STRATIGRAPHY OF THE MARINE LIMESTONES AND SHALES OF THE ORDOVICIAN TRENTON GROUP IN CENTRAL NEW YORK

by

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INTRODUCTION

For about 150 years the Ordovician rocks of the Mohawk Valley region have been under study. Many geologists and paleontologists of the 19th and 20th centuries have studied the limestones, shales, and fossils of the Black River Group and the Trenton Group in the Black River, West Canada Creek, and Mohawk River valleys (see Kay, 1937, for an historical review of early work). As a result, these rocks have become well-known as part of the medial (middle time of a three-fold subdivision) Ordovician standard section of North America.

However, the geology of the Trenton Group, as well as the Black River Group, still poses several relatively complex and interesting stratigraphic problems. Exposures are occasionally complete, but many are not. The repetitious nature of the sedimentary layers of the Trenton Group often mask significant variations critical to correct lithostratigraphic, biostratigraphic, and paleoecologic interpretations. The modern approaches to the study of paleoenvironments of carbonate rocks have just recently been applied with emphasis to parts of the medial Ordovician sequence in central and northwestern New York. Many previous investigators who have studied these formations have been, by necessity, primarily concerned with lithostratigraphy, such as statistical analysis of rock types (especially Chenoweth, 1952, and Lippitt, 1959), biostratigraphy and correlation, and mapping. Present and future work depends and will depend heavily on that of earlier workers who prepared the way by determining the basic lithostratigraphic and biostratigraphic frameworks which will be examined and evaluated on this field trip.

The interests of this author center around establishing a detailed time and lithic microstratigraphic framework for the Trenton Group in central and northwestern New York. This would form the basis and provide the confidence for reconstructing the environments of deposition and determining the paleogeography. At present, special emphasis is being placed on statistical analysis of the rock types from both detailed field measurements and carbonate petrography, small scale physical and biological correlation, primary sedimentary structures, trace fossils, fossilization, and fossil community analysis. This information should better document the initial and subsequent wider transgressions and regrassions of the Trentonian sea.

The purposes of this field trip to the Trenton Group limestones of central New York are to:

1) Demonstrate the stratigraphic succession and lateral facies changes.
2) Discuss and evaluate the age relationships and time correlations.
3) Examine and evaluate the criteria for determining the conditions and environments of deposition and paleogeography.

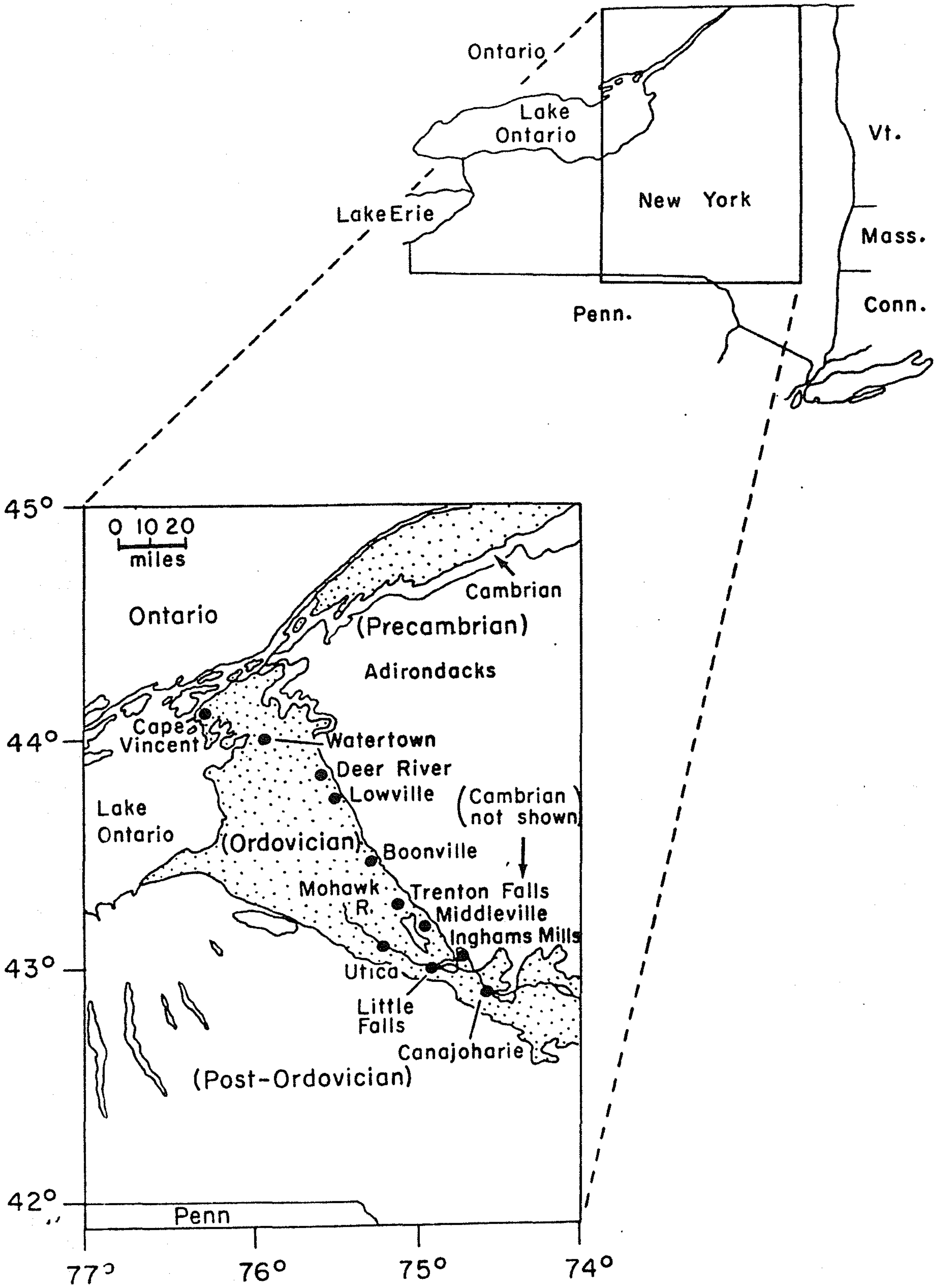

Figure 1. Geologic outline map of study area.

This field trip guide will summarize previous work on the Trenton Group in central and northwestern New York. The order of localities has been chosen to be as conveniently as possible for economy of travel along a southeast to northwest traverse that also essentially climbs up the stratigraphic succession.

