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DEVONIAN BLACK SHALES OF WESTERN NEW YORK

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INTRODUCTION

The road log that follows is essentially a condensed version of the final day of a 5-day trip through the Middle and Upper Devonian clastics of central and western New York (Patchen and Dugolinsky, 1979). That particular trip was organized to give various contractors in DOE's Eastern Gas Shales Project (EGSP) the opportunity to examine, in the field, stratigraphic relations and facies changes hidden deep in the subsurface in the central Appalachian basin. The stops on the fifth day were designed to simulate a 2,200 to 2,500 foot stratigraphic section of "Devonian shale" in a typical "Brown Shale" gas well in West Virginia, Kentucky, or Ohio. The stops on this trip will enable us to visualize what the lowest 1,000-1,100 feet of section in such a well would look like. The main difference will be that the Dunkirk Shale, which is only 40-50 feet thick in this area, thickens westward and merges with the basal black shale of the Huron Shale. In southwestern West Virginia this black shale ranges from 300-400 feet in thickness and serves as both source bed and reservoir in more than 30 gas fields. More recently, prolific oil wells with initial potentials (IP's) ranging from 50 to 1,000 barrels per day have been drilled to this and other shales in the Devonian section in several counties along the Ohio River (Fig. 1). Thus, even though the EGSP is now defunct, interest in the Devonian Shales, both in the surface and subsurface, remains high.

When we agreed, at a rather late date, to organize this trip, we secured from Art Van Tyne a promise to submit a companion article for the guidebook discussing surface to subsurface correlations and gas production from Devonian shales in New York. Furthermore, Wallace de Witt informed us that he would present a paper on Devonian shale stratigraphy at the Eastern Section meeting of the American Association of Petroleum Geologists that immediately precedes the NYSGA field trips. Therefore, we refer the readers to their articles and will present only the barest of stratigraphic summaries herein.

STRATIGRAPHY

Devonian rocks in New York have been studied for more than 100 years and have emerged as the standard reference section for the eastern United States. The resulting physical stratigraphic framework, biostratigraphic zonation, and facies relations of the Catskill clastic wedge are all illustrated in the most recent Devonian correlation chart (Rickard, 1975). On this chart black shales are shown to parallel biostratigraphic zones and, therefore, can be used not only as time lines but to define the bases of thick time-stratigraphic units as well (Fig. 2).

In western New York, each of the main stratigraphic units (Hamilton, Genesee, Sonyea, West Falls, Java, and Canadaway) to be observed on the trip is defined at the base by a black shale (Marcellus, Geneseo, Middlesex, Rhine-

street, Pipe Creek, and Dunkirk, respectively). However, due to time restrictions, the 2 oldest black shales (Marcellus and Geneseo) will not be observed.

The oldest time-stratigraphic unit that we will see on this trip, the Hamilton Group, is divided farther to the east by 3 persistent limestones (Stafford, Centerfield, and Menteth/Portland Point) into 4 formations: the Marcellus, Skaneateles, Ludlowville, and Moscow. In the Buffalo area, the Hamilton units have thinned drastically to less than 225 feet and are cut by at least 2 unconformities. Black shales, the Oatka Creek Member of the Marcellus and Levanna Member of the Skaneateles, are confined to the lower half and are difficult to observe in this relatively flat area. Exposures of the younger Ludlowville and Moscow are more accessible, and 3 members (Wanakah Shale and Tichenor Limestone Members of the Ludlowville; Windom Shale Member of the Moscow) will be observed in the gorge of Eighteenmile Creek (Fig. 3, Stop 1).

The base of the Genesee Formation is defined by the black Geneseo Shale Member east of Buffalo. However, in the Buffalo area the entire formation ranges from 10-20 feet in thickness (Tesmer, 1966) and consists of the black Geneseo Shale (0-2 feet), dark gray Penn Yan Shale (0-1 feet), Genundewa Limestone (2 inches to 2 feet), and gray West River Shale (8-14 feet). A local limestone facies of the lower Penn Yan Shale, the North Evans Limestone, can be observed near the mouth of Pike Creek where it is less than 1 foot thick and unconformably overlies the Windom Shale, the Geneseo Shale being absent. The Geneseo also is absent in the gorge of Eighteenmile Creek where only the Penn Yan, Genundewa, and West River will be observed.

