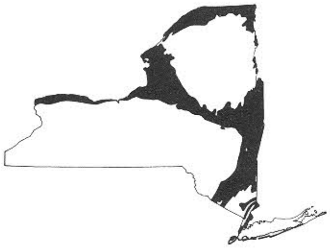


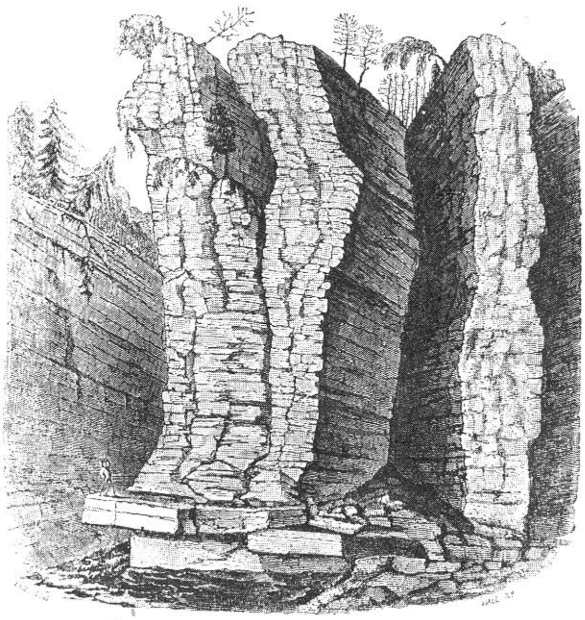
Correlation of the Hadrynian, Cambrian and Ordovician Rocks in New York State

by DONALD W. FISHER

State Paleontologist

NEW YORK STATE MUSEUM

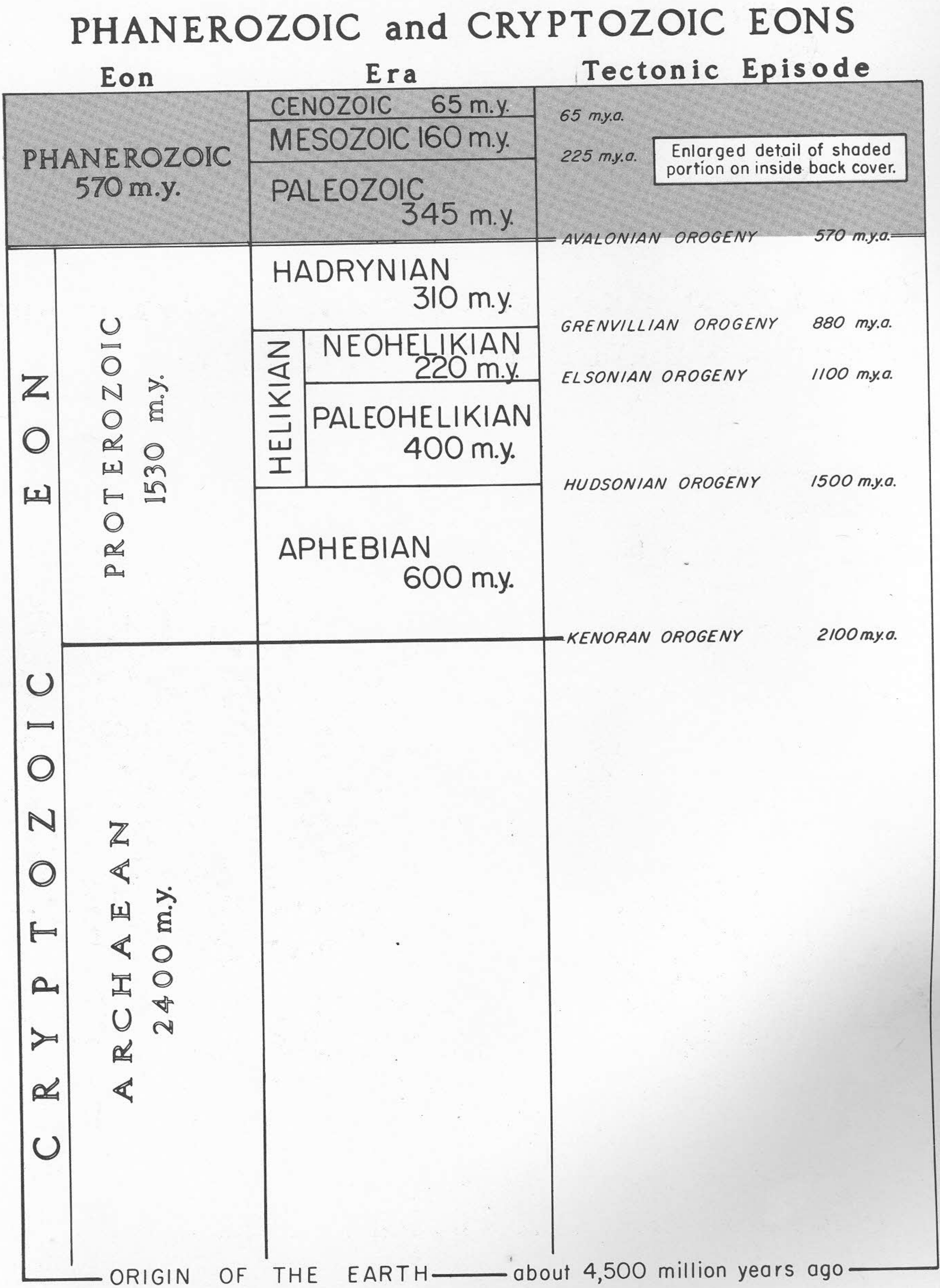
MAP AND CHART SERIES NUMBER 25



Potsdam Sandstone, Ausable Chasm, Clinton-Essex Counties, northern Champlain Valley. From a sketch by Ebenezer Emmons, Jr., in "Geology of New York, comprising the Survey of the Second Geological District" (1842) by Ebenezer Emmons, Sr.

The University of the State of New York/The State Education Department/Albany, 1977

Figure 1. Geologic Time Scale



NOTE: m.y. = millions of years m.y.a. = millions of years ago

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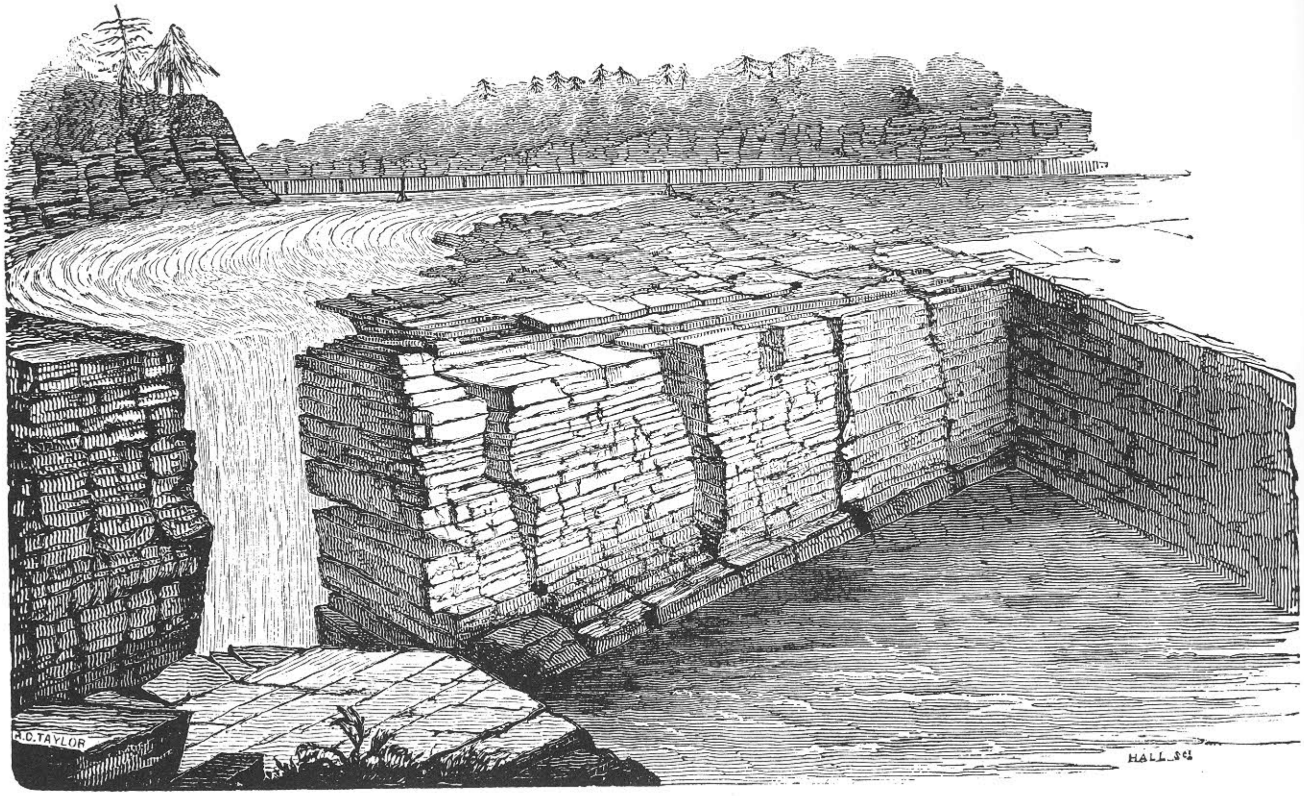
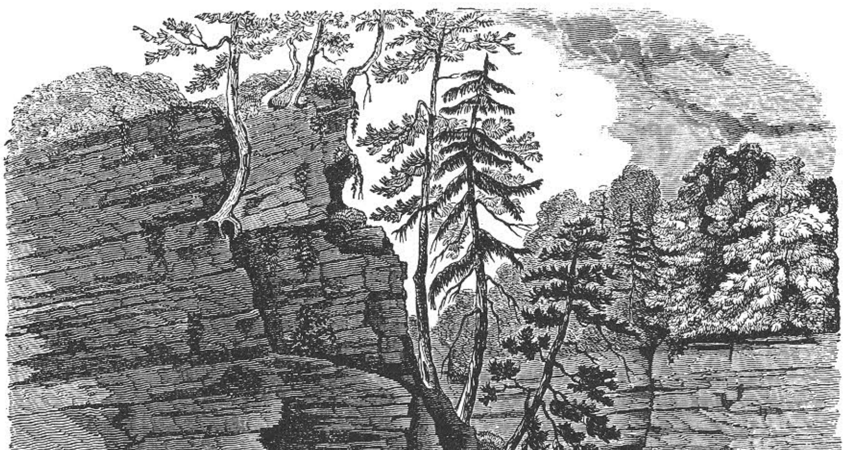
ILLUSTRATIONS



Trenton Limestone, Trenton Falls, West Canada Creek, Oneida-Herkimer Counties, upper Mohawk Valley. From a sketch by R. C. Taylor, in "Geology of New York, comprising the Survey of the Third Geological District" (1843) by Lardner Vanuxem.

Lorraine Group (Pulaski shales and sandstones), Sandy Creek, near Lorraine, Jefferson County. From a sketch by Ebenezer Emmons, Jr., in "Geology of New York, comprising the Survey of the Second Geological District" (1842), by Ebenezer Emmons, Sr.

LORRAIN SHALES.



Correlation of the Ordovician, Cambrian, and Hadrynian Rocks in New York State[1]

by Donald W. Fisher[2]

ABSTRACT

Two large colored correlation charts depict the chronologic, geographic, paleoecologic, and stratigraphic relations of the Ordovician, Cambrian, and Hadrynian (Late Proterozoic) rocks in New York State. Complementing these correlation charts are three stratigraphic profiles, two thickness tables, two distribution maps, and a color legend which identifies and classifies the primary paleoenvironments. Another chart portrays a panorama of paleogeographic maps of Late Hadrynian to Early Silurian time.

On the correlation charts, the biostratigraphic frameworks, based on evolutionary changes of organisms through time, employ conodont, graptolite, and trilobite zones. Where the primary zonation is unknown, uncertain, or disputed, there is made supplemental use of brachiopods, nautiloid cephalopods, gastropods, and, occasionally, other fossil groups. Characteristic symbols of key fossils document this paleontologic control.

Twenty-six colors, overprinted on the rock units, represent forty-five designated facies. These facies are categorized according to their presumed depositional setting relevant to the plate tectonics concept, *i.e.*, rift facies, continental margin facies, and intracontinental facies. Major physical and biological attributes of each facies permits discrete identification.

An accompanying explanatory text treats the Ordovician, Cambrian, and Hadrynian rocks separately. The following items are included: (1) history of the names, (2) previous stratigraphic and paleontologic work, (3) recent advances in knowledge, (4) major problems remaining, (5) a roster of approved, questionable, and rejected stratigraphic names, and (6) a comprehensive bibliography.

This compendium encompasses about 350 million years, covers about 25 percent of the State's area, and involves a cumulative thickness of about 5,500 meters (18,000 feet) of sedimentary rock.

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[1]Submitted for publication, September 1976.

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Introduction

PURPOSE AND AUDIENCE

Why more correlation charts of New York State rocks? Those of the early 1960's are out-of-stock and out-of-date. Earlier correlation charts of New York rocks (Silurian-Fisher, 1960; Cambrian-Fisher, 1962a; Ordovician-Fisher, 1962b; Devonian-Rickard, 1964) were issued separately in association with the preparation of the 1961 State Geologic Map (Broughton, *et al.*, 1961). Now that a revision of that map has been issued (Fisher, Isachsen, Rickard, 1972), it is mandatory that we once again synthesize our stratigraphic knowledge in the light of more recently acquired paleontologic and stratigraphic data. Rickard has assumed responsibility for Silurian and Devonian correlations (New York State Museum and Science Service, Map and Chart Series 24, 1975). My purpose here is to present, in a single publication, an illustrated compendium of the currently known chronologic and paleoecologic relations of the pre-Silurian and post-Helikian (those affected by the Grenville Orogeny) rocks of New York State. In an accompanying explanatory text I have attempted to show the strong and weak points of the stipulated relations, a listing of the major previous works, recommendations for the retention or abandonment of certain stratigraphic names, paleogeographic maps for selected portions of geologic time, and a comprehensive bibliography.

In summarizing our status of knowledge on these rocks, this present effort is specifically addressed to researchers in Early Paleozoic paleoecology, stratigraphic paleontology, stratigraphy, and sedimentology, and to teachers and students of these subjects. Hopefully, this work will stimulate professional and student (via theses studies) alike to test the chronologic and paleoecologic information presented here; I urge that additional paleobiologic and stratigraphic research be undertaken in order to fill existing deficiencies in our knowledge of New York's pre-Silurian strata.

PHILOSOPHY

Despite recent advances in our knowledge of New York's Paleozoic rocks since the publication of the earlier detailed correlation charts for the Cambrian (Fisher, 1962a), Ordovician (Fisher, 1962b), Silurian (Fisher, 1960), and Devonian (Rickard, 1964) Periods, many gaps remain in our knowledge toward a fuller understanding of the paleontology, stratigraphy and sedimentology of these strata. In preparing revised charts for the pre-Silurian rocks, I have taken certain liberties. Units lacking diagnostic fossils have their stratal relations and chronologic placement dictated largely by geologic intuition. And inaccuracies are introduced by the relative timespans allotted such units. Some bias is created by the geographic arrangement chosen and prejudice is supplied from personal impressions for the presumed depositional environments of little-studied units. Great emphasis has been placed on the more mobile taxa as better chronologic indicators. This does not mean to imply that other less mobile or stationary taxa possess no potential for correlation purposes. The fact is that most other major taxa (brachiopods excluded) are inadequately known from the evolutionary standpoint to be employed successfully for a sequential zonation.

New York enjoys an enviable and valued paleontologic heritage. Its exceptionally fossiliferous and numerous rock sections motivated the nineteenth and early twentieth century pioneers in New York paleontology and stratigraphy to zealously pursue their investigations. The fruits of their endeavors acted as both example and catalyst for similar work elsewhere in North America. Among these indefatigable workers, Henry Platt Cushing, T. Nelson Dale, William Buck Dwight, Amos Eaton, Ebenezer Emmons, Silas W. Ford, James Hall, William W. Mather, William J. Miller, Percy E. Raymond, Rudolf Ruedemann, Lardner Vanuxem, Charles D. Walcott, and Robert Parr Whitfield stand out. Their momentous works have left an indelible impression on their successors who, in turn, have sought to unravel the mysteries hidden in New York's pre-Silurian strata. Among the mid-twentieth century geologists who have specifically addressed their efforts toward refining the earlier views and filling the gaps in knowledge of our pre-Silurian strata have been, John M. Bird, John Dewey, Donald W. Fisher, Marshall Kay (recently deceased), Franco Rasetti, George Theokritoff, and E-an Zen.

GEOGRAPHIC, CHRONOLOGIC, AND TECTONIC SETTINGS

Ordovician, Cambrian, and Hadrynian strata of New York possess an aggregate thickness of about 5,500 meters (18,000 feet). Their area of potential rock outcroppings is 25 percent of the State. These rocks are exposed in areas peripheral to the Adirondack Mountains and outcrop in a belt up to 40 km (25 miles) wide along the eastern New York border (Figures 2a and 2b). The northern portion of the Lake Ontario Plain and the Tug Hill Plateau (tableland between the eastern end of Lake Ontario and the Black River Valley) are underlain by undeformed terrigenous strata of Late Ordovician age. The Black, Champlain, Mohawk, and St. Lawrence Lowlands are floored with undeformed to slightly deformed carbonate shelf rocks of Late Cambrian through Medial Ordovician ages. The Hudson Valley and the Taconic region east of the Hudson, consists largely of moderate hills reaching an elevation of 625 meters (ca. 2000 feet). This region exposes moderately deformed litharenites and pelites of Hadrynian through Medial Ordovician ages, transported westerly some 25-80 kilometers (15-50 miles) and deposited on the slope and in the basin. Paleozoic deformation and metamorphism (Taconian, Acadian, and probable Alleghenian), has masked the original stratigraphic relationships and destroyed fossils (if they were originally there!) so that precise age assignments and paleoenvironmental reconstructions of these Taconic Sequence rocks are imperfectly known.

The prominent north-south linear ridge which parallels the Hudson River from Kingston south to Newburgh comprises Hussey Hill (on the north), Shaupauneak Mt., Illinois Mt., and Marlboro Mt. (on the south). This resistant upland consists of late Medial Ordovician molasse (Quassaic Quartzite), derived from the erosion of the Taconic gravity slides. Subsequent Taconic (Hudson Valley Phase) folding and faulting deformed these strata prior to the deposition of overlying Silurian rocks. The relatively flat lowland extending southwest from this ridge to the State line is termed the Wallkill Lowland and is floored, primarily, by deformed Snake Hill shale, argillite, and siltstone; small patches of older rock occur near the New Jersey State line.

Westchester County and the New York City counties are underlain by intensely deformed and metamorphosed Helikian (Fordham Gneiss), Hadrynian (Yonkers, Poundridge gneisses), Cambrian (lower Inwood, Manhattan B.C.), and Ordovician (upper Inwood, Manhattan A) rocks. This belt, together with other metamorphosed units of uncertain age (Bedford, Harrison, Hartland), is usually termed the Manhattan Prong.

Subsurface Ordovician, Cambrian, and questionable Hadrynian (commonly reported in wells as "granite wash") form a continuous blanket beneath the Silurian and Devonian cover-rocks of the Allegheny Plateau region (including the Catskill Mountains).

Late Proterozoic (Hadrynian) and Early Paleozoic (Cambrian, Ordovician) rocks in New York offer a provocative, though inadequately known, segment of geologic history—about 250 million years. These rocks document the breakup of a single tectonic plate (during Late Hadrynian-Early Cambrian), an expanding Proto-Atlantic[1] Ocean (Early Cambrian through Early Ordovician), and a constricting Proto-Atlantic Ocean (starting in the early Medial Ordovician). This attraction of the American and Afro-European plates produced a near collision of continents and an intricate mountain-building episode—the Taconian Orogeny—in the late Medial and Late Ordovician. Open and tight folding, basin formation, subaerial uplift, gravity sliding, thrust slicing, metamorphism, igneous emplacement, and finally, block faulting all contributed to a complex suite of both ancient environments and structural arrangements. The resultant rock record forms the subject of this summarization.

ACKNOWLEDGMENTS

Especial appreciation goes to Dr. Stig Bergstrom and Dr. John Riva, who in scrutinizing various drafts of the charts, graciously gave of their time and generously provided their unpublished views so as to make the correlations as up to date as possible.

Additional critical review of the charts, in whole or in part, has been supplied by Drs. Christina Lochman-Balk, William B. N. Berry, Raymond Ethington, Rousseau H. Flower, Marshall Kay, James Miller, Allison Palmer, Lawrence V. Rickard, Richard A. Robison, Reuben J. Ross, Jr., James Stitt, Walter Sweet, Michael Taylor, and Harry B. Whittington. Leo M. Hall made suggestions as to age of the rocks in the Manhattan Prong. For their helpful suggestions and time extended, I offer my profound thanks. However, the responsibility for the basic plan and contents of the charts is wholly mine. All photographs were taken by Donald W. Fisher.

[1]Recently named Iapetus—an appropriate name because, in Greek mythology, Iapetus was the father of Atlas, which name has to do with the Greek Atlantikos, *i.e.*, Atlantic.

Figure 2a.

PRINCIPAL PHYSIOGRAPHIC PROVINCES OF NEW YORK STATE AS RELATED TO AGE OF THE ROCKS

by Donald W. Fisher — 1976

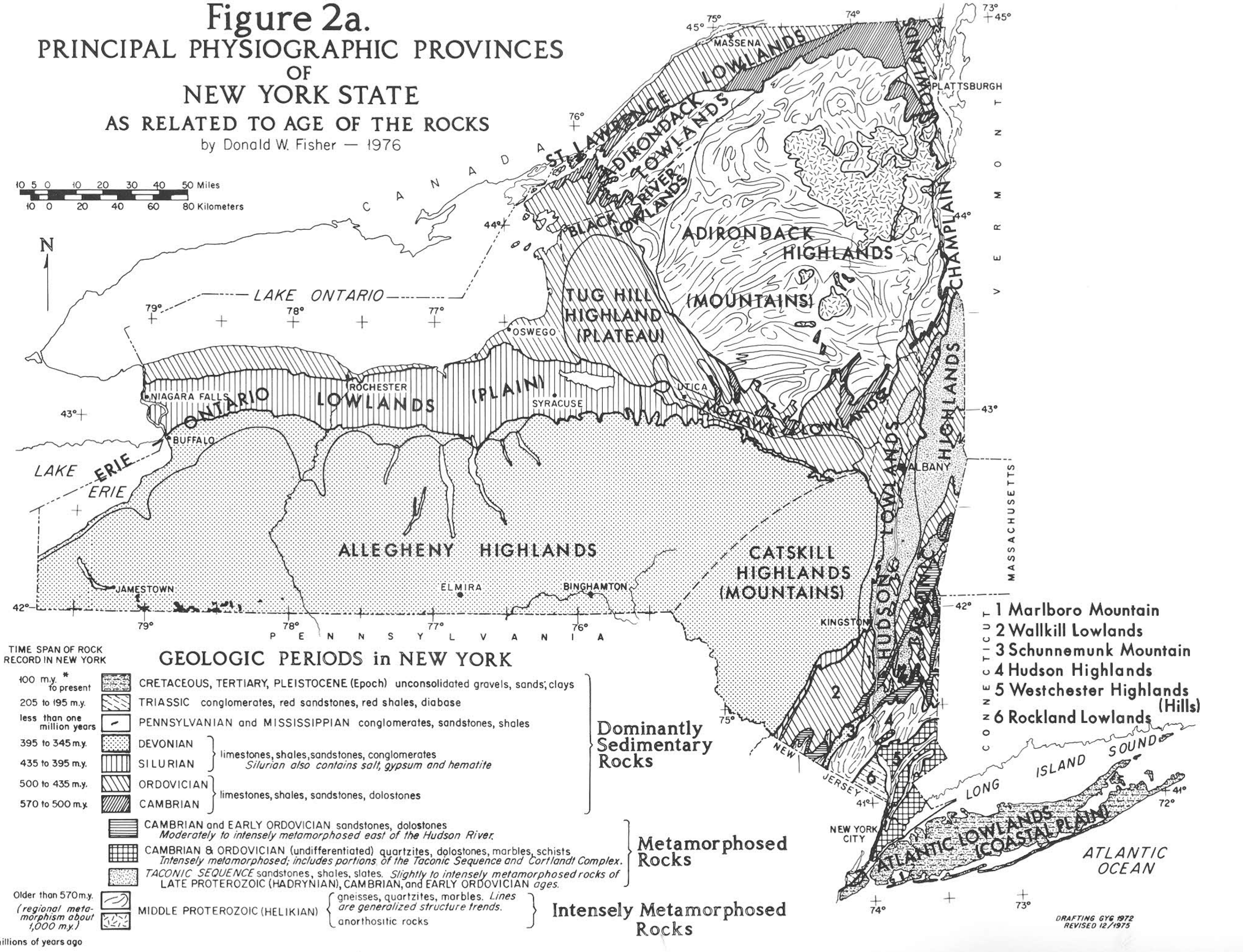
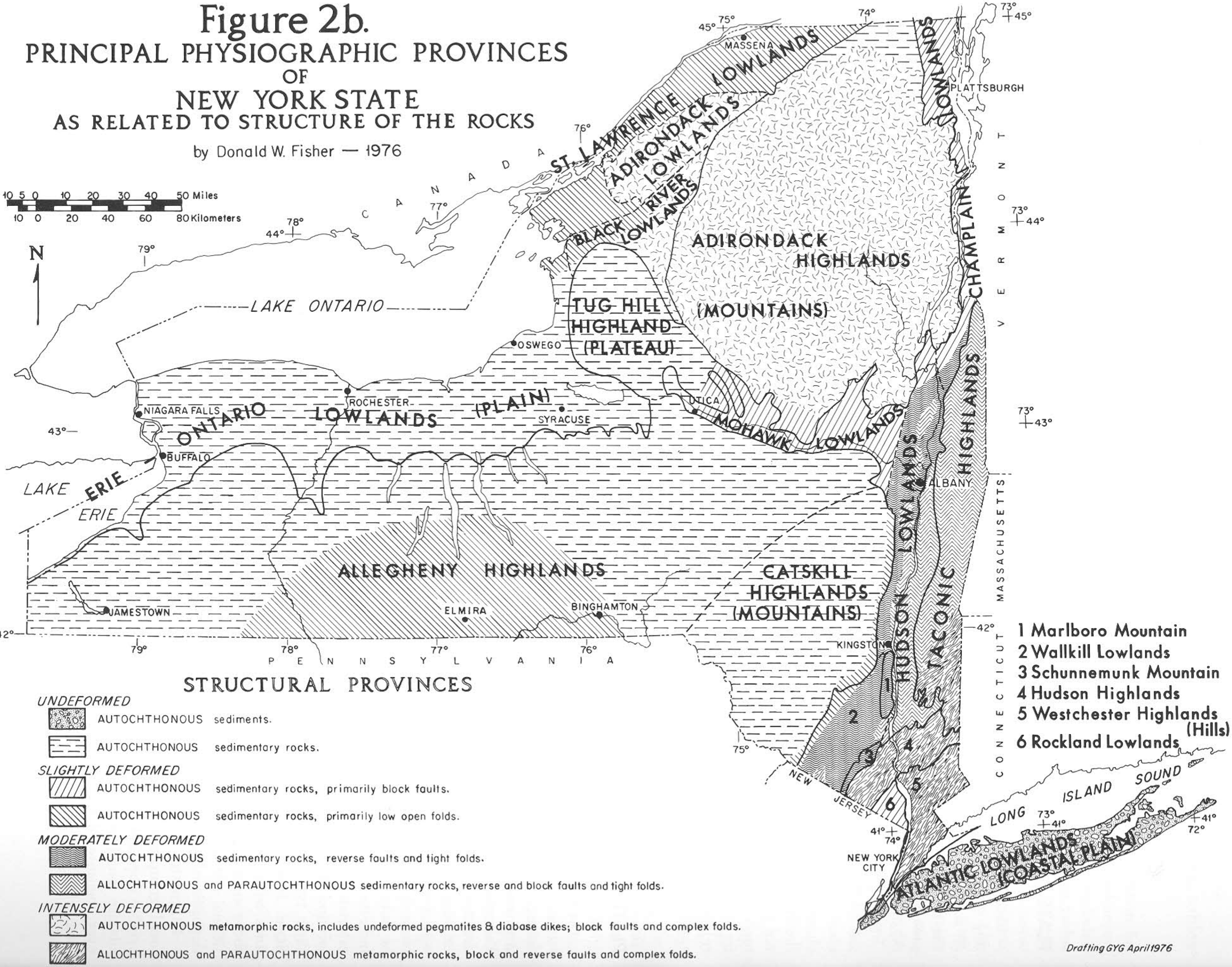


Figure 2b.
PRINCIPAL PHYSIOGRAPHIC PROVINCES OF NEW YORK STATE AS RELATED TO STRUCTURE OF THE ROCKS

by Donald W. Fisher — 1976



Scheme of the Charts

(Plates 1, 2, 3, 4, 5)

PLATE 1 (legend and facies chart)

Plate 1 is a multipurposed effort designed to: (1) distinguish and describe the primary pre-Silurian facies, (2) serve as color legend for Plates 2 and 4, (3) portray the facies relevant to the broad tectonic picture, (4) provide a crude chronostratigraphic arrangement, and (5) suggest paleoenvironmental realms.

During the early stages of planning, Plate 1 of Rickard (1975) was intended to serve for both his and my charts. However, as preparation of the pre-Silurian charts progressed, it became increasingly apparent that the Hadrynian, Cambrian, and Ordovician facies would not properly fit into this prearranged design. Accordingly, Rickard's Plate 1 is not used as a color legend for my work because it would create and promulgate relationships and settings that are known to be inapplicable or ambiguous for pre-Silurian rocks.

PLATES 2 and 4 (correlation charts)

On these charts vertical dimension approximates relative timespan as currently known from radiometric dating, excepting that the Proterozoic portion of Plate 2 is not drawn to the same vertical scale as the Paleozoic portion. Absence of a rock record (hiatus) is denoted by a gray screen. Diagonal ruling signifies concealed older strata. Solid-line boundaries indicate well-established contacts, approximately placed chronologically; dashed-line boundaries indicate vague or dubious contacts; queried dashed-line boundaries indicate questionable placement of contacts. Position of asterisk denotes longitudinal (15-minute 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. Solid lines with spurs, enclosing rock names, indicate that those units have been transported from an alien depositional site and, in any given area, do not lie in the depositional sequence of that area.

Diagnostic faunal control is shown by appropriate fossil group symbol although horizontal position of symbol does not necessarily mean that significant fossils are found only in that quadrangle column. However, because of the scarcer diagnostic fossils in the Cambrian and Lower Ordovician (Canadian) rocks, quadrangle position of the fossil symbols does denote longitudinal site of critical fossils. The use of paleontologic control symbols obviates the need for lengthy citations of evidence for chronologic placement of each rock unit.

Time-rock units and biostratigraphic names (shown by inclined letters) are those deemed, after careful consideration, to be most useful for intra- and interstate correlation as well as for international correlation. It will be obvious to those who are familiar with the 1959–64 charts that the portion which attempted to show the stratigraphic ranges of individual species has been omitted. Because total ranges are never really known and because most species are ecologically controlled, the stipulated faunal ranges were ambiguous, misleading, and sometimes erroneous. Instead, greater emphasis has been placed on establishing a firmer biostratigraphic framework using more than one fossil zonation sequence (shown by slanted letters). Accordingly, the primary basis has been relating rock units to suggested zones of trilobites (Cambrian, Ordovician), graptolites (Ordovician, Silurian), conodonts (Ordovician, Silurian, Devonian), and ammonoids (Devonian). Secondary basis (brachiopods, gastropods, nautiloids, ostracodes, acritarchs, etc.) are employed as supplements or where primary ones are controversial or lacking. Where faunal evidence is inconclusive or absent, lithologic markers or groupings of lithologic characteristics have been used with limited success.

The columnar arrangement, from west to east, on the Middle-Upper Ordovician Chart (Plate 4) is based on principal geographic regions, further subdivided into 15-minute quadrangles; in eastern New York (Champlain and Hudson Valleys) a north to south quadrangle arrangement is used. The tripartite division on the Hadrynian-Cambrian-Ordovician Chart (Plate 2) is based on degree of structural transport or lack of it, *i.e.*, autochthonous (no transport), parautochthonous (rocks transported up to 35 kilometers), allochthonous (rocks transported over 35 kilometers); within each geographic subdivision the 15-minute quadrangles are geographically arranged from west to east or north to south.

For those who so desire, the top of the Middle-Upper Ordovician Chart (Plate 4) may be fitted to the base of the Silurian Chart (Rickard, 1975, Plate 2) along the common cut or fold line—shown by arrows;

about three-fourths of the respective charts have identical columnar arrangement. However, for pre-Middle Ordovician rocks their pattern of distribution does not permit this to be done. Thus, the chart (Plate 2) showing the Hadrynian, Cambrian, and Lower Ordovician rocks stands separately with different vertical scale and different quadrangle arrangement; the remainder of the Ordovician (that shown on Plate 4) is annexed, in a condensed version, for the sake of completeness.

Rock-unit names shown (by vertical letters) 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 either because they possess questionable validity, are not rock units, are ill-defined, are synonymous with existing names, or are unnecessary. A few names are proposed for recognizable units which previously possessed no formal status or for which the nomenclature was unclear. Only principal lithologies of a rock unit are mentioned by conventional abbreviations (arg. = argillite, ark. = arkose, cgl. = conglomerate, cht. = chert, ds. = dolostone, gywk. = graywacke, ls. = limestone, mar. = marble, mél. = mélange, phyl. = phyllite, qtzt. = quartzite, sch. = schist, sh. = shale, silts. = siltstone, sl. = slate, ss. = sandstone). (See chapter on "Roster of pre-Silurian stratigraphic names".)

Color is used on the charts to depict principal facies—a summation of the lithologic, paleontologic, and sedimentologic characteristics of the rocks. This innovation was earlier adopted by Rickard (1964) for the Devonian chart. On the charts (plates 2,4) uncolored units are metamorphic rocks whose original facies setting is uncertain. Twenty-six colors representing forty-five facies, are portrayed on the sedimentary rock units; igneous rocks are shown by a separate color overprint.

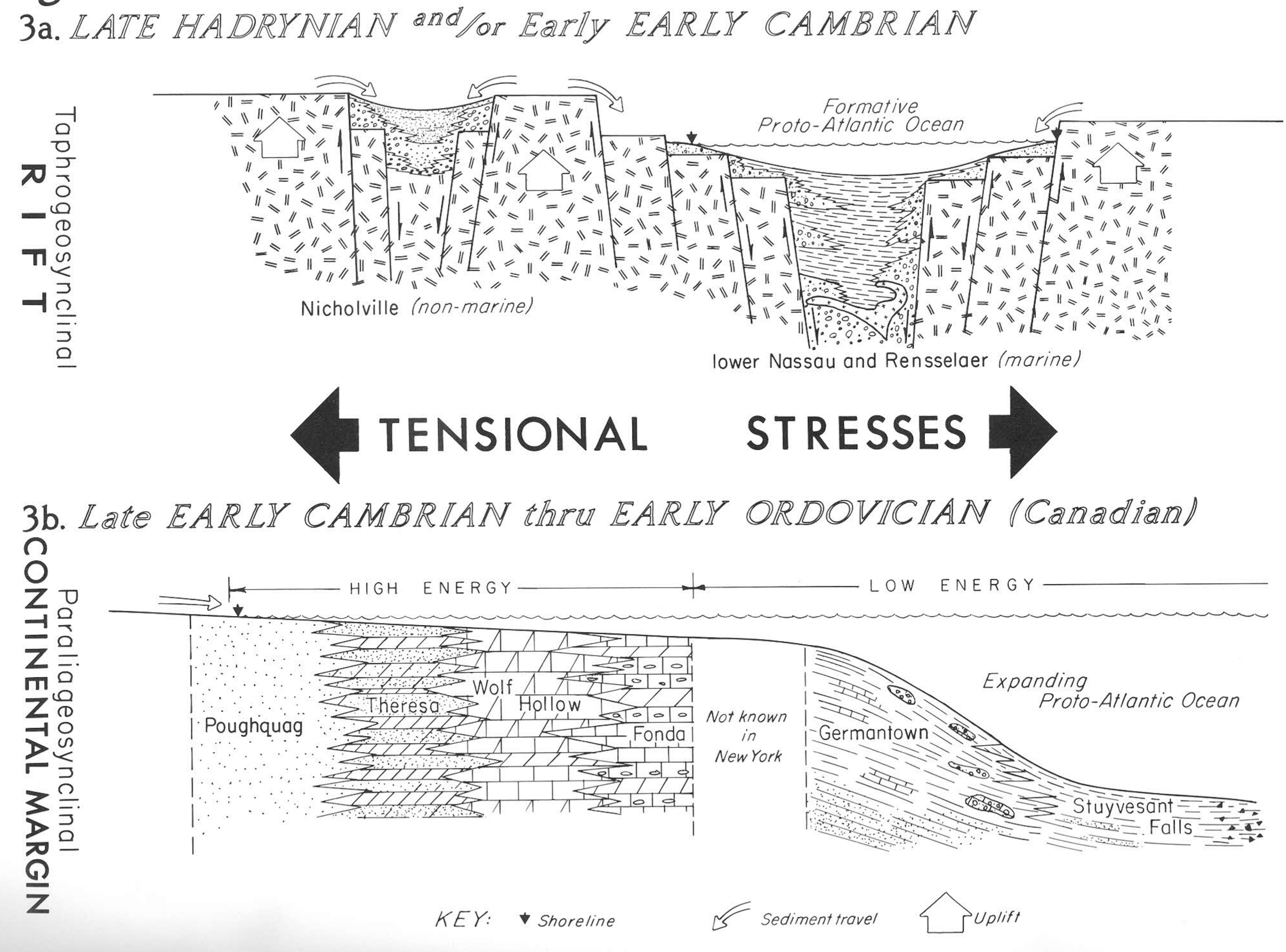
PLATES 3 and 4 (Stratigraphic profiles, tables of rock thicknesses)

Because correlation charts offer no connotation for the thicknesses of rock units, tables of rock thicknesses and selected stratigraphic profiles have been included for additional stratigraphic utility. The thickness tables are designed to agree with the arrangement of 15-minute quadrangle columns; however, in some cases, it should be noted that there may be great thickness variation within such columns. The colors on the stratigraphic profiles do not necessarily agree with those selected to depict facies. For certain major groupings (ex. Trenton Group) a single blue color may represent several limestone facies. Where a single facies has relatively great thickness (ex. Queenston), the colors on the stratigraphic profile and that of the facies are identical.