REGIONAL GEOLOGIC SETTING

Lower Paleozoic rocks nearly surround the Adirondack Dome, a complex of Precambrian igneous and metamorphic rocks, of northern New York which forms with the Frontenac Arch in southeastern Ontario on the northwest the northern boundary of the Allegheny Synclinorium (Kay, 1948). In northwestern New York and southeastern Ontario, medial Ordovician Bolarian and Trentonian strata comprise most of these bordering sedimentary rocks (figs. 1-2). Subsurface contours drawn on the base of the combined Black River-Trenton sequence indicate a gentle (about ½ to 1½ degrees) regional dip southwestward (Flagler, 1966, pl. 5). A few northeast-southwest trending normal faults cut Paleozoic and Precambrian rocks (Cushing, 1905a; Kay, 1937).

Along the margin of the Adirondacks from central to northwestern New York, Cambrian rocks occur only in the Mohawk Valley (Little Falls Dolomite) and in the St. Lawrence Lowland (Potsdam Sandstone). Early Ordovician (Canadian) limestones and dolostones occur in the Mohawk Valley, but disappear immediately to the northwest (Tribes Hill and Chuctanuda formations, Fisher, 1954). Thus, the limestones of the Black River Group progressively overlap the late Cambrian and early Ordovician strata in central New York and part of the late Cambrian strata of northwesternmost New York. Along the west-central margin of the Adirondacks, they lie nonconformably on the Precambrian.

In northwestern New York, the Black River and Trenton groups are complete. However, to the southeast in central New York the lowest Black River, upper Black River, and lowest Trenton limestones progressively disappear and a disconformity representing at least two stages appears to exist along the Black River-Trenton boundary (fig. 2) (Cameron, 1968, 1969a, 1969b). Eastward in the Mohawk River valley south of the Adirondacks, the Black River Group and the Trenton Group limestones pinch out across the Adirondack Arch east of Canajoharie (figs. 1-2), reappearing farther to the east in the Mohawk and Champlain valleys. In addition, the middle and upper Trenton Group changes facies in central New York from interbedded shelly limestones and shales to non-shelly limestones and shales and finally to black, graptolite-bearing shales over a few miles from east of the type section at Trenton Falls to west of Canajoharie (figs. 1-2).

THE TRENTON GROUP

Significance:

The Ordovician rocks of New York State have customarily served as the North American standard for the early and medial Ordovician (Kay, 1937; Fisher, 1962), of which the Trenton Group has comprised the top. A standard section (or group of sections) is important because it is generally used to supplement a type section and is used for comparison and correlation. It is chosen "...to serve as a standard of reference for a certain part of the geologic column in a certain geologic province" (Dunbar and Rodgers, 1957, p. 301). In North America, standard sections are necessary because the type sections for the geologic periods are in Europe where the geologic column was first established.

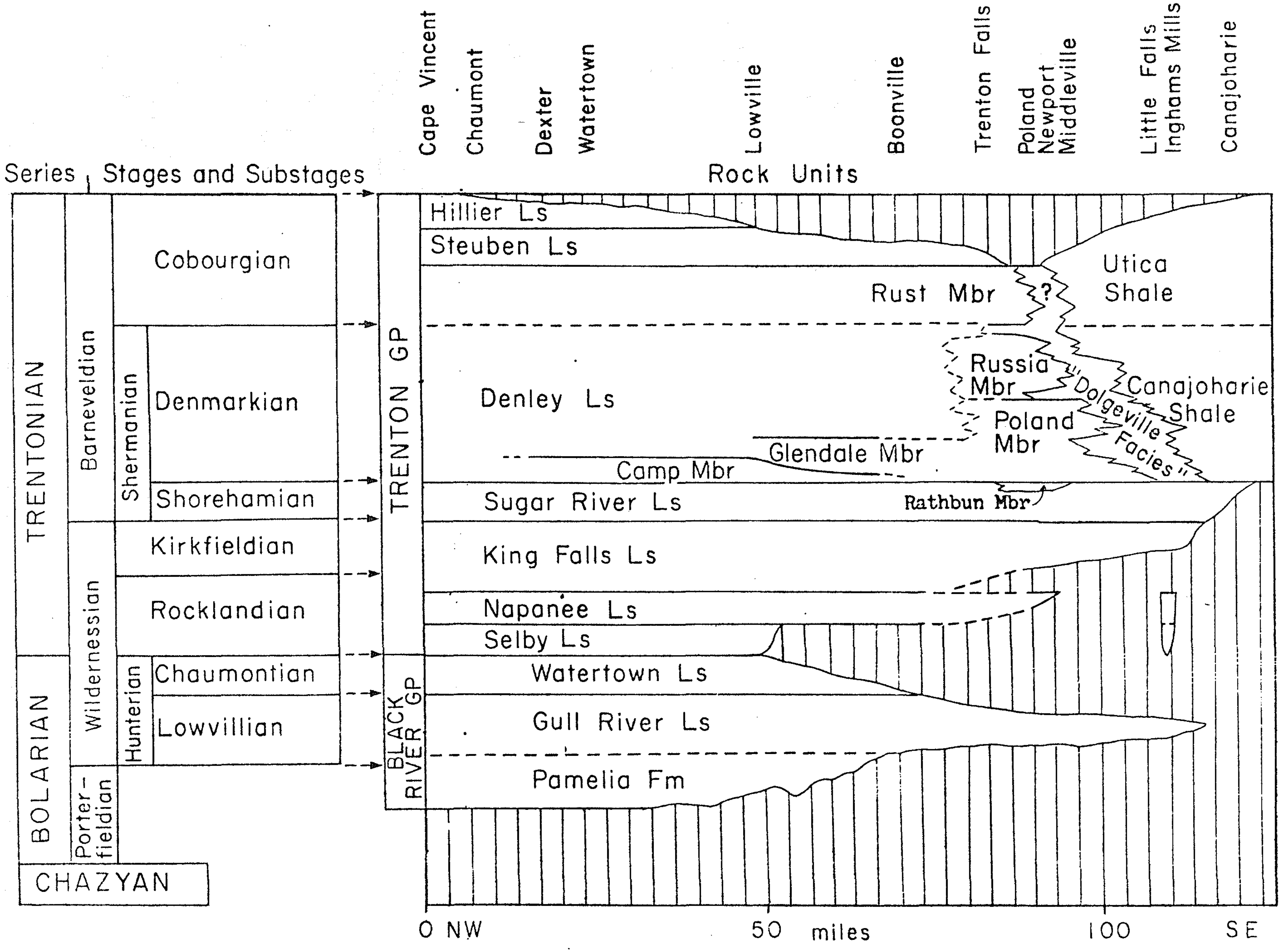

Figure 2. Medial Ordovician stratigraphic classification and nomenclature for central and northwestern New York.

