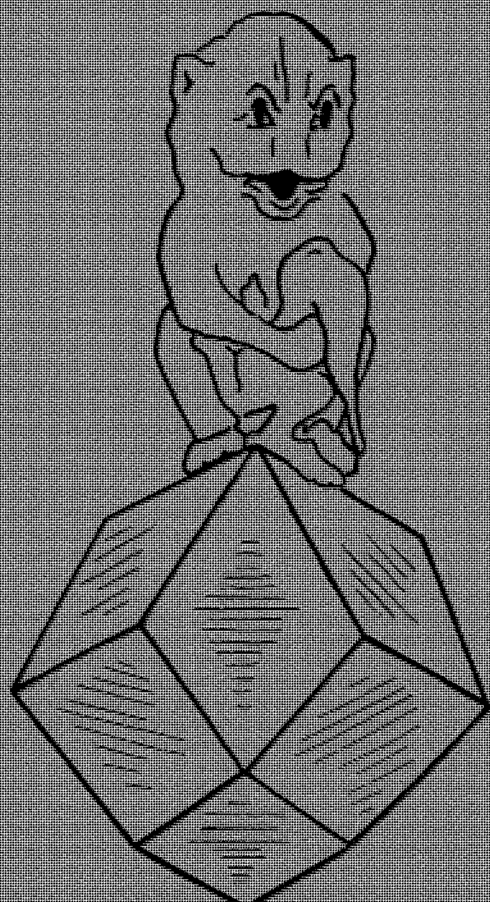
GUIDE BOOK

FIELD TRIPS IN THE SCHENECTADY AREA



NEW YORK STATE GEOLOGICAL ASSOCIATION

37th ANNUAL MEETING

UNION COLLEGE

SCHENECTADY, NEW YORK APRIL 30 - MAY 2, 1965

GUIDEBOOK TO FIELD TRIPS

NEW YORK STATE GEOLOGICAL ASSOCIATION

37th Annual Meeting

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UNION COLLEGE

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Preface

The area surrounding Schenectady provides a wealth of material for the student of geology. Lying in an area of sedimentary rock containing plentiful fossils, it is also possible to study metamorphic and igneous rock within a very short distance of Schenectady. Structure, stratigraphy, sedimentation, paleontology, in all aspects the region is classic ground in the field of geology. The Adirondacks, Taconics, Helderbergs, and the Mohawk and Hudson Valleys each provide wonderful sites of interest to the student and of great use to the teacher.

In planning a series of field trips such as those for this 37th Annual Meeting of the New York State Geological Association, it is difficult to decide just which of these areas to cover. Since the Taconic area has been visited recently by the Association and the Lower Devonian was so well treated at the 36th Annual Meeting at Syracuse, it was decided that totally different trips should be presented. Therefore, the lower Mohawk Valley (a region of prime interest) and the southeastern Adirondacks (a critical area in the early history of eastern North America) were decided upon as being of sufficient distinction to provide a new phase of the geology of this part of New York State. In addition, much new data have been found regarding the glaciation of the area. A glacial trip was considered to be essential, for this information should be presented. One other factor was considered. In any area there are phenomena which are of interest though they may not be fully solved problems and not related to the total geologic picture. Often certain of these are excellent teaching outcrops of great interest for the student who may never have seen the features available. It is for this reason that a field trip of this type was planned.

So many individuals have helped to make this meeting possible that it is difficult to acknowledge the help of them all. In addition to the authors of the text (and, therefore, field trip leaders) many individuals are assisting as bus leaders. These include Lawrence V. Rickard, James F. Davis, R. Lynn Moxham and Roger L. Borst. Thanks are also due to John Broughton of the New York State Geological Survey of the State Museum and Science Service who helped in planning and in making his staff available as leaders and as authors.

Union College is pleased to welcome you all to the area. We hope you will enjoy your study of the region.

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TRIP A

MOHAWK VALLEY STRATA AND STRUCTURE

Saratoga to Canajoharie*

by

Donald W. Fisher

State Paleontologist
New York State Museum & Science Service

"The crust of our earth is a great cemetery, where the rocks are tombstones, on which the buried dead have written their own epitaphs".

---- Agassiz

INTRODUCTION

Seldom can professors, teachers, or students locate a compact area where many phases of geology have their pertinent features displayed or their principles and processes demonstrated in a relatively short period of time. Seldom, too, can they examine rocks and fossils that encompass a broad expanse of time or many segments of time. Fortunate, indeed, are the universities, colleges, and schools who possess so much geology at their "front door", and doubly fortunate are those who make maximum use of such an "outdoor textbook". We regard ourselves in this category for the Mohawk Valley, in the broad sense, is precisely such an area. Permit us to show you its geologic wealth.

Whatever may be your geological specialty, be it igneous and metamorphic geology, stratigraphy, structural geology, sedimentation, glacial geology, engineering geology, ground-water geology, mineralogy, petrology, geology of economic mineral deposits, or that of geobiology - paleontology -, there is something of interest for you in the Mohawk Valley. Obviously, one day is hardly adequate to examine features representative of these many facets of geology. But one day is all we are allotted and therefore we shall merely introduce you to a few basic concepts together with some teasing problems which, to date, have defied solution. In so doing, we shall

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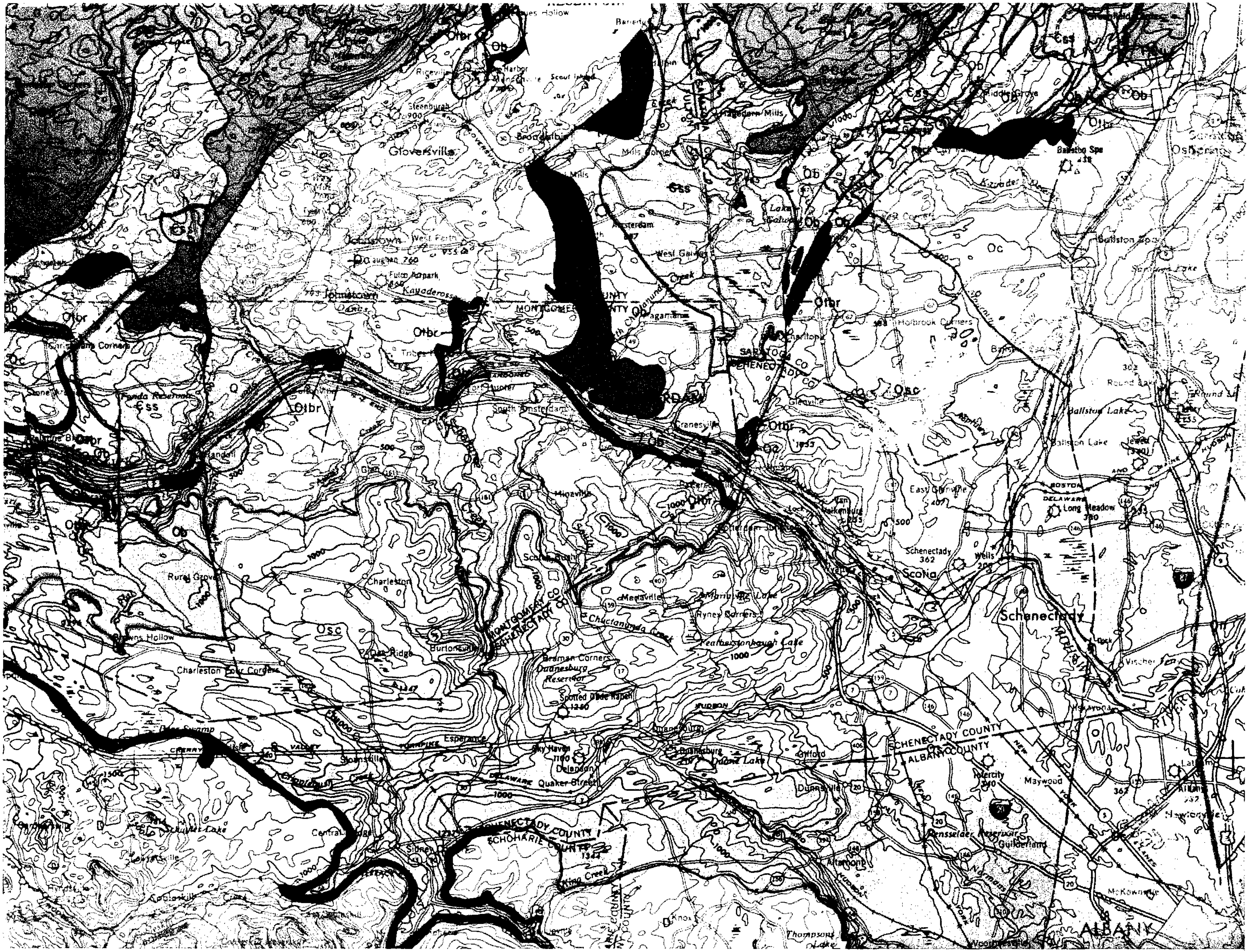
CONTINUED PAGE A-4

LEGEND

Q	Glacial & alluvial deposits. Underlying geology unknown
D	DEVONIAN, UNDIFFERENTIATED Hamilton Group - siltstone and shale Onondaga Limestone, Schoharie Sandstone, Carlisle Center Formation, Esopus Shale, Oriskany Sandstone Helderberg Limestones
S	SILURIAN Cobleskill Limestone Brayman Shale
Osc, On	MIDDLE ORDOVICIAN Osc: Schenectady Formation- graywacke, siltstone, shale (grades into Frankfort Shale, west of the Noses fault) On: Normanskill Formation-graywacke, siltstone, shale (in extreme east only)
Otbr	Trenton Group- "Shoreham" & Larrabee Limestones Black River Group- Amsterdam & Lowville Limestones
Ob	LOWER ORDOVICIAN (BEEKMANTOWN GROUP) Chuctanunda Creek Dolostone (cherty) Tribes Hill Formation- dolomitic limestone, dolomitic shale, calcitic dolostone
Єss	UPPER CAMBRIAN (SARATOGA SPRINGS GROUP) Little Falls Dolostone (cherty) Hoyt Limestone, dolostone- algal reefs, oolites Theresa Formation- dolostone, sandstone
PЄu	PRECAMBRIAN Undifferentiated gneisses, quartzite
	Fault; hachures on downthrown side, dashed where inferred



Gloversville
Johnstown
Amsterdam
Schenectady
Scotia
ALBANY
Ballston Spa
Ballston Lake
Charleston
Charleston Four Corners
Burtonsville
Esperance
Duanesburg
Delanson
Quaker Street
Altamont
Guilderland
Maywood
Mariaville
Rynex Corners
Glenville
Cranesville
Fonda Reservoir
Rural Grove
MONTGOMERY COUNTY
SCHENECTADY COUNTY
ALBANY COUNTY
SCHOHARIE COUNTY
SARATOGA CO.
SCHENECTADY CO.
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Ob
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examine both the ordinary and extraordinary features of the sedimentary rocks, the fractures disrupting them, and the "you are there" approach to a reconstruction of past geologic settings and events.

Our clues will be sought in Upper Cambrian, Lower Ordovician, and Middle Ordovician rocks (of Late Cambrian, Early Ordovician, and Medial Ordovician ages) which were deposited from about 520 million years ago to about 435 million years ago. This 85-million year "chapter" of our geological "book" is superbly illustrated and can be deciphered no better than in the Mohawk Valley. Because of this completeness of the sedimentary record, the Medial Ordovician is termed the "Mohawkian".

Bounded by the Adirondack Mountains on the north and the foothills of the Catskill Mountains on the south, the Mohawk Lowland has an east-west extent of slightly over 100 miles and a maximum north-south extent of about 35 miles. Only the eastern or Lower Mohawk Valley is treated in this article. This area includes portions of six 15-minute (1:62,500) U.S. Geological Survey topographic quadrangles (Canajoharie, Fonda, Amsterdam, Broadalbin, Saratoga, Schenectady, Albany). Except for the Saratoga quadrangle, all are also available on 7 1/2-minute (1:24,000) base. The Valley is moderately well populated, industrialized, with much open farmland and excellent road coverage. Coupled with splendid long stratigraphic sections along the tributaries to the Mohawk, the field geologist's work is made easier. But this was not always so.

For better understanding of this guidebook and the fundamentals of physical geology, stratigraphy, and paleontology, the user should have prior knowledge of these subjects or refer to elementary texts in these fields.

Physical Geology - "The Earth Beneath Us" (1964) by Kirtley F. Mather
"Principles of Geology" (1959) by Gilluly Waters & Woodford

Stratigraphy - "Stratigraphic Principles and Practices" by J. Marvin Weller
"Principles of Stratigraphy" (1957) by C. O. Dunbar & John Rodgers

Paleontology - "Search for the Past" (1960) by James Beerbower
"Invertebrate Fossils" by R. C. Moore, C. Lalicker, & A. G. Fischer
"The Fossil Book" by C. L. Fenton & M. A. Fenton (1958)

ACKNOWLEDGEMENTS

Much appreciation is extended to the N. Y. State Conservation Department for their willingness to make Lester Park presentable by removing underbrush and repairing the descriptive plaque. Mr. Stan Farmer and Morgan Smith of that Department are especially thanked for the role they played in this endeavor.

Thanks, also, to Mr. Francis Harrington, General Manager, Cottrell Paper Co., Rock City Falls, for permission to examine the strata in their quarry and along Kayaderrosseras Creek.

HISTORY, -- GEOLOGIC AND HUMAN

"Not to know the events which happened before one was born, that is to remain always a boy".

---- Cicero

Synoptic geologic history of the Mohawk Valley and environs:

Precambrian [2000 - 600 million years (my) ago]	- Ancestral Canadian Shield received sediments: sand, silt, clay, calcium carbonate. Successive cycles of sedimentation produced a geosynclinal prism which buckled, was subjected to elevated temperatures and tectonic pressures resulting in metamorphism of the sedimentary rocks into quartzites, marbles, and gneisses. This mountain-making event (Grenville Orogeny) has been radiometrically determined to have taken place about 1100 million years ago. A lengthy period of erosion, accompanied by small intrusions of mafic dikes, ensued.
Early Cambrian [600 - 560 my ago]	- Sediments were deposited in eastern New York and western New England which we see today as the graywackes, micaceous siltstones and shales of the Cossayuna Group.
Medial Cambrian [560 - 530 my ago]	- Peneplantation of Adirondacks and its southern periphery with some sedimentation atop the Early Cambrian rocks east of the present Hudson River.
Late Cambrian [530 - 500 my ago]	- Flooding by shallow epeiric seas transgressing from southeast and east toward the northwest. Quartz sand and dolomite deposited in varying intermixed quantities with localized algal reefs fringing the southern Adirondack shore (Saratoga Spring Group).
Early Ordovician [500 - 470 my ago]	- Extensive carbonate deposition (Beekmantown Group) in widespread, shallow, continental shelf environments. Local uplifts, of brief duration, temporarily expose the shelves.

Waters were probably temperate to cool, as evidenced by great development of thin-shelled mollusks. Continental emergence at close of the Canadian of long duration in some areas. This marked break is, probably, but a slight manifestation of an intense orogeny in New England, now masked by subsequent periods of folding, faulting, and metamorphism.

Medial Ordovician

[470-435 my ago]

- Thick carbonate deposition in Champlain Valley (Chazy Group); lack of contemporaneous record in Black River and Mohawk Valleys. Warm Chazy seas exhibited variety of environments; one type was host to lush reef development of stromatoporoids, algae, and bryozoans. Later, more widespread environments of carbonate deposition inundated most of New York State (Black River and Trenton Groups). These reefless seas supported immense numbers and varied types of brachiopods and mollusks. Thick terrigenous deposits were dumped in eastern New York reflecting the initial phases of the Taconian Orogeny. Folding and thrust faulting of these and older strata occurred with eventual westward emplacement of the Taconic Allochthone. Earthquake and volcanic activity further demonstrates crustal instability. A southern prolongation of the Adirondacks, the Adirondack Axis, exerts influence on Medial Ordovician sedimentation and faunal distribution.

Late Ordovician

[435-425 my ago]

- Adirondack Mountains domed; extensive block faulting in Mohawk and Champlain Valleys and throughout eastern Adirondacks possibly culminating in localized intrusions of basic dikes. Period of vigorous erosion with thick wedge of sediments deposited to the west of the Adirondack Axis. This Queenston

Early & Medial Silurian

[425-410 my ago]

- Delta, together with lesser thicknesses of coarse Early and Medial Silurian clastics (Medina and Clinton Groups) is the debris from the uplifted Adirondack Mountains, Adirondack Axis, and Taconic Mountains. It is unlikely that the Mohawk Valley region proper was peneplaned sufficiently to permit Early and Medial Silurian seas to inundate it.

Late Silurian

[410-405 my ago]

- Once again the Mohawk Valley region was submerged under marine seas but this time the transgression came from the west - the pattern of flooding during the entire Silurian in

New York. A thick delta or coastal plain clay deposit (Vernon "Delta") along the west flank of the Adirondack Axis, is the product of further washing away of residual soil derived from the older eroded rocks. Nearly land-locked hypersaline seas appeared; within these isolated environments, dolomite an and evaporites (chiefly halite and anhydrite) were precipitated with land-derived clays (Salina and Bertie Groups). These muddy supersaline waters with unstable sea floors were not conducive to the usual marine animals; typically marine invertebrates such as brachiopods and echinoderms are absent whereas the bizarre eurypterids are fairly abundant. The closing stages of the Late Silurian - deposition of quartz and clay-free carbonates -

Early Devonian

[405-385 my ago]

- herald the oncoming of warm, shallow, clear seas, with a prolific bottom fauna, which persisted into the Early Devonian. These carbonates (Helderberg Group) represent several types of lime environments (supra-tidal, inter-tidal, lagoon, reef, off-reef, shelf, etc.). Uplift and erosion followed (no orogenic episode in New York) and a thin quartz-sand veneer (Oriskany) was spread (wind blown?) over a broad area. Quartz-silt and clay (Esopus-Carlisle Center) with some lime, continued to accumulate for the remainder of the Early Devonian. Uplift and erosion

Medial & Late Devonian

[385-355 my ago]

- brought a halt to this clastic cycle. Shallow seas with a prolific marine fauna, including coral reefs, blanketed the southern half of New York. The resultant record of this period is a limestone (Onondaga). We have no knowledge of how much, if any, of the younger Devonian seas covered the Mohawk Valley region. The former northward extent of these rocks (Hamilton Group, etc.) must fall within the realm of speculation. Effect of the Acadian Orogeny in the Mohawk Valley is unknown.

Late Paleozoic & Mesozoic Eras

[355-60 my ago]

- No record of sedimentation; Mohawk area presumably undergoing regional uplift and erosion.

Tertiary

[60 - 1 my ago]

- Regional upbowing in New York producing renewed vigorous erosion. Major topographic features and drainage patterns created. Detritus carried to the continental shelf where it now constitutes a thick wedge of the shelf. Mohawk River came into existence; course dotted with waterfalls where water cascaded over fault-line scarps (examples: Little Falls, St. Johnsville, Noses, Tribes Hill, Hoffmans). At least three large rivers entered Mohawk River from the north (Sacandaga River between Fonda and the Noses, "Cranesville" River between Cranesville and Toureuna Road, "Niskayuna" River, east of Schenectady).

Pleistocene

[1 - 0.01 my ago]

- Southward advancing continental ice sheet blanketed New York (except for small area in southwestern New York). Extensive removal of residual soils and dumping of heterogenous de detritus coupled with glacial sculpturing greatly altered existing topography and drainage patterns. As ice front receded northward, outlet for the newly formed Great Lakes was opened to the east via the Mohawk Valley to the Hudson Valley and ultimately to the Atlantic Ocean. Brief westward re-advance (and/or stagnation) of ice in the Mohawk Valley (Mohawk Lobe) left the Adirondack Mountains as a large rock island surrounded by ice (nunatak). Potentially economic water-laid gravels and sands accumulated at wider parts of the Valley, at eastern side of largest faults. Melted ice produced temporary lakes in which varved clays and silts and sands built up. These lacustrine beds, like those which formed in glacial Lake Albany, are important reservoirs for water, are useful sand and gravel deposits for concrete manufacture, and the clays were once the source of a lucrative brickmaking industry.

Recent

[0.01 - 0 my ago]

- Land undergoing erosion, sediments travelling down the Mohawk and Hudson Rivers, some deposited as river alluvium and some reaching the continental shelf or forming turbidity deposits in the Hudson River submarine canyon on the Atlantic sea floor.

Our geological excursion could well be labelled "from the place of herrings" to the "pot that washes itself" for this is the literal translation of Saratoga to Canajoharie in the Mohawk language. Saratoga - from Sa-rag-ho-go - received its name from alewives (cousins of herrings) which formerly migrated up the Hudson River, through Fish Creek into Saratoga Lake, then up Kayaderosseras (Kay-der-oss) Creek to Rock City Falls. Canajoharie was so-called by the Mohawks from the splendid potholes (up to 12 feet across) in the dolostone of Canajoharie Creek at the southern edge of the town. These potholes truly do "wash themselves" for their tools, the pebbles and cobbles, are swirled about by rushing water, like a ball mill.

The Mohawks, the most eastern segment of the Iroquois Nation, are indigenous descendents of the Owasco people which inhabited the Valley almost 1000 years ago. To date, the most ancient human implements discovered within the Mohawk Valley (near Schenectady) are some Clovis fluted points, dated in the southwest U.S. to some 10,000 years ago.

We cannot be sure who was the first white man that ventured into the Mohawk Valley; probably it was one of a small party of French trappers or explorers. At any rate, the Mohawks resented intrusion by any foreigner, Indian or white. Because of their grisly cannibalistic rites, the Mohawks were called the "people eaters". Trespassers were usually brutally killed; occasional captives were atrociously tortured and devoured. French traders, trappers and Jesuits were prime targets. Among those who were martyred were Father Isaac Joques, Rene Goupil, William Couture, and Lalande, to whom the shrine at Auriesville is dedicated.

The Mohawks were equally inhospitable to their Indian cousins. During the middle of the 17th century, the Mohicans had invaded the Valley from the east but their penetration was thwarted at the Mohawk palisaded village of Kanyeagah on the Fonda sand flats. Smarting under this defeat, the Mohicans retreated to the eastern terminus of the Valley, the high hills near Hoffmans. Like sentinels, the two flanking hills creating an ideal defensible gateway at Hoffmans are, Yantaputchaberg (sleeping lady) on the south and Kinaquarione (place of the last great battle) on the north. To the Mohawks, these high hills symbolized the eastern terminus of the Iroquois "Long House" and they could not tolerate any enemy in so strategic a position. In 1669, a bloody two day battle decided which nation was to remain master of the Valley. The Mohicans were so severely decimated that never again did they pose a threat and they remained, peacefully, in the Hudson Valley until the flood of white colonialism gradually forced them to depart.

In the late 17th and early 18th century Dutch and German colonists emigrated westward from the Hudson Valley. The obvious route was through the Mohawk Valley, the only natural path to the west across the Appalachian Mountains. But this strategic Valley was still controlled by the savage Mohawks and passage seemed virtually unthinkable unless a small-sized army was dispatched for protection. Strangely, the Dutch and Germans never moved very far west. Owing to their small numbers, the Mohawks regarded them as no serious threat to their "empire". In fact, many of these whites intermarried with the Mohawks. A highly successful barter system was set up whereby the whites were permitted to remain and till the soil in return for supplying the Mohawks with rifles and trinkets. In years to come, this arrangement would be regretted.

Until 1772, all of the Mohawk Valley was included in Albany County. Then, a new county, named Tryon (from the then governor of the region) was separated off as all of the state west of a line trending due north of the Delaware River along the eastern limit of the present counties of Montgomery, Fulton, and Herkimer to the Canadian boundary. In 1838, Montgomery and Fulton Counties were separately distinguished.