PLATE 5 (Panorama of Paleogeography)

In order to better visualize the changes in the distribution of Early Paleozoic lands and seas together with the changes in the types of sediments that were deposited, the Panorama of Paleogeography (Plate 5) is presented as a single mosaic rather than having the numerous maps separated throughout the text. In this fashion, the maps are segregated into two suites comparing the land-sea changes during an expanding Proto-Atlantic Ocean with those during a contracting one. Owing to the scarcity of radiometric determinations for Early Paleozoic time, the stated geologic ages are understandably approximate. Areas of dominant kinds of lithologies are illustrated by conventional symbol patterns; only principal rock units are named in their general area of deposition. Accordingly, Plate 5 is a pictorial overview of Early Paleozoic paleogeography and lithofacies distribution.

Figure 3. FACIES SETTINGS



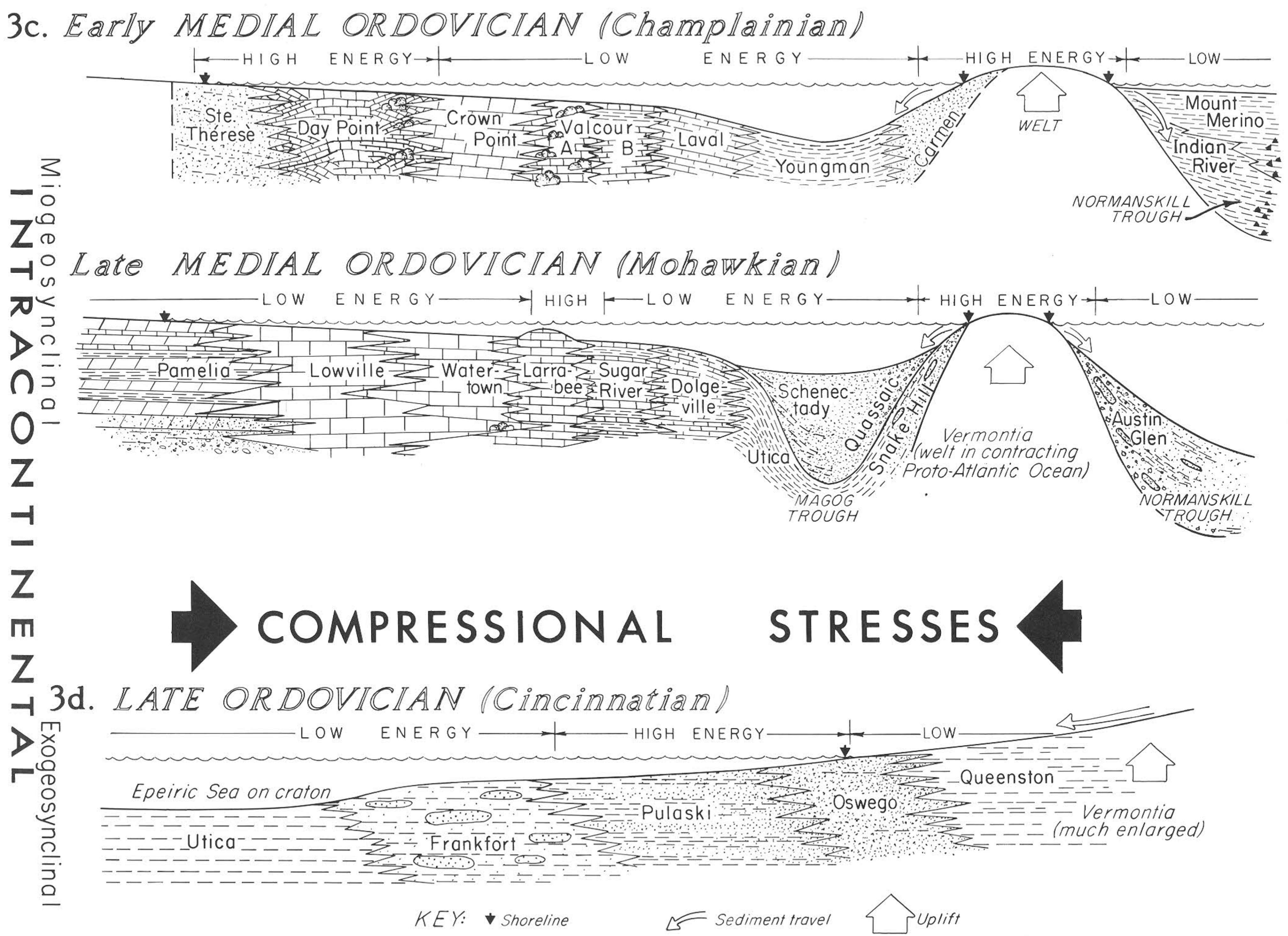
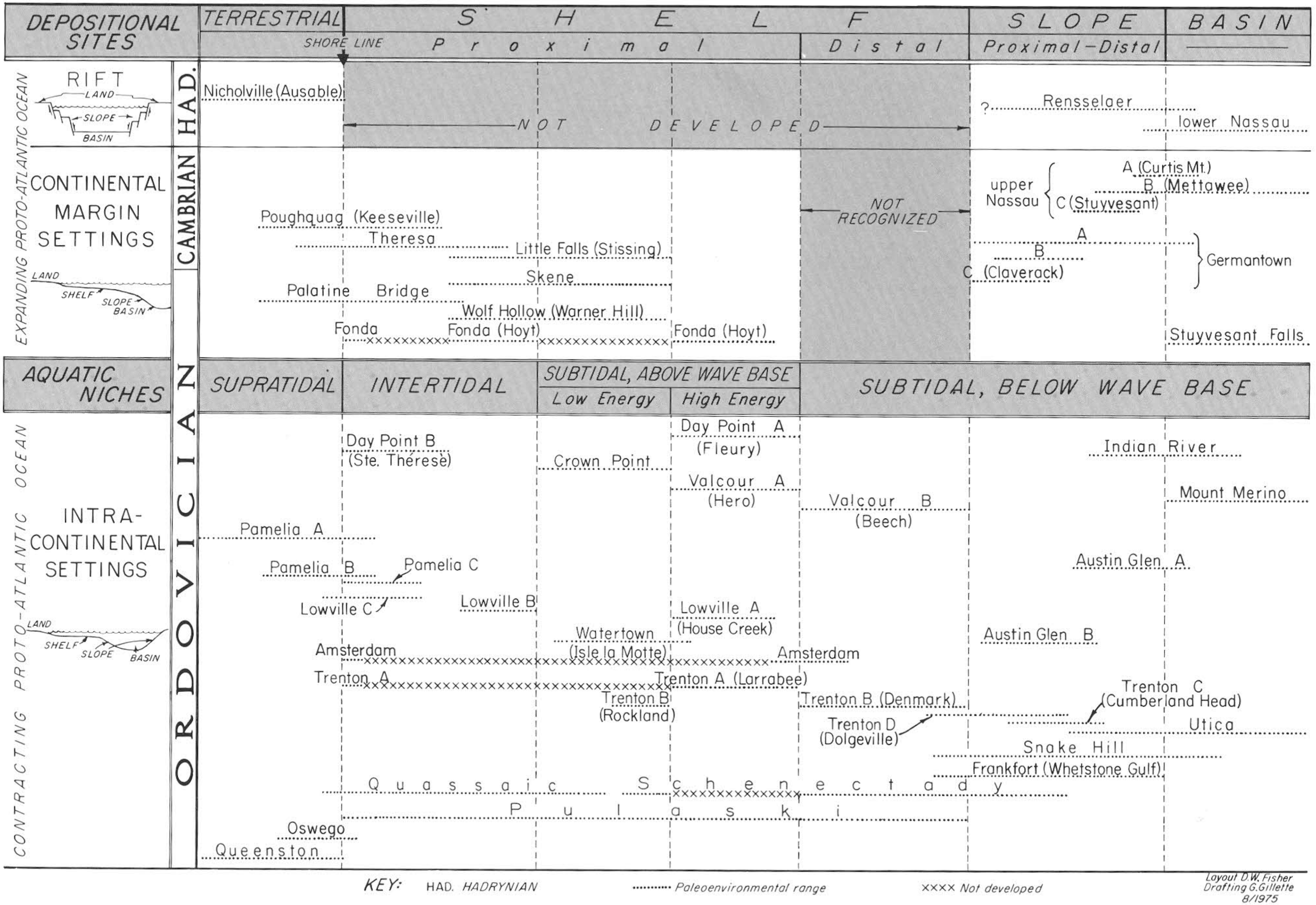

3c. Early MEDIAL ORDOVICIAN (Champlainian)
HIGH ENERGY
LOW ENERGY
HIGH ENERGY
LOW
Ste. Thérese
Day Point
Crown Point
Valcour A B
Laval
Youngman
Carmen
WELT
Mount Merino
Indian River
NORMANSKILL TROUGH
Late MEDIAL ORDOVICIAN (Mohawkian)
LOW ENERGY
HIGH
LOW ENERGY
HIGH ENERGY
LOW
Pamelia
Lowville
Watertown
Larrabee
Sugar River
Dolgeville
Schenectady
Quassaic
Snake Hill
Utica
MAGOG TROUGH
Vermontia (welt in contracting Proto-Atlantic Ocean)
Austin Glen
NORMANSKILL TROUGH
Miogeosynclinal
INTRACONTINENTAL
Exogeosynclinal
COMPRESSIONAL STRESSES
3d. LATE ORDOVICIAN (Cincinnatian)
LOW ENERGY
HIGH ENERGY
LOW
Epeiric Sea on craton
Utica
Frankfort
Pulaski
Oswego
Queenston
Vermontia (much enlarged)
KEY: Shoreline
Sediment travel
Uplift

Figure 4. PROVISIONAL PALEOENVIRONMENTAL RANGES OF THE PRINCIPAL HADRYNIAN, CAMBRIAN, and ORDOVICIAN FACIES in NEW YORK



Principal New York Facies and Tectono-Sedimentary Assemblages

(Figures 3, 4: Plate 1)

For the purposes of this summation, 45 facies have been delineated in the Hadrynian, Cambrian, and Ordovician strata. Utilizing the plate tectonics concept promoted by Bird and Dewey (1970) for the Appalachian Geotectonic Cycle and the geosynclinal tectono-sedimentary concept of Kay (1951), these facies have been allocated to three plate-tectonics settings (rift, continental margin, intracontinental) and three depositional provinces (shelf, slope, basin). In Kay's terminology (1951), taphrogeosynclines are represented in the Hadrynian and Triassic, paraliageosynclines in the Late Cambrian-Early Ordovician (carbonate shelf) and Late Cretaceous-Neogene (terrigenous shelf), miogeosynclines in the Middle Ordovician, autogeosynclines in the Late Silurian-Early Devonian, and exogeosynclines in the Late Ordovician, Early and Middle Silurian, and Middle and Late Devonian. Eugeosynclines occur in the Early Cambrian through Medial Ordovician portion of the Taconic Sequence.

Because some of the facies are of short duration or of limited geographic extent, they are combined with their nearest analogs and only 26 separate colors are utilized on the correlation charts. A typical rock-unit example of each facies is given in each color box on the facies chart (Plate 1): where possible, this example has been the subject of a detailed paleoecological study.

Subfacies are known, in many cases, and with additional work a more refined classification eventually will be perfected. For some of the units, the paleoenvironmental setting is uncertain and a tentative classification (Figure 4) is presented with the full realization that future workers may modify some of the assignments here suggested.

From the standpoint of plate- and sedimentary-tectonics, three primary divisions are distinguished:

Figure 6. *Nicholville Facies. Closeup of conglomeratic arkose at type locality.*

Figure 5. *Nicholville Facies. Arkose; type locality along northeast side of St. Regis River at Nicholville, St. Lawrence County, N.Y.*

1. **Rift deposits** (Figure 3a), or fault-trough deposits, include the taphrogeosynclines of Kay (1951). In New York, these are represented, during the Late Triassic, by the Newark Group of fanglomerates, arkoses, sandstones, and shales in Rockland County and, during the Early Cambrian and Late Hadrynian, by the marine deposits in eastern New York and nonmarine deposits in northern New York.

2. **Continental margin deposits** (Figure 3b), include the paraliageosynclines of Kay (1951) and miogeoclines

and eugeoclines. In New York, terrigenous shelf, slope, and basin deposits were produced during the Late Cretaceous and Neogene on the Atlantic Coastal Plain. Carbonate shelf deposits, and pelitic slope and basin deposits accumulated from Early Cambrian through Early Ordovician (Canadian) times.

3. **Intracontinental deposits** (Figures 3c, 3d), include the autogeosynclines, miogeosynclines, and exogeosynclines of Kay (1951). In New York, these sediments accumulated from Medial Ordovician through Late Devonian time, and volume-wise compose most of New York's Paleozoic strata. All of the Silurian and Devonian facies belong to the intracontinental setting, either as autogeosynclines or exogeosynclines.

The Hadrynian, Cambrian, and Ordovician facies are provisionally distinguished as follows:

RIFT ASSEMBLAGE (Figures 3a, 4; Plate 1)—For Late Hadrynian-Early Cambrian time, three principal facies (Nicholville, Rensselaer, Lower Nassau) are designated (Figure 4); subfacies are known to be present in the pre-trilobite portion of the Taconic Sequence. All rocks in the rift assemblage are of the litharenite-pelite suite. There is no marine shelf representation in this setting and slope and basin deposits are not obviously discrete. This rift setting characterizes the initiation (during the Hadrynian) of the Appalachian Geotectonic Cycle and the initiation (during the Late Triassic) of the Atlantic Geotectonic Cycle.

Figure 7. *Quartz-cobble conglomerate. Hadrynian or Early Cambrian basal deposit unconformably on quartz-biotite gneiss; along north side of N.Y. 29, twelve miles west of Saratoga Springs, Saratoga County, N.Y.*

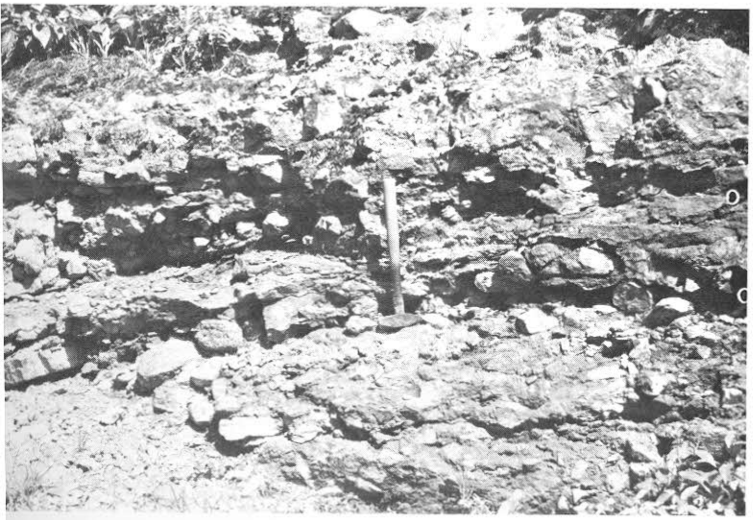


Figure 8. *Rensselaer Facies. Graywacke; along N.Y. 203, east of Spencertown, Columbia County.*

Figure 9. *Rensselaer Facies. Closeup of coarse graywacke; along north side of N.Y. 203, east of Spencertown, Columbia County, N.Y.*

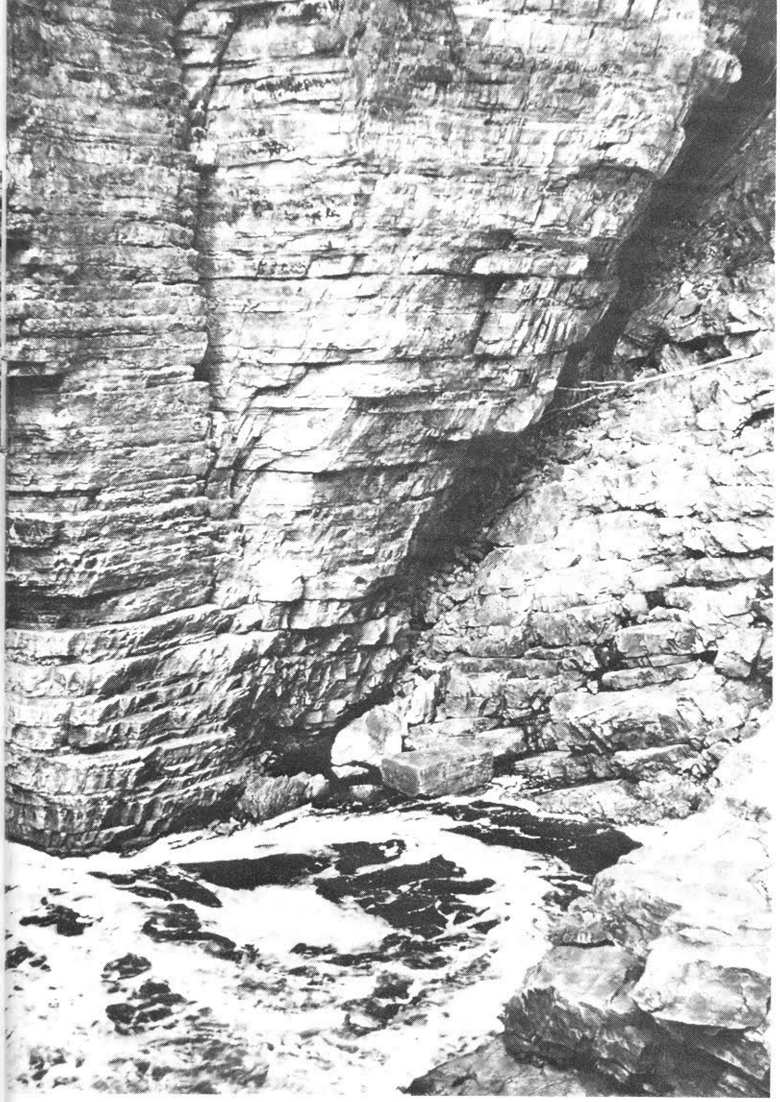


Figure 10. *Potsdam (Keeseville) Facies. Sandstone; along Ausable River at Ausable Chasm, Clinton-Essex Counties, N.Y.*

Terrestrial (nonmarine)

NICHOLVILLE (AUSABLE)—*Late Hadrynian*
—**Arkoses:** tan, yellow, pink, red, green, thin-thick irregularly bedded, medium-very coarse textured feldspathic and hematitic **sandstones,** and pebble-boulder **conglomerates** (clasts of quartzite and gneiss in a feldspar-quartz matrix). Locally crossbedded, poorly sorted.
—No fossils observed.

Proximal to Distal Slope

RENSSELAER—*Late Hadrynian*
—**Graywackes** and **Subgraywackes:** gray-olive green, medium-thick bedded, medium-coarse textured, local pebble and cobble conglomerate; some red, maroon, and green shales with greenish-gray quartzites; locally with interbedded volcanics. Turbidite features, manganese nodules, and graded bedding in graywackes.
—Rare trace fossils *(Oldhamia)* in red shale.

Basin

LOWER NASSAU—*Late Hadrynian*
—**Siltstones:** green, pink, lavender, micaceous, and quartzites alternating with **pelites,** green-purple, silty, micaceous.
—Rare trace fossils *(Oldhamia)*.

CONTINENTAL MARGIN ASSEMBLAGE (Figures 3b, 4; Plate 1)—Two sedimentological suites are recognized (Figure 4) in the Early Cambrian through Early Ordovician (Canadian) shelf rocks peripheral to the Adirondack Mountains and sporadically exposed in the Hudson Valley and Taconic Regions. First, the quartzarenite-carbonate suite is represented by seven facies [Keeseville (Poughquag): Theresa; Palatine Bridge; Little Falls; Skene; Warner Hill (Wolf Hollow); Fonda (Hoyt)], all deposited above wave base. Carbonate suite facies deposited below wave base are unknown in New York. Second, the litharenite-pelite suite is represented by seven facies [Germantown A, B, C (Claverack); Upper Nassau A (Curtis Mountain), B (Mettawee), C (Stuyvesant); Stuyvesant Falls] in the Early Cambrian through Ordovician slope and basin rocks in the Taconic region. These Paleozoic strata were structurally transported from a more easterly depositional site. Later, during Late Cretaceous and

Figure 11. *Potsdam (Keeseville) Facies. Sandstone; along Champlain Canal in Whitehall, Washington County, N.Y.*

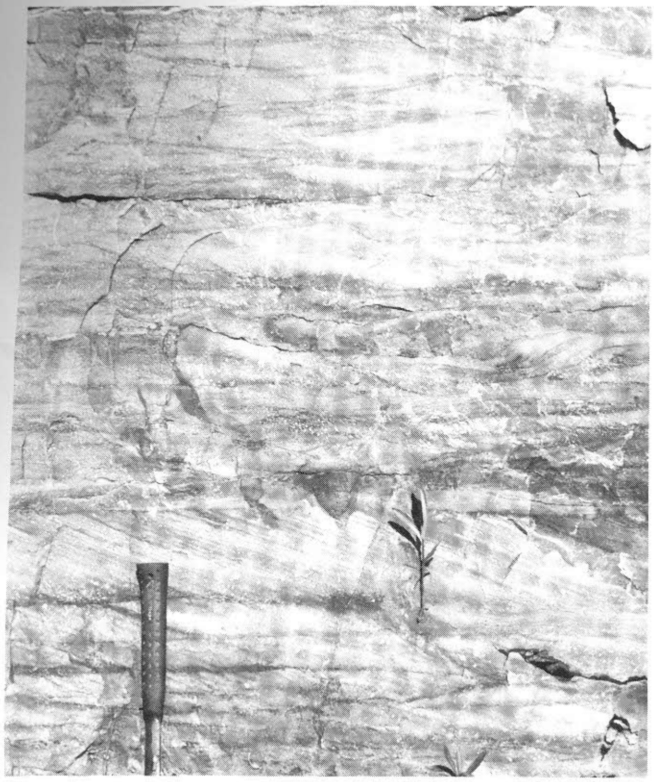


Figure 12. *Potsdam (Keeseville) Facies. Closeup of sandstone illustrating crossbedding; along Champlain Canal in Whitehall, Washington County, N.Y.*

Neogene times, the litharenite-pelite suite is represented by shelf and slope sediments on Long Island.

Shelf (nonmarine to marine)—supratidal to intertidal

KEESEVILLE (POUGHQUAG)—*Early Cambrian through Early Ordovician (Gasconadian)*

—**Sandstones** and **siltstones:** tan, gray, cream, white, rarely black (weathers yellow-tan-gray), thin-thick bedded, fine-coarse textured, quartzose, locally conglomeratic. Ripple-marked. laminated, cross-laminated, crossbedded.

—Fossils very rare: few trilobites, trace fossils.

THERESA—*Early Cambrian through Early Ordovician (Gasconadian)*

—**Calcitic dolostones:** tan, gray to brownish (fretwork-weathering) feldspathic, quartzose, alternating with **dolomitic sandstones** and rare

Figure 13. *Theresa Facies. Quartzose dolostone and dolomitic sandstone; west side of I-81, north of Perch Lake, Jefferson County, N.Y.*

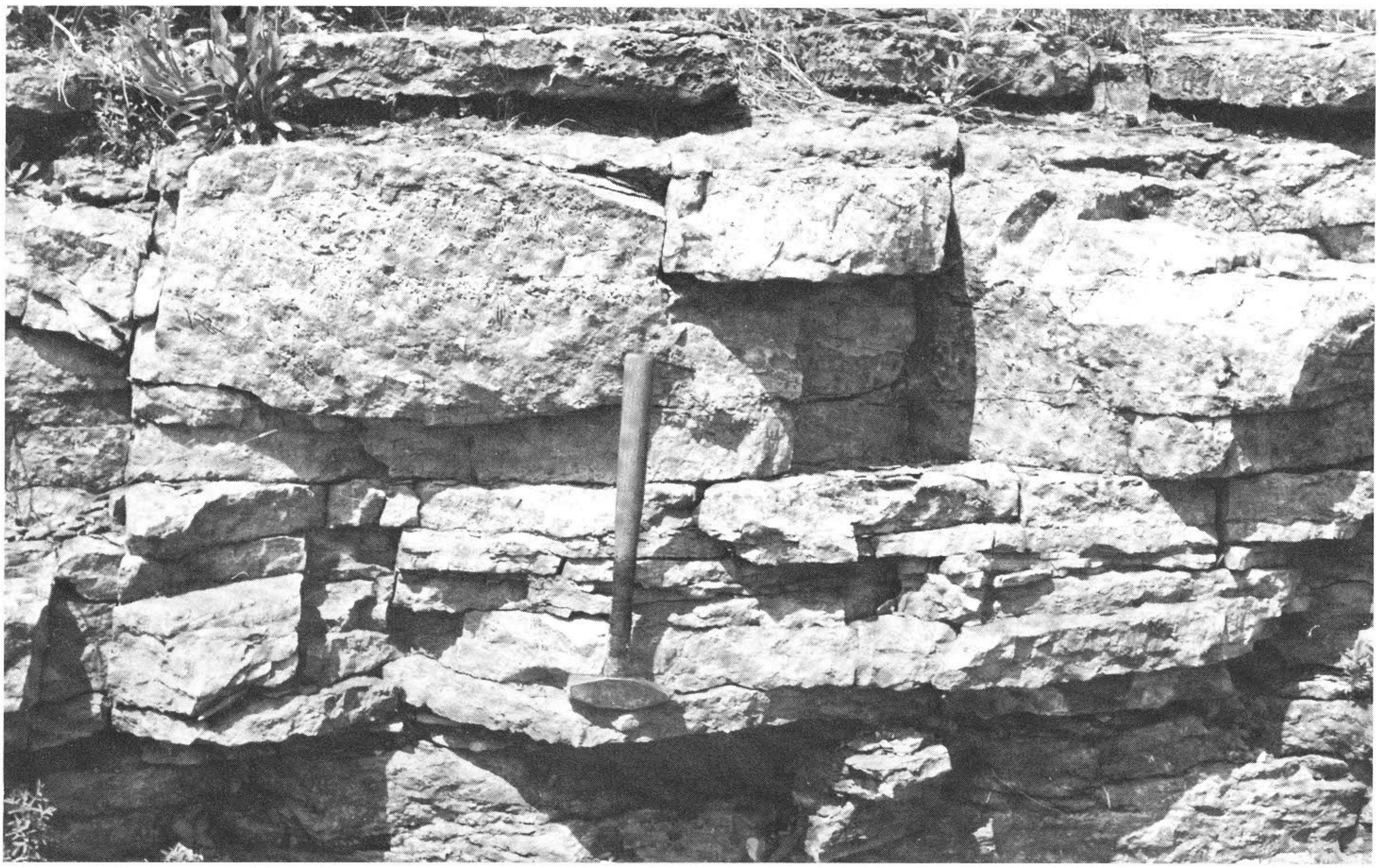


Figure 14. *Palatine Bridge and Wolf Hollow Facies. Dolomitic shale, quartzose dolostone, and dolomitic calcilutite; north side of N.Y. 5, east of Amsterdam, Montgomery County, N.Y.*

white orthoquartzites or gray silty shales. Locally cross-laminated and crossbedded.

—Fossils rare: *Scolithus*, trilobite fragments, gastropods, lingulid brachiopods, in shales, trace fossils.*

PALATINE BRIDGE—*Early Ordovician (Gasconadian)*

—**Dolomitic siltstones** and **argillaceous dolostones:** pale greenish-gray, (weathers bluish-gray), thin-bedded, fine-medium textured, feldspathic, laminated, interbedded with calcareous or dolomitic silty **shales,** locally glauconitic, pyritic, oolitic. Intraformational breccias, cyclical sedimentation.

—Fossils common: "fucoids," trilobites, gastropods, lingulid brachiopods.

Figure 15. *Fonda Facies. Limestone; east side of Borden Road, West of Fultonville, Montgomery County, N.Y.*

Proximal Shelf

LITTLE FALLS—*Early through Late Cambrian*

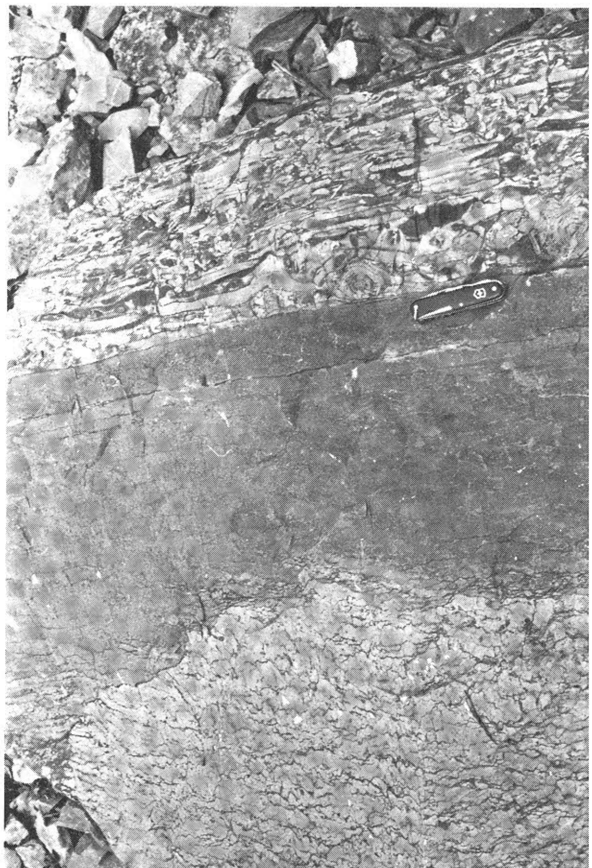
—**Dolostones:** pale bluish-gray, light-dark gray, tan, fine-medium bedded, fine-medium textured, sometimes quartzose; local bedded and nodular chert, quartz knots, vugs. Locally laminated.

—No fossils observed other than stromatolites.

SKENE—*Late Cambrian through Early Ordovician*

—**Dolostones:** white, light tan to light gray, medium-thick bedded, massive, coarse tex-

Figure 16. *Several Hoyt Facies. Intraformational slab breccia blanketing small Cryptozoon heads, off-reef calcarenite, and reefoid stromatolitic calcilutite; north side of Washington County 10, northeast of Whitehall, Washington County, N.Y.*



*Fossils here and in succeeding descriptions listed in order of relative abundance.

Figure 17. *Hoyt stromatolite Facies. Limestone; north side of Washington County 10, northeast of Whitehall, Washington County, N.Y.*

tured; grades laterally and vertically into limestones.

—No fossils known.

WARNER HILL (WOLF HOLLOW)—*Late Cambrian through Early Ordovician*

—**Limestones:** conchoidally fracturing light gray to dark gray (very light gray to light gray weathering), massive, medium-thick bedded, fine-medium textured; with varying dolomite, quartz, and chert. Local flatpebble conglomerates.

—Fossils scarce: stromatolites, trilobites, low-spired gastropods, orthoconic and cyrtoconic cephalopods.

FONDA (HOYT)—*Late Cambrian through Early Ordovician*

—**Limestones:** light-medium gray (medium-dark gray weathering), irregularly bedded, medium-coarse textured, quartzose, dolomitic; local pebble conglomerates, oolites, glauconite.

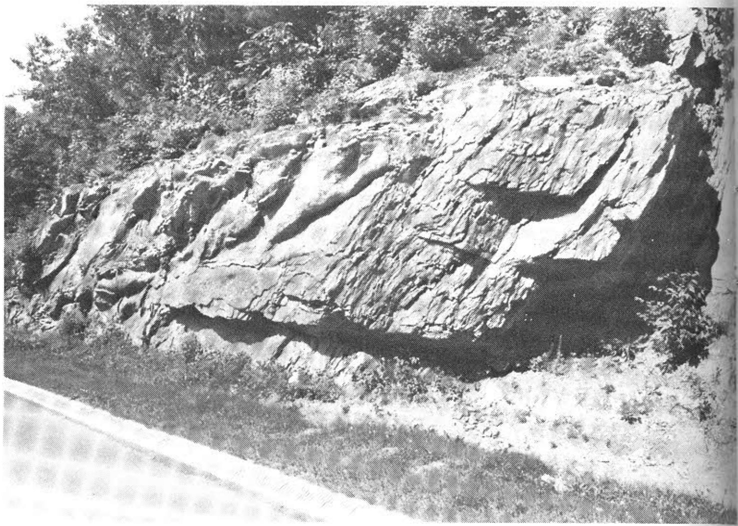


Figure 18. *Germantown A Facies. Dark gray-black platy shale; along Taconic State Parkway, near Hibernia, Dutchess County, N.Y.*

—Fossils common: trilobites, high- to low-spired gastropods, ribeirids, small orthoconic cephalopods, lingulid brachiopods; local *Cryptozoon* blanket reefs. Fossils exhibit evidence of transport.

Proximal to Distal Slope

GERMANTOWN—*Early Cambrian through Early Ordovician*

A.—**Silty shales:** dark gray to black, platy, with dolomitic sandstones and siltstones; locally ferruginous and quartzitic.

—Fossils rare: dendroid graptolites, phosphatic brachiopods, problematica.

Figure 19. *Germantown B Facies. Interbedded thin intervals of fine textured limestone and gray-black shale; along east side of U.S. 9, south of Hudson, Columbia County, N.Y.*

B.—**Limestones:** dark gray to black, ribbon, fine-medium textured, alternating with dark gray-black calcareous or dolomitic shales.
—Fossils rare: diminutive trilobites, phosphatic brachiopods.

C.—Claverack
—**Conglomerates:** with clasts of light gray-dark gray, fine-medium textured limestones and dolostones in a matrix of well-rounded quartz sand; carbonate conglomerates sometimes grade into calcareous sandstones or quartzites with turbidite features.
—No fossils in matrix but limestone clasts have trilobites, lingulid brachiopods, and a great variety of phosphatic problematica.

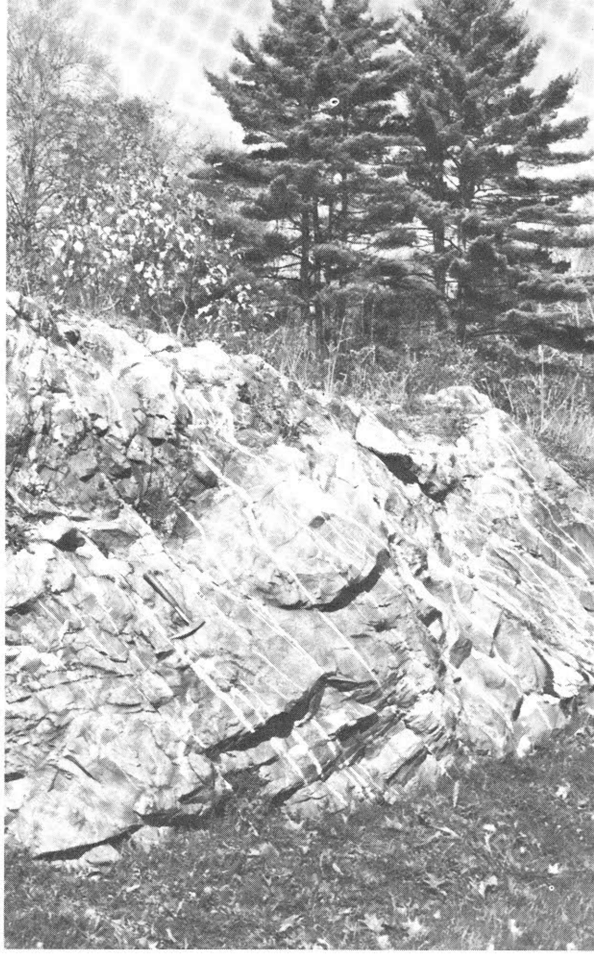


Figure 21. *Upper Nassau A (Curtis Mountain) Facies. Green-gray quartzite cut by quartz veins; along Taconic State Parkway, north of N.Y. 82, Columbia County, N.Y.*

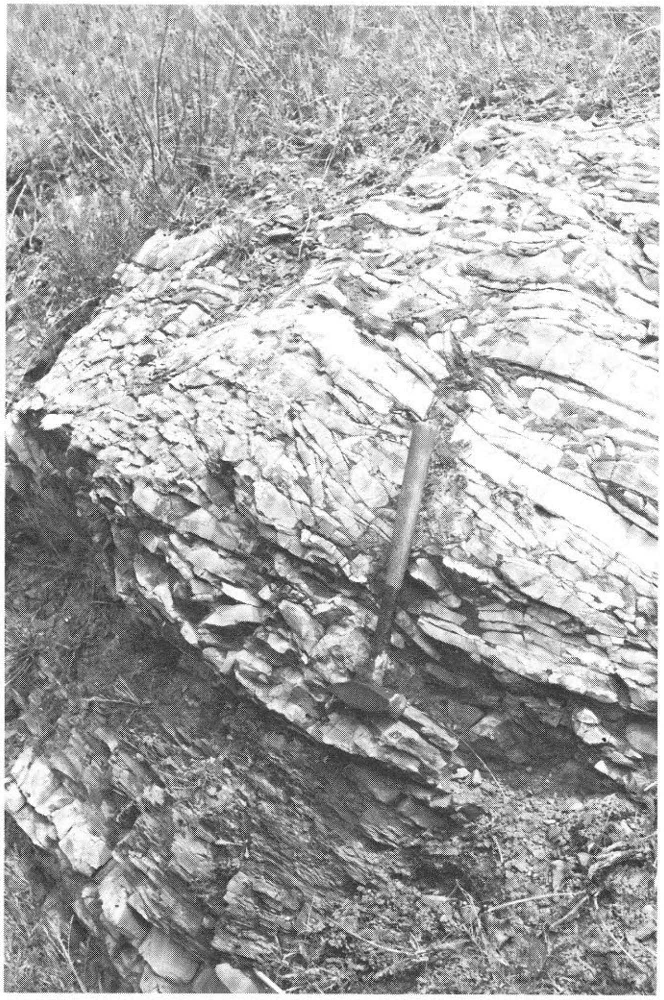


Figure 20. *Germantown C Facies. Carbonate clast conglomerate with quartz-sand matrix; east side of U.S. 9, south of Hudson, Columbia County, N.Y.*

Figure 22. *Upper Nassau B (Mettawee) Facies. Green-gray argillite; along Taconic State Parkway, north of N.Y. 82, Columbia County, N.Y.*

Figure 23. *Upper Nassau C (Stuyvesant) Facies. Carbonate clast conglomerate in argillaceous matrix, Penn-Central R.R. cut, south of Schodack Landing, Columbia County, N.Y.*

Distal Slope to Basin

UPPER NASSAU—*Early Cambrian*

A.—Curtis Mountain

—**Orthoquartzites:** dark green, light green-gray (tan-orange weathering), massive. Commonly with load casts on underside of bedding.