Formations:

Introduction - Seven vertically successive Trenton limestone formations occur in northwestern New York (fig. 2). Southward to central New York, however, the Hillier at the top disappears due to an erosional unconformity (disconformity). In addition, the Selby at the base is also absent to the south because the early Trentonian transgression was not completed until later during the third (Shorehamian) stage, marking the end of the early Trentonian (fig. 2). The middle Trenton Group is dominated by the relatively thick Denley Limestone (250 feet) which is subdivided into 5 members. Three of these comprise the whole formation in central New York where the lower and middle Denley grades into the Dolgeville Facies which, with the upper Denley, in turn grades, by facies change, into the Canajoharie and Utica black shales.

Selby Limestone - The Selby Limestone, defined by Kay (1937) and raised to formational rank by Cameron (1967), is a somewhat massive unit averaging about 10 feet thick and composed of burrow-reworked, calcisiltites and fine-grained calcarenites. The Selby extends from southeastern Ontario where the type section is located southeastward to disappearance in the Black River valley west of the Adirondacks between Lowville and Boonville (figs. 1-2) (Cameron, 1968). It will not be seen on this field trip.

Napanee Limestone - The 20- to 40-foot thick Napanee Limestone, defined by Kay (1937) and raised to formational rank by Cameron (1967), is characterized by fine- to medium-grained calcisiltites interbedded with calcareous shales (Cameron, 1968). Its type section is in southeastern Ontario from which it extends southeastward to disappearance in central New York where two unnamed members illustrate complicated early Trentonian paleogeography (fig. 2). Although the Napanee will not be seen on this field trip, it will be studied in detail on another trip at this meeting (see the field trip guide by Cameron, Mangion, and Titus elsewhere in this book).

Kings Falls Limestone - The fairly widespread Kings Falls Limestone was defined by Kay (1968b) and is composed of interbedded medium- to thick-bedded, coarse-grained, very fossiliferous limestones and thin calcareous shales. It disappears west of Canajoharie (fig. 2). The limestones are dominantly horizontally and cross-laminated calcarenites, being shelly throughout central New York, but less shelly in the upper half in northwestern New York. See the field trip guide by Cameron, Mangion, and Titus elsewhere in this book for a description of this formation.

Sugar River Limestone - The fairly widespread Sugar River Limestone was defined by Kay (1968b). This formation, which disappears east of Canajoharie across the Adirondack Arch (fig. 2), is composed of interbedded burrow-reworked, thin- to medium-bedded, fine- to medium-grained calcarenites and thin, calcareous shales. (For a detailed description, see the field trip guide by Cameron, Mangion, and Titus elsewhere in this book.) The Rathbun Member has been recognized in the valley of West Canada Creek as comprising the topmost 6 to 10 feet of the Sugar River Limestone (Chenoweth, 1952). At the type section at Rathbun Brook, Kay (1943) described "...6 feet of brachiopod coquina, calcilutite and calcareous shale..." directly underlying the Trocholites subzone of the Poland Member of the Denley Limestone.

Denley Limestone - In central and northwestern New York, the Denley Limestone has been subdivided into 5 members. The basal Camp and Glendale members, defined by Chenoweth (1952), comprise the lowest Denley Limestone to the north where they are succeeded by a very thick unnamed member. The Camp member forms the base and is composed of about one to 12 feet of burrow-reworked, rubbly, nodular, argillaceous, calcisiltites and fine-grained calcarenites interbedded with thin calcareous shales. It will not be seen on this field trip, but it resembles, to some degree, the limestones of the Trocholites subzone (Stop #4) that are also at the base of the Denley Limestone in central New York where the Camp is absent.

The Glendale Member is composed of "...35 feet of even-bedded, hard blue-gray barren calcilutites, calcareous shales, and coquinal calcarenites..." (Chenoweth, 1952, p. 530) located west of the Adirondacks from Boonville to Lowville. The calcilutites and calcisiltites contrast strongly with the underlying Camp Member and the undifferentiated overlying Denley limestones. Because of the similarity between the Glendale to the north and the Poland Member to the south, the Glendale is considered a northward tongue of the lower Poland Member exposed at Trenton Falls (Chenoweth, 1952). The interval immediately south of Sugar River (Boonville) to Trenton Falls (about 16 miles) is concealed.

The Denley has not been further subdivided in northwestern New York, except for local unnamed members (Chenoweth, 1952). However, along West Canada Creek at Trenton Falls three members are recognized and comprise the whole formation which is fully exposed except for the extreme base. In ascending order, the Poland, Russia, and Rust shaly limestones possess a thickness of about 250 feet.

The Poland Member, defined by Kay (1943), is about 60 feet thick (including about 10 feet covered at the base) at the type section at Trenton Falls It is composed of argillaceous, bituminous, fine-grained calcisiltites and calcareous shales (Kay, 1943). At Trenton Falls it is overlain by the Russia Member, but southeastward, e. g., at Middleville, it is overlain by a tongue of the Dolgeville Facies (fig. 2).

The Russia Member, defined by Kay (1943), is about 75 feet thick at the type section at Trenton Falls. It is composed of rubbly, burrow-reworked, shaly limestones that nearly lack shelly calcarenites. Southward, e. g., south of Poland and Middleville, fine-grained calcisiltites become more abundant and eventully this member, like the Poland Member, is replaced laterally by the Dolgeville Facies (Kay, 1937, 1943, 1953). The top of the type section contains beds that resemble the Dolgeville, thus indicating another tongue of the Dolgeville Facies (fig. 2).

The Rust Member, defined by Kay (1943), "...comprises 115 feet of argillaceous and Rafinesquina deltoidea (Conrad)-bearing coquinal limestone to the base of the coarse-textured Steuben limestones..." (kay, 1943, p. 602). The famous slumb breccias at Trenton Falls occur near the top of this member. To the south, in western Herkimer County, the Rust apparently changes to the black shale facies of the lower Utica; It is more argillaceous in the poorly exposed intervening area around Poland, New York. The undivided upper Denley of northwestern New York resembles to some degree the Rust Member of central New York.

Steuben Limestone - The Steuben Limestone, defined by Kay (1943), is composed of horizontally and cross-laminated, heavy-ledged, medium- to coarse-textured, massive, encrinitic calcarenite with little interbedded shale. It forms a scarp at the top of the Denley Limestone (Lippitt, 1959) in northwestern New York where it is less encrinitic, more shaly, well-burrowed, and resembles the overlying Hillier Limestone. In the vicinity of Trenton Falls it appears to be only up to about 26 feet thick, but to the north it reaches about 50 feet.

Hillier Limestone - The Hillier Limestone, defined by Kay (1937), is about 60 to 70 feet thick in northwestern New York. Because it thins southward to disappearance in southern Lewis County, it will not be seen on this field trip. It is less massive than the subjacent Steuben Limestone, being composed of argillaceous, fine-grained calcarenitic and calcisiltitic limestones and interbedded thin, calcareous shales. Above this unit are the Collingwoodian (late Ordovician, i. e., Cincinnatian) shales which are time-equivalent with the upper Utica shales of central New York (Kay, 1937).

