Correlation of the Silurian and Devonian Rocks in New York State

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by Lawrence V. Rickard[2]

ABSTRACT

Two charts showing the classification and correlation of Silurian and Devonian rock units in New York State and adjacent border areas are presented. Evidence for the classifications and correlations shown is discussed in a text. The thickness of principal stratigraphic intervals across the State is given in tables and cross sections. Major facies delineated among these rocks are briefly described and shown in color on the charts.

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INTRODUCTION

The Silurian and Devonian rocks of New York comprise a sequence of richly fossiliferous strata, about 13,000 feet maximum thickness, made known throughout the world by the efforts of a host of geologists and paleontologists. The incomparable James Hall, of course, was the most famous of these, but the long list also includes the beginning investigators—Amos Eaton, W. H. Mather and Lardner Vanuxem; those most active shortly after the turn of the century—J. M. Clarke, Amadeus Grabau, C. A. Hartnagel, C. S. Prosser, H. S. Williams, and Charles Schuchert; and several more recent scientists—K. E. Caster, G. H. Chadwick, G. Arthur Cooper, and Winifred Goldring. It was the intensive efforts of these people that made the New York Silurian-Devonian sequence so well known and established it as the standard reference section for eastern North America.

A succession of correlation charts of the Silurian and Devonian rocks of New York have appeared during the past 150 years of study. Each has been a summary of the knowledge accumulated up to the time of its publication. The work continues and the charts published in this report represent similar statements of progress.

PLAN OF THE CHARTS

On the charts, vertical dimension approximates relative timespan as currently known from radiometric dating (Harland and others, 1964; Miller and Senechal, 1965). The horizontal dimension of the charts refers, of course, to the geographic extent of rock units along their outcrop, also shown on the small inset map. Because correlation charts offer no feeling for the thicknesses of rock units, tables of thicknesses for major rock units and a stratigraphic cross section have been added.

Vertical ruling denotes an hiatus—absence of a rock record. Diagonal ruling signifies concealed strata. Solid line boundaries indicate well-established contacts, approximately placed chronologically. Dashed line boundaries indicate vague or dubious contacts; queried solid or dashed line boundaries indicate questionable chronological placement of contacts. Position of asterisk denotes longitudinal (quadrangle) location of type locality; units lacking an asterisk have their type localities beyond the limits of New York State. Horizontal dotted lines are stage limits. Diagnostic faunal control is shown by appropriate abbreviations although position of letter does not mean that significant fossils are found only in that quadrangle column. Only principal lithologies of a rock unit are mentioned by conventional abbreviations (cgl. = conglomerate, qtzte. = quartzite, ss. = sandstone, silt. = siltstone, sh. = shale, arg. = argillite, gywk. = graywacke, cht. = chert, ls. = limestone, dol. = dolostone, h. = hematitic, py. = pyrite).

Rock unit names are shown in vertical letters and are those accepted by the New York State Geological Survey and are recommended for future use. Names in print but absent from the charts are omitted because either they are not valid rock units, apply to minor rock units too small to be shown, are ill-defined, are synonymous with existing names, or are thought unnecessary. Some new names are proposed for recognizable mapping units which previously possessed no formal status or for which the nomenclature was unclear.

The time and time-rock units shown are those currently used for intra- and interstate correlation as well as for international correlation. Biostratigraphic units (zones) are shown in inclined letters. No attempt has been made to show the stratigraphic ranges of individual fossil species. For many species the total range is not accurately known and, because most species are ecologically controlled, indicated faunal ranges frequently are ambiguous, misleading, or erroneous. Instead, emphasis has been placed on establishing a firm biostratigraphic framework using the best available fossil zonations. Accordingly, the primary basis has been relating rock units to established or proposed zones defined by graptolites (Silurian, Devonian), conodonts (Silurian, Devonian), and ammonoids (Devonian). Secondary bases employed are brachiopods (Silurian, Devonian) and ostracodes (Silurian).

For those who desire to do so, these charts may be joined together. By either folding back or cutting off the top of the Silurian chart along the Silurian-Devonian boundary (marked by triangles at the base of the area indicating overlying rock units), the Silurian chart can be matched across the base of the Devonian one (concealing the area indicating underlying rocks on that chart). A similar procedure will permit matching the forthcoming Middle-Upper Ordovician chart across the base of the Silurian one.

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The Facies and Their Inferred Environments

On the Devonian correlation chart published by Rickard in 1964, color was used to delineate the major facies (called depositional phases) present in that classic sequence. The attempt was the first of its kind and was well received. Color has been used again on these new, revised charts and for the same purpose—to show the distribution of major facies differentiated through consideration of the combined lithologic, biologic and sedimentologic aspects of the rock units. This new attempt has been coordinated with a similar effort by D. W. Fisher on correlation charts of the Cambrian and Ordovician rocks of New York.

The facies we are able to delineate among the Paleozoic rocks of New York can be classified into three major groups. First, rift facies—a few kinds that form in rifts during the breakup of continents. Second, continental margin facies—those forming on the continental shelf, slope and rise facing the open ocean. Third, intracontinental facies, a large group that forms in epeiric seas flooding portions of continents, usually with more or less restricted access to the open ocean. The third group could be divided into two suites of genetically related facies—a) those characteristic of slow deposition in "clear-water" epeiric seas whose near shore terrigenous sediments, if any, usually are extensively reworked and winnowed, and b) those that form by more rapid deposition in "turbid-water" epeiric seas receiving a large volume of terrigenous debris from the vigorous erosion of an adjacent landmass. The first suite usually, but not necessarily, is characteristic of transgressive seas; the second of regressive seas (progradation).

In New York we presently recognize a total of 22 principal facies distributed among these groups and suites. We do not mean to imply that there are not other kinds of facies characteristic of these or other groups, nor that any of the principal facies cited here could not be differentiated into various subfacies. For example, within the continental margin group, we do not show a suite of facies composed principally of terrigenous rocks, such as that contained within the Cretaceous-Tertiary sequence along the east coast of the United States. Such facies are not known to occur among the Paleozoic rocks of New York considered here.

A concise description of each of the 22 facies shown on these charts and those to be published shortly by D.W. Fisher is given in Plate 1. These descriptions include brief statements regarding the lithologic, sedimentologic and biologic features of each facies and the environment in which we believe it was formed. Also, we have included the name of a rock unit that might be taken as an example of that particular facies. Where practical, these are rock units that already have received detailed paleoenvironmental study and analysis.

Silurian

To review the progress recently made in our study of the lithologic, paleontologic, and stratigraphic features of the Silurian rocks of New York and their correlation, one might begin with a comparison of the principal Silurian correlation charts published during the past 50 years. Such charts include those by Swartz and others (1942), Schuchert (1943), Fisher (1960), Berry and Boucot (1970) and this report. These charts present condensed statements regarding the relationships that exist among the Silurian rocks of New York and provide a convenient base from which more comprehensive and detailed reviews can be made. A correlation chart (Cocks and others, 1971) for the Silurian of the British Isles is available which will serve to introduce readers to the type section. A second such chart prepared by Ziegler, Rickards and McKerrow will be published soon by the Geological Society of America.

Time and Time-Rock Units

The limits of the Silurian System of New York are time planes defined by the spatial distribution of points synchronous with the initiation and cessation of sedimentation in the type (or standard) Silurian sequence in Europe. Accordingly, the recognition, classification and correlation of the New York Silurian System must include a consideration of the type in Europe.

Considerable improvement in our knowledge of the European type sequence has occurred during the past decade. There have been major advances in the resolution of boundary problems, the delineation of biostratigraphic zones based on graptolites, conodonts, ostracodes, and brachiopods, and in the correlation of the Silurian of Great Britain with that in Czechoslovakia. Chief among these advances have been recognition of the persistence of the monograptids from the Silurian into the Devonian, the use of conodonts to establish zones and to facilitate correlations and establishment of the Pridolian as a post-Ludlovian series. Many of the publications cited in the bibliography appended to this report deal with these matters.

The principal sources of information used in construction of the biostratigraphic framework shown along the left side of the chart are listed below.

Graptolite, brachiopod and ostracode zonation:

- Berry and Boucot, 1970
- Chlupac and others, 1972
- Cocks, 1971
- Cocks and others, 1971
- Gillette, 1947
- Jones and others, 1969
- Toghill, 1971
- Warren, 1971

Conodont zonation:

- Aldridge, 1972
- Davis, 1974
- Fåhraeus, 1969
- Klapper and Murphy, 1974
- Klapper, Berry and Boucot, 1970
- Nicoll and Rexroad, 1968
- Pollock, Rexroad and Nicoll, 1970
- Rexroad and Nicoll, 1971
- Walliser, 1964, 1971

Nomenclature:

- Cocks, Toghill and Ziegler, 1970
- Holland and others, 1963
- Lawson, 1971
- Martinsson, 1969
- Strachan, 1964

Despite the intensive efforts of the past decade there has been no change in the position of the Ordovician-Silurian and Silurian-Devonian boundaries in New York State from those shown on the earlier charts by Fisher (1960) and Berry and Boucot (1970). Indeed, many uncertainties regarding the upper boundary have disappeared and final resolution of the problem seems imminent (Rickard, 1962; Berdan, 1964; Berdan and others, 1969).

The Silurian of Europe usually has been divided into Lower (Early) and Upper (Late) subsystems. The term Middle (Medial) Silurian of widespread usage in North America means little to European stratigraphers and indeed, its application outside of New York has come to mean "any Silurian beds containing a rich marine fauna" (Berry and Boucot, 1970, p. 16). Accordingly, use of Middle Silurian in New York is abandoned and application of the terms Lower and Upper Silurian is brought into agreement with their use in Europe. The Lower-Upper Silurian boundary in New York presently is placed in the upper Clinton Group at the base of the Rockway Dolomite.