—No fossils known.

B.—Mettawee

—**Argillites:** olive green-gray-purple, silty, laminated, weathering to an orange-brown crumbly shale. Locally with incipient concretionary limestone beds.

—Fossils rare: algal impressions, jellyfish ?, trilobites.

C.—Stuyvesant

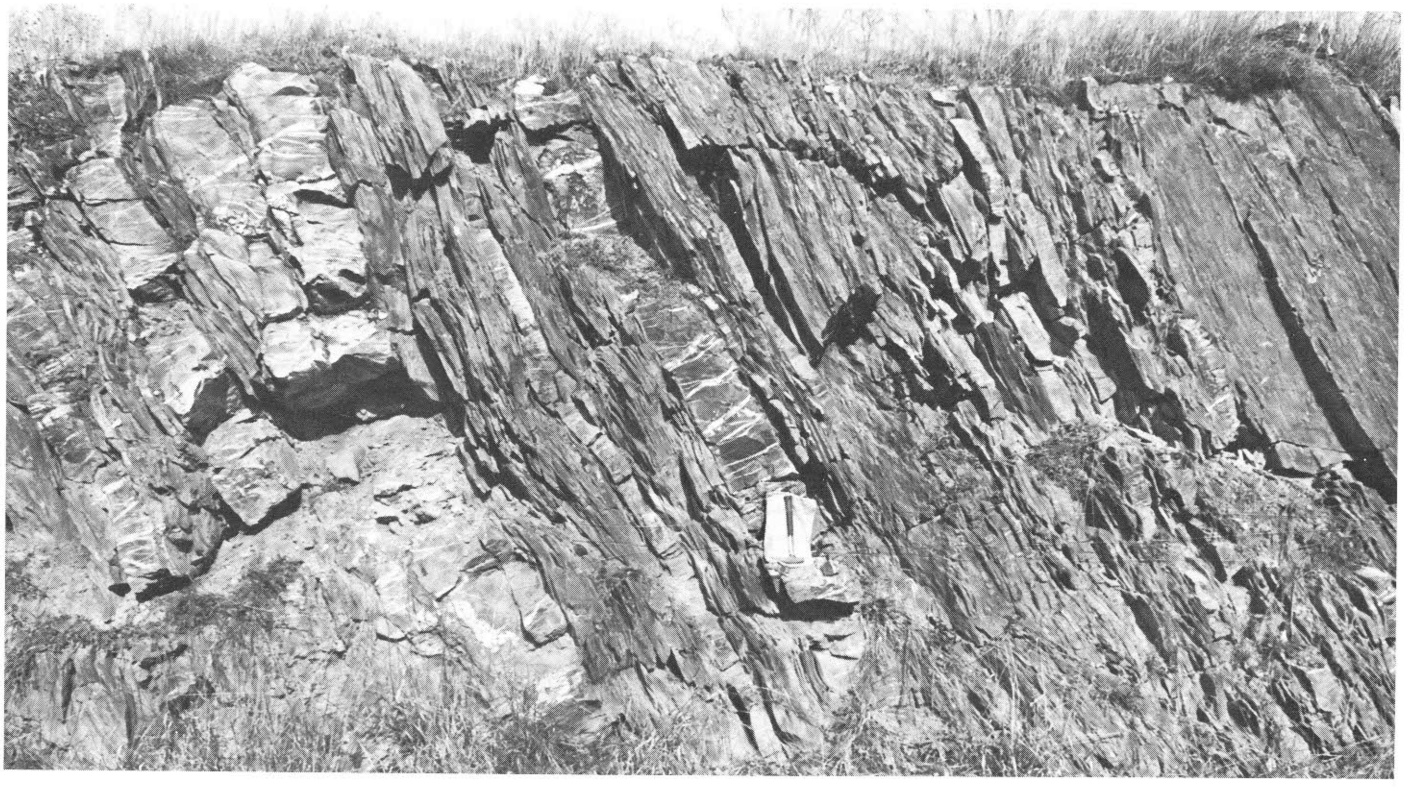
—**Conglomerates:** clasts of fine and coarse grained dark and light gray limestones in an argillaceous matrix.

—Fossils locally abundant in coarse textured limestone clasts; trilobites, phosphatic problematica.

Figure 24. *Upper Nassau C (Stuyvesant) Facies. Closeup of above.*

Figure 25. *Stuyvesant Falls Facies. Alternating thin bedded quartzite and green shale; along Taconic State Parkway, near Washington Hollow, Dutchess County, N.Y.*

Figure 26. *Stuyvesant Falls Facies. Alternating green quartzite, with quartz veins, and green-gray shale and argillite of Elizaville Formation; along Dutchess County 19, near Milan, Dutchess County, N.Y.*



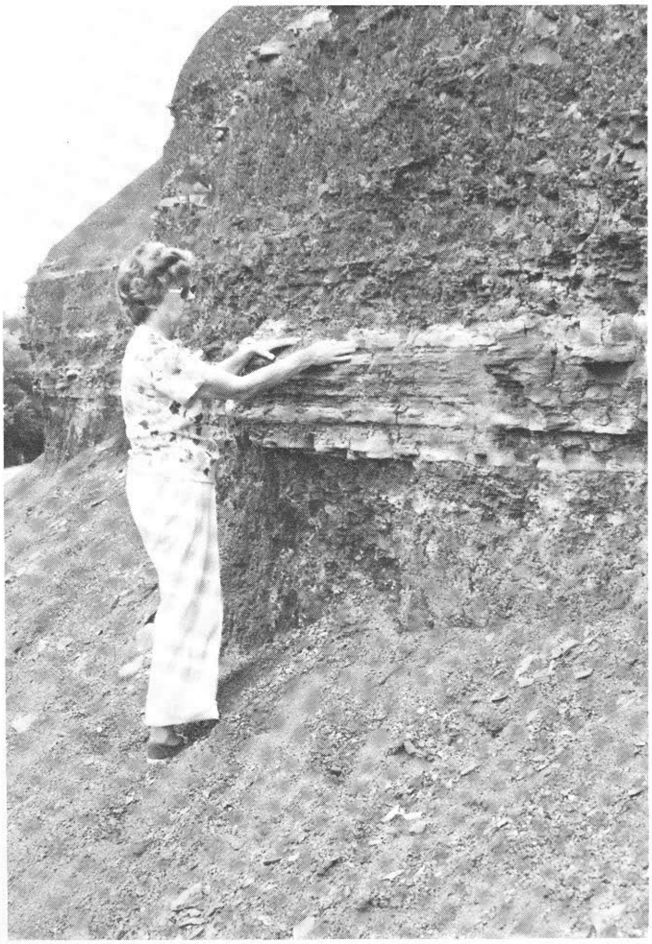
Basin

STUYVESANT FALLS—*Early Ordovician*
—**Shales:** pale green-gray, dolomitic, with interbedded thin dolostones (tan weathering) and gray **quartzites** with bedded **chert;** rare black shale seams.
—Fossils very rare: graptolites in some shales, trace fossils on some quartzite beds.

INTRACONTINENTAL ASSEMBLAGE (Figures 3c, 3d, 4; Plate 1)—For the Middle Ordovician, seventeen carbonate shelf facies [Trenton A (Larrabee), B (Balmville), C (Sugar River), D (Dolgeville), E (Cumberland Head); Watertown; Lowville A (House Creek), B, C; Valcour A (Hero), B (Beech); Crown Point; Day Point A (Fleury), B (Ste. Thérese)] and seven pelitic slope and basin facies [Quassaic; Utica; Frankfort (Snake Hill); Austin Glen A, B; Mount Merino, Indian River] are represented in the Hudson Valley and three

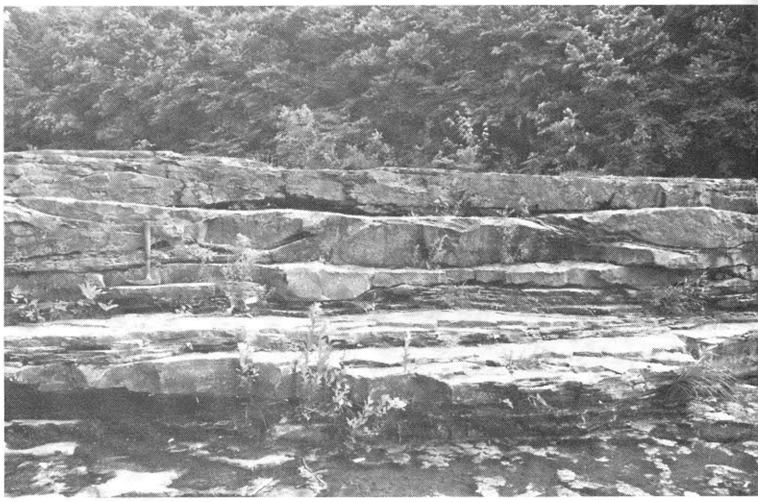
Figure 28. *Salmon River Falls. Salmon River flowing over caprock of Oswego Sandstone with face of falls composed of Pulaski siltstone and shale; near Altmar, Oswego County, N.Y.*

Figure 27. *Queenston Facies. Maroon to red shale with interbedded calcareous buff siltstone; east side of Niagara Gorge at Lewiston, Niagara County, N.Y.*



[Utica, Frankfort (Snake Hill), Schenectady] in the Mohawk, and one [Utica] in the Champlain Valley. For the Late Ordovician, five facies [Queenston, Oswego, Pulaski, Frankfort, Utica] of the litharenite-pelite suite are represented in the Tug Hill Plateau (between the Black River Valley and Lake Ontario) and adjacent regions and the Lake Ontario Plain; the nonmarine Queenston redbed facies is particularly widespread.

Figure 29. *Oswego Facies. Sandstone; caprock of Salmon River Falls, near Altmar, Oswego County, N.Y.*



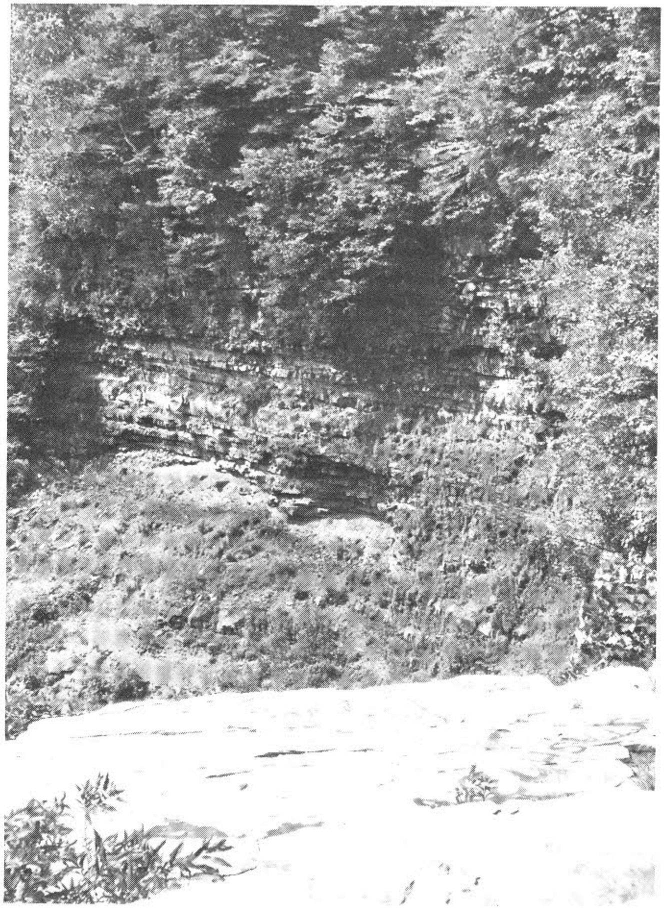


Figure 30. *Pulaski Facies. Alternating siltstone and shale; below Salmon River Falls, near Altmar, Oswego County, N.Y.*

Terrestrial (nonmarine)

QUEENSTON—*Late Ordovician (Richmondian-Gamachian)*

—**Shales:** red (locally bright green), crumbly, with red-pink **siltstones** and fine **sandstones** eastward into central New York. Locally has dessication cracks.

—No fossils known.

OSWEGO—*Late Ordovician (Maysvillian-Richmondian)*

—**Sandstones:** greenish-gray (weathering tan), thin-thick bedded, fine-medium textured, with interbedded seams of red-green-gray shales. Crossbedded. Channel and fill structures.

—Few trace fossils.

Proximal Shelf—marine terrigenous facies

PULASKI—*Late Ordovician (Maysvillian)*

—**Siltstones** and **sandstones:** tan-gray (weathering

Figure 31. *Frankfort Facies. Interbedded siltstone and silty shale; along southwest side of I-90 near Schenectady West exit, Schenectady County, N.Y.*

Figure 32. *Frankfort Facies. Closeup of above.*

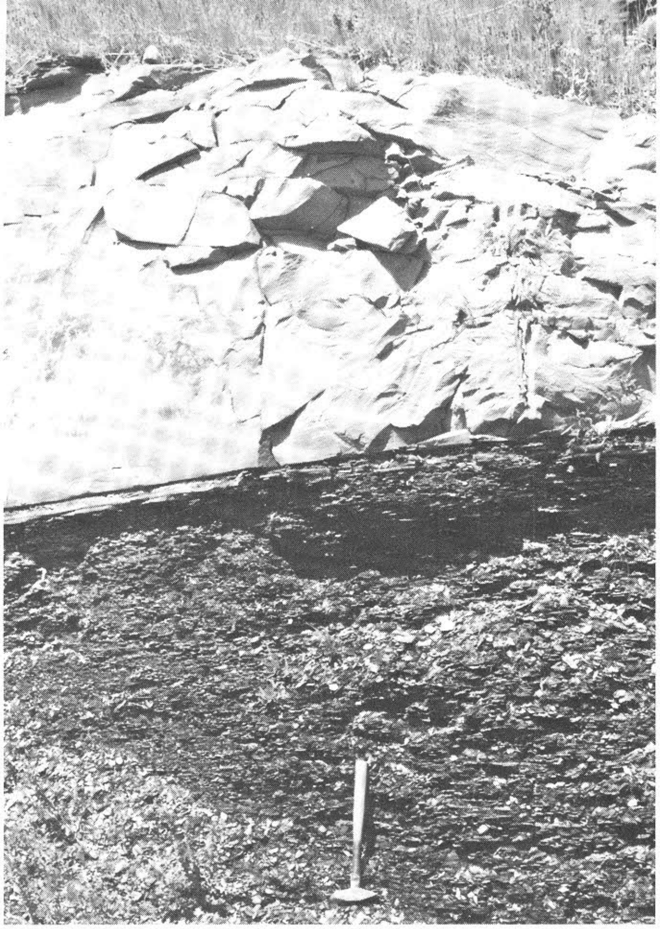


Figure 33. *Schenectady Facies. Massive tan-gray sandstone with shale intervals; Schenectady County, N.Y.*

tan-brown), thin-medium bedded, fine-medium textured, alternating with intervals of gray silty **shales.**

—Abundant benthonic fauna: pelecypods, brachiopods, bryozoans, fewer trilobites, gastropods, crinoid columnals, cephalopods, ostracodes; some coquinites of fossils.

QUASSAIC—*Medial Ordovician*

—**Quartzites** and **quartzitic sandstones:** pink-green, medium-very thick bedded; local conglomerates have quartz and red clay matrix with clasts of red and pale green shale, dark green shale, laminated fine-textured limestone, red, green, black chert, and gray-tan graywacke. Local ripple marks and crossbedding in quartzites. This is a molasse facies.

—Fossils scarce: brachiopods, bryozoans, crinoid columnals.

Figure 34. *Quassaic Facies. Massive pink and green quartzite; west side of Penn-Central R.R. cut, south of Esopus, Ulster County, N.Y.*

Distal Shelf to Proximal Slope

SCHENECTADY—*Late Ordovician*

—**Siltstones, sandstones,** and **subgraywackes:** light gray-bluish dark gray, thin-thick bedded, (all weather yellowish-tan) alternating with silty dark gray (weather medium gray) **shales.** Channel and fill structures.

—Fossils rare: graptolites in shales; eurypterids, seaweeds, trace fossils, brachiopods, trilobites, ostracodes, and cephalopods in siltstones and sandstones.

Slope

FRANKFORT (SNAKE HILL)—*Medial Ordovician to Late Ordovician*

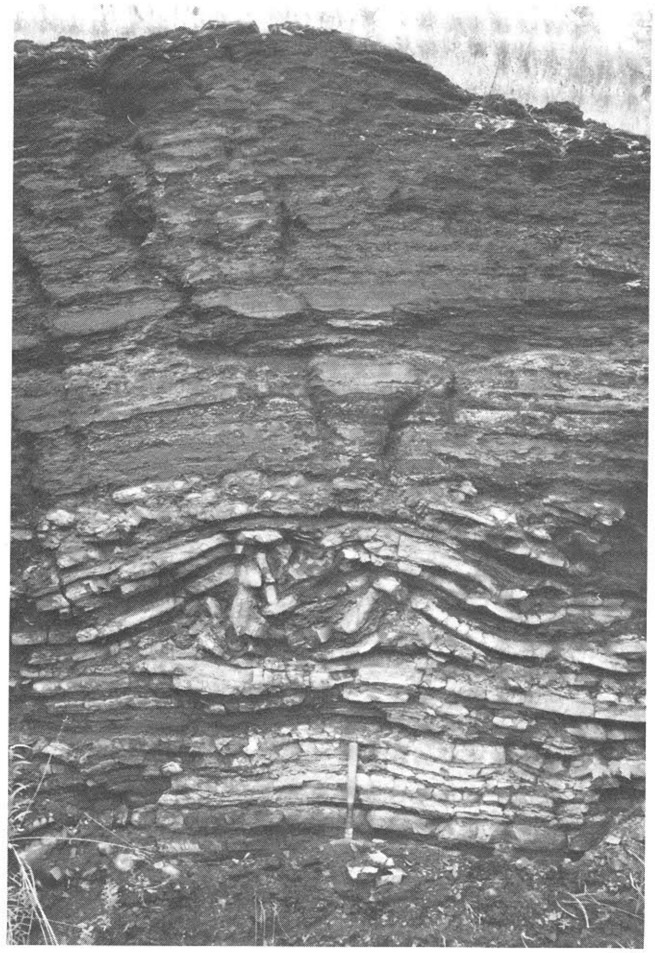
—**Shales:** medium-dark gray, silty, micaceous, with intervals of thin-thick bedded gray (weathering tan), laminated, **siltstones** and fine-medium textured **sandstones.** Locally has flysch deposits.

—Fossils rare: shales have few small graptolites; siltstones and sandstones have brachiopods, pelecypods, bryozoans, ostracodes, crinoid debris.

Figure 35. *Quassaic Facies. Closeup of conglomeratic red subfacies with clasts of red shale and red chert in a quartz sand matrix; west side of Penn-Central R.R. cut, south of Esopus, Ulster County, N.Y.*

Figure 36. *Utica Facies. Black shale; north side of N.Y. 5, west of Tribes Hill, Montgomery County, N.Y.*

Figure 37. *Utica Facies on Dolgeville Facies. Black shale conformably on alternating thin bedded, fine textured limestone and gray-black shale; north side of I-90, west of Little Falls exit, Herkimer County, N.Y.*



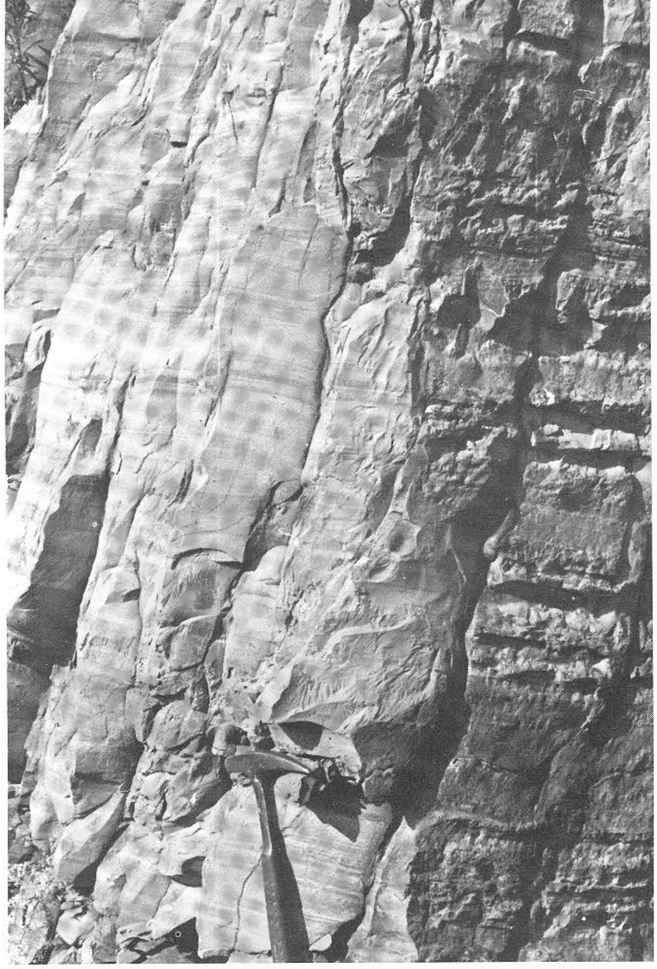


Figure 38. *Trenton E (Cumberland Head) Facies. Laminated gray, buff-weathering, argillite; along I-87, north of Plattsburgh, Clinton County, N.Y.*

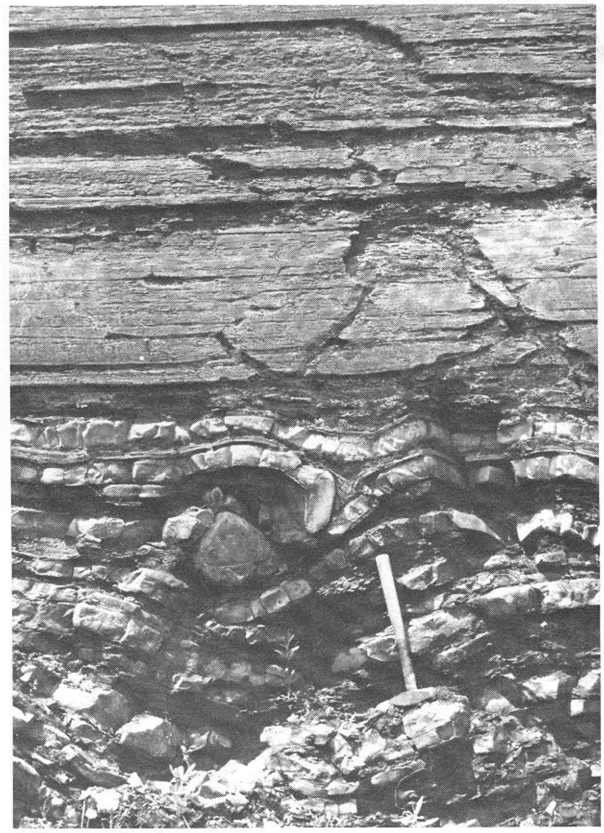


Figure 39. *Trenton D (Dolgeville) Facies. Interbedded thin bedded limestone and gray-black shale; north side of I-90, west of Little Falls exit, Herkimer County, N.Y.*

Distal Slope and Basin

UTICA—*Medial to Late Ordovician (Canajoharian, Nowadagan)*

- —**Shales:** dark gray-black (weather gray to dark brown), platy, finely laminated, locally calcareous.
- —Fossils common: pelagic-epipelagic fauna of graptolites, with fewer trilobites, lingulid and orbiculoid brachiopods, orthoconic cephalopods, algae.

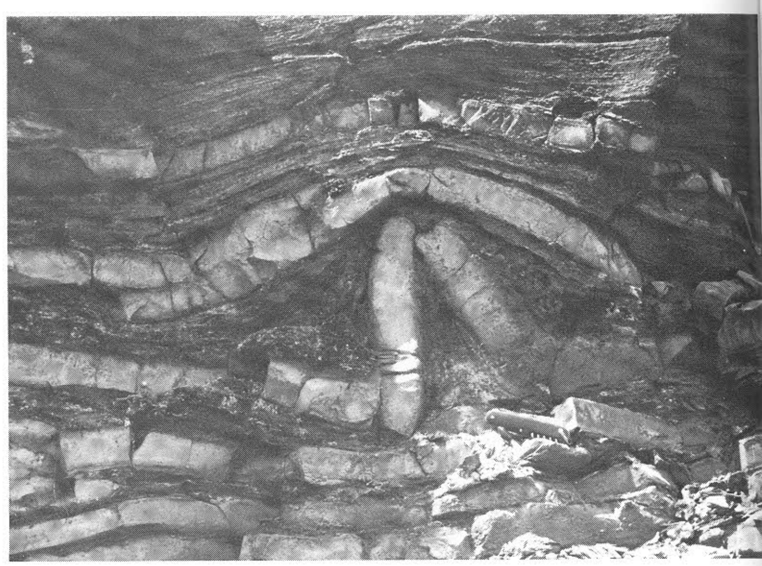
Slope

TRENTON E (CUMBERLAND HEAD)—*Medial Ordovician (Barneveldian)*

- —**Argillites:** medium gray (tan-gray weathering), fine textured, laminated, calcareous.
- —Diminutive sparse fauna: graptolites, trilobites, brachiopods, cephalopods.

TRENTON D (DOLGEVILLE)—*Medial Ordovician (Barneveldian)*

Figure 40. *Trenton D (Dolgeville) Facies. Closeup of above.*



—**Limestones:** dark gray (light gray weathering), fine textured, very uniformly bedded (2″–5″), alternating with uniform intervals of dark gray calcareous **shale.**

—Diminutive sparse fauna: graptolites, trilobites, brachiopods, cephalopods.

Distal Shelf

TRENTON C (SUGAR RIVER)—*Medial Ordovician (Barneveldian)*

—**Limestones:** light-dark gray, (locally blue), thin bedded, fine-medium textured; **argillaceous limestones** alternating with gray calcareous **shale** seams. Pararipple-marks and rare coquinite beds.

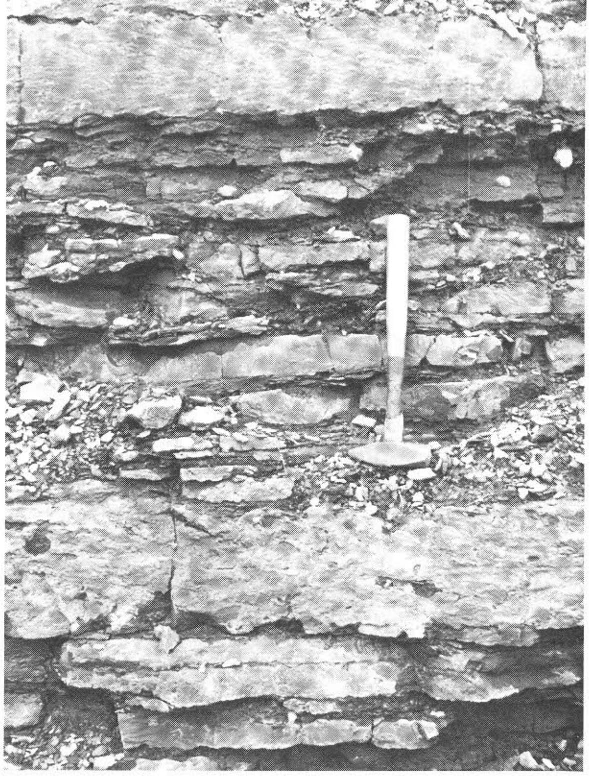
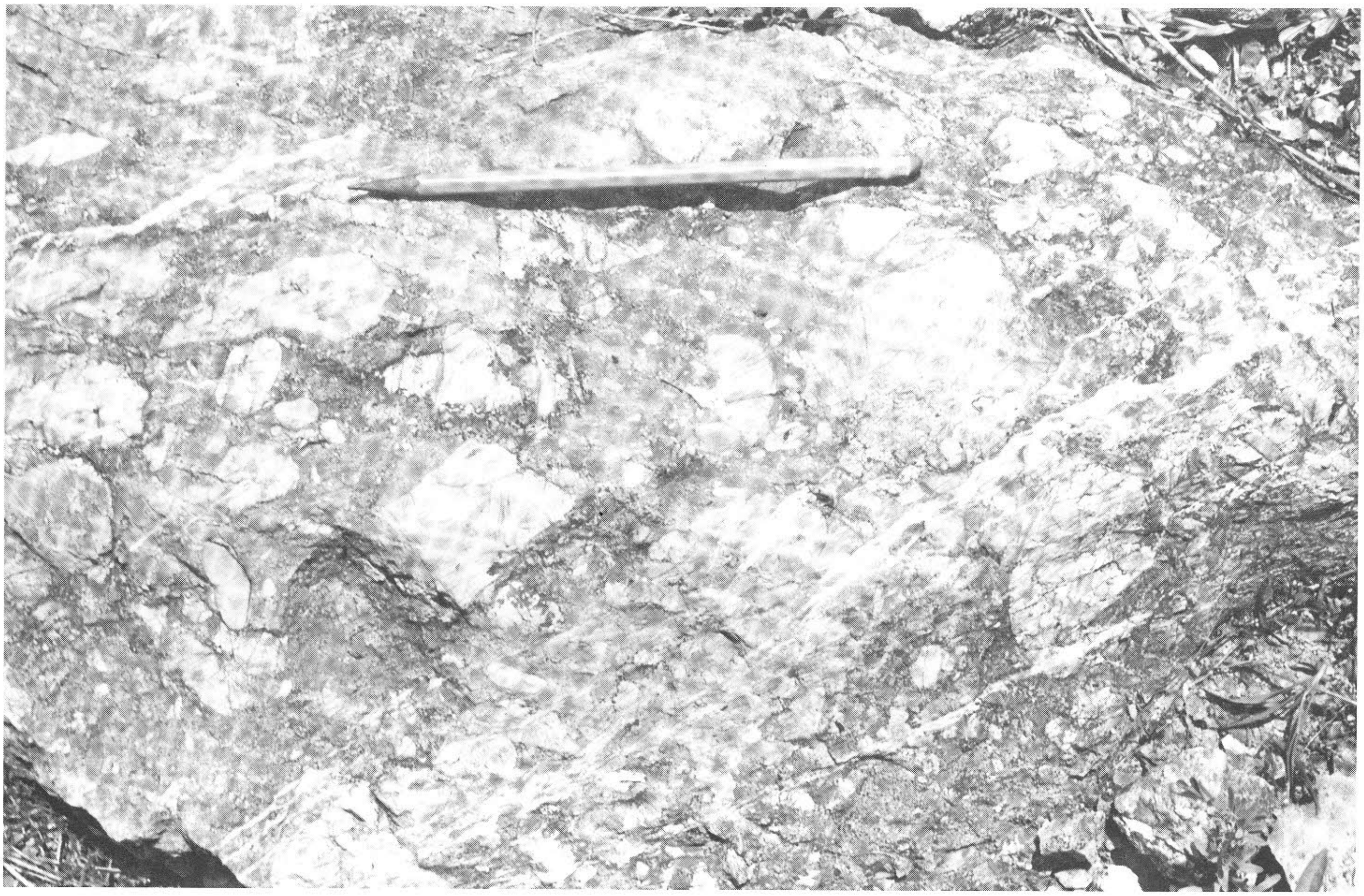


Figure 41. *Trenton C (Sugar River) Facies. Interbedded fine textured limestone and calcareous shale; Napanee Limestone, northwest exit road, interchange of N.Y. 3 and I-81, Watertown, Jefferson County, N.Y.*

Figure 42. *Trenton B (Balmville) Facies. Limestone conglomerate; intersection of N.Y. 52 and N.Y. 82, Brinckerhoff, Dutchess County, N.Y.*



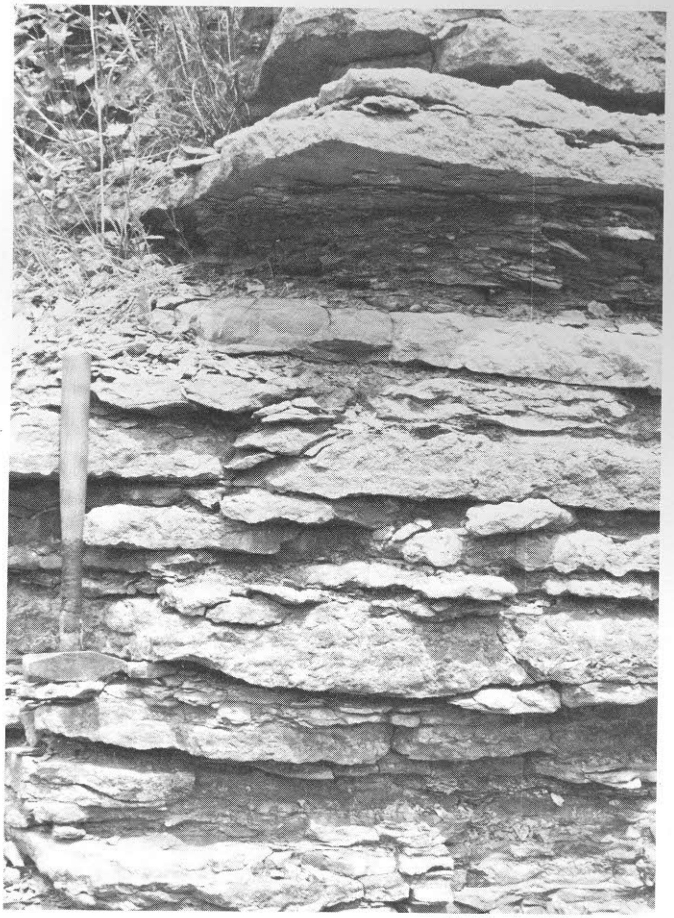


Figure 43. *Trenton A (Larrabee) Facies. Thin to medium bedded, light gray, coarse textured limestone; northwest exit road, interchange of N.Y. 3 and I-81, Watertown, Jefferson County, N.Y.*

—Exceedingly fossiliferous: sometimes bedding planes are covered with flat brachiopods; other fossils are bryozoans, ostracodes, crinoids, gastropods, trilobites, with lesser cephalopods, conularids, algae.

Proximal Shelf

TRENTON B (BALMVILLE)—*Medial Ordovician*

—**Conglomerates, limestones:** light-medium gray, cobble to coarse textured; grading upward into fine textured argillaceous limestone with interbedded pelites.

—Fossils common: fragmentary brachiopods, bryozoans, crinoid debris, algae.

TRENTON A (LARRABEE)—*Medial Ordovician (Barneveldian)*

—**Limestones:** light gray (weathers medium gray), thin-thick bedded, medium-coarse textured, locally conglomeratic and faintly crossbedded.

—Fossiliferous: highly fossil fragmental with echinoderm debris and thick-shelled robust brachiopods and bryozoans predominant subordinate horn corals, relatively large gastropods, and trilobite fragments.

AMSTERDAM—*Medial Ordovician (Turinian)*

—**Limestones:** medium-dark gray (light-medium gray weathering), irregularly lumpy bedding, fine textured.

—Fossils abundant and varied: low- and high-spired gastropods, flat and robust brachiopods, bryozoans, horn corals, ostracodes, trilobites, orthoconic cephalopods, favositid corals, echinoderm debris.

WATERTOWN—*Medial Ordovician (Turinian)*

—**Limestones:** dark gray (light gray weathering), massive, thick bedded, fine-medium textured; locally cherty.