Dolgeville Facies - The term Dolgeville beds (Cushing, in Miller, 1909, p. 21) was applied to the interbedded, limestones and shales transitional between the Denley (Poland and Russia members) and Canajoharie-lower Utica black shales. The limestones are relatively thick, black, fine-grained, argillaceous, and sparsely fossiliferous. The shales are also relatively thick, black, and sparsely fossiliferous. This 50- to 100-foot thick facies has a limited distribution from southeast of Trenton Falls to west of Canajoharie. Insufficient exposure makes detailed evaluation of its stratigraphic relationships difficult, but tongues into the Denley Limestone are known. See the description of the Poland and Russia members of the Denley Limestone in the text above for further details. Its fauna is characterized by some graptolites, inarticulate brachiopods, and the trilobite Triarthrus becki (Green). Occasionally, thin beds with typical Trenton shelly faunas dominated by the articulate brachiopod Dalmanella can be found (Stop #2).

Canajoharie and Utica Shales - The Canajoharie Shale, which is at least 50 feet thick, is Denmarkian in age and is the time-equivalent of the Dolgeville Facies and the Poland and Russia members of the Denley Limestone (Kay, 1937, 1943, 1953, 1968). The Utica Shale, which is up to 750 feet thick, overlies the Canajoharie Shale to the southeast and the Coboургian limestones to the northwest. It is Coboургian and younger in age (fig. 2). Essentially, both formations are a monotonous sequence of graptolite-bearing, black shales (Kay, 1937, p. 268-271, 282-283; Kay, 1953, p. 57-58, 62-64). The Utica shales will not be seen on this field trip, but the lower Canajoharie will be examined at Stop #1.

TIME-STRATIGRAPHIC UNITS

The Trentonian Series refers to the time during which the Trenton Group was deposited. Five stages are recognized as subdivisions of the Trentonian Series (fig. 2). These are, in ascending order, the Rocklandian, Kirkfieldian, Shorehamian, Denmarkian, and Coboургian. Kay (1960, p. 30) thought that "Probably the term stage is too high an order for the named divisions of the Trentonian..." and proposed larger subdivisions which have not been generally accepted, except possibly for Shermanian which includes the Shorehamian and Denmarkian (Sweet and Bergstrom, 1971). The formations (described above) deposited during these stages are indicated by figure 2.

TRANSGRESSIVE AND REGRESSIVE SEQUENCES

Most of the limestone formations of the Trenton Group represent sediments deposited from relatively shallow epicontinental seas. The lower Trenton limestones resulted from an early Trentonian sea transgressing from about west to east according to the northwest-southeast outcrop belt. This transgression, which reached the Adirondack Arch near Canajoharie, was completed by Shorehamian time with the relatively deep water Sugar River Limestone (fig. 2). For a more detailed discussion of this transgression, see the field trip guide by Cameron, Mangion, and Titus elsewhere in this book.

The early Trentonian transgression was followed in Denmarkian time by subsidence of the Adirondack Arch into a deep water region that accumulated the Canajoharie and Utica black shales. This resulted in the formation of a shallow marine bank to the northwest whose margin accumulated the Poland, Russia, and Rust members of the Denley Limestone. These three members grade into the northern relatively undifferentiated main body of the relatively shallow marine Denley limestones. Possibly, along the slope of this bank the Dolgeville Facies accumulated.

During the late Trentonian, a regression occurred in the Trenton Falls area with the deposition of the coarse-grained, cross-laminated Steuben Limestone which is followed by an erosional unconformity. Finally, a post-Hillier, Cincinnatian (late Ordovician) sea accumulating black shales retransgressed the whole area.

TIME CONTROL AND CORRELATION

Due to the belief that many rock units of the Trenton Group are diachronous (e. g., Fisher, 1962; Barnes, 1965, 1967) rather than being time-parallel (Kay, 1968), the criteria used for determining time will be briefly summarized. Age and time-correlations within the Trenton Group are established by means of both fossils and certain lithic criteria. Lithic criteria can supply useful evidence for accurate local correlating and dating, especially if a general temporal framework is available from paleontological evidence. These include metabentonites (Kay, 1935, 1943, 1953), marker beds, tongues, persistance of contrasting lithologies (Chenoweth, 1952; Cameron, 1968), lithic similarity, and stratigraphic position and sequence.

In the medial Ordovician rocks of northwestern New York, assemblage zones, range zones, epiboles, overlapping ranges, first occurrences, last occurrences, and so forth, are used in correlation. Many of these criteria are limited in large part to intrabasinal correlation in New York, Ontario, and surrounding areas, such as the trilobite *Cryptolithus* which has a much larger stratigraphic range in the southern Appalachians. Two zones mark the Rocklandian Stage at the base of the Trentonian Series (Cameron, 1969a): the *Doleroides ottawanus* and *Triplesia cuspidata* assemblage zones. No named zone has yet been defined for the fossil assemblages of the Kirkfieldian aged Kings Falls limestones. The Shorehamian Sugar River limestones contain the *Cryptolithus tesselatus* assemblage zone which includes a characteristically unusual abundance of the bryozoan *Prasopora*. The differentiation of the Denmarkian limestones "...is arbitrary and difficult, for although the..." Shorehamian and lower Cobourgian "...have persistent guide fossils, none that are both distinctive and abundant have been discerned in..." most of "...the intermediate beds..." (Kay, 1937, p. 263), i. e., much of the lower Denley Limestone. Some local zones and subzones have been recognized: (1) the *Trocholites* subzone occurs in the lower Poland in the vicinity of Trenton Falls (Kay, 1943, 1953), (2) the zone of abundant *Sinuites* and *Ctenodonta* in the Camp Member of northwestern New York (Chenoweth, 1952), and (3) the *Diplograptus amplexicaulis* (Hall) zone occurs in the lower Canajoharie Shale, Poland Member, and the top of the Glendale Member (Chenoweth, 1952). Stratigraphically above, the Rust and Steuben contain the *Rafinesquina deltoidea* zone. The zone of *Hormotoma* and *Fusispira* occurs in the Hillier Limestone at the top of the Trenton Group.

