTERN AND WEST-CENTRAL NEW YORK

SHOWING MAJOR BLACK SHALE UNITS

(NOT TO SCALE)

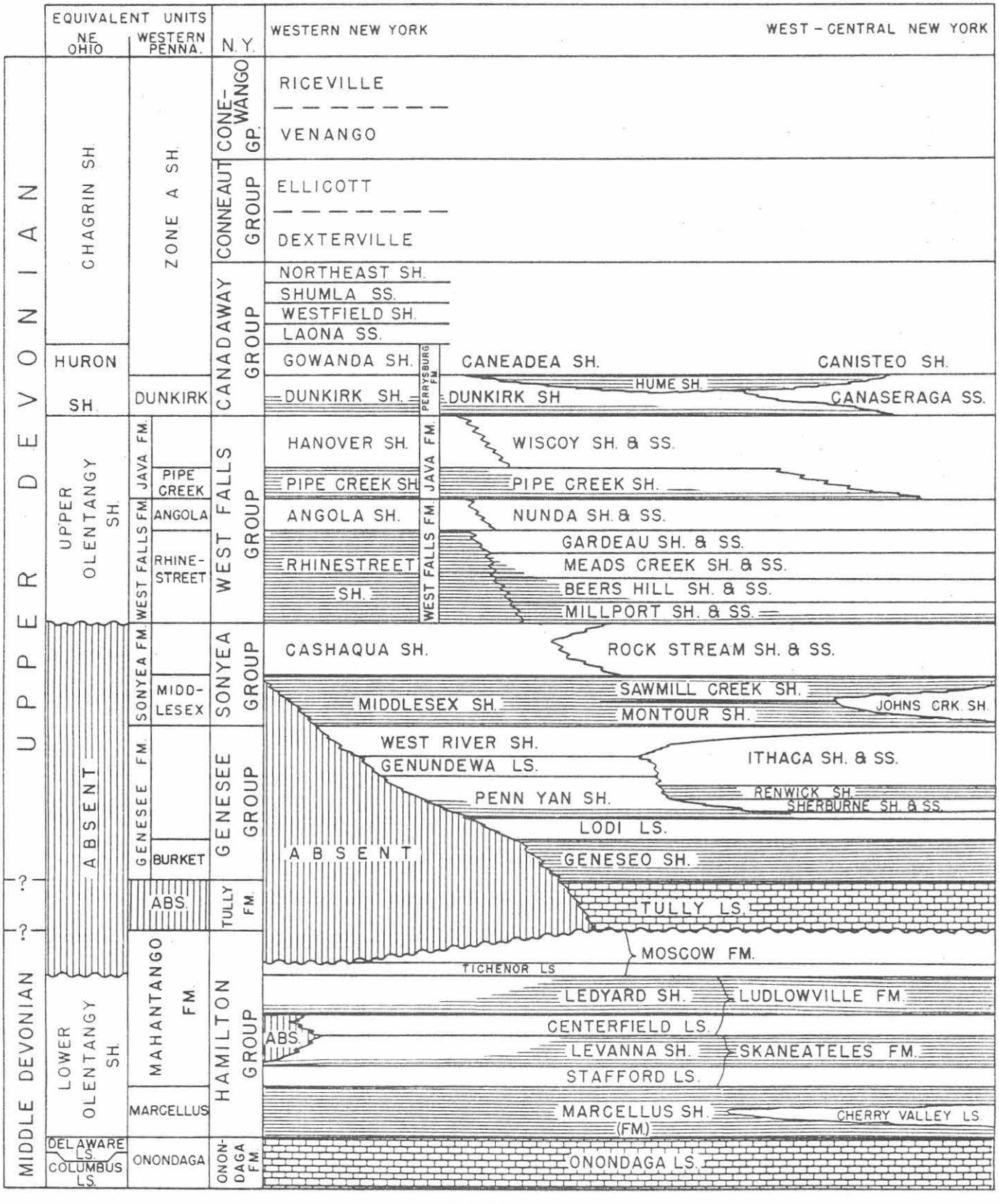

FIGURE 1

Hamilton Group

The base of the Hamilton (base Marcellus), the lowest of the units studied, lies conformably upon the Onondaga limestone (Rickard, 1975). In ascending order, the group is composed of the Marcellus, Skaneateles, Ludlowville and Moscow Formations. At the outcrop, the three formations above the Marcellus have been delineated by persistent basal limestone beds and these are also traceable in the subsurface. The Stafford limestone lies at the base of the Skaneateles and the Centerfield limestone forms the base of the Ludlowville. Recent work by Baird (1979) has shown that the Tichenor-Portland Point is the basal limestone bed of the Moscow. Previous work by Cooper (1930) had placed the Tichenor within the upper Ludlowville as shown by Rickard (1975). The top of the Hamilton (top of Moscow) is at a regional unconformity overlain by the Tully limestone from eastern to west-central New York (where the Tully wedges out) and by progressively younger beds westward to Lake Erie (fig. 1). The total thickness of the Hamilton increases from 235 feet at Lake Erie to more than 2,800 feet in Ulster and Greene Counties in eastern New York, a distance of about 300 miles.