One of the greatest personages in the story of the Mohawk Valley was Sir William Johnson (1715-1774), superintendent of Indian affairs for the British government. It was he who welded amicable relations between the inherently hostile Mohawks and the British colonists. This was accomplished primarily because of the Mohawks intense hatred for the French and the fact that the British were proving their dislike for the French by driving them out of much of North America: following Wolfe's victory over Montcalm at Quebec in 1759 which secured Canada for the British, French influence in the New World declined. Johnson was a superb administrator. Evidence of his "era of good feeling" is that the blood of the Mohawks flows in the veins of many valley families today, thereby demonstrating the fraternization between Indian and white. Johnson, himself, took Joseph Brant's sister Molly as mistress of his baronial home at Fort Johnson for many years. It has been said that had Johnson lived, he probably would have sided with the rebels and that his name would have ranked with that of Washington and other heroes of the American Revolution.

However, the Johnson name was blackened by his son, Sir John, an avowed Loyalist, who was responsible for allowing particularly savage massacres of colonists to be conducted by Tory and Indian raiders. The Infamous Cherry Valley massacre, led by Walter Butler, regarded by many as one of the most hated men of the period, but by some as most maligned, was but one of these ghastly acts.

The importance of the Valley was evident again during the American Revolution. British control of the natural artery to the west -- the Mohawk Valley -- was mandatory toward suppressing the rebellion. The British "squeeze plan" was to have General John Burgoyne move south through the Champlain Valley and General Barry St. Leger move south through the Black River Valley and east through the Mohawk. The two expeditions would join forces at Albany and move down the Hudson and secure New York City. But the stalwart patriots of Dutch and German ancestry of the Mohawk had other ideas. Under the command of General Nicholas Herkimer, they stopped St. Leger's combined British, Tory, and Mohawk Indian advance at Oriskany - at the western terminus of the Mohawk Valley - , the turning point of the American Revolution. With General Horatio Gates and General Philip Schuyler's victory over Burgoyne at Saratoga in 1777, the French joined the Americans against their arch foe, the British. The British command could see the "handwriting on the wall" and Lord

Cornwallis surrendered the British army and navy at Yonkers in October 1781. Unaware of this, the last Mohawk Valley battle of the war occurred at Johnstown. In pursuit by the victorious colonists, Walter Butler was killed. A new country was born and the greatest 18th and 19th century "trunk line" to the west was safe for colonization. Like all adolescents, the Mohawk Valley has experienced its "ups and downs". Reid's (1901) treatment is a fascinating expose of Mohawk Valley history.

* * * * *

Geological investigation in the Mohawk Valley commenced relatively early in our nation's history. When in the early 1880's the astute DeWitt Clinton envisioned a canal connecting the Hudson River with the Great Lakes, it was necessary that a geological survey be made to ascertain the kind of rocks that would be encountered in excavating for the "Big Ditch". Amos Eaton, ransomed from a debtor's prison, was chosen for the job because of his earlier areal survey of Rensselaer County. The survey of the Erie Canal (Eaton, 1824) served not only to establish geological investigations as an integral part of engineering projects but it set up a sequence of geological formations which stood as the framework for subsequent geologic studies.

With the establishment, in 1836, of a Geological Survey of New York by Governor Marcy, attention was again focused on the geology of the Mohawk Valley. The State was divided into four Geological Districts, with a geologist in charge of each. Portions of two Districts extended into the Mohawk Valley; W.W. Mather's First District included Albany, Schenectady and Saratoga Counties and Lardner Vanuxem's Third District included Montgomery, Fulton, Herkimer and Oneida Counties. Out of this endeavor a state geologic map and four large District Reports were prepared. These District Reports form the basis for all subsequent work on New York's strata. So comprehensive were these reports that half a century elapsed before additional studies were required. The new work was prompted by the need for an up-to-date state geologic map. Nelson H. Darton was assigned the counties which lay astride the Valley. His chief contributions (1895) were the mapping of many normal faults and refinement of bedrock mapping.

Figure 2

Summary of Stratigraphic Nomenclature in the Lower Mohawk Valley

Eaton 1824 Mohawk Valley	Conrad 1837-1839 Mohawk Valley	Vanuxem 1842 Mohawk Valley	Prosser and Cumings 1900 Amsterdam Saratoga	Cushing 1905 Little Falls	Miller 1911 Broadalbin	Ruedemann 1912 Mohawk Valley	Cushing 1914 Saratoga	Ruedemann 1930 Capital District	Kay 1937 Mohawk Valley	Fisher and Hanson 1951 Saratoga	Fisher 1957-1965 Mohawk Valley
Metalliferous Graywacke: Second Graywacke	Green Slate	Frankfort Slate and Rubblestone	Hudson River Shale	ERODED	Frankfort Shale Utica Shale Canajoharie Shale	Trenton "age": Schenectady Sandstone & Shale	Trenton: Schenectady	Trenton: Schenectady	Trenton Group: Schenectady	ERODED	Trenton Group: Schenectady Grayw, Shale
Transition Graywacke	Trenton Limestone and Slate	Utica Slate	Utica Shale	Utica Shale		Canajoharie	Canajoharie =Snake Hill	Canajoharie	Canaj.: Fairfield Minaville	Canajoharie	Canajoharie
Metalliferous Limerock		Trenton Limestone	Trenton Limestone	Trenton Limestone & Shale	Trenton Limestone	Basal Trenton: Glens Falls Limestone	Glens Falls	Glens Falls	Gl. Falls Ls.: Shoreham Limestone	Trenton Limestone	"Shoreham" Limestone & Shale
							Base of Trenton: Amsterdam		Larrabee Limestone		Larrabee
"Sparry Limerock"	Mohawk Limestone	Black River Limestone: Base of the Trenton	Black River	Black River	Black River: Amsterdam Limestone	Black River: Amsterdam	black Lowville	*Not Discussed*	Amsterdam	Amsterdam	Black River: Amsterdam
	Gray Limestone with sparry veins	Birdseye Limestone	Birdseye	Lowville Limestone	Lowville	Lowville	Lowville		Lowville	Lowville	Lowville
Calciferous Sandrock	Bastard Limestone Gray Limestone with sparry veins (1837)	Calciferous Sandrock: Mohawk Limestone (1840) Fucoidal Layers	Calciferous Sandrock: Fucoidal Layers of Calciferous Sandrock	Beekmantown Formation	Tribes Hill Limestone, Dolomite	*Not Discussed*	*Considered Absent*		Tribes Hill Limestone, Dolomite	Gailor Dolomite	Chuctanunda Cr. Dolostone Tribes Hill: Fonda Wolf Hollow Palatine Bridge Fort Johnson
	Calciferous Sandstone of Mohawk Valley	Calciferous Sandrock			Little Falls Dolomite Theresa Sandstone Dolomite Potsdam Sandstone		Little Falls Hoyt Limestone Theresa Potsdam		Little Falls	Ritchie Limestone Hoyt Galway Potsdam	Saratoga Springs Little Falls: Theresa Potsdam
Primary	Gneiss (1837) Primary (1839)	Gneiss (1838) Primary	*Not Discussed*	Precambrian	Precambrian		Precambrian		Precambrian	Precambrian	Precambrian

GYG 4-65

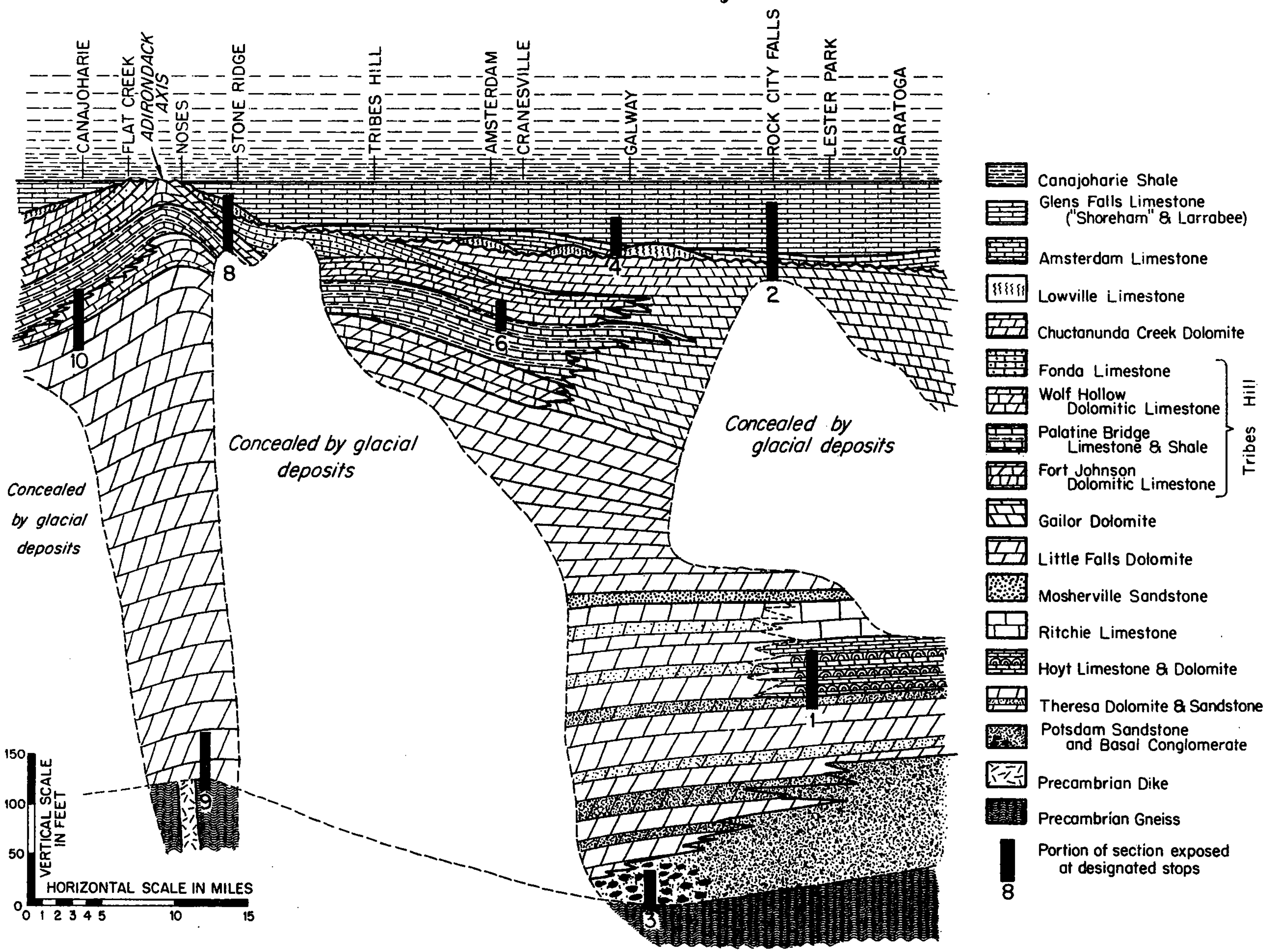
In general, the fossils of the Mohawk Valley have suffered from inattention. Following Hall's initial volume (1847) of his monumental "Paleontology of New York", half a century passed before application was made of the fossil wealth of the Valley. Charles Smith Prosser (first professor of geology at Union College) and Edgar R. Cumings (later to enjoy many years as Professor of Geology at Indiana University) demonstrated the stratigraphic usefulness of fossils in their studies of Black River and Trenton limestones (1900). In conjunction with this work, the Amsterdam quadrangle became the first 15-minute topographic quadrangle to be geologically mapped (1897, Prosser, Cumings, and Fisher). Herdman F. Cleland's work (1900, 1903), stemming from a Cornell summer field camp under Professor Gilbert D. Harris, was of taxonomic and correlative importance. He announced a new fauna, older than the Black River and younger than the Potsdam-Hoyt Fauna, described a few years earlier by that great student of the Cambrian, Charles D. Walcott (1884). This Tribes Hill (early Ordovician) fauna stimulated search for fossils in other areas at this stratigraphic level.

A rash of quadrangle mapping was in vogue in New York State in the period 1905-1930 motivated chiefly by John M. Clarke and Rudolf Ruedemann who were engaged in several ambitious paleontologic endeavors. It was during this acceleration program that the Little Falls (Cushing, 1905), Broadalbin (Miller, 1911) Saratoga-Schuylerville (Cushing and Ruedemann, 1914) and Schenectady and Albany (Ruedemann, 1930) quadrangles were geologically mapped. Similarly, mapping of glacial deposits was undergoing an "explosion". James H. Stoller, second Professor of Geology at Union College (1911, 1916), Albert Perry Brigham (1929) and, probably foremost, Herman Leroy Fairchild (1912, 1919) labored toward the enlightenment of Pleistocene Geology in eastern New York.

Owing to the intensive study of the extinct strange graptolites by Ruedemann (1912, 1925), it was discovered that the great monotonous thickness of Ordovician black shales was capable of faunal subdivision; several biostratigraphic graptolite zones were formulated. Now that the Middle Ordovician shales were shown to be divisible it remained for Marshall Kay to attack the Middle Ordovician limestones with the same purpose. This resulted in the illuminating classic "Stratigraphy of the Trenton Group" (Kay, 1937), undoubtedly more referred to than any other single work on New York Ordovician geology. With the completion of this work, there remained two major segments of Mohawk Valley geology virtually unstudied: the Lower Ordovician-Upper Cambrian strata, and (2) bedrock mapping of the Canajoharie and Fonda quadrangles. These I commenced in the summer of 1947 and since then have worked on them intermittently.

Figure 3

STRATIGRAPHIC PROFILE — CANAJOHARIE TO SARATOGA



PALEO ENVIRONMENTS, -- AN ENIGMA

"The interest in a science such as geology must consist in the ability of making dead deposits represent living scenes" ---- Hugh Miller

The above quotation together with the opening statement in Derek Ager's recent book on "Principles of Paleoecology", -- "Fossils were once animals and plants that lived and breathed, fed and bred, moved and died. Their lives were a continuous battle with their environment. Their story is the essential prelude to the fleeting present and the unknown future" -- succinctly outline what is in store for those who attempt to recreate pictorally the settings which sedimentary rocks can reveal with proper study.

The study of rocks and fossils with the goal of reconstructing ancient environments is termed paleoecology. The approaches utilize many of the methods of paleontology, stratigraphy and ecology, the study of present-day environments, except that the paleoecologist is concerned with another dimension -- time, and another medium -- rocks. He, thus, works with untold numbers of faunas and floras usually imperfectly preserved. Furthermore, he is handicapped by the fact that no past environment is preserved in its original state for the fossils that one finds in a rock are death assemblages; they may represent life that was:

(1) Native [endemic] to the environment

(2) Foreign [exotic] to the environment

or, more probably, a

(3) Mixture. Such assemblages may be

(a) Ecologically mixed

(b) Chronologically mixed

(c) Geographically mixed

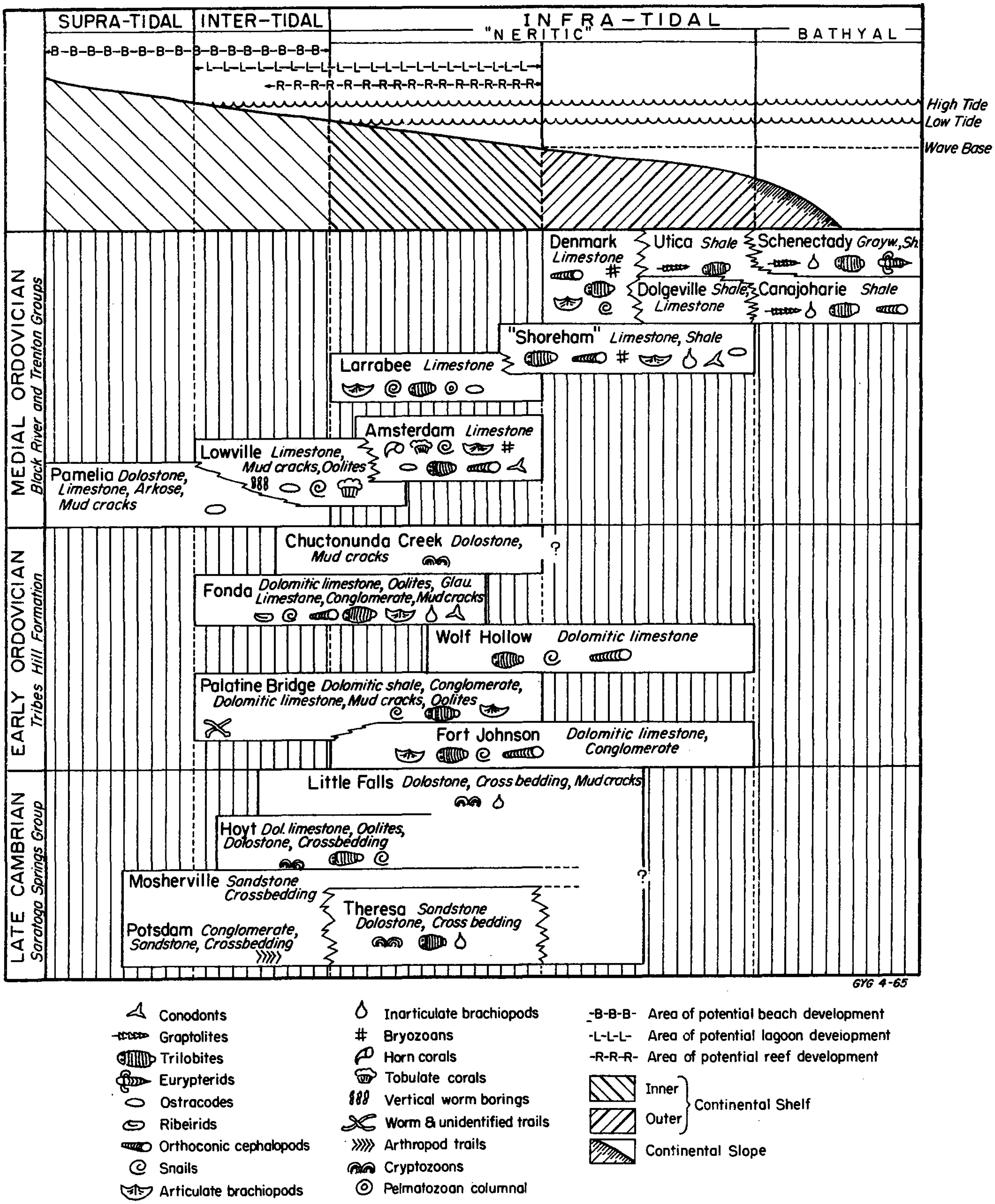
(d) Combinations of the above

Furthermore, an environment may be divided into physical, chemical, and biological components. Some of these cannot be determined whereas others can be restored only with uncertainty.

In reconstructing past environments, it should be remembered that:

Figure 4

SUMMARY of MARINE PALEO-ENVIRONMENTS in the MOHAWK VALLEY



(1) Not all animals and plants that have lived on this Earth have left a fossil record.

(2) Those that have left a fossil record may have left

(a) only parts of their bodies

(b) only an incomplete chronologic record

(c) a misleading record as far as abundance is concerned (Ex. animals that molt)

(d) as yet, undiscovered remains

(3) Some environments are less apt to be preserved in the sedimentary record (Ex. rocky shore)

(4) Habits and habitats of extinct animals are unprovable (We do the best we can with the available evidence)

(5) The assumption that the Law of Uniformatarianism, -- The Present is the key to the past -- has always been so, may be fallacious. Organisms may have changed their habits and habitats with time.

With all the above qualifications and uncertainties, you may rightly ask, "What paleoecological deductions can one make from the sedimentary rocks?" Utilizing tools from chemistry, physics, and biology, the paleoecologist can arrive at some pretty well substantiated ideas of ancient environments. True, we are still making some educated guesses and there are many questions that, for now, must remain unanswered but paleoecology has come a long way in the past 20 years. The groundwork, however, must remain the tedious descriptive stratigraphy and taxonomic paleontology that will forever be basic to any paleoecological study. Albeit traditional, it appears that the presentation of the description of the stratigraphic units in their proper chronologic sequence is the most feasible manner to examine the past environments of the Mohawk Valley.

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PRECAMBRIAN ERA (P€u)

Precambrian rocks do not comprise much of the surface rock in the Mohawk Valley. But these rocks are important toward the understanding of the derivation of the younger strata and the events which preceded the accumulation and lithification of the fossil-bearing rocks of the subsequent Paleozoic Era.

For a more complete discussion of the rock types of the Adirondack Mountains, the reader is referred to Y. W. Isachsen (1965). Within the Mohawk Valley, three kinds of Precambrian rock are exposed at the two inliers or "windows".

(1) garnet-biotite gneiss (at the Noses Inlier)

(2) mafic pyroxenite dike (at the Noses Inlier)

(3) augite-hornblende syenitic-gneiss (at the Little Falls Inlier)

Only the garnet-biotite gneiss will be examined on this trip (Stop 9, see Road Log).

P A L E O Z O I C   E R A

LATE CAMBRIAN (CROIXIAN) - SARATOGA SPRINGS GROUP

POTSDAM SANDSTONE (Єss)

Typically, the Potsdam is a white to cream colored, clean, quartz sandstone cemented by silica, calcium carbonate, or dolomite. The type locality at Hannawa Falls near Potsdam, St. Lawrence County, N.Y. is, paradoxically, atypical for there it is a red to maroon colored, feldspathic sandstone with cobbles and pebbles of older rock. Elsewhere, the white Potsdam is customarily pebble-free, regular - and cross-bedded with infrequent wave and current ripple marks. Bedding varies from thin - to thick bedded.

Along the southern margin of the Adirondacks, the Potsdam is thin, never exceeding 100 feet, or absent and has failed to yield any diagnostic fossils. Near Fort Ann, 25 miles northeast of Saratoga, the trilobite Komaspidella fixes a Dresbachian (Early Croixian) age.

Ecologically, it is likely that the Potsdam represents a beach deposit (wind-blown and water abraded quartz) on the shore of a westwardly transgressing sea (see Fig. 4). The lack of sedentary fossils attests to the instability of the sand bottom. Trails, looking like tractor tire-tracks, so common in the Potsdam, would be expected in this environment. Very short wave length ripple marks are, similarly, ubiquitous in our present-day shifting beach sands of the supratidal zone. Localized patches of quartz-boulder or cobble conglomerate atop the Precambrian have, rightly or wrongly, been termed Potsdam. One of these will be examined at Stop 3 (see Road Log).

THERESA FORMATION (Єss)

The Theresa is a facies of alternating dolomitic quartz sandstones and quartzose dolostones interfingering shoreward with the Potsdam sandstone facies and seaward with the Little Falls Dolostone facies (see Figs. 3 and 4). The sandstones in the Theresa vary from the Potsdam-type to one in which the quartz to dolomite ratio is nearly 1:1. The Dolostones are, characteristically, coarsely crystalline with pockets of pink and orange dolomite crystals. Rarely, thin dolomitic shale zones may occur. One of these along the West Galway Road, east of Bunn Corners, has abundant lingulid brachiopods. This zone is very near the summit of the Theresa Formation, here overlain by the Mosherville Sandstone - a local, persistent 5-6 foot bed useful as a stratigraphic marker (see Fig. 3).

Isolated algal stromatolites (Cryptozoon) and the trilobites Elvinia and Camaraspis (indicies of the early Franconian) complete the known fauna in the Saratoga-Mohawk Valley region. Elsewhere in the State, the Theresa has trilobites of late Franconian age and at the type locality at Theresa, Jefferson County, N.Y. the formation is demonstrably Early Ordovician holding the gastropods Helicotoma and Holopea. Thus, the Theresa, like its shoreward facies the Potsdam, is time-transgressive toward the northwest and sedimentation would seem to be continuous from Late Cambrian into Early Ordovician time (Fisher, 1962a). However, the lack of any faunal proof of the middle (Conaspis zone) or upper (Ptychaspis-Prosaukia zone) Franconian in the Saratoga-Mohawk Valley region may signify a cessation of sedimentation and a gap in the stratigraphic record (paraconformity). The Theresa appears to be a deposit in the inter-tidal and inner continental shelf areas (see Fig. 4).