STRATIGRAPHIC CLASSIFICATION AND PROBLEMS

Geologists have applied several contradictory working hypotheses to interpretations of the stratigraphic relationships of the medial Ordovician sedimentary rocks in New York and Ontario: (1) that the formations are time parallel (Kay, 1937, 1942, 1968b; Young, 1943; Chenoweth, 1952; Cameron, 1968, 1969a, 1969b), (2) that the formations gradually transgress time (Winder, 1960; Barnes, 1965, 1967), (3) that some formations are miscorrelated (Sinclair, 1954; Kay, 1968a), and (4) that some formations radically transgress time and are time-equivalent facies of each other over relatively short distances (Fisher, 1962). While some workers have almost failed to apply the facies concept (Twenhofel, et. al., 1954; Fisher, 1962), others have over-applied it to the point of confusion and produced misleading and incorrect correlations.

As a result of these varying viewpoints, several terminological difficulties arose: (1) Since the formations were thought to be time-parallel, some stratigraphers and paleontologists applied the same name to biological zones, rock units, and time-parallel units (Fisher, 1962). (2) As a corollary of the above, formations were often recognized by certain so-called characteristic fossils (Kay, 1937, p. 251), rather than lithic criteria because some geologists were only interested in time (Kay, 1968b). (3) Because of this confusion, because some faunas were thought to be ecologically restricted, and because there are gaps in the New York sequence, new reference sections in other regions were proposed by G.A. Cooper (1956).

Early workers applied a single term for the rock units and the time-rock units (stages) because they were principally interested "...in distinguishing rocks of an age rather than of one kind" (Kay, 1968b, p. 1373). These time-rock units were called stages by Clarke and Schuchert (1899), Cushing (1905b), and Kay (1937, 1947), but others (Grabau, 1913; Willis, 1901) generally called them formations, relying upon context for distinction between the two concepts (Kay, 1968b). "Formations formed divisions of the 'standard time-scale' (Williams, 1901, p. 573)" (Kay, 1968b, p. 1373).

Fisher (1962) stated that "...misunderstanding persists, owing to mixed usage of lithostratigraphic, biostratigraphic, and chronostratigraphic units all termed 'formations'. Furthermore, some geographic names are used in a dual or even triad sense (viz, Rockland Limestone, Rocklandian Stage, Rocklandian-*Dalmanella* zone), and one is never quite certain of the writer's intention." According to standard usage, Rockland Limestone ought to be a lithic unit, Rocklandian stage a time-stratigraphic unit, and *Dalmanella* zone a biostratigraphic unit. To remedy the dual usage of nomenclature, some paleontologists and stratigraphers have been adding the suffix "-ian" or "-an" to the formation names to clearly indicate whether a stage, i.e., a time-rock unit is being discussed. Rocklandian and Kirkfieldian (Figure. 2) were used as stages by Kay in 1935, although not with the "-ian" ending until 1948 when he used the name Trentonian, as did Grabau (1909).

Raymond (1914, 1921) named the "Rockland" and succeeding Trenton formations and "...applied the names to units recognized by a succession of faunal zones; these were chronostratigraphic" (Kay, 1968a, p. 167.) Wilson (1946) correctly regarded the subdivisions as biostratigraphic. Thus, biostratigraphic units came to be used as lithostratigraphic units which seem to parallel time lines independently drawn from studies of the faunas and the lithologies, including metabentonites (Kay, 1937, 1942, 1943, 1953; Young, 1943; Chenoweth, 1952; Lippitt, 1959; Cameron, 1968, 1969a, 1969b). These lithic units are not completely uniform throughout their geographic distribution, but contain lithofacies changes (Cameron, 1968) or change systematically along the outcrop belt and contrast with overlaying and underlying units in a constant way (Chenoweth, 1952; Cameron, 1968). Actually, the outcrop belt in northwestern New York may follow approximately the original shoreline, so as to expose the axis of linear lithosomes that once paralleled the medial Ordovician coast (Cameron, 1968; Walker, 1969). In this case, then, the lithic units are most probably both lithic and time-stratigraphic. A cross-section cut perpendicular to the present outcrop belt, i. e., perpendicular to the ancient shoreline, might show them to be time-equivalent facies of each other, as suggested by Fisher (1962) in his correlation chart of the Ordovician rocks of New York State.

There has been much controversy over the usefulness and limits of the divisions of the North American medial Ordovician standard. Systematic paleontologists working independently on many different fossil invertebrate groups have independently concluded that the New York Ordovician sequence is incomplete and that, for some portions, other areas should be sought to serve as a standard (Fisher, 1962), e.g. B.N. Cooper (in G.A. Cooper, 1956) working on trilobites, G.A. Cooper (1956) working on brachiopods, Flower (1957) working on nautiloids, Whittington (in Kindle and Whittington, 1958) working on trilobites, Berry (1962), and Sweet and Bergstrom (1971) working on conodonts. Many workers now [working on graptolites] follow G.A. Cooper's (1956) scheme of six stages for the medial Ordovician, which are (in ascending order): Whiterock of Nevada, Marmor and Ashby of Tennessee, Porterfield and Wilderness of Virginia, and Trenton of New York.

The original standard sections for the medial Ordovician were defined from New York, but not from completely contiguous sections. Fisher (1962) correctly states that "...widely separated successive stages of the time scale are accepted in some cases, but this practice should not be encouraged." Also, "...widely separable locales are chosen for a supposed continuum, thereby increasing the chance of omission or duplication of time..."

Cooper (1956) believed the Black River faunas to be closely related to those of the lower Trentonian Rocklandian Stage. He proposed the "wilderness" as a stage term for the upper Bolarian and lower Trentonian interval and restricted the "Trenton" to the medial and late Trentonian of Kay's (1937) usage. Fisher (1962) substituted "Barneveld" for this restricted "Trenton" Stage and kept the terms Trenton and Black River for rock-stratigraphic units. Cooper overlooked the Kirkfieldian Stage which Fisher (1962) added to the top of the "Wilderness".

In addition, much evidence gathered recently indicates there is an overlap of the medial Ordovician Trentonian Series and the late Ordovician Cincinnatian Series which are both part of the North American Ordovician Standard. Conodont research suggests that the Edenian Stage of the early late Ordovician (Cincinnatian Series) is time-equivalent to the later Trentonian Cobourgian Stage (Fisher, 1962; Schopf, 1966; Sweet and Bergstrom, 1971). Because of this overlap, Sweet and Bergstrom (1971) suggested leaving the Cincinnatian Series in tact and further modifying the Trentonian part of the North American Standard for the medial Ordovician.

In central New York west of the Adirondack Arch complex facies relationships compound time-correlations and additional stratigraphic and paleontologic studies are needed (Fig. 2). Exposures are not often complete and the seemingly repetitious nature of the complex sedimentary rock types make study difficult. Lack of ecological understanding of the macrofossils has lead many to doubt their usefulness in correlation.