The base of the overlying Sonyea Formation is marked by the black Middlesex Shale Member, which is only 6-8 feet thick in the Buffalo area (Tesmer, 1966). The overlying Cashaqua Shale Member is greenish-gray with calcareous concretions, and is about 40 feet thick along Eighteenmile Creek.

The Cashaqua Shale is overlain in the Buffalo area by the black Rhinestreet Shale, the basal member of the West Falls Formation. The Rhinestreet is about 195 feet thick in the area (Pepper, et al, 1956), and is typically very dark, platy, and organic-rich. Very large concretions, 2-3 feet in diameter, are characteristic of the Rhinestreet in this area. The younger Angola Shale Member of the West Falls is about 250 feet thick in the area and is greenish gray with smaller concretions.

The thin Pipe Creek Shale Member overlies the Angola Shale and marks the base of the Java Formation. Whereas the Pipe Creek is 20 feet thick farther east near Java village, it is less than 2 feet thick near Lake Erie. The overlying Hanover Shale Member consists of greenish-gray, thinly bedded shales with concretions, and becomes more silty in the upper one third.

The black Dunkirk Shale overlies the Hanover Shale and is the basal member of the Perrysburg Formation. As defined by Pepper and de Witt (1951) the Perrysburg consists of the Dunkirk, South Wales, Hume, and Gowanda Members, although Rickard's Devonian correlation chart (1975) includes only the Dunkirk and Gowanda.

The overlying Laona Sandstone marks a significant change in the Upper Devonian rocks along Lake Erie. Below this, the Genesee, Sonyea, West Falls,

Java, and lower Canadaway rocks consist mainly of black or greenish gray shales with minor limestones and a few siltstones. Above the Laona, the rocks of the Canadaway, Conneaut and Conewango Groups are predominantly gray shales and siltstones with increasing numbers of sandstone beds toward the top. Thin black shales are common only in the upper Canadaway, and there they are interbedded with gray shales, none of which is thick enough to warrant member status. These youngest black shales probably thicken westward, like the Dunkirk, and eventually merge with the black Huron Member of the Ohio Shale.

REGIONAL CORRELATIONS

Subsurface correlations by Schwietering (1970, 1979) between Devonian outcrops in central Ohio and western New York have established the physical correlation of the Dunkirk and basal Huron, and the facies relations of the Canadaway, Conneaut and Conewango with the Ohio Shale. These correlations can be extended southward through Ohio into eastern Kentucky and southern West Virginia. In those areas the youngest, coarsest, gray rocks (sandstones, siltstones, and shales) are usually termed "Upper Devonian undifferentiated" (Neal, 1979; Dowse, 1980), but the black shales, because they can be traced physically on gamma-ray logs, are correlated and named with either the Ohio or New York outcrop terminology (Fig. 4).

The older black shales in western New York, the Geneseo and Middlesex, thin to the west and southwest, and thicken eastward. However, these units can be recognized on gamma-ray logs in western West Virginia above the Middle Devonian unconformity. The thin Pipe Creek Shale also has been found to be a useful marker bed in the subsurface (Neal, 1979; Dowse, 1980). The oldest black shale, the Marcellus, is not present, due to unconformity, in western West Virginia, eastern Kentucky, and Ohio. The thick Rhinestreet Shale section in part of that area has traditionally been called "Marcellus" by drillers because of its close proximity to the top of the Onondaga Limestone where the Hamilton to Sonyea equivalents are missing. Farther west, in Ohio, the Rhinestreet also is cut out by the unconformity, leaving only the Ohio Shale and Olentangy Shale present above the Onondaga equivalents (Schwietering, 1970; 1979).

PETROLEUM PRODUCTION

Natural gas has been produced from the Huron (Dunkirk), Rhinestreet, Geneseo, and Marcellus in West Virginia, the Huron in Ohio, and the Huron and probably Rhinestreet in eastern Kentucky. Commercial production, particularly of oil in recent drilling, is due to the extensive development of a fracture system within the black Devonian shales. As you can observe on this trip, the fracture systems change vertically. Dark, organic-rich, lower density black shales are more highly fractured than overlying and underlying greenish-gray "normal" density shales.

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ROAD LOG FOR DEVONIAN BLACK SHALES OF WESTERN NEW YORK

STARTING POINT: The bus will leave the parking lot at the Marriott Inn promptly at 8:00 a.m. The road log begins at the traffic light on Rt. 263 (Millersport Highway) at the Marriott entrance.