The Marcellus Formation consists mainly of massive black shales. The basal Union Springs black shale is the most highly radioactive shale in the entire New York Devonian section. It is recognized by a distinctive strong righward deflection on a gamma ray well log. The Union Springs is overlain by the thin, dark Cherry Valley limestone which is quite distinctive in eastern and central New York but which passes westward into a calcareous shale zone. This occurs in the area of Allegany and Livingston Counties in western New York. At the outcrop it is not present west of the Geneva area in Ontario County.

Above the Cherry Valley in eastern New York, the massive Marcellus black shales are represented by the Chittenango shale. This shale passes westward into the Oatka Creek black shale which is overlain by the thin Stafford limestone, the basal member of the succeeding Skaneateles Formation. Our correlations indicate that the Oatka Creek thickens in Chautauqua County, the western part of Erie County, and northwestern Cattaraugus County. Eastward from Cattaraugus County the Marcellus gradually thickens.

The three thin limestone beds in the lower Hamilton (Cherry Valley, Stafford and Centerfield) are convenient for subdividing the group but have caused some confusion in gamma ray log correlation work. In eastern and central New York, the Cherry Valley splits the Union Springs from the overlying Chittenango-Oatka Creek. The sooty, black Union Springs shale thins to disappearance in western New York as does the overlying Cherry Valley limestone. As these units disappear, the next higher limestone in the sequence, the Stafford, becomes a prominent marker between the Oatka Creek and the overlying black Levanna shale. Because of its stratigraphic position and the similarity of the gamma ray log signatures, the Stafford has often been called Cherry Valley. From central Erie and Cattaraugus Counties westward, the Centerfield becomes less prominent and converges toward the Stafford as the Levanna shale thins. Some workers

feel that they merge to the west with the Stafford thinning out and the Centerfield continuing. The data available for this study appeared to indicate that the Centerfield wedges out as the two limestones converge while the Stafford continues to the west. Further detailed work with better log control from later drilling in the western Erie and Cattaraugus County areas, where this critical change takes place, will probably resolve this disagreement.

The Skaneateles Formation, which overlies the Marcellus Formation, consists of the basal Stafford and the dark gray to black Levanna shale in the area from central to western New York (fig. 1). On a gamma ray log the Levanna is the most highly radioactive shale above the Marcellus in western New York. Eastward from central New York, the Levanna becomes less black and contains interbedded sandy shale and siltstone members.

The Centerfield limestone forms the basal unit of the succeeding Ludlowville Formation. From central to western New York, this is overlain by the Ledyard black shale. In that area, the Ledyard does not always show a high response on the gamma ray log, but sample studies show that the shale is dark gray to black in color. Shales above the Ledyard are lighter gray, calcareous and contain numerous thin limestone beds. For a discussion of these shales and the proposed regional paraconformity at the top of the Ludlowville, reference is made to the paper by Baird (1979).

The Moscow Formation is at the top of the Hamilton Group. As proposed by Baird, the Tichenor forms the base of the Moscow and is overlain by calcareous gray shales. In western New York, the Moscow is progressively cut out by the overlying basal Tully unconformity.

According to Heckel (1973), the disconformity at the Hamilton-Tully contact in central and western New York is entirely of submarine origin. In eastern New York, the Hamilton and overlying Tully clastic equivalent is conformable. Tully limestone was deposited in central and central-western New York but pinches out along a westward and southwestward trending line from Canandaigua Lake through Livingston and Wyoming Counties then southward through eastern Cattaraugus County (METC/EGSP Series 120). Gradual deepening of the sea and an increase in reducing conditions brought about the demise of carbonate producing organisms and the cessation of Tully limestone deposition. The black muds which were to become the Geneseo shale were deposited on top of the Tully (Heckel, 1973).