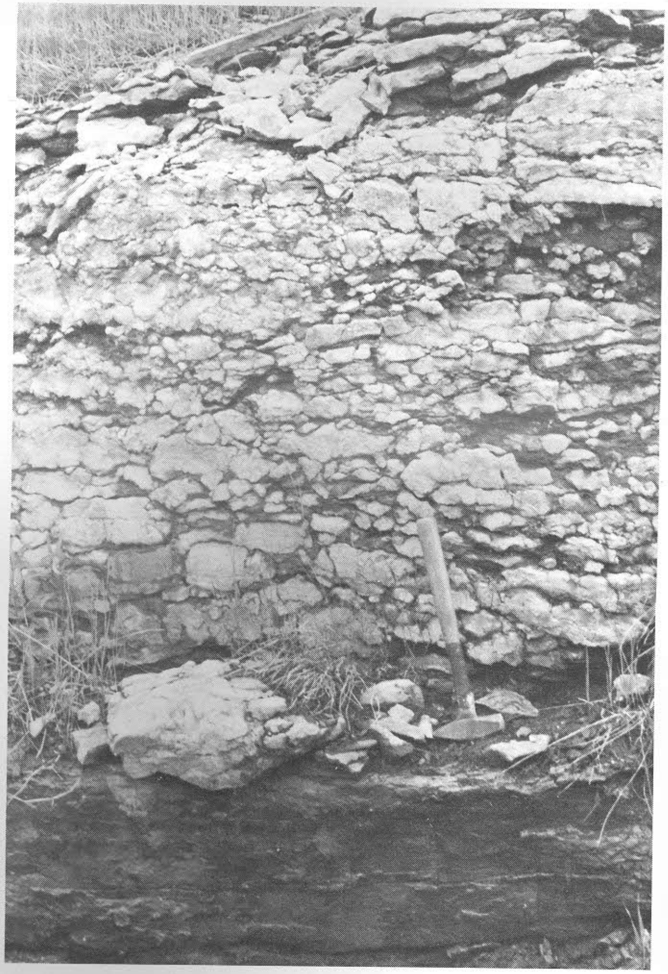


Figure 44. *Amsterdam Facies. Irregularly bedded, conglomeratic, fine to medium textured, dark gray limestone; disconformably on Lower Ordovician Tribes Hill Formation, south of I-90, west of Fultonville, Montgomery County, N.Y.*

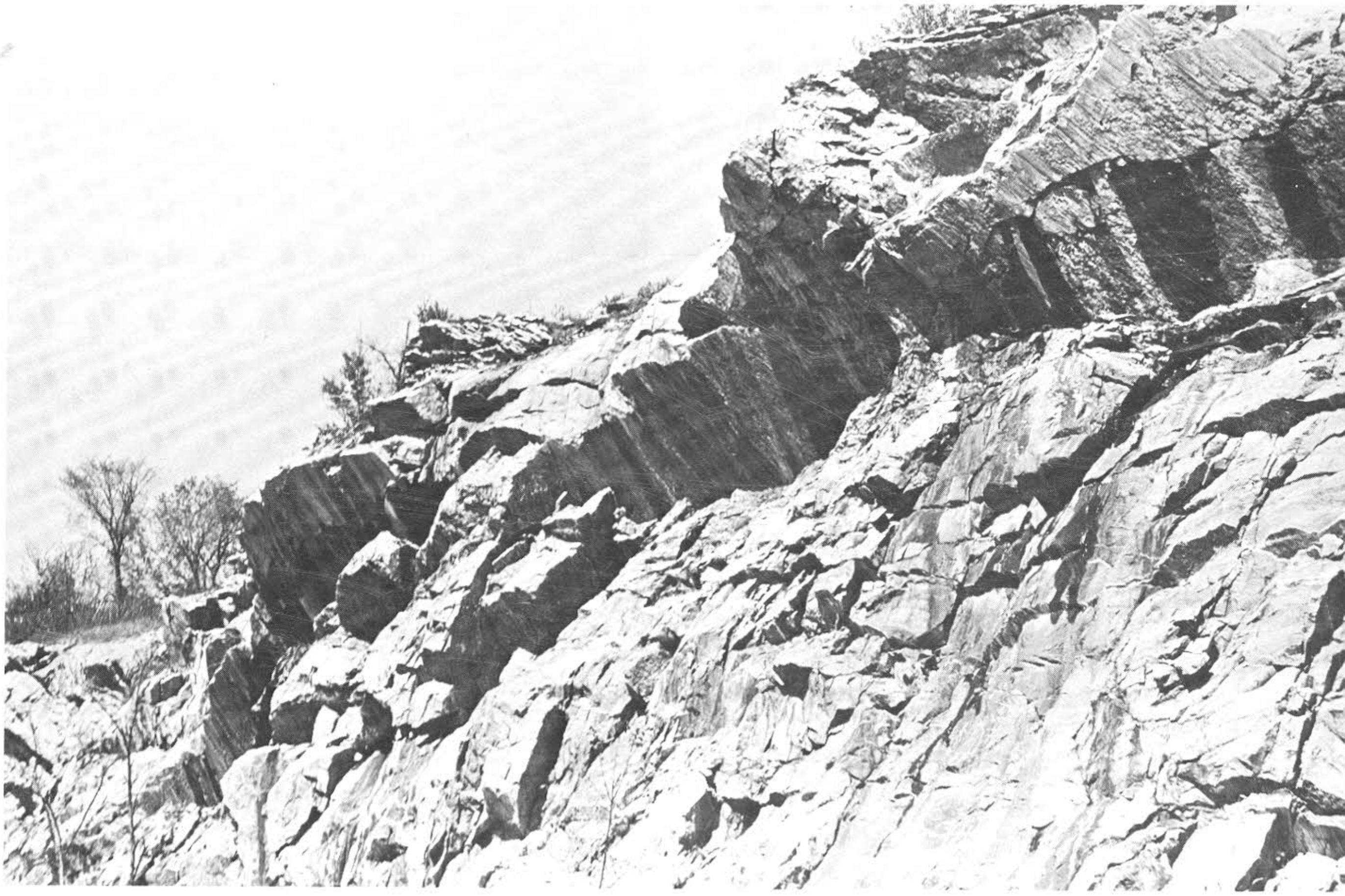


Figure 45. *Orwell Facies. Massive bedded compact, fine textured, dark gray to black limestone; slickensided bedding surfaces, abandoned quarry, east of Smiths Basin, Washington County, N.Y.*

—Fossils common and varied: large actinoceroid and endoceroid cephalopods, gastropods, favositid corals, horn corals, brachiopods, bryozoans.

LOWVILLE A (HOUSE CREEK)—*Medial Ordovician (Turinian)*

—**Limestones:** medium gray (light-medium gray weathering), massive, thick bedded (locally slightly crossbedded), medium-coarse textured. Locally reefoid.

—Fossils abundant: the coral *Tetradium* is most abundant; favositid corals, horn corals, bryozoans, gastropods, brachiopods, echinoderm debris, ostracodes, trilobites, orthoconic cephalopods.

Shelf-intertidal

LOWVILLE B—*Medial Ordovician (Turinian)*

—**Limestones:** dove tan-medium, dark gray (white-very light gray, light bluish-gray weath-

Figure 46. *Lowville A (House Creek) Facies. Medium to coarse t-tured, light gray, medium to thick bedded, limestone; along I-8 north of Watertown, Jefferson County, N.Y.*

ering), thin bedded, fine textured. Dessication cracks abundant.

—Fossil fragments rare: ostracodes, trilobites, gastropods, "birdseyes."

LOWVILLE C—*Medial Ordovician (Turinian)*

—**Limestones:** dove tan-light gray (white-very light gray weathering), thin-medium bedded, fine textured. Dessication cracks common.

—*Phytopsis;* worm borings profuse; practically no other fossil fragments except ostracodes.

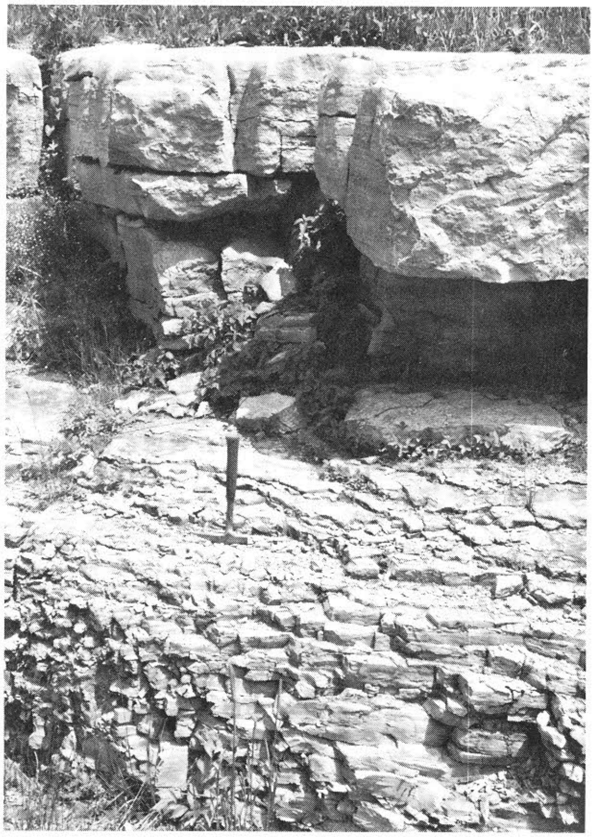


Figure 47. *Lowville A (House Creek) Facies on Lowville B Facies. Lowville B Facies is fine textured, dove tan colored, dessication marked, limestone; along I-81, north of Watertown, Jefferson County, N.Y.*

Shelf—largely supratidal and high intertidal

PAMELIA A—*Medial Ordovician (Turinian)*

—**Arkoses:** pink and green, thin-medium bedded, medium-coarse textured, quartzitic, locally conglomeratic; with feldspathic green **shale,** and green **dolostone** beds which fracture conchoidally. Dessication cracks.

—No fossils observed.

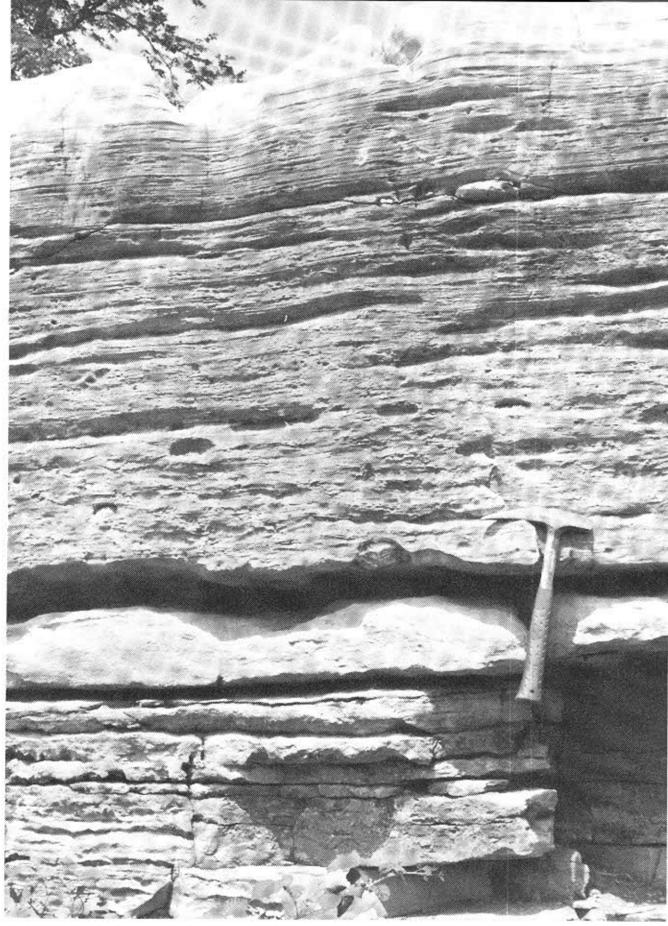


Figure 48. *Pamelia B Facies. Greenish-gray dolostone, with cavities of evaporite minerals, interbedded with greenish-gray dolomitic shale; along I-81 south of Perch Lake, Jefferson County, N.Y.*

Figure 49. *Pamelia C Facies. Very light gray weathering, massive, fine textured, dark gray to black, limestone resting on Pamelia B Facies; along I-81, south of Perch Lake, Jefferson County, N.Y.*

PAMELIA B—*Medial Ordovician (Turinian)*

—**Dolostones:** light greenish-gray (buff weathering), thin-thick bedded, fine-medium textured, laminated, conchoidally fracturing, with buff crumbly green-gray **shale.** Solution cavities with selenite, dolomite, and calcite common—as are dessication cracks.

—No fossils observed.

PAMELIA C—*Medial Ordovician (Turinian)*

—**Limestones:** medium-dark gray (light gray weathering), medium-thick bedded, finely laminated, fine textured, conchoidally fracturing.

—Fossils exceedingly rare: few ostracodes and gastropods.

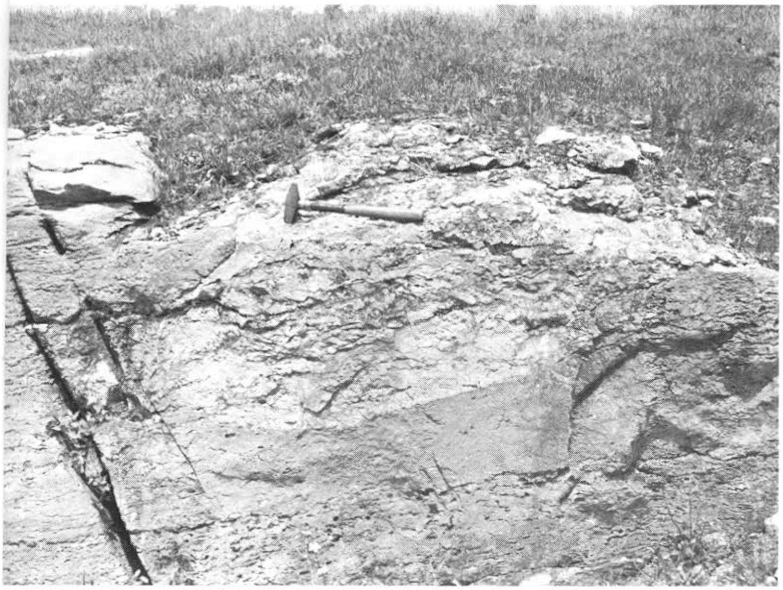


Figure 50. *Valcour A (Hero) Facies. Unbedded, fine textured, reef limestone and massive, coarse textured, off-reef limestone; Kings Bay, south of Rouses Point, Clinton County, N.Y.*

Proximal Shelf

VALCOUR A (HERO)—*Early Medial Ordovician (Montyan)*

—**Limestones:** intermixture of light-medium gray (medium-dark gray weathering), medium-coarse textured, quartz free, fossil fragmental limestone and light gray (very light gray weathering) unbedded reef rock.

—Very fossiliferous: calcarenites have much echinoderm debris, robust brachiopods, and gastropods; reef rock composed of stromatoporoids, bryozoans, sponges, algae, and a few

Figure 51. *Valcour A (Hero) Facies. Nested nautiloid cephalopods in reef flank limestone; Kings Bay, south of Rouses Point, Clinton County, N.Y.*

Figure 52. *Valcour A (Hero) Facies.* Stromatoporoid-*bearing reef limestone; Kings Bay, south of Rouses Point, Clinton County, N.Y.*

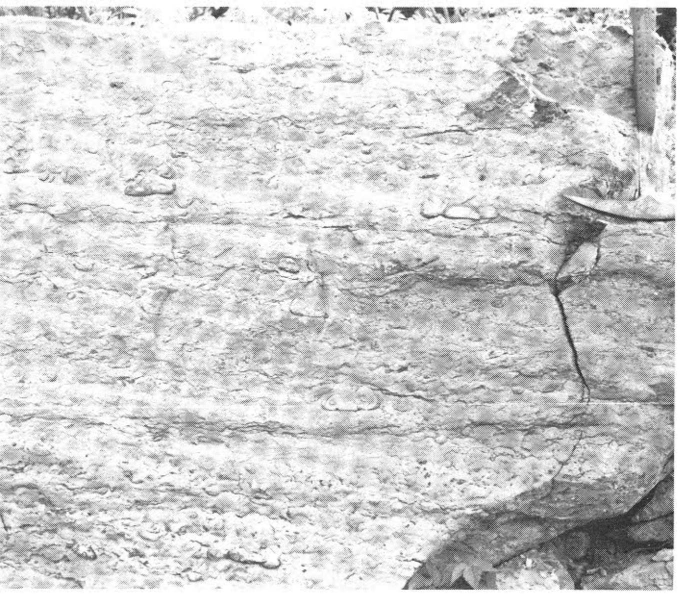


Figure 53. *Crown Point Facies. Massive, dark gray, fine textured limestone; along I-87, west-southwest of Chazy, Clinton County, N.Y.*

corals. Large orthoconic and cyrtoconic cephalopods nested along reef rock and flanking reef deposits.

Distal Shelf

VALCOUR B (BEECH)—*Early Medial Ordovician (Montyan)*

—**Limestones:** argillaceous, bluish-gray-dark gray (gray weathering), thin bedded, fine textured, with intercalated calcareous **shale;** few green-gray dolostone beds.

—Fossils common: principally brachiopods, zone of *Rostricellula plena.*

Proximal Shelf

CROWN POINT—*Early Medial Ordovician (Montyan)*

—**Limestones:** medium-dark gray (very light gray weathering), fine-medium textured, massive, medium-thick bedded, tendency to irregular bedding.

—Fossils abundant and varied: largely a molluscan and trilobite fauna dominated by profusion of the large discoidal gastropod, *Maclurites magnus.*

Figure 54. *Crown Point Facies. Bedding plane exhibiting the large gastropod,* Maclurites magnus, *along I-87, west-southwest of Chazy, Clinton County, N.Y.*

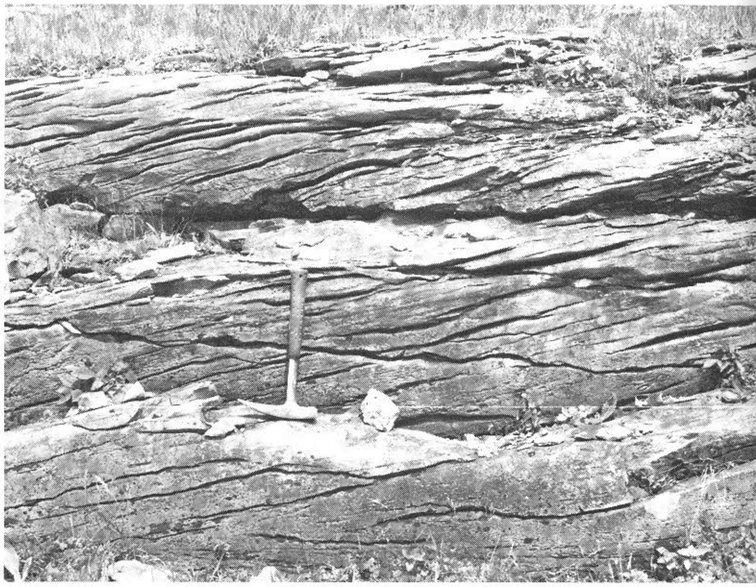
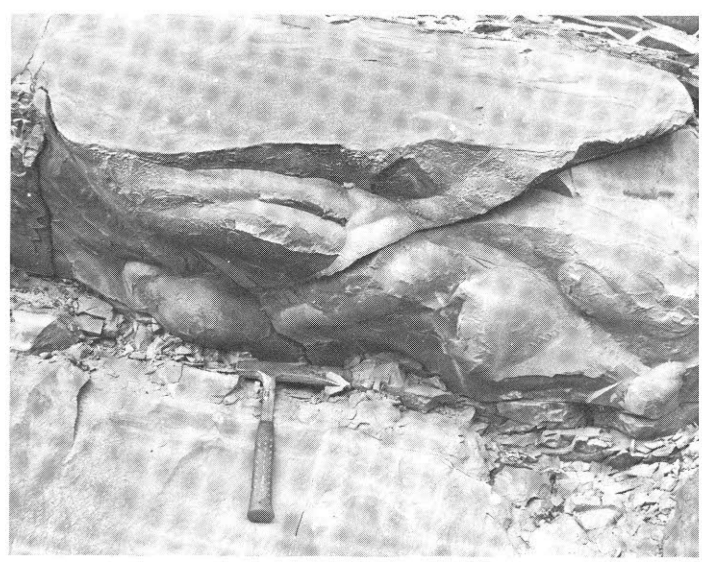


Figure 55. *Day Point A (Fleury) Facies. Coarse textured, cross-bedded, limestone; south of Chazy, Clinton County, N.Y.*

Figure 56. *Austin Glen A and B Facies. Austin Glen A Facies is thin bedded siltstone and subgraywacke with interbedded gray silty shale (on right) overlain conformably by Austin Glen A Facies—a very massive coarse graywacke; along N.Y. 55, west approach to Mid-Hudson Bridge, Ulster County, N.Y.*

Figure 57. *Austin Glen A Facies. Thin bedded siltstone and subgraywacke with interbedded gray shale (strongly cleaved); Thorn's Road, Highland, Ulster County, N.Y.*

Figure 58. *Austin Glen B Facies. Flow rolls on underside of graywacke bed. Old U.S. 44, at west end of Mid-Hudson Bridge, Ulster County, N.Y.*



DAY POINT A (FLEURY)—*Early Medial Ordovician (Montyan)*

—**Limestones:** light gray-pink (medium gray weathering), coarse textured, medium-thick bedded commonly with steep crossbedding, fossil fragmental; interspersed are beds of quartzose calcarenite and some greenish-gray siltstone. There are local small patch reefs of unbedded fine textured limestone.

—Fossils common: echinoderm debris is dominant with robust brachiopods and gastropods in the calcarenites; stromatoporoids and algae in the calcilutitic reefs.

DAY POINT B (STE. THÉRESÈ)—*Early Medial Ordovician (Montyan)*

—**Siltstones:** medium-dark (greenish) gray (dark brown-gray weathering), thin-medium bedded, fine-medium textured dolomitic; sandy at base. Cross-laminated, ripplemarks.

—Fossils rare: trace fossils, lingulid brachiopods.

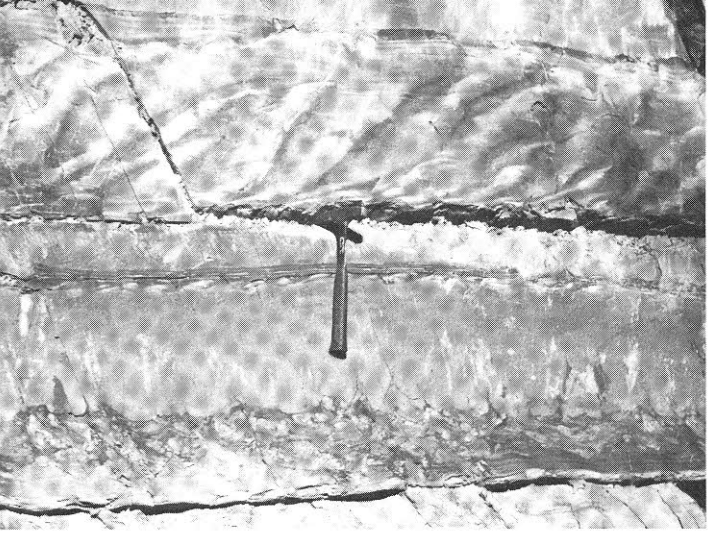


Figure 59. *Austin Glen B Facies. Climbing ripple marks, graywacke bed. North side St. Andrew's Road, Hyde Park, Dutchess County, N.Y.*

Slope

AUSTIN GLEN A—*Early Medial Ordovician (Normanskillian)*

—**Graywacke, subgraywacke, calcareous siltstones,** all alternating with silty, micaceous, gray **shales:** strata (except shales) are thin-medium bedded, tan-bluish gray, medium-coarse textured; few turbidites in graywackes.

—Fossils rare: graptolites in gray shales and rarely in the thin graywackes. No benthonic fauna.

AUSTIN GLEN B—*Early Medial Ordovician (Normanskillian)*

—**Graywackes, graywacke conglomerates:** tan-bluish gray (tan-light brown weathering), coarse textured, few intercalated gray shales, medium-thick bedded; turbidites profuse.

—Fossils very rare: few graptolites, mostly in the shales.

Figure 60. *Mount Merino Facies. Interbedded black mudstone and shale with bedded black chert; N.Y. 40 near Hartford, Washington County, N.Y.*

Basin

MOUNT MERINO—*Early Medial Ordovician (Normanskillian)*

—**Mudstones, shales,** or **slates:** dark gray-black, with bedded black-dark green **chert.**

—Fossils rare: graptolites in pelites and radiolarians in chert. No benthonic fauna.

INDIAN RIVER—*Early Medial Ordovician (Normanskillian)*

—**Mudstones, shales,** or **slates:** red-pale green, with bedded red-light green **chert;** rare greenish-gray, fine textured limestone near top.

—Fossils very rare: graptolites in pelites and radiolarians in chert. No benthonic fauna.

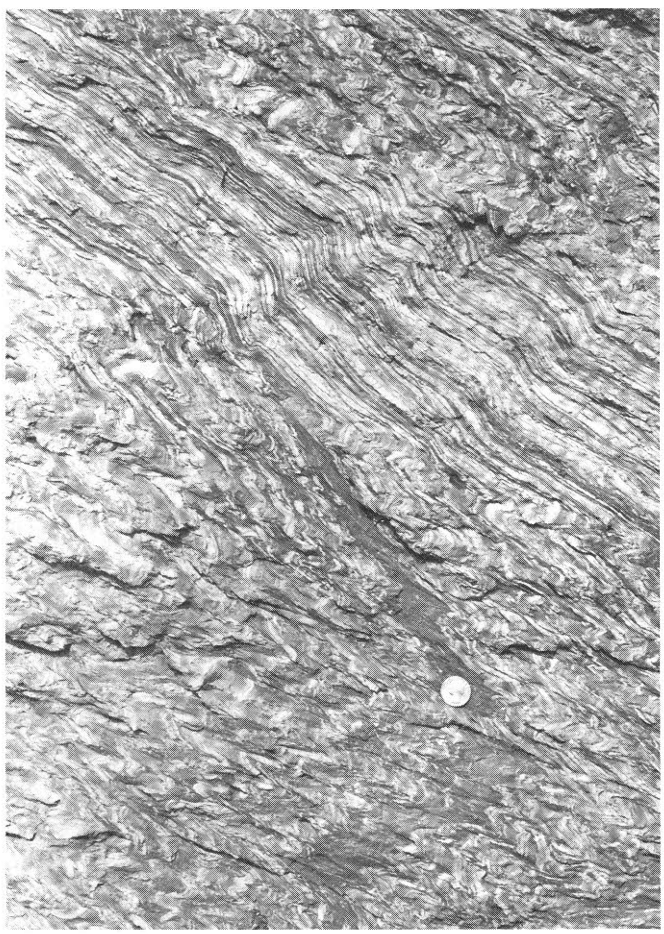


Figure 61. *Indian River Facies. Interbedded red and green shale with bedded red and green chert; Brown Road, east of Pleasant Valley, Dutchess County, N.Y.*

Hadrynian

(See Plates 1, 2, and 3)

HISTORY AND PREVIOUS WORK

In New York State, above the intensely deformed Middle Proterozoic (Helikian) rocks and, also, beneath the oldest known fossil-bearing strata of the Taconic region, there are unmetamorphosed rock units which have been variously termed Pre-Cambrian or ? Cambrian because they lack diagnostic fossils and radiometric dates. Thus, correlation and age are uncertain as is the duration of time represented by these questionably aged strata. The matter is further compounded by the lack of an internationally acceptable boundary for the base of the Cambrian.

Usually, the base of the Cambrian is selected as either: (1) the contact of unmetamorphosed Cambrian rock on metamorphosed or truncated rock, or (2) the lowermost level of recorded trilobites in a comformable sequence of unmetamorphosed strata. Certainly neither position can positively identify the same time plane to within even the same tens of millions of years! Thus, it is obvious that different philosophies for the subdivisions of geologic time are implicitly necessary—Phanerozoic divisions based on faunal evolution, and Cryptozoic divisions based on selected dates and/or tectonic events (Figure 1).

Locally, meters or kilometers of unmetamorphosed strata lie beneath the lowest trilobite horizon as, for example, in the Chilhowee (Southern Appalachians), Beltian (Montana), Bukoban (East Africa), and Sinian (China) Systems. One is never certain whether these divisions without diagnostic fossils should be regarded as having been deposited in Early Cambrian time or Late Proterozoic time. In most instances these and other rocks of disputed age are assigned to a separate time interval which sports various names throughout the world, *i.e.*, Adelaidean (Australia), Eocambrian (Norway; Europe, in part; United States, in part), Infracambrian (Morocco), Torridonian (British Isles), Varangian (Norway), Vendian (U.S.S.R.), etc. Because the Paleozoic-Proterozoic boundary has a different meaning for geologists working in different regions, the boundary problem remains unresolved pending action on the establishment of the base of the Cambrian by an international commission. It would seem prudent that this level be selected in an area where a thick conformable sequence is accessible, relatively free of structural complications, and hopefully diagnostically fossiliferous—as for example, the Lena River Valley of Siberia.

In an effort to remove much of the confusion regarding usage of terminology in the Pre-Cambrian of North America, C. H. Stockwell (1964) proposed names for divisions of the Proterozoic Eon (Figure 1). These were based on mean dates of orogenic episodes which were derived from the wealth of radiometric data from described rock units of the Canadian Shield. How did Stockwell's proposal affect the interpretation of New York's geologic history? First, it suggested that orogenies older than the Grenvillian had affected New York State. Stockwell suggested that the bulk of metasedimentary rocks of the Adirondacks were Aphebian in age (Figure 1) because of intercalated crystalline limestones (marbles) and metaquartzites—lithologies unknown in the older Archaean Era; obviously, this does not preclude a post-Aphebian age! Secondly, Stockwell suggested that Adirondack rocks were folded during the Hudsonian Orogeny and later intruded by Paleohelikian anorthosites and gabbros during the Elsonian Orogeny; the anorthosite of Labrador was indirectly dated and Stockwell assumed that all eastern North American anorthosites were of the same age. Subsequently, granitic intrusions, folding, and metamorphism (1020-1100 m.y., Pb-U, zircon) took place during the Grenvillian Orogeny; unmetamorphosed pegmatites (930 m.y., muscovite) in the eastern Adirondacks are considered a closing phase of the Grenvillian in the Adirondacks (Fisher, Isachsen, and Rickard, 1970). Late Proterozoic (Hadrynian) basic dikes (as yet undated radiometrically) penetrated the existing metamorphic rocks. Stockwell later (1973) revised his time scale for the Cambrian Shield. His revision mandates that the radiometric dates obtained on Adirondack gneisses and anorthosites are due to the Grenvillian Orogeny. However, Adirondack metasedimentary rocks are not fixed as to their time of origin.

Whatever the sequence of Grenvillian and pre-Grenvillian rocks, there are some younger unmetamorphosed rocks that seem to fall in the succeeding 300-million-year Hadrynian interval. Rupture of a continental plate during the Late Hadrynian created a widespread system of rifts—some of which were filled with subaerial terrigenous sediments whereas others were filled with submarine terrigenous sediments and volcanics. Three general areas of New York possess outcroppings of presumed Hadrynian rocks: (1) the Adirondack Lowlands in northwestern New York—arkoses, hematitic sandstones, conglomerates, reported as "granite wash" in some deep boreholes in the Allegheny Plateau area; (2) the Taconic Region in eastern New York—graywackes, micaceous pelites and siltstones beneath bonafide Lower Cambrian trilobite-bearing rocks; (3) the Manhattan Prong in southeastern New York—the Yonkers Gneiss dated radiometrically as 575±10 m.y. (Long, 1969) a date that straddles the Hadrynian-Paleozoic boundary—as customarily accepted (570 m.y.)

For a discussion of rocks here regarded as Hadrynian, see: Balk (1953), Bird (1962), Dale (1892, 1904), Fisher (1956), Hall (1968), Kirchgasser and Theokritoff (1971), Krynine (1948), Potter (1973), Ruedemann (1930), Wiesnet (*in* Postel *et al.*, 1959).

RECENT DEVELOPMENTS AND REMAINING PROBLEMS

In the allochthonous Taconic Sequence of eastern New York, below the lowest known trilobites (*Elliptocephala asaphoides* Zone), there is a thick sequence of unmetamorphosed graywackes, quartzites, and pelites which have failed to yield organic remains other than trace fossils (*Oldhamia*). This sequence includes the lower Mettawee and lower Nassau Formations, the Elizaville Argillite, the Everett Schist (thought to be a metamorphic equivalent of the Elizaville and Nassau), and the Rensselaer Graywacke.

In the parautochthonous Wappinger Group of eastern New York, the Poughquag (=Cheshire and Hardyston) quartzite level possesses the oldest known olenellid-type trilobites; I regard these quartzites as extensions of the Diamond Rock-Mudd Pond quartzite level (at the base of the Germantown Formation) in the Taconic Sequence. But the Early Cambrian trilobite fauna extends lower in the allochthonous Taconic Sequence than in the parautochthonous Wappinger Sequence, reaching down to the Stuyvesant Conglomerate level within the uppermost Nassau Formation. Elsewhere, allegedly earliest Lower Cambrian rocks yield archaeocyathids but no trilobites. In New York, this correlative interval is believed to be within the Mettawee-Nassau pelites and the green quartzite level (Zion Hill-Curtis Mountain) is regarded, arbitrarily, as the base of the Cambrian. Thus, all pre-Zion Hill and pre-Curtis Mountain strata are considered to be latest Proterozoic (Hadrynian).

In the autochthonous sequence fringing the Adirondack Mountains on the north and northeast (Clinton, Franklin, and St. Lawrence Counties) beneath sparsely fossiliferous relatively clean quartz sandstones (Keeseville division of the Potsdam), there are localized pockets of more poorly sorted hematitic, arkosic sandstones and conglomerates. These (Allens Falls, Nicholville) I presume to be fault-trough deposits of either fluvial or glacial origin. The patchy outcroppings exhibit a linear northeasterly trend and 90 percent of them occur west of the Carthage-Colton Zone of cataclasis. A widespread glaciation in Late Proterozoic time has been well documented by tillites and tilloids in Norway, Greenland, and Spitzbergen—areas which, according to the plate tectonics concept, were connected to northeastern North America during the latest Proterozoic and earliest Phanerozoic Eons. In many of the deeper boreholes in New York where the Proterozoic Basement (metamorphic rocks) is penetrated, there are a few meters of arkosic rock called "granite wash" by the drillers. I regard these as subsurface representations of nonmarine fault-trough deposits of Hadrynian age. The spotty distribution of the northern New York Hadrynian rocks probably is the result of large scale erasure by erosion and subsequent reworking into initial Paleozoic deposits which transgressed the deeply eroded metamorphic terrane following the Neohelikian Grenville Orogeny. Of course the age of these localized unmetamorphosed arenites is unfixed; I have chosen to regard them as Pre-Cambrian—as did Krynine (1948).

In the Manhattan Prong area (Figure 2), between the Lowerre Quartzite (Early Cambrian) and the Fordham Gneiss (Neohelikian) is the Yonkers granitic gneiss, which has been radiometrically dated (Rb-Sr) as 575±10 m.y. by Long (1969). The base of the Cambrian commonly is regarded as about 570 m.y. If one favors a plutonic origin for the Yonkers this would place an acid-igneous event in the Manhattan Prong area as latest Hadrynian and equated with the Avalonian Orogeny, a deformational event recognized in Newfoundland. Similarly, if one prefers a rhyolitic-tuff origin for the Yonkers, this correlates well with the tensional episode of rifting which has been advocated for the Late Proterozoic and Early Cambrian (Bird and Dewey, 1970). On the other hand, if one interprets the Yonkers as of sedimentary origin, say a meta-arkose, this would imply that a clastic deposit rich in feldspar accumulated during the Late Hadrynian—a rock type not incompatible with types of fault-trough deposition elsewhere at this time. The Poundridge Gneiss of northeastern Westchester County (Carmel and Stamford 15-minute quadrangles) is lithologically similar to the Yonkers and has also been dated as latest

Hadrynian age (596±19 m.y., Rb-Sr, Mose and Hayes, 1975).

On the west side of the Hudson River in the West Point quadrangle, and along the Ramapo Fault Zone, is the Rosetown Pluton—a basic igneous rock with a reported radiometric age of 810±8 m.y. (K-Ar, Ratcliffe and Shuart, 1970). Ratcliffe later (1971) reported an anomalous 580±20 m.y., K-Ar age from hornblende in the Rosetown diorite that includes a xenolith of Manhattan "A" phyllite. This inclusion of Middle Ordovician rock suggests that the radiometric dates for the Rosetown are unreliable and that it is a probable Cortlandt Complex equivalent of latest Ordovician age. Mose and others (1975, p. 97) have demonstrated that the Ramapo Fault Zone was the scene of multiple intrusions in Helikian time (1,141±111 m.y.) and in Late Ordovician time (444±15 m.y.).

Many unmetamorphosed basic dikes exist within the Adirondack and Hudson Highland Pre-Cambrian terranes. The Champlain Valley and Finger Lakes region lamprophyre dikes may be Late Jurassic-Early Cretaceous as has been demonstrated by radiometric dating (Zartman, and others, 1967). However, some of the basic dikes, such as the one along N.Y. 5 in the western part of the Fonda Quadrangle, are demonstrably pre-Potsdam (Keeseville). Tentatively, these dikes are classed as Hadrynian, and here interpreted to be related to the rifting and volcanism which initiated the Appalachian Geotectonic Cycle.

Cambrian

(See Plates 1, 2, and 3)

HISTORY AND PREVIOUS WORK

Although the term Cambrian System was introduced by the pioneer British geologist Adam Sedgwick in 1835, the name did not become fashionable in New York State until several decades later. The name is derived from Cambria, a Latin variant of the old Celtic name Cumbria—the ancient name for Wales. Rocks currently included within the Cambrian System, however, constitute only the original Lower Cambrian of Sedgwick; the remainder of his Cambrian included the present day Ordovician and the Lower Silurian (Llandovery) to the base of the Woolhope Limestone.

During the first years of the New York Geological Survey (1836–1843), a quartet of field geologists (William W. Mather, Ebenezer Emmons, Lardner Vanuxem, James Hall) promoted the "New York System." This category encompassed all sedimentary rocks in New York from the base of the Potsdam Sandstone through the Catskill redbeds, *i.e.*, from the early Late Cambrian through the Late Devonian. Among these early pioneers, however, was a "maverick"—Timothy A. Conrad. Although originally commissioned as geologist of the "Third District," Conrad was appointed first State Paleontologist in 1837 in order to study the masses of fossils that accumulated as a result of the field efforts of the pioneers of the State Geological Survey. Unlike his associates, Conrad was more internationally minded and he used the names, Palaeozoic, Cambrian, Silurian, and Devonian as early as 1838. Regrettably, he failed to persuade his "District Geologist" colleagues to do likewise and the "New York System" persisted in New York for many years afterward—owing to the persuasive influence of James Hall.

Hall's perennial antagonist, Ebenezer Emmons, author of the encyclopedic *Second District Report*, discovered (1844) "Primordial Fossils" in the Taconic region. Emmons believed that these fossils and their entombing rocks were older than the Potsdam Sandstone. Thus was born the "Taconic System." Hall, Dana, Lyell, and Mather vehemently opposed Emmons' views, instead claiming that the rocks in the Taconics were metamorphosed equivalents of the "New York System" further west. Thirty-five to forty years later, Emmons' ideas were vindicated by additional discoveries of "Primordial" (now recognized as Early Cambrian) fossils by Silas W. Ford and William B. Dwight. Emmons' pre-Potsdam "Taconic System" was proven undeniably. Subsequent work has demonstrated that Emmons (and his opponents!) were both right and wrong. Emmons was correct in maintaining that fossils and rocks older than the Potsdam existed in eastern New York but he was incorrect in maintaining that *all* Taconic rocks were older than the Potsdam. Some, indeed, were equivalents of younger Cambrian and Ordovician rocks elsewhere in New York.

The Taconic Problem or the Taconic Controversy, that is, the manner in which the Cambrian and Ordovician pelites of the Taconic region came to be where they are, has been dealt with at great length in previous publications. For a discussion of this matter, the reader is referred to Fisher (1961) and Zen (1961, 1967, 1972). It is now accepted that the Hadrynian through Middle Ordovician (Normanskill) litharenites and pelites reached their present locations by a westward imbricate stacking of gravity slides and thrust slices. This deformation (Taconian Orogeny) began during the early Medial Ordovician and terminated during the Late Ordovician (Richmondian).

Fortunately, there are a number of summary-type works available which deal with New York Cambrian rocks. Among these are, the now out-of-date *Correlation of the Cambrian Formations of North America* (Howell, *et al.*, 1944), *Correlation of the Cambrian rocks in New York State* (Fisher, 1962a), and *The Cambrian System of New York State* (Fisher, 1956). There is also a brief account of New York Cambrian rocks and fossils in the six-article *Cambrian of the New World* (Holland, C. H., *ed.*, 1974) by Allison R. Palmer (p. 179–182, 186–189) and Christina Lochman-Balk (p. 104–107, 141–142). The type area of the Cambrian of the British Isles is discussed in *A correlation of Cambrian rocks in the British Isles* (Cowie, Rushton, and Stubblefield, 1972) and in *Cambrian of the British Isles, Norden and Spitzbergen* (Holland, C. H., *ed.*, 1974, seven articles); those by Rushton (p. 43–114) and Martinsson (p. 185–283) are of especial significance to those working on Cambrian rocks in New York.