Following the suggestion of Fisher (1960) the New York Silurian System is divided into two series—the Niagaran and Cayugan. There seems to be no firm faunal basis or utility for an Albion (or Alexandrian) Series in the Lower Silurian. Rickard (1969) indicated a slight overlap of the original Niagaran and Cayugan Series. The detailed biostratigraphy needed for proper resolution of this problem being unavailable, it temporarily has been resolved in favor of the older Niagaran Series, *i.e.*, the boundary is taken as the top of the Niagaran in the Niagara Gorge.

The stages proposed by Fisher (1960) were based upon local lithologic sequences. Their faunas are ill-defined and rarely encountered outside New York State and adjacent areas. Consequently, they were rejected by Berry and Boucot (1970) as a basis for subdivision and correlation of the Silurian of North America. At present there seems to be little justification for the establishment of local stages based upon the New York sequence principally because of the lack of diagnostic fossils in that sequence and continued improvement in our ability to utilize the European subdivisions.

Rock Units

During the 15 years since the compilation of Fisher's (1960) correlation chart every group in the New York Silurian has been the subject of a major study. A complete and thorough review of the lithologic, paleontologic and stratigraphic features of these groups has occurred. Frequently, extensive revision of their classification and correlation has resulted. Stratigraphic and paleoenvironmental studies of the **Medina Group** were published by Fisher (1966) and Martini (1971). Kilgour (1963) clarified relationships among units of the lower **Clinton Group** in western New York and Ontario. Zenger (1966, 1971) and Muskatt (1972) contributed to our knowledge of the eastern portion of that group. Although a restudy of the age relationships and environments of deposition of the entire Clinton Group is in progress (A. M. Ziegler, 1971), the work of Gillette (1947) remains the definitive study of this group. The equivalency of much of the upper Clinton Rochester and Herkimer Formations of east-central New York to the lower portion of the Lockport Group in the western part of the State, suggested by Zenger (1965, 1971) has been confirmed by subsurface studies (Rickard, 1974).

A comprehensive study of the stratigraphy and paleontology of the **Lockport Group** was published by Zenger (1962, 1965) and a detailed analysis of the Gasport reefs was completed by Crowley (1973). Both surface and subsurface stratigraphy of the **Salina Group** were discussed by Rickard (1969), carrying on the work initiated earlier by Leutze (1959). The Bertie is considered part of the Salina Group, as suggested by Rickard (1969, p. 4). A paleoenvironmental analysis of the Salina Group has been completed by Treesh (1972, 1973) and Treesh and Friedman (1973). Near the top of the Silurian, research by Rickard (1962) and Harper (1969) and data supplied by S. J. Ciurca of Rochester have provided better knowledge of the Cobleskill-Akron and Chrysler. Following a suggestion by Harper, these are now considered members of the **Rondout Formation.**

The **Shawangunk-Bloomsburg** of southeastern New York was reexamined by Smith (1967a). However, the key to understanding correct stratigraphic relationships between the Shawangunk and overlying units was discovered in an obscure and overlooked report by Bird (1941) describing the Warwarsing Limestone. This resulted in further clarification by Smith (1967b). Higher strata in southeastern New York were studied by Rickard (1962), Epstein and others (1967) and Barnett (1970). Silurian strata in southwestern Ontario were examined by Bolton (1964) whose conclusions have a bearing on our understanding of the New York sequence.

Correlation

The **Medina Group** remains one of the most difficult portions of the New York Silurian to correlate because of the lack of any diagnostic fossils. It is unknown how much or what portion of Llandovery time may be represented and its placement on the chart is purely arbitrary. Despite some lithologic similarity to adjacent strata, particularly the underlying Queenston, the group may be bounded by major unconformities.

In contrast, the **Clinton Group** probably is more firmly correlated than any other portion of the New York Silurian. Conodonts, brachiopods, ostracodes and graptolites—all these may be used. Although it contains a large fauna, the upper Clinton Rochester Shale is not as well dated as the remainder of the group. It is correlated with the Wenlock Series largely by dating overlying and underlying units. Conodonts of the Clinton Group are discussed in reports by Rexroad and Rickard (1965), Nicoll and Rexroad (1968), Rexroad and Nicoll (1971), and Gartland (1973). Condonts of the *irregularis* zone occur in the Neahga Shale; *celloni* zone species occur in the Hickory Corners, Merritton and Wallington Limestones, and in the lower Sodus Shale. Conodonts of the *amorphognathoides-ranuliformis* zone have been recovered from the Willowvale Shale, Rockway Dolomite and the lower portion of Irondequoit Limestone that overlies the Rockway. Uppermost Irondequoit conodonts have been referred to the *patula* zone. Most of the conodonts of the Rochester Shale are not diagnostic and the important genus *Kockelella* has not been found. The highest Rochester contains conodonts of the *sagitta* zone. Ostracode occurrences are those of Gillette (1947) and Berry and Boucot (1970). Brachiopods have been recorded in many reports on the Clinton Group (Gillette, 1947) but the dating used here is chiefly that of A.M. Ziegler (1971, personal communication), summarized below, based upon various species of *Eocoelia* and certain pentameroids.

UNIT	SPECIES	DATE
Willowvale	*E. sulcata* (late form)	late C_6 or early Wenlock
top of Sauquoit	*E. curtisi* (late form)	C_5 or early C_6
basal Sauquoit	*E. curtisi*(?) (early form)	C_4
upper Sodus	*E. intermedia* (late form)	early C_4
lower Sodus	*E. intermedia*	late C_3 or early C_4
lower Sodus	*E. hemisphaerica*?	C_2?
top of Wallington	*E. hemisphaerica* (late form)	C_2
Hickory Corners	transient from *C. uniplicata* to *E. hemisphaerica*	B
Merritton	*Pentameroides*	maximum C_5

The **Lockport Group** is dated principally by conodonts of the *sagitta* and *snajdri* zones, recorded by Rexroad and Rickard (1965), Rexroad and Nicoll (1971), and Shaver and others (1971). Some information on ostracodes in the equivalent portion of the upper Clinton is available from Berdan and Zenger (1965), and Zenger (1966, 1971). Additional work is in progress by R. M. Liebe at Brockport.

Rare conodonts in the middle Vernon, Syracuse and Bertie Formations are the most useful fossils for dating the **Salina Group.** Those from the Syracuse and Bertie contain species indicative of the *eosteinhornensis* zone. The youngest Silurian rocks of New York are dated principally by the coral *Cystihalysites,* the brachiopod *Eccentricosta* and conodonts of the *eosteinhornensis* zone. These occur in the Akron, Cobleskill, Wilbur, Glasco and other members of the **Rondout Formation** (Berry and Boucot, 1970; Barnett, 1971, 1972; Berdan, 1972). A lack of diagnostic fossils of any kind prohibits accurate dating of the sequence in south eastern New York from the base of the Shawangunk-Green Pond to the base of the Decker Formation. The Decker contains the same late Silurian species found in the Rondout.

Devonian

Progress in our understanding of the complex lithologic, paleontologic and stratigraphic features of the Devonian System of New York seems characterized by two periods of increased activity. The first period, 1925 to 1935 saw recognition of the fact that major facies changes occur within this sequence. Indeed, the New York Middle and Upper Devonian became a classic area in the development and application of the concept of facies change. The second period, 1950 to the present, has involved the tracing of particular black shale tongues across the major facies boundaries to further elucidate the stratigraphy and paleontology of the rocks. The principal correlation charts of the New York Devonian published during the last 50 years reflect the great progress that has been made. These charts include Goldring (1931), Chadwick (1933, 1935), Cooper and others (1942), Schuchert (1943), Rickard (1964), Oliver and others (1967, 1969) and this report.

Time and Time-Rock Units

The limits of the Devonian System of New York are time planes defined by the spatial distribution of points synchronous with the initiation and cessation of sedimentation in the type (or standard) Devonian sequence in Europe. As with the Silurian, the recognition, classification and correlation of the New York Devonian System must include a consideration of the European type and standard.

The principal advances made in our knowledge of the European type sequence during the past decade include progress in the resolution of boundary problems, improvements in the biostratigraphic zonations based on ammonoids and brachiopods, establishment of a new biostratigraphic zonation based on conodonts, and better correlations between the major Devonian sequences in Great Britain, Belgium, France, Germany and Czechoslovakia. Many of the publications cited in the bibliography included in this report describe and discuss these topics.

The biostratigraphic framework shown along the left side of the chart was compiled through the use of many papers and reports, both foreign and domestic. The major sources of information are listed here.

Ammonoid zonation:
- House, 1962, 1965, 1966, 1967
- House, 1972, personal communication
- House and Pedder, 1963
- Kirchgasser, 1975

Brachiopod zonation:
- Boucot and Johnson, 1967
- Boucot and others, 1969
- Harrington, 1972
- Savage, 1973

Conodont zonation:
- Barnett, 1972
- Bouckaert and Ziegler, 1965
- Huddle, 1969, 1974
- Kirchgasser, 1975
- Klapper, 1971
- Klapper and Murphy, 1974
- Klapper and Ziegler, 1967
- Klapper and others, 1971
- Kullman and Ziegler, 1970
- Orr and Klapper, 1968
- Orr, 1971
- Sandberg and Ziegler, 1973
- W. Ziegler, 1971

Graptolite occurrences:
- Jaeger, 1969
- Johnson and Murphy, 1969

Formal biostratigraphic zones based on conodonts have not yet been proposed for the Lower Devonian of Europe nor for the Lower and parts of the Middle and Upper Devonian of North America. However, conodont species characteristic of faunas encountered in these parts of the system are listed on the chart. It should not be assumed that all the zones shown are present in New York.

The limits of the New York Devonian System remain unchanged from those shown on recent charts (Rickard, 1964; Oliver and others, 1967, 1969). The position of the lower boundary is discussed in papers by Rickard (1962), Berdan, (1964) and Berdan and others (1969). Application of the terms Lower, Middle and Upper Devonian is the same as that in Europe. Series and stages remain the same as those proposed by the writer in 1964 except that 1) the Taghanic Stage is included in the Erian rather than the Senecan Series, and 2) the Helderbergian is returned to stage rank within the Usterian Series, as proposed by Cooper and others (1942). The Onesquethaw Stage of Cooper has been dropped in favor of the two stages proposed by the writer in 1964.