CUMULATIVE MILEAGE	MILES FROM LAST POINT	
0.0	0.0	Turn right at the traffic light onto Rt. 263 (Millersport Highway).
0.4	0.4	Turn right after overpass onto the parallel feeder for I-290.
1.4	1.0	Stay left at Sheridan Drive (Rt. 324) exit.
1.7	0.3	Merge left onto I-290 (Youngmann Memorial Expressway)
3.3	1.6	Exposures of Onondaga Limestone along both sides of the highway. The black Marcellus Shale that overlies the Onondaga cannot be readily observed in the Buffalo area due to the relatively flat topography near Lake Erie.
3.8	0.5	Stay right for I-90 west toward Erie; continue on I-90 west.
9.5	5.7	Stay left on I-90 as I-190 goes to the right.
14.1	4.6	Stop; get ticket for the NY Thruway.
18.4	4.3	Town of Hamburg water tower. Good exposure of black Rhinestreet Shale with large concretions.
19.5	1.1	Exit 57 (Hamburg); leave I-90.
20.1	0.6	Stop; pay toll and then turn right toward Rt. 75 north.
20.4	0.3	Merge onto Rt. 75 northbound.
20.9	0.5	JCT with U.S. 20; continue straight through intersection.
22.2	1.3	Stay left on Camp at traffic light as Rt. 75 turns right.
22.4	0.2	JCT with Rt 5. Turn left (south).

23.1	0.7	Entrance for Hamburg Park. Exposures of the Ledyard and Wanakah Shales of the Ludlowville Formation can be observed near lake level in the park but not from the highway. Stop 1 of Tesmer (1966); Stop 47 of Patchen and Dugolinsky (1979).
25.2	2.1	Wanakah
26.4	1.2	Turn right on Lake Shore Road at the traffic light (Rt. 5 goes straight).
29.6	3.2	Bridge over Eighteenmile Creek.
29.7	0.1	Turn left on South Creek Road; park on right side of road. Walk carefully back along the road and over the bridge.

STOP 1: EIGHTEENMILE CREEK GORGE

Upstream from the bridge over the main highway are exposures of the Wanakah Shale, Tichenor Limestone, Windom and Penn Yan Shales, Genundewa Limestone, and a few feet of West River Shale. The black shale near the top of the outcrop, which is weathered a reddish color and displays well-developed fractures, is the base of the Middlesex Shale. Notice the weathered pyrite associated with the base of the Tichenor Limestone, along with the abundant fossils, both characteristic of the Tichenor.

It is possible to walk from the exposures on the beach at the mouth of this stream where the Wanakah and Tichenor are present, upstream past this point and see the Middlesex, Cashaqua and Rhinestreet. Thus, continuous exposures from the Ludlowville Formation of the Upper Hamilton Group, through the Moscow Formation, the Genesee and Sonyea Formations, and into the West Falls Formation are present and all visible, representing a large proportion of Middle and Upper Devonian time.

The following 2 stops will be farther upstream from this locality.

Continue east on South Creek Road.

30.0	0.3	JCT with Rt. 5. Cross and park on right. Descend gorge under the bridge.

STOP 2: RT. 5 BRIDGE OVER EIGHTEENMILE CREEK

The Wanakah Shale is exposed in the stream bed and may be under water, depending on water level. This is followed upward by one or two feet of Tichenor Limestone, about ten feet of Windom and Penn Yan Shale, some thin Genundewa Limestone, about 3 feet of West River Shale, a few feet of dark, platy Middlesex Shale, and the lower few feet of Cashaqua Shale which cap the section. The entire section is perhaps 35 to 40 feet thick and all is accessible.

Continue east on South Creek Road.

30.9	0.9	Railroad Bridge. Short walk along path to left before RR bridge offers a view of upper Cashaqua and lower Rhinestreet (Stop 3 of Tesmer, 1966). Continue on South Creek Road.
31.8	0.9	JCT with U.S. Rt. 20. Turn left, drive slowly across bridge in right lane; turn around in parking area to right and drive back. Observe excellent, thick exposures of black Rhinestreet Shale in stream banks.
32.1	0.3	Turn right onto South Creek Road.
32.4	0.3	Turn right on Versailles at intersection. Drive down into gorge.
32.6	0.2	Park at Town of Evans Nature Park.