For discussions of Cambrian rocks in the Taconic Region, see Bird (1962), Bird and Rasetti (1968), Craddock (1957), Cushing and Ruedemann (1914), Dale (1904), Elam (1960), Fisher (1961), Goldring (1943), Prindle and Knopf (1932), Potter (1973), Ruedemann (1930, 1942), Theokritoff (1964), and Zen (1961, 1964, 1967, 1972). For discussions of Cambrian rocks in the Adirondack Border region, see Chadwick (1920), Cushing (1905, 1916), Cushing, *et al.*, (1910), Cushing and Ruedemann (1914), Fisher (1968), Fisher and Hanson (1951), Greggs and Bond (1973), Gordon (1911), Knopf (1927, 1962), Miller (1911), Otvos (1966), Rodgers (1937), and Wheeler (1942).

For discussions emphasizing Cambrian fossils, see Dwight (1886, 1887, 1890), Ford (1875, 1876, 1884), Landing (1974), Lochman (1946, 1956), Rasetti (1946, 1966, 1967), Theokritoff (1969), and Walcott (1884, 1890, 1910).

RECENT DEVELOPMENTS AND REMAINING PROBLEMS

Since the preparation of the first correlation chart of New York's Cambrian rocks (Fisher, 1962a), surely the most notable item relevant to Cambrian paleontology and stratigraphy in New York has been the discovery, within the Taconic Sequence, of bonafide Middle Cambrian fossils. Rasetti (1967) and Bird and Rasetti (1968) have described and discussed the following trilobites: *Bathyuriscus, Kootenia, Meneviella, Oryctocephalus, Pagetia, Peronopsis, Zacanthoides*, and several other diagnostic agnostids and eodiscids. Landing (1974, 1975) has recognized the following conodonts: *Acodus cf. cambricus, Distacodus cambricus, Hertzina bisulcata, H. bokoni*, and *Protoconodontus sp.* All of these fossils were found at several sites in Columbia County (Kinderhook Quadrangle) within the Germantown Formation—a slope deposit. This disclosure should stimulate search for additional Middle Cambrian fossils, especially within the presumed corresponding shelf carbonates (upper Stissing, lower Pine Plains).

Additional corroboration of ages of parts of the Germantown Formation has been supplied by: (1) the discovery of diagnostic trilobites *(Elliptocephala, Acimetopus*, and *Pagetides* faunas), conodonts *(Hertzina danica)*, and problematica of Early Cambrian age (Rasetti, 1966; Landing, 1974); (2) the discovery of Late Cambrian trilobites *(Aphelaspis* Zone) and conodonts from the upper Germantown (Bird and Rasetti, 1968; Landing, 1974, 1976); and (3) the discovery of Early Ordovician conodonts from the uppermost Germantown (Landing, 1976) in strata yielding the dendroid graptolite *Dictyonema cf. flabelliforme* (Berry, 1962).

In the Taconic region, the problem of the ages of the pre-*Elliptocephala asaphoides*-bearing rocks remains preeminent. Whether these pre-trilobite strata should be classed as Cambrian, ? Cambrian, or Hadrynian must be left unsettled until either diagnostic fossils are found or nonpaleontologic definitive methods can be employed for determining whether this interval should be termed Paleozoic or Proterozoic. Potter (1972) has mapped and described these units in the Hoosick Falls region of Rensselaer County. Similarly, the ages of basal or near basal sandstones atop the Adirondack gneisses are uncertain because of the lack of fossil control; their age assignment is, admittedly, speculative. Bruce Selleck is currently investigating the Theresa Formation and "Potsdam sandstones."

The precise position of the Little Falls Dolostone remains unsettled. Rickard (1973) favors a latest Cambrian and earliest Ordovician age—a somewhat younger assignment than I make. However, Rickard recognizes a more restricted Little Falls. My view is that shown on the chart, namely a pre-Hoyt and largely pre-Trempealeau age. This is based on the lithologic similarity to the lower cherty dolostone of the Whitehall Formation—which unit lies beneath the Warner Hill Limestone, which yields indisputable Trempealeau trilobites. Additional support is furnished by the lateral continuity of the Little Falls with the *Elvinia*-bearing Galway Formation (Franconia age) as one proceeds northward toward the Adirondack Mountains (Fisher, 1955). Many years ago, while mapping the bedrock geology of the Fonda Quadrangle, I collected (in company with R. H. Flower) an *Elvinia* free cheek, loose, at the base of a 400-foot cliff of Little Falls Dolostone, seven miles southwest of Fonda. No other fossils except lingulid brachiopods, Cryptozoon, and some nondescript gastropods found by Ulrich (1911) have been reported from the Little Falls Formation.

The definition of Beekmantown is here revised. In its original usage—for all carbonates (Cambrian and Lower Ordovician) above the basal Potsdam Sandstone—the name Beekmantown served a most useful purpose. However, over the years the meaning has been changed to be synonymous with only the Lower Ordovician carbonates throughout the Appalachians. As a consequence, occasionally (and in my opinion wrongly) Beekmantown has been used in a time sense (Beekmantownian) for the Early Ordovician series. It is impractical and, in most areas, impossible to employ the name Beekmantown for only the Ordovician portion of this relatively thick carbonate sequence. In most areas of exposure, fossils are extremely rare, undiscovered, or nondiagnostic and the Cambrian-

Ordovician contract (Trempealeau-Gasconade) is so elusive that the lower limit of a "Beekmantownian" series cannot be placed with precision. Similarly, the lithologic transition, intertonguing, and interlayering of limestone and dolostone prohibits a meaningful placement of the lower limit of a Beekmantown Group, based on a lower limit of limestone—the criterion usually utilized on the surface and almost always used in the subsurface to mark the base of the Ordovician within this thick carbonate sequence.

But Beekmantown should remain useful as a rock name. My recommendation here is that we should return to the original definition but modify the application to embrace the entire sedimentological suite of quartzarenites and carbonates beginning at the base of the Keeseville division of the Potsdam Sandstone (or its equivalents) and including all overlying rock to the base of the Chazy Group—or in its absence to the base of the Black River or Trenton Groups in New York. This would include in New York, rocks of Late Cambrian Dresbachian (perhaps older) through Early Ordovician Canadian ages.

In like fashion, the Wappinger Group of the Hudson Valley is here modified by appending the basal Poughquag Quartzite to the overlying carbonates. This combination emphasizes the sedimentologic unity of the quartzarenite and overlying carbonates. The Wappinger Group terminates upward at the base of the Balmville Limestone or—in its absence—the Walloomsac slate or schist. The Wappinger Group ranges in age from Early Cambrian (*Elliptocephala asaphoides* zone) through the Early Ordovician (Cassinian Stage).

The following unpublished bedrock mapping by me has furnished much new paleontologic, stratigraphic and structural data on Cambrian and Ordovician strata:

(1) in the Mohawk Valley (Canajoharie, Fonda, Lassellsville, Amsterdam quadrangles);
(2) in the Glens Falls-Whitehall area (Glens Falls, Fort Ann, Whitehall quadrangles);
(3) in Columbia County (Kinderhook, Pittsfield, Catskill, Copake quadrangles);
(4) (with A. Scott Warthin, Jr.) in preparation, a manuscript on the "Geology of the Mid-Hudson Valley" which includes a colored geologic map of the Rhinebeck, Poughkeepsie, and part of the Newburgh quadrangles; the discovery that Cambrian and Ordovician allochthonous rocks extend south to Beacon, New York, at the north edge of the Hudson Highlands, has been one noteworthy contribution;
(5) stratigraphic (DWF) and structural (James McLelland) studies in eastern Dutchess and northeastern Putnam Counties.

All of the above projects have supplied new information which is incorporated on the correlation charts.

In addition, the following are in progress:

(1) Donald H. Zenger has made an intensive study of the stratigraphy and petrology of the Little Falls Formation. Like Rickard, he favors a very Late Cambrian age for the unit. But unlike Rickard, he recognizes no Galway (=Theresa facies) in the type Little Falls.
(2) Paleoecological studies are underway on the Potsdam and Theresa in the St. Lawrence Valley by Bruce Selleck.
(3) Ed Landing is continuing his investigations of the microfossils in the Germantown, Stuyvesant Falls, and equivalent strata.

In summary, solutions to problems of correlating New York's Cambrian rocks suffer from scarcity of fossils. Future investigators of these rocks should explore the potential of conodonts and Early Cambrian phosphatic Problematica as index fossils. More precise correlation can surely be accomplished by more intensive search for trilobite genera and species which are yet unused. Anticipated solution of the placement of the Phanerozoic-Proterozoic contact by an International Commission should remove much of the age assignment problems attendant to age-disputed rocks straddling this presently vague boundary.

Ordovician
(See Plates 1, 2, 3, and 4)

HISTORY AND PREVIOUS WORK

During the 1830's and 1840's, Adam Sedgwick, working up from the crystalline basement rocks in Wales, was championing his Cambrian System—which terminated at the base of the Woolhope Limestone (Wenlock). Simultaneously, Roderick Murchison working down section from the "Old Red Sandstone" (Devonian) drew the lower limit of his Silurian System at the base of the Menevian with its *Paradoxides* fauna. The result was that a large part of the rock section became "both Cambrian and Silurian!" It was inevitable that these two great "stars," who were riding in a collision course should, in 1852, spark a verbal dual that would erode their abilities, diminish their productiveness, and cause international repercussions more than a century later. Their passioned quarrel over the Cambrian-Silurian boundary consumed most of their lives and persisted after their deaths in 1871 (Murchison) and 1873 (Sedgwick).

Adherents to the Murchisonian and Sedgwickian causes were somewhat placated, by the quieting introduction of the name Ordovician by Charles Lapworth in 1879. The name was selected from the Ordovices, the last of the old British tribes to surrender to the Roman conquest. Because the Silures were inhabitants of *South* Wales, it was deemed appropriate that the new name should recognize the ancient inhabitants of *North* Wales. The Ordovician System was unmistakably defined as extending from the basal grit of the Arenig Group (resting unconformably on Tremadocian Amnod Shales) to the top of the Foel y Ddinas Mudstones (the youngest formation of the Bala Group). Thus, the newly erected compromise system did not encompass all of the "overlapped" or disputed rocks.

Meanwhile, while British geologists were choosing up sides and wrangling over what should be Cambrian and Silurian, great strides were being accomplished elsewhere. Accumulated paleontological data favored the inclusion of the Tremadocian into the Ordovician

Figure 62. *Pillow lava, Stark's Knob, north of Schuylerville, Saratoga County, N.Y.*

Figure 63. *Closeup of pillow lava at Stark's Knob.*

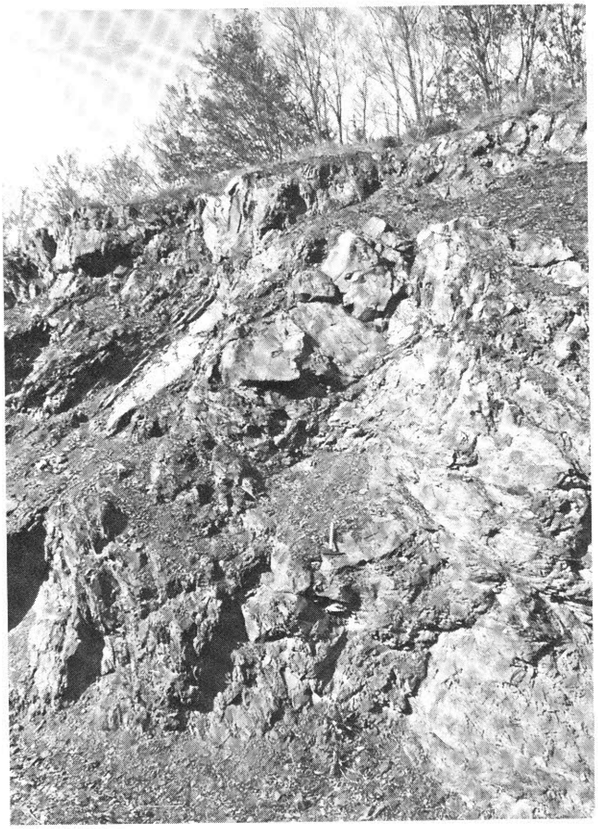


Figure 64. *Poughkeepsie Mélange, Red Mill Road, Rensselaer County, N.Y.*

System. Whereas most British geologists are steadfast in their view that the Tremadoc should be treated as Cambrian (by priority) most non-British are equally as adamant that the Tremadoc should be regarded as the opening stage (or series) of the Ordovician System. Hopefully, the efforts of the International Subcommissions on Cambrian and Ordovician Stratigraphy will resolve this boundary dispute within the next few years. For a history and development of the Ordovician in the British Isles one should consult *A correlation of Ordovician rocks in the British Isles*, Williams, *et al.*, (1972).

New York's Ordovician rocks have generally been regarded as "standard" for North America. But in recent years it has become obvious, that even on single continents, fossils of the same age may be frustratingly different. Now, it is generally recognized, that discrete areas (provinces) exist with characteristic fossils—and, often, characteristic facies. Whereas intraprovincial correlation is relatively easily accomplished, interprovincial correlation may be exceedingly difficult. Accordingly, New York can serve suitably as the standard for the Appalachian Province Ordovician Period because New York possesses admirable shelly and graptolitic rock sequences, and their mutual stratigraphic and paleontologic relationships are known in large part. In fact, the eminent Charles Schuchert thought so much of the New York Ordovician that he encouraged an attempt, though unsuccessful, to revive the name Champlainian (Emmons, 1842)—a name with 37 years priority over Ordovician (Lapworth, 1879)—for the entire system.

No synthesis of the New York Ordovician is complete without a discussion of the Taconian Orogeny. This mountain-making episode produced dramatic effects on eastern New York structure and sedimentation. Following the epeirogeny and rifting of the Quebecian (Penobscot) Taphrogeny, which terminated the Early Ordovician (Canadian) in New York, the North American and Afro-European plates moved together shrinking the Proto-Atlantic Ocean (Iapetus) and formed a series of intervening welts and troughs. The welts were eroded and the resultant debris was deposited in adjacent deepening troughs along with volcanic ejecta. The Normanskill rocks represent such deposits formed during the Early Medial Ordovician. Continued compression magnified the welt uplifts and trough downwarps. Eventually, large and small masses of the recently lithified Normanskill rocks slid downhill westward off the western flank of a large welt (Vermontia) into a deepening Snake Hill trough, formed on the earlier continental shelf. Here, detritus derived from Vermontia was accumulating which would eventually form the flysch of the Snake Hill-Martinsburg Formations during the Medial Mohawkian (Early Barneveldian Canajoharie Stage). This Vermontian Phase

Figure 65. *Poughkeepsie Mélange, N.Y. 9-J, south of Rensselaer, Rensselaer County, N.Y. Note carbonate and graywacke blocks.*

Figure 66. *Poughkeepsie Mélange, N.Y. 9-J, south of Rensselaer, Rensselaer County, N.Y. Note angular carbonate clasts.*

of the Taconian Orogeny concluded when uplift ceased permitting cleaner sediments (molasse)—Schenectady-Quassaic-Ramseyburg—to fill the Snake Hill-Martinsburg trough. The Hudson River Phase of the Taconian Orogeny began, during the Early Maysvillian, with intensified compression, accompanied by hard-rock westward thrusting of several large rock masses, overturned folding, and metamorphism. Intrusion of mafic rocks (Cortlandt and Croton Falls Complexes) terminated the Taconian Orogeny and initiated a period of relaxation evidenced by tensional faults. The resultant uplands were vigorously eroded to produce the detritus for the creation of the Lorraine-Queenston clastic wedge. Subsequent tension formed a widespread block-fault system which fractured all of eastern New York, offsetting the earlier thrust faults. This is particularly well shown in the Champlain and Mohawk Valleys and, accordingly, this taphrogeny is tentatively termed the "Chamhawk Taphrogeny." This episode endured from latest Ordovician (Gamachian) time through Early Silurian (Llandovery, Wenlock) time. I believe the Shawangunk-Vernon-Bloomsburg clastics are the products of intermittently intense erosion of block-faulted Taconic uplands. A mild folding episode may have occurred during Salina deposition—the Salinic Disturbance of Boucot. During the Devonian, a two-phased (Emsian and Givetian) Acadian Orogeny of folding, thrusting, and metamorphism affected eastern New York. This, coupled with Alleghenyan (Late Paleozoic) cross-folding, Palisadian (Late Triassic and possible Jurassic) block- and slip-faulting, has overprinted the earlier structures and rocks making the geologic history of eastern New York most perplexing.

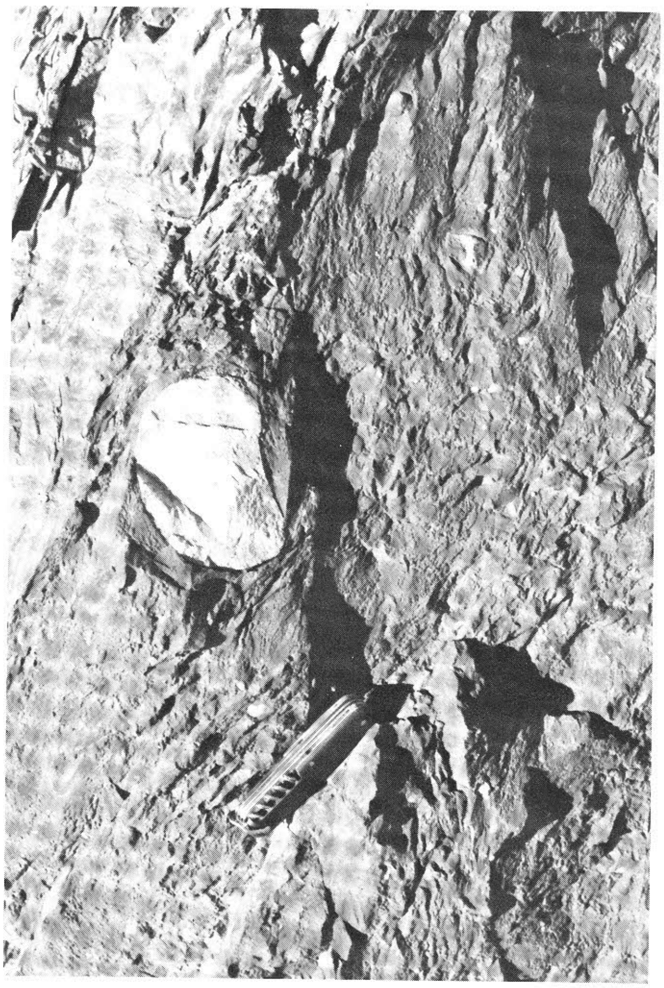
For older summaries of New York Ordovician rocks, see *Correlation of the Ordovician Rocks in New York State* (Fisher, 1962b) and *Correlation of Ordovician Formations in North America* (Twenhofel, *et al.*, 1954). For a comprehensive treatment of the structure and stratigraphy of the Taconic Sequence, which includes Early and Medial Ordovician rocks, see Zen (1961, 1964, 1967). A full exposé of the Taconian Orogeny is well chronicled by Zen (1968, 1972) and Rodgers (1971) and, in the framework of the complete tectonics of the Appalachian System, by Rodgers (1970).

For detailed discussions of New York's Ordovician rocks and fossils, see for the:

Beekmantown Group

Brainerd and Seely (1890), Braun and Friedman (1969), Cleland (1900, 1903), Cushing (1916), Fisher

Figure 67. *Poughkeepsie Mélange, N.Y. 9-J, south of Rensselaer, Rensselaer County, N.Y. Note rounded carbonate clast.*



(1954, 1965), Flower (1964, 1968), Mazullo (1974), Rodgers (1937), Ruedemann (1906), Taylor and Halley (1974), Wheeler (1942), Yochelson and Barnett (1972).

Wappinger Group

Dwight (1880, 1881, 1886), Gordon (1911), Holzwasser (1926), Knopf (1927, 1962), Offield (1967).

Chazy Group

Brainerd and Seely (1896), Cooper (1956), Cushing (1905b), Fisher (1968), Hudson (1904), Oxley (1951), Oxley and Kay (1959), Pitcher (1964), Raymond (1902, 1905a, 1905b, 1906, 1910b, 1910c, 1911, 1916, 1924), Ross (1963a, 1963b, 1963c, 1963d), Ruedemann (1906), Shaw (1968), Swain (1956, 1962).

Black River Group

Johnson (1971), Miller (1909, 1910), Ross (1964), Ruedemann *in* Cushing, *et al.*, (1910), Walker (1973), Young (1943).

Trenton Group

Cameron (1968), Johnson (1971), Kay (1929, 1937, 1943, 1953, 1960, 1968, 1969), Miller (1909, 1910), Raymond (1903), Ruedemann (1901b, 1912), Ruedemann *in* Cushing, *et al.*, (1910), Schopf (1966).

Black shales (and graptolites)

Berry (1962, 1963, 1970, 1971), Kay (1937, 1953), Riva (1968, 1969, 1974), Ruedemann (1901a, 1904, 1908, 1912, 1925, 1947).

Lorraine Group

Bretsky (1970), Kay (1953), Ruedemann (1925, 1926), Vanuxem (1842).

Ordovician rocks in the Taconic Region

Bird (1962), Bird and Dewey (1970), Craddock (1957), Elam (1960), Fisher (1961), Potter (1973), Rickard and Fisher (1973), Ruedemann (1901, 1930, 1942), Weaver (1957), Zen (1964, 1967).

Ordovician rocks in the Manhattan Prong

Friedman (1956), Hall (1968), Prucha (1968).

Ordovician fossils (articles dealing almost exclusively with fossils)

Berry (1962, 1970, 1971), Bretsky (1970), Cleland (1900, 1903), Cooper (1956), Dwight (1880, 1881, 1886), Flower (1968), Hudson (1904), Pitcher (1964), Raymond (1902, 1903, 1905a, 1905b, 1906, 1910b, 1910c, 1911, 1916, 1924), Riva (1974), Ross (1963a, 1963b, 1963c, 1963d, 1964), Ruedemann (1901b, 1904, 1906, 1908, 1926, 1947), Schopf (1966), Shaw (1968), Swain (1956, 1962), Taylor and Halley (1974), Yochelson and Barnett (1972).

RECENT DEVELOPMENTS AND REMAINING PROBLEMS

Various schemes have been proposed and utilized for series differentiation in the Ordovician of North America. Probably, the separation into Canadian, Champlainian, and Cincinnatian Series, as used in the National Research Council's Correlation Chart of the Ordovician Formations of North America (Twenhofel, *et al.*, 1954) has been most widely employed. This arrangement treats the Chazyan, Mohawkian, Edenian, Maysvillian, Richmondian, and Gamachian as separate stages. However, these aforementioned divisions should not be allotted equal importance as time divisions. For example, the Chazyan and Mohawkian are more faunally disparate than are the Maysvillian and Richmondian; their durations, also, are presumably very different. And their tectono-sedimentary histories are less related than are those of the stage divisions of the Cincinnatian. Clearly, a more practical division of the American Ordovician is required in order to discriminate segments of time that individually display faunal coherence, demonstrate lithologic and sedimentologic unity, and record unique tectonic events. Combining Chazyan with Mohawkian thwarts these desirable conditions.

Overlap has been demonstrated between the Cincinnatian and Champlainian (*sensu lato*) largely as a result of Flower's work on nautiloid cephalopods and Bergstrom's work on conodonts. Accordingly, Sweet and Bergstrom (1971) have proposed a scheme for determining the Champlainian-Cincinnatian boundary in North America. Their proposal places the contact between the Shermanian and Edenian Stages but in practice this time plane is virtually indeterminable in New York. Their boundary falls somewhere within the *Amorphognathus superbus* conodont zone, somewhere within the *Climacograptus spiniferus* graptolite zone, and somewhere within the *Cryptolithus bellulus* and *Triarthrus eatoni* trilobite zones. Their boundary would lie somewhere within the Utica Shale in the black shale facies and somewhere within the Denley Limestone in the carbonate facies. Adherence to their view is impractical—if not impossible! Instead, I would argue for the base of the Cincinnatian to be placed at the *Amorphognathus ordovicicus-A. superbus* boundary, an horizon which has been precisely fixed within the relatively thin Hillier Limestone. This satisfies the original definition of the Cincinnatian which was for strata "younger than the Trenton Limestone"; admittedly, a few feet of upper Hillier (topmost Trenton Group) would become Late Ordovician (Cincinnatian). This series limit comes close to (if not coincident with) the *Climacograptus pygmaeus-C. spiniferus* boundary and equates with the known hiatus within the upper Utica Shale. Therefore, for practical correlation and mapping purposes, my recommendation for an official base of the Cincinnatian possesses greater utility than that suggested by Sweet and Bergstrom. The traditional inclusion of the Edenian Stage within the Cincinnatian Series would have to be abandoned if my proposal is adopted.

Undoubtedly, committee action will determine how the name Champlainian will be used in future discussion. Some of the choices are:

(1) as the series name for the North American Medial Ordovician between the Canadian below and the Cincinnatian above,
(2) as the series name for the Early Medial Ordovician with Mohawkian reserved for the Late Medial Ordovician series,
(3) as the subsystemic name for the post-Canadian part of the Ordovician,
(4) as a time term (series or stage) for the post-Whiterock and pre-Turinian (Black River Group)—in the same sense as I am currently using Montyan.

Tentatively, I am opting for (2).

Although the type Cincinnatian is not known to include rocks of Gamachian age, it seems unwise to erect a separate series for these youngest Ordovician rocks (type locality on Anticosti Island in the Gulf of St. Lawrence). Accordingly the Gamachian Stage (*Amplexograptus prominens* Zone) is annexed as the youngest division of the Cincinnatian Series.

R. H. Flower's (1957, p. 18) division names for the Canadian (Gasconadian, Demingian, Jeffersonian, Cassinian) are inserted on this revised chart. Earlier I (Fisher, 1962a) had expressed reservations about these names as they were chosen from different areas (Missouri, New Mexico, New York) thus increasing the likelihood of duplication or omission of time. It would have been preferable to select all subdivision names from the type area of the Canadian—the Levis, Quebec region or the standard shelly region, the Champlain Valley. Flower regards the Canadian as a system and, hence, his divisions are series; they are here regarded as stages.

Personally, I believe there is merit in returning to Grabau's and Ulrich's view of a restricted Ordovician System and separating the Upper Ozarkian and Canadian as a separate system—Flower's Canadian or initially Dana's (1874) Canadian. Such a divorcement would emphasize the faunal, sedimentological, and structural differences of the Canadian and post-Canadian Ordovician. The top of the Canadian, in most of North America, is one of the easiest boundaries to locate. Fossils are easily distinguishable and rocks are lithologically dissimilar above and below this boundary. From the standpoint of plate tectonics, this boundary is nearly coincidental with the change from an expanding to a contracting Proto-Atlantic Ocean. On the negative side, to restrict the chronologic limits of the Ordovician would intensify confusion for those studying the voluminous existing literature on the system.

Chazy is currently employed as a name for rocks (Chazy Group) and for time (Chazyan Series or Stage). This dual usage creates ambiguity and promotes carelessness in discussion and in print. Chazy was initially used (Emmons, 1842) as a rock name. In subdividing the Chazy, Cushing (1905) referred to his divisions as "substages." But, in my opinion, his articles do not verify that he was using "substage" in a time sense. At the turn of the century, it was fashionable (probably because of the influence of A. W. Grabau) to use what, we accept today as time terms in a purely lithological context. Following Shaw (1968), I urge that Chazy be used as a rock name, but unlike Shaw I disapprove of using Chazyan as a time term. So as to avoid any further obfuscation, the name Montyan is introduced as the stage designation for the time interval represented by the varied and abundant fauna of the Chazy Group. Specifically, the Montyan Stage is the trilobite zone of *Pliomerops canadensis*. The name is selected from Monty Bay on Lake Champlain where splendid exposures of the Chazy Group occur 6.5 kilometers (4 miles) southeast of Chazy Village. Appropriately, both type areas are in the Chazy, New York region of Clinton County, in the northern Champlain Valley.

G. A. Cooper's (1956) stages, which were used as the carbonate standard for my 1962 chart, are abandoned in New York (except for the Whiterock). Conodont studies by Bergstrom during the past few years have shown that many of Cooper's stages are partly or wholly equivalent to each other. Assuming that conodonts were less affected by environmental changes than relatively sessile benthonic animals, it appears that Cooper's distinctions, based on brachiopods, are ecologic rather than chronologic.

Marshall Kay's (1933, 1937, 1943, 1953, 1960, 1968,

1969) enduring efforts toward a better understanding of the stratigraphy of the Middle Ordovician carbonates, particularly the Trenton Group, have been commendable. But his several proposals for series and stage divisions of the Ordovician have been received with mixed reaction because the nomenclature seems unnecessarily burdensome considering the capability to distinguish the various units. Some of the stages seem of so short a timespan and paleontologically vague that they are difficult—if not impossible!—to recognize beyond their type regions. Some time divisions were established by adding -an or -ian to rock units—a poor procedure because it leads to confusion; names of time units should be different from those of rock units.

The distinctiveness of the black shale of the Mohawk Valley has been recognized since the formative years of the State Geological Survey (1836–1843) when Vanuxem (1842) applied the name Utica. So as to emphasize that the Utica was older in the east than in the west, Ruedemann (1912) introduced the names Canajoharie and Snake Hill; he noted that the Snake Hill was siltier than the Utica but admitted that the Canajoharie was inseparable from the restricted Utica, except for the presence of different graptolites. In order to further emphasize the age differences of the black shale facies, many geographic names were proposed for individual graptolite zones within the black shale facies by Ruedemann (1912, 1925) and Ruedemann and Chadwick (1947). All of these names for biostratigraphic parts of the Utica black shale continuum have no validity as rock-unit names. Two of these names, Canajoharie and Nowadaga, are retained by me as designations for identifiable and functional stages within the Utica black shale facies. The Canajoharie Stage embraces the zones of *Corynoides americanus* and *Orthograptus ruedemanni* of Riva (1968, 1969). The Nowadaga Stage embraces the zones of *Climacograptus spiniferus* and *Climacograptus pygmaeus* of Riva (1968, 1969). Riva's research has enhanced immeasurably New York's graptolite zones—which possess great utility for eastern North America. He has ably demonstrated that Berry's zonation (1960, 1962, 1968), which served as the biostratigraphic base for the 1962 correlation chart of the Ordovician of New York, is incomplete for eastern North America. Berry's standard zones were based on the geographically distant Marathon region of Texas where significant hiatuses are now known to occur. Riva's zones are modifications of Ruedemann's original zonation.

Amendations to the Beekmantown and Wappinger Groups by the inclusion of the basal quartzarenites (Keeseville and Poughquag, respectively) have already been mentioned in the chapter on the Cambrian. Current bedrock mapping by John Rodgers in the Copake Quadrangle in eastern Columbia County and by James McLelland and me in eastern Dutchess County is providing new information on the Wappinger carbonates. Paleoecological contributions have been made on the Tribes Hill Formation (Braun and Friedman, 1969) and on the Great Meadows and Fort Ann Formations (Mazzullo, 1974). Despite the scarcity and poor preservation of fossils in New York rocks of Canadian age, much work needs to be done in order to sharpen up the correlations and better interpret the paleoenvironments. Conodonts, trilobites, nautiloid cephalopods, and gastropods offer the greatest potential in the carbonates; a more intensive search for graptolites must be made in the off-shelf pelites.

Happily, the Chazy Group of limestones has experienced relatively intensive paleontologic study. Raring's (1969) conodont study of these strata has improved the accuracy of our correlations. Major deficiencies in knowledge of the Chazy Group are: (1) the proper correlation of this profuse shelly fauna with the graptolite sequence, and (2) details of the sedimentary petrology of the several limestone facies.

The placement of the Normanskill Group (Indian River, Mount Merino, Austin Glen) remains unfixed because of the inability to relate precisely the Normanskill graptolite zonation to the shelly zonation. Efforts toward reconstruction of the Normanskill's sedimentary history suggest a number of possibilities:

1. wholly equivalent to the Chazy Group carbonates,
2. wholly equivalent to the Chazy-Black River hiatus,
3. wholly equivalent to the Black River Group carbonates,
4. wholly equivalent to the earliest Trenton (Rocklandian),
5. partly equivalent to the early Trenton Group,
6. partly equivalent to some or all of the above.

Normanskill pelites (Indian River, Mount Merino) represent deep water, low-energy deposits as evidenced by enclosed graptolites, a total absence of a benthonic fauna, bedded cherts with enclosed radiolarians, and laminated argillites. The older pelites (Indian River) are red, purple, and light green shales and mudstones with red- and light green-bedded cherts; local unfossiliferous concretionary calcilutites to carbonate-clast conglomerates occur in the uppermost part. The younger pelites (Mount Merino) are dark gray to black shales and mudstones with black- and dark green-bedded cherts. Both Indian River and Mount Merino yield graptolites which characterize the *Nemagraptus gracilis* Zone.

Normanskill litharenites (Austin Glen) can be subdivided into: (1) a lower unit of interbedded silty, micaceous gray shales and thin-medium bedded, laminated siltstones to subgraywackes, and (2) an upper unit of massively bedded graywackes with a great profusion and variety of sole markings—indicative of turbidites; small amounts of thinner-bedded graywackes and gray shales are interbedded with the thick graywackes. The lower unit of the Austin Glen contains graptolites of the *Nemagraptus gracilis* Zone; the upper unit, however, yields scarcer graptolites denoting the *Diplograptus multidens* Zone. The identifications are those of John Riva.

Available evidence suggests that the Normanskill rocks are slope (Austin Glen) and basin (Mount Merino, Indian River) deposits which originated in welt-flanked troughs in a closing Proto-Atlantic Ocean in Early Medial Ordovician time. The Indian River red and green pelites may represent residual soil transported from atop the carbonate shelf rocks to the west. Such soils would likely have accumulated atop the Beekmantown and Wappinger rocks during post-Canadian and pre-Mohawkian time. It is noteworthy that residual iron oxides atop the Wappinger Group on the shelf were mined during the nineteenth century. The Austin Glen siltstones and graywackes reflect vigorous erosion from nearby source areas (welts and island arcs) produced by the heightening compressional stresses of the earliest phase of the Taconian Orogeny (*sensu stricto*).

Whereas the Indian River and Mount Merino may conceivably equate with the Chazy carbonates, they must have formed in different depositional basins. Chazy carbonates are known to grade eastward (in Vermont and Quebec) into the Laval Formation of interbedded limestones and shales which, in turn, grade into the Youngman shales and siltstones which further grade into the relatively pure Carman Quartzite. Collectively, these rocks are unlike those of the Normanskill and, instead, reflect a different source terrane marked by crustal stability. By contrast, the graywackes signify crustal instability and derivation from a noncarbonate terrane of high relief and vigorous erosion.

Because of the absence of sedimentary-tectonic correlation of the Normanskill strata with the shelf limestones, it seems plausible that the Normanskill may more rightly equate with the Chazy-Black River hiatus. Little else can be added concerning this correlation because rocks known to occupy this interval are so far removed from New York. Perhaps such post-Chazy and pre-Black River shelf carbonates were deposited in New York but were eroded prior to the deposition of the Black River Group.

As for a Normanskill equivalency with the Black River Group, I have seen no field evidence which shows that the Black River carbonates grade eastward into argillaceous strata—as do the Trenton carbonates grading eastward into Utica black shales. In fact, the supratidal, intertidal, and high subtidal nature of the Black River carbonates in the eastern Mohawk and Hudson Valleys strongly suggests that a low-lying land existed east of the present distribution of Black River carbonates. However, the possibility should not be dismissed that a more easterly basin or basins might have received clastic sediments contemporaneously with the disconnected Black River carbonate shelf. If this were true, it is difficult to reconcile the contradictory features of the relatively thin and pure Black River carbonates (reflecting a stable crustal condition with coral reef development) with the relatively thick Normanskill graywackes and pelites (signifying crustal instability and vigorous erosion from source areas).

Riva (1969) has made an interesting and somewhat puzzling discovery from two deep well cores on Anticosti Island in the Gulf of St. Lawrence. He has found Normanskillian graptolites *(Dicellograptus sextans* var. *exilis*, *Glyptograptus euglyphus*, *Pseudoclimacograptus* cf. *P. Scharenbergi)* in green shales interbedded with Trenton limestones containing the brachiopod *Cyclospira bisulcata;* previously *Cyclosvira bisulcata* had only been reported from the upper Trenton limestones! This occurrence is 500 feet stratigraphically higher than a few feet of Black River limestone and 280 feet of Chazy carbonates. This allegation assumes that *Cyclospira* is a facies fossil, low in the Trenton (or pre-Trenton and post-Black River strata) on Anticosti Island. Partial correlation of the latest Normanskillian with post-Black River limestone is, thus, demonstrated.

The Normanskill Group must have ceased forming and become lithified prior to, contemporaneously with, or shortly after the formation of the Balmville Limestone; the initial sediments may have been laid down as early as those of the Early Chazy (Day Point Limestone) Group. Blocks of Austin Glen Graywacke are incorporated into the lower Snake Hill Shale as the Poughkeepsie Mélange. Austin Glen lithification, thus, preceded *Corynoides americanus* time. This unduly long discourse on the Normanskill serves to emphasize that the correlation of the Normanskill rocks with the shelf carbonates claims the highest priority in New York Ordovician research.

Within the past few years great strides in perfecting conodont zonation have resulted in more reliable correlations within the Ordovician Period (Bergstrom, 1971a, 1971b, 1973a, 1973b, 1973c; Landing, 1970; Raring, 1969; Schopf, 1968; Sweet, Ethington, and Barnes, 1971). In New York, this is particularly true for post-Canadian and pre-Cincinnatian time and has been especially applicable to the Trenton Group. Despite this enlightenment, correlatable conodonts have yet to be discovered within the Black River Group. Over the years three differing concepts of Black River stratigraphic relations have arisen:

1. Winder (1953, 1960) believed that the Black River units were transitionally linked with the Trenton Group units—that they were all essentially contemporaneous but represented rock records of different peritidal and subtidal environments.
2. Rickard (1973), using notable gamma-ray "kicks," believed that Black River and Trenton units were each chronologically distinct and that the principal Black River divisions were chronologically separate. This was also the view of Young (1943).
3. Between these two extremes is an intermediate view which I favor. Some units are demonstrably interrelated and can be traced through lateral and vertical transitional intervals into other units; others are chronologically distinct. I have observed intertonguing facies in the Pamelia-Lowville, Lowville-Watertown, and Lowville-Isle la Motte. There is lesser intertonguing of Trenton carbonates.