Rock Units

The most significant revisions in the stratigraphy and paleontology of the New York Devonian continue to be made in the upper portion of the system. The Lower and Middle Devonian remain relatively unchanged from that shown on previous charts (*e.g.*, Rickard, 1964). However, it is helpful for those unfamiliar with the New York Devonian to cite the important and definitive studies for all portions of the system.

A detailed study of the stratigraphy of the **Helderberg Group** (Rickard, 1962) provided the framework necessary for a series of paleoenvironmental analyses initiated by Laporte (1967, 1969) and continued by Anderson (1967, 1971, 1972), Harper (1969), Head (1969), Epstein (1970) and Arif (1973). Consequently, the origin of this group of transgressive limestones is much better known. Names for subdivisions of the Kalkberg Limestone in the Hudson Valley were proposed by Dunn and Rickard (1961). Additional work in this group in southeastern New York has been completed by Epstein and others (1967), Barnett (1970) and Boucot and others (1970).

The name Tristates is proposed here for a rock unit of group rank to include the strata between the base of the Port Jervis Limestone and the top of the Schoharie Formation. The type section consists of the exposures located along the top and west flank of Trilobite Mountain, north of the village of Tristates in the Port Jervis quadrangle. For the Tristates Group the most important papers are Laskowski (1956), Johnsen (1957), Boucot (1959), Johnsen and Southard (1962) and Boucot and others (1970). Recently Oliver (1966, 1967) has described the occurrence of the Bois Blanc Formation in western New York and clarified the occurrence and nomenclature of sands at the base of the Bois Blanc and Onondaga.

Oliver's series of reports on the **Onondaga Limestone** and its coral reefs are the significant papers on the stratigraphy and paleontology of this formation (Oliver, 1954, 1956a, 1956b, 1960, 1963, 1966). Subsequently, Ozol (1963) and Lindholm (1967) have described Onondaga petrology in greater detail. Data from Ozol's report and from subsurface lithic and gamma-ray logs indicate that the Clarence Member of the Onondaga is older than the Nedrow and correlative with the upper Edgecliff. Merger of the Cherry Valley Limestone with the Seneca Member of the Onondaga is demonstrated by subsurface gamma-ray and lithic logs and the lithic logs of three salt mine shafts at Livonia, Griegsville and LeRoy described by Luther (1894).

Additional details regarding the **Hamilton Group** have been furnished by Smith (1935) for members of the Ludlowville, Oliver (1951) for coral biostromes of the Ludlowville, Rickard (1952) for the Cherry Valley Limestone, and McCave (1968, 1973) for the Portland Point Member. The classic study by Cooper (1930, 1933, 1934, 1941) remains the most definitive work on this group. Paleoenvironmental studies in the Hamilton have been completed by Fernow (1961), Grasso (1970), Mazullo (1973) and Way (1972). Petrology of the nonmarine Hamilton was studied by Lucier (1966).

The report by Cooper and Williams (1935) remains an important source of faunal data on the **Tully Limestone.** However, a new study by Heckel (1973) contains a wealth of detailed stratigraphy and information on the origin of the Tully. Heckel's use of upper and lower members of the Tully is adopted here. Johnson and Friedman (1969) and Johnson (1972) provide new stratigraphic and paleoenvironmental information on the terrigenous equivalents of the Tully in east-central New York.

The stratigraphy and paleontology of the lower two groups of the Upper Devonian are now fairly well known. But as one proceeds higher in the section and especially above the Dunkirk, our knowledge becomes smaller and data is progressively less reliable. The key to unraveling the complex facies changes that occur in this part of the Devonian has proven to be the tracing of black or dark gray shale tongues that persist eastward across the major facies boundaries. Above the Rhinestreet black shale this work has not yet been completed although considerable progress has been made by R. G. Sutton and L. Roe, University of Rochester, and the writer, correcting and advancing the earlier work of J. F. Pepper, W. deWitt, Jr., and G. W. Colton, U.S. Geological Survey. Consequently, the correlation chart presented in this report represents current understanding of the stratigraphy of the Upper Devonian. Several unnamed units appear on the chart simply because there is not sufficient data available concerning them to apply existing names or to adequately propose new names and type sections. Several old and, to some stratigraphers, more familiar names are absent from this new chart mainly because they no longer appear to serve useful purposes. Others have been inserted in appropriate places to serve as a guide to the older literature on these rocks.

Above the Tully Limestone, the Ohio black shale sends four major tongues eastward across New York State—the Geneseo, Middlesex, Rhinestreet and Dunkirk. Although there are numerous other tongues between these four, the intervening ones (which include the Pipe Creek) are thinner and less easily traced. It now seems logical to base definition of the principal rock units (groups) of the Upper Devonian on these four major tongues of black shale. These groups are the Genesee, Sonyea, West Falls and Canadaway-Conewango. The West Falls Group, as used here, includes the Java Group of Rickard (1964) and the Java Formation of deWitt (1960). To be consistent, the highest and youngest group, beginning with the Dunkirk, perhaps should extend to the top of the Devonian. There is no major black shale above the Dunkirk and the Canadaway appears to be only the lower portion of the final group or "cycle" of the Upper Devonian. However, it is thought that further investigation and study should be made before major changes in the existing classification of post-Dunkirk strata are proposed.

Papers outlining the modern interpretation of the stratigraphy and paleontology of the **Genesee Group** are Grossman (1944), Sutton (1959, 1963b), deWitt and Colton (1959), Sutton and others (1962), and Kirchgasser (1973, 1975). Thayer (1974) has completed a comprehensive paleoenvironmental analysis of the Genesee Group. His report follows the pioneering effort and excellent standard set by Sutton and others (1970) and Bowen and others (1974) for the overlying **Sonyea Group.** Additional details regarding stratigraphy of the Sonyea Group may be obtained from Colton and deWitt (1958), deWitt and Colton (1959), Sutton (1959, 1960, 1963a, 1963b), Sutton and others (1962) and Kirchgasser (1969, 1975). Studies of the non-marine portion of these two groups have been made by Fletcher (1962, 1963, 1964, 1967), Buttner (1963), Allen and Friend (1968), Buttner (1968), and Fletcher and Woodrow (1970). Lateral changes in the depositional environments of the Middlesex black shale were outlined by Byer (1972).

The stratigraphy of the **West Falls Group** is described in reports by Pepper and deWitt (1950), Pepper and others (1956), deWitt and Colton (1959), Sutton (1959, 1960, 1963a, 1963b), deWitt (1960), Sutton and others (1962), Woodrow and Nugent (1963), and Woodrow (1968). Currently work is in progress to differentiate and map the black shale tongues of the West Falls Group, particularly those occurring above the Corning. New names will be proposed for unnamed black shales and for intervening strata. For the present report, it can be noted that: 1) the name Meads Creek is suggested for the strata of Portage facies lying between the Roricks Glen and Corning black shales; 2) the type Gardeau overlies the Corning Shale; 3) the Nunda as used here includes the West Hill of Pepper and others (1956); 4) the Canseraga and Canisteo of Pepper and deWitt (1951) are equivalent to the Wiscoy, and therefore are superfluous; and 5) the Hume Shale of Pepper and deWitt (1951) is the basal black shale of the Dunkirk of western New York. The name Meads Creek, suggested by R. G. Sutton, is derived from the stream of the same name located in the southeastern portion of the Hammondsport 15 minute quadrangle (Bradford 7.5 minute quadrangle). The type section of the Meads Creek shale and sandstone is in the tributary to Meads Creek descending the steep valley side 1 mile southeast of Monterey, above the Roricks Glen black shale at 1,280 feet elevation.

The **post-West Falls strata** of the Late Devonian are perhaps the least understood portion of the New York Devonian sequence. Only the studies of Woodruff (1942), Pepper and deWitt (1951), Tesmer (1955, 1963, 1967) and Manspeizer (1963) constitute relatively recent contributions to the stratigraphy of these rocks. Work now in progress, however, has resulted in a number of significant changes. The Caneadea of Pepper and deWitt (1951) consists of strata of Portage facies equivalent to the Dunkirk of western New York. The Wellsville and Whitesville Formations of Woodruff (1942) are equivalent; their type sections are equidistant above the base of the Hume black shale (basal Dunkirk). Both formations occur below, not above, the horizon of the Cuba Sandstone. In Chautauqua County the interval between the Dunkirk and Dexterville has been subdivided into several named units (Tesmer, 1963). However, along the main and south branches of Cattaraugus Creek in western Cattaraugus County, this subdivision is no longer possible. The name Forty Bridge, from a locality along the south branch of Cattaraugus Creek, is suggested for this undivided interval of shales and sandstones. The Wellsville and Whitesville Formations of the Genesee River Valley are equivalents of the Forty Bridge—all represent different facies of the same stratigraphic interval. The name Towanda was proposed by Woodrow (1968) for interbedded marine and nonmarine rocks above the base of the Dunkirk black shale. All the formations mentioned above are parts of the Canadaway Group. They appear to be marine equivalents of the lower portion of the nonmarine Sunfish shales and sandstones, a name also suggested by Woodrow (ibid.). No significant changes in the nomenclature and correlation of post-Canadaway rock units are evident at the present time.

Correlation

The precision with which many of the New York Devonian rock units can be correlated with the European type and standard sections has been much improved during the past decade. It is believed that the major outline of Devonian correlations is now known and that further work will permit reinforcement and refinement.

The **Helderberg Group,** except for the Port Ewen Formation, is correlated with the initial Early Devonian stage of Europe, the Gedinnian. In Europe, the first occurrence of the conodont *Icriodus woschmidti* is slightly below the base of the Devonian. This species occurs commonly in the Coeymans and Kalkberg Limestones of New York. Terebratulid brachiopods first appear in the Gedinnian of Europe and the terebratulid genera *Nanothyris* and *Podolella* are found with other early Devonian brachiopods, *e.g.*, *Cyrtina* and *Schizophoria,* in the Dayville and lower Ravena Members of the Coeymans.