STOP 3: TOWN OF EVANS NATURE PARK

Exposures of the Rhinestreet may be seen along the road and adjacent to the parking lot by the pedestrian bridge. The base of the Rhinestreet is exposed farther downstream but not here. The shale here is the typical dark, platy shale characteristic of the Rhinestreet, with reddish weathering in places and concretions being very common, although not as evident at this locality as they are in Rhinestreet exposures along I-90 southeast of Hamburg.

		Return to South Creek Rd. on Versailles.
32.8	0.2	Turn right onto South Creek Rd. Return along Eighteenmile Creek, across Rt. 5 to Lake Shore Road.
34.7	1.9	Lake Shore Rd. Turn left.
34.8	0.1	Entrance to home of Piarist Fathers, Stop 48 of Patchen and Dugolinsky (1979); Stop 2 of Tesmer (1966). Exposures of the Wanakah Shale, Tichenor Limestone and Windom Shale are present along the beach. If anyone is interested in examining this site, permission should be obtained from the residents. Also, access to the beach is by way of an old metal stairway. Extreme caution should be used.
36.5	1.7	Gibralter on the Lake (PRIVATE ROAD). Stop 52 of Patchen and Dugolinsky (1979). The Windom Shale to Middlesex Shale interval is exposed along the beach.
36.6	0.1	Bear right at the "Y" intersection.
39.5	2.9	Lake Shore Rd. turns right at Dennis Rd. Stay on Lake Shore Rd.

41.2	1.7	Prominant sand ridges to the right.
45.5	4.3	Turn left at entrance to Evangola State Park. This was Stop 53 of Patchen and Dugolinsky (1979); Stop 5 of Tesmer (1966).
46.7	1.2	JCT with Rt. 5. Turn right.
47.3	0.6	Farnham
49.4	2.1	JCT with U.S. Rt. 20. Go right on U.S. Rt. 20 and Rt. 5.
49.5	0.1	Cattaraugus Creek. Chautauqua County line.
52.2	2.7	Rts. 5 and 20 split. Go straight on U.S. Rt. 20.
52.6	0.4	Silver Creek
53.2	0.6	Turn left at traffic light in center of village (Rt. 5 goes straight).
53.5	0.3	JCT with Rt. 428; continue on U.S. Rt. 20.
53.7	0.2	Bear right on Main St.
53.8	0.1	Turn right on Ward St.
53.9	0.1	Turn right on Parkway.
54.0	0.1	Park along Parkway near fire hydrant. Walk through small lot to edge of Walnut Creek. Descend into creek bed. Observe Pipe Creek Shale above Angola Shale. Wade under bridge to 60 ft. exposure of Hanover. Dunkirk Shale is exposed 2 miles upstream.

STOP 4: WALNUT CREEK IN TOWN OF SILVER CREEK

The contacts of the Pipe Creek Shale with the underlying Angola Shale and the overlying Hanover Shale are exposed in the stream bed of Walnut Creek in the Town of Silver Creek. The top 5 feet or so of the Angola is all that is clearly exposed, but the entire Pipe Creek and the lower 60 feet of Hanover are accessible, although wading boots are suggested. Lithologies in the Hanover range from green-gray, thinly bedded shales to silty beds which are more prominent due to higher resistance to weathering.

		Continue west on Parkway.
54.5	0.5	JCT Rt. 5 (Central Avenue). Turn left (south). Continue south along Lake Erie into Dunkirk.
63.8	9.3	JCT Rt. 60 (to left) with Rt. 5. Continue straight on Rt. 5.

64.9	1.1	Turn right at 3rd traffic light where sign says "Point Gratiot ahead".
65.3	0.4	Turn right (just after paved entrance to power station) into unpaved parking area and park.

STOP 5: POINT GRATIOT, DUNKIRK

The base of the Dunkirk is well exposed on the beach just south of the power plant. The distinct transition zone between the Hanover and the Dunkirk is at, and just beneath (but visible in clear water), the water at normal lake level. The greenish-gray beds of the Hanover and the black beds of the Dunkirk are separated by two black and two greenish-gray transition beds. A small flexure may be seen, particularly if the water is calm, by tracing the lighter colored units along the beach and noticing a slight northward dip in this location.

Feeding trails and carbonized plant fragments may be seen on the tops of the beds within the transition zone. Pyrite nodules are common. A freshly broken surface of Dunkirk Shale provides a strong petroleum odor.