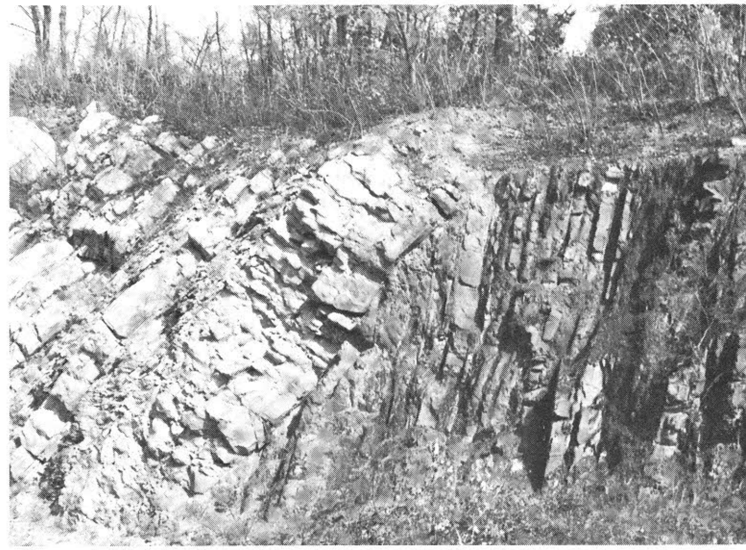
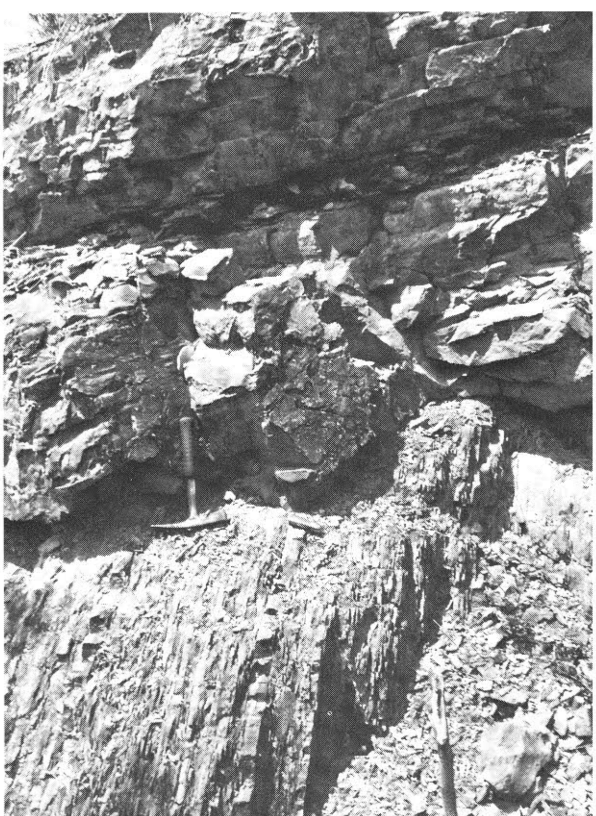


Figure 69. *Supra-Ordovician contact; angular unconformity, Late Silurian Rondout Dolostone on Medial Ordovician Austin Glen Graywacke, N.Y. 23 access road to I-87, Leeds, Greene County, N.Y.*

Figure 68. *Supra-Ordovician contact: angular unconformity, Early Devonian Manlius Limestone on Early Ordovician Stuyvesant Falls Formation. Mt. Ida, Columbia County, N.Y.*



Both Rickard and I oppose Winder's linkage of Black River with Trenton carbonates, and we recognize a significant break between the two groups. From the longitude of Utica eastward, basal Trenton rests on different units because of the absence of some or all of the Black River units. Walker's (1973) recent study has furnished useful paleoecological data. An accelerated search for zonal conodonts and equivalency with the

Figure 70. *Supra-Ordovician contact; disconformity, Medial Silurian Oneida Conglomerate on Late Ordovician Frankfort Shale, Frankfort Gorge, Herkimer County, N.Y.*

Figure 71. *Supra-Ordovician contact; paraconformity, Early Silurian Whirlpool Sandstone on Late Ordovician Queenston Shale, Niagara Gorge, Niagara County, N.Y.*

graptolite sequence are the two outstanding unresolved problems of the Black River Group.

Little research has been conducted on the Lorraine and Queenston rocks in New York State until the last few years. Bretsky (1970) has made an exceptional paleoecological study of the Lorraine strata and graduate students are currently engaged in sedimentologic and petrologic study of the Queenston rocks, both at the surface and in the subsurface. There is remote hope of discovering fossils in the Queenston useful for correlation.

In the Manhattan Prong belt, additional mapping and petrologic studies on the Bedford, Harrison, and Hartland gneisses should provide beneficial data toward resolving the ages of each. Radiometric dating of the Staten Island Serpentinite would be especially useful in perfecting the geologic history.

In summary, lucrative areas of research relevant to correlation of New York Ordovician rocks are: conodont studies in the Canadian carbonates; continued evolutionary studies of nautiloids so as to establish a formal zonation; trilobite studies throughout the section; relationship of graptolites to conodonts and trilobites in units which consist of alternating black shales and limestones; an exploration into the potential of ostracodes for zonation of the post-Canadian Ordovician; search for graptolites in the Lorraine Group; and subsurface relations of the Upper Ordovician post-carbonate strata—especially to ascertain the regional relationships of the Queenston and Oswego to the Juniata and Bald Eagle of Pennsylvania and to the Medina Group of Early Silurian age.

Roster of Pre-Silurian Stratigraphic Names

Listed here, in alphabetical order, are the formal geographic names that have been proposed for use with pre-Silurian rocks in New York State. The nomenclator and date-page of the original designation are supplied. This register, possessing the advantages of assembling New York State stratigraphic units together for ready reference and up-to-date views, should be used in conjunction with the *Lexicon of Geologic Names of the United States* (Wilmarth, M. Grace, 1938; Keroher, G. *et al.*, 1966; Keroher, G., 1970) so that a fuller history of past usage can be ascertained. The key to symbols is as follows:

(**boldface**)	+	names accepted and recommended for future use
(roman regular)	?	names of questionable value
(*italics*)	–	names rejected and recommended for abandonment

A short note on reason(s) for rejection accompanies those names preceded by a minus sign (–) or a query sign (?). And, occasionally, a note to explain new usage or furnish new information accompanies those names preceded by a plus sign (+).

HADRYNIAN OR ? CAMBRIAN

+ **Allens Falls Fanglomerate** (Krynine, P. D., 1948, p. 1333) *abstract*
+ **Austerlitz Phyllite** (Fisher, D. W., 1961, p. D5)
+ **Bomoseen Graywacke** (Cushing, H. P., and Ruedemann, R., 1914, p. 69)
? Bull Formation (Keith, A., 1932, p. 360)
  Accepted by U.S. Geological Survey (Keroher, G. *et al.*, 1966, p. 526) to include several earlier-named units—now regarded as members of the Bull Formation. If there need be a name to embrace these units, Nassau (Cushing, H. P. and Ruedemann, R., 1914, p. 70) has priority.
+ **Elizaville Argillite** (Weaver, J. D., 1957, p. 739)
+ **Everett Schist** (Hobbs, W. H., 1893, p. 717–736)
+ **Mettawee Slate,** part (Cushing, H. P. and Ruedemann, R., 1914, p. 69)
– *Mount Anthony Schist* (MacFadyen, J. A., 1956, p. 16)
  Name is superfluous; rocks mapped as Mount Anthony could be termed metamorphosed Nassau, Austerlitz, or the older name Rowe (Emerson, B. K., 1898)
+ **Nassau Formation,** part (Cushing, H. P. and Ruedemann, R., 1914, p. 70)
+ **Nicholville Conglomerate** (Wiesnet, D. R. *in* Postel, A. W., Nelson, A. E., and Wiesnet, D. R., 1959, map)
+ **Poundridge Granitic Gneiss** (Bell, G. K., Jr., 1936, p. 65)
+ **Rensselaer Graywacke** (Dale, T. N., 1893, p. 291)
+ **Yonkers Granitic Gneiss** (Merrill, F. J. H., 1890, p. 388)

CAMBRIAN

– *Adirondack Border Series* [Group] (Wheeler, R. R., 1942, p. 143, 145)
  Name used for Upper Cambrian rocks (Potsdam, Theresa, Little Falls, Whitehall) rimming the Adirondack Mountains. Name not derived from a mapped geographic or cultural feature. Upper limit based on ability to find diagnostic fossils rather than on characteristic lithologic criteria. To me these rocks are better placed in the lower part of the Beekmantown Group.
+ **Ashley Hill Limestone** (Dale, T. N., 1893, p. 312)
+ **Ausable Sandstone** (Alling, H. L. 1919, p. 144)
  Red and pink-white mottled lower Potsdam; probably the red, highly crossbedded sandstones at Hannawa Falls, the type (but atypical!) Potsdam. Age pre-Late Cambrian.
+ **Briarcliff Dolostone** (Knopf, E. B., 1946, p. 1211) *abstract*
? Bull Formation (Keith, A., 1932, p. 360) (see note under Bull-Hadrynian and ? Cambrian)
+ **Castleton Conglomerate** (Zen, E-an, 1959, p. 2)
? Claverack Conglomerate (Chadwick, G. H., 1946, p. 585)
  This is but one of several carbonate-clast conglomerates in the Germantown Formation. Its usefulness is suspect because of the inability to trace separate conglomerates with assurance from one area to the next. There may be merit to referring all of these as the "Claverack Conglomerate Suite."
– *Cossayuna Group* (Fisher, D. W., 1961, map)
  Name suggested as a gross mapping unit to include all pre-Poultney (alleged Lower Cambrian) rocks within the Taconic Sequence. Usability negated by inability to locate the Hatch Hill-Poultney contact in a suf-

ficiently widespread area and the lack of a need for distinguishing Cambrian from Ordovician rocks on a rock-unit basis.

Curtis Mountain (Fisher, D. W., 1961, p. D6; 1962a, chart)

This may be but one of several discontinuous green-gray quartzites within the Nassau and Elizaville Formations. There may be merit to referring these as the "Curtis Mountain Quartzite Suite."

– *Dewey Bridge Formation* (Flower, R. H., 1964, p. 156, 157)

Unnecessary; junior synonym of Ticonderoga Formation (dolostones and sandstones, and gradations between) (Welby, 1959, p. 23, Ticonderoga attributed to John Rodgers, M. S. never published).

+ **Diamond Rock Quartzite** (Cushing, H. P. and Ruedemann, R., 1914, p. 70)

Interpreted as the basal member of the Germantown Formation.

+ **Eagle Bridge Quartzite** (Prindle, L. M. and Knopf, E. B., 1932, p. 277)

– *Eddy Hill "Grit"* (Cushing, H. P. and Ruedemann, R., 1914, p. 69)

Thin (few inches) lenses of gray-black, coarse-textured sandstone in lowest portion of West Castleton Formation. Its thinness and localized occurrences cause it to be virtually useless as a formally designated unit.

+ **Finch Dolostone** (Fisher, D. W., new, herein)

Name proposed for the lowest dolostone member of the Whitehall Formation in eastern New York and adjacent Vermont. The type locality (Thorn Hill 7.5′ quadrangle) is on the Ward Farm, 4 miles (6.4 kilometers) north-northeast of the intersection of U.S. 4 and N.Y. 22 in Whitehall. Here, about 40 feet (12.2 meters) is seen beneath the overlying Warner Hill Limestone and above the basal orthoquartzite member of the Whitehall Formation. Elsewhere, the Finch may reach 75 feet (22.8 meters). The name is selected from Finch Marsh south of Warner Hill and 2.3 miles (3.7 kilometers) north-northeast of Whitehall.

The Finch Dolostone is a fine-medium textured, medium-dark gray (sometimes bluish) on fresh fracture (weathers medium gray), thin-thick bedded, frequently laminated dolostone with a fetid odor. Black-dark gray, bluish-gray chert beds and nodules are common. Quartz knots and vugs containing quartz crystals, dolomite, and anthraxolite are also abundant. The Finch's physical makeup is akin to that of the Little Falls Dolostone of the Mohawk Valley.

The Finch Dolostone may be distinguished from the younger Skene Dolostone Member of the Whitehall Formation by its finer texture, darker color, thinner bedding, laminated strata, and presence of chert.

No fossils have been found in the Finch Dolostone, but it lies beneath the demonstrable Trempealeauan Warner Hill Limestone: likewise, it lies above the Franconian *Elvinia* Zone. Thus, the Finch is either Late Franconian or Early Trempealeauan.

+ **Galway** (Clarke, J. M., 1910, p. 11-12; revived by Fisher, D. W. and Hanson, G. F., 1951, p. 797, 799, 802)

– *Greenwich* (Dale, T. N., 1904, p. 43)

Name never used subsequent to Dale's casual mention of it. Seemingly, the name was approved for usage by the U.S. Geological Survey for a manuscript (C. D. Walcott) which was never published.

+ **Hardyston Quartzite** (=Hardiston and Hardistonville of Wolff and Brooks, 1898 and Kummel and Weller, 1901) (Wolfe, J. E., and Brooks, A. H., 1898, p. 442)

+ **Hatch Hill Formation** (Theokritoff, G., 1959, p. 53, 55)

+ **Hoyt Limestone** (Clarke, J. M., 1903, p. 16)

+ **Keeseville Sandstone** (Emmons, E., 1841, p. 130)

Upper white-cream purer quartzarenites of the Potsdam Formation.

– *Lansingburgh beds* (Ford, S. W., 1875, p. 206)

Name casually used for slates and sandstones in vicinity of Troy, New York. Appears to be basal Germantown (=Diamond Rock). Insufficiently described as senior synonym of Diamond Rock Quartzite (Cushing and Ruedemann, 1914, p. 70)

+ **Little Falls Dolostone** (Clarke, J. M., 1903, p.16)

+ **Lowerre Quartzite** (Merrill, F. J. H., 1898, p. 24, 25)

+ **Mosherville Sandstone** (Fisher, D. W. *in* Fisher, D. W. and Hanson, G. F., 1951, p. 806)

+ **Mudd Pond Quartzite** (Zen, E-an, 1959, p. 1, 2)

– *North Brittain Conglomerate* (Zen, E-an, 1961, p. 303)

Junior synonym of Castleton Conglomerate (Zen, 1959, p. 2)

+ **Pine Plains Formation** (Knopf, E. B., 1946, p. 1212) *abstract*

+ **Poughquag Quartzite** (Dana, J. D., 1872, p. 250)

Herein appended to the basal part of Wappinger Group

– *Saratoga Springs Group* (Fisher, D. W., 1962, chart)

Named for combined Upper Cambrian lithologic units which rim the Adirondack Mountains. Difficultly usable because the Cambrian-Ordovician boundary (as now recognized) falls within rocks of almost identical lithologies where fossils are found or else paucity of fossils prevents the location of the top of the Group. I favor including these rocks within the lower part of the Beekmantown Group—to emphasize the similarity of sedimentary environments—and the abandonment of the name Saratoga Springs.

? Schodack Formation (Cushing, H. P. and Ruedemann, R., 1914, p. 69)

Regrettably, the name Schodack was not redefined to accommodate data obtained during the 1950's for the name was deeply entrenched in New York geologic literature (Ruedemann, 1930, 1942; Goldring, 1931, 1943). The fact that the *Elliptocephala asaphoides* fauna was found to occur lower than the Schodack Formation—in the uppermost Nassau Formation—and the fact that the upper Schodack was found to contain younger Cambrian fossils prompted Zen (1959, 1961) and Theokritoff (1957, 1959) to introduce the names West Castleton and Hatch Hill. It would have been proper and undoubtedly less confusing to have retained the name Schodack for the mappable lithologic entity (black shales with interbedded limestones and carbonate-clast conglomerates), acknowledging its greater timespan and divorcing the *Elliptocephala asaphoides* Zone concept from a part of the definition. There would then have been no necessity for the introduction of West Castleton, Hatch Hill, or Germantown, (Fisher, D. W., 1961, p. D9).

\+ **Stissing Formation** (dolostones, limestones, shales) (Walcott, C. D., 1891, p. 360)

\+ **Stuyvesant Conglomerate** (Ford, S. W., 1884, p. 206)

? Taconic System (Emmons, E., 1842, p. 135)

Taconic has come to be associated with: 1) the Taconic Sequence (transported pelitic rocks of Hadrynian through Middle Ordovician ages), 2) the Taconic or Taconian Orogeny which occurred during the Medial and Late Ordovician, and 3) as Taconian, a series name for the Early Cambrian. It is ironical that in New York during the 19th century, Ebenezer Emmons had rightly recognized rocks which he thought were older than the Potsdam Sandstone (the base of the New York System); discoveries of fossils by Ford and Dwight supported his doctrine of a "Primordial Fauna." It would seem fitting that the name Taconian should be perpetuated for a series or stage within the Early Cambrian—a tribute to the astuteness of Emmons and his advocates.

\+ **Ticonderoga Formation** (dolostones, sandstones, and all gradations between) (Welby, C. W., 1959, p. 23, 33)

Name attributed to John Rodgers, whose manuscript, describing the unit and its type locality, was never published.

? Troy Limestone, Conglomerate, Shale (Ford, S. W., 1871, p. 34; 1875, p. 206; 1873, p. 136, 137; 1884, p. 37, and Cushing, H. P. and Ruedemann, R., 1914, p. 70)

Name originally given by S. W. Ford to shales, limestones, and limestone conglomerates in the vicinity of Troy which held a "Primordial (Early Cambrian) fauna." Cushing and Ruedemann gave name for Division H of T. N. Dale's Rensselaer County series of rocks. In Ford's sense, Troy is a senior synonym of Schodack. In Cushing and Ruedemann's sense, Troy is Division H of Dale and Schodack is Division I; it is implicit that Cushing and Ruedemann regarded Schodack as younger than Troy. It is also fairly obvious that the latter were unaware of Ford's prior designation for their application of the name Troy to Division H (green, red, and purple shales with thin quartzites) indicates that they regarded the Troy as a recurrent Nassau lithology. It is ironical that had succeeding geologists paid attention to Ford's work, the name for the black shale with limestones would, today, be Troy! Whether the name should still be retained as a rock unit is debatable but there may be some merit in using Troy as a stage name (Troy series; Ford, S. W., 1884, p. 37) for the *Elliptocephala asaphoides* Zone within a Taconian Series—in recognition of the significant investigations of Silas W. Ford.

? Waramaug Formation (gneisses, quartzites) (Gates, R. M. *in* Gates, R. M. and Bradley, W. C., 1952, p. 7)

According to Leo Hall (personal communication) the Waramaug is lithologically identical to Manhattan "C."

\+ **Warner Hill Limestone** (Fisher, D. W., new, herein)

Name proposed for a prominent light-gray weathering, light-dark gray calcilutite member of the Whitehall Formation in Washington County, New York. The type locality (Whitehall, 7.5′ quadrangle) is in the abandoned quarry on the north side of Washington County Highway 10, two miles (3.2 km) northeast of the intersection of U.S. 4 and N.Y. 22 in Whitehall. The name is selected from Warner Hill, one mile (1.6 km) north of the type section. Numerous small exposures exist throughout the Fort Ann 7.5′ quadrangle to the south. The Warner Hill is unknown south and west of Glens Falls. Its correlative, the Hoyt Limestone, outcrops in and near Saratoga Springs, New York, but it has a different physical makeup and reflects deposition in a high-energy environment.

The Warner Hill Limestone is a relatively massive-bedded, light-dark gray calcilutite, dolomitic in places but unmottled. The rock weathers very light gray. Discontinuous beds and nodules of green-gray chert usually show a buff-colored rind. Splendid stromatolite *(Cryptozoon)* mounds flanked by darker gray, coarser textured calcarenites are characteristic features. There is a sharp lithologic contact with the underlying cherty quartzose dolostone member of the Whitehall Formation; this member displays abundant vugs containing quartz crystals (=Little Falls Dolostone ?). The Warner Hill is gradational upward and laterally into the coarse-textured Skene Dolostone; where the Skene does not overlay the Warner Hill, younger (Gasconadian) calcilutites, lithologically indistinguishable from the Warner Hill but within the upper Whitehall Formation, rest directly on the Warner Hill.

The Warner Hill Limestone yields undeniable Late Cambrian (Trempealeau) age trilobites (Taylor and Halley, 1974). Its thickness varies from about 10 feet (3 m) near Smiths Basin to about 90 feet (27.5 m) at the type locality, northeast of Whitehall.

\+ **West Castleton Formation** (black shales, limestones, conglomerates) (Zen, E-an, 1959, p. 2)

\+ **Zion Hill Quartzite** (Cushing, H. P. and Ruedemann, R., 1914, p. 70)

CAMBRIAN AND ORDOVICIAN

(*or* ? Cambrian and Ordovician *or* Cambrian and ? Ordovician)

– *Barnegat Limestone* (Mather, W. W., 1838, p. 168); spelled Barnegate (Mather, 1843, p. 367, 410)

Name given to the carbonate rocks in Dutchess County but never used since Mather's day. Obsolete senior synonym of Wappinger (Dana, J. D., 1879, p. 378).

\+ **Beekmantown Group** (Clarke, J. M. and Schuchert, C., 1899, p. 876, 877)

As now advocated by me, to include all rocks of the carbonate-quartzarenite sequence beginning with the Keeseville Sandstone and terminating at the top of the Providence Island Dolostone. This union emphasizes the paleontological and sedimentological association of this facies suite.

\+ **Carringtons Pond Schist** (Hall, L., 1968, p. 5)

– *Essex Sandstone* (Emmons, E., 1838, p. 230)

Junior synonym of Potsdam Sandstone (Emmons, E., 1838, p. 214).

– *Fishkill Limestone* (Clarke, J. M., 1909, p. 16)

Name given for carbonate rocks in the Fishkill Valley, Dutchess County. Obsolete junior synonym of Wappinger (Dana, J. D., 1879, p. 378).

\+ **Germantown Formation** (gray-black shales, limestones, carbonate-clast conglomerates) (Fisher, D. W., 1961, p. D9)

Contains, Early, Middle, and Late Cambrian trilobites in Columbia County; uppermost part yields Ordovician (Gasconadian) conodonts as well.

? Hartland Schist (Gregory, H. E., 1906, p. 96–100)

"Waste-basket" term for undifferentiated schists east of "Cameron's Line." Age uncertain but presumed to be Early Cambrian through Early Ordovician.

– *Hudson River Slate Group, Hudson River Group* (Mather, W. W., 1840, p. 256)

As originally applied, includes what we know today as pelites, quartzites, and graywackes ranging in age from Early Cambrian through Middle Ordovician. Early twentieth century usage tended to restrict the name to only Ordovician rocks. To perpetuate the use of this name would only serve to cloud the relationships and ages that are currently known.

\+ **Inwood Marble** (Merrill, F. J. H., 1890, p. 389)

Age established by lithologic correlation with units north of the Hudson Highlands as Early

Cambrian through Early Ordovician (Canadian).

+ **Manhattan Schist** (Stevens, R. P., 1867, p. 116)
Work within the past two decades indicates that Manhattan "A" (basal unit) is Middle Ordovician, that Manhattan "B" is an amphibolite within Manhattan "C" and that the latter is overthrust westward and largely of Early Cambrian or ? Cambrian age.

– *Newburgh Limestone* (Mather, W. W., 1840, p. 257, 410)
Name never used since Mather's day; obsolete senior synonym of Wappinger (part) (Dana, J. D., 1879, p. 378).

– *Pawling Limestone* (Dana, J. D., 1872, p. 252)
Name casually used for the carbonates in the Pawling Valley, Dutchess County. Obsolete senior synonym of Wappinger (Dana, J. D., 1879, p. 378).

+ **Potsdam Sandstone** (Emmons, E., 1838, p. 214)
Though largely Late Cambrian in age, the lower Potsdam may be earlier Cambrian or even Pre-Cambrian. The uppermost Potsdam in Clinton County has yielded some Ordovician-like gastropods and the unit may extend into the lowermost Ordovician (Gasconadian); similarly, the upper Potsdam in St. Lawrence County (and extending into Ontario) may be lowermost Ordovician in age.

+ **Rowe Schist** (Emerson, B. K., 1898, p. 76–78)
Originally classed as Early Cambrian. Now regarded (Hatch, N., Jr.; Chidester, A. H.; Osberg, P. H.; Norton, S. A.; 1966) as Early, Middle, and Late Cambrian and Early Ordovician ages and to include all rocks between the Hoosac Schist below and Middle Ordovician Moretown Formation above. Present along New York-Vermont border on hilltops, structurally above the Walloomsac Slate. As such, the name Rowe antedates Mount Anthony (MacFadyen, 1956).

– *Sing Sing Limestone* (Dana, J. D., 1880, p. 27). Sing Sing Marble (Berkey, C. P. and Healy, J. R., 1912, p. 1907–1912)
These are senior and junior synonyms, respectively, of Inwood (Merrill, F. J. H., 1890, p. 389).

+ **Skene Dolostone** (Wheeler, R. R., 1941, p. 1938) *abstract;* (Wheeler, R. R., 1942, p. 522); *not* Skene of Flower, R. H., (1964, p. 156, 158)
Wheeler's type locality for the Skene is on Skene Mountain in Whitehall, stratigraphically beneath the basal siltstone of the Cutting Formation (or Great Meadows Formation of Flower, 1964). As such, the Skene is an upper dolomitic facies of the Whitehall Formation. The Skene is light tan to cream colored, medium-coarse textured and very massive. On the other hand, Flower (1964) used the name Skene for a lower mottled quartzose member of his Great Meadows Formation—a very different unit lithologically from the Skene of Wheeler.

+ **Stockbridge Limestone** [and Dolostone] (Emmons, E., 1842, p. 154)
Name useful in easternmost New York (New York-Vermont, Massachusetts, Connecticut, boundaries) where metamorphism has masked the characteristics of the subdivisions of the Wappinger Group.

+ **Theresa Formation** (dolostones, sandstones, and gradations between) (Cushing, H. P., 1908, p. 159)
Along the southern and southeastern Adirondack border, the Theresa is wholly of Late Cambrian (Franconia) age. In the St. Lawrence Valley, the lower Theresa is latest Cambrian (Trempealeau) age and the upper Theresa is earliest Ordovician (Gasconadian) age. Along the northern Adirondack border, the Theresa is wholly lowermost Ordovician (Gasconadian). Thus, the unit transgresses time in a northerly direction.

+ **Wappinger Group** (Dana, J. D., 1879, p. 378)
Originally included the uppermost unit (Balmville Limestone) with Trenton fossils. As advocated here, the Wappinger Group is conceived of as a carbonate-quartzarenite suite embracing the Poughquag Quartzite at the base and terminating with the Copake Limestone at the top. Thus, the Group straddles ages from Early Cambrian through Early Ordovician (Canadian).

– *Wappinger Valley Limestone* (Dwight, W. B., 1881, p. 78; 1886, 1887)
Name consistently used by Dwight for group of carbonates which earlier were termed Wappinger (Dana, J. D., 1879, p. 378)—thus a junior synonym.

– *Warwick Limestone* (Mather, W. W., 1843, p. 367, 410)
Casually mentioned by Mather and never used since Mather's day. Obsolete senior synonym of Wappinger (part) (Dana, J. D., 1879, p. 378).

+ **Whitehall Formation** (limestones, dolostones) (Rodgers, J., 1937, p. 1576) *not* Whitehall of Wheeler, R. R. (1942, p. 518–524) *nor*

Whitehall of Flower, R. H. (1964, p. 156, 157)
Includes, in ascending order, basal sandstone (=Mosherville ?), Finch (new name) cherty dolostone (=Little Falls ?), Warner Hill Limestone (new), Skene Dolostone with lower Steve's Farm Limestone and upper Rathbunville School Limestone Members. The Warner Hill Limestone yields Late Cambrian (Trempealeau) trilobites; the Steve's Farm and Rathbunville School Limestones yield earliest Ordovician (Early Gasconadian) trilobites and nautiloid cephalopods. Accordingly, the Cambrian-Ordovician boundary lies about midway within the Whitehall Formation.

PRE-CAMBRIAN (HELIKIAN) AND CAMBRIAN AND ORDOVICIAN

– *New York City Group* (Scotford, D. M., Sept. 1956, p. 1158–1159)* (Prucha, J. J., Nov. 1956, p. 672–674)
* Name credited to Prucha, manuscript in preparation
Name given to include, in ascending order, Fordham Gneiss, Inwood Marble, and Manhattan Formation in Manhattan Prong region (south of Hudson Highlands). As such, is a "waste-basket" term for rocks of Helikian through Middle Ordovician ages. Recent investigators in this area have suggested rejection of the name New York City Group as it masks the known geologic relationships.

ORDOVICIAN

+ **Amsterdam Limestone** (Cushing, H. P., 1911, p. 141)
– *Annsville Phyllite* (Lowe, K., 1947, p. 10)
In the Peekskill outlier, name given to the phyllite overlying the Trenton marble equivalent (=Balmville). Name is unnecessary as Manhattan "A," Snake Hill, or Walloomsac are all available.
– *Atwater Creek Shale* (Ruedemann, R., 1925, p. 60)
Portion of Frankfort Shale characterized by *Climacograptus typicalis posterus* and *Glossograptus quadrimucronatus*. As such, it is a faunal unit and has no standing as a rock-stratigraphic unit.
+ **Austin Glen Graywacke** (Ruedemann, R., 1942, p. 28) *not* Austin Glen of Offield, T. W., (1967, p. 51)
– *Bald Mountain Limestone* (Mather, 1843, p. 367, 402) (Ruedemann, R. *in* Cushing, H. P. and Ruedemann, R., 1914, p. 78)
It is unclear whether Mather's Bald Mountain Limestone was as restrictive in type and age as Ruedemann's Bald Mountain Limestone. The latter usage is for tectonic blocks in a fault zone in the vicinity of Middle Falls, Washington County; fossils suggest a Canadian (Jeffersonian) age. Mather included this area but much more, probably not all tectonic blocks.
– *Baldwin Corner Formation* (limestones, dolostones) (Flower, R. H., 1964, p. 156, 157)
Unnecessary; forms upper portion of original Whitehall Formation (Rodgers, J., 1937, p. 1576).
+ **Balmville Limestone** (Holzwasser, F., 1926, p. 40)
The discovery of *Encrinurus cybeliformis* may make a correlation with the Larrabee (=Kirkfield) more reasonable.
+ **Barneveld** (Fisher, D. W., 1962, chart)
Name originally given for the stage interval, in the shelly sequence, between the base of the Shoreham (zone of *Cryptolithus tesselatus*), now termed Sugar River, to the top of the Cobourg Limestone. It is now recommended that the top of the Barneveld Stage be placed within the Hillier Limestone, at the *Amorphognathus superbus—A. ordovicicus* conodont zone boundary.
– *Bascom Formation* (limestones, dolostones, siltstones) (Cady, W. M., 1945, p. 542)
The interval known as Bascom in Vermont can be separated into several mappable units in New York. It is urged that the Bascom not be employed in New York as its usage tends to conceal the observable stratigraphic relations.
+ **Bedford Gneiss** (Fettke, C. R., 1914, p. 239)
Thought by Leo Hall (personal communication) to be of Late Ordovician age.
+ **Beech Limestone** (Oxley, P. and Kay, M., 1959, p. 836)
– *Bennett Bridge beds* (Ruedemann, R., 1925, p. 138)
Name given to a faunal zone *(Pholadomorpha nasuta)* in the Pulaski siltstones and shales; it, thus, has no standing as a rock-stratigraphic name.
– *Benson Dolostone* (Wheeler, R. R., 1941, p. 1938) *abstract*
Poorly defined; no description nor type locality given. Exact intention unclear; said to be

C_4 and D_1 of Brainerd and Seely (1890).

+ **Black River Group** (Vanuxem, L., 1842, p. 38)
  As presently conceived, name embraces more than the original Black River Limestone. Group includes the Pamelia, Lowville and Watertown units in the Black River Valley and the Amsterdam, Isle la Motte, and Orwell Limestones elsewhere in New York.

– *Bridport Dolostone* (Cady, W. M., 1945, p. 545)
  Junior synonym of Providence Island Dolostone (Ulrich *in* Ulrich, E. O. and Cooper, G. A., 1938, p. 26, pl. 58).

+ **Bucks Bridge Formation** (dolostones, sandstones) (Chadwick, G. H., 1915, p. 289)

+ **Bushkill Shale** (Drake, A. and Epstein, J., 1967, p. H6–H9)

? Camp Limestone (member of the Denmark Formation) (Chenowith, P. A., 1952, p. 530)
  There is some reservation whether the "rubbly-weathering blue-gray nodular argillaceous calcilutite and shale with thinner intercalated beds of hard, pure calcilutite, calcisiltite, and a few calcarenites" is lithologically distinct enough from the remainder of the Trenton units to be readily recognized.

– *Canajoharie Shale* (Ruedemann, R., 1912, p. 28)
  Name given for the older Utica, recognizable by different graptolites. Lithologically, the Canajoharie is no different from the Utica except the lower portion is slightly calcareous. Its top is lithologically indefinable within the Utica black-shale facies. The name Canajoharie has no status as a rock-stratigraphic unit. However, there is much merit in regarding the Canajoharie as a stage name to emphasize (as Ruedemann intended) the fact that the eastern part of the Utica facies is older than the western part. Accordingly, the Canajoharie Stage includes the graptolite zones of *Corynoides americanus* (older) and *Orthograptus ruedemanni* (younger)—an interval very close to Ruedemann's original definition of Canajoharie Shale.

– *Cassin Formation* (limestones, dolostones) Cushing, H. P., 1905, p. 362)
  Abbreviated form of Fort Cassin Formation (Whitfield, R. P., 1890, p. 25) and, thus, a junior synonym.

? Champlain (Emmons, R., 1842, p. 100)
  This name has endured a long and checkered history. Name originally given for all rocks in a sequence, beginning at the base of the Potsdam Sandstone and terminating at the top of the "Grey Sandstone" (Oswego Sandstone). As such, it included Late Cambrian rocks. Subsequently, Schuchert vainly attempted to promote the name Champlainian for the system of rocks now known as Ordovician. During the past half-century, the term has come to be synonymous with Middle Ordovician in North America. In some instances, it has been used synonymously with Mohawkian (Conrad, 1839, p. 63; Hall, J., 1842, p. 52). If the geologists of the late 19th century had not been so eager to adopt Lapworth's name Ordovician (1879), Champlainian would, today, be the official name for the system of rocks between the Cambrian below and the Silurian above. Whereas, there is no chance of supplanting the name Ordovician, it is appropriate that the name Champlainian be retained in recognition of the pioneer work performed on these rocks in New York. Precisely how the name should be employed in the future is debatable and probably must await committee action. A few suggestions follow: (1) use name as a subsystem for all post-Canadian Ordovician; because from the plate tectonics standpoint, and sedimentologically and faunally, the Champlainian is more distinct from the Canadian than the Devonian is from the Silurian, (2) use name for the Middle Ordovician series, (3) use name as a series between the Canadian and the Mohawkian, (4) greatly restrict the name to the stage occupied by Chazy Group rocks.

– *Chaumont Limestone* (Kay, M., 1929, p. 664)
  Originally applied to include Leray and Watertown Limestones of the Black River Group. Later, Kay, (1960, 1969) used the name in time-sense as a stage division (Chaumontian) of his Bolarian Series. More recently, Kay (1968) returned to using the name Watertown for the dark gray-black cherty limestone above the Lowville and beneath the Rocklandian Selby and Napanee Limestones.

+ **Chazy Group** (limestones, basal siltstone) (Emmons, E., 1842, p. 107)
  This name should only be used in the rock-stratigraphic sense. It has, sometimes, been used in a time-stratigraphic sense as Chazyan. This practice of dual-usage, while recognized by the Code of Stratigraphic Nomenclature, is not encouraged as it promotes much ambiguity. The stage name Montyan is herein suggested in preference to "Chazyan."

+ **Chuctanunda Creek Dolostone** (Fisher, D. W., 1954, p. 90–92)

? Cobourg Limestone (Raymond, P. E., 1921, p. 1)

In his classic study of the Trenton Group of New York, Kay (1937) used Cobourg to include a Hallowell (lower) and Hiller (upper) members. Later, the name came to be used in a time-sense as Cobourgian. In recent years it has been found that the Cobourgian is essentially equivalent to the Eden Stage of the Cincinnatian Series. Kay (1968) proposed Denley to include rocks previously called Denmark and Cobourg. Seemingly, in Ontario, Cobourg is a valid rock-stratigraphic name.

+ **Cohoes** (Fisher, D. W., new, herein)

Name introduced as a stage designation for the *Diplograptus multidens* Zone. The Cohoesian Stage is, thus, older than the Canajoharian Stage (Zones of *Corynoides americanus* and *Orthograptus ruedemanni)* and younger than the Normanskillian *(Nemagraptus gracilis)* Stage. The type locality is along the lower Mohawk River at Cohoes, New York.

+ **Copake Limestone** (Dana, J. D., 1879, p. 376–383)

+ **Cortlandt** (originally as Cortland) mafic complex (Dana, J. D., 1880, p. 194)

? Cranesville Dolostone (Fisher, D. W., 1954, p. 92–94)

Separation of this unit rested largely on identification of two poorly preserved specimens referred to as *Eccyliopterus*, suggesting that strata of Jeffersonian age occurred in the Mohawk Valley. Subsequent work by Fisher (unpublished) shows that the Cranesville is a dolomitized facies of the Fonda and Wolf Hollow Members of the Tribes Hill Formation. The earlier identification is overruled; the specimens were probably *Ecculiomphalus multiseptarius*, a common Tribes Hill gastropod. Name could be retained as a dolomitic facies of part of the Tribes Hill limestones.

? Croton Falls mafic complex (Fettke, C. R., 1914, p. 228)

An eastern Westchester County occurrence of a Late Ordovician mafic intrusion, represented by the compositionally similar Cortlandt mafic complex of western Westchester County.

+ **Crown Point Limestone** (Cushing, H. P., 1905, p. 368)

+ **Cumberland Head Argillite** (Cushing, H. P., 1905, p. 375)

? Cutting Formation (siltstones, dolostones, limestones) (Cady, W. M., 1945, p. 541)

Flower believed (1964) that the Cutting (Division C of Brainerd and Seely, 1890) was absent in New York by unconformity and introduced the name Great Meadows Formation for this rock interval. Fisher, D. W. and Mazzullo, S. J. (1976) prefer to use Flower's name Great Meadows for this rock interval, although they regard this as equivalent to Division C.