HOYT LIMESTONE (€ss)

This formation, named by Ulrich and Cushing (1910, p. 98), is lithologically variable. Primarily, it is dark to medium gray, coarse - to medium textured quartzose dolomitic limestone. Purer layers of dolostone, oolite-rich beds, and quartz sand-rich beds are frequent. Unique to the Hoyt, in comparison with other stratigraphic units of the region, are the several biostromal reef limestones constructed by colonial algal stromatolites -- the Cryptozoons or "fossil cabbages or brussel sprouts". The Cryptozoon heads were periodically smothered by quartz sand thus halting or inhibiting their growth. Trilobite fragments were distributed haphazardly and, luckily, enable us to rather precisely fix the age of this key unit as late Late Cambrian (Trempealeauan), for the formation has yielded Dikellocephalus, Keithiella, Plethometopus, Plethopeltis, Prosaukia, and Saratogia. Primitive snails like Matharella, Palaeacmaea, and Pelagiella, the monoplacophoran Tryblidium, the lingulid brachiopods Lingulepis and Obolella, and the curious hyolithid-like Matthevia complete the known fauna and flora.

Fortunately, we can assign the Hoyt to its paleoecological niche with some conviction. Recent studies (Logan, 1962) in Shark Bay, Western Australia, demonstrate that living Cryptozoons thrive in an inter-tidal zone in an elongated bay with salinity somewhat higher than the open ocean. The adjacent land, of low relief and slight rainfall, supplies little detritus to the ocean. At Lester Park (Stop 1) the Hoyt Formation is a Late Cambrian portrayal of this modern Australian oceanic environment (see Fig. 4). And like the Shark Bay setting, the Cambrian Hoyt counterpart was seemingly geographically restricted for the Hoyt facies has not been found outside of the Saratoga area. Correlative strata in the Mohawk and Champlain Valleys are dolostones or limestones which lack the reef development of the Hoyt.

LITTLE FALLS DOLOSTONE (€ss)

J. M. Clarke (1903, p. 16) introduced the name Little Falls for the magnesian limestone underlying the "Birdseye" or Lowville Limestone (Middle Ordovician) and overlying the Greenfield (later named Hoyt because of preoccupation) Limestone. As thus defined, the Little Falls embraced an interval occupied by Lower Ordovician (Tribes Hill - Gailor) strata. And so a common error was perpetrated in selecting the name from one area and defining the unit from an area where the stratigraphic relations are different. In the Saratoga region, Wheeler (1942) had thought that the Hoyt overlay the Little Falls but he overlooked the effect of faulting on the stratigraphic sequence. Fisher and Hanson (1951) showed that the dolostone previously termed Little Falls in the Saratoga vicinity was actually a Lower Ordovician dolostone which they named Gailor and which proved to be a facies of the Tribes Hill Formation of the Mohawk Valley.

In the Mohawk Valley, the Little Falls consists of a thick series (up to 550') of dolostones variable in color and texture, usually admixed with rounded quartz grains and frequently penetrated by light gray and white chert nodules and stringers. Glauconite is occasionally present. Locally, pyrite may be common. Detrital quartz increases in volume stratigraphically downward and geographically northward; the northward increase is of such proportions that a separate facies, the Theresa, is seen to intertongue with the Little Falls (see Figure 3). Interstitial hematite is prevalent in a red zone, 8 to 15 feet thick, at the summit of the Little Falls Dolostone. This zone is riddled with pockets (vugs) of quartz crystals, termed "Herkimer Diamonds", and anthraxolite, a black lustrous carbonaceous mineral with nearly the same chemical composition as coal though it has different physical properties (see Dunn and Fisher, 1954). This anthraxolite became concentrated, as a liquid, in a zone of relatively high porosity and permeability in a manner similar to that of petroleum. Having first saturated the carbonate strata, it underwent subsequent changes which produced a decrease in volume and a corresponding increase in viscosity until it attained its present solid, brittle or sooty condition. These changes occurred, in part, contemporaneously with the introduction of silica. The parent material (proto-anthraxolite) was probably vegetable and derived from the algal biostromal reefs of Cryptozoon, now largely obscured through dolomitization; migration from the Hoyt reefs is also plausible.

Except for the aforementioned dolomitized Cryptozoon, the Little Falls is frustratingly barren of fossils; exceedingly rare and undiagnostic lingulid brachiopods and a trilobite free cheek (Elvinia), not in place, have been found at the Noses. For this reason the age of the Little Falls, unproved by direct fossil evidence, must be ascertained through fixing the ages of its overlying, underlying, and lateral equivalents (see Fig. 3). The first two provide minimum (Early Canadian= Tremadoc) and maximum (Precambrian) ages; the last signifys an Early Franconian age as illustrated by the trilobites of the Theresa in the Saratoga region. The Little Falls may span a broader interval than Early Franconian but this must await corroboration from discovery of additional key fossils. The "prominent unconformity" mentioned by Ulrich and Cushing (1910) will be seen at Stop 10 (see Road Log); it is more correctly termed a paraconformity (see section on unconformities).

EARLY ORDOVICIAN (CANADIAN) - BEEKMANTOWN GROUP

In 1899, Clarke and Schuchert (p. 876) recognized that the Cambrian and Ordovician portions of the "Calciferous" should be differentiated. Faunally this seemed plausible owing to Walcott's (1884) study of the Potsdam-Hoyt fauna and Cleland's (1900) study of the "new Tribes Hill" fauna; lithically, such a division was not obvious. Unfortunately, they chose the name Beekmantown for the Ordovician portion although neither the then known Tribes Hill (Early Canadian) nor Fort Cassin (Late Canadian) faunas were known to occur at Beekmantown, N.Y. Only 25 feet of dolomitic limestone and calcitic dolostone crop out at Beekmantown and the fossils (Lecanospira zone) indicate only a Medial Canadian age. Subsequently, Clarke (1903, p. 16) proposed the name Little Falls Dolomite for the Cambrian portion of the "Calciferous" though no fossils were known by which its age could be established! Strangely, Clarke called it Champlainic or "Lower Siluric", thereby implying an Ordovician age.

Confusion mounted when Cushing (1905) placed all the strata between the Potsdam and Lowville in the Beekmantown Formation (see Fig. 2) automatically relegating the entire "Calciferous" to the Ordovician. Perplexingly, the name Little Falls Dolomite appears on the geologic map (dated 1901) for the strata in question but the name was not formally proposed in the literature until 1903!

Out of this chaos, the name Beekmantown has come to be employed for all carbonate rock of Early Ordovician (Canadian) age in the eastern and central United States.

TRIBES HILL FORMATION (Ob)

Named by Ulrich and Cushing (1910, p. 99), this unit was initially separated from the Calciferous Sandrock as the Bastard Limestone (see Fig. 2). The Tribes Hill has more calcite and far less quartz than the underlying Little Falls Dolostone; it is also non-cherty. In some places the Tribes Hill is capped by a thin cherty dolostone, the Chuctanunda Creek Dolostone. In my original report (1954) on the Lower Ordovician of the Mohawk Valley, I designated yet another formation - the Cranesville Dolomite - a separation based partly on identification of a gastropod supposedly indicative only of the Upper Canadian. Additional stratigraphic information, not available at the time of the original study, coupled with the now dubious identification and stratigraphic reliability of this gastropod (Eccyliopterus = Lesueurilla) clearly reveals that Cranesville should be abandoned as a stratigraphic name.

The Tribes Hill Formation is subdivisible into four members (Fisher, 1954). They are, in ascending order:

- Fort Johnson Member: massive, dark gray-black, dolomitic calcilutite (fine grained limestone) grading into calcitic dolostone with the calcite portion weathering white and the dolomite portion weathering buff. A fretwork appearance is produced as the patches of dolomite weather out in relief. Occasional quartz grains are present. The fine-grained, massive character coupled with the molluscan fauna and lack of shallow water features produced by waves implies deposition in the outer shelf zone.

- Palatine Bridge Member: distinguished by its relatively large amount of interbedded shale and persistent thin-beddedness of its quartzitic calcilutite layers. Pyrite, some of which is oolitic, and orange-brown iron staining are common. Glauconite is locally common. Some bedding planes are replete with tracks and trails erroneously alluded to as "fucoids". Trilobite fragments are common in the limestone layers. This unit is interpreted to have been formed in the inter-tidal and inner shelf zone.

- Wolf Hollow Member: massive, dark gray-black, dolomitic calcilutite with a single stratum of dolostone, 2-7' thick, a few feet above the base. The calcite weathers white and the dolomite weathers buff and in relief produces a fretwork appearance. This is a recurrent Fort Johnson facies but with a more varied and abundant fauna. Quartz is virtually absent as is pyrite and glauconite. An outer shelf environment seems a likely site of deposition. This and the Palatine Bridge member will be seen at Stop 6 (see Fig. 4 and Road Log).

- Fonda Member: has the most varied fossil content and lithologic makeup of any part of the Tribes Hill Formation. Calcarenites (coarse grained limestones) with quartz sand and silt and with glauconite and pyrite yield most of the fossils, many of which are abraded. Flat-pebble conglomerates (calcirudites), calcitic dolostone, dark gray oolitic quartzose calcarenite, and gray dolomisiltite complete the lithologies. Stratigraphic breaks are common, probably of diastemic value. Ribeirids and gastropods are most numerous, followed by trilobites, orthoconic and cyrtoconic cephalopods, brachiopods, conodonts, and cystid plates in that order. The Fonda seems unquestionably to be a deposit in the high wave energy inter-tidal and inner shelf zones. The Fonda member will be examined at Stop 8 (see Fig. 4 and Road Log).

Where the basal Tribes Hill (Fort Johnson) grades into purer dolostone, the separation from the underlying Little Falls Dolostone then becomes a problem (see Fig. 3). Similarly, where the Tribes Hill laterally changes to dolostone (Gailor facies), separation from the older strata is difficult. In general, the Gailor is a gray, coarsely crystalline, massive bedded dolostone, somewhat cherty and quartzose. Discovery of the gastropods Ophileta and Lytospira (=Ecculiomphalus) and the ellesmeroceroid cephalopod Ectenoceras at Saratoga confirms the existence of Early Ordovician dolostone above the Hoyt Formation; the Little Falls Dolostone is absent in this region, having passed laterally into the Potsdam and Theresa Formations (see Fig.3).

CHUCTANUNDA CREEK DOLOSTONE (Ob)

This, the youngest Canadian unit in the Mohawk Valley, has been named from its type locality along the North Chuctanunda Creek within the city of Amsterdam (Fisher, 1954, p. 90). It is entirely dolostone varying in grain size from the dolomisiltite (medium grained dolostone) through dolomarenite. The upper portion is so impregnated with silica cement that, in some places, the rock behaves physically like chert. Stringy, hackly and nodular chert may be found. Some quartz silt and sand occur and black interstitial carbonaceous material is also present. Bedding varies from 6" to 2'. The maximum thickness is 40'; usually it is 10-25' thick, where present. The erosional surface atop the Canadian, in some places, reaches as low stratigraphically as the Wolf Hollow Member and the Chuctanunda Creek Dolostone is absent in many sections (see Fig.3).

The sparse fossils found are some poorly preserved Ophileta and Lytospira, a silicified cyrtoconic cephalopod (Clarkoceras) and some dolomitized Cryptozoon mounds which resemble hippopotami backs when observed in stream beds. The few available environmental criteria point to deposition in the inter-tidal and inner shelf zones.

The Canadian units offlap the Little Falls Dolostone, or its correlatives, to the north and west.

MEDIAL ORDOVICIAN (MOHAWKIAN) - BLACK RIVER GROUP

The Black River Group receives its name from the splendid extensive exposures in the Black River Valley, flanking the western Adirondacks. There, the Grou~ consists of the Pamelia, Lowville, and Chaumont Formations; the Chaumont includes the Leray and Watertown Limestones of the older literature. At its base, the Pamelia is dolomitic arkose grading upward into greenish, massive bedded, conchoidal fracturing dolostone; rare black calcilutite beds occur. The Pamelia facies grades laterally and vertically into the "dove-gray", white weathering calcilutite of the Lowville which, in turn, grades laterally into the Chaumont black, massive, slightly cherty calcilutite. Faunally, the Pamelia is barren except for ostracodes, the Lowville has a sparse fauna chiefly characterized in its upper part by coral biostromes of Tetradium, whereas the Chaumont holds horn and favositid corals, orthid brachiopods, and large orthoconic cephalopods.

In the Champlain Valley, the Pamelia is dubiously present and the Lowville facies intertongues with a black, massive, calcilutite termed the Isle la Motte Limestone. In the southern Champlain Valley, the lumpy bedded, black Amsterdam Limestone separates the Lowville and Isle la Motte. This facies concept is not as extreme a view as that proposed by Winder (1960) who considered all the limestones of the Black River and Trenton Groups to be contemporaneous. I believe there is a slight hiatus between the two Groups. Locally, disconformable contracts are visible or Trenton limestones are known to overlap the Black River Group. The faunas, too, though imperfectly known, seem chronologically distinct. Accordingly, I place the Black River Group in the Wilderness Stage and most of the Trenton Group in the Barneveld Stage (see Fig. 6).

LOWVILLE LIMESTONE (Otbr)

Named from its type exposure in Lowville, Lewis County, this rock unit has one of the most distinctive physical appearances of any in the State. An extremely fine grain-size, a conchoidal to sub-conchoidal fracture, chalk-white weathering, coupled with a tan-gray color known as "dove gray", stamps the Lowville as a rock not likely to be confused with any other in the State. Occasional well-rounded quartz grains are thought to have been introduced by wind. Dessication cracks are profusely distributed on the bedding planes. The thin-to medium bedded rock is finely laminated; oolites are sometimes present.

The Lowville's fauna, too, is unique. At least four subfacies occur: a Phytopsis facies, a Tetradium facies, a gastropod facies, a fossil-free facies. Phytopsis is a vertical worm boring which in some places riddles the rock as though peppered with bullet holes. It is these holes which caused the early geologists to label this the Birdseye limestone. This is a deposit of the inter-tidal zone. Tetradium is a colonial tabulate coral which is so abundant locally as to form reefs -- thus an inner shelf reef deposit. The gastropod-rich beds probably accumulated as off-reef deposits in the inner shelf zone. The fossil-free laminated beds may have formed in lagoons behind the Tetradium reefs. Bean shaped ostracodes are the most abundant organic remains in the Lowville. Rare brachiopods and trilobites complete the fauna.

In the Mohawk Valley, the Lowville is neither continuous nor is it thick; six feet is the maximum observed thickness. Elsewhere in the State it reaches 65' where it interfingers with the supratidal Pamelia and the infra-tidal Chaumont, Amsterdam, or Isle la Motte calcilutites. In many places, basal Trenton limestones rest on Lowville Limestone without evidence for a time gap. The Lowville will be examined at Stop 4 (see Fig.3 and Road Log).

AMSTERDAM LIMESTONE (Otbr)

Cushing (1911, p. 143) applied the name Amsterdam to the Mohawk Limestone of Conrad (1840). Its type exposure was said to be "in the vicinity of Amsterdam". There is much doubt as to what unit Cushing had in mind for he gave no lithic or faunal description nor were the superjacent and subjacent units mentioned. Furthermore, in his description of the Paleozoic rocks of the Saratoga region, Cushing (1914) reports 39 feet of Amsterdam at Rock City Falls. The only limestone there with a thickness of such magnitude is tne Trenton, most of it being the gray Larrabee coarse-textured limestone with a typical Trenton fauna. It follows that Cushing, the nomenclator of the Amsterdam, utilized his name for the coarse-textured "base of the Trenton" limestone, referred to by Ruedemann to the lower half of his Glens Falls Limestone. Kay (1937, p. 259) employed the name Amsterdam for approximately 10' of gray-black, rough fracturing limestone with wavy bedding planes above the Lowville and beneath the Glens Falls (Larrabee member). This application seems more in keeping with the usage of Mohawk Limestone of the early geologists of the New York Survey (see Fig.2).

It would seem that Vanuxem's "Third District" report would shed light on the matter but, on this point, Vanuxem himself wavered. In 1840, he clearly stated that the Mohawk Limestone <u>underlay</u> the Birdseye (Lowville) Limestone; this would place the <u>Mohawk Limestone</u> in the Tribes Hill Formation. Later, (1842) he refers to the Base of the Trenton and Black River Limestone as Mohawk Limestone. In summary, different workers have applied the name Amsterdam to different rock units. Ordinarily, priority would be respected but in this case the main usage has been for a unit not intended to be termed Amsterdam by its nomenclator! It, thus, seems prudent to accept the principal usage -- that the Amsterdam overlies the Lowville and underlies the Larrabee.

As so defined, the Amsterdam is a lumpy bedded, blocky, dark gray to black, calcilutite to calcisiltite which weathers grayish-white and has a hackly or brittle fracture. In commenting on the Black River Limestone of the Amsterdam quadrangle, Cumings (1900, p. 465) stated, "The lumpy structure mentioned by the early New York geologists as a characteristic of the <u>Columnaria</u> horizon at Watertown is its [Amsterdam] most constant <u>lithologic</u> character in the present region [Amsterdam quadrangle]". Its maximum thickness in the Mohawk Valley is about 11 feet but usually it is 4-6 feet; in some places it is absent from its accustomed stratigraphic position. Its fauna is large in numbers and variety but is, as yet, unstudied (Fisher, in progress). Snails, orthid and strophomenid brachiopods, trepostome bryozoans, ostracodes, horn and columnarid corals, trilobites, actinoceroid cephalopods, conodonts, and pelecypods occur in that order of abundance. This is a typical infratidal shelf fauna. The lumpy bedding together with haphazard fossil orientation suggests deposition above wave base and in the inner shelf zone.

Figure 5

COMPARISON OF CLASSIFICATION OF NEW YORK ORDOVICIAN

Kay 1960			RADIOMETRIC DATES IN MILLIONS OF YEARS	Fisher 1962		
SERIES	STAGES	SUBSTAGES		SERIES	STAGES	ROCKS
			425			
CINCINNATIAN	Richmondian Maysvillian Edenian			CINCINNATIAN	Richmond Maysville Eden	QUEENSTON FORMATION LORRAINE GROUP
			435			
TRENTONIAN	Pictonian Shermanian Nealmontian	Gloucesterian Collingwoodian Cobourgian Denmarkian Shorehamian Kirkfieldian Rocklandian	445	MOHAWKIAN	Barneveld	TRENTON GROUP *including* UTICA
BLACKRIVERAN	Chaumontian Lowvillian Pamelian				Wilderness	BLACK RIVER GROUP
			455			
CHAZYAN	Valcourian Crownian Dayan Whiterockian			*UNNAMED*	Porterfield Ashby Marmor Whiterock	*absent in New York* CHAZY GROUP *absent in New York*
			470			
CANADIAN	Cassinian Jeffersonian Demingian Gasconadian	*Proposed by Flower (1957) but not used by other Ordovician workers except Kay.*		CANADIAN	*(Stages not yet established)*	BEEKMANTOWN GROUP
			500			

GYG 4-65

As early as 1900 Prosser (p. 470), in discussing the Ingham's Mills section on East Canada Creek, recognized the interfingering of the Birdseye [Lowville] and Black River Limestone [Amsterdam] lithologies. Such intergradation is demonstrable in several places.

The Amsterdam is not certainly present west of Tribes Hill; a few feet of lumpy-bedded limestone at Stone Ridge are questionably referred to the Amsterdam.

MEDIAL ORDOVICIAN (MOHAWKIAN) - TRENTON GROUP

There has been much ambiguity in the use of the name Trenton. To some it means rocks (Trenton Group, Trenton Formation); to others it denotes time (Trentonian Series, Trenton Stage). In addition, there are varying opinions as to the stratigraphic limits of these rock or time units. My preference is that Trenton be used as a rock term (Group). The type section of the Trenton Group is at Trenton Falls, N.Y. on West Canada Creek. Not all the Trenton rock units are exposed here but most of the typical limestones are well displayed.

Marshall Kay has been the most intensive worker in the New York Trenton. His classic paper (1937), "Stratigraphy of the Trenton Group", was an elaboration for subsequent studies in these rocks in New York and Ontario and a reference for Medial Ordovician stratigraphic studies elsewhere. Because of fundamental differences in our philosophies on a "Formation" and faunal zonation, our respective stratigraphic frameworks are noticeably different. Figure 5 is a comparison of Kay's most recent terminology (1960) with mine (Fisher, 1962b) which is patterned after that adopted by G. A. Cooper (1956).

GLENS FALLS LIMESTONE (Otbr)

For the limestone intervening between the Amsterdam below and the Canajoharie Shale above, in the Mohawk Valley and in the Saratoga - Glens Falls region, Ruedemann (1912, p. 22) proposed the name Glens Falls Limestone. He recognized that it was older than any limestone at Trenton Falls. Earlier, that perceptive geologist E. R. Cumings (1900, p. 466) reported, "The Trenton substage is composed of two members, a lower, massive, crystalline and an upper, thin-bedded, fine-grained member. The lower member is usually about 8 feet in thickness and the upper probably not far from 30 feet. This, together with Ruedemann's repeated references to a twofold division of the Glens Falls prompted Kay (1937, p. 262-265) to apply formal names to these divisions -- Larrabee for the lower Glens Falls and Shoreham for the upper.

LARRABEE LIMESTONE (Otbr) This is a light to medium gray, thin - to medium bedded dark gray weatherin calcarenite to calcisiltite which typically produces field ledges and has been extensively quarried in the past. Cross-bedding and pebble beds are rarely encountered. Locally, there is a basal, lumpy bedded somewhat conglomeratic argillaceous calcilutite as at Rock City Falls, north of Tribes Hill along NY 67, and at Stone Ridge. It is noteworthy that this subunit, never exceeding 8 feet in thickness occurs only where the subjacent Amsterdam is thin or absent.

The Larrabee's fauna is large with orthid and strophomenid brachiopods being the most numerous. Crinoid debris and snails are common. Among the trilobites, Encrinurus cybeliformis and Bathyurus ingalli seem to be reliable guides to the Larrabee.

The nomenclatorial confusion surrounding this unit has already been discussed under the Amsterdam Limestone (see Fig.2). It is debatable whether the name Larrabee should be carried west of the Adirondack Axis.

The paleoecological niche of the Larrabee seems unquestionably to be the inner shelf zone, as the sedimentary evidence clearly points to deposition in a high energy zone but one with a prolific marine bottom fauna (see Fig. 4).

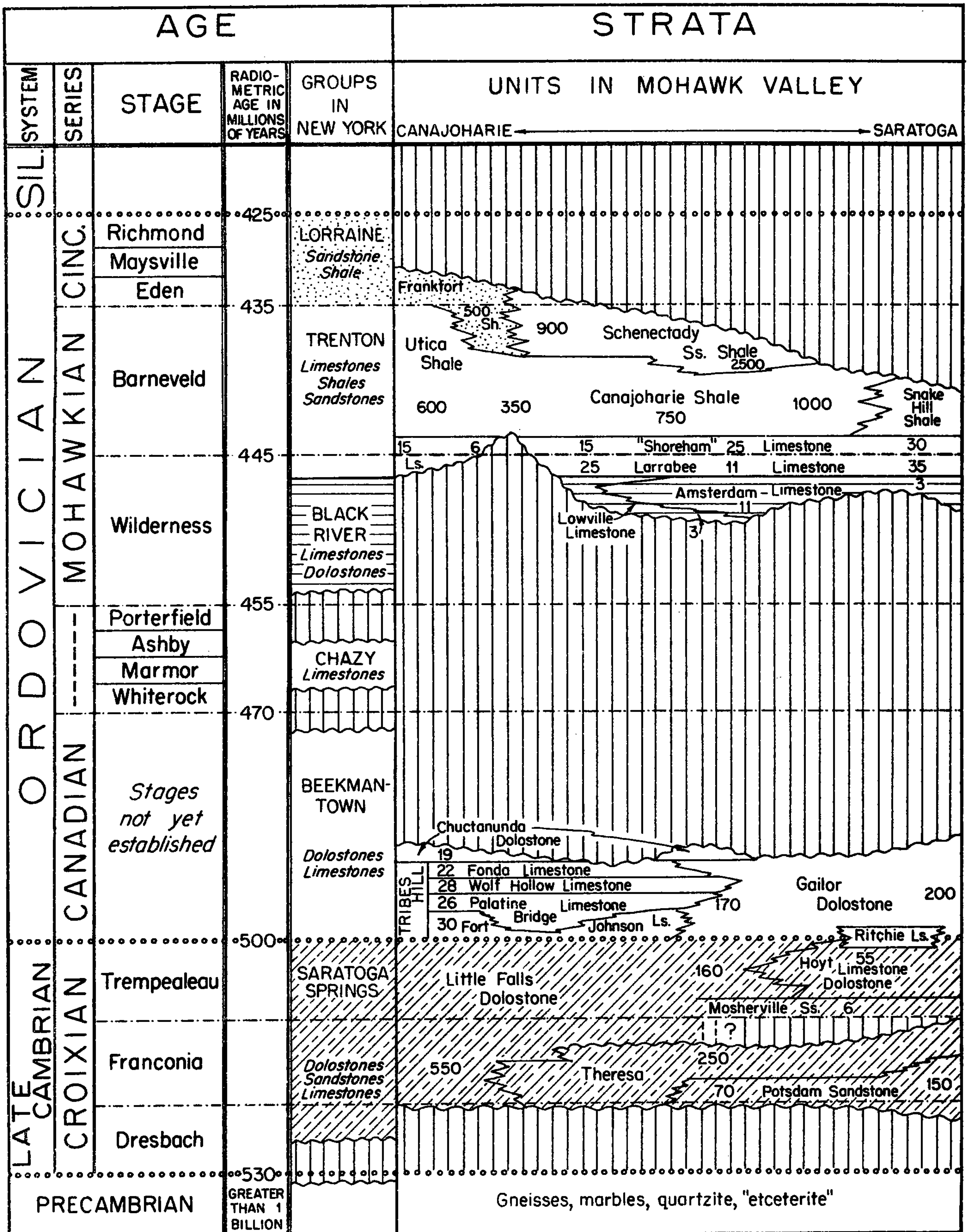
The Larrabee may be seen at Stops 2, 4 and 8 (see Fig. 3 and Road Log).