The Thacher Limestone has almost no species in common with underlying rocks and a major portion of its fauna also occurs in the Olney Limestone of central New York, an equivalent of the Coeymans of eastern New York. Barnett (1971, p. 294) reports *I. woschmidti* from a bed in the Rondout Formation at Cornwall, New York, believed equivalent in age to the lower Thacher of the main outcrop belt. Terebratulid brachiopods occur in the upper Keyser Limestone of Maryland and Pennsylvania, an equivalent of the Thacher of New York (Bowen, 1967). These observations support inclusion of the Thacher Limestone in the Devonian.

Higher Helderberg rocks contain conodont species indicative of later Gedinnian age—*Spathognathodus repetitor* occurs in the Jamesville; *S. transitans* and *Ancyrodelloides kutcheri* have been recovered from the Alsen. Early Devonian brachiopod genera such as *Trematospira, Rensselaerina, Leptospira, Skenidium, Levenea, Chonostrophiella, Spinoplasia* and *Leptocoelia* are common or abundant in the Kalkberg, New Scotland, Becraft, Alsen, and Port Ewen.

The Port Ewen Formation and the **Tristates Group** are correlated with the remaining stages of the European Early Devonian, the Siegenian and Emsian. Conodonts from the Alsen Limestone, cited above, indicate a correlation of the Alsen with the *Quadrithyris* zone. The latter now is referred to the Gedinnian (Savage, 1973). The overlying Port Ewen Formation, correlated with the *Spinoplasia* zone (Johnson and Murphy, 1969), thus becomes the oldest New York unit referred to the Siegenian. The Port Jervis and Glenerie Formations of New York contain the conodont *Icriodus huddlei* that occurs in beds of Siegenian age in Europe (W. Ziegler, 1971, pp. 241–247). The "big-shell community" (Boucot and Johnson, 1967) of the Oriskany Sandstone is characterized by such large spiriferids as *Costispirifer* and *Acrospirifer* but also includes *Costellirostra, Hipparionyx, Dalejina, Plethorhyncha, Rensselaeria,* and others. This fauna, which in Nevada is associated with the conodont *Spathognathodus sulcatus,* has been considered Siegenian in age (Johnson and others, 1967, p. 688) based on the evolution of the acrospiriferids. To date the position of the Siegenian-Emsian boundary is not clearly delineated in New York, partially due to the fact that fossils are rare in the Esopus-Carlisle Center shales. Boucot and Johnson (1967) and Boucot and others (1969) refer the *Etymothyris* zone of the Esopus-Carlisle Center to the Emsian. Conodont data from this portion of the New York sequence is lacking.

There is little direct conodont or brachiopod evidence to support correlation of the Schoharie and Bois Blanc with the Emsian. The highest occurrences of the conodont *Icriodus huddlei* are in the Schoharie and Bois Blanc of New York and the Emsian Princeps-, Zorgensis-, and Schönauer-Kalk of Europe (Klapper and Ziegler, 1967, p. 70; Klapper and others, 1971, p. 242; W. Zielger, 1971, p. 245). Boucot and Johnson (1967) state that "the Schoharie-Bois Blanc brachiopod fauna is the highest that includes a preponderant number of genera that are characteristic of the Lower Devonian." The Schoharie conodont fauna is characterized by the joint occurrence of *Icriodus huddlei* and *I. latericrescens robustus,* a combination unknown in Europe.

Conodonts from the **Onondaga Formation** are described or listed by Klapper and Ziegler (1967), Klapper and others (1971) and Klapper (1971). They conclude that, with the exception of those from the Edgecliff Limestone, an Eifelian age is directly indicated by the presence of *Polygnathus costatus patulus, P. linguiformis cooperi, P. robusticostatus, P. angusticostatus, P. costatus costatus, Icriodus corniger, I. nodosus* and *Polygnathus* aff.*P. trigonicus*. Correlations with the *I. corniger, S. bidentatus* and *P. kockelianus* conodont zones of Europe are suggested. Correlation of the Seneca-Cherry Valley with the *I. angustus* zone of North America is suggested by Klapper and others (1971, p. 296) and Orr (1971, p. 10). The Edgecliff conodont fauna contains only one platform type, *Icriodus latericrescens robustus,* a species unknown in Europe. House (1962, p. 253) suggested an Eifelian age for the ammonoid *Foordites buttsi,* recovered from the Nedrow Limestone, and Oliver (1960, p. 174) considers most Onondaga corals to be Middle Devonian types. There seems to be little doubt that at least the post-Edgecliff portion of the Onondaga Formation should be correlated with the Eifelian Stage of Europe. However, the exact position of the Emsian-Eifelian boundary in New York remains uncertain.

On this new Devonian chart the **Cherry Valley Limestone** deliberately is placed astride the Eifelian-Givetian boundary because of the conflicting evidence regarding its age. House (1962, p. 254) referred the *Werneroceras* bed of the uppermost Union Springs, which contains the ammonoid *Cabrieroceras plebeiforme,* to the basal Givetian *C. crispiforme* zone of Europe; subsequently he has reaffirmed this correlation (House, 1965, pp. 81, 82; 1966, p. 53; 1967, p. 1064). W. Ziegler (1971, p. 257) notes that *Cabrieroceras, Parodiceras* and *Agoniatites* are associated with the lower Givetian *Icriodus obliquimarginatus* zone. All these cephalopod genera occur in the upper Union Springs and Cherry Valley. On the other hand, Klapper and others (1971, p. 295) and Klapper (1971, p. 60) cite conodont species that support correlation of the *Werneroceras* bed and the Cherry Valley with the *P. kockelianus* zone of the Eifelian of Europe. Cooper (Cooper and others, 1942, pp. 1732, 1772) cited the occurrence of the brachiopod *Paraspirifer* in the Onondaga and Mottville as evidence of an Eifelian age for the entire Marcellus Formation. The writer knows of no conodont evidence bearing upon the age, Eifelian or Givetian, of the post-Cherry Valley portion of the Marcellus. Statements to the effect that the entire Marcellus is Eifelian in age would not seem to be adequately supported. Obviously, the total ranges of the ammonoids, conodonts and brachiopods involved are not yet accurately known and the problem cannot be satisfactorily resolved at present. However, it does not seem probable, based on present knowledge, that the Eifelian-Givetian boundary lies very far above or below the Cherry Valley.

The remainder of the **Hamilton Group** is correlated with the Givetian of Europe by means of its ammonoids and conodonts. House (1965, 1966) describes the evolution of the ammonoid *Tornoceras* throughout the Hamilton, proposing new zones based upon *T.* (*T.*) *arkonense* and *T.* (*T.*) *uniangulare*. Tornoceratids occur in the Chittenango, Cardiff, Levanna, Centerfield, Ledyard, Windom, Leicester and Tully. Among the conodonts, *Icriodus latericrescens latericrescens* appears in the Mottville and Delphi Station and ranges up into the Tully and Genundewa; specimens formerly referred to *Polygnathus varcus* have been restudied—these include *P. timorensis* from a thin phosphatic bed on top of the Centerfield, *P. rhenanus* from the Tichenor, and *P. varcus* from the Windom and Tully (Klapper and Ziegler, 1967, pp. 69, 72; Klapper, Philip and Jackson, 1970, pp.655, 656,658; Klapper and others, 1971, p. 297; Huddle, 1974, p. 516).

House (1965, p. 83) referred the type **Leicester Pyrite** to the Middle Devonian because it contains *T. (T.) uniangulare* and pointed out that Cooper and Williams (1935, p. 795) earlier had correlated the pyrite with the *Vitulina* zone of the Windom. However, pyrite lenses also occur above as well as below the Tully, as at Gorham, New York, and these higher occurrences are Late Devonian in age. Oliver and others (1967, p. 1034) and Huddle (1974) state that the pyrite at Eighteen Mile Creek is of Late Devonian age, based on its conodont content.

The **Tully Limestone** was correlated with the Upper Devonian Frasnian Stage of Europe on the earlier chart (Rickard, 1964). This correlation was based upon the occurrence of the ammonoid *Pharciceras* in the upper Tully, recorded by House (1962, pp. 256, 265, 272-274), although House himself was cautious regarding a Frasnian age for the Tully. House also (*ibid,* p. 256) pointed out that the Tully contains Frasnian-type tornoceratids with lingulate lateral lobes that he later (1965, pp. 83, 108) compared with *T. arcuatum* This species occurs with the Frasnian ammonoid *Koenenites* in the Squaw Bay Limestone (Michigan) whose Late Devonian age has not been disputed. Despite statements to the contrary (Cooper, 1967, pp. 706, 708; Orr and Klapper, 1968, pp. 1066, 1069), House did not suggest a correlation of the Tully with the Squaw Bay, only that both formations should be referred to the same ammonoid zone, the zone of *Pharciceras lunulicosta*.

Cooper (1967), Klapper and Ziegler (1967), Orr and Klapper (1968), Oliver and others (1967, 1969), Orr (1971) and Klapper and others (1971) continued to support the Medial Devonian age for the Tully advocated by Cooper and others (1942). Excepting Cooper, they referred the Tully conodont fauna to the supposedly exclusively Givetian *Polygnathus varcus* zone. In addition, Cooper and Oliver consider the Tully brachiopods and corals to be Middle Devonian types (Cooper, 1967, pp. 703-704; Oliver and others, 1967, p. 1034).