At the present time, some disagreement exists as to whether one should follow Cooper's terminology or that of Kay and his predecessors. In either classification, the "Trenton" (restricted) or "Barneveld" and Trentonian are still taken from the New York section whose upper part is believed by many investigators to be equivalent to the lower Cincinnatian Series of Ohio. Kay (1968b) proposed a classification of the Ordovician of northwestern New York in which he attempted to clarify the terminology by usage of completely separate and unambiguous time and rock nomenclature, as did Liberty (1955, 1963, 1969) in southern Ontario. The stratigraphic classification used herein (Fig. 2) for the Trentonian of northwestern New York follows that of Kay (1968) with modification for the lower Trenton Group from Cameron (1967, 1968, 1969a, 1969b). A thorough historical review of the early classification of these limestones can be found in Kay (1937, p. 237-249); for a review of some later work, see Cameron (1968).

DESCRIPTIONS OF INDIVIDUAL STOPS

Stop #1. Canajoharie Creek:

Three formations will be seen along Canajoharie Creek at the southern edge of the village of Canajoharie: Chuctanunda Creek Dolostone, Sugar River Limestone, and Canajoharie Shale. The Chuctanunda Creek is a stromatolite-bearing, otherwise unfossiliferous, early Ordovician (Canadian) dolostone disconformably underlying 17 feet of Sugar River Limestone. The later is succeeded conformably by the Canajoharie graptolite-bearing black shales. At this locality the Sugar River probably represents more shallower water conditions than the relatively deeper water, more-burrow reworked, Sugar River lithologies to the northwest. The base contains atypical shelly calcarenite and a pararippled bed, followed by a concentration of calcisiltites. The middle contains more typical burrow-reworked non-shelly calcarenite. Near the top, along the macadam path, several thick, shelly calcarenitic lenses occur that probably represent channels.

Stop #2. Route 55 South of Little Falls:

Along the west-facing hillside, a quarry and roadside exposures may be found. The quarry contains about 2½ feet of Gull River Limestone (middle Black River Group) succeeded by about 18 feet of very fossiliferous Kings Falls Limestone. The latter contains shelly and non-shelly calcarenites with current laminations alternating with thin shales and burrow-reworked horizons. Along the roadside, there are 15 feet of Sugar River non-shelly, somewhat burrowed calcarenites with horizontal and cross-laminations visible. This is succeeded by about 10 feet of Dolgeville Facies which is composed of 6 feet of alternating thick black shales and black, argillaceous calcisiltites followed by about 4 feet of shale.

Stop #3. City Brook (locality #C1):

The Gull River Limestone of the Black River Group lies disconformably on the quartz arenite-rich late Cambrian Little Falls Dolomite below the bridge. The lower falls is supported by the upper Gull River Limestone, and the upper falls (Craig, 1941, fig. 5; Kay, 1953, fig. 11) is supported by the middle Kings Falls Limestone. The Rathbun member at the top of the Sugar River Limestone and the superjacent Denley Limestone will not be examined because we will have to respect the NO TRESPASSING signs.

Gull River Limestone. The lower 8 feet are tan weathering, gray, quartz arenite-rich, ostracod-bearing, impure, thick-bedded, medium-textured, argillaceous limestones interbedded with a few calcareous shales up to 3 inches thick. Vertical burrows are abundant. A 3-inch thick metabentonite occurs at 6' 9" (Kay, 1943, 1953).

The upper 19½ feet of the Gull River is composed of relatively pure, light gray weathering, dove gray, conchoidally fracturing calcilutite (sublithographic) and some calcisiltites. Stylolites are abundant from 11 to 16 feet. Thin shales are frequent between 13 and 16 feet, at the 18th foot, and especially between 19½ and 21½ feet where the limestones are very argillaceous (Fig. 3). Vertical burrows (Phytopsis) are abundant between 11 and 16 feet and in the top foot. Mudcracks occur above and below the 25th foot. An intertidal to lagoonal origin is probable for these limestones.

Kings Falls Limestone. Sediment from a coquinal calcarenite bed at the base of the Kings Falls fills some of the burrows in the highly burrow-reworked calcilutite bed at the top of the Gull River. The Kings Falls is characterized by coquinal calcarenites, as at the previous locality, in contrast with the non-coquinal calcarenites of the superjacent Sugar River Limestone. Cross-laminated and pararippled beds are frequent.

At 7 feet a deep reentrant marks where a metabentonite is weathering out. Less than a mile north, at Buttermilk Creek, this clay is 9 feet above the base of the Kings Falls (Kay, 1953). If this altered volcanic ash near the base of the Kings Falls between Stony Creek and Buttermilk Creek is part of a single bed, then it represents a synchronous time surface indicating that this formation is onlapping the Gull River eastward. Therefore, the base of the Kings Falls becomes progressively younger eastward, increasing the gap in time marked by the black River-Trenton boundary in that direction.

Sugar River Limestone. The contact between the Kings Falls and Sugar River limestones is drawn where shale becomes more abundant. This coincides with a contact drawn where non-coquinal calcarenites become persistently abundant and coquinal calcarenites almost disappear. The Sugar River at this exposure is mainly composed of interbedded coarse-grained calcarenites and calcareous shales. These calcarenites are encrinitic and rich in bryozoa, especially cryptostomes. The shales are especially abundant in the lower 10 feet, thus further accentuating lithic contrast with the upper Kings Falls below. The Sugar River Limestone contains the Cryptolithus tesselatus Zone which is characterized by C. tesselatus and the relative abundance of Prasopora. Unusually large Prasopora occur near the top.

Stop #4. Rathbun Brook:

The upper Sugar River and lower Denley limestone will be seen on Rathbun Brook. The 2½ feet of very fossiliferous, burrow-reworked, argillaceous, black, hard Trocholites subzone beds of the base of the Denley form the top of the waterfall. Immediately succeeding these, one can see the typical fine-grained calcisiltite beds of the lower Poland Member in the stream bed. About 50 feet of Poland and about 52 of Russia are incompletely exposed over a long distance upstream. About 55-60 feet of Utica shale outcrops farther upstream after about 30 feet of covered interval. Beneath the Trocholites subzone in a stepwise fashion the Sugar River Limestone is fully exposed with the 9 foot thick Rathbun Member at the top. Note the shelly calcarenites of the Rathbun contrasting with the non-shelly calcarenites of the lower member of the Sugar River below and the Poland above. Also note the relatively thick calcisiltite beds of the Rathbun which contrast with the lower Sugar River and show similarities with the Poland above.

Stop #5. Bridge at Trenton Falls Gorge:

About 13 feet of Middle Poland limestone and thin shales are exposed upstream from the bridge on West Canada Creek. Note that the middle Poland is coarser grained and more fossiliferous than the lower Poland at Rathbun Brook (Stop #4). Burrowed fine-grained limestones are still characteristic of this member, however.