+ **Day Point Limestone** (Cushing, H. P., 1905, p. 368)

? Deepkill zone, beds (limestones, black shales) (Ruedemann, R., 1902, p. 546–575)

Although many workers have used the name "Deepkill Shale" in a rock-stratigraphic sense, it seems unquestionable that Ruedemann used the name in a time sense—the usage employed by some later workers. In fact, by the very nature of the title of the article, "The graptolite (Levis) facies of the Beekmantown Formation in Rensselaer County, New York" and from the chart on page 575, it is clear that the rock unit that Ruedemann found his graptolites in is his Beekmantown and that Deepkill was used in a time-sense. In subsequent papers, however, Ruedemann considered the Deepkill a rock unit, but of varying lithologies. His identification of the Deepkill was based on graptolites, not on lithologic criteria. Because the Deepkill section is tectonically isolated and these rocks of this age are unknown elsewhere, it seems that if the name is to be continued, that it be used in a time-sense.

– *Deer River Shale* (Ruedemann, R., 1925, p. 52)

Not a rock-stratigraphic unit. Zone of *Climacograptus typicalis posterus*, within the Utica black shale.

+ **Denley Limestone** (Kay, M., 1968, p. 1377)

Name proposed to include former Denmark and Cobourg Limestones, since altered to stage designations, Denmarkian and Cobourgian.

– *Denmark Limestone* (Kay, M., 1937, p. 267)

Top and bottom admittedly poorly defined lithologically. Later, came to be used as a stage term, Denmarkian, but its diagnostic fauna was not defined.

+ **Dolgeville facies** (alternating limestones and black shales) (Cushing, H. P. *in* Miller, W. J., 1909, p. 21, footnote)

– *Fairfield Slate* (Vanuxem, L., 1842, p. 56)
Mentioned under synonymies of Utica, as "Fairfield Slate of the Reports" but I was unable to find mention of this name in any of the four preceding annual reports. Name Fairfield revived by Kay (1937, p. 270) for upper three graptolite zones of Ruedemann's Canajoharie Shale, hence not a rock-stratigraphic unit.

? Fleury Limestone (Oxley, P. and Kay, M., 1959, p. 827, 829)
In New York, not readily distinct from remainder of Day Point.

\+ **Fonda Limestone** (Fisher, D. W., 1954, p. 89, 90)

? Fort Ann Limestone (Wheeler, R. R., 1941, p. 1938) *abstract*, Wheeler, R. R., 1942, p. 518), Rodgers, J., 1952, *in* Billings, M. P., Rodgers, J., and Thompson, J., p.35) *not* Fort Ann of Flower, R. H. (1964, p. 156, 158)
Wheeler originally applied the name Fort Ann Limestone to Division C3 of Brainerd and Seely (1890), but C3 was described as a sandstone! It is clear that the name was given to a thin calcilutite with solution cavities that yielded a Gasconadian fauna. In the Geological Society of America Guidebook for Field Trips for 1952, Rodgers used several names by R. H. Flower which were in press (galley proofs) by American Journal of Science. One of these, Fort Ann, was used as Wheeler had used it. However, Flower withdrew the paper and it was not published at that time. Essentially, the same paper (with some deletions and additions) appeared 12 years later in New Mexico Bureau of Mines and Mineral Resources, Memoir 12 (1964), with the name Fort Ann used for a different lithological unit! This overlay the original Fort Ann, which was given a new name—Smith Basin—the name given in 1952 to the younger unit of limestone and dolostone of Medial Canadian age. Flower's 1964 Fort Ann is this dolostone—limestone with Demingian fossils whereas Wheeler's Fort Ann and Flower's 1952 Fort Ann yield Gasconadian fossils. This transposition of the names Fort Ann and Smith Basin has created much confusion and their usefulness to future workers has been seriously impaired.

\+ **Fort Cassin Formation** (siltstones, limestones, dolostones) (Whitfield, R. P., 1890, p. 25)

\+ **Fort Edward Dolostone** (Fisher, D. W., new, herein)
Name proposed for the middle member of the Great Meadows Formation in Washington County, New York and Addison and Rutland Counties, Vermont. The type locality is on the Bushlea Farm, in pastures north of New York Highway 149 and one mile east of Smiths Basin on the Champlain Canal (Hartford 7.5′ quadrangle). The name is selected from the village of Fort Edward, 10 miles (16 km) southwest of the type section. Other reference sections are: Peckham Quarry, north of Hudson Falls on Washington County Highway 35; Kane Falls, one mile (1.6 km) northwest of Fort Ann; roadcut on New York Highway 22, two miles (3.2 km) east of Comstock.

The Fort Edward is a medium-thick bedded, quartzose and calcitic dolostone, locally cherty, which transitionally overlies the Winchell Creek Siltstone Member of the Great Meadows Formation. The lower half of the Fort Edward is a vermicular mottled calcitic dolostone with rare limestone lenses. These lenses yield asaphid (*Symphysurina*) and hystricurid trilobites, ellesmeroceroid nautiloids, and gastropods (*Gasconadia, Ophileta*) which denote a Medial Gasconadian age (trilobite Zone B of Ross and Hintze). The upper half is less mottled, lighter colored, and locally very cherty. Where the mottling is vague or absent and chert is lacking, the Fort Edward is not lithologically divisible—as usually is the case. Cryptalagal laminites, algal "biscuits," and small hemispheroidal stromatolites (*Cryptozoon*) are plentiful in some horizons. The Fort Edward Dolostone varies from 60 feet (18.2 m) to 150 feet (45.5 m) in Washington County. The Fort Edward is abruptly overlain by the *Paraplethopeltis*-bearing Smith Basin Limestone—Zone C of Ross and Hintze.

\+ **Fort Johnson Member** (limestones, dolostones) of Tribes Hill Formation (Fisher, D. W. 1954, p. 84, 85)

– *Fort Plain Shale* (Ruedemann, R. and Chadwick, G. H., 1935, p. 400)
Not a rock-stratigraphic unit. Zone of *Climacograptus spiniferus* in the Utica black shale facies.

\+ **Frankfort Shale** (Vanuxem, L., 1840, p. 372)

\+ **Gailor Dolostone** (Fisher, D. W. *in* Fisher, D. W. and Hanson, G. F., 1951, p. 807)

– *Gansevoort Shale* (Ruedemann, R. and Chadwick, G. H., 1935, p. 400)
Not a rock-stratigraphic unit. Zone of *Glos-*

sograptus quadrimucronatus cornutus in the Utica black shale facies.

+ **Glenburnie Shale** (Kay, M., 1929, p. 664)

? Glendale Limestone Member of Denmark Formation (Chenowith, P. A., 1952, p. 530)
Lithologic identity questionable in a sequence of greatly alternating calcarenites, calcisiltites, calcilutites, and calcareous shales.

+ **Glens Falls Limestone** (Ruedemann, R., 1912, p. 22)

+ **Great Meadows Formation** (Flower, R. H., 1964, p. 158)
Introduced as including Division A (a lower Skene Member and an upper Vly Summit Member) and part of Division B (Smith Basin Limestone Member) in Washington County, N.Y. However, I believe that the Great Meadows represents Division C of Brainerd and Seely (1898). Whether Cady's (1945) name for Division C (Cutting) should supplant Great Meadows is questionable because the respective lithologic sequences are somewhat different. Furthermore, Flower's use of Skene is incorrect and does not agree with Wheeler's original intention (1941, p. 1938) which was for a unit subjacent to Flower's Great Meadows Formation.

+ **Halcyon Lake Calc-Dolostone** (Knopf, E. B., 1946, p. 1212) *abstract*

− *Hallowell Limestone* (Kay, M., 1937, p. 278)
Name proposed for lower more massive Cobourg Limestone. Drawback is that base of unit is defined as abundance of *Pasceolus globosus*; there is no lithologic separation from underlying Denmark. Kay (1968) recommended that Denmark and Hallowell part of Cobourg be combined into Denley Limestone.

+ **Harrison Quartzdiorite Gneiss** (Merrill, F. J. H., 1898, p. 30)
Leo Hall (personal communication) regards this unit as a volcanic, intrusive into the upper schist and granulite member of the Hartland Formation.

+ **Harter Shale Member** of the Frankfort Formation (Kay, M., 1953, p. 64)

+ **Hasenclever Sandstone** (Kay, M., 1953, p. 66)

+ **Hathaway Breccia [Mélange]** (Hawley, D., 1957, p. 58, 68–77)
Doubtfully present in New York but locally well developed in northwestern Vermont. A submarine slide breccia (mélange) now regarded as low in the Iberville Shale, rather than atop the Iberville as Hawley believed.

− *Head Siltstone* (Oxley, P. and Kay, M., 1959, p. 821)
Junior synonym of Ste. Théresè Siltstone (Clark, T. H., 1952, p. 43)

+ **Hero Limestone** (Oxley, P. and Kay, M., 1959, p. 834, 835)
Lower reefy and calcarenitic limestone member of the Valcour Limestone.

+ **Heuvelton Sandstone** (Chadwick, G. H., 1915, p. 289, 291)

? Hewittville Limestone (Chadwick, G. H., 1920, p. 33)
Defined as uppermost calcilutite member of Bucks Bridge Formation. However, scarcity of outcrop prevents positive stratigraphic placement and identity.

+ **Hillier Limestone** (Kay, M., 1937, p. 280, 281)

− *Holland Patent Shale* (Ruedemann, R. and Chadwick, G. H., 1935, p. 400)
Not a rock-stratigraphic unit. Zone of *Climacograptus pygmaeus* in the Utica black shale facies.

+ **House Creek Limestone** (Walker, K., 1973, p. 11)

− *Hudson System* (Conrad, T. A., 1839, p. 58)
Name synonymous with Cambrian of eastern New York.

− *Hull Limestone* (Raymond, P. E., 1912, p. 348, 349)
Name antedated by Kirkfield (Johnston, R. A. A., 1911, p. 190)

+ **Iberville Shale** (Clark, T. H., 1934, p. 5)
Utilizing graptolites, Riva has demonstrated that the Iberville is a northwesterly facies of the Stony Point Shale.

+ **Indian Ladder shale and siltstone** (Clarke, J. M., 1911, p. 10)

+ **Indian River Formation** (shales, slates, cherts) (Keith, A., 1932, p. 360)

+ **Isle la Motte Limestone** (Emmons, E., 1842, p. 110)

+ **Kings Falls Limestone** (Kay, M., 1968, p. 1376)

? Kirkfield Limestone (Johnston, R. A. A., 1911, p. 190)
Whether the Larrabee Limestone is an attenuated eastern extension of the type Kirkfield is uncertain; use of Larrabee in N.Y. is preferred.

+ **Lacolle Conglomerate** (Clark, T. H. and McGerrigle, 1936, p. 665)
I do not consider this to be a sedimentary conglomerate. Rather, it shows all characters of a tectonic breccia, derived from passage of a thrust sheet of shale overriding a terrain of various carbonate units. Accordingly, the

Lacolle becomes a tectono-stratigraphic unit.

\+ **Larrabee Limestone** (Kay, M., 1937, p. 262, 263)

? Leray Limestone (Cushing, H. P. and Ruedemann, R., 1910, p. 84)

Name given for cherty phase of Watertown Limestone. In Ontario, this unit seems to possess more utility than in New York, where amount of chert is much less and imperceptibly gradational into noncherty limestone.

\+ **Lorraine Group** (Emmons, E., 1842, p. 119)

Comprises the litharenites and pelites above the Utica black shale facies and below the Queenston red shale facies. The Lorraine Group includes in ascending order, the Whetstone Gulf Shale (=Frankfort Shale), Pulaski shales and siltstones, and Oswego Sandstone.

\+ **Lowville Limestone** (Clarke, J. M. and Schuchert, C., 1899, p. 876, 877)

Name applied to the "Birdseye Limestone" of earlier articles and, thus, unquestionably a rock-stratigraphic unit. Kay (1960, 1969), however, has promoted the name as a Lowvillian Stage within the Bolarian Series. This is poorly founded as no chronologically diagnostic fossils are known from the Lowvillian Stage.

– *Loyal Creek Shale* (Ruedemann, R. and Chadwick, G. H., 1935, p. 400)

Not a rock-stratigraphic unit. Zone of *Dicranograptus nicholsoni*, a part of the Utica black shale facies.

\+ **Martinsburg Group** (Geiger, H. R., and Keith, A., 1891, p. 156–163)

– *Minaville Shale* (Kay, M., 1937, p. 268, 269)

Not a rock-stratigraphic unit. Includes the zones of *Mesograptus mohawkensis* and *Diplograptus amplexicaulis*, parts of the Utica black shale facies.

\+ **Mohawkian Series** or **Stage** (Conrad, 1839, p. 63; Hall, 1842, p. 52)

Originally encompassed carbonate rocks beginning at the top of "The Bastard Limestone" (Palatine Bridge Member of the Tribes Hill Formation) and including the remainder of the Tribes Hill, Black River Group, and lower Trenton Group. Later, only Black River and Trenton Groups were included—the time usage that is currently employed.

\+ **Montreal Limestone** (Clark, T. H., 1952, p. 65)

\+ **Monty** (Fisher, D. W., new, herein)

Name introduced as a stage designation to include the Chazy Group of rocks. The Montyan Stage should be used specifically as the trilobite zone of *Pliomerops canadensis* and generally to embrace the time represented by the varied and abundant fauna of the Chazy Group. The Monty Stage is older than the Turin Stage and younger than the Whiterock Stage in the shelly sequence. The name is selected from Monty Bay on the New York shore of Lake Champlain; appropriately the type locality is in the Chazy region of Clinton County, New York.

– *Moose Creek Shale* (Ruedemann, R., 1925, p. 137)

Not a rock-stratigraphic unit. Zone of *Dalmanella emacerata* and *Plectambonites rugosus major* in the Whetstone Gulf Shale.

– *Morphy Shale* (Ruedemann, R., and Chadwick, G. H., 1935, p. 400)

Not a rock-stratigraphic unit. Zone of *Mesograptus mohawkensis*, part of the Utica black shale facies.

– *Mount Anthony Formation* (MacFadyen, J. A., Jr., 1956, p. 28–29)

Argillaceous-schistose rocks overlying the Walloomsac Slate along the New York-Vermont line near Bennington. Considered to be Middle Ordovician by MacFadyen and P. C. Hewitt (1961) and to transitionally overlie the Walloomsac. Now regarded as thrust-faulted on the Walloomsac and as Early Cambrian or older age. Name unnecessary as Nassau or Rowe are available.

\+ **Mount Merino Formation** (shales, cherts) (Ruedemann, R., 1942, p. 23)

Not Mount Merino of Offield, T. W. (1967, p. 50).

\+ **Moyer shale and siltstone** (Kay, M., 1953, p. 66)

? Napanee Limestone (Kay, M., 1937, p. 255)

There is some reservation among some Canadian stratigraphers whether the Napanee of Napanee, Ontario occurs in New York State.

– *Neelytown Limestone* (Horton, W., 1839, p. 148) (Mather, W. W., 1843, p. 400, 401)

Field investigation (Fisher, D. W., unpublished) shows this isolated carbonate locality to consist of Middle Ordovician Balmville Limestone (with fossils) disconformably on the Halcyon Lake division of the Wappinger Group. Perpetuation of the name Neelytown would serve no useful purpose.

? New Rochelle serpentine [Serpentinite] (Dana, J. D., 1880, p. 31)

Isolated patch of ultramafic intrusion near New Rochelle, Westchester County; see also Merrill, F. J. H., 1898 (report for 1896) p. 39.

Figure 72. *Poughkeepsie Mélange. Type locality: Kaal Park, under east approach to Mid-Hudson Bridge, Poughkeepsie, Dutchess County, N.Y.*

Figure 73. *Poughkeepsie Mélange. Type locality: Kaal Park, under east approach to Mid-Hudson Bridge, Poughkeepsie, Dutchess County, N.Y. Note angular blocks of Austin Glen Graywacke.*

+ **Normanskill Group** (Ford, S. W., 1884, p. 207; Lapworth, 1886, p. 170, 171, 173; Ruedemann, R., 1901, p. 538)

Comprises, in ascending order, Indian River shale and chert, Mount Merino shale and chert, and Austin Glen Graywacke. However, name Normanskill was clearly intended as a faunal or time term by Lapworth and Ruedemann. Accordingly, many use Normanskill(ian) as a time term rather than as a rock unit name.

− *Norton Member* of Tribes Hill Formation (Wheeler, R. R. 1941, p. 1938) *abstract;* (Wheeler, R. R., 1942, p. 522, 523)

Poorly defined; delimited as upper part of C_1 and all of C_2 of Brainerd and Seely (1890) in Washington County, New York. But Tribes Hill Formation does not occur in Washington County! No description nor type locality given.

− *Nowadaga Shale* (Ruedemann, R. and Chadwick, G. H., 1935, p. 400)

Not a rock-stratigraphic unit. Zone of *Climacograptus typicalis* of Ruedemann, a part of the Utica black shale facies. I have revived the name, still in its time-sense, for the zones of *Climacograptus spiniferus* and *C. pygmaeus* of Riva.

+ **Ogdensburg Dolostone** (Chadwick, G. H., 1915, p. 289)

Senior synonym of Oxford (named by Wilson, A. E., 1937, p. 45; 1938, map) not defined until 1946 (Wilson, A. E.)

+ **Orwell Limestone** (Cady, W. M., 1945, p. 556)

+ **Oswego Sandstone** (Vanuxem, L., 1842, p. 67) *not* Oswego of Vanuxem (1839, p. 245)

+ **Owl Kill Member** of Poultney Formation (Potter, D. B., 1972, p. 20)

+ **Palatine Bridge Member** (dolostones, limestones, shales) of the Tribes Hill Formation (Fisher, D. W., 1954, p. 85–87)

+ **Pamelia Dolostone** (Cushing, H. P., 1908, p. 158)

? Pawlet Graywacke (Zen, E-an, 1961, p. 307) (Doll, C. G., *et al.*, 1961, map)

Credited to Robert Shumaker, MS. in preparation; as new (Shumaker, 1967, p. 31). Exactly how the Pawlet differs from the Austin Glen Graywacke is unclear.

? Peach Lake mafic intrusive (Balk, R., 1936, map)

+ **Pen Argyl Shale** (Behre, C. H., Jr., 1926, p. 485–487)

+ **Poland Limestone** (Kay, M., 1943, p. 598)

+ **Poughkeepsie Mélange** (Fisher, D. W., new, herein)

Name proposed for the tectono-sedimentary breccia consisting of poorly sorted, vari-sized and vari-lithological clasts in an unbedded or poorly bedded mudstone within the Snake Hill Shale in the Mid-Hudson Valley. The type locality is at Kaal Park, beneath the Mid-Hudson Bridge, in the city of Poughkeepsie. Splendid reference sections occur along the Penn-Central railroad in and north of Poughkeepsie; the mélange is widespread in western Dutchess County—generally west of the Taconic Parkway. The Poughkeepsie Mélange extends northward into Columbia and Rensselear Counties where it is observed to be well developed in Emmon's (or Logan's) Fault Zone.

For the most part, the mélange is characterized by clasts of Austin Glen graywacke, quartzite, siltstone, argillite, and shale; locally, carbonate clasts (as young as Balmville Conglomerate and including the famous Rysedorph Hill Conglomerate) are prevalent. In some areas, such as in the Wappinger Creek Valley, from New Hamburg on the south to Upton Lake on the north, relatively large disoriented blocks of carbonate form a linear mega-breccia which should not be confused with the random-distributed Poughkeepsie Mélange.

Graptolites from the surrounding Snake Hill Shale are indicative of the *Diplograptus multidens*, *Corynoides americanus*, and *Orthograptus ruedemanni* Zones, denoting that the mélange formation was of Medial Mohawkian (late Cohoes and Canajoharie ages).

Obviously, the thickness of the Poughkeepsie Mélange is virtually indeterminable but it must possess a maximum thickness in excess of 200 feet (61 m).

+ **Poultney Formation** (slates, argillites, cherts, siltstones) (Keith, A., 1932, p. 360, 403)

+ **Providence Island Dolostone** (Ulrich, E. O. *in* Ulrich, E. O. and Cooper, G. A., 1938, p. 26)

+ **Pulaski shale and siltstone** (Vanuxem, L., 1840, p. 373)

+ **Quassaic Quartzite** (and sandstones, siltstones, shales) (Fisher, D. W., 1971, map)

Quassaic was chosen (Fisher, *in* Fisher, Isachsen, Rickard, 1970) to fill the absence of a geographic name for the prominent molasse (largely quartzite and sandstone) which forms the Hussey Hill-Illinois Mountain-Marlboro Mountain north-south ridge extending from Kingston on the north to Newburgh on the south—in the Mid-Hudson Valley.

The type locality is along the railroad one mile (1.6 km) southwest of Esopus in Ulster County, where a continuous section of 400 feet (122 m) is exposed to advantage; the total thickness is estimated to be near 2,000 feet (610 m). The Quassaic's lower contact with the Snake Hill shales and siltstones is seemingly conformable but lithologically sharp; the upper contact (only known at Kingston) is unconformable with the overlying Late Silurian Wilbur Limestone.

The Quassaic is predominantly massive pink or green quartzite and massive tan quartzitic sandstone, with lesser amounts of red conglomerate, tan subgraywacke, and interbeds of green and greenish-gray shale. Ripple marks are common in the quartzites; trace fossils are less common. The sandstones hold molds of articulate brachiopods, gastropods, straight-shelled nautiloids, and rare bryozoans and ostracodes. Clasts in the red conglomerates can be identified as Indian River red slate and red chert, Mount Merino black chert, laminated calcilutites from the Germantown Formation, green slate and greenish-gray quartzites of the Stuyvesant Falls Formation, and green micaceous slate from the Nassau Formation; no gneisses were observed. This composition points to a derivation from subaerially exposed allochthonous units of the gravity slides in Dutchess County. Accordingly, a late Mohawkian (Nowadagan) sediment-filling of the Snake Hill basin is advocated.

\+ **Queenston Shale** (Grabau, A. W., 1908, p. 622)

\+ **Ramseyburg Member** (shales, siltstones, graywackes) of Martinsburg Formation (Drake, A., and Epstein, J., 1967, p. H9–H12)

? Rathbun Limestone Member of Denmark Formation (Kay, M., 1943, p. 598, 599)

Identity questionable within a sequence of lithologically identical alternating types of limestone.

\+ **Rathbunville School Limestone Member** of Whitehall Formation (Flower, R. H., 1964, p. 156, 157)

? Ravenswood Gneiss (Berkey, C. P., 1910, p. 250)

Future work needs to be done in the Long Island City area, to verify the separate designation of this unit.

\+ **Ritchie Limestone** (Fisher, D. W., and Hanson, C. F., 1951, p. 805)

Fisher originally classed this unit as latest Cambrian or earliest Ordovician as fossils then known were nondiagnostic; Hanson believed that Ritchie might have been a facies of the Late Cambrian Hoyt Limestone. D. H. Zenger (unpublished) has established the Ritchie as a limestone lens within the Gasconadian Gailor Dolostone; diagnostic fossils have been found in the Ritchie by Zenger.

\+ **Rochdale Limestone** (Dwight, W. B., 1887, p. 32)

\+ **Rockcliffe shale and sandstone** (Wilson, A. E., 1946, p. 17)

\+ **Rockland Limestone** (Raymond, P. E., 1912, p. 348, 349)

During the past two decades, Kay and his students have employed a time-stratigraphic sense to this name by the use of Rocklandian Stage.

\+ **Russia Limestone Member** of the Denmark Formation (Kay, M., 1943, p. 598, 601)

\+ **Rust Limestone Member** of the Cobourg Formation (Kay, M., 1943, p. 598, 601)

? Rye serpentine [Serpentinite] (Dana, J. D., 1880, p. 31)

Name casually mentioned for isolated exposure of ultrabasic rock in Rye, New York.

? Rysedorph Hill Conglomerate (Ruedemann, R., 1901, p. 7)

In later papers by other workers the name has been abbreviated to Rysedorph Conglomerate. It has now been established that the type Rysedorph Hill Conglomerate is a transported block within an extensive mélange; other localities where this unit has been mapped are also tectonic blocks but all are not of the same age. The advisability of continuing to use this name is highly dubious.

\+ **St. Martin Formation** (limestones, shales, sandstones) (Wilson, A. E., 1946, p. 19)

\+ **Ste. Thérèse Siltstone** (Clark, T. H., 1952, p. 43)

Basal Chazy Group clastic; senior synonym of Head (Oxley, P. and Kay, M., 1959, p. 821)

– *Salmon River Sandstone* (Conrad, T. A., 1837, p. 164; 1839, p. 63) (Vanuxem, 1840, p. 374)

Whereas this name has priority and the type locality at Salmon River Falls on the Salmon River, Oswego County is a superb one, the name fell into disuse by the "District Geologists of New York," themselves—to be supplanted by Oswego. Obsolete senior synonym of Oswego Sandstone.

– *Sandy Creek* (Ruedemann, R., 1925, p. 137)

Not a rock-stratigraphic unit. A lower zone of *Lyrodesma poststriatum* and *Ischyrodonta unionoides* and an upper zone of *Rafines-*

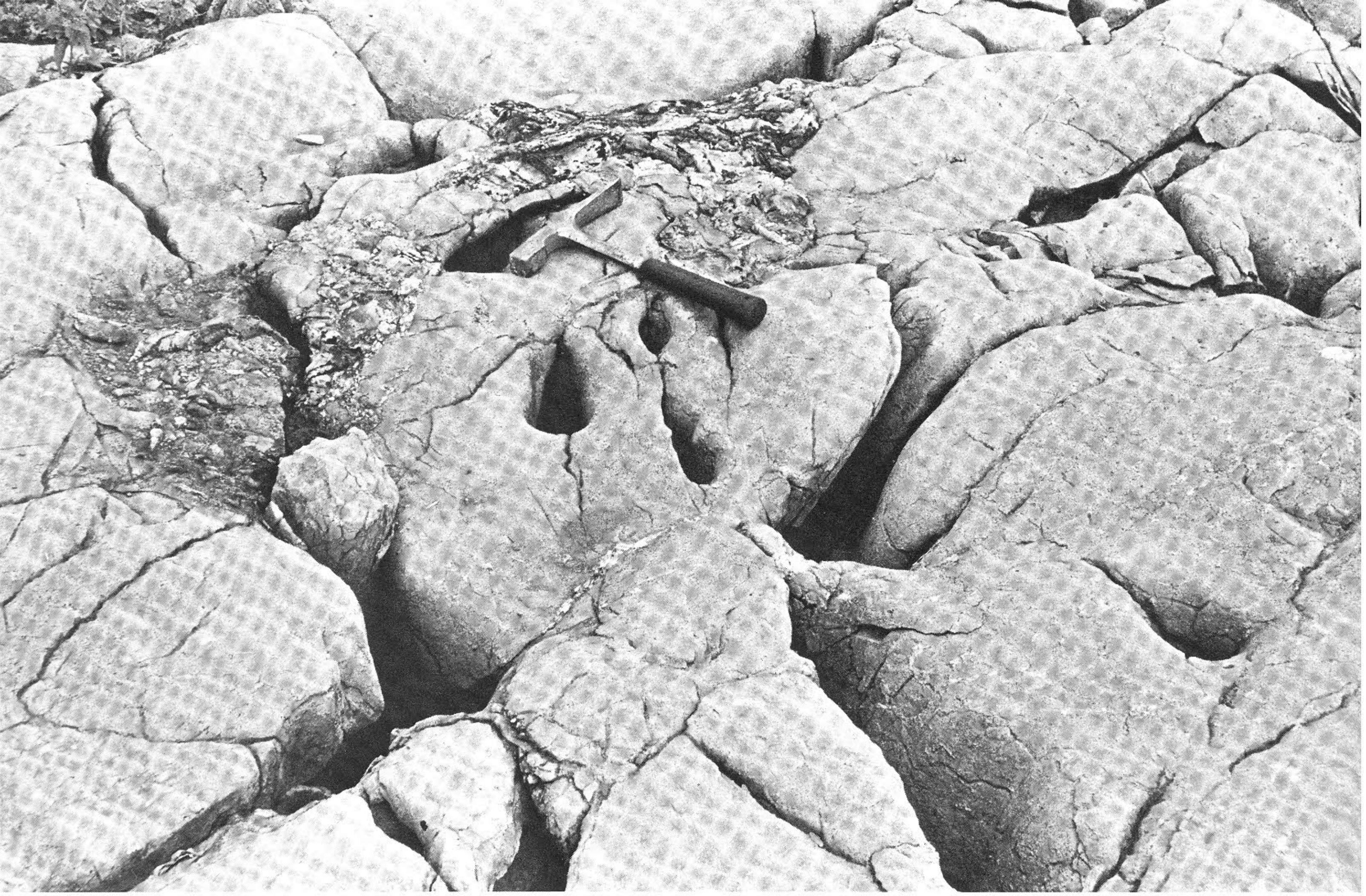


Figure 74. *Ordovician solution cavities, Smith Basin Limestone. Bushlea Farm, east of Smiths Basin, Washington County, N.Y. Note breccia filling of overlying basal Fort Ann Formation.*

quina mucronata and *Zygospira* (?) *erratica* in the Pulaski shales and siltstones.

\+ **Schaghticoke Shale** (Ruedemann, 1903, p. 935)
Type exposure is in a tectonic sliver along Emmon's Line. Equivalent to lower member (A) of Poultney Formation.

\+ **Schenectady Formation** (sandstones, siltstones, shales) (Ruedemann, R., 1912, p. 37)

\+ **Sciota Limestone** (Fisher, D. W., new herein)
Name proposed for the middle calcitic (and most fossiliferous) member of the Fort Cassin Formation in the Champlain Valley. The type locality (Thorn Hill 7.5′ quadrangle) is in the vicinity of the abandoned Sciota School, along Washington County Route 10, 5.3 miles (8.5 kilometers) north-northeast of the intersection of U.S. 4 and N.Y. 22 in Whitehall. The Sciota is transitional with the subjacent Ward Siltstone Member (new) and the superjacent Providence Island Dolostone Member.

The Sciota Limestone is a medium-thick bedded, fine-coarse textured, dolomitic limestone with lesser calcitic dolostone, and quartzose beds. The thicker limestones are dark gray-black, weather very light gray, and are fine-textured; some thinner limestones are light-medium gray, weather medium gray, and are coarse-textured. The thicker fine-textured limestones fracture conchoidally and commonly are laminated. Where dolomite is present, fretwork weathering is ubiquitous.

Fossils are relatively common in the Sciota Member of the Fort Cassin Formation. Straight and coiled cephalopods (*Protocameroceras, Eurystomites, Tarphyceras*), a great variety of low-spired (*Ophileta*) and high-spired (*Fusispira*) gastropods, trilobites (*Isoteloides whitfieldi*) and locally profuse ostracodes (*Isochilina punctata*) as well as brachiopods, conodonts, and stromatolites constitute the principal faunal elements. The Sciota is of Late Canadian (Cassinian) age.

The Sciota Limestone is absent in southernmost Washington County but increases steadily northward to about 115 feet (35 meters) in the northernmost part of the County.

? Scott Limestone (Oxley, P. and Kay, M., 1959, p. 821, 827)

Not separately identifiable within the Day Point Limestone of New York.

? Selby Limestone (Kay, M., 1937, p. 252)

Some Canadian stratigraphers question whether there is any true Selby in New York. Lithologically like the Watertown Limestone except for isolated chert; both have *Gonioceras* along Mill Creek in village of Lowville.

? Sherman Fall Limestone (Kay, M., 1929, p. 664)

Name given for combined Shoreham and Denmark Limestones of Kay (1937). Later Kay attached time-significance by using name as Shermanian Stage. Just what fossils characterize this stage is not clear.

– *Shoreham "Limestone"* (Kay, M., 1937, p. 264, 265)

Not a rock-stratigraphic unit. Defined as zone of *Cryptolithus tesselatus*. Now used almost exclusively in time-sense as Shorehamian Stage or Substage.

? Smith Basin Limestone (Rodgers, J. *in* Billings, M. P., Rodgers, J., and Thompson, J., 1952, p. 35) *not* Smith Basin of Flower, R. H. (1964, p. 156, 158)

Flower's original intention, in Rodgers, 1952 and in unpublished MS. (galley proof) for American Journal of Science was to name *Lecanospira*-bearing (Middle Canadian) strata in the Fort Ann, Washington County, area-Smith Basin Limestone. However, in his 1964 article (essentially that of the earlier MS.) he transposed the names Smith Basin and Fort Ann, so that his published Smith Basin is the name given to a thin Gasconadian limestone at the top of his Great Meadows Formation and beneath the Smith Basin (Demingian) of Rodgers! This transposition of names has caused confusion to later workers.

+ **Snake Hill Formation** (shales, siltstones) (Ruedemann, R., 1912, p. 58)

Ulrich, E. O. (1911, pl. 27) was first to cite name but Ruedemann had MS. in preparation at the time and name should be credited to Ruedemann, who first described the unit. Berry, W. B. N. (1963, p. 731, 736) advocated the abandonment of the name Snake Hill. Work by Riva (unpublished) and Fisher (unpublished) emphasizes the fact that the Snake Hill Shale is a perfectly valid mapping unit in the Hudson River Valley—as Holzwasser (1926) and Ruedemann (1930, 1942) used it.

+ **Spellman Limestone** (Fisher, D. W., 1962b, chart)

– *Sprakers* (Ruedemann, R. and Chadwick, G. H., 1935, p. 400)

Not a rock-stratigraphic unit. Zone of *Diplograptus amplexicaulis*, a part of the Utica black shale facies.

+ **Staten Island serpentine** [Serpentinite] (Merrill, F. J. H., 1898, report for 1896, p. 43)

+ **Steuben Limestone Member** of Cobourg Formation (Kay, M., 1943, p. 598, 601, 602)

+ **Steve's Farm Limestone** (Flower, R. H., 1964, p. 156, 157)

+ **Stony Point Shale** (Ruedemann, R., 1921, p. 112)

+ **Stuyvesant Falls Formation** (shales, quartzites, cherts, limestone conglomerates) (Fisher, D. W., 1961, p. D9, 1962b, chart)

+ **Sugar River Limestone** (Kay, M., 1968, p. 1376)

– *Tackawasick Limestone* (Ruedemann, R., 1929, p. 410; 1930, p. 99, 115)

Now known as a sliver of Trenton (Balmville) Limestone along a fault.

+ **Trenton Group** (limestones) (Conrad, T. A., 1838, p. 108) (Vanuxem, L., 1838, p. 257)

Conrad's introduction of the name Trenton has page precedence.

– *Tremaines Bridge* (Ruedemann, R., 1925, p. 137)

Not a rock-stratigraphic unit. Zone of *Dekayella ulrichi* and *Arthropora cincinnatiensis*, the basal part of the Pulaski shales and siltstones.

+ **Tribes Hill Formation** (limestones, dolostones, all gradations between; shales) (Ulrich, E. O. and Cushing, H. P., 1910, p. 780)

+ **Turin** (Fisher, D. W., new, herein)

Name introduced as a stage designation to include the shelly faunas in the carbonates of the Black River Group and the Rocklandian division of the Trenton Group. The name is selected from Turin Township in the Black River Valley where there is a splendid development of these rocks. As presently conceived, the Turinian Stage equates with the *Bathyurus extans* and *Raymondites spiniger* trilobite zones and approximately to conodont zones 7 and 8 of Sweet, Ethington, and Barnes (1970); The Turinian Stage is approximately correlative with the *Diplograptus multidens* graptolite zone of Riva.

+ **Utica Shale** (Vanuxem, L., 1842, p. 56; Emmons, E., 1842, p. 106)

+ **Valcour Limestone** (Cushing, H. P., 1905, p. 368)

– *Vly Summit Dolostone* (Flower, R. H., 1964, p. 156, 158)

Described as an upper member of the Great Meadows Formation. Usability questioned as base is vague; lithology not unlike lower Great Meadows.

– *Wait Siltstone* (Oxley, P. and Kay, M., 1959, p. 827)

Thin siltstone (few inches to two feet) on Isle la Motte, Vermont is unrecognizable in New York. Name seems unnecessary.

+ **Walloomsac Slate** (Prindle, L. M. and Knopf, E. B., 1932, p. 268)

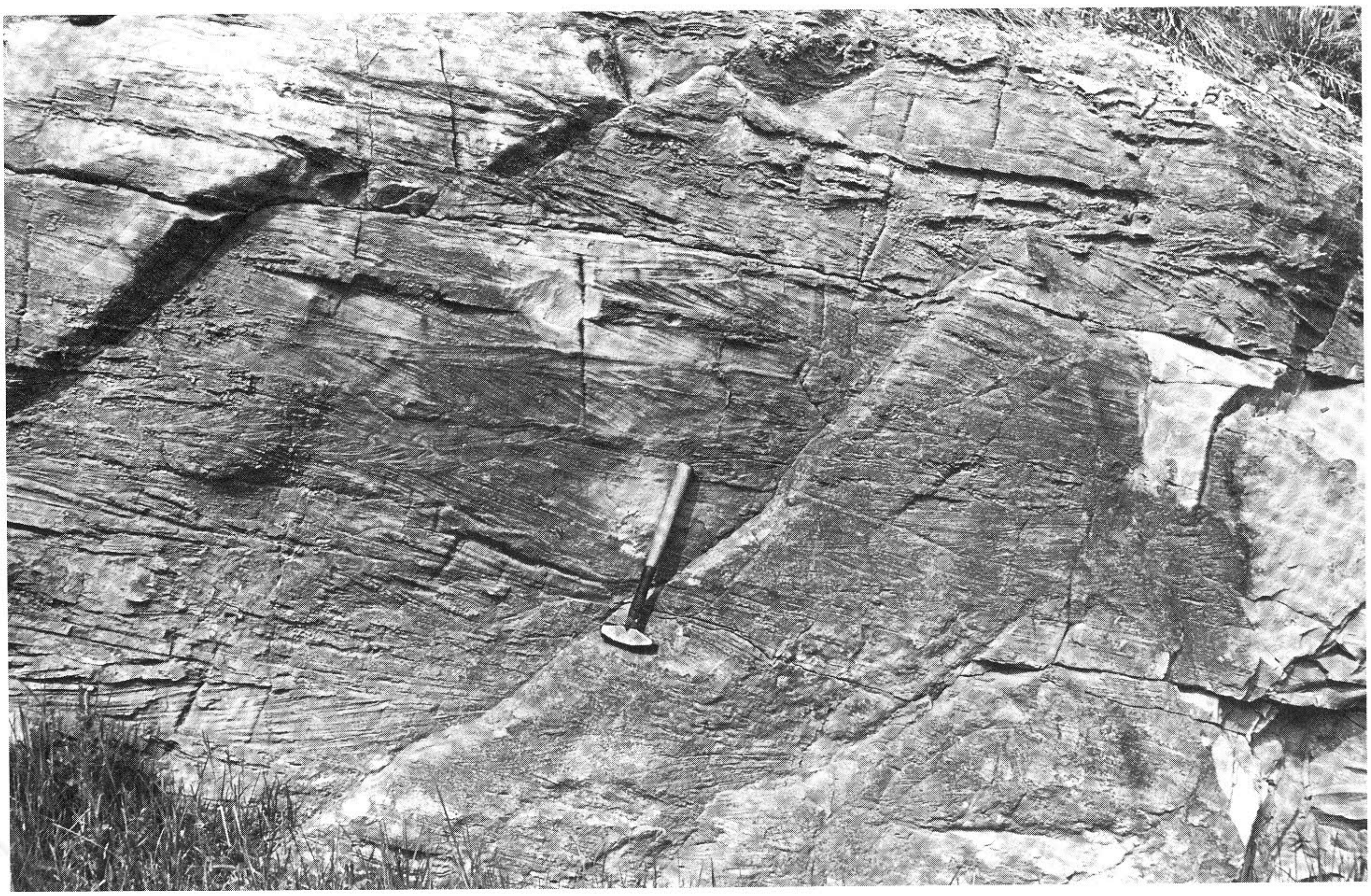
+ **Ward Siltstone** (Fisher, D. W., new, herein)

Name proposed for the basal quartzose member of the Fort Cassin Formation in Washington County, N.Y., and neighboring Vermont. The type locality (Thorn Hill 7.5′ quadrangle) is near the Ward Farm, along Washington County Route 10, 4.4 miles (7.1 kilometers) north-northeast of the intersection of U.S. 4 and N.Y. 22 in Whitehall. The name is taken from Ward Marsh, which flanks the Ward Farm on the south.