However, the problem is more complex than the disagreement based on the faunal data outlined above would suggest. There also is disagreement on the position of the Middle-Upper Devonian boundary in the standard Devonian sequence in Belgium. House (1973) presents arguments for retaining this boundary at the base of the Assise de Fromelennes and adds that it appears to fall within the upper portion of the *Polygnathus varcus* zone and that it may not be far from the base of the *Pharciceras lunulicosta* zone of the *Manticoceras* Stufe. Bultynck (1972, p. 71) refers the basal portion of the Assise de Fromelennes to the *varcus* zone. These data suggest a Late Devonian (Frasnian) age for the Tully Limestone. On the other hand, Errera, Mamet and Sartenaer (1972, pp. 3, 22, 34-35) would refer the entire Assise de Fromelennes to the Givet Group, usually considered to be coterminous with the Givetian Stage and part of the Middle Devonian. Some Belgians currently are discussing placement of the Middle-Upper Devonian boundary at the top of the Assise de Fromelennes or at the base of the upper third (F_{1c}) of the Assise de Fromelennes. The latter appears to be the base of the lowermost *Polygnathus asymmetricus* zone (see Klapper, *in* Coen and Coen-Aubert, 1971, p. 17) and would place the Tully Limestone and some of the overlying Geneseo Shale in the Middle Devonian. Regardless of which definition above or some other definition may become permanent, many stratigraphers agree that the Tully Limestone correlates with the lower portion of the Assise de Fromelennes. Pending a decision by the International Subcommission on Devonian Stratigraphy, the Tully Limestone and Taghanic Stage of New York are not referred to either European stage.

Conodonts and ammonoids continue to be the principal fossils used for correlating the Upper Devonian. The **Genesee, Sonyea** and **West Falls Groups** correlate with the Frasnian Stage of Europe. Conodont distribution is described in papers by Huddle (1969, 1974), Oliver and others (1967), Klapper and others (1971), and Kirchgasser (1973, 1975). Conodonts of the upper part of the *Schmidtognathus hermanni-Polygnathus "cristatus"* zone occur at the base of the Genesee Group from Seneca Lake to Cazenovia Creek. No evidence is yet known for the presence of the *Spathognathodus insitus* fauna in New York. Huddle (1974, personal communication) refers the Lodi conodont fauna to the Lowermost *Polygnathus asymmetricus* zone (W. Ziegler, 1971, p. 267) because it lacks *Ancyrodella rotundiloba*. The redefined Lower *P. asymmetricus* zone begins in the lower Penn Yan where *A. rotundiloba* first appears 16 feet above the base in Menteth Gully. *Palmatolepis punctata* first appears in the upper West River and marks the base of the Middle *P. asymmetricus* zone. The Cashaqua Shale contains *P. punctata* and is referred to the Upper *P. asymmetricus* zone. *P. asymmetricus* has been found in the base of the Rhinestreet Shale, but the middle and upper Rhinestreet have been referred to the *Ancyrognathus triangularis* zone. *A. triangularis* occurs in the Gardeau Shale and *Palmatolepis gigas* has been found in the Angola and lower Nunda (West Hill). Conodonts of the Upper *Palmatolepis triangularis* zone have been reported from the upper Hanover and Dunkirk Shales.

The distribution of ammonoids in the lower portion of the Upper Devonian is described in papers by House (1962, 1965, 1966, 1967) and Kirchgasser (1973, 1975). The

Geneseo Shale contains *Epitornoceras peracutum* and, near the top, *Ponticeras perlatum* which also occurs in the Lodi and Sherburne. *Manticoceras* first appears in the upper Penn Yan, above the first occurrence of the conodont *Ancyrodella rotundiloba,* is common in the Genundewa and also occurs in the West River and Ithaca. The Middlesex Shale has produced *Sandbergeroceras syngonum*. *Probeloceras lutheri* is common in the lower and middle Cashaqua Shale but the upper Cashaqua and lower Rhinestreet are referred to a new zone based upon *P. strix,* described by W.T. Kirchgasser (1975). *Manticoceras rhynchostoma* occurs in the lower Hanover. *Crickites* cf. *C. holzapfeli* has been recovered from the upper Hanover.

The exact position of the Frasnian-Famennian boundary in Belgium currently is under discussion although the traditional placement at the base of the Assise de Senzeille has been in effect for about a century. House (1973, p. 10) states that "there is direct evidence that the base of the *Cheiloceras* Stufe lies either within or not far from the base of the Assise de Senzeille." According to Bouckaert and Zeigler (1965, p. 12) the lowest conodont fauna studied by them from the Assise de Senzeille is that of the Middle *P. triangularis* zone.

Stratigraphers the world over have for many years utilized the appearance of *Cheiloceras* to indicate the beginning of the Famennian. There is not complete agreement on the position of the *Manticoceras-Cheiloceras* boundary relative to the conodont zonation. W. Zeigler (1971, p. 266, chart 4) places this boundary between the *triangularis* and *crepida* conodont zones but Buggisch and Clausen (1972, p. 165) show the boundary near the base of the Upper *triangularis* zone. In New York, *Crickites* (indicative of the upper *Manticoceras* Stufe) was found about 30 feet below the top of the Hanover Shale (House, 1967, p. 1066; 1973, p. 11) and Klapper and others (1971, p. 304) refer the Upper Hanover to the Upper *triangularis* zone. It would appear that all these boundaries—the Frasnian-Famennian, the *Manticoceras-Cheiloceras* and the Middle-Upper *triangularis*—are near one another and to the Hanover-Dunkirk contact in New York. Pending further evidence and clarification, there the matter rests.

Ammonoids and conodonts become rarer upward throughout the upper portion of the Upper Devonian and correlation with Europe becomes increasingly more difficult. But some data exist regarding correlation of the **Canadaway, Conneaut** and **Conewango Groups** with the Famennian of Europe. Conodonts are reported by Huddle (1969), Oliver and others (1967), and Klapper and others (1971); ammonoid distribution is given by House (1962, 1966, 1967).

Conodonts of the Upper *P. triangularis* zone are reported from the Dunkirk; species indicative of the *Palmatolepis crepida* zone occur with the ammonoid *Cheiloceras* in the Gowanda. *P. rhomboidea* has been recovered from the Shumla and the *P. marginifera* zone has been recognized in the Northeast and Chadakoin. But in every case, the precise limits of the conodont zone represented are unknown in New York.

The ammonoid *Cheiloceras amblylobum* from the Gowanda Shale gives a direct correlation with the *Cheiloceras* Stufe of Europe. A specimen of *Sporadoceras* comparable with *S. pompeckji,* zonal index to the upper *Cheiloceras* Stufe, has been obtained from the Panama conglomerate in Pennsylvania. This species suggests an upper limit to the equivalent of the *Cheiloceras* Stufe in New York as it seems to be similar to specimens from the overlying *Platyclymenia* Stufe.

Spathognathodus antiposicornis has been recovered from the Knapp Formation (Oliver and others, 1967, p. 1035). This conodont is known from the latest Devonian *Protognathodus* fauna and the earliest Mississippian *Siphonodella sulcata* zone (Sandberg and others, 1972, p. 182). But on other grounds, chiefly brachiopods (Holland, 1959), the Knapp has been refered to the Mississippian.

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GEOLOGICAL SURVEY
James F. Davis, State Geologist

RIFT FACIES

1 H — **Nicholville**

Quartz cobble-pebble conglomerates; cross bedded, cross laminated hematitic, feldspathic quartz sandstones; arkoses; quartzose shale; red, pink, green or cream colored; exceedingly rare trace fossils.

Non-marine fluvial fault trough or glacial environment.

2 H — **Rensselaer**

Medium-thick bedded, medium-coarse gray-dark green graywacke with quartz and feldspar clast conglomerate and breccia; subordinate purple-red shale and green quartzite; graded bedding common; occasional sole markings; manganiferous concretions; interbedded volcanic rocks; red, purple and green quartzose, micaeous shales with ribbon green-gray quartzites; exceedingly rare trace fossils *(Oldhamia)*.

Marine fault-trough.

CONTINENTAL MARGIN FACIES

3 Є,C — **Poughquag**

Quartz sandstones, orthoquartzites; feldspathic calcareous or dolomitic sandstones and siltstones; quartz pebble conglomerates; cross bedding, cross lamination, wave ripples, bioturbated; relatively unfossiliferous, low diversity, marine benthic fauna; trilobites, lingulids.

Intertidal, high energy, shoal, beach.

4 Є,C — **Theresa**

Quartzose, feldspathic dolostones, locally cherty; thin gray shales; dolomitic quartz sandstones and siltstones; strata locally cyclical; wave ripples, dessication cracks, stromatolites, cross bedding, birdseye, bioturbated; fossils rare, low diversity, marine benthic fauna; trilobites, low-spired gastropods, lingulids.

Supratidal, intertidal, low energy, lagoon.

5 Є,C — **Rochdale**

Medium-massive bedded dolomitic calcilutites and calcitic dolostones; carbonate slab conglomerates; stromatolites, scour and fill, bioturbated; moderately fossiliferous, low diversity, marine benthic fauna; low-spired gastropods, nautiloids, trilobites.

Intertidal, protected subtidal, low energy.

6 Є,C — **Fonda**

Unevenly bedded calcarenites, calcisiltites, carbonate pebble conglomerates; dolomitic limestones; quartzose limestones and dolostones; oolites; moderately fossiliferous, high diversity, marine benthic fauna; high and low-spired gastropods, nautiloids, trilobites, ribeirids, articulate brachiopods, ostracodes.

Subtidal, high energy, above (?) wave base.

May be present in metamorphosed carbonates along N.Y. - Mass. - Conn. border.

7 Є,C — **Germantown**

Gray-black silty, platy and crumbly shales, often laminated; ribbon limestones; gray-tan calcareous and dolomitic sandstones or quartzites; carbonate clast conglomerates in a quartz sand matrix; relatively unfossiliferous, low diversity; graptolites, pelagic and epipelagic trilobites and brachiopods, phosphatic problematica.

Slope.

8 H,Є,C — **Nassau**

Olive-green to gray argillite, mudstone, shale, siliceous and finely laminated; local cabonate clast conglomerates in a pelitic matrix and discrete concretionary calcilutites; massive green quartzites with quartz-pebble lenses; ribbon dolomitic quartzites; planar and cross laminated siltstones; nearly unfossiliferous; trace fossils, few graptolites.

Base-of-slope and basin.