The isopach map of the total Hamilton section (METC/EGSP Series 121) shows a gradually increasing rate of thickening of 3 to 4 feet per mile in far western New York. This becomes 6 to 8 feet per mile in the Allegany and western Steuben County areas. At about the Seneca Lake meridian, the rate of thickening increases to 12 to 15 feet per mile. This rate is maintained for about 100 miles to the east into central Delaware County where it becomes 20 to 25 feet per mile. Several east-west oriented troughs and lobes are shown, and these may represent areas of turbidite flows.

Genesee Group

With the close of Tully deposition, clastics from the east began spreading over the Tully and the regional erosion surface to the west. The first sediments formed the black shales and mudstones of the Geneseo.

Overlying the Geneseo black shale is a zone of argillaceous, nodular limestone which has been called the Lodi limestone. This zone, which may be less than one foot to a few feet in thickness, separates the Geneseo from the overlying Penn Yan black shale. The Lodi makes a very distinctive limestone signature on the gamma ray log but is misleading as to actual limestone thickness because only a small zone of impure limestone nodules and limey shale is present. However, it makes a convenient break on the log between the two black shale units.

The Penn Yan shale consists of dark to light gray shale and mudstone with interbedded black shales. Thin interbedded siltstones occur in this unit in central New York where the lower Penn Yan interfingers with the Sherburne member (fig. 1). The middle and upper parts of the Penn Yan interfinger with Sherburne, Renwick black shale and Ithaca members in west-central to central New York (deWitt and Colton, 1978).

The Penn Yan is topped by the thin, argillaceous Genundewa limestone. This was originally defined as a 12 to 15 foot thick sequence of dark gray to black shales and interbedded dark gray to black argillaceous limestone nodules capped by a thin limestone containing abundant Styliolina fossils. DeWitt and Colton (1978) restrict the Genundewa to the top, thin styliolinid limestone bed. In the subsurface, this unit can be traced eastward to central Steuben and Yates Counties.

The uppermost member of the Genesee is the West River shale. This is a medium to dark gray shale and mudstone which contains interbedded siltstones in central New York. All of the Genesee Group units pinch-out to the west by non-deposition. These pinch-outs migrate westward with each stratigraphically higher unit.

Genesee Group thickness increases eastward from zero in the subsurface at Lake Erie in Chautauqua County to more than 1,500 feet in Broome County, a distance of about 200 miles. West of Steuben County, the change in thickness is subtle, but, in central Steuben County, there is a large increase in the thickening rate. This is due to the appearance of the Ithaca clastics which thicken rapidly to the east. A southeasterly sediment source is indicated by the NE-SW strike of the isopachs.

Some interesting sedimentological features are present on the Genesee isopach map (METC/EGSP Series 120). In central Steuben County, a trough greater than 100 feet deep and up to 3 miles wide occurs in Genesee Group rocks. This is believed to be an ancient submarine channel. Gamma ray logs from wells within this channel show that the channel occurs within the stratigraphic and geographic limits of the Ithaca Formation and show the Ithaca Formation rocks to be more clastic than in surrounding wells.

In a direct line with the channel to the northwest in Wyoming and Erie Counties, a thicker lobe of Genesee sediments occurs. This appears to be a sediment fan built out in front of the channel area.

Two other similar features occur in the same general area; one in southwestern Steuben County and the other in northwestern Schuyler County. The southwest Steuben feature is probably a channel. Thinning in the Schuyler County area may be due to upward salt core movement during Genesee time in a prominent structure located in that area (Wayne-Dundee).

Sonyea Group

The Sonyea conformably overlies the Genesee Group and is, in turn, conformably overlain by rocks of the West Falls Group.

In western New York, the Sonyea consists of the basal Middlesex black shale overlain by the calcareous, gray Cashaqua shale. In the Finger Lakes region of west-central to central New York, the Middlesex is split into a lower black shale tongue, the Montour, and an upper black shale tongue, the Sawmill Creek, by the Johns Creek gray shale and siltstone wedge. In the same area, the Cashaqua is split by a wedge of gray shale, sandstone, siltstone and mudstone known as the Rock Stream. The Rock Stream and Johns Creek thicken to the east.

The Middlesex black shale commonly consists of laminae of dark blackish brown organic matter alternating with clays and silt-size quartz grains. Upon fracturing it exudes a strong hydrocarbon odor.

In the subsurface, the Sonyea increases from 4 feet at Lake Erie near the New York-Pennsylvania state line to about 900 feet in central Tioga County, New York, a distance of 175 miles. The isopach (METC/EGSP Series 119) is similar to that for the Genesee Group. The highest thickening gradient is located in the area from central Steuben eastward into Chemung County. This is the area where the Johns Creek and Rock Stream turbidite wedges enter into the section. In the underlying Genesee Group this is also the area where the Sherburne and Ithaca wedges come into the section from the east.