Stop #6. Lower Trenton Falls Gorge:

Poland (about 50 feet thick) and Russia (about 75 feet thick) members of Denley limestone can be seen on the opposite bank from the road at the powerhouse. Two reentrants 9 feet apart in the upper Poland represent metabentonites. At the powerhouse gate, the Poland-Russia contact is about 12 feet above the road. The coarser-grained, more rubbly, burrow-reworked, more fossiliferous Russia Member can be examined along the hillside exposures on the walk back to the cars.

Stop #7. Dam at Trenton Falls Gorge:

The lower Steuben Limestone and much of the Rust Member of the Denley Limestone can be seen after crossing the dam. By the spillway, the 26 feet of massively bedded, horizontally and cross-laminated, encrinitic Steuben Limestone can be examined from the top of the dam. The contact with the Rust is clearly visible from the reservoir and in the spillway wall. In the spillway, the slump structures in the upper Rust can be examined. Below the spilling the very fossiliferous calcarenites of the upper part of the 115 feet of Rust are excellently exposed. See text above for a detailed description of the Rust at this exposure.

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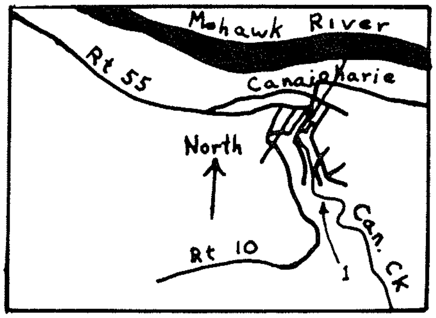
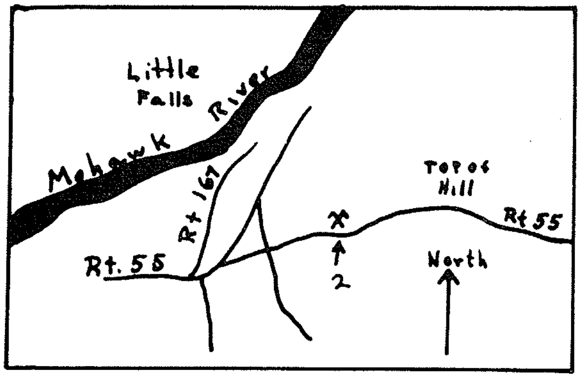


STOP 1



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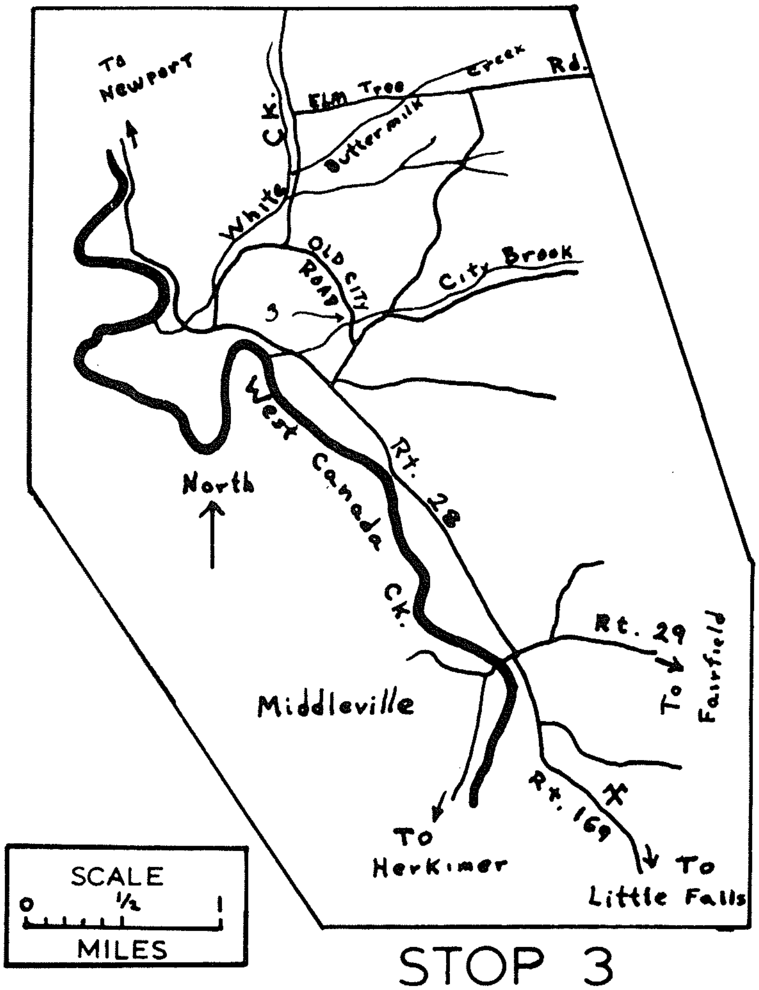

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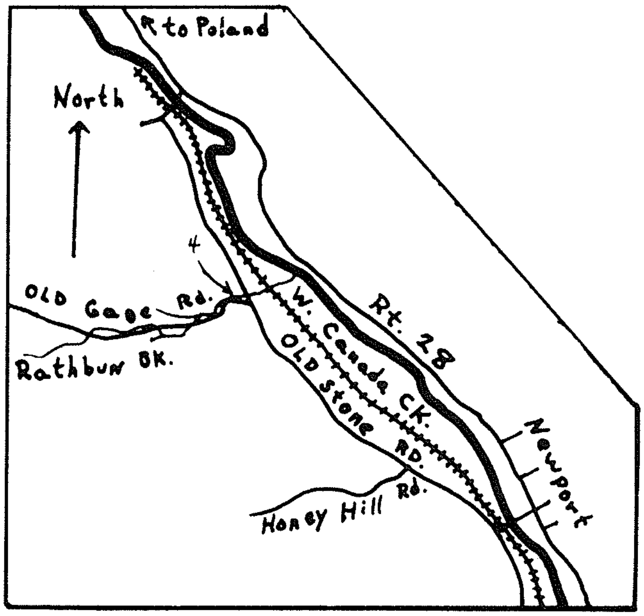

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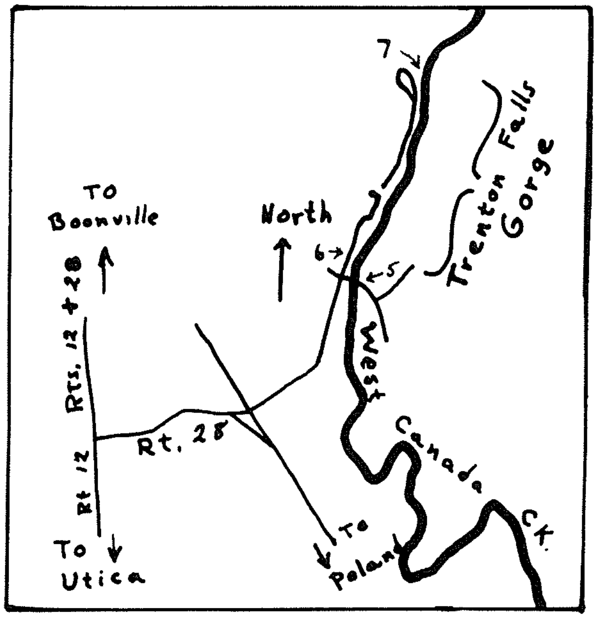

STOP 5 & 6 & 7

Road maps for field trip stops.