65.8	0.5	Return to Rt. 5. Turn left.
66.8	1.0	Turn right on Rt. 60. Stay on Rt. 60.
68.4	1.6	Cross over the thruway. Turn left and enter the thruway north toward Buffalo (Interchange 59). Along the route notice new gas wells in vineyards to east. These are in the Medina sands (Lower Silurian).
77.7	8.3	Cross bridge adjacent to an old bridge on a parallel route to the right (east). This was Stop 55 of Patchen and Dugolinsky (1979). About 55 feet of Dunkirk Shale are exposed in the gully under the bridge. The transitional zone between the Hanover and Dunkirk can be observed in the stream bed.
82.1	4.4	Exit 58 (Silver Creek). Observe excellent Hanover-Dunkirk contact on the right.
90.2	8.1	Cross gorge with fairly poor exposure.
95.5	5.3	Cross gorge with a good section exposed.
101.3	5.8	Exit 57 (Hamburg).
102.8	1.5	Excellent Rhinestreet exposure along both sides of the thruway near the town of Hamburg water tower. The large concretions are characteristic of the Rhinestreet in this area. (Same as mile point 18.4.)

104.0	1.2	Rhinestreet-Cashaqua contact in the ditch to the east.
105.3	1.3	Blasdell Interchange (exit 56).
111.2	5.9	JCT with I-190 at exit 53. Continue on I-90 (free portion).
116.9	5.7	Exit I-90 at Interchange 50 for I-290 north (Youngmann Memorial Expressway). Return to the Marriott on I-290 and Rt. 263 (Millersport Highway).
120.7	3.8	Marriott Inn. End of trip.