"SHOREHAM LIMESTONE" (Otbr) Kay defines this unit thusly, "The Shoreham member (Shoreham Township, Addison County, Vermont) constitutes the zone of Cryptolithus tesselatus Green, the limestones of lowest Sherman Fall age". Clearly, the name Shoreham applies to a biostratigraphic unit and not a lithologic one. Since its inception, the name Shoreham has come to be employed for the rock between the Denmark above and the Kirkfield or Larrabee below despite the fact that the lithology varies and the trilobite Cryptolithus tesselatus is not known everywhere from this stratigraphic interval. For example, Kay (1937) places the Shoreham along Flat and Canajoharie Creeks but, after intensive search no Cryptolithus could be found and the rock is coarser textured than the "Shoreham" elsewhere. I would agree with Kay (1960) that the Shoreham may be utilized as a substage (zone of Cryptolithus tesselatus) but I disagree that, in addition, it can be regarded as a rock unit with fixed physical characters.

In the Mohawk Valley and Saratoga-Glens Falls region, the "Shoreham" (upper Glens Falls Limestone) is composed of alternating dark gray to black calcareous shale and thin-bedded dark gray to black argillaceous calcilutite and calcisiltite. Because the upper Glens Falls deserves a new rock name, which ought not to be proposed here, the name Shoreham is provisionally retained in quotes.

Figure 6

CORRELATION CHART – LOWER MOHAWK VALLEY



Note: All thicknesses shown in approximate feet.

Faunally, the "Shoreham" is a trilobite-brachiopod facies and several genera of each occur in immense numbers (see under Faunal Zonation) . Bryozoans are next in abundance. Inarticulate brachiopods and orthoconic cephalopods are not uncommon. The site of deposition seems to be the outer shelf zone, below the effective depth of wave base (see Fig.4).

CANAJOHARIE SHALE (Oc)

Named (Ruedemann, 1912, p. 28) from the section along Canajoharie Creek south of the village, the Canajoharie Shale is thicker than the composite thickness of the older Paleozoic strata; it approaches 1100' in the eastern Mohawk Valley thinning westward to 350' over the Adirondack Axis expanding again westward to 650'. It is lithologically remarkably uniform being a slightly calcareous dark gray to black shale. In some places the rock is so dense and compact as to be called an argillite. Pyrite nodules, up to 4", are rarely found.

To the west, the Canajoharie passes through the Dolgeville facies (alternating black shale and thin-bedded black calcilutite) into typical Trenton limestone (Denmark). To the east, the Canajoharie grades into the silty Snake Hill Shale and into the lower Schenectady graywacke and gray shale (see Fig. 6).

In the main, the fauna is a pelagic one consisting chiefly of planktonic graptolites and nektonic orthoconic and gyroconic cephalopods. Epiplanktonic brachiopods, snails, and sponges adhered to floating seaweed. A meager benthonic fauna of scavengers or "garbage collectors" appears in the upper Canajoharie and Utica Shales. Chief among these are the trilobites Triarthrus and Flexicalymene.

The origin of black shales has been the subject of much dispute. Some regard the foul hydrogen-sulfide rich muds as having been deposited in fairly deep waters; others believe the highly reducing conditions to have taken place in virtually land-locked lagoons. Whatever the depositional site, black shales generally lack a normal bottom fauna, lack calcareous fossils and, in the Ordovician, are apt to yield those strange extinct graptolites - excellent devices for correlation.

SCHENECTADY FORMATION (Osc)

For the great thickness of interbedded silty gray and black shales, buff-weathering graywackes, and argillaceous sandstones that form the surface rock throughout virtually all of Schenectady County, Ruedemann (1912, p. 38) applied the name Schenectady beds. Thicker than the whole of the preceding Paleozoic section, the Schenectady's actual thickness is undetermined owing to insufficient long sections and lack of marker beds within the monotonous repetitive lithologies. Well data disclose that 2000' are penetrated before the Canajoharie Shale is reached; the Schenectady may approach 2600'.

The Schenectady's meager fauna indicates a Mohawkian age; graptolites, (orthograptus truncatus) eurypterids, and seaweeds are the chief elements.

The formation is a terrigenous product of vigorous erosion and rapid sedimentation. Much turbidite phenomena exist such as sole markings and flow rolls. Lithologically, the Schenectady is reminiscent of the Chemung beds of the Upper Devonian but the bottom fauna so profuse in the Chemung is almost non-existent in the Schenectady. The Schenectady is a younger extension of the Normanskill. Presumably the Schenectady accumulated in a sinking basin, on the continental slope (see Fig. 4) in front of the rising Taconic Mountains. Its great thickness may be attributed to the shedding of older Cambrian and Ordovician clastics from the recently emplaced Taconic Allochthone in Mohawkian time. In turn, the younger Late Ordovician Pulaski and Oswego facies were derived from the erosion of the Schenectady sediments.

FAUNAL ZONATION

Not only are the fossils of the Cambrian and Ordovician strata in the Saratoga to Canajoharie region useful for reconstructing past environments but they are usable for determining relative ages and for correlating with other areas. Whereas benthonic (bottom dwellers) animals, particularly those that are immobile, are superior indicies to environments, nektonic (swimmers) and planktonic (floaters) ones are more valid for zonation and correlation purposes because of quicker and wider dispersal. On the other hand, the factors of abundance and easy identification bear on the matter. For this reason, the Mohawk Valley strata, especially the carbonates, are more easily zoned through the use of mobile or vagrant benthos, specifically the trilobites. It was during the Cambrian and Ordovician Periods that trilobites attained their maximum diversity and numbers -- the zenith or acme of their evolutionary cycle. Because of their profusion and relative ease of identification nine biostratigraphic zones may be distinguished:

Triarthrus, *Flexicalmene*	-	Lower Schenectady - Upper Canajoharie
Cryptolithus tesselatus, *Flexicalmene*, *Isotelus*	-	"Shoreham", Snake Hill
Bathyurus ingalli, *Encrinurus cybeliformis*, *Isotelus*	-	Larrabee
Bathyurus spiniger, *Bumastus trentonensis*, *Isotelus*	-	Amsterdam
Hystricurus ellipticus, *Clelandia parabola*	-	Upper Tribes Hill
Asaphellus gyracanthus, *Symphysurina*, *Bellefontia*	-	Lower Tribes Hill
Plethopeltis, *Keithiella*	-	Upper Hoyt
Dikellocephalus, *Prosaukia*, *Plethometopus*, *Saratogia*	-	Lower Hoyt
Elvinia, *Camaraspis*	-	Theresa (Galway)

In relating strata of one area or continent with another, it is customary to compare fossil assemblages rather than fossil species. The reason for this is that individual species are usually provincial, that is, they are ecologically or geographically controlled and species are more liable to subjective rather than objective refinement. The faunal summary (by series) below is not intended to be comprehensive but it does illustrate the gross composition of the respective faunas.

SERIES	abundant to frequent	scarce to rare
	*graptolites (Orthograptus, Lasiograptus, Glossograptus)	*orthoconic cephalopods (Geisenoceras)
	*trilobites (see earlier tabulation)	*ostracodes (Primitiella)
		*inarticulate brachiopods (Obolus, Trematis)
		*algae
	strophomenid brachiopods (Rafinesquina)	lingulid & obolid brachiopods (Lingula, Trematis)
	orthid brachiopods (Paucicrura, Dinorthis, Zygospira, Sowerbyella)	endoceroid cephalopods
	bryozoans	actinoceroid cephalopods
MOHAWKIAN	trilobites (see above)	conularids
	gastropods (Trochonema, Hormotoma, Liospira, Phragmolites)	pelecypods
		worm borings
	ostracodes (Eoleperditia, Isochilina, Kloedinella)	receptaculitids
	conodonts	
	crinoid fragments	
	corals (Foerstephyllum, Favistella=Columnaria)	

* items prefixed with asterisk occur in black shale

	abundant to frequent	scarce to rare
CANADIAN	ribeirids (<u>Ribeiria</u>) gastropods (<u>Ophileta</u>, <u>Bucanella</u>, <u>Liomphalus</u>, <u>Gasconadia</u>) orthoconic cephalopods (<u>Ectenoceras</u>, <u>Walcottoceras</u>) cyrtoconic cephalopods (<u>Clarkoceras</u>) trilobites (see earlier tabulation)	lingulid brachiopods (<u>Lingula</u>) orthid brachiopods (<u>Finkelnburgia</u>) worm trails cystid plates conodonts tentaculitids
CROIXIAN	trilobites (see earlier tabulation) algae (<u>Cryptozoon</u>)	gastropods (<u>Matherella</u>, <u>Rhachopea</u>) lingulid brachs. (<u>Lingulepis</u>) matthevids (<u>Matthevia</u>) hyolithids worm borings

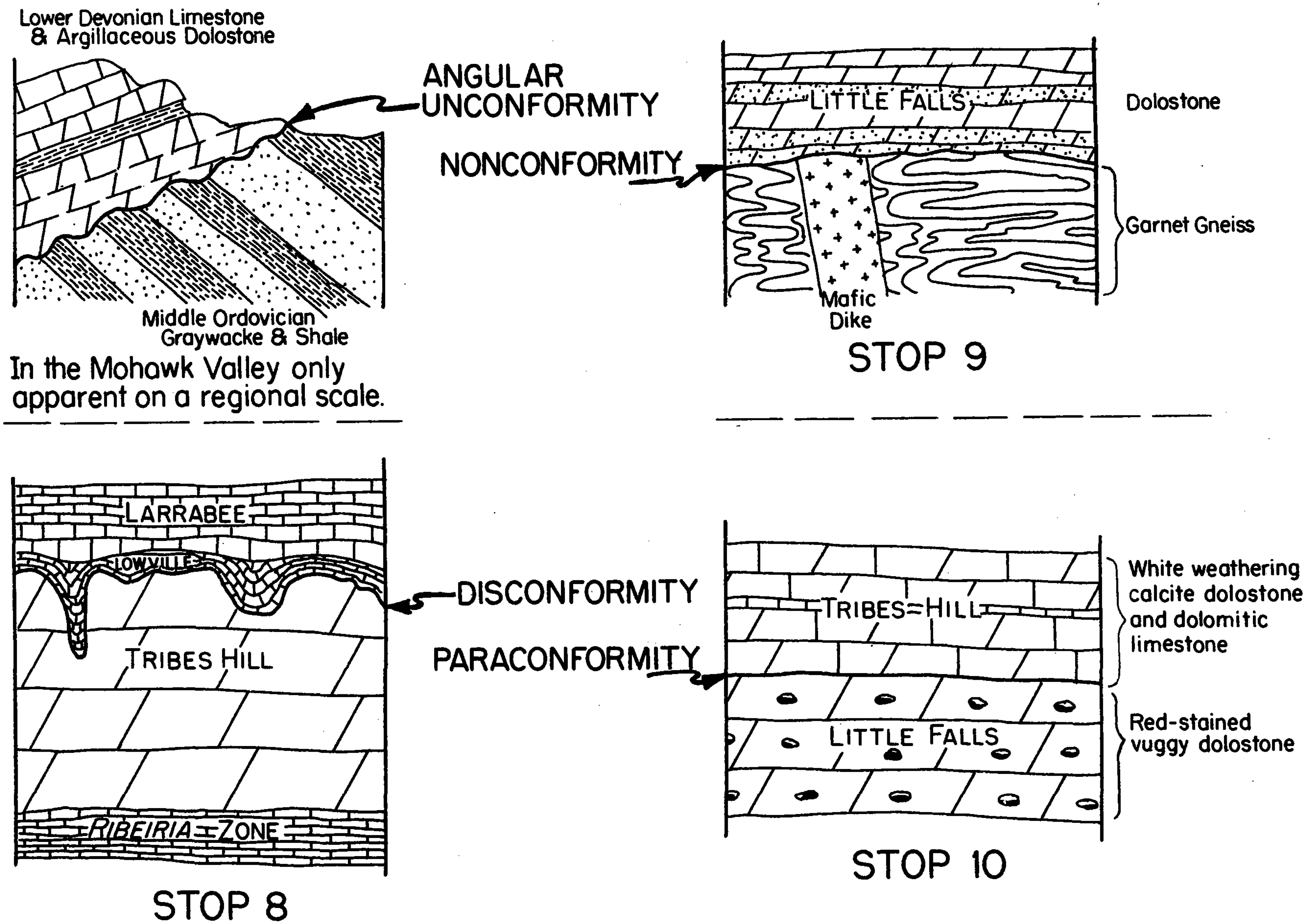


Figure 7 Types of Unconformities

STRUCTURE

UNCONFORMITIES - OBVIOUS AND OBSCURE

Lack of continuity in the sedimentary record has long been recognized. In fact, every bedding plane is an interruption of that continuum. But these gaps in the record are of geologically short duration, perhaps daily, weekly, or yearly cessations of sedimentation; other gaps may span millions of years as, for example, Recent alluvium resting on early Precambrian rocks. Any break in the sedimentary sequence signifies subtraction from the steady supply of stratigraphic data, whether produced by the neutral condition of non-deposition or the negative one of erosion. Stratigraphic gaps are constantly being filled by extension of investigation but, as Darwin once intimated, there is probably more time represented by breaks than by record.

To those concerned with reconstructing geologic history, stratigraphic breaks or unconformities are of the utmost importance. Originally, they were delineated by abrupt changes from basement metamorphic rocks to unmetamorphosed sedimentary rocks. Discordance of bedding between two adjacent units was early recognized as reflecting a diastrophic event in which uplift and folding caused a stoppage of the normal sedimentary cycle prior to the return of sedimentation; the duration of the period of omission of the record was called an hiatus. However, the amassed paleontologic evidence sometimes illustrated great gaps in evolutionary sequences where physical gaps are not apparent. Closer scrutiny of the field relations disclosed no angularity of bedding between two units with fossils of different ages but it did reveal that the contact surface was an irregular one which, when traced over a broad area, proved that the underlying strata had undergone erosion. This disconformable surface was sometimes capable of being traced into an area where an angular bedding relationship could be demonstrated. Still another more baffling situation commonly arose where, within a single lithologic unit, faunas of markedly differing ages occurred.

Few geologic phenomena are of more interest and importance than unconformities for they record emergence, erosion, non-deposition and diastrophism. Four types of unconformities may be distinguished (see Fig. 7). It is apparent that the nonconformity, in which two units of stratified rock and the angular unconformity, in which two units of stratified rocks are discordant are easily detected. Less easily discerned is the disconformity, in which two units of stratified rock are parallel but the surface of unconformity is an old erosion surface of measurable relief, because some bedding planes are undulatory and some intraformational conglomerates produce pseudo-disconformable surfaces. The really obscure unconformity is the paraconformity in which strata, often of identical lithology, are parallel but the contact is a simple bedding plane and the stratigraphic gap must be determined by faunal analysis.

It should be kept in mind that the length of time missing is not necessarily a function of the obviousness of the unconformable surface. Cross-bedded formations show marked angular discordance of bedding but there is little or no break in sedimentation. Conversely, some paraconformable surfaces are of long duration as, for example, Mississippian Redwall Limestone on Middle Cambrian Mauv Limestone in the Grand Canyon.

Bear in mind, too, that an unconformity may appear in more than one guise. When considered on a regional basis it may manifest itself as an angular unconformity but at a single exposure it may appear as a disconformity or even a paraconformity. Breaks of short extent (diastems), when compounded, probably account for more geologic time than more obvious unconformities.

The following is a summation of stratigraphic breaks in the lower Mohawk Valley and Saratoga region presented in order of increasing time:

Pleistocene and Recent deposits

---- angular unconformity (regionally) and disconformity (locally)----

Trenton Group

---- disconformity (regionally) and paraconformity (locally) ----

Black River Group

---- angular unconformity (regionally) and disconformity (locally) ----

Tribes Hill Formation (diastems within unit)

---- paraconformity (locally) ----

Little Falls Dolostone (diastems within unit)

---- nonconformity ----

Precambrian gneiss

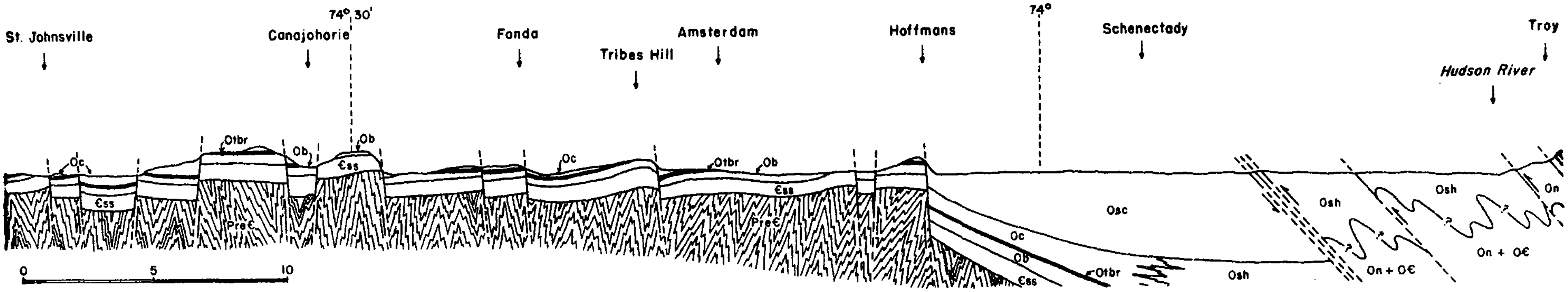


Figure 8 Structural Section of the Mohawk Valley — St. Johnsville to the Hudson River

FAULTS - HORSES, HORSTS, AND GRABEN

Fractures in the Earth's crust along which there has been movement parallel to the fracture surface are known as faults. One type, called normal faults, is well displayed in the Mohawk Valley. Normal faults, in contrast with reverse faults, are those in which the hanging wall has dropped down relative to the foot wall. If parallel faults are downdropped on the same side, a step-like topography may result. If, however, some of the parallel faults are downdropped on the opposite side, a series of troughs and ridges known as graben and horsts are produced (see Fig. 8). This series of upthrown blocks (horsts) and downthrown blocks (graben) extend from the Hoffmans Fault on the east to Little Falls on the west. The faults are all very high angle, the fault planes dipping from 75° to verticality. Occassional dips as low as about 45° are observable, for example, where the Little Falls Fault crosses the N. Y. State Thruway.

In general, the gravity or normal faults with the greatest vertical displacement (throw) are downdropped on the east. This produces a series of staggered steps as one proceeds west, up the Valley (see Fig. 8). Northward these faults extend into the Precambrian gneisses of the Adirondack Mountains (see Fig. 1). The throw increases to the north but whether it continues to increase within the Adirondacks is not determinable owing to the lack of marker beds. Southward, thick glacial debris piled against the foot of the Devonian Helderberg and Onondaga Escarpments and an east-trending drumlin field prohibits tracing the faults with accuracy. The youngest strata cut are of the late Barneveld Schenectady Formation; the oldest strata not cut are those of the Medial Silurian Clinton Group. Either the faults extend beneath the Helderberg Escarpment or else they hinge out in the Ordovician shales prior to reaching the Escarpment.

The cause of the Mohawk Valley faulting is conjectural. At least three hypotheses have been suggested to explain the reason why such block faulting should occur. Chadwick (1917) believed that the faults were crustal readjustments on the shelf due to the tremendous weight exerted by the Taconic Klippe on the crust in the thicker portion of the geosynclinal strata, i.e. isostatic compensation. Megathlin (1935) regarded the faults as tensional responses following a period of compressional stress which gave rise to folds and reverse faults in eastern New York, i.e. relaxation of stresses. Yet another hypothesis may be offered which attributes the gravity faults to differential updoming of the Adirondacks; it is significant that the faults increase in throw to the north.

The age of the faulting is as much a mystery as is the cause. Block faulting is known in the Triassic Period in eastern New York and New England. Regional uplift is known in the Tertiary but no faulting is presumed to have taken place then. Reverse faulting is proved in the Taconian and Acadian Orogenies. In all probability, the Mohawk Valley faults were active early in the Paleozoic and renewed movement took place at subsequent times in geologic history.

Certain it is that the Noses Fault Scarp was a formidable barrier to sedimentation. The whole pattern of Late Ordovician deposition (Lorraine Group and Queenston Shale) shifted to the west indicating that the Mohawk Valley was sufficiently uplifted to prohibit epeiric seas from covering this portion of N.Y.

A structural feature of importance bisects the Mohawk into an Upper and Lower Valley. This Adirondack Axis (or arch) was effective as a barrier as early as Early Ordovician time and continued to be effective until sometime during Canajoharie sedimentation, then again during Schenectady sedimentation. The entire Valley region was uplifted during the Late Ordovician and remained a source area for a greater part of the Silurian Period. Marine seas were unable to inundate the region until Late Silurian (Brayman) time. The stratigraphic sequence from Brayman Shale through the Devonian shows no evidence of an Adirondack Axis. The crest of the Axis seems to have occurred in Late Ordovician time when the thick regressive Queenston Delta deposits changed to Early Silurian transgressive deposits; from the base of the Clinton to the end of the Silurian the pattern is one of eastward transgression except for a regressive period at the close of Herkimer deposition and two minor regressive periods during the formation of the Clinton Group. The most plausible age, then, for the culmination of block faulting in the Mohawk Valley seems to be during the latest Ordovician with minor reactivity perhaps in the earliest Silurian and again prior to the formation of the late Silurian Vernon Delta.

The normal faults with the greatest throw are from east to west, the MacGregor Fault (from Saratoga north), the Hoffmans Fault, the Noses Fault (midway between Fonda and Canajoharie), the St. Johnsville Fault and the Little Falls Fault. The largest graben is that occupied by the Sacandaga Reservoir; the largest horst is that atop the Noses. Many of the faults, especially the largest ones, split into two or more faults when traced north. In contrast, the faults with smaller displacements seem to die out both northward and southward (Tribes Hill Fault, Fonda Fault).

A feature attendant to faulting that is shown to advantage in the Mohawk Valley is a horse, a small block or sliver caught along the fault surface. The strata within the horse are intermediate in age between the older strata of the upthrown side and the younger strata of the downthrown block. Within the horse, the rocks invariably posses a northerly component to their dip, which may be either westerly or easterly. Horses are probably more prevalent than customarily supposed but are infrequently seen because of scarcity of rock exposure. Horses will be observed at Stops 4 and 5.(see Road Log).