The two submarine channels seen on the Genesee Group isopach are also present on the Sonyea isopach trending to the northwest through central and southwestern Steuben County. No sediment fan, such as that seen on the Genesee isopach, is evident northwest of the central Steuben County channel.

West Falls Formation

This unit forms the lower part of the West Falls Group and has been defined by Pepper, deWitt and Colton (1956). In western New York, it consists of the Rhinestreet massive black shale at the base overlain by the light to medium gray Angola shale and mudstone.

The contact of the base of the Rhinestreet with the underlying Cashaqua is sharp and conformable. However, the top of the Rhinestreet is not well defined. In western New York, the upper Rhinestreet contains interbedded medium gray shale and thin-bedded argillaceous limestones. The top was described by Luther (1903) as, "A concretionary layer 6 inches to 8 inches thick, the upper surface of which is a scraggly mass of angular fragments of impure limestone...". Some scattered black shale beds occur above this zone. The location of this zone on nearby gamma ray logs is questionable, but, for correlation purposes, the top may be picked where gray shale becomes predominant over black shale in the same manner as Pepper, deWitt and Colton when they mapped surface rock exposures (1956).

Eastward into west-central and central New York, the Rhinestreet has been divided into several members. Some of these contain black shales and others are mostly gray shales and siltstones (fig. 1). To the east, the Rhinestreet gradually loses the massive black shale characteristic of western New York as the black shale beds are split by thin gray shale and siltstone beds. The black shales also drop to lower positions in the section as the total Rhinestreet thickens. In eastern Steuben County, the black shales are pretty much confined to the lower one-third of the formation. Siltstone beds, which are interpreted to be turbidites, become more common and thicken in an eastward direction as the sediment source is approached.

The upper member of the West Falls Formation, the Angola, is a light to medium gray shale and mudstone in far western New York. It contains numerous concretions and calcareous nodules in this area and interfingers at the top with the greenish-gray Nunda sandstone. In an eastward direction, the Angola is rapidly replaced in the section by the Nunda sandstone. The Nunda is a sequence of very fine grained greenish to bluish gray quartz sandstone overlying gray silty shale and siltstone at its type section in west-central New York. In the subsurface, the Nunda sandstone thickens in northern Allegany and southern Wyoming Counties. This buildup may be the result of the dispersal of clastics from the central Steuben County submarine channel which is evident on the West Falls isopach. Sand buildup is also seen in various areas in Steuben County.

The West Falls isopach (METC/EGSP Series 118) shows a steady rate of thickening from west to east across the state. An abrupt change in the rate of thickening in Steuben County is related to a major zone of turbidite deposition. The submarine channels noted on the Genesee and Sonyea Group isopach maps are also present on this isopach. Their positions have migrated slightly to the southwest.

Java Formation

The Java forms the upper part of the West Falls Group. In the Lake Erie area, it consists of the basal Pipe Creek black shale and the overlying Hanover shale. The Pipe Creek is a thin black shale which increases from about one foot thick at Lake Erie to over 20 feet in central Erie County. The Hanover is a gray to greenish-gray shale containing numerous calcareous nodules. To the east, the Hanover interfingers with the greenish-gray siltstones, sandstones and gray shales of the Wiscoy.

The base of the Pipe Creek is in sharp contact with the underlying Angola (west) and Nunda (east). However, in the subsurface, local interfingering shales in these units sometimes make it difficult to pick the base. In these cases the density log (if available) is helpful as the Pipe Creek shows the lowest density because of its high organic content. The upper contact of the Pipe Creek is difficult to determine because of interfingering with the Hanover and Wiscoy. The Pipe Creek is thickest in eastern Erie County, western Wyoming County and south into central Cattaraugus County in the subsurface.

Above the Pipe Creek, in the Hanover-Wiscoy section, occur two black shale beds. These usually are about one-third and two-thirds of the distance between the Pipe Creek and the base of the Dunkirk black shale which overlies the Java. The lower black shale has been termed "Shale A" and the upper "Middle Java" by Rickard (personal communication). This sequence of black shales is sometimes useful in correlating the Pipe Creek-Dunkirk section but should be used with caution because the two middle black shale beds tend to vary in thickness and occurrence. The top of the Hanover-Wiscoy section makes a sharp contact with the overlying Dunkirk black shale.