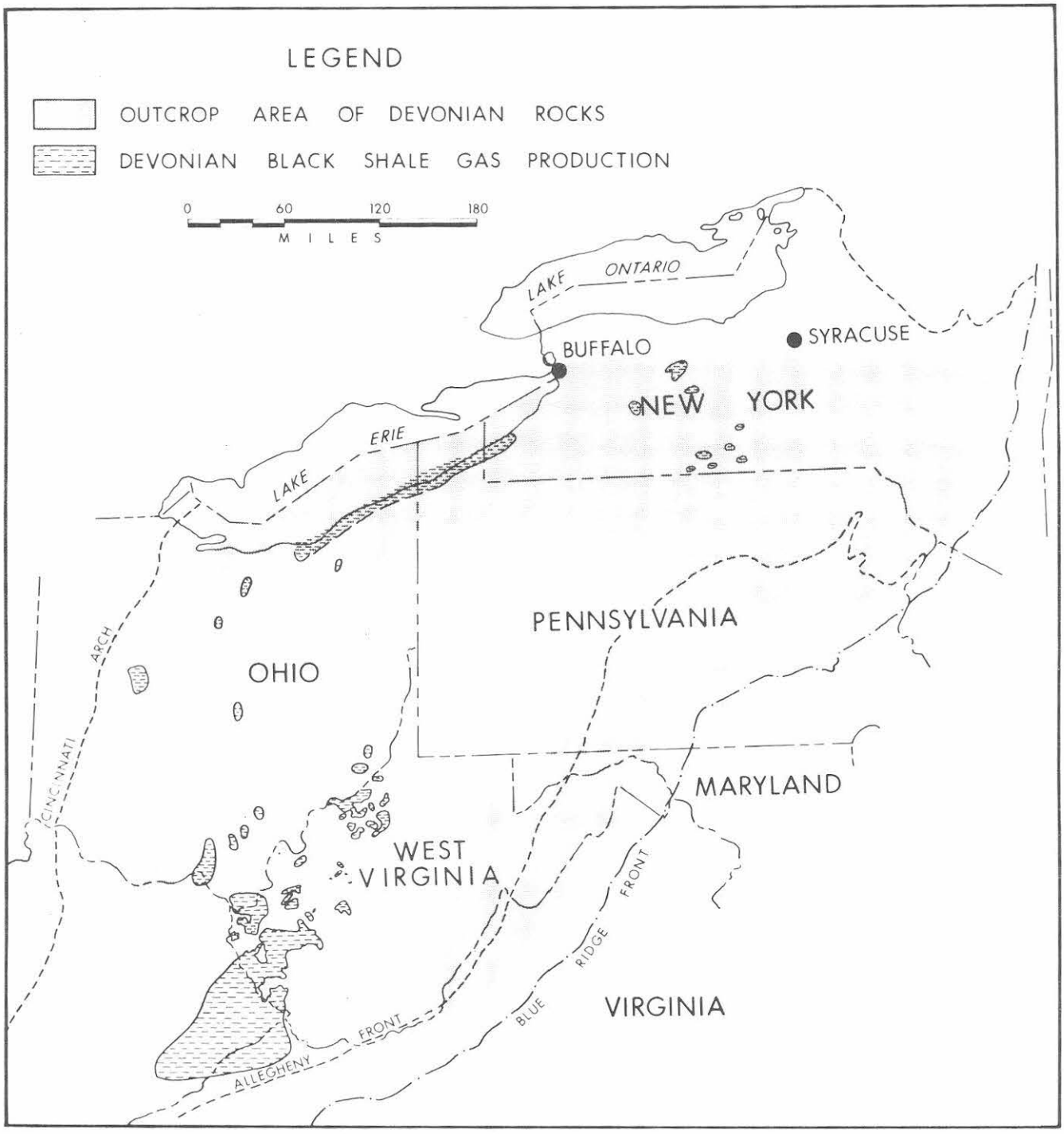

Figure 1. Regional outcrop pattern of Middle and Upper Devonian clastics and generalized locations of Devonian shale gas (and oil) fields.