Reverse faults are unknown west of Schenectady but they are plentiful in the Taconic region east of the Hudson River where imbricate or shingle blocks have been pushed westward by compressional and gravitational forces.

No special study of joints, fractures in rocks along which there is no movement parallel to the ruptured surface, has been made. We are unsure what relation persistence or non-persistence of joint patterns means with respect to faulting or regional uplift (epeirogeny).

SELECTED REFERENCES

"Some books are to be tasted, others to be swallowed, and some few to be chewed and digested" --- Francis Bacon

Brigham, A.P., 1929, Glacial geology and geographic conditions of the Lowe Mohawk Valley: N. Y. State Museum Bull. 280, p. 5-85, illus.

Broughton, J.G., & Fisher, D.W., Isachsen, Y.W. & Rickard, L.V., 1962, The geology of New York State, N. Y. State Museum and Sci. Serv. Map and chart Series 5 (a 40,000 word text)

Clarke, J.M., 1903, Classification of New York series of geological formations: N. Y. State Museum Handbook 19, 28 p.

Clarke, J.M., & Schuchert, C., 1899, Nomenclature of New York series of geological formations: Science, n. ser., V. 10, p. 876.

Cleland, H.P., 1900, The Calciferous of the Mohawk Valley: Bull. Amer. Paleon., V. 3, No. 13, 26 p., illus.

______________, 1903, Further notes on the Calciferous (Beekmantown) formation of the Mohawk Valley; with descriptions of new species: Bull. Amer. Paleon., V. 4, No. 18, 24 p.

Conrad, T.A., 1837, First annual report of the geological survey of the third district of the State of New York: N. Y. Geol. Surv., 1st Ann. Rpt. p. 155-186.

______________, 1839, Second annual report on the paleontological department of the survey: N. Y. Geol. Surv., 3rd Ann. Rpt., p. 57-66.

Cooper, G.A., 1956, Chazyan and related brachiopods: Smith. Misc. Coll., V. 127, 1024 pp., 269 pls.

Cumings, E.R., 1900, Lower Silurian System of eastern Montgomery County, New York: N. Y. State Museum Bull. 34, p. 419-467, illus., map.

Cushing, H.P., 1905, Geology of the vicinity of Little Falls, Herkimer County: N. Y. State Museum Bull. 77, 95 p., map.

______________, 1911, Nomenclature of Lower Paleozoic rocks of New York: Amer. Jour. Sci., 4th ser., V. 31, p. 135-145.

Bibliography - cont'd

_______________, & Ruedemann, R., 1914, Geology of Saratoga Springs and vicinity: N.Y. State Museum Bull. 167, 177 p., map.

Darton, N.H., 1895, A preliminary description of the faulted region of Herkimer, Fulton, Montgomery, and Saratoga Counties: N. Y. State Museum Ann. Rpt. 48, p. 31-53, map.

Dunn, J., & Fisher, D.W., 1954, Occurrence, properties, and paragenesis of Anthraxolite in the Mohawk Valley: Amer. Journ. Sci., V. 252, p. 489-501.

Eaton, A., 1824, A geological and agricultural survey of the district adjoining the Erie Canal, in the State of New York: Albany, Packard and Van Benthuysen, 163 p.

Fairchild, H.L., 1912, The glacial waters in the Black and Mohawk Valleys: N. Y. State Museum Bull. 160, 48 p., illus.

_______________, 1919, Pleistocene marine submergence of the Hudson, Champlain, and St. Lawrence Valleys. N. Y. State Museum Bull. 209-210, 76 p.

Fisher, D.W., 1954, Lower Ordovician (Canadian) stratigraphy of the Mohawk Valley, New York: Geol. Soc. Amer. Bull., V. 65, p. 71-96, illus.

_______________, 1962a, Correlation of the Cambrian rocks in New York State: N. Y. State Museum and Science Serv., Map & Chart Ser. No. 2.

_______________, 1962b, Correlation of the Ordovician rocks in New York State: N. Y. State Museum and Science Serv., Map & Chart Ser. No. 3.

_______________, 1955, Time Span of the Theresa and Potsdam Formations in the region peripheral to the Adirondack Mountains, New York: Geol. Soc. Amer. Bull., V. 66, No. 12, Pt. 2, p. 1558-1559.

_______________, 1956, The Cambrian System of New York State: Cambrian Symposium, 20th Inter. Geol. Congress, Mexico City, V. 2, p. 321-351, illus.

_______________, & Hanson, G.F., 1951, Revisions in the geology of Saratoga Springs, New York and Vicinity: Amer. Jour. Sci., V. 249, p. 795-814, illus.

Fisher, D.W., Isachsen, Y.W., Rickard, L.V., Broughton, J.G. & Offield, T.W., 1961, Geologic Map of New York, N. Y. State Museum and Sci. Serv., Map and Chart Series 5 (especially Mohawk-Hudson sheet).

Bibliography - cont'd

Goldring, W., 1958, Algal barrier reefs in the Lower Ozarkian (Late Cambrian) of New York: N. Y. State Museum Bull. 315, p. 5-75.

Hall, J., 1847, Descriptions of the organic remains of the lower division of the New York System, equivalent of the Lower Silurian rocks of Europe: Paleontology of New York, V. 1, 338 p., illus.

Isachsen, Y.W., 1965, Geologic excursion from Albany to the Glen via Lake George, in Guidebook for 37th Ann. meeting of N. Y. State Geol. Assoc.,(available as separate from N. Y. State Museum & Sci. Ser.).

Kay, G.M., 1937, Stratigraphy of the Trenton Group: Geol. Soc. Amer. Bull., V. 48, p. 233-302, illus.

__________, 1960, Classification of the Ordovician System in North America: Inter. Geol. Con., 21st session in Ord. & Sil. Strat. & Correlation, pp. 28-33.

Megathlin, G.R., 1938, Faulting in the Mohawk Valley: N. Y. State Museum Bull. 315, p. 85-122.

Miller, W.J., 1911, Geology of the Broadalbin quadrangle, Fulton-Saratoga Counties, New York: N. Y. State Museum Bull. 153, 65 p., map, illus.

Prosser, C.S., 1900, Notes on stratigraphy of Mohawk Valley and Saratoga County, New York: N. Y. State Museum Bull. 34, p. 469-484, map, illus.

Rasetti, F., 1946, Revision of some late Upper Cambrian trilobites from New York, Vermont, and Quebec: Amer. Jour. Sci., V. 244, p. 537-546, illus.

Reid, W.M., 1901, The Mohawk Valley, its legends and its history, G.P. Putnam's Sons.

Ruedemann, R., 1912, The Lower Siluric shales of the Mohawk Valley: N. Y. State Museum Bull. 162, 151 p., illus.

__________, 1925, The Utica and Lorraine Formations of New York; Part I, Stratigraphy, 175 p., illus.

__________, 1930, Geology of the Capital District (Albany, Cohoes, Troy and Schenectady quadrangles): N. Y. State Museum Bull. 285, 218 p., illus., map.

Stoller, J.H., 1911, Glacial Geology of the Schenectady quadrangle: N. Y. State Museum Bull. 154, 44 p., illus.

__________, 1916, Glacial Geology of the Saratoga quadrangle: N. Y. State Museum Bull. 183, 50 p., illus.

Bibliography - cont'd

Ulrich, E.O., & Cushing, H.P., 1910, Age and relations of the Little Falls Dolomite of the Mohawk Valley: N. Y. State Museum Bull. 140, p. 97-140.

Vanuxem, L., 1840, 4th Annual Report of the Geological Survey of the Third District, pp. 355-383

__________, 1842, Survey of the Third geological District, in Geology of New York, Part 3, Albany, 306 p.

Walcott, C.D., 1884, Potsdam fauna at Saratoga, New York: Science, V. 3, p. 279-281, illus.

__________, 1912, Cambrian geology and paleontology, No. 9, New York Potsdam-Hoyt fauna: Smith. Misc. Coll. V. 57, p. 1-498, illus.

Wheeler, R.R., 1942, Cambrian-Ordovician boundary in the Adirondack Border region: Amer. Jour. Sci., V. 240, p. 518-524.

Winder, C.G., 1960, Paleoecological interpretation of Middle Ordovician stratigraphy in southern Ontario, Canada: Inter. Geol. Con., 21st session, Norden, in Ordovician and Silurian Stratigraphy and correlation, p. 18-27, illus.

Figure 9

ALGAE

Cryptozoon

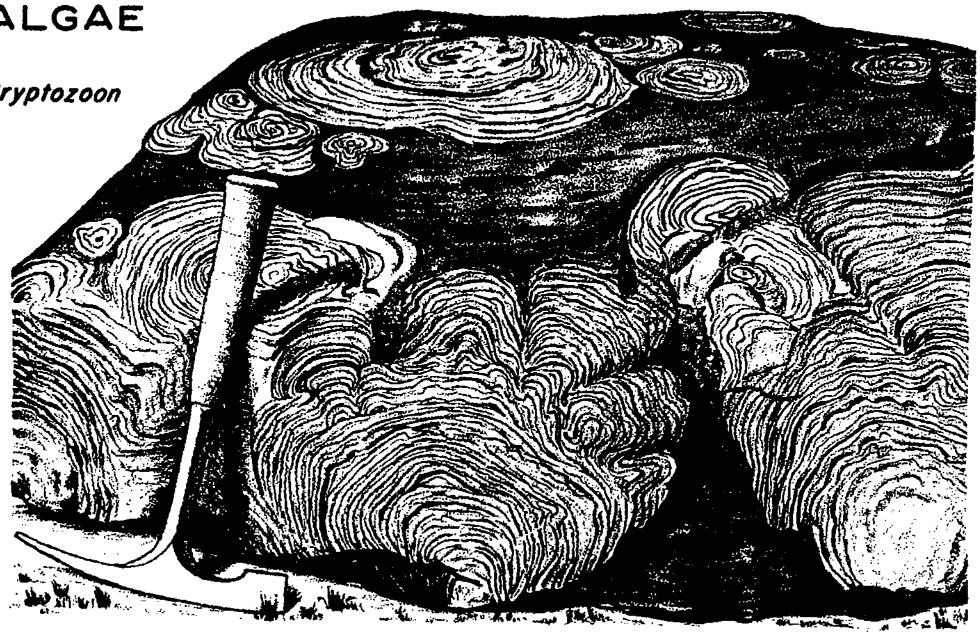
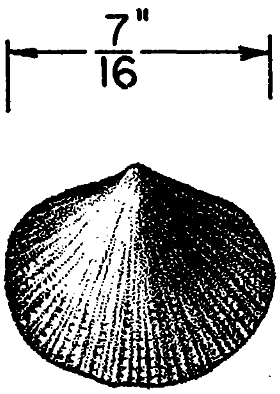


Figure 10



Paucicrura

Figure 11

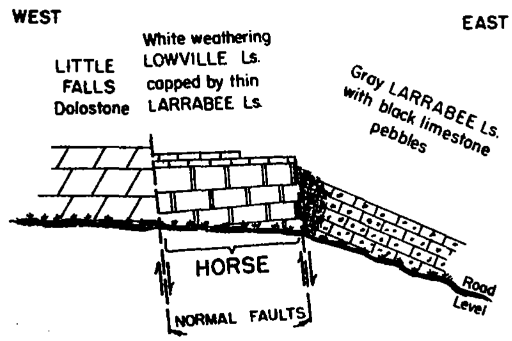
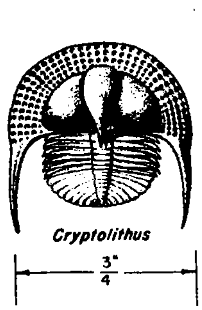


Figure 12



GRAPTOLITE
(ORTHOGRAPTUS)

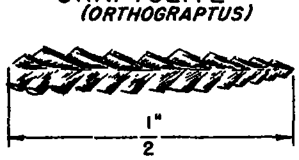


Figure 13

RIBEIRIA

Figure 14

ROAD LOG

TRIP A - Saratoga to Canajoharie (use with Fig. 1)

Time	Miles	Distance between points	
8:15	0		Leave Thruway Motel, proceed west on Washington Ave. to intersection with Northway and Thruway (Interchange #23)
	1.0	1.0	Turn right (north on Northway, Interstate 87)
	8.0	7.0	Outcrop of Middle Ordovician Normanskill Graywacke and Shale along east (northbound) lane. This is the westernmost extent of a large area of Normanskill, interpreted as a thrust outlier of the Taconic Allochthone or as a north-trending anticline protruding from beneath a cover of younger rocks.
	8.2	0.2	Crossing Mohawk River. These dual tied-arch bridges won an award in 1958 for their design.
	20.2	12.0	Crossing former channel of the Mohawk River. To the east, Round Lake occupies a portion of this now abandoned channel.
	22.2	2.0	Long exposure in Middle Ordovician Snake Hill Shale, a dark gray silty facies of the Canajoharie Shale of the Mohawk Valley.
	29.2	7.0	Exit from Northway on NY 9P & proceed west.
	29.7	0.5	Turn right after crossing over Northway and take connecting road north to NY 29.
	30.7	1.0	Turn left (west) on NY 29.
	32.7	2.0	Straight thru Saratoga Springs, crossing Main St. where road becomes NY 9N.
	35.7	3.0	Turn left on Middle Grove Rd. (Saratoga County 21).
	36.2	0.5	Turn left on paved road to Lester Park.
9:05	36.6	0.4	STOP 1 (35 minutes). LESTER PARK This is the type section for the Late Cambrian Hoyt Limestone, noted for its biostromal reefs of colonial algae called *Cryptozoon* (see Fig. 9, Plate 1). The lowest reef

has been planed by glacial erosion revealing the algal heads in horizontal section; a higher reef, in the recently enlarged road cut, exhibits a vertical section of *Cryptozoon*. A still higher reef in the abandoned Hoyt Quarry displays a reef of algal mats rather than heads. Between the lowest and middle reefs is a coarse-grained dolomitic limestone with oolites and trilobite fragments; the genera *Prosaukia*, *Saratogia*, *Plethometopus*, *Plethopeltis*, and *Dikellocephalus* have been collected here, thereby establishing a Trempealeau age.

9:40	36.6		LEAVE LESTER PARK, continue south on town road.
	37.3	0.7	On left (east) is entrance to Petrified Gardens, a privately owned exhibit of the Hoyt Limestone and its *Cryptozoon* reefs.
	37.4	0.1	On right is old quarry in the Ritchie Limestone, either a local facies of the Hoyt or a slightly younger unit. Its rare fossils (the gastropod *Rhachopea*) are not diagnostic. An east-trending normal fault separates this quarry from Lower Ordovician Gailor Dolomite on the downthrown, southern side.
	37.8	0.4	Turn right on NY 29.
	41.3	3.5	Turn left at Cottrell Paper Mill in Rock City Falls.
9:50	41.5	0.2	Cross Kayaderosseras Creek and park behind Fire House at abandoned quarry. STOP 2 (25 minutes). ROCK CITY FALLS stratigraphic section. In addition to studying several rock units here, there is a fine display of the Lower Ordovician-Middle Ordovician unconformity (disconformity) between the older Gailor Dolomite forming the face of the falls and the Amsterdam Limestone. The falls marks a fault-line scarp, upthrown on the west. The downthrown block exhibits Middle Ordovician Larrabee Limestone beneath the road bridge, some 70 feet lower than in the quarry on the upthrown block.
10:15	41.5		Leave Rock City Falls quarry, return to NY 29.
	41.7	0.2	Turn left (west) on NY 29.
	45.7	4.0	East Galway

	46.7	1.0	Morainal pond on north side of road; extensive cover of glacial sand and gravel in this region.
	47.3	0.6	Mosherville
10:25	48.5	1.2	STOP 3 (15 minutes). Basal Paleozoic cobble conglomerate consisting of quartz cobbles, derived from a Precambrian quartzite atop the hill to the north, in a siliceous, pyritic matrix. Midway in the exposure is some coarse-textured, bedded, quartzose sandstone. This entire unit has been called Potsdam in the past because of its basal position and subjacency to the Theresa Formation, which crops out along the road to the west. Lithologically it is atypical for Potsdam; it seems to be a talus deposit, probably formed at the base of a sea cliff in Late Cambrian time. Precambrian biotite-gneiss may be uncovered by digging beneath this basal Paleozoic conglomerate.
10:40	48.5		LEAVE. Continue west.
	48.7	0.2	Road cut in Theresa Formation, a unit with alternating quartzose dolomites and dolomitic sandstones with occasional golf-ball size quartzite pebbles.
	48.8	0.1	Turn left (south) on NY 147 at Kimball's Corners. Mohawk Valley to the south in the distance.
	51.4	2.6	Turn right (west) at signal in Galway on Saratoga County route 45.
	52.2	0.8	Climb fault-line scarp; this is the northern extension of the Hoffmans Fault, the most easterly of the Mohawk Valley normal or step faults.
	52.5	0.3	Sharp left curve, remain on County route 45.
	53.1	0.6	Intersection with West Galway Road, proceed straight ahead. Cliff of Upper Cambrian Little Falls Dolomite on upthrown side of fault parallels road on the right.
	53.3	0.2	Middle Ordovician Larrabee Limestone along road, on right, opposite old cemetery. This is the eastern downthrown block. Scarp veers southwestward.
	53.7	0.4	Turn right on recently graded town road.

10:55	53.8	0.1	STOP 4 (20 minutes). There are two normal (gravity) faults here, both downthrown on the east with a small fault block (horse) caught between them (see Fig. 11, Plate 1). The eastern block shows steep east-dipping Larrabee Limestone with included round pebbles of a black, fine-grained, limestone (Amsterdam?) dragged against slightly westward dipping fine-grained, tan-gray, white weathering Lowville Limestone. The Lowville within this horse is overlain directly by the gray, coarse-grained Larrabee Limestone; the Amsterdam Limestone is missing from its accustomed position between the two in the Lower Mohawk Valley. Like all other horses observed by me, this one dips north or reverse from the regional dip. The west block exposes nearly horizontal Little Falls Dolomite.
11:15	53.8		LEAVE horse, continue west on town road, crossing main branch of Hoffmans Fault.
	54.2	0.4	Atop hill, good view of Mohawk Valley to the southwest, looking downdip.
	54.6	0.2	Turn left, south on Jersey Hill Road. This region underlain by Little Falls Dolomite.
	55.9	1.3	Turn right, west on NY 67.
	56.3	0.4	Long road cut in Little Falls Dolomite (both sides of road). Quartz crystals and chert are absent here although we are less than 50 feet below the Tribes Hill Fm.
	56.8	0.5	Road cut in Little Falls Dolomite.
	56.9	0.1	Turn left on Toureuna Road, parallels electric transmission line. Lower area to west is the course of a pre-glacial valley, tributary to the Mohawk.
	59.1	2.2	Turn half left at Green Corners on Wolf Hollow Road Extension.
	60.4	1.3	Straignt ahead at intersection with West Glenville Road. Outcropping of thick-bedded, coarse-grained, light gray Larrabee Limestone (with "Shoreham" fossil Cryptolithus) on lumpy-bedded, fine-grained, dark gray to black Amsterdam Limestone on southwest corner. This is the fault-line scarp of the Hoffmans Fault.
	60.8	0.4	Entering Wolf Hollow, bear right.

11:35	61.5	0.7	STOP 5 (60 minutes), WOLF HOLLOW and LUNCH Park on left, horse on right. The road and stream follow the fault trace of the Hoffmans Fault which, here, has a vertical displacement (throw) of at least 1000 feet and very probably as much as 1600 feet (see Figure 8). The downthrown (east) block exposes Middle Ordovician Schenectady Graywacke and Shale in the southern part of the Hollow and Canajoharie black shale in the northern part. The upthrown (west) block shows the Lower Ordovician Gailor Dolomite forming the impressive cliff. A small horse on the west side of the road of "Shoreham" Limestone and Canajoharie Shale dips north. Wolf Hollow well exemplifies the role exerted by faults in controlling drainage.
12:35	61.5		LEAVE, proceed south downhill.
	61.6	0.1	Sharp left curve. Schenectady Graywacke and Shale dragged at a 40°angle, diminishing to less than 5° at eastern limit of exposure, some 500' distant.
	62.4	0.7	Turn right on NY 5.
	62.7	0.3	Long high road cut begins where Toureuna Road joins NY 5; lower 40' is Little Falls Dolostone and the remainder of the cliff is Gailor Dolostone. A small hill atop the cliff exhibits Lowville, Amsterdam, Larrabee, and "Shoreham" Limestones and Canajoharie Shale in their normal stratigraphic positions.Thus, the stratigraphic succession can be demonstrated conclusively in this single section.
	63.5	0.8	Beginning of two-mile stretch of clay and sand deposits.
	64.4	0.9	Across river, active quarry in Tribes Hill and Chuctanunda Creek Formations.
	65.6	1.2	Cranesville. Western limit of large pre-glacial valley which entered the Iromohawk from the north. Across river, large active quarry in Tribes Hill and Chuctanunda Creek Formations.
	66.1	0.5	Across river, Niagara-Mohawk steam generating electric plant (now abandoned).
12:45	67.1	1.0	STOP 6 (20 minutes), road cut on NY 5 at railroad overpass. The two middle members of the Tribes Hill Formation are exposed here;the massive Wolf Hollow dolomitic calcilutite (fine-grained limestone) is in contact with the thin bedded Palatine Bridge dolomitic

shale and quartzose calcisiltite (medium-grained limestone) and calcilutite. Note the white and buff fretwork weathering of the Wolf Hollow member with the buff dolomite in relief. The Palatine Bridge member is lighter colored and more quartzose and pyritic. A single dolomite bed, 2 1/2 feet thick, in the lower part of the Wolf Hollow member can be traced throughout the Valley; it is a bluish-gray, medium-textured dolostone with pockets (vugs) of dolomite crystals. Fossils are scarce in both members. The Wolf Hollow member has a molluscan fauna of large, loosely coiled gastropods and straight or gently curved ellesmeroceroid and clarkoceroid cephalopods. In contrast, the Palatine Bridge member has an arthropod (trilobite) and brachiopod fauna. Both faunas indicate an Early Canadian (=Tremadoc) age.

1:05	67.1		LEAVE, continue west on NY 5 through Amsterdam.
	71.5	4.4	Fort Johnson. Intersection with NY 67. Baronial home of Sir William Johnson built in 1749 on northwest corner.
	73.0	1.5	Cross Tribes Hill Fault, upthrown on west.
	73.5	0.5	On north side of NY 5 is a cut in the same portion of the section viewed at the previous stop. Note the change in appearance owing to longer weathering (exposed initially in 1958). When first revealed, there was a two-foot iron-oxide zone at the top of the Palatine Bridge member; this corresponds to the two-foot dolomitic shale zone at the previous stop.
	75.5	2.0	Parking area, splendid view of Mohawk Valley with Schoharie Valley in distance.
1:35	76.0	0.5	STOP 7 (20 minutes). On north side of NY 5, Middle Ordovician Canajoharie Shale, here more of a calcareous argillite which is typical of the lowest 200' of the formation, has graptolites (See Figure 13, Plate 1) in the upper few feet of the exposure. These extinct animals, excellent guide fossils for subdividing the Ordovician and Silurian Periods, are thought to have been floaters (plankton) and, thus, achieved wider distribution in a relatively short period of time as compared to bottom dwellers.
1:55	76.0		LEAVE, continue west on NY 5.