The Java isopach (METC/EGSP Series 117) shows a gradual thickening southeast of Lake Erie where the thickness is about 100 feet. The rate of thickening increases in eastern Cattaraugus County approaching a large thick area in central Allegany County where the Java is 225 feet thick. To the east, in western Steuben County, the northwest-southeast trending submarine channel seen in the underlying units is also evident in the Java. Thin zones occur on both sides of the channel, to the north and south, while a thick pod of sediments is present to the northwest in the mouth of the channel. South and southeast of the channel the Java thickens again. At the Java outcrop in southeastern Steuben County the section consists largely of siltstones and fine grained sandstones. Examination of gamma ray logs shows an increase in siltstone and/or fine grained sandstone in the Wiscoy in wells in the channel area.

Thick silt and sand deposits in the Allegany-Steuben area may indicate a stillstand in the westward prograding movement of the Catskill delta in this area. During this time turbidites filled the submarine channels and poured out over the basin floor where they were spread to the southwest by currents. In north-central Steuben County, J.G. Sorauf (personal communication, 1980) found shallow water deposits and indications of proximity to the shoreline.

Perrysburg Formation

This formation was defined by Pepper and deWitt (1951) as comprising the rock section from the base of the Dunkirk black shale to the base of the Laona sandstone in Chautauqua County, New York.

In Chautauqua County, the Dunkirk is a massive black shale that forms a sharp contact with the underlying Hanover shale. The massive Dunkirk black shale is more than 40 feet thick in Chautauqua County but thins rapidly to the east (Van Tyne and Peterson, 1978). Eastward, the basal Dunkirk contact is harder to pick on gamma ray logs because the Dunkirk begins to lose its massive black shale aspect and becomes more gray in color. Two black shale beds which occur between the Pipe Creek and Dunkirk are useful in making this gamma ray log correlation (see discussion of Java Formation). In west-central New York, only a thin black shale is present at the base of the Dunkirk while its upper portion is medium to dark gray in color and silty.

The top of the Dunkirk, at the South Wales contact as defined by Pepper and deWitt (1951), can only be picked on gamma ray logs in Chautauqua County. To the east into Cattaraugus County, the upper Dunkirk becomes silty and grayer in color and this correlation is uncertain. Rickard (1975) has dropped the South Wales designation. The contact of the top of the Dunkirk (formerly South Wales) with the overlying Gowanda gray shales may be picked on gamma ray logs in Chautauqua County but cannot be picked east of there because of the similarity of the upper Dunkirk and lower Gowanda gray shales.

Pepper and deWitt (1951) described and named the Hume black shale and designated its type section in north-central Allegany County. They suggested that the Hume grades eastward into the Canisteo shale and westward lies below the Gowanda. Rickard (1975) saw the Hume as an eastward basal black shale tongue of the Dunkirk.

Our recent studies indicate that the Hume is probably an upper Dunkirk black shale pulse which did not quite reach Chautauqua County. Pepper and deWitt (1951) give a thickness of 70 feet for the Hume at its type locality. Log studies show a Hume thickness of 30 feet in central Cattaraugus County decreasing to 15 feet in the northwestern part of the County and to a questionable thin sliver in eastern Chautauqua County.

In the Cattaraugus-Erie County area, the lower Dunkirk black shale is separated from the Hume black shale by intervening gray shales. To the east in the Allegany-Steuben County area, the black shales are separated by the Canaseraga sandstone and shale. This cycle of black shale tongues separated by westward prograding clastics is repeated several times in the Upper Devonian section of New York. Other examples are: lower Penn Yan and Renwick black shales separated by the Sherburne; Montour and Sawmill Creek black shales separated by the Johns Creek. Similar cycles with the larger black shale units separated by clastic incursions from the east are also apparent (fig. 1). These cycles represent oscillations of the shoreline during Upper Devonian time.

In the Lake Erie area, the Gowanda gray shale overlies the Dunkirk section. The eastern equivalents are the Caneadea gray shale and siltstone in Allegany County and the Canisteo gray to olive shales and siltstones in Steuben County.

Pepper and deWitt (1951) designated the base of the Laona sandstone, which overlies the Gowanda, as the top of the Perrysburg Formation in Chautauqua County near Lake Erie. This siltstone, or zone of interfingering siltstone beds as shown by gamma ray log correlations, can be traced through most of Chautauqua County but is not correlative with any certainty southward into Pennsylvania or eastward in New York. Eastward from Chautauqua County, based on outcrop work, they designated the base of the Rushford sandstone as the top of the Perrysburg although calling attention to the possibility that the Rushford may be older than the Laona.