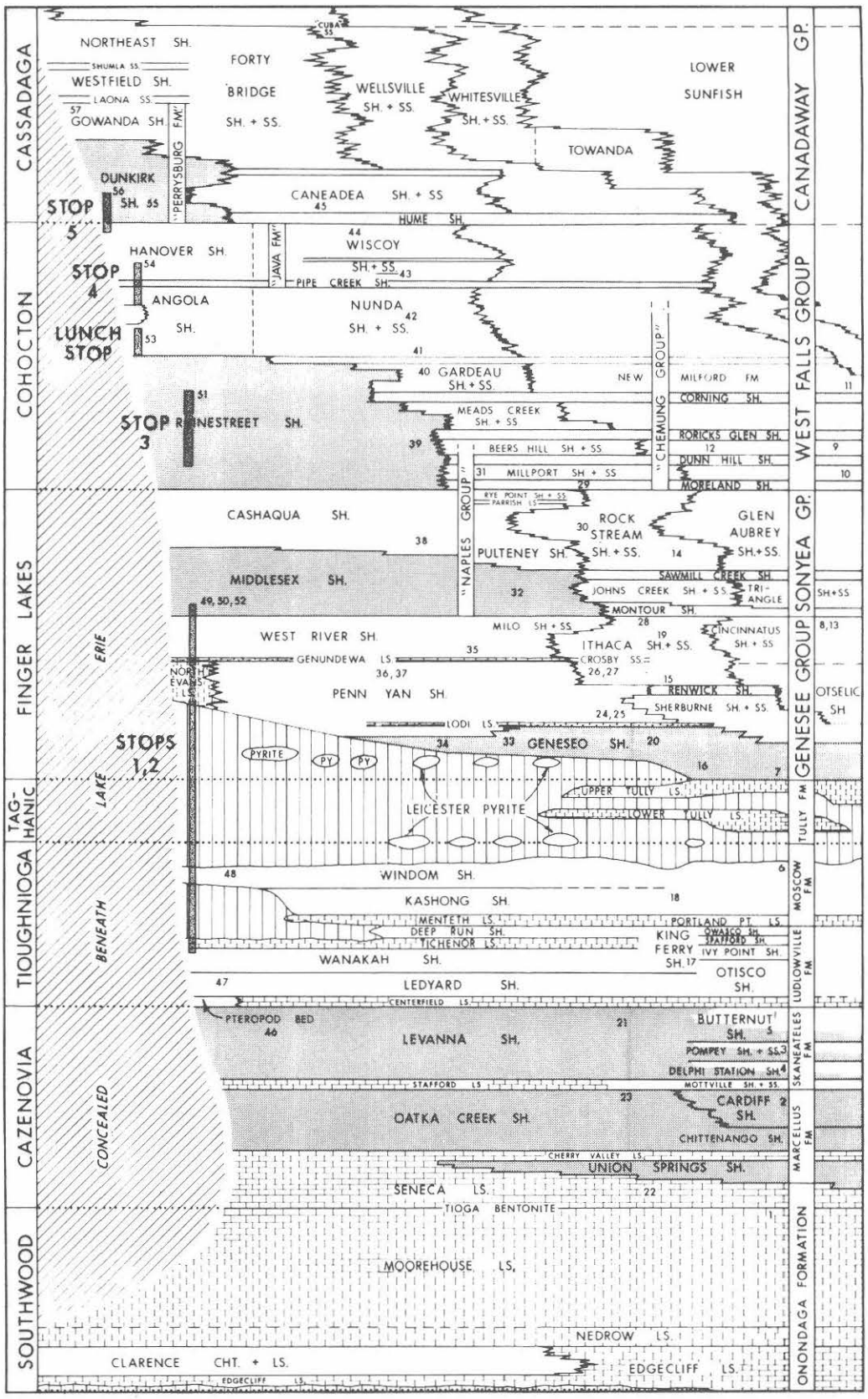

Figure 2. Middle and Late Devonian correlation chart for central and western New York (modified from Rickard, 1975). Stratigraphic ranges of stops are indicated; vertical scale is time, not thickness.

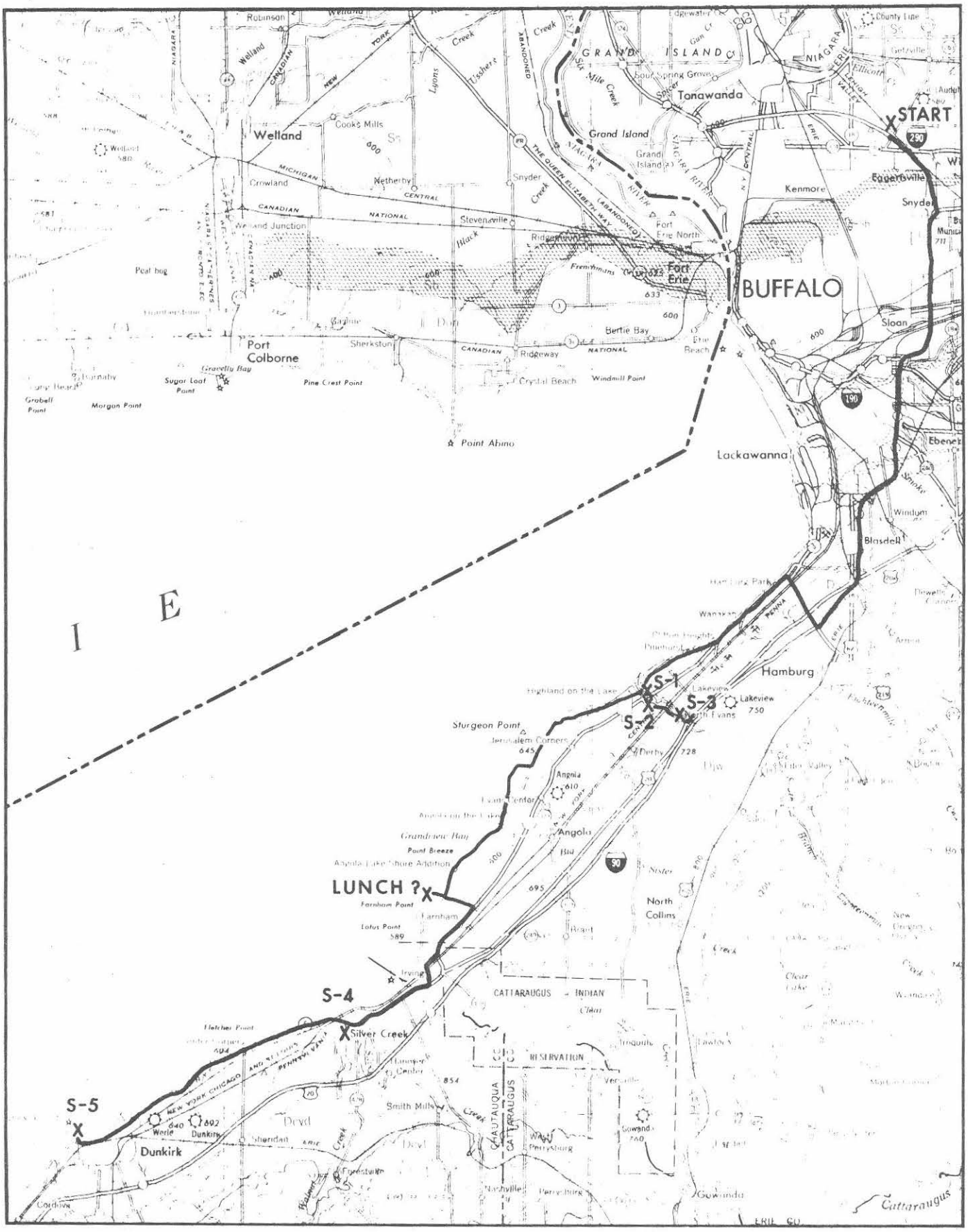

Figure 3. Field trip route and stop locations.