9 S,D — **Salina**

Drab, argillaceous, finely laminated dololutites; greenish-gray dolomitic shales; red mudstones; gypsiferous and/or with molds of halite crystals, beds of gypsum, anhydrite and halite in subsurface; dessication cracks, no bioturbation; nearly barren, low diversity; eurypterids, bivalve mollusks, lingulid brachiopods.

Peritidal, often restricted and hypersaline.

10 O — **Austin Glen**

Thin-medium bedded, laminated and cross laminated siltstones and subgraywackes; interbedded gray silty shales; massive bedded tan-weathering graywackes with various sole markings; local shale-clast conglomerates; nearly unfossiliferous; few graptolites.

Slope.

11 O — **Mt. Merino-Indian River**

Red, green, black shales, mudstones; bedded red, green, gray, black cherts; relatively unfossiliferous, pelagic fauna; graptolites, radiolarians.

Basin.

INTRACONTINENTAL FACIES

12 O, S, D — **Oriskany**

Siliceous and calcareous quartz arenites; siliceous calcisiltites and calcarenites; quartz pebble conglomerates with siliceous matrix; laminated, cross bedding, wave ripples, bioturbated; variously fossiliferous, low diversity, marine benthic fauna; robust brachiopods.

Intertidal, shallow subtidal, high energy, shoal, beach.

13 O, S, D — **lower Manlius**

Thin-medium or laminated, evenly bedded calcilutites, or dololutites; calcareous shales; green and gray shales; minor evaporites; stromatolites, oncolites, scour and fill, birdseye, dessication cracks, wave ripples, bioturbated; sparse to moderately fossiliferous, low diversity, marine benthic fauna; ostracodes, brachiopods, gastropods, tentaculites.

Supratidal, intertidal, low energy, lagoon.

14 O, S, D — **upper Manlius**

Medium-thick slightly unevenly bedded calcisiltites; hematitic limestones; carbonate pebble conglomerates; coral and stromatoporoid biostromes; scour and fill, birdseye, wave ripples and cross bedding, bioturbated; sparsely to moderately fossiliferous, low to moderate diversity, marine benthic fauna; corals, stromatoporoids, brachiopods, mollusks, ostracodes, trilobites.

Protected subtidal, moderate energy, wave baffle or barrier.

15 O, S, D — **Coeymans**

Medium-massive unevenly bedded calcisiltites and calcarenites; often with carbonate bioherms or reefs; accretion and low-angle cross bedding, bioturbated; moderately fossiliferous, moderate diversity, marine benthic fauna; pelmatozoans, corals, brachiopods, mollusks, trilobites, ostracodes.

Subtidal, high energy, above wave base.

16 O, S, D — **Kalkberg**

Thin-thick bedded, siliceous and argillaceous calcisiltites; often with bedded or nodular cherts; bioturbated; abundant marine shelly fauna, high diversity; bryozoans, brachiopods, crinoids, corals, trilobites, mollusks, ostracodes.

Subtidal, low energy, at or near wave base.

17 O, S, D — **New Scotland**

Thin-medium evenly bedded, argillaceous calcisiltites and calcilutites; calcareous shales; bioturbated; abundant marine shelly fauna, high diversity; brachiopods, crinoids, corals, trilobites, pelecypods, cephalopods, ostracodes, bryozoans.

Subtidal, low energy, below wave base.

18 O, S, D — **Catskill**

Red, green, and gray shales; red and green mudstones and siltstones; medium to coarse cross bedded quartz sandstones or subgraywackes; pebbly sandstones; round, white quartz pebble conglomerates; scouring, fining-upwards cycles; root traces, dessication cracks, calcareous nodules; relatively unfossiliferous, low diversity; plants, fish.

Piedmont and alluvial flood plain, braided and meandering streams.

19 O, S, D — **Cattaraugus**

Gray and green marine shales, siltstones, sandstones; winnowed, bioturbated, wave ripples; few fossils, low diversity; brachiopod-crinoid fauna; alternating with non-marine red shales, siltstones sandstones; root traces, dessication cracks, calcareous nodules; rare fossils, low diversity; plants.

Peritidal, cyclic interbedded marine and non-marine.

20 O, S, D — **Chemung, Hamilton**

Gray shales, mudstones; siltstones, fine to medium sandstones; coquinites, flat pebble conglomerates; laminated, cross bedded; wave and current ripples, flute and groove casts, ball and pillow structures, biogenic structures common; abundant marine shelly fauna, high diversity; brachiopods and bivalve mollusks predominate. Along landward margin includes various nearshore facies having similar rocks, fewer fossils.

Diverse subtidal shelf (includes prodelta, delta front sands, delta platform) and nearshore zone (e.g., distributary mouth bars, channels, estuaries, tidal flats, swamps, marshes).

21 O, D — **Portage**

Black and dark-medium gray shales, mudstones; siltstones, few fine sandstones; turbidites; casts of grooves, tracks, trails and flutes on lower surfaces of siltstones with cross lamination; bioturbated, convolute bedding, current ripples; relatively unfossiliferous, low diversity, mixed benthic and pelagic fauna.

Open shelf well below wave base, slope and proximal basin.

22 O, S, D — **Portage, Marcellus**

Fissile black and/or greenish-gray shales; thin dark argillaceous limestones; pyritiferous, septaria, concretions; relatively unfossiliferous, low diversity, pelagic fauna; ammonoids, graptolites, conodonts, tentaculites, epipelagic brachiopods, mollusks, trilobites.

Distal basin, relatively deep anaerobic.

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D Devonian
S Silurian
O Ordovician *(post-Canadian)*
C Ordovician *(Canadian)*
Є Cambrian
H Hadrynian

Geologic periods in which this facies is shown.

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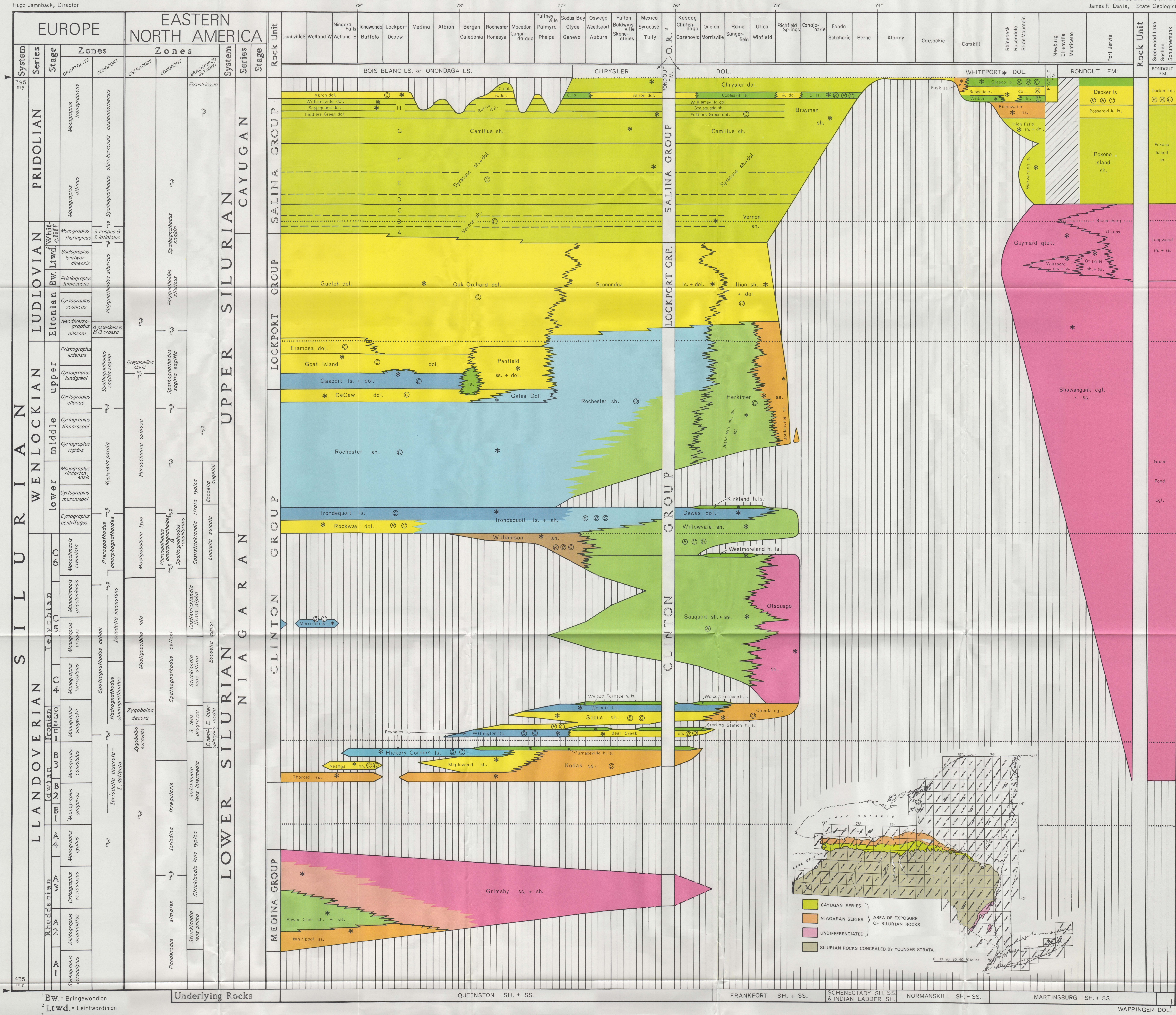
Plate 1. The Facies and Their Inferred Environments

by D. W. Fisher and L. V. Rickard

NEW YORK STATE MUSEUM AND SCIENCE SERVICE
Hugo Jamnback, Director

THE UNIVERSITY OF THE STATE OF NEW YORK
THE STATE EDUCATION DEPARTMENT

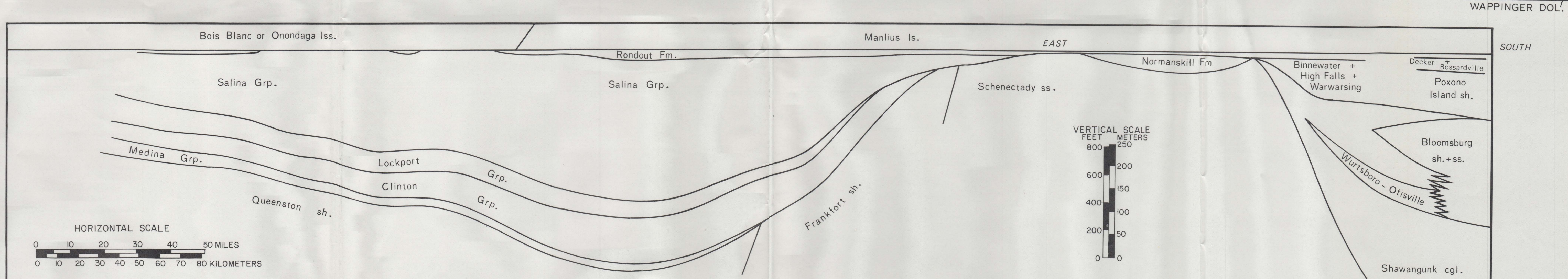
GEOLOGICAL SURVEY
James F. Davis, State Geologist