In the present study, we have not been able to trace the Laona eastward from Chautauqua County in the subsurface by the use of gamma ray logs and/or well sample studies. Although control is sparse, it appears that the Rushford does lie below the Laona as suggested by the above authors. Therefore, the top of the Perrysburg Formation, as defined above, drops downward in the section from Chautauqua County eastward to central Allegany County. Further to the east there is no discernible top to the Perrysburg. After the Dunkirk-Hume black shale deposition, no comparable long-range marker beds were laid down during the remaining time of Upper Devonian sedimentation in New York.

GAS PRODUCTION

Prior to 1980 there were eight Devonian black shale gas fields, or areas of gas production, in New York. The oldest of these is the Lakeshore shale gas belt located along the shoreline of Lake Erie in western Chautauqua County (fig. 2). This belt extends westward into Pennsylvania and Ohio. Gas production in the Lakeshore area is from the Dunkirk shale and possibly also from the overlying Gowanda. Most of the wells were drilled in the late 1800's and early 1900's and were only 100 to 300 feet deep. It is estimated that up to 300 wells may have been drilled here (Van Tyne, 1974), but records were not kept and the exact locations of most of these wells is unknown.

The Naples shale gas field (fig. 2) was discovered in 1880. Nineteen wells were eventually drilled in and around the Village of Naples and twelve of these produced gas from the Marcellus shale, the basal unit of the Middle Devonian Hamilton Group. The wells average 1,200 to 1,400 feet in depth. Eleven wells are said to be still delivering a small amount of gas into a local utility system.

The Rushville shale gas field (fig. 2) was discovered in the latter 1800's. Eventually, 23 wells were drilled in the Rushville area, but records are non-existent or poor, and it is not known how many of these wells were productive. Apparently, the depths of the wells averaged 700 to 900 feet, and gas was found in the Hamilton section at unspecified depths.

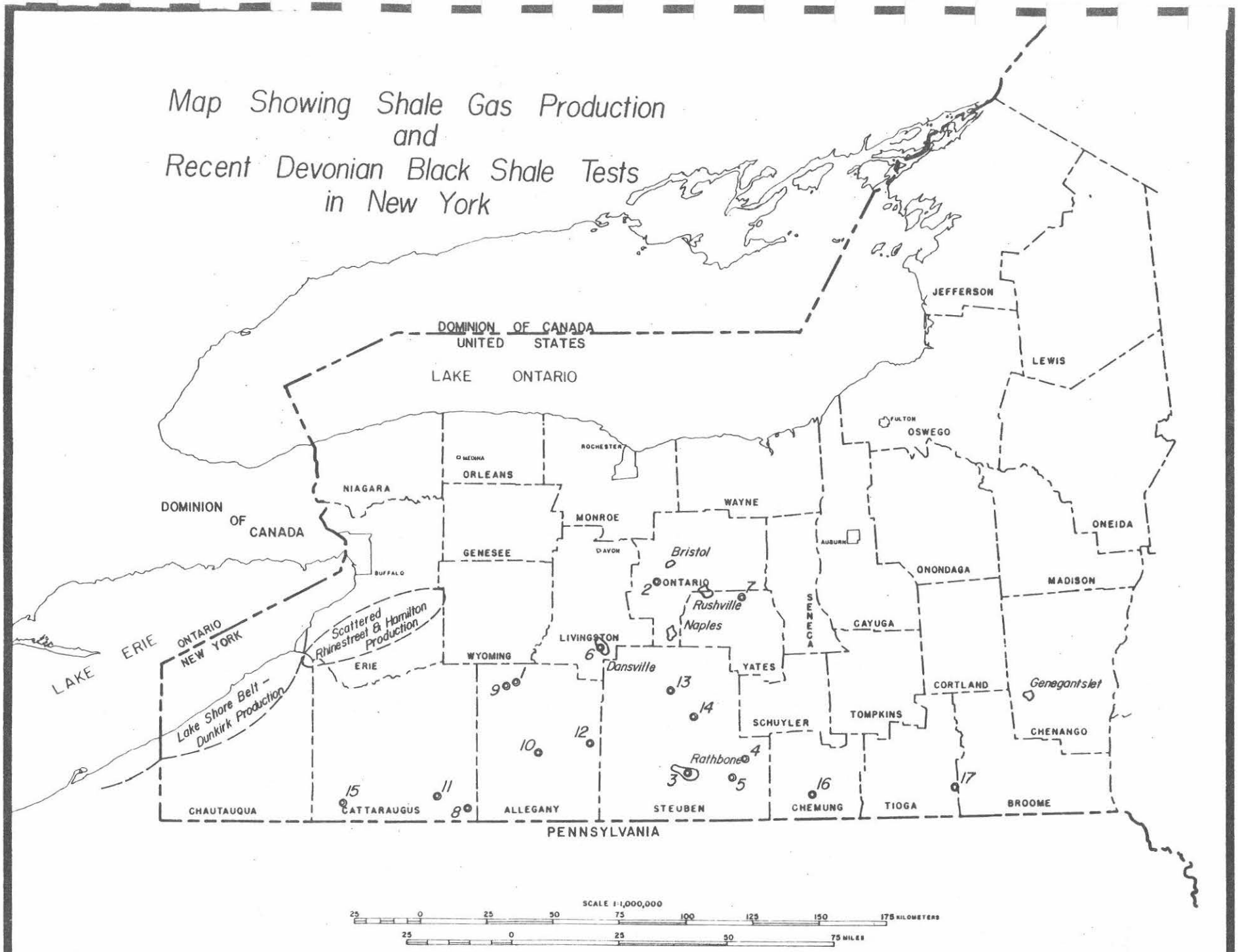
Map Showing Shale Gas Production
and
Recent Devonian Black Shale Tests
in New York
DOMINION OF CANADA
UNITED STATES
LAKE ONTARIO
JEFFERSON
LEWIS
FULTON
OSWEGO
MEDINA
ROCHESTER
ORLEANS
NIAGARA
DOMINION
OF
CANADA
WAYNE
MONROE
ONEIDA
AUBURN
GENESEE
AVON
Bristol
BUFFALO
ONTARIO
ONONDAGA
MADISON
Rushville
Naples
SENECA
CAYUGA
LAKE ERIE
ONTARIO
NEW YORK
Scattered
Rhinestreet & Hamilton
Production
LIVINGSTON
WYOMING
ERIE
Dansville
YATES
CORTLAND
Genegantslet
Lake Shore Belt
Dunkirk Production
SCHUYLER
TOMPKINS
CHENANGO
Rathbone
CHAUTAUQUA
CATTARAUGUS
ALLEGANY
STEUBEN
CHEMUNG
TIOGA
BROOME
PENNSYLVANIA
SCALE 1:1,000,000
25 0 25 50 75 100 125 150 175 KILOMETERS
25 0 25 50 75 MILES