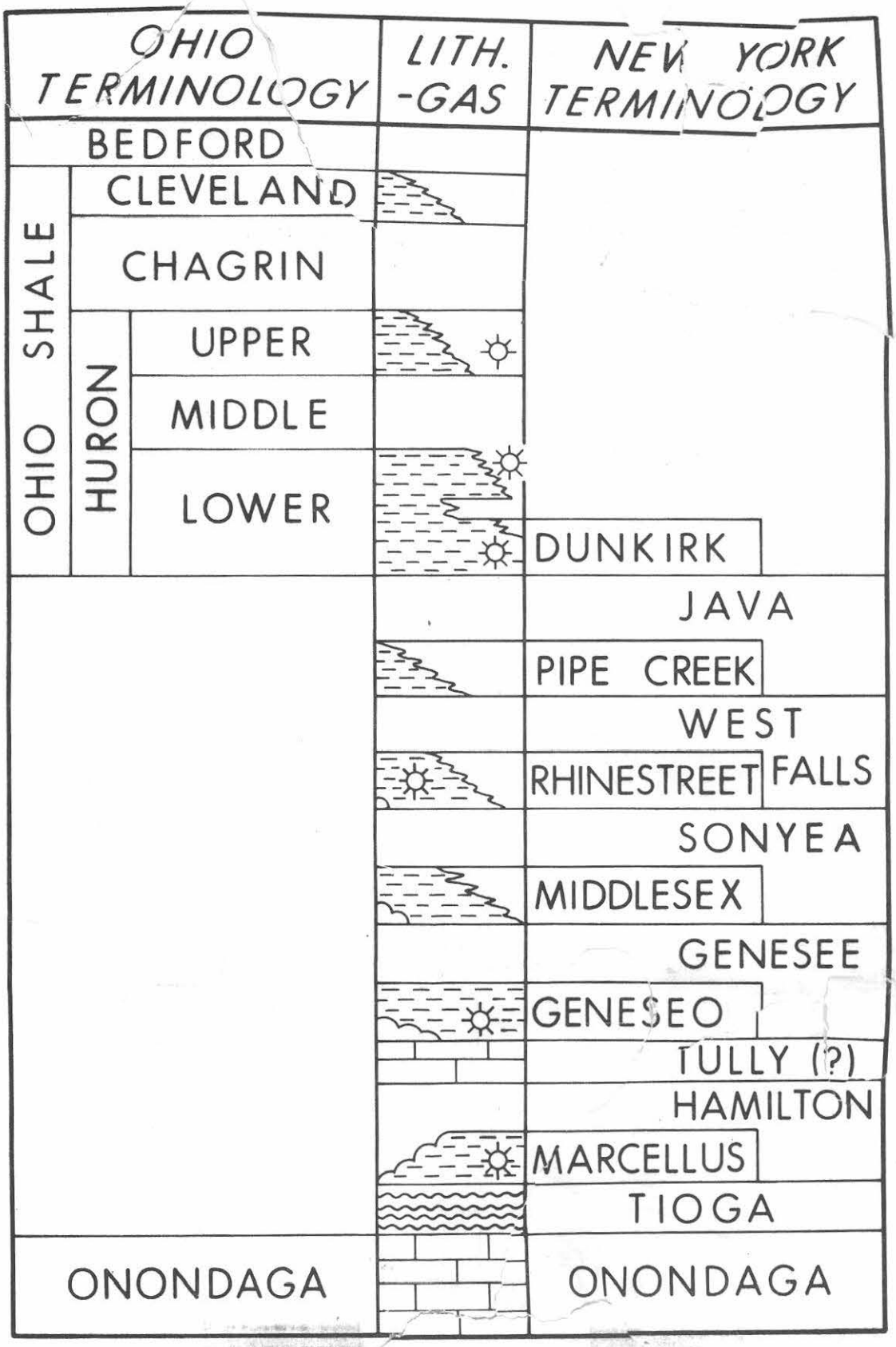

Figure 4. Terminology used in subsurface mapping of black Devonian shales in the central Appalachians. New York names are used for older shales; Ohio names for younger shales.

FIGURE CAPTIONS

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