The Ward Siltstone consists of thin-bedded, laminated and cross-laminated, calcitic and dolomitic siltstones, with minor fine-grained sandstones, bluish-gray on fresh fracture, and weathering tan to tan-gray. Lithologically, the Ward is strikingly similar to the Winchell Creek Siltstone at the base of the older Great Meadows Formation. The Ward everywhere overlies the Medial Canadian Fort Ann Formation and underlies the Sciota Member (new) of the Late Canadian Fort Cassin Formation. Its thickness varies from zero and reaches 95 feet (29 meters) at Shoreham, Vermont.

A few trace fossils, but no diagnostic fossils, have been discovered in the Ward.

Figure 75. *Winchell Creek Siltstone, Fort Ann Quadrangle. Along road east from Baldwin Corner, south of Fort Ann, Washington County, N.Y.*



+ **Watertown Limestone** (Cushing, H. P. and Ruedemann, R., 1910, p. 84)

+ **Whetstone Gulf Shale** (Ruedemann, R., 1925, p. 147)

+ **Whipstock Breccia** (Zen, E-an, 1963, p. 345; Bird, J. M., 1963, p.18)

    Bird credits name to D. B. Potter, work in progress (Potter, D. B., 1972, p. 30). Part of the extensive mélange associated with the gravity slides of the Taconian Orogeny; in the Hoosick Falls, Rensselaer County, area.

+ **White Creek Member** of Poultney Formation (Potter, D. B., 1972, p. 19)

+ **Winchell Creek Siltstone** (Fisher, D. W., new, herein)

    Name proposed for the basal siltstone member of the Great Meadows Formation in Washington County, New York and Addison and Rutland Counties, Vermont. The type locality is on the Bushlea Farm, in pastures and an abandoned quarry north of N.Y. Highway 149 and one mile east of Smiths Basin on the Champlain Canal (Hartford 7.5′ quadrangle). The name is selected from Winchell Creek which flows north and west into the canal at Dewey Bridge (Fort Ann 7.5′ quadrangle). Supplemental reference sections occur along the north side of U.S. Highway 4 and in the currently inactive Tri-States quarry 1.2 miles (1.9 km) east of Whitehall (Whitehall 7.5′ quadrangle) and along Dewey Bridge Road 1.1 mile (1.76 km) east of U.S. Highway 4 (Fort Ann 7.5′ quadrangle).

    This conspicuous and superb mapping unit consists of laminated, cross-laminated, and cross-stratified, dolomitic, quartzo-feldspathic siltstones with thin lenses of sandstone and argillaceous siltstone; thin silty shale interbeds are rare. Ripple marks, dessication cracks, and trace fossils are characteristic of the Winchell Creek. Prolonged weathering of the rocks accentuates the laminations an cross-stratifications, producing the appearance of fine-grained wood—as noted by Brainerd and Seely (1890, p. 2). The thickness of the Winchell Creek varies from near zero in the Glens Falls area to 110 feet (34 m), 4 miles (6.4 km) northeast of Whitehall; the average thickness in Vermont is about 60 feet (18.2 m).

+ **Wolf Hollow Limestone Member** of Tribes Hill Formation (Fisher, D. W., 1954, p. 87–89)

– *Wood Creek* (Ruedemann, R., 1925, p. 137)

    Not a rock-stratigraphic unit. Zone of *Cryptolithus bellulus* and *Bollia pulchra* in the Whetstone Gulf Shale.

– *Worthville* (Ruedemann, R., 1925, p. 137)

    Not a rock-stratigraphic unit. Zone of *Pholidops subtruncata* and *Lyrodesma cincinnatiense* in the Pulaski shales and siltstones.

CAMBRIAN, ORDOVICIAN, SILURIAN, DEVONIAN

– *New York System* (Vanuxem, L., 1842, p. 11–13; Emmons, E., 1842, p. 99; Hall, J., 1843, p. 17–18; Mather, W. W., 1843, p. 298, 299)

    Name used by the "District Geologists" of the Geological Survey of New York (founded 1836) for the then-thought-to-be essentially continuous sequence of fossil-bearing rocks that occurred in New York State. The name never gained favor outside of New York and, following disbandonment of the Survey, the name fell into disuse after 1843.

AGE UNKNOWN

? Amawalk Granite [granitic gneiss] (Fluhr, T. W., 1948, p. 699)

    Indicated on map legend as underlying Croton Falls diorite [mafic complex] and overlying Thomaston Granite [granitic gneiss]. No additional information is available on this unit.

? Riga Schist (Hobbs, W. H., 1893, p. 717–736, 780–802)

    Unit may be present in easternmost Dutchess County but name has not been used since Hobb's day. Future mapping should determine the advisability of continuing to use this name.

? Siscowit Granite [granitic gneiss] (Scotford, D. M., 1956, p. 1177)

    Name proposed for rock that was formerly termed Thomaston Granite in the Siscowit Reservoir, Westchester County area. Name not used since and no additional information is available.

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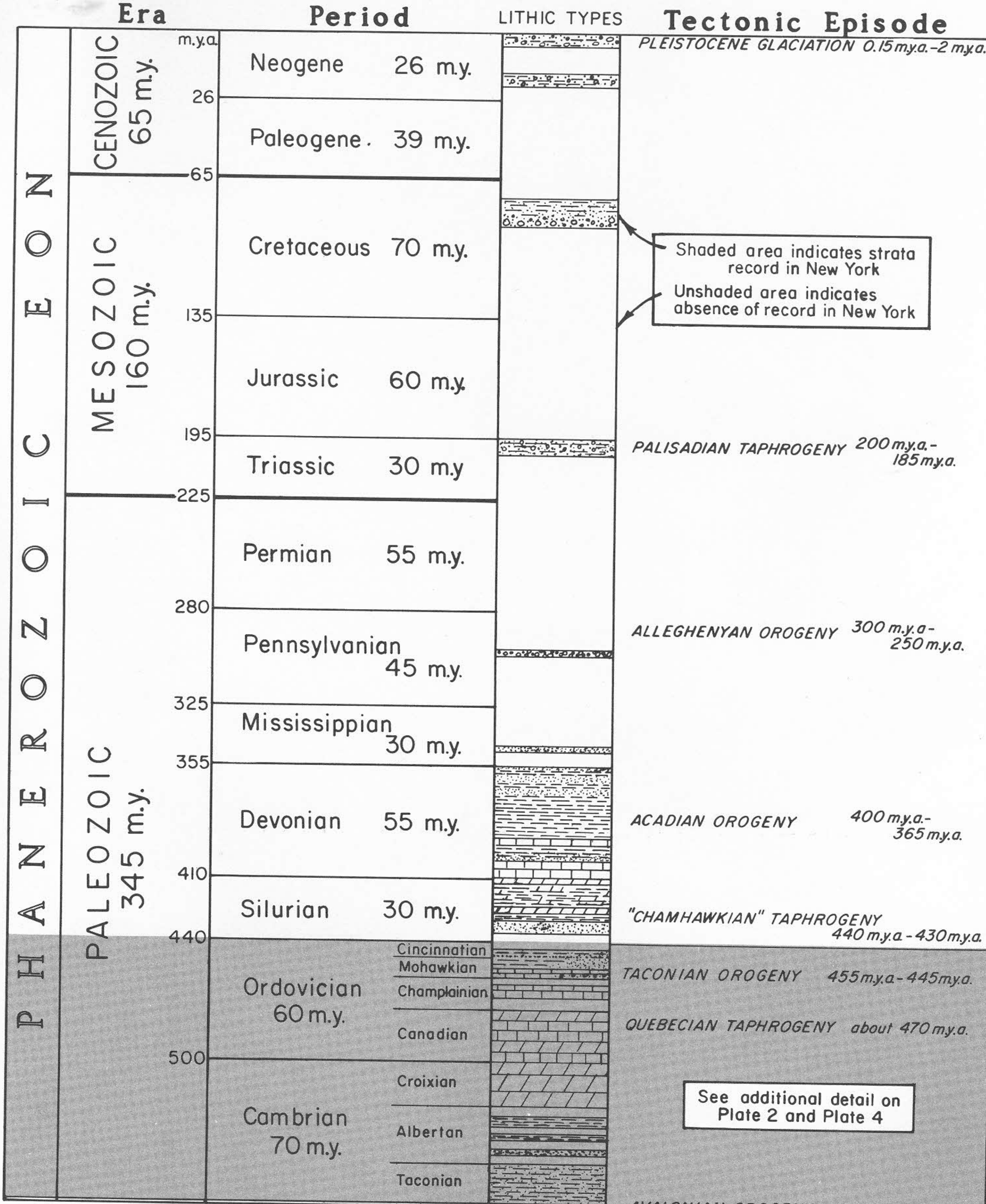
Figure 76. Geologic Time Scale

PHANEROZOIC EON



NOTE: m.y. = millions of years　　*m.y.a. = millions of years ago*

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GEOLOGICAL SURVEY
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PLATE 1. PRINCIPAL ORDOVICIAN, CAMBRIAN, and HADRYNIAN FACIES in NEW YORK STATE (LEGEND FOR PLATE 2 and PLATE 4)

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PLATE 2. CORRELATION of the HADRYNIAN, CAMBRIAN, and ORDOVICIAN ROCKS in NEW YORK STATE

Fisher, Donald W. (1977)
New York State Museum
Map and Chart Series--Number 25

Chart layout-D.W.Fisher
Drafting-G.Y.Gillette 12/1975

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TABLE OF ROCK THICKNESSES

For identification of quadrangles, align columns with Plate 2.

Key:

500 Outcrop thickness in feet.
500 Outcrop thickness in meters.
— Rock absent.

ADIRONDACK BORDER REGIONS

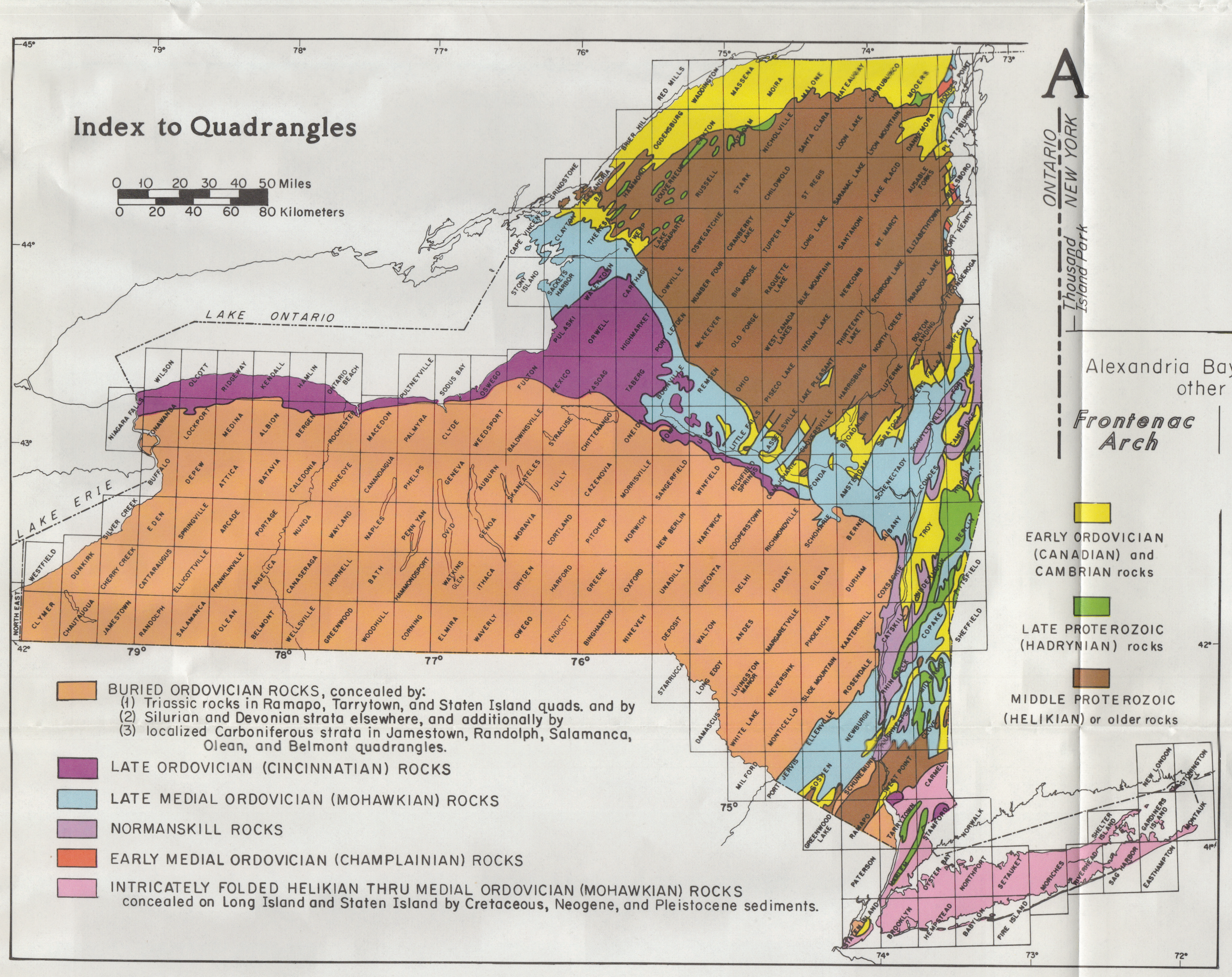
Major Rock Units	Lake Ontario Plain	Tug Hill Plateau, Black R. Valley	St. Lawrence Valley					Champlain Valley				Mohawk Valley				
QUEENSTON	500-970 *152-296*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
LORRAINE, QUASSAIC	0-1000 *0-305*	550-1000 *168-305*	—	—	—	—	—	—	—	—	—	2500 *762*	2000 *610*	1200 *366*	150-500 *46-152*	550 *168*
UTICA-SNAKE HILL	—	150-275 *46-84*	—	—	—	—	—	1000+ *305+*	2000 *610*	3000 *914*	3500 *1067*	2500 *762*	1600 *488*	1200 *366*	1000 *305*	400-700 *122-214*
TRENTON	—	400-525 *122-160*	—	—	—	—	—	250 *76*	200 *61*	150 *46*	150 *46*	75 *23*	55 *17*	45 *14*	0-20 *0-6*	200 *610*
BLACK RIVER	—	150-275 *46-84*	—	—	—	—	—	35 *11*	—	—	0-2 *0-07*	—	0-6 *0-2*	0-20 *0-6*	0-3 *0-1*	40 *12*
CHAZY	—	—	—	—	100 *30*	—	0-100 *0-30*	300-770 *91-235*	0-350 *0-107*	—	—	—	—	—	—	—
BEEKMANTOWN *ORDOVICIAN*	—	—	50-100 *15-30*	250-325 *76-99*	350 *107*	200 *61*	450 *137*	750-900 *229-274*	750-900 *229-274*	650-800 *198-244*	350-400 *107-122*	300 *91*	220 *67*	200 *61*	100-175 *30-53*	0-35 *0-11*
BEEKMANTOWN *CAMBRIAN*	—	—	—	—	—	—	50 *15*	100-150 *30-46*	400 *122*	450 *137*	400 *122*	250 *76*	200 *61*	550 *168*	400 *122*	0-300 *0-91*
POTSDAM, POUGHQUAG	—	—	30-75 *9-23*	50-100 *15-30*	100-350 *30-107*	100-350 *30-107*	1750 *533*	1500 *457*	500 *152*	300 *91*	75-125 *23-38*	70-100 *21-30*	0-70 *0-21*	0-80 *0-24*	0-30 *0-9*	—
TACONIC SEQUENCE	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

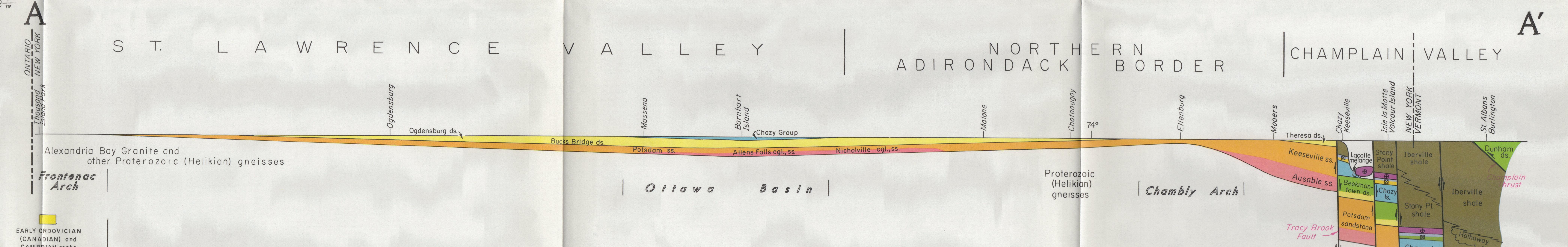
HUDSON VALLEY REGIONS

Major Rock Units	High Taconics			Low Taconics				High Tac.	Man. Prong
QUEENSTON	—	—	—	—	—	—	—	—	—
LORRAINE, QUASSAIC	—	—	—	1500 *457*	3000 *914*	2500 *762*	3500 *1067*	—	—
UTICA-SNAKE HILL	500-1000 *152-305*	1000+ *305+*	1000+ *305+*	500+ *152+*	2000+ *610+*	6000 *1830*	6500 *1980*	1000+ *305+*	900 *274*
TRENTON	0-50 *0-15*	0-40 *0-12*	0-75 *0-23*	0-10 *0-3*	5-75 *2-23*	70 *21*	0-60 *0-18*	5-75 *2-23*	0-50 *0-15*
BLACK RIVER	—	—	—	—	0-40 *0-12*	—	—	—	—
CHAZY	—	—	—	—	—	—	—	—	—
BEEKMANTOWN *ORDOVICIAN*	700-1000 *213-305*	700-1200 *213-366*	1100 *335*	600+ *183+*	750 *229*	500+ *152+*	550 *168*	1000+ *305+*	} 2000 *610*
BEEKMANTOWN *CAMBRIAN*	50+ *15+*	2500+ *762+*	2700-3000 *823-914*	1200+ *366+*	2500+ *762+*	1000+ *305+*	2700 *823*	2000+ *610+*	}
POTSDAM, POUGHQUAG	—	—	250 *76*	—	0-100 *0-30*	40 *12*	0-40 *0-12*	100 *30*	0-40 *0-12*
TACONIC SEQUENCE	—	—	—	—	—	—	—	—	—

Major Rock Units	High Taconics			Low Taconics							High Taconics		Manhattan Prong	
QUEENSTON	—	—	—	—	—	—	—	—	—	—	—	—	—	—
LORRAINE, QUASSAIC	—	—	—	—	—	—	—	—	—	—	—	—	—	—
UTICA-SNAKE HILL through POTSDAM, POUGHQUAG	NOTE: IF PRESENT, THICKNESSES INDETERMINABLE OWING TO INTRICATE STRUCTURE.													
TACONIC SEQUENCE	3300 *1005*	4000 *1220*	6000 *1830*	5000 *1525*	700 *214*	6500 *1980*	6500 *1980*	5000 *1525*	5000 *1525*	4500 *1340*	1200 *366*	1500 *457*	?	?

Thickness in Taconic Sequence is estimated maximum.





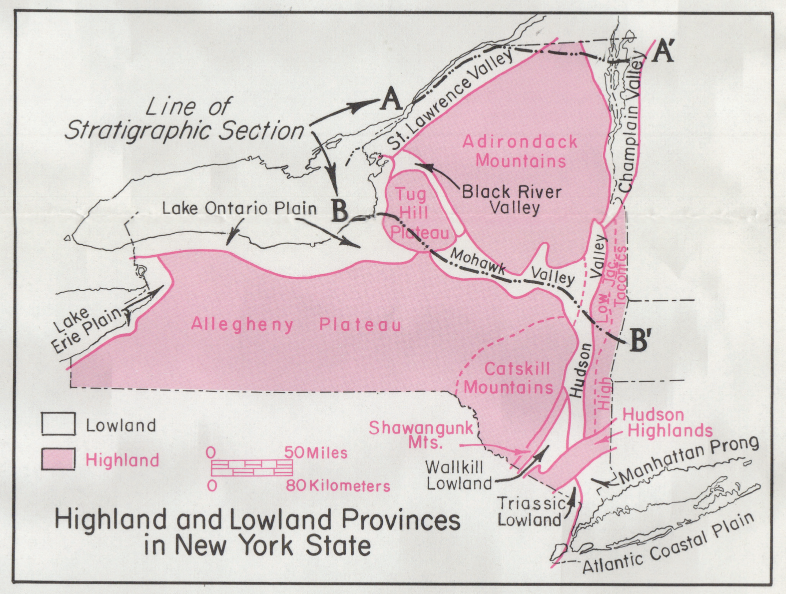


PLATE 3.

SUPPLEMENTAL DIAGRAMS RELATED TO HADRYNIAN, CAMBRIAN, and ORDOVICIAN CHART (Plate 2):

Table of Rock Thicknesses
Index to Quadrangles
Stratigraphic Profiles A–A′ and B–B′

Fisher, Donald W. (1977)
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Map and Chart Series Number 25

Chart layout D.W. Fisher
Drafting G.Y. Gillette 9/1975

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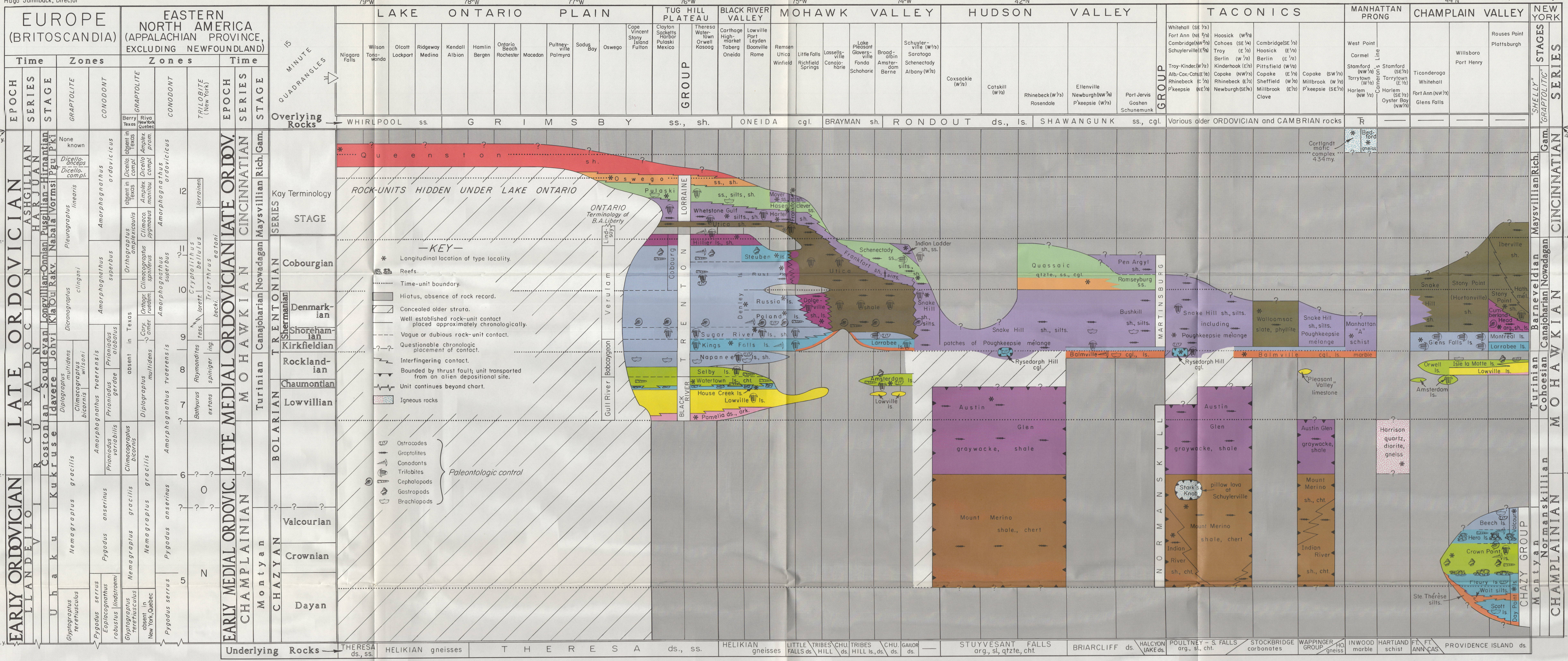
James F. Davis, State Geologist



ABBREVIATIONS--

m.y. millions of years ago

5 to 12 Zones of Sweet, Ethington, and Barnes, (1970)

N, O Zones of Ross (1951) and Hintze (1952)

Series-Stages

Gam.	Gamachian
K'la.	Keila
O'u.	Oandu
P'gu.	Pirgu
P'ki.	Porkuni
Rak.	Rakvere
Rich.	Richmondian

Formations

Chu.	Chuctanunda dolostone
Ft. Cass.	Fort Cassin ds., ls., silts.
Hath. mél.	Hathaway mélange
Ho.	Housatonic gneiss

Fossils

Amplex. manitou.	*Amplexograptus manitoulinensis*
Amplex. prom.	*Amplexograptus prominens*
Climaco. pygmaeus	*Climacograptus pygmaeus*
Cory. amer.	*Corynoides americanus*
Cryptolithus lorett.	*Cryptolithus lorettensis*
Cryptolithus lorrainen.	*Cryptolithus lorrainensis*
Cryptolithus tess.	*Cryptolithus tesselatus*
Dicello. anceps	*Dicellograptus anceps*
Dicello. compl.	*Dicellograptus complanatus*
Orthogr. ruedem.	*Orthograptus ruedemanni*
Raymondites ing.	*Raymondites ingalli*

Rocks

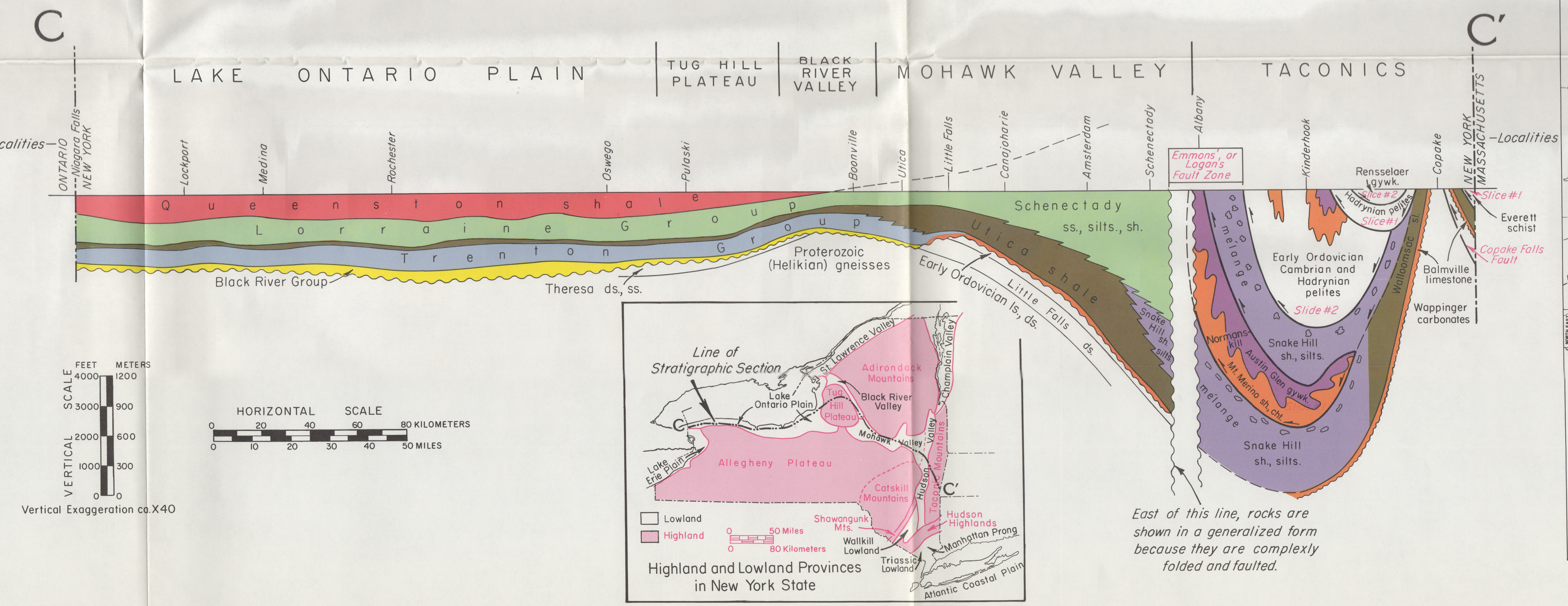
arg.	argillite	mél.	mélange
ark.	arkose	qtzte.	quartzite
cgl.	conglomerate	sh.	shale
cht.	chert	silts.	siltstone
ds.	dolostone	sl.	slate
gywk.	graywacke	ss.	sandstone
ls.	limestone		

TABLE of ROCK THICKNESSES

KEY: 500 Outcrop thickness in feet. *500* Outcrop thickness in meters. 500 (underlined) Subsurface thickness in feet. *500* (underlined) Subsurface thickness in meters. ▭ Rock absent

QUEENSTON	700 / 213	970 / 296	900 / 274	800 / 244	900 / 274	850 / 259	990 / 302	865 / 264	840 / 256	780 / 238	750 / 229	725 / 221	500 / 152		250 / 76	80 / 24	—	—	—
LORRAINE	790 / 241	735 / 224	645 / 197	920 / 280	740 / 226	750 / 229	805 / 245	740 / 226	775 / 236	710 / 216	900 / 274	890 / 271	1015 / 311		630 / 192	530 / 162	570 / 174	550 / 168	500 / 152
UTICA-SNAKE HILL	220 / 67	215 / 66	195 / 59	35 / 11	140 / 43	135 / 41	180 / 55	150 / 46	130 / 40	110 / 34	125 / 38	70 / 21	150 / 46		200 / 61	200 / 61	300 / 91	750 / 229	800 / 244
TRENTON	560 / 170	575 / 175	580 / 177	600 / 183	650 / 198	710 / 216	725 / 220	725 / 220	740 / 225	750 / 229	700 / 213	550 / 168	525 / 160		500 / 152	500 / 152	450 / 137	400 / 122	85 / 26
BLACK RIVER	200 / 60	220 / 67	230 / 70	260 / 79	300 / 91	370 / 112	400 / 122	420 / 128	450 / 137	420 / 128	360 / 110	275 / 84	275 / 84		250 / 76	225 / 69	150 / 46	75 / 23	35 / 11
NORMANSKILL – AUSTIN GLEN	—	—	—	—	—	—	—	—	—	—	—	—	—		—	—	—	—	—
NORMANSKILL – MOUNT MERINO	—	—	—	—	—	—	—	—	—	—	—	—	—		—	—	—	—	—

QUEENSTON	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	QUEEN.
LORRAINE	150 / 46	1200 / 366	2000 / 610	2500+ / 762+	—	—	3000+ / 914+	3500+ / 1067+	3500± / 1067±	—	—	—	—	—	—	—	—	—	LORR.
UTICA-SNAKE HILL	1000 / 305	1200 / 366	1600 / 488	3500+ / 1070+	3500± / 1070+	5500± / 1676+	7500± / 2286+	7500± / 2286+	6500± / 1980+	NOTE: THICKNESSES INDETERMINABLE OWING TO INTRICATE STRUCTURE					—	3500 / 1070	3000 / 914	2500+ / 762+	black sh. arg.
TRENTON	0-25 / 0-8	50 / 15	60 / 18	50 / 15	—	0-75+ / 0-30	—	0-50 / 0-15	0-100 / 0-30						—	150 / 46	165 / 60	200 / 61	TRENT.
BLACK RIVER	0-10 / 0-3	0-7 / 0-2	0-15 / 0-5	0-10 / 0-3	—	—	—	—	—					—	—	40 / 12	30 / 9	37 / 11	BL. RIV.
NORMANSKILL – AUSTIN GLEN	—	—	—	— 500+	300+ / 91+	1000+ / 305+	2200+ / 670+	—	—					—	?	0-50 / 0-15	300-350 / 91-107	300-800 / 91-244	CHAZY
NORMANSKILL – MOUNT MERINO	—	—	—	— 152+	500+ / 152+	1500+ / 457+	1500+ / 457+	—	—					—	?				



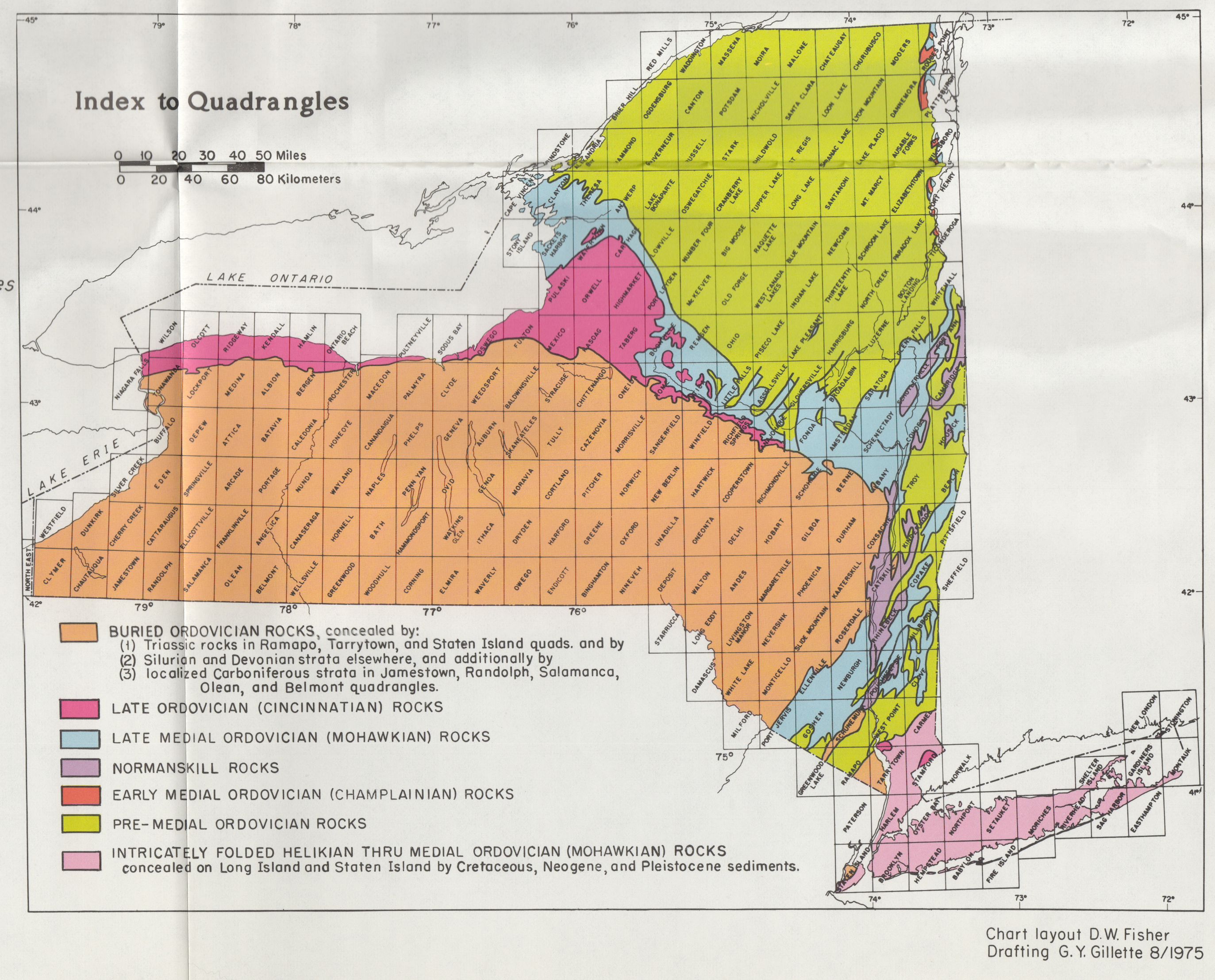


PLATE 4.

CORRELATION of the MIDDLE and UPPER ORDOVICIAN ROCKS in NEW YORK STATE

Fisher, Donald W. (1977)
New York State Museum
Map and Chart Series Number 25

Chart layout D.W. Fisher
Drafting G.Y. Gillette 8/1975

NEW YORK STATE MUSEUM
STATE SCIENCE SERVICE
Hugo Jamnback, Director

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

PLATE 5. PANORAMA OF PALEOGEOGRAPHY IN NEW YORK STATE--HADRYNIAN THRU EARLY SILURIAN TIME