FIGURE 2

The Dansville field (fig. 2) was discovered in 1881. Twenty seven wells were drilled in this field and most were small gas producers from the Hamilton section. The wells averaged 1,000 to 1,200 feet in depth. Recent drilling activity in this field is discussed in the next section of this paper.

The Bristol shale gas field (fig. 2) was discovered in 1914. Wells there average 700 to 900 feet deep and have produced gas from the Marcellus black shale formation of the Hamilton Group. Ten gas wells and six dry holes have been drilled in this field.

In southern Erie County, there is a northeast-southwest trending belt of gas production from the Rhinestreet and Hamilton black shales (fig. 2). Wells in this area also produce gas from the Akron section beneath the Onondaga and from the deeper Medina sandstone. Productive shale wells are scattered erratically throughout this area, but many wells which were completed to produce gas only from the Akron or Medina encountered good gas shows in the black shale sections. Most of the shale shows and production have been encountered above depths of 1,200 to 1,500 feet.

The Rathbone field (fig. 2) was discovered in 1931. Thirty two tests have been drilled in the field and nearby area. These wells average 1,200 to 1,600 feet in depth and encountered gas, and a little oil, in the Nunda siltstone and Rhinestreet shale section. Gas flows in this field have been rather spectacular but short-lived.

In mid 1964, a well drilled in the southern part of the Town of Smithfield in Chenango County encountered a good flow of gas in the upper Hamilton. This was the discovery well of the Genegantslet field (fig. 2), and subsequently, nine more wells were drilled there. Three of these were gas wells and six were dry holes. Except for a small amount of local farm use, the field has been shut-in since 1964.