	78.1	2.1	Turn left (south) in Fonda on NY 30A (NY 148 on maps)
	78.4	0.3	Crossing Mohawk River.
	78.6	0.2	Pass under N.Y. State Thruway in Fultonville.
	78.7	0.1	Turn right (west) on NY 5-S.
	79.2	0.5	Beginning of a long series of rock cuts (1.5 miles) in Canajoharie Shale.
	80.2	1.0	Crossing Stone Ridge Fault, upthrown on west.
	81.0	0.8	Upper Tribes Hill Formation (Fonda member) and overlying Larrabee Limestone on south side of road.
	81.6	0.6	Turn left on Borden Road.
2:05	81.8	0.2	STOP 8 (20 minutes) STONE RIDGE This is a critical section in deciphering structure and Ordovician stratigraphy in the Valley. The three upper members of the Tribes Hill Formation are exposed (upper Palatine Bridge and Wolf Hollow in Van Wie Creek to the west of Borden Road and Fonda member in road ditch and road cut). The Chuctanunda Creek Dolostone is missing due to erosion. This is a superb example of a disconformity (See Figure 7). The older Tribes Hill Formation has been subjected to subaerial erosion and the crevices at its summit are filled, in places, with white-weathering Lowville Limestone with vertical worm borings. Lumpy bedded limestone (Amsterdam or Larrabee ?) occurs above; the fossils are not diagnostic in distinguishing which Middle Ordovician unit crops out in this cut. Further up Van Wie Creek, undoubted Larrabee and "Shoreham" Limestones are overlain by Canajoharie Shale. In the road ditch a coarse grained limestone (calcarenite) with glauconite yields abundant fossils. Most of these are stained with iron oxide and are water-worn. Gastropods are abundant but the unusual pelecypod-like arthropod, *Ribeiria*, (See Figure 14, Plate 1) exceeds all others in numbers. Trilobites, ellesmeroceroid cephalopods, and brachiopods round out the major faunal elements. Rare calyx plates of cystids and conodonts complete the known fauna.
2:25	81.8		LEAVE. Turn around in driveway 500' to the south and return to NY 5-S.

82.2 0.4 Turn left (west) on NY 5-S. Note flat-topped Fonda wash plain across river. This is an Ice Age delta consisting of water-laid gravels and sands which extends north for 4 1/2 miles and west for 3.5 miles from Fonda to the Noses Fault.

83.8 1.6 Turn left in Randall at church onto Currytown Road.

2:30 84.3 0.5 STOP 9 (50 minutes) NOSES FAULT and ANTICLINE ? NONCONFORMITY or FAULT CONTACT ?

Park next to barn at intersection of Anderson and Currytown Roads, walk across bridge over Yatesville Creek through private property to rock exposures along railroad and old Erie Canal. Precambrian garnet-biotite-gneiss brought to surface along old canal and railroad in upthrown (western) block of Noses Fault. These exposures of the basement could be due to relief of the Precambrian surface or to an anticline being upwarped slightly west of the Noses Fault. The basal Paleozoic rock here is the Late Cambrian Little Falls Dolostone. This Precambrian outcrop (one of five within this inlier) is capped by a one foot shaly zone rich in quartz and pyrite; some traces of gold and silver were reported by Darton (1895). Is the shaly zone fault gouge or is it residual soil atop the Precambrian? One must look to the basal Little Falls breccia to determine whether it is tectonic or sedimentary. You be the judge! Much of the Little Falls Dolostone here is heavily chertified; quartz crystals may be found after careful search. Elsewhere within the inlier, the basal Little Falls is not brecciated but is a dolostone rich in rounded quartz grains. At the Precambrian exposure north of the river along NY 5, a six-foot wide mafic dike (unmetamorphosed) cuts the older garnet-biotite-gneiss. The basal Little Falls is concealed but exposures 20 feet above the Precambrian are not penetrated by the dike. Presumably, the dike was injected during a late Precambrian (Keewanawan) orogenic episode. Very scarce lingulid brachiopods are the sole fossils discovered in place in the lower Little Falls at the Noses Inlier. A loose Elvinia free cheek was found by me along the railroad in 1949. Within the Late Cambrian, this would signify an early Franconian age.

3:30	84.3		LEAVE, proceed south (uphill) paralleling Noses Fault. Note that Yatesville Creek's course is largely controlled by the fault.
	84.1	0.1	Fault scarp on right.
	84.6	0.2	(and 84.7) Dragged Canajoharie Shale along road on right. Dips up to 75°E.
	86.7	2.1	Ledge of Wolf Hollow Limestone crosses to the east of the road. Canajoharie Shale in road ditch near house. Upper Tribes Hill (Fonda), Chuctanunda Creek Dolostone and Lowville, Amsterdam, Larrabee, and "Shoreham" Limestones are missing here owing to either non-deposition or, more probably, erosion. The Canajoharie Shale, too, is but 350' thick. This area atop the Noses is considered to be the crest of the Adirondack Axis and was an effective barrier to sedimentation and faunal interchange during the Wilderness and early Barneveld Stages of the Mohawkian Series.
	87.0	0.3	PAUSE. Looking backward, note Noses scarp extending north toward Precambrian Adirondack Mountains. Land to the east (downthrown block) underlain by Middle Ordovician Schenectady Formation. Throwof the Noses Fault here about 500'.
	87.6	0.6	Turn right at intersection with NY 162. For the next two miles we are travelling across the top of the largest horst in the Mohawk Valley.
	87.7	0.1	Note hills to the southwest near Cherry Valley composed of Lower and Middle Devonian strata. At Sharon Springs, 8 miles south of Canajoharie, Late Silurian Brayman Shales are in contact with Medial Ordovician Schenectady shales. A few miles west of Cherry Valley, the Medial Silurian Clinton Group intervenes between the Late Ordovician Frankfort Shale and the Late Silurian Vernon Shale. The Paleozoic section, thus, thickens markedly as one proceeds west from the Adirondack Axis. The section also thickens markedly east of the Axis but the thickening occurs within the Medial Ordovician.
	90.3	2.6	Dropping off western side of the Noses horst; good view looking up the Mohawk Valley toward Fort Plain and St. Johnsville.
	91.3	1.0	Turn left (west) in Sprakers on NY 5-S, cross Flat Creek and drive on river alluvium to Canajoharie.
	93.7	2.4	Sharp reverse left on Sprakers Road at inactive quarry. Park to the left on road paralleling

railroad track.

4:00 93.8 0.1 STOP 10 (25 minutes)

Inactive quarry at eastern limit of Canajoharie on south side of NY 5-S exposes the Cambrian-Ordovician contact, i.e. Little Falls Dolostone-Tribes Hill Formation. The uppermost Little Falls Dolostone is stained red with interstitial hematite and has vugs of quartz and anthraxolite. Anthraxolite is a black mineral with 92-98% carbon with much the same composition as anthracite coal. The physical properties, however, are quite different. For example, anthraxolite does not ignite. Note that anthraxolite occupies the lower half of the vugs; the upper half is usually filled with quartz but sometimes dolomite crystals complete the cavity. Anthraxolite is believed to be a hydrocarbon residue of petroleum and to have been derived from algal reefs in the Late Cambrian seas.

The overlying Fort Johnson member of the Tribes Hill Formation is a calcitic dolostone to dolomitic calcilutite. Its scarce fossils (Ophileta, Finkelnburgia, Asaphellus) denote an early Canadian age. Because the uppermost Little Falls Dolostone here has not yielded any fossils (except the non-diagnostic Cryptozoon we cannot be certain whether the Little Falls-Tribes Hill contact here is a paraconformity (surface of erosion but with no relief) indicating a gap in the record or whether the subtle change from relatively pure dolomite below to dolomitic limestone above indicates continuous sedimentation from the Cambrian into the Ordovician Period. The physical clues (zone of hematite, vuggy dolomite with contained minerals) lean toward the paraconformity view (see Figure 7).

The splendid long stratigraphic sections along Flat and Canajoharie Creeks cannot be examined by large groups. They are, however, critical in reconstructing the geologic history of the Valley and are accordingly included in Figure 3.

4:25 93.8 LEAVE, return to NY 5-S and turn left (west).

94.1 0.3 Turn right, enter N.Y. State Thruway (Interstate 90) at Interchange #29. Bear right, proceed east (Albany and New York).

NOTE: NO STOPPING PERMITTED ON THRUWAY

96.4 2.3 Valley narrows to water gap at the "Noses"; valley walls are entirely Little Falls Dolostone.

97.0 0.6 Crossing Flat Creek.

98.4	1.4	Entering the water gap and the Precambrian inlier.
98.7	0.3	Across river, road cut in Precambrian on NY 5 showing six-foot dike cutting garnet-biotite-gneiss.
99.7	1.0	Precambrian gneiss and Little Falls Dolostone on right along old Erie Canal and West Shore branch of N.Y. Central Railroad displaying anticlinal effect.
100.5	0.8	Across river, two kames (chocolate-drop-shaped hills) of gravel and sand in shadow of Noses escarpment. Fonda flat-topped wash plain extends from here for 3.5 miles eastward to Fonda.
103.3	2.8	Road cut along eastbound lane exposing uppermost Tribes Hill Formation, Amsterdam, Larrabee, and "Shoreham" Limestones.
105.0	1.7	Fultonville, Interchange #28. Water-laid gravel and sand overlying boulder till blankets much of the inner valley from here eastward.
108.4	3.4	Auriesville Shrine atop hill to the south.
109.5	1.1	Schoharie Creek, east side of Schoharie Valley here is boulder till.
113.3	3.8	Amsterdam, Interchange #27 with NY 30.
118.7	5.4	Across river, large cut in Gailor Dolostone, the dolomitic facies of the Tribes Hill Formation.
119.0	0.3	Road cuts along eastbound lane in Lower Ordovician Dolostone.
119.3	0.3	Crossing Hoffmans Fault.
120.0	0.7	Hills forming Valley walls composed of Schenectady Graywackes and Shales.
122.0 +	2.0	Road cuts on eastbound lane in Schenectady Graywacke
122.7	0.7	and Shale.
123.3	0.6	Mohawk Valley broadens into Lake Albany Plain. Note gravels along north river bank. These thick gravels and sands are excellent reservoirs for ground water; the entire city of Schenectady and neighboring suburbs obtain their public water supplies from these almost inexhaustable water-bearing glacial deposits.
124.0	0.7	Schenectady, NY 5-S, Interchange # 26. Climb over south valley wall out of Mohawk Valley proper.

	124.7 + 124.8	0.7	Road cuts in Schenectady Graywacke and Shale.
	126.5	0.7	Prominent topographic feature straight ahead is the Helderberg Escarpment (not produced by faulting). Note terraces of Lower and Middle Devonian Limestones.
	127.4	0.9	Approximate west shore of glacial Lake Albany. Sand plains with profuse growth of pine trees extend from here to Albany. Area of sand dunes atop lacustrine varved clays, the dunes produced by wind whipping the relatively thin veneer of lacustrine sands into north-south trending hills.
	129.1	1.7	Crossing N.Y. Central Railroad.
	132.0	2.9	Schenectady, NY 7, NY 146, Interstate 890, Interchange 25.
	133.3	1.3	Sand dune.
	133.5	0.2	Boulder till.
	137.2	3.7	Albany (Northway, Washington Ave.), Interchange #24. LEAVE Interstate 90, proceed east on Washington Ave.
5:15	138.2	1.0	Arrive at Thruway Motel. End of excursion.

GEOLOGIC EXCURSION FROM ALBANY TO THE GLEN VIA LAKE GEORGE

by
Yngvar W. Isachsen

The purpose of this guide is three-fold: to describe very briefly the geology of the Adirondack region as a whole, to offer in the southeastern Adirondack region a smorgasbord of representative Adirondack lithologies and structures, and to discuss features of pre-glacial drainage along the excursion route. Laymen using this guide would profit by first reading a more elementary presentation by Broughton and others (1962).

The present Adirondacks are dome mountains which came into existence during one or more periods of uparching in Phanerozoic, not Precambrian time. This is clear from the quaquaversal dips of bounding Cambrian and Ordovician strata, and from the preservation of Cambrian and Ordovician rocks on the floors of graben within the Adirondack perimeter (Figs. 1,2,3). A profound unconformity separates the mantling Paleozoics from the Precambrian core of the dome. A striking and puzzling feature of the dome is that it exhibits the highest elevations in the Canadian Shield south of the Torngat Mountains which are located nearly 1200 miles distant at the northern tip of Labrador.

To the northwest, the Precambrian core is connected to the rest of the Grenville Province of the Canadian Shield across a narrow arch called the Frontenac Axis, an uplift which is responsible for the "Thousand Islands" region of the St. Lawrence River. On the east, the Adirondack dome is bounded by the down-faulted Champlain basin, beyond which lies the Middlebury synclinorium and thence the Green Mountain anticlinorium with its Precambrian core. Along its eastern and southern flanks, the Adirondack dome is much broken by block faulting, and the Precambrian-Paleozoic contact is a fault, along most of its length (Figs. 2,3). From the latitude of Ticonderoga southward, the central part of the Middlebury synclinorium is occupied by the Taconic Mountains, an elongate mass of Cambrian and Ordovician clastics which are interpreted by most workers to have slid into their present position as a giant klippe from the east during the Taconic disturbance, about 450 m.y. ago (Fig. 5). The Taconic range is clearly visible from the excursion route on auspicious days (Fig. 6).

Rock Types and Metamorphism

The Adirondack Precambrian has been conveniently subdivided on the basis of topography and lithology, into two parts: The Central Highlands which comprise 80% of the area, and the Northwest Lowlands. The Highlands are composed dominantly of resistant feldspathic and quartzo-feldspathic rocks, including the extensive sheet of anorthosite which forms the high peaks region. The northwest Lowlands are underlain mainly by less resistant calcitic and dolomitic marbles, biotite-quartz-plagioclase paragneiss, and granitic gneisses. Areal extents of the major rock types are given as follows:

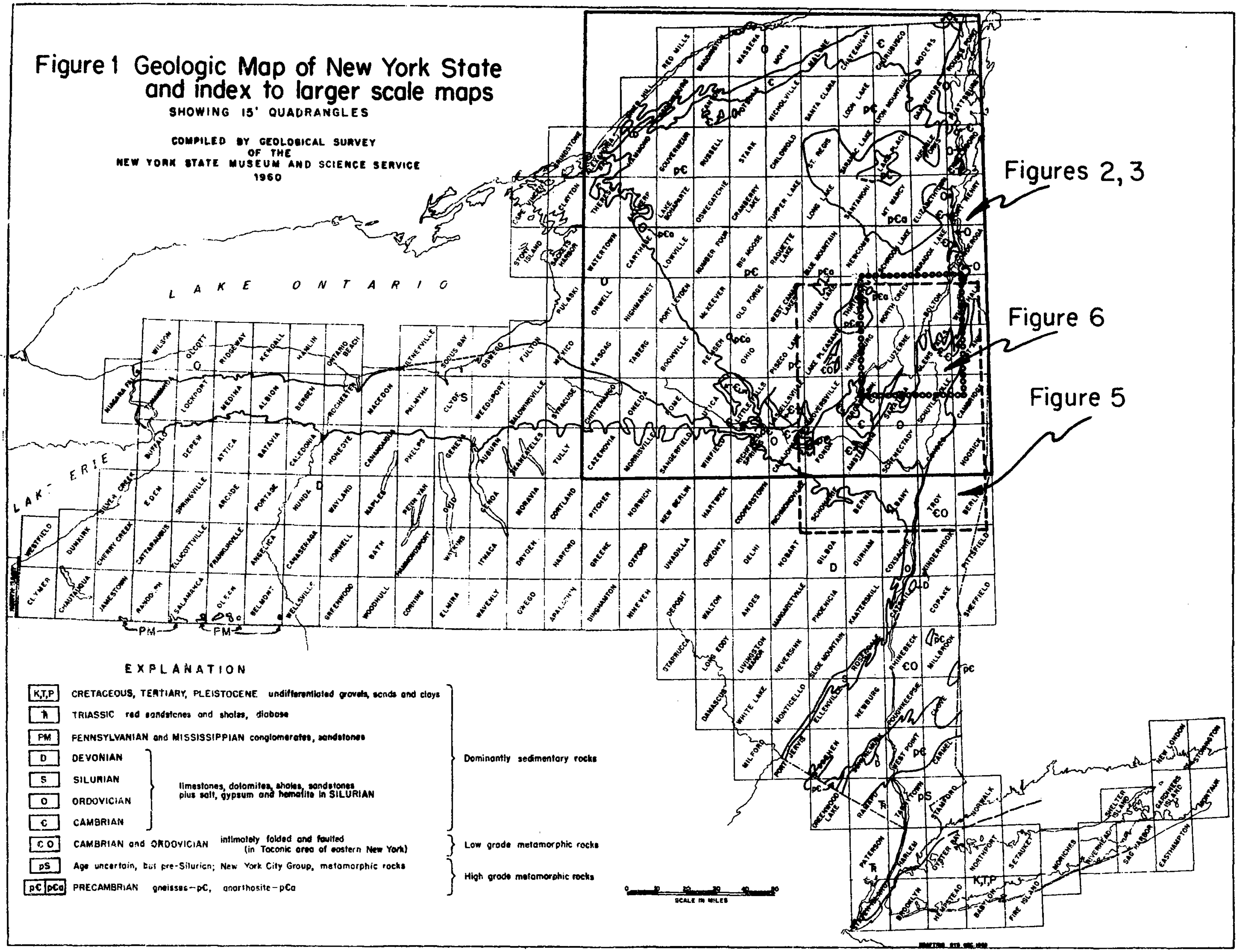


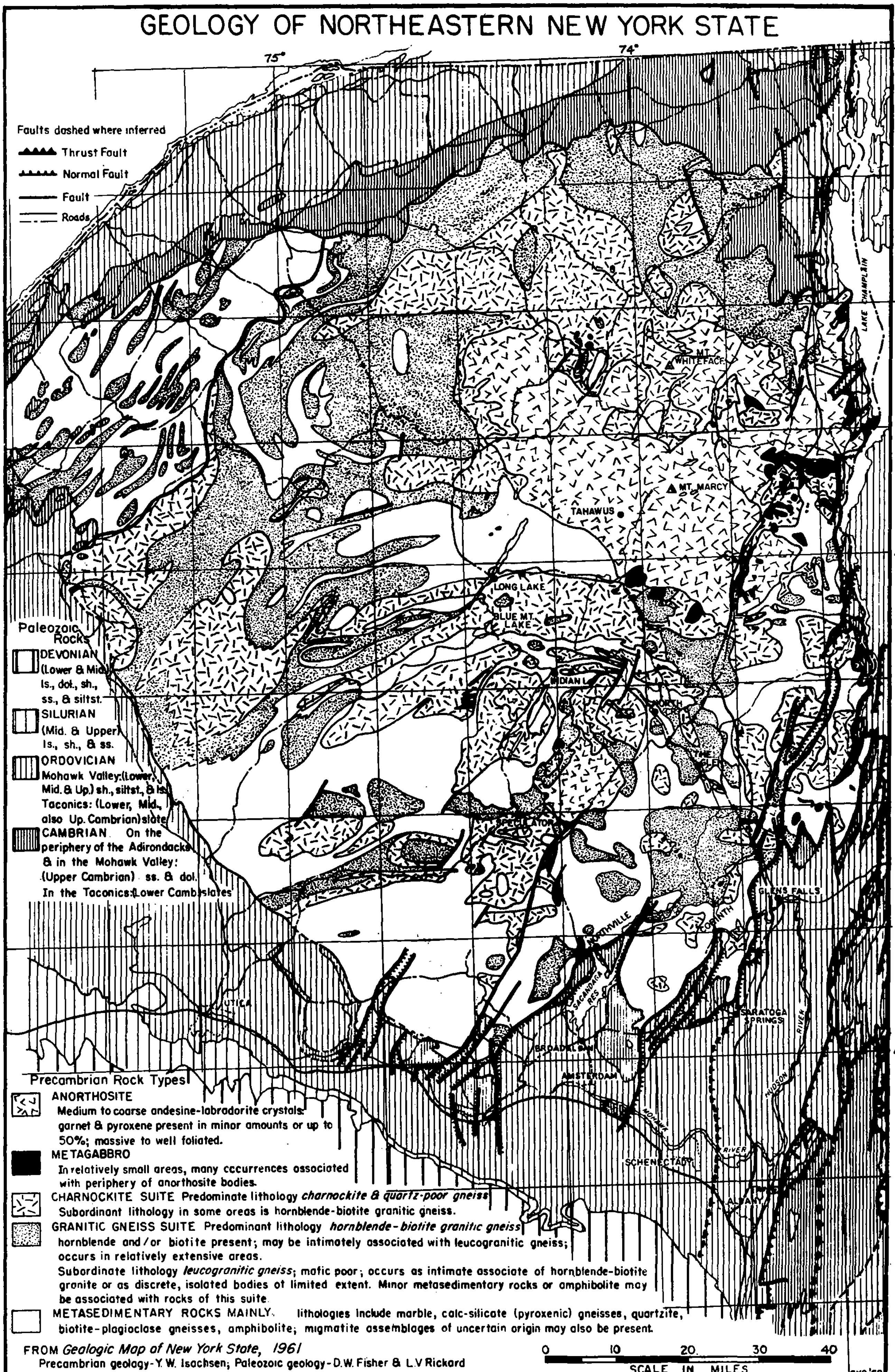
Figure 1 Geologic Map of New York State
and index to larger scale maps
SHOWING 15' QUADRANGLES
COMPILED BY GEOLOGICAL SURVEY
OF THE
NEW YORK STATE MUSEUM AND SCIENCE SERVICE
1960
Figures 2, 3
Figure 6
Figure 5
LAKE ONTARIO
LAKE ERIE
EXPLANATION
K,T,P CRETACEOUS, TERTIARY, PLEISTOCENE undifferentiated gravels, sands and clays
Ћ TRIASSIC red sandstones and shales, diabase
PM PENNSYLVANIAN and MISSISSIPPIAN conglomerates, sandstones
D DEVONIAN
S SILURIAN
O ORDOVICIAN
C CAMBRIAN
limestones, dolomites, shales, sandstones plus salt, gypsum and hematite in SILURIAN
Dominantly sedimentary rocks
CO CAMBRIAN and ORDOVICIAN intimately folded and faulted (in Taconic area of eastern New York)
Low grade metamorphic rocks
pS Age uncertain, but pre-Silurian; New York City Group, metamorphic rocks
High grade metamorphic rocks
pC pCa PRECAMBRIAN gneisses—pC, anorthosite—pCa
SCALE IN MILES

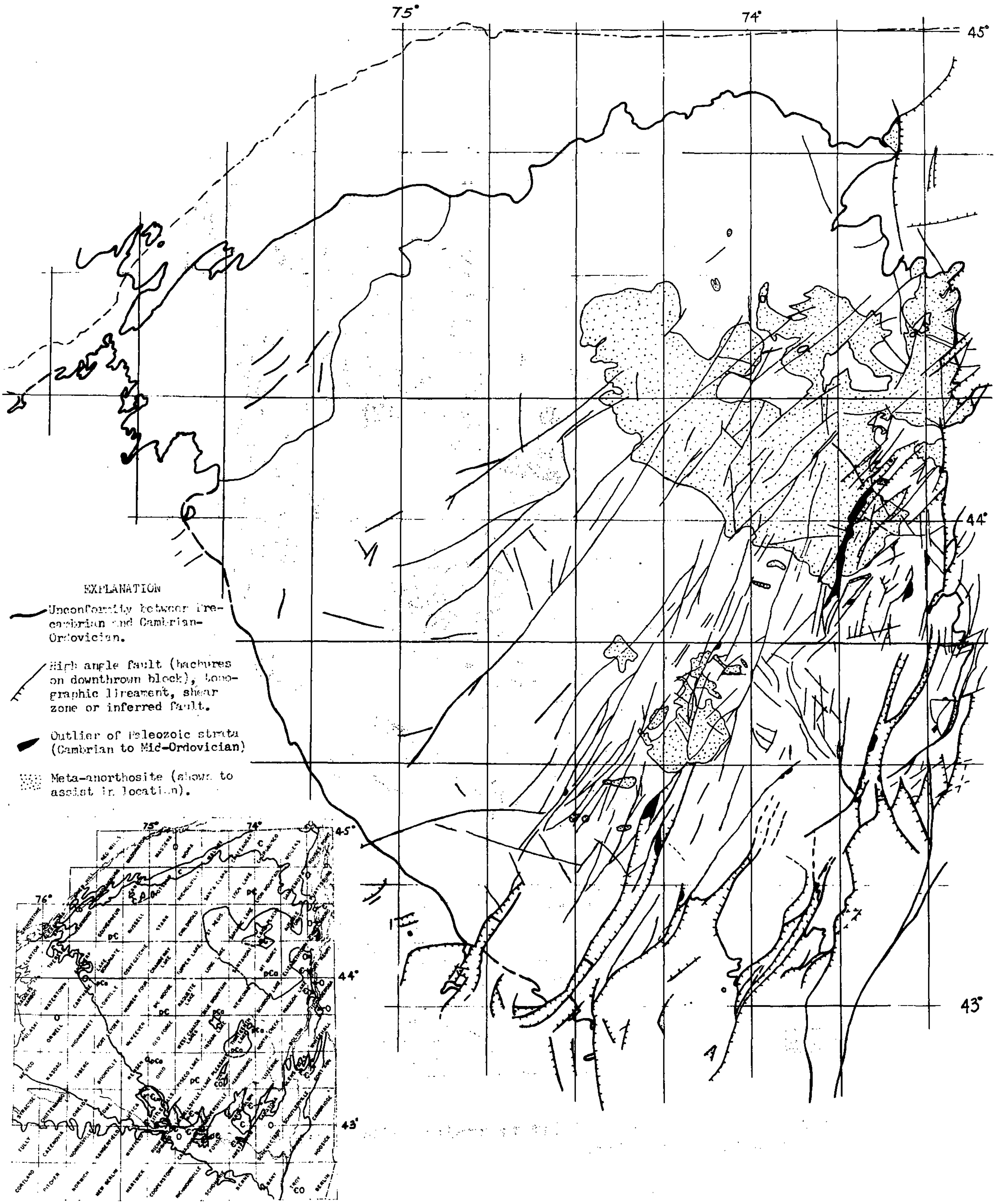
LITHOLOGIC TYPE	Area, Km^2	Area, Mi^2	Area, %
Metagabbro	40	17	0.1
leucogranitic (alaskitic) gneiss	820	320	3.1
hornblende-(biotite)-granite gneiss	6400	2470	23.8
syenitic gneiss	770	300	2.9
charnockitic gneisses	6400	2480	23.8
meta-anorthosite	3750	1450	14.0
metasedimentaries, amphibolite, mixed gneisses	8700	3350	32.4
TOTAL	$27x10^3$	$10x10^3$	100.1

Adirondack Precambrian rocks may be classified under three genetic categories: metasedimentary, metaigneous, and metamorphic of complex and/or uncertain origin. Practically all are characterized by metamorphic textures and mineral assemblages, the only notable exceptions being the relatively anhydrous lithologies - metagabbro and meta-anorthosite - which commonly have relict ophitic textures and cores of relict mineral grains. Of the other rocks, the only ones whose parentage is certain are those having diagnostic chemical compositions, namely, marble, calc-silicate rock, quartzite, and pelitic paragneisses. The paragenesis of the remainder, particularly amphibolite and various feldspathic gneisses of syenitic, granitic and charnockitic composition, is still a matter of conjecture inasmuch as matching compositions can be found among sedimentary, volcanic, and plutonic rock types. This dilemma is, of course, not unique to the Adirondacks, but applies to all terranes of deep seated regional metamorphism. The structural patterns of these units does not generally provide a basis for decision either: the rocks are not cross-cutting but occur as folded layers within thick stratigraphic sequences. Hence, the degree to which the parent rocks are interpreted as sediments, volcanics, or concordant intrusives depends at present largely upon the particular area under study and the predilections of the investigator.