[1] Bw. = Bringewoodian
[2] Ltwd. = Leintwardinian
[3] O. R. = Overlying Rocks
* Longitudinal location of type section

FAUNAL CONTROL
Ⓑ Brachiopod
Ⓒ Conodont
Ⓖ Graptolite
Ⓚ Coral
Ⓞ Ostracode

Stratigraphic Cross-section of Silurian Rocks



Rondout	R				10 / 3	10 / 3				25 / 8			30 / 9	45 / 14	65 / 20	75 / 23	R
Salina	S				375 / 115	425 / 130	500 / 150	600 / 180	650 / 200	700 / 210	700 / 210	750 / 230	850 / 260	950 / 290	1000 / 300	1000 / 300	S
Lockport	L	Feet / Meters		190 / 58	180 / 55	170 / 52	165 / 50	165 / 50	165 / 50	160 / 49	170 / 52	160 / 49	150 / 46	150 / 46	140 / 43	125 / 38	L
Clinton	C			120 / 36	120 / 36	130 / 40	140 / 43	140 / 43	160 / 49	180 / 55	190 / 58	230 / 70	270 / 82	300 / 91	320 / 98	320 / 98	C
Medina	M			115 / 35	105 / 32	95 / 29	80 / 24	75 / 23	70 / 21	60 / 18							M

R	60 / 18	65 / 20	55 / 17	55 / 17	45 / 14	45 / 14	45 / 14	20 / 6	10 / 3	10 / 3	30 / 9	R
S	900 / 275	775 / 236	700 / 210	400 / 120	200 / 61	100 / 30	50 / 15	—	—	—	—	S
L	100 / 30	80 / 24	75 / 23	45 / 14	—	—	—	—	—	—	—	L
C	330 / 100	320 / 98	230 / 70	260 / 79	150 / 46	—	—	—	—	—	—	C
M			—	—	—	—	—	—	—	—	—	M

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Plate 2. Correlation of the Silurian Rocks in New York

by L. V. Rickard

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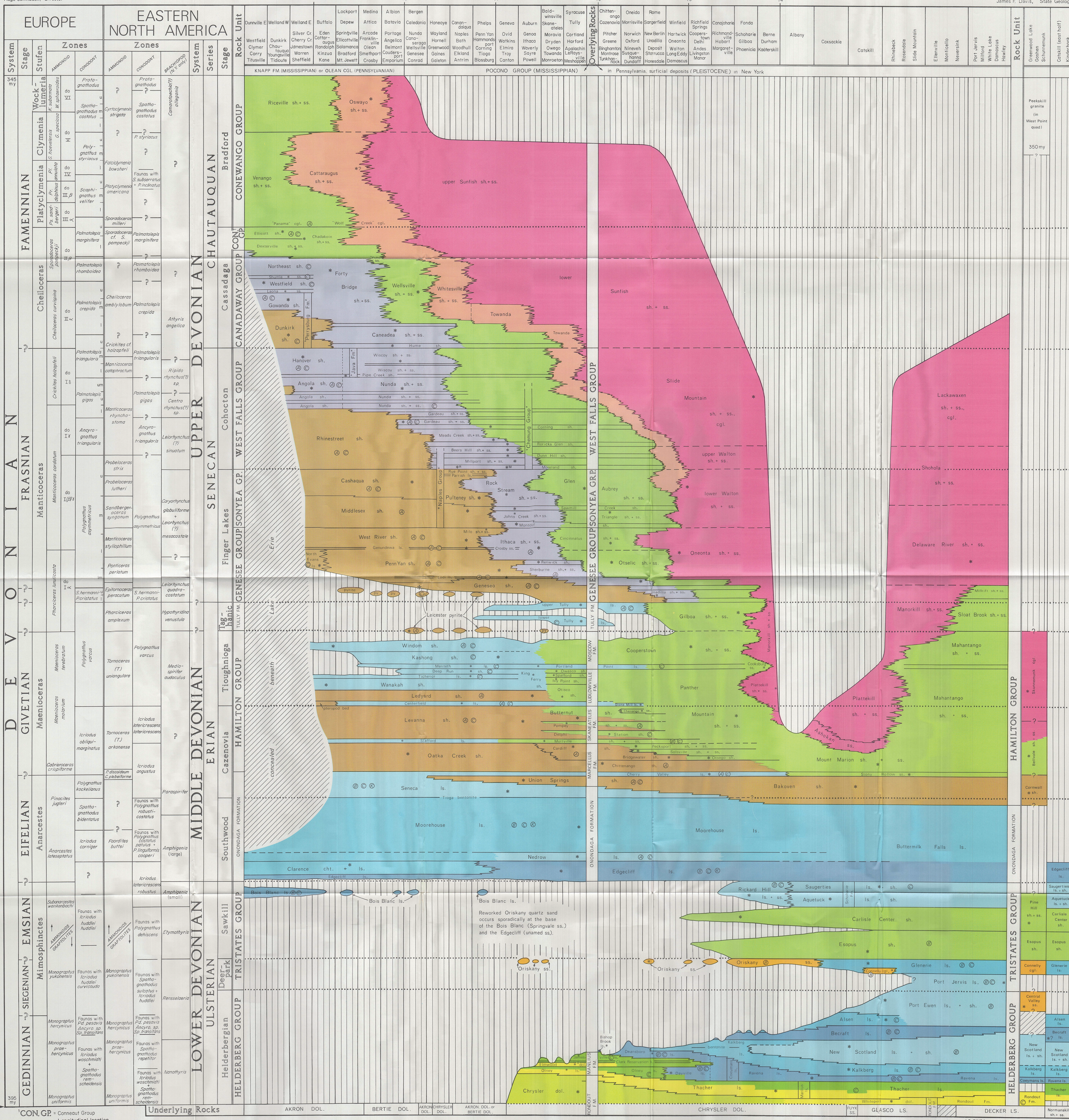

'CON. GP.' = Conneaut Group
* Longitudinal location of type section

In Conodont Zones: um = uppermost, u = upper, m = middle, l = lower, lm = lowermost

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FAUNAL CONTROL
Ⓐ Ammonoid
Ⓑ Brachiopod
Ⓒ Conodont
Ⓧ Coral