MILEAGE LOG

This mileage log is designed to start at the toll booths of the Canajoharie Exit (#29) of the New York State Thruway. Mileage was taken from a car's odometer and "hundreds" of a mile are estimated where turns occur in rapid succession. This field trip will visit the Canajoharie, Little Falls, and Remsen 15' quadrangles.

Take the Thruway to Canajoharie (Exit #29). After leaving toll booths, bear left a short distance until you reach Route 5S. Then turn right and go west until the first stop light in the village of Canajoharie. Turn left and drive a short distance until you reach the stop light in the triangular "square".

*InMi	CumMi	
0.0	0.0	At stop light in triangular "square" in Canajoharie. Turn left onto Montgomery Street.
0.05	0.05	Intersection with Moyer Street. Turn right.
0.35	0.4	Intersection with Floral Avenue on right. Turn right.
0.1	0.5	Park in parking lot on right side of road.
		Stop #1: Walk straight ahead on road, keeping to right of green house, until you reach the first wooden posts on the right that are blocking a macadam path. Take this macadam path down to the west bank of Canajoharie Creek. The Sugar River Limestone is exposed along the path. At the end of the path, walk about 100 feet onto the flat area to get a better look at the exposure.
0.0	0.5	Return to cars, turn around, and drive back to Moyer Street.
0.1	0.6	Turn left onto Moyer Street.
0.35	0.95	Turn left onto Montgomery Street.
0.05	1.0	Turn wide right (second right) at triangular "square" and follow signs for Route 5S.
0.1	1.1	Turn left at intersection with stop light, following signs for Route 5S West.
3.3	4.4	Turn left at stop light in village of Fort Plain, following signs for Route 5S.
0.05	4.45	Turn right (west), following signs for Route 5S.
14.45	18.9	Park on right side of Route 5S near edge of woods on right.
		Stop #2: Walk to quarry 100 feet to the right (north) side of road. Then return to highway and examine exposures along south side of Route 5S.

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*InMi = Incremental Mileage; CumMi = Cumulative Mileage.

0.0	18.9	Return to cars and proceed straight ahead downhill on Route 5S.
0.8	19.7	Turn right at intersection with Route 167.
1.8	21.5	Crossing bridge.
0.15	21.65	Cossing another bridge.
0.15	21.8	Turn right onto Albany Street at intersection.
0.1	21.9	Turn left at intersection.
0.05	21.95	Stop light. Go straight ahead uphill.
0.02	21.97	Turn wide left onto Church Street and go uphill.
0.78	22.75	Merge right cautiously with Route 169 and continue straight ahead.
8.55	31.3	Stop light in village of Middleville. Proceed straight ahead through intersection onto Route 28 North.
1.8	33.1	Turn right and drive straight uphill.
0.25	33.35	Fork. Bear left, going downhill, onto Old City Road.
0.15	33.5	Park on either side of road before bridge over City Brook.
		<u>Stop #3</u>: Walk across bridge and down steps on upstream side of bridge leading to stream bed. Then, climb back to bridge and walk up the opposite bank of City Brook. Obey no tresspassing signs farther upstream.
0.0	33.5	Proceed straight ahead, crossing bridge.
1.25	34.75	Junction with Route 28. Turn right, heading north on Route 28.
1.9	36.65	Traffic light in village of Newport at intersection with Newport Road. Turn left.
0.25	36.9	Turn right onto Old State Road.
1.7	38.6	Fork. Turn left onto North Gage Road and proceed uphill.
0.2	38.8	Park along right side of road.
		<u>Stop #4</u>: Walk to right, down farm road and be careful as you go through barbed wire fence.
0.0	38.8	Return to cars. Be sure gate in barbed wire fence is closed! Drive uphill 0.3 miles until you can safely turn around in a driveway and return to Old State Road.
0.3	39.1	Turn into first driveway on left in order to back out and face downhill. Return to Old State Road.
0.5	39.6	Turn left at intersection with Old State Road.

1.1	40.7	Bear right and continue straight on Old State Road.
0.3	41.0	You should now be on a narrow bridge over West Canada Creek.
0.1	41.1	Bear left at intersection and go north on Route 28.
0.5	41.6	Village of Poland, continue north on Route 28 (bear left on curve at main intersection).
1.5	43.1	Fork. Bear right and cross bridge, continuing north on Route 28.
3.9	47.0	Fork. Bear right and cross bridge, continuing north on Route 28.
1.2	48.2	Fork. Go straight, leaving Route 28.
0.1	48.3	Turn right at intersection.
0.8	49.1	Turn right at intersection and cross bridge over West Canada Creek.
0.1	49.2	Once across bridge, immediately turn right and park in parking area.
		Stop #5: Walk across road (watch for traffic) and down to the exposures along the east bank just upstream from the bridge.
0.0	49.2	Return to cars and go back across the bridge.
0.1	49.3	Turn right at intersection.
0.15	49.45	Turn right and park in area on right side of road. Do not block dead end driveway on far right by edge of river bank.
		Stop #6: Walk about 200 yards down this gravel driveway to the exposures by the powerhouse at its end.
0.0	49.45	Return to cars and continue driving up the paved road.
0.1	49.55	Stone gate. Continue straight ahead.
0.1	49.65	Bear right.
0.05	49.7	Bear left.
0.1	49.8	Metal (wire) gate ahead.
0.05	49.85	Park in parking lot after turning left, but do not block driveway or access to building. Good drinking water is available here from running faucet.
		Stop #7: Walk back to road and go uphill, walking around fence gate (opening on left side slightly concealed). Continue uphill for about a quarter of a mile to the dam.
0.0	49.85	Return to cars, turn around, and return to Route 28.
0.1	49.95	Bear right.

0.05	50.0	Bear left.
0.1	50.1	Stone gate. Go straight ahead.
0.25	50.35	Intersection. Go straight ahead.
0.8	51.15	Intersection. Go straight ahead.
0.05	51.2	Intersection with Route 28. Take Route 28 (straight ahead) to Route 12.
0.75	51.95	Junction with Route 12. Turn left and take Route 12 south to Utica. End of field trip.