RECENT DRILLING

By 1979, a good deal of information about the Devonian black shales of New York was becoming available from the ongoing studies, and interest was being stimulated to drill for possible shale gas production. In the summer of 1979, a Devonian black shale test was drilled on the campus of Houghton College in northern Allegany County (fig. 2, No. 1). The well was fracture treated in the Marcellus black shale (Middle Devonian) section just above 2,300 feet and responded with a strong flow and good pressure. The well was tested and completed in 1980 and hooked up to college buildings for use in heating systems. It continues to be a good gas producer. In mid 1979, Honeoye Storage Corp. drilled a shallower pool test in the Honeoye Medina storage field in central-western Ontario County (fig. 2, No. 2) to explore for possible gas production in the Hamilton shale. The well was located about four miles south of the previously discussed Bristol shale gas field. No shows were encountered in the Hamilton and the well was abandoned.

The Houghton College well was jointly financed by the U. S. Department of Energy and the New York State Energy Research and Development Authority. Following the success of this well, NYSERDA signed a contract with a private company to drill several black shale test wells in areas of south-central New York where gas production was likely to be obtained from Devonian black shales. Four wells were subsequently drilled in Steuben and southeastern Livingston County. NYSERDA's purpose in this, and later drilling, was to find out more about the Devonian black shale gas potential in New York and to stimulate drilling to develop this resource.

In Steuben County, the Valley Vista View well (fig. 3, No. 3) was drilled in the later summer and early fall of 1980 in the Rathbone field. The Marcellus and Rhinestreet sections were both fracture treated, but the treated zone in the Rhinestreet showed little or no response, so it was plugged off. The well was completed as a fair Marcellus gas producer in early 1981. The Scudder well (fig. 2, No. 4) was drilled through the Rhinestreet in July of 1980. A section which had produced some gas in nearby wells was cored, but no gas was found, so the well was not treated but was abandoned. The Dann well (fig. 2, No. 5) was drilled through the Rhinestreet in August 1980. A good gas show was encountered so the well was fracture treated. However, the well responded poorly to the treatment and was completed as a very small Rhinestreet gas producer. The Meter well (fig. 2, No. 6) was drilled in the Dansville field in southeastern Livingston County in late 1980. The well was completed in early 1981 and produces a small amount of gas from a fracture treated section in the lower half of the Hamilton.

In the fall of 1980, while drilling a Medina test located about four miles northwest of Penn Yan in Yates County (fig. 2, No. 7), Pennzoil encountered a large flow of gas from the Hamilton. The well was eventually completed as a small gas producer from the upper Hamilton shale. In early 1981, a second well was drilled nearby, but a commercial gas flow was not encountered, and the well was plugged and abandoned.

During 1981, NYSERDA contracted for five additional Devonian black shale tests to be drilled on various school properties in Allegany and Cattaraugus Counties. All five wells were drilled to the Onondaga limestone in June and July of 1981 and were fracture treated and completed by the fall of 1981 as small gas producers from the Marcellus shale. These wells are: Portville Central School (fig. 2, No. 8), Houghton College No. 2 (fig. 2, No. 9), Allegany County Board of Cooperative Educational Services (fig. 2, No. 10), St. Bonaventure University (fig. 2, No. 11) and Alfred University (fig. 2, No. 12).

Also in 1981, four Devonian black shale wells were drilled in central Steuben County. The C. L. Haines Manufacturing Company completed a good Marcellus shale well in early 1981 (fig. 2, No. 13) at Avoca. A second such well was drilled and completed during the summer of 1982. The Village of Bath, with financial assistance from the U. S. Department of Energy funds administered by the American Public Gas Association, had three Devonian black shale tests drilled at Bath during the summer of 1981 (fig. 2, No. 14).

Two of the wells were completed during the early fall as good gas producers from the Marcellus shale. The third well was completed as a poorer gas producer from this section.

In late 1981, a Devonian black shale gas well was drilled and completed by the Seneca Nation of Indians on their lands south of the Village of Steamburg in Cattaraugus County (fig. 2, No. 15). The Rhinestreet and Marcellus sections in this well were fracture treated, and the well is said to be a good gas producer from these zones.

In 1982, NYSERDA has contracted for four more Devonian black shale tests to be drilled in New York. Two of these wells have been drilled and fracture treated in the Marcellus black shale section, but final results are not known as yet. These two wells are located at Elmira (fig. 2, No. 16) and near Endicott (fig. 2, No. 17). The remaining two wells will be drilled in the Naples and Rushville shale gas fields.

The Devonian black shale studies and gas tests drilled in New York indicate that there is a large area of the state which has some productive gas potential from these shales. Some of the black shale zones have not been tested as yet for possible gas production. Such production tends to be small, by comparison with other producing zones, but it may be important locally as an auxiliary source of gas. The economics of a black shale drilling venture must be carefully considered, and the locations picked with the maximum possible available geologic knowledge of these formations.

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