Plate 3. Correlation of the Devonian Rocks in New York

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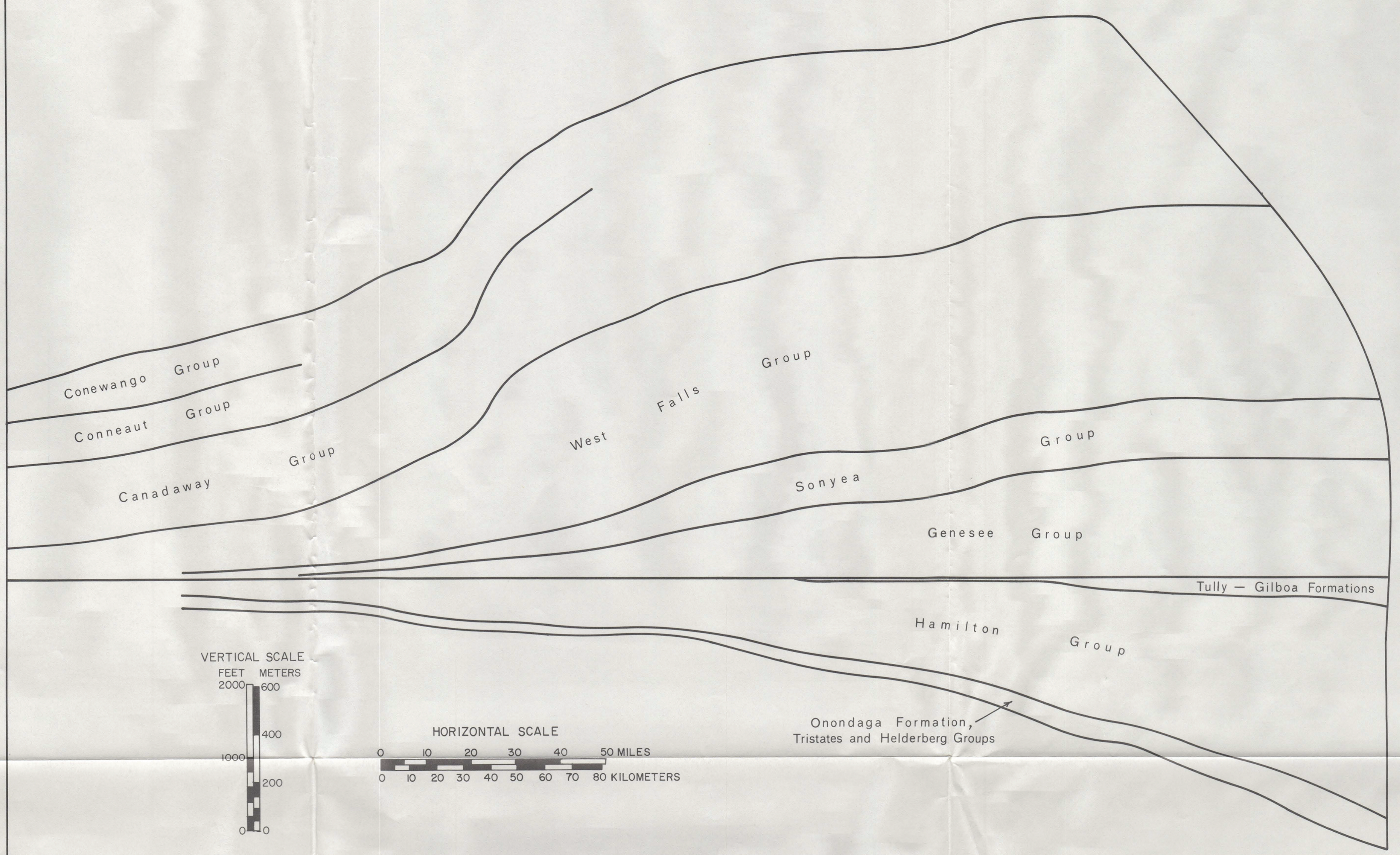
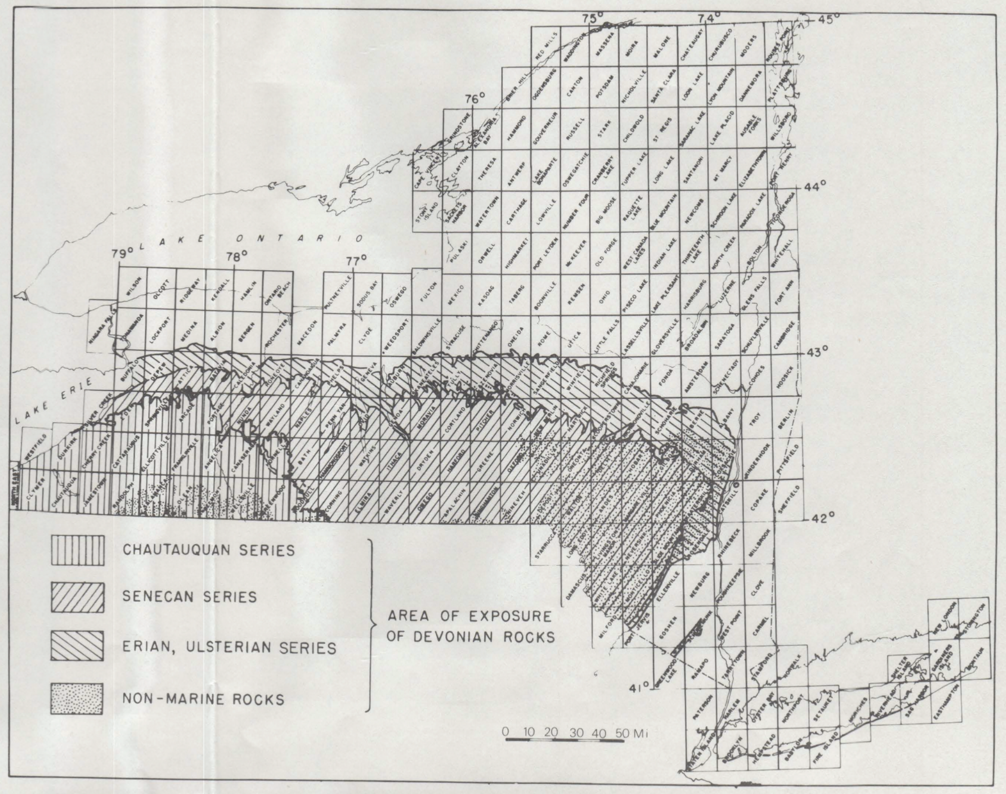
Stratigraphic Cross section of Devonian Rocks





Conewango	Co	500 152	600 183	700 213	700 213	700 213	1350 411	1350 411	1300 396	1100 335	1100 335
Conneaut	Ct	600 183	650	650	650	700					
Canadaway	Cy	1100 335	1100 335	1100 335	1200 366	1250 381	1300 396	1350 411	1350 411	1700 578	1800 549
West Falls	WF		500 152	580 177	650 198	680 207	850 259	1100 335	1350 411	2100 640	2500 762
Sonyea	Sy				50 15	100 30	130 40	180 55	230 70	300 91	320 98
Genesee	Gn				30 9	40 12	55 17	100 30	180 55	240 73	330 101
Tully-Gilboa	T-G	—	—	—	—	—	—	—	—	—	—
Moscow	Mo	Feet Meters			60 18	80 24	80 24	100 30	120 37	140 43	120 37
Ludlowville	Ld				90 27	135 41	105 32	120 37	120 37	155 47	180 55
Skaneateles	Sk				60 18	120 37	100 30	210 64	230 70	260 79	290 88
Marcellus	Mr				55 17	30 9	30 9	30 9	30 9	45 14	50 15
Onondaga	On				175 53	160 49	140 43	140 43	140 43	130 40	115 35
Tristates	Tr				4 1		—			—	—
Helderberg	Hl	—	—	—	—	—	—	—	—	—	—
		Dunnville E Westfield Clymer Corry Titusville	Welland W Dunkirk Chautauqua Youngsville Tidioute	Welland E Silver Cr. Cherry Cr. Jamestown Warren Sheffield	Buffalo Eden Cattaraugus Randolph Kinzua Kane	Lockport Depew Springville Ellicottville Salamanca Bradford Mt. Jewett	Medina Attica Arcade Franklinville Olean Smethport Crosby	Albion Batavia Portage Angelica Belmont Coudersport Emporium	Bergen Caledonia Nunda Canaseraga Wellsville Genesee Conrad	Honeoye Wayland Hornell Greenwood Gaines Galeton	Canandaigua Naples Bath Woodhull Elkland Antrim

Conewango	Co	2900 884	2900 884	2900 884	2800 853	2800 853	Co	2800 853	2700 823	2700 823	—	—	—	—
Conneaut	Ct						Ct					—	—	—
Canadaway	Cy						Cy							—
West Falls	WF	2600 792	2600 792	2600 792	2600 792	2600 792	WF	2600 792	2600 792	2600 792	2600 792	2600 792	2600 792	
Sonyea	Sy	400 123	570 174	670 204	710 216	700 213	Sy	730 223	800 244	800 244	800 244	800 244	800 244	800 244
Genesee	Gn	470 143	640 195	750 229	960 293	1000 305	Gn	1100 335	1350 411	1450 442	1550 472	1600 488	1600 488	1600 488
Tully-Gilboa	T-G	5 2	10 3	15 5	20 6	30 9	T-G	25 8	20 6	100 30	170 52	220 67	250 76	250 76
Moscow	Mo	140 43	135 41	160 49	150 46	170 52	Mo	240 73	200 61	240 73	300 91	420 128	400 123	500 152
Ludlowville	Ld	220 67	260 79	320 98	335 102	230 70	Ld	260 79	280 85	280 85	850 259	800 244	1000 305	2000 610
Skaneateles	Sk	280 85	300 91	300 91	360 110	430 131	Sk	390 119	500 152	560 171				
Marcellus	Mr	60 18	65 20	100 30	250 76	270 82	Mr	410 125	490 149	550 168	600 183	780 238	800 244	
Onondaga	On	100 30	80 24	100 30	70 21	70 21	On	70 21	90 27	85 26	100 30	120 37	110 34	
Tristates	Tr		—	10 3	5 2	5 2	Tr	—	—	15 5	10 3	50 15	50 15	100 30
Helderberg	Hl	—	20 6	70 21	80 24	100 30	Hl	140 43	180 55	200 61	170 52	210 64	240 73	250 76
		Phelps Penn Yan Hammondsport Corning Tioga Blossburg	Geneva Ovid Watkins Elmira Troy Canton	Auburn Genoa Ithaca Waverly Sayre Powell	Baldwinsville Skaneateles Moravia Dryden Owego Towanda Monroeton	Syracuse Tully Cortland Harford Apalachin LeRaysville Meshoppen		Chittenango Cazenovia Pitcher Greene Binghamton Montrose Tunkhannock	Oneida Morrisville Norwich Oxford Nineveh Susquehanna Dundaff	Rome Sangerfield New Berlin Unadilla Deposit Starrucca Honesdale	Winfield Hartwick Oneonta Walton Long Eddy Damascus	Richfield Springs Cooperstown Delhi Andes Livingston Manor	Canajoharie Richmondville Hobart Margaretville	Fonda Schoharie Gilboa Phoenicia

Conewango	Co	—	—	—	—				Co	—	—
Conneaut	Ct	—	—	—	—				Ct	—	—
Canadaway	Cy	—	—	—	—				Cy	—	—
West Falls	WF	—	—	—	—				WF	—	—
Sonyea	Sy	800 244	—	—	—				Sy	—	—
Genesee	Gn	1600 488	—	—	—				Gn	—	—
Tully-Gilboa	T-G	325 99	—	—	—				T-G	—	—
Moscow	Mo	2800 853	—	—	—		3200 975	2600 792	Mo		—
Ludlowville	Ld		—						Ld		
Skaneateles	Sk								Sk		
Marcellus	Mr								Mr		
Onondaga	On	140 43	115 35		250 76			200 61	On		
Tristates	Tr	100 30	160 49	330 101	350 107	480 146	540 165	750 229	Tr	600 183	300 91
Helderberg	Hl	240 73	240 73	290 88	320 98	360 110		450 137	Hl	130 40	300 91
		Berne Durham Kaaterskill	Albany	Coxsackie	Catskill	Rhinebeck Rosendale Slide Mountain	Ellenville Monticello Neversink	Port Jervis Milford White Lake Damascus Hawley		Greenwood Lake Goshen Schunnemunk	Catskill (east half) Kinderhook

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Plate 4. Cross Section and Thickness of Devonian Rocks

by L. V. Rickard