Metamorphic rank in the Adirondacks increases progressively from the upper amphibolite facies in the Northwest Lowlands to the granulite facies in the Central Highlands. Further subdivisions have been made by Buddington (1939, 1963) who has drawn 5 isograds on the basis of first appearance of garnet or orthopyroxene in specified gneisses, and by de Waard (1964; in press) who has subdivided the granulite facies of the Central Highlands into six subfacies.

A variety of geothermometers has been used in the Adirondacks in an attempt to measure the temperatures at which metamorphic recrystallization occurred. From four independent geothermometers temperatures are inferred to have ranged from 525°C for rocks of the sillimanite - almandite-muscovite subfacies of the Northwest Lowlands, to as high as 750°C for rocks of the pyroxene granulite facies in the Central Highlands (Engel and Engel 1958, Buddington, 1963).


GEOLOGY OF NORTHEASTERN NEW YORK STATE
75°
74°
45°
44°
43°
Faults dashed where inferred
Thrust Fault
Normal Fault
Fault
Roads
MT. WHITEFACE
MT. MARCY
TAHAWUS
LONG LAKE
BLUE MT. LAKE
INDIAN L.
NORTH
SPECULATOR
NORTHVILLE
CORINTH
GLENS FALLS
SACANDAGA RES.
SARATOGA SPRINGS
UTICA
BROADALBIN
AMSTERDAM
SCHENECTADY
MOHAWK RIVER
HUDSON RIVER
LAKE CHAMPLAIN
Paleozoic Rocks
DEVONIAN (Lower & Mid.) ls., dol., sh., ss., & siltst.
SILURIAN (Mid. & Upper) ls., sh., & ss.
ORDOVICIAN Mohawk Valley: (Lower, Mid. & Up.) sh., siltst., & ls. Taconics: (Lower, Mid., also Up. Cambrian) slate
CAMBRIAN. On the periphery of the Adirondacks & in the Mohawk Valley: (Upper Cambrian) ss. & dol. In the Taconics: (Lower Camb.) slates
Precambrian Rock Types
ANORTHOSITE
Medium to coarse andesine-labradorite crystals: garnet & pyroxene present in minor amounts or up to 50%; massive to well foliated.
METAGABBRO
In relatively small areas, many occurrences associated with periphery of anorthosite bodies.
CHARNOCKITE SUITE Predominate lithology charnockite & quartz-poor gneiss
Subordinant lithology in some areas is hornblende-biotite granitic gneiss.
GRANITIC GNEISS SUITE Predominant lithology hornblende-biotite granitic gneiss
hornblende and/or biotite present; may be intimately associated with leucogranitic gneiss; occurs in relatively extensive areas.
Subordinate lithology leucogranitic gneiss; mafic poor; occurs as intimate associate of hornblende-biotite granite or as discrete, isolated bodies of limited extent. Minor metasedimentary rocks or amphibolite may be associated with rocks of this suite.
METASEDIMENTARY ROCKS MAINLY. lithologies include marble, calc-silicate (pyroxenic) gneisses, quartzite, biotite-plagioclase gneisses, amphibolite; migmatite assemblages of uncertain origin may also be present.
FROM Geologic Map of New York State, 1961
Precambrian geology - Y. W. Isachsen; Paleozoic geology - D.W. Fisher & L.V. Rickard
0 10 20 30 40
SCALE IN MILES
GYG '62



Index to quadrangles

Figure 3. Map showing faults, inferred faults, topographic lineaments and shear zones in the Adirondack-Mohawk Valley region.

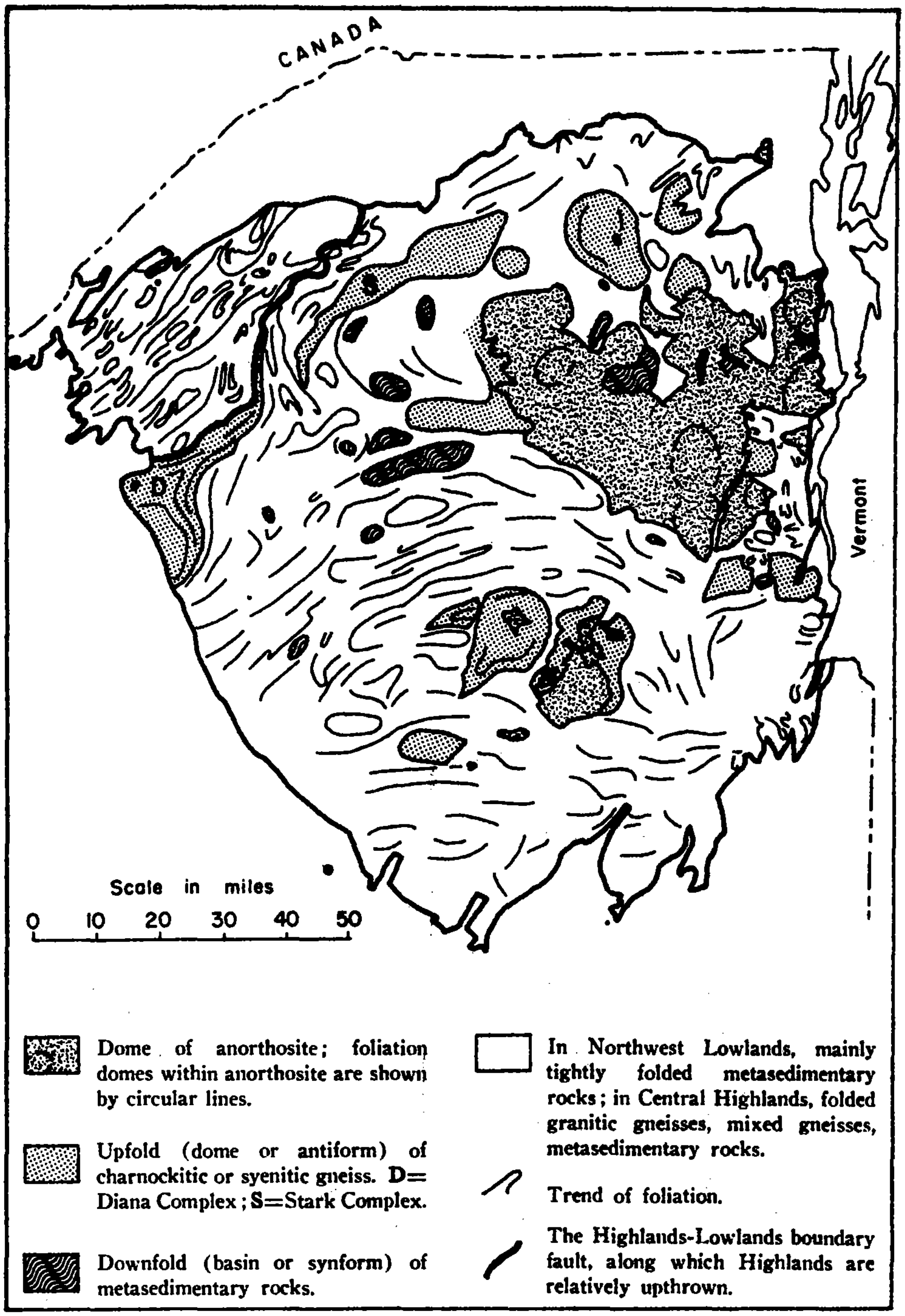
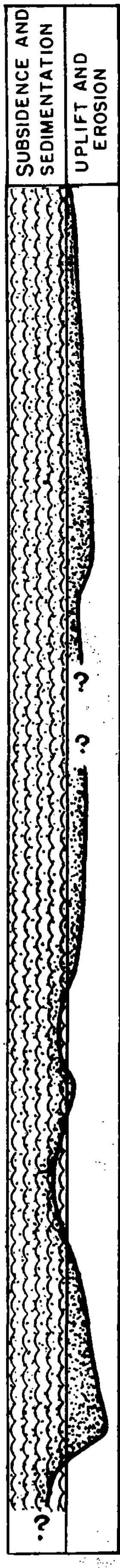


Figure 4. Highly simplified tectonic-geologic map of the Adirondack Precambrian.



MILLIONS OF YEARS AGO	ERA	GEOLOGIC PERIOD	NATURE OF THE ADIRONDACK REGION IN THE GEOLOGIC PAST
	CENOZOIC	Present	Area undergoing erosion, and supplying sediments to continental shelf
	CENOZOIC	Pleistocene	Champlain Valley and St. Lawrence Valley become temporary estuaries of the sea immediately following recession of glacial ice sheet. Upper New York State begins to rebound in response to unburdening of ice; rebound to date is more than 500 feet near Canadian border. Southward advancing continental ice sheet reaches Long Island, modifying the Tertiary drainage and landscape; during waning stages, mountain glaciation occurs sharpening Adirondack ridges and peaks, while glacial scouring of river valleys and damming by glacial debris brings into existence the many lakes and ponds of the Adirondacks. Finally ice recedes and vegetation begins to reclaim the land
0.6	CENOZOIC	Tertiary	Regional upbowing elevates eastern North America, causing renewed, vigorous erosion; major features of the present Adirondacks were sculptured following this uplift; the rock debris carried down from the rejuvenated Adirondacks now lies buried in the continental shelf beneath the surface of the Atlantic Ocean.
63	MESOZOIC	Cretaceous Jurassic Triassic	
230	PALEOZOIC	Permian Pennsylvanian Mississippian Devonian Silurian	No record of sedimentation in the Adirondacks; if sediments were laid down, they have since been removed; area was probably eroded to a surface of low relief by the beginning of Cretaceous time.
425	PALEOZOIC	Upper Ordovician	Adirondack region forms the western foothills of this range, and its Paleozoic rocks are block-faulted but not folded or metamorphosed; the valleys occupied by Lake George and Sacandaga Reservoir were probably created by down-faulting at this time. Upwarp of Adirondack region accompanied by stripping off of earlier Paleozoic sediments into a western sea as the geosynclinal prism of sediments to the east buckles to form a fold mountain range in eastern New England.
	PALEOZOIC	Middle Ordovician	Brief, gentle upwarp and erosion of this continental margin, followed by resubmergence and the formation of fringing coral reefs concurrently, the deeper eastern part of the geosynclinal sea (now eastern New England) continues to fill with graywacke and volcanic material supplied by an offshore arc of islands
	PALEOZOIC	Lower Ordovician	Adirondack plain submerges beneath the westward advancing eastern sea and the region once again becomes the site of continental shelf deposits (now represented by sandstone and associated thick deposits of sandy dolomite and limestone); algal reefs flank the submerging Adirondack surface on the south and east.
500	PALEOZOIC	Upper Cambrian	
	PALEOZOIC	Middle Cambrian	Now worn down to a nearly level plain, the beveled roots of the Ancestral Adirondacks supply clean sandstone and carbonate mud to the eastern sea.
	PALEOZOIC	Lower Cambrian	Ancestral Adirondacks, somewhat lowered by erosion, continue to supply graywacke to the east.
600+	PRECAMBRIAN		Geosynclinal prism of sediments buckles to form the Ancestral Adirondack Mts., a towering range which begins to erode and supply impure sandstone (graywacke) to a new northerly trending basin developing to the east.
1100	PRECAMBRIAN		A submerged continental shelf, which receives deposits of sand, clay and calcium carbonate from the mainland
?			

Figure 5. Synopsis of geological history of the Adirondack region during the past billion years. (after Isachsen, 1962)

Sand-veneered Tertiary rock terrace(s); Cambrian and Ordovician strata

Dissected Appalachian Plateau, bounded by Helderberg escarpment; horizontal Devonian strata; Silurian present west of Gallupville

Taconics; folded and faulted Cambrian and Ordovician strata

Southeastern Adirondacks; Precambrian metamorphics

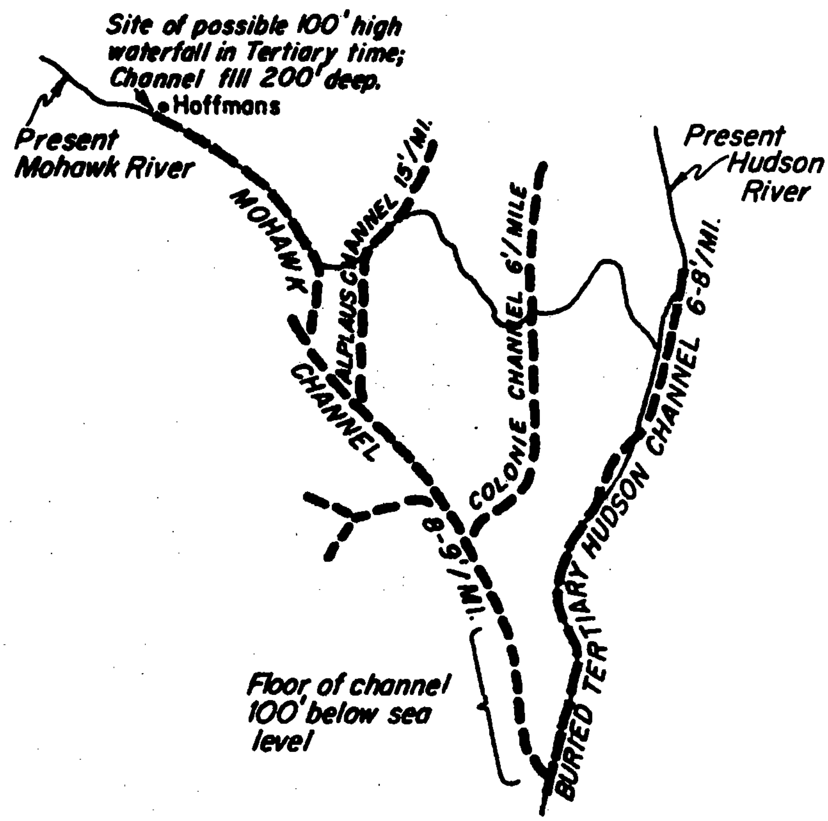
Buried Tertiary stream channel cut into bedrock; dashed where inferred

High angle fault, topographic lineament, or inferred fault

Thrust fault; teeth on thrust plate

Excursion route

Scale 1:500,000

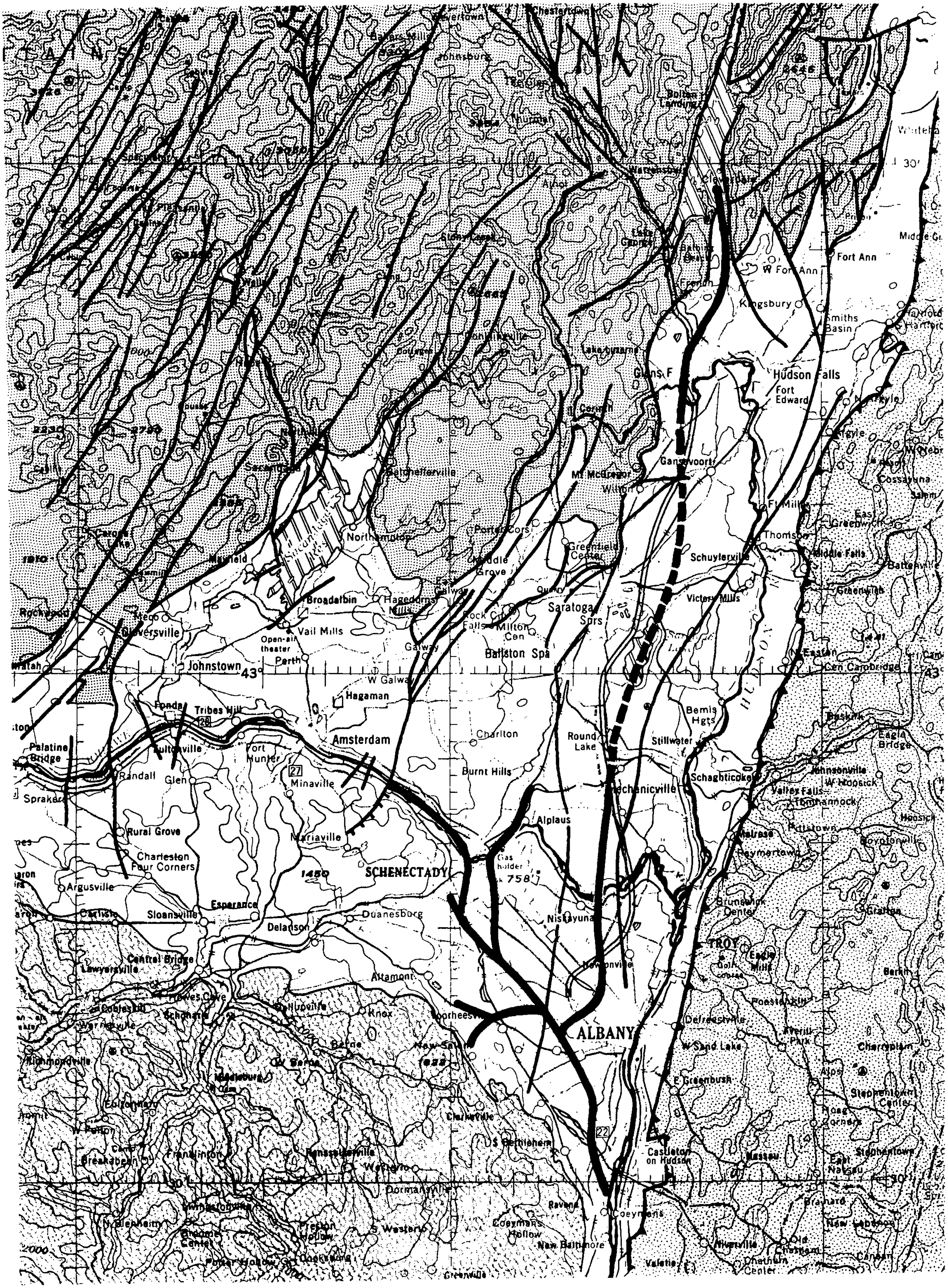


Index map showing names and approximate gradients of buried paleostream channels (mainly after Simpson, 1949; Hudson channel data from Bruehl, 1965.

0 10 20 mi.

0 10 20 30 km.

Explanation for figure 6: Topographic-geologic map of the Albany-Lake George region showing the Tertiary Hudson-Mohawk rock terrace surface(s) with incised Tertiary stream channels, and the bordering upland areas.



Chestertown
Johnsburg
Bolton Landing
Whiteha
30'
Fort Ann
W Fort Ann
Kingsbury
Smiths Basin
Lake Luzerne
Glens F
Hudson Falls
Fort Edward
Corinth
Gansevoort
Mt McGregor
Wilton
Argyle
Cossayuna
Ft Miller
Thomson
Schuylerville
Middle Falls
Greenwich
Batchellerville
Northampton
Porter Cors
Greenfield Center
Middle Grove
Saratoga Sprs
Victory Mills
Mayfield
Broadalbin
Hagedorns Mills
Rock City Falls
Milton Cen
Ballston Spa
Easton
Cen Cambridge
43°
Gloversville
Vail Mills
Open-air theater
Perth
Galway
Johnstown
43°
W Galway
Hagaman
Fonda
Tribes Hill
Palatine Bridge
Fultonville
Fort Hunter
Amsterdam
Charlton
Round Lake
Bemis Hgts
Stillwater
Buskirk
Eagle Bridge
Randall
Glen
Minaville
Burnt Hills
Mechanicville
Schaghticoke
Johnsonville
W Hoosick
Valley Falls
Tomhannock
Sprakers
Rural Grove
Mariaville
Alplaus
Pittstown
Melrose
Hoosick
Boyntonville
Haymertown
Charleston Four Corners
1450
SCHENECTADY
Gas holder
758
Argusville
Esperance
Duanesburg
Niskayuna
Brunswick Center
Grafton
Carlisle
Sloansville
Delanson
TROY
Golf course
Eagle Mills
Central Bridge
Lawyersville
Altamont
Newtonville
Berlin
Howes Cave
Cobleskill
Schoharie
Gallupville
Knox
Voorheesville
Poestenkill
Defreestville
ALBANY
Averill Park
Cherryplain
Berne
New Salem
W Sand Lake
Richmondville
W Berne
1932
Middleburg
E Greenbush
Alps
Stephentown Center
Clarksville
Rensselaerville
Round Lake
22
Castleton on Hudson
Nassau
East Nassau
Stephentown
S Bethlehem
30'
Dormansville
Ravena
Coeymans
Brainard
New Lebanon
Preston Hollow
S Westerlo
Coeymans Hollow
New Baltimore
Niverville
Old Chatham
Chatham Center
2000
Greenville

Pressure during metamorphism can only be roughly bracketed. At a temperature of 750°C, sillimanite is stable between 5 and 14 k.b. (Waldbaum, 1965) which corresponds to depths of burial ranging from about 20 to 50 km. The present boundary between the crust and mantle in the Adirondack region is calculated from seismic velocities to be about 35 km (Katz, 1955).

Structural Geology

In Adirondack metasedimentary rocks and mixed gneisses, compositional layering, most of it relict bedding, is common. Foliation characterizes almost all lithologies except the more pure facies of meta-anorthosite, metagabbros, and certain calc-silicate granulites. Lineation, prevailingly aligned with minor and major fold axes, is fairly common, especially in the axial portions of folds.

The larger structural features of the Adirondacks as defined by trends of foliation are shown in figure 4. In gross manner, the Central Highlands may be subdivided into two major domical areas; the main massif of meta-anorthosite, and the cluster of meta-anorthosite bodies and surrounding charnockitic gneisses south of it. Upfolds in the Adirondacks include domes, doubly-plunging isoclinal anticlines, recumbent folds and nappes. The downfolds range in cross section from open to isoclinal.

Both of the major domical areas correspond to topographic highs. Within them the main grain of the topography is largely determined not by rock foliation, but by accelerated erosion along north-northeast trending high-angle faults which define the present pattern of lakes and drainage in the southeastern half of the Adirondacks (compare figure 3 with any road map). The number of faults and the magnitudes of displacement diminish gradually to the northwest. From topographic relief in the vicinity of Paleozoic outliers, minimum vertical displacements of 3000 feet are indicated. South of the Adirondacks the faults extend into Cambrian and Ordovician strata, but seem to end in the Ordovician of the Mohawk Valley (Fig. 2).

Dating the Adirondack doming and faulting is a major problem; it is not even certain they are related in time. The presence of downfaulted Middle Ordovician carbonate rocks within the Adirondack massif, however, proves that both doming and some fault movement occurred after the Middle Ordovician (Fig. 3). It is not known to what extent the fault movements represent reactivation along Precambrian fracture zones.

Geological History

A simplified synopsis of the geological history of the Adirondack region during Phanerozoic time is set forth in Figure 5. The Precambrian sequence of events is considerably less certain owing to the structural complexity and the high rank of metamorphism. At present, two interpretations are under consideration. That advocated by Buddington (1939, 1952) is based largely on the concept that a unit is younger than any rock it transgresses. Following this premise, the metasedimentary rocks are the oldest in the region, and were intruded successively by 1) the anorthosite series, 2) olivine diabase and gabbro, and 3) concordant sheets of the syenitic and charnockitic series. This was followed in turn by a period of orogenic folding, intrusion of hypersthene diabase, a period of orogenic deformation and metamorphism, intrusion of granite and leucogranite (alaskite), and a final period of orogenic deformation and metamorphism - the Grenville orogeny.

According to a second interpretation (Walton, 1953, Walton and deWaard, 1963) the anorthositic, syenitic, and charnockitic gneisses represent the deeply eroded roots of an earlier mountain system whose beveled roots became submerged and received the sediments which we see today as metasedimentary rocks. Following this sedimentation, the composite terrane was subjected to the deep-seated deformation and metamorphism of the Grenville Orogeny which resulted in partial melting and local remobilization of granitic components in the earlier basement to produce the local transgressive relationships now seen. Relative metamorphic mobilities ranged from slight for anorthosite (which deformed mainly by granulation and recrystallization), through moderate for the syenitic and charnockitic gneisses (which mainly underwent plastic deformation) to maximum for hydrous fractions of granitic composition (which underwent partial or total fusion). Some of the pink granitic gneisses presumably formed in this way.

This sequence of relative mobilities would thus explain, in quite a different way, the intrusive relationships on which Buddington's interpretation of Adirondack geological history was based; namely, the greater the metamorphic mobility, the more transgressive the rock, and consequently, the younger its apparent age. Intrusion of gabbro, which cuts virtually all Adirondack lithologies, is interpreted as the last event before the Grenville Orogeny.

Radiometric dating of minerals and whole rocks from the Adirondacks, totaling more than 30 determinations thus far (Isachsen, 1963; Silver, 1963) indicates that this last major thermal event occurred about 1100± 100 million years ago. As indicated above, the prior geologic history of the region is still a matter of considerable conjecture - despite the fact that the Adirondacks are among the most thoroughly studied of Precambrian terranes.

PHANEROZOIC

Quaternary	Q	Glacial and alluvial deposits, underlying geology unknown
Middle & Lower Ordovician	Osh, Otbr Ob	Ob: Beekmantown Group carbonates, Otbr: Undifferentiated Trenton and Black River Groups; Osh: Snake Hill Shale
Upper Cambrian	Ꞓp, Ꞓss	Ꞓp: Potsdam Sandstone; Ꞓss: Saratoga Springs Group
Lower Ordovician, Upper & Lower Cambrian	ꞒO	Undifferentiated Taconic rocks - largely pelites

PRECAMBRIAN

	gb	metagabbro
Relative Ages Uncertain	hbg, lg	hbg: hornblende-(biotite)-granitic gneiss, generally pink; lg: leucogranitic gneiss, generally pink
	ch	charnockitic gneiss, generally dark green
	a	meta-anorthosite
	am, amg	am: amphibolite; amg: interlayered amphibolite and granitic gneiss
	mu	metasedimentaries, mainly distributed as follows: topographic highs: biotite-quartz-plagioclase gneiss, interlayered metasedimentary and granitic gneisses, quartzite; topographic lows: calcite marble, calc-silicate rock

―┬┬┬―――	high angle fault; where known to be a normal fault, hachures on downthrown side
---------	topographic lineament, inferred fault, or shear zone

Scale 1:250,000

0 5 10 15 mi.

0 5 10 15 20 25 km.

Explanation for figure 7, Geologic Map of the Lake George Region

Glens Falls
Hudson Falls
Fort Edward
Glen Lake
WARREN COUNTY
Sacandaga Reservoir
Northwest Bay
322

ROAD LOG FOR GEOLOGIC EXCURSION FROM ALBANY TO THE GLEN VIA LAKE GEORGE

MILEAGE		
Cum.	B.P.	
0.0	0.0	From the Thruway Motel proceed west on Washington Avenue toward Northway entrance. To the south, Lower Devonian carbonates form the Helderberg escarpment which marks the northern boundary of the Appachachian Uplands (fig. 6).
0.4	0.4	The road cuts through an arrested sand dune developed on a former sand terrace of glacial lake Albany. The excursion route between Albany and the Lake George region passes over the floor of this glacial lake. It is marked by lacustrine sand terraces which have, in part, been reworked by wind to form an undulating dune topography. The landscape has been further modified by post-glacial drainage. Beneath the sand veneer, which is generally less than 50 feet thick, is a rock terrace at about 300 feet elevation. This Tertiary erosion surface forms a broad platform extending between the block-faulted scarp of the Adirondack Highlands on the northwest, and the Taconic Mountains on the east and the Appalachian Uplands to the south.
1.2	0.8	Leave Washington Ave. and proceed north onto the Northway (Interstate Highway 87). Avoid continuing westward onto the Thruway (Interstate Highway 90).
9.0	7.8	Road descends toward the Mohawk River cutting through the blanket of lacustrine sands and into the Middle Ordovician Normanskill Formation which is exposed on the right. Lithologies represented are graywacke with mud pellets ("flysch and chips") and overlying shale. The large area of Normanskill of which this is a part has been interpreted alternatively as a thrust outlier of the Taconic klippe and as the core of a north-trending anticline.
9.5	0.5	The attractive pair of tied arch bridges spanning the Mohawk River ahead received honorable mention for design in 1958 by the American Institute of Steel Construction.
9.6	0.1	Cross the Mohawk River which here occupies a post-glacial gorge cut into the Normanskill Formation. Immediately to the west is a deeply buried pre-glacial gorge referred to as the Colonie channel (Fig. 6). Since this paleostream channel has the flattest gradient of the tributaries as presently known, it may have been the major river draining the southeastern Adirondack region in Tertiary times. In contrast, the buried Tertiary Hudson channel probably drained the Hoosic and Batten Kill water sheds, as does the present Hudson River, but did not extend much farther north (Simpson, 1949). Beneath the

MILEAGE

Cum.	B.P.	
		present Hudson River at the foot of Madison Avenue in Albany, the buried Tertiary Hudson channel is almost 100 feet below sea level.

Immediately west of our present location, the floor of this filled channel is about 200 feet below the present Mohawk River which meanders across it at right angles. At the north end of Saratoga Lake it is about 45 feet above sea level, and west of the City of Albany about 80 feet below sea level.

The Northway roughly follows the course of this channel for the next 20 miles or more to a point at the north end of Saratoga Lake (Fig. 6). Beyond this, its extension is largely hypothetical, although supported where drawn across the present Hudson River near Glens Falls by an anomalous lack of outcrop in that short stretch. From Albany north for a distance of about 10 miles where the configuration is best known, it is a relatively steep-walled channel, perhaps owing to glacial scour.

The main tributary to the Colonie channel, the ancestral Mohawk Channel shown on figure 6, has been traced as far west as the Hoffman Fault where a 100 foot high waterfall may have existed in pre-glacial times (Simpson, 1949). There are about 200 feet of channel-fill in the stretch between Schenectady and Hoffmans, and the present Mohawk River meanders over its surface.

Within the next mile the road climbs back up on the Pleistocene cover. Immediately to the east, a bedrock ridge protrudes a hundred feet above the level of the Tertiary terrace. Such relatively rare projections were islands in glacial lake Albany, which had a shoreline at about the present 300 feet contour.

21.5	4.7	Northway crosses one of the glacial meltwater channels which is now occupied by Ballston Creek. Looking down the valley to the southeast the Round Lake depression may be seen. This and Saratoga Lake to the north represent unfilled depressions, perhaps kettle lakes, on the glacial debris occupying the pre-glacial Colonie channel (Woodworth, 1905; Cook, 1930 p. 197).
23.8	2.3	Road descends into the valley of Drummond Creek, and for one-half mile cuts into highly fissile black shale of the Snake Hill Formation.
31.5	7.7	The escarpment which has been intermittently visible to the west extends from Saratoga Springs northward for a distance of 25 miles. It is a fault line scarp produced by differential erosion along the McGregor fault which marks the boundary between the Precambrian (here composed mainly of east-west trending metasedimentary rocks) and the Paleozoics. On the basis of measured Paleozoic sections in the Mohawk and south Champlain

MILEAGE
Cum. B.P.

valleys, it is estimated that the vertical displacement along the McGregor is at least 2200 feet.

It is only possible at present to date the normal faulting of the eastern and southern Adirondacks and the adjoining Mohawk Valley region as post-Frankfort (i.e. post Late Ordovician) inasmuch as these are the youngest rocks known to be involved. All of the faults in the Mohawk Valley region either hinge out before reaching the Silurian at the base of the Helderberg escarpment, or pass beneath it without being recognized. Field relationships do not permit an absolute resolution of this question, but the fault movement is inferred to have occurred during the Taconic disturbance (Kay, 1942, p. 1627).

52.5 7.8 Outcrop of Precambrian; the rock here a quartzo-feldspathic gneiss, similar to that exposed at Stop 1.

52.8 .3

Stop 1 Large scale recumbent folding and related structures in biotitic paragneiss.

55.0 Leave Northway, turn east for 0.1 mile, then proceed north on Route 9 for 1 mile. Note views of Lake George which lies in a graben between two blocks of Precambrian gneiss. Leave Route 9 a short distance beyond the Tiki Motel; turn right on road marked "Lake George Beach" (a State Park), and proceed 0.3 miles to junction of Route 9L.

56.3 0.3 Turn right on 9L for 0.1 miles.

56.4 0.1 Turn right at Park entrance.

Stop 2 You are standing on Paleozoic rocks at the floor of the Lake George complex graben, completely surrounded by Precambrian rocks. The steeply rising valley walls are fault-line scarps which give the region a spectacular relief such as is generally found only well within the Adirondack perimeter; the local relief here reaches 2000 feet. Combining this value with the 500 foot estimated thickness of the Paleozoics here gives a minimum vertical displacement of at least 2500 feet.

The crystal clear waters for which this lake is noted, result from the fact that only short mountain brooks drain into the lake, and hence the very fine clay fraction common to most drainage systems is virtually absent. Most of the lake is not deeper than 50 feet, although measured depths of up to 190 feet are shown on the hydrographic map published by the Lake George Power Squadron. The many islands in Lake George number 184, and of those 154 are State-owned. Most are composed of bedrock but several are gravel drumlins according to Newland and Vaughan (1942).

MILEAGE

Cum. B.P.

Lake George now drains northward into Lake Champlain, with a decent of more than 200 feet (from 319 ft. to 95 ft.). In Tertiary time, however, both lake basins were river valleys separated by a drainage divide. The Lake Champlain valley drained into the St. Lawrence as it does today but the Lake George basin drained southward through the relatively wide graben valley located just east of French Mountain (Fig. 7). This valley is now clogged with glacial debris including a well-shaped drumlin 1 and 1/2 miles long (Fig. 7). The inferred Tertiary drainage course is shown in Figure 6.

At the close of the last ice advance, a glacial lake occupied the basin as indicated by the presence of sand terraces representing several transitory levels in the lowering of the lake to its present elevation. The highest of the terraces has an elevation of 600 feet, and is well represented 1 and 1/2 miles to the southeast, just uphill from the Northway exit on Route 9L (see mileage 56.3).

The Paleozoics here are exposed in the railroad bed of an abandoned spur of the Delaware and Hudson Railroad, which carried vacationers from down-state to Lake George via Fort Edward and Glens Falls, until 1957. The exposed dolomite strata are either Little Falls or Beekmantown equivalents; fossils have not been found. A fault breccia in the cut contains fragments of lithographic limestone which are probably down-dragged Beekmantown limestone.

A brief summary of Colonial history of the Lake George region is given in the appendix.

Leave Stop 2 and proceed west on 9L for 0.4 miles to Route 9 in Lake George Village.

56.8	0.4	Leave Route 9L and turn north on Route 9.
57.4	0.6	Junction with Route 9N. Stay on Route 9 which bears left.
59.2	1.7	Spheroidally weathered metagabbro is exposed in road cuts on the right.
59.6	0.4 Stop 3	Be alert for falling rock!

This outcrop is interpretated as an u transported soil (saprolith) formed by weathering during the Tertiary from biotitic quartz-feldspar gneiss. Note the degree which Precambrian structures, textures, and minerals are preserved. Above the Tertiary saprolith, the Pleistocene is represented by two fluvioglacial boulder gravel units. The lower gravel is weathered and hence of probable pre-classical Wisconsin age; the upper gravel is unweathered

Cum. B.P.

and of presumed classical Wisconsin age.

When the exposure was first created in 1936, a 2 to 3 foot thick layer of varved clay was visible between the boulder gravels. This clay is thought to have accumulated in a local body of water along the ice edge rather than as part of the main glacial lake that occupied the Lake George valley, inasmuch as the clay here is some 180 feet above the highest glacial sand terrace in Lake George Basin (Newland & Vaughan, 1942).

Tertiary saproliths such as this rarely survive Pleistocene glaciation, and are even more rarely exposed, owing to rapid mechanical disintegration and concommitent plant overgrowth. This steep outcrop apparently survives only due to constant removal of material for human use from its base. Similar saproliths have, however, been discovered in a number of localities in the Adirondacks, and in the Hudson Highlands as well, by geologists of the State Department of Public Works in connection with highway construction; they are generally short lived exposures. The structural and topographic conditions that control the preservation of these soils have not been investigated.

Continue northward on Route 9.

60.0 0.5 Where hill starts to level off, note the spheroidally weathered metagabbro cropping out on the right. A fresh outcrop of this lithology will be seen at Stop 5, just north of Warrensburg.

61.0 0.9
Stop 4 New road cuts being made for the Northway here expose pink, gray and green varieties of granitic gneiss. The typical pink granitic gneisses of the Adirondacks are composed chiefly of microcline or microperthite and quartz along with subordinate amounts of oligoclase and one or more of the dark minerals, hornblende, biotite, pyroxene. In most areas, these gneisses are equigranular, but in parts of the southeastern and northwestern Adirondacks they are inequigranular, containing pink microcline crystals (probably porphyroblasts) which measure up to an inch or more in length. This variety is generally considered to have formed by metasomatism of a biotite-quartz- plagioclase paragneiss into which it grades laterally. A

MILEAGE

Cum. B.P.

subordinate lithology in this suite is leucogranitic (alaskitic) gneiss which is most prominent in the Northwest Lowlands, although it appears in the southern and southeastern Adirondacks. In the eastern Adirondacks, several large magnetite ore bodies occur in this gneiss. The granitic gneisses occur as sheets or lenses in a variety of other rock types.

Continue north of Route 9.

The highway follows the flood plain of the meandering Schroon River. Sand terraces at an elevation of about 760 feet may be seen 80 feet above the valley floor. These are representative of Glacial Lake Warrensburg. (Miller, 1923).

62.7 0.2 Village of Warrensburg. Continue on Route 9 to first outcrop north of the village.

64.6 1.9 Drive into parking area on left side of the highway.

Stop 5 Metagabbro sill in biotite-quartz-feldspar gneiss. Both contacts of this thick sill are clearly delimited, and the lower one is actually exposed.

Aside from obvious metasedimentaries, metagabbro is the only metamorphic rock in the Adirondacks whose origin has never been questioned for reasons given earlier.

Although all the minerals of this sill are the product of metamorphic recrystallization, the textures are relict igneous except at the very margin where the rock has been converted to a biotite schist.

The textures are best shown on weathered surfaces. Throughout most of its width, the sill displays a subophitic fabric, but within a few feet of the contact, the rock has a finer-grained chill border with a diabasic texture. The laths of plagioclase that define these relict textures are not single crystals of plagioclase, as originally, but granoblastic aggregates of andesine-labradorite which presumably represents an equilibrium composition for this metamorphic grade and for this bulk chemical composition. In some Adirondack metagabbros, cores of unrecrystallized igneous minerals have survived metamorphism; most notable are "dusty" plagioclase, augite, hypersthene, and olivine.

Primary constituents of the Adirondack metagabbros are plagioclase (labradorite to bytownite), augite, hypersthene, olivine, ilmenite, and magnetite. Reequilibration of this mineral assemblage under conditions of granulite facies metamorphism has resulted primarily in reaction between plagioclase and the mafic minerals to produce less calcic plagioclase plus garnet and/or augite. Where water has entered the system, hornblende is a common metamorphic mineral. In many metagabbros the border zone has been coverted to amphibolite lacking all trace of the parent igneous texture. Aside from the local addition of small amounts of water, however, the metamorphic reconstitution of gabbroic rocks in the Adirondacks has been an essentially isochemical process. In this exposure, the relatively high biotite content of the metagabbro along its lower contact indicates limited influx of K_2O as well as H_2O.

This roadcut clearly shows the metagabbro to be a sill. Commonly, however, the poor outcropping characteristics of the thinner metagabbros make it difficult or impossible to determine shape of the intrusives. This may account in part for the fact that the bodies are commonly shown on the older reconnaissance quadrangle maps as circular masses (Fig. 2).

MILEAGE

Cum. B.P.

Continue driving north and stop at the next outcrop.

65.1 0.5

Stop 6 Fault breccia in chloritic hornblende-biotite granitic gneiss is evidence of an episode of brittle deformation. Rotated angular and tectonically-rounded fragments of the gneiss are cemented by a chlorite paste, and within the gneiss biotite is largely altered to chlorite. This retrograde metamorphism and the local presence of drusy cavities are among the features of Phanerozoic faults that transect the Precambrian.

Dating the normal faulting that is so prevalent in the southern and eastern Adirondacks and in the adjacent Mohawk Valley (Fig. 6) is a major regional problem. The wise adage of mining geologists, "Once a fault always a fault", doubtless applies here and further complicates the problem. Inasmuch as the trends, steep dips, and other structural characteristics of those faults which are wholly confined to Precambrian crystallines do not differ from those which also involve the peripheral Paleozoics, it might be assumed that all are of the same age, namely, post-Frankfort, as mentioned under Mileage 31.5. Some faults, however, are marked by healed breccias whose mineral assemblages are in equilibrium with the regional metamorphic grade of the Precambrian Grenville orogeny. Thus some Phanerozoic normal faulting apparently represents reactivation along Precambrian zones of weakness.

It may be of interest to note in passing that such normal faulting accounts for the rectangular drainage pattern in the Elizabethtown quadrangle to the north. Prior to detailed geologic mapping by Matt Walton, the Elizabethtown quadrangle had been cited for many years as a classic area of rectangular drainage induced by rectangular jointing.

65.8 0.7 On the left are outcrops of paragneiss, and immediately to the north are exposures of intricately contorted and refolded calcite marble and interlayered calc-silicate rock.

66.5 0.7 Junction of Routes 9 and 28: turn left on Route 28. River road joins Route 28 on the left.

69.0 0.6 Road cuts through isoclinally folded beds of calcite marble containing laminae of calc-silicate minerals.

69.6 0.6

Stop 7 At junction of Route 28 and Potter Brook Road. Charnockitic gneiss. This rock is part of a "charnockitic suite" of metamorphic rocks which has widespread occurrence in the Adirondacks (Fig. 2). The suite includes the true charnockites (hypersthene-bearing gneisses of granitic composition) and varieties departing from

MILEAGE

Cum. B.P.

granitic composition by: 1) having a lower quartz content than the required 10% (or 20%, depending upon rock classification used), and 2) a range in the ratio of plagioclase to K-feldspar of from less than 1 to more than 1. The gneisses are characteristically gray to dark green in fresh exposures, and weather to a maple-sugar brown; pink facies occur also, however. Microperthite is the predominant mineral; mafic minerals may include hypersthene, augite, hornblende, biotite, and garnet. Owing to the variation in percentages of the "essential" minerals, (commonly within a single mapping unit) and the attempt to fit these lithologies into igneous-rock pigeonholes, they have been mapped under at least 12 different names during the past 50 years. They have been most commonly designated "quartz syenite" and "syenite". However, such terms carry a misleading connotation inasmuch as the rocks are at present largely, if not wholly, metamorphic, whatever their ultimate origins.

In much of the Adirondacks, rocks of this suite occur as unbanded, relatively monolithic layers many hundreds of feet thick. In the southern Adirondacks however, banded charnockitic gneiss with intimately interlayered sedimentary rocks occurs in a number of areas. The monolithic layers are most commonly exposed as the cores of domes and antiforms, as is expectable from their relatively high resistance to erosion.

The Hudson River, which flows by a few hundred feet to the west, is cut into metasediments.

70.0 0.4 Charnockitic gneiss in road cut on right.

70.7 0.7 Biotite-quartz plagioclase paragneiss in road cuts on right.

70.9 0.2
Stop 8 Quarry on right side of the road in banded, pink and gray paragneisses with scattered biotite schist layers. Breccias occur at northern end of outcrop but more prominent there is a diabese sill with fine-grained chill borders. This is one of many such undeformed diabase intrusives in the Adirondacks. They generally occur as this, steeply-dipping dikes. Inasmuch as they are undeformed they must postdate the Grenville Orogeny. They have been generally interpreted as Late Precambrian.

Continue northward on Route 28.

71.6 0.7
Stop 9 Roadcut in marble across from junction with road to Friends Lake.

MILEAGE

Cum. B.P.

The calcite marble and calc-silicate beds here are typically highly deformed, having been isoclinally folded - and probably refolded as well. The relatively competent calc-silicate layers have been stretched, attenuated, and dismembered well beyond the boudinage stage so that they occur as disconnected lenses, hooks, and clots. Such floating fragments have sometimes been picturesquely tagged "tectonic fish", and "dead snakes".

Minerals which can be readily found and identified include graphite, diopside, brown tourmaline (dravite), pyrite, sphene. Undeformed mafic dikes with fine-grained chill borders may be seen cutting the marble.

Continue on Route 28 across Hudson River, which here cuts into metasedimentaries.

72.0 0.4 Cross a second bridge, over small tributary to the Hudson River, and immediately park on the left at entrance to closed road.

Stop 10 Descend to stream, where may be found glacial boulders of most of the resistant Adirondack lithologies. The only major rock type not yet seen on this excursion - anorthosite - is well represented. Both the relatively pure Marcy-type anorthosite and the more mafic Whiteface-type may be found.

Proceeding upstream a short distance, a wide variety of metasedimentary lithologies may be seen cropping out in the stream bed. These include paragneisses, quartzites of varying purity, amphibolite, marble and calc-silicate rocks.

APPENDIX

History of the Lake George Region

The important historical role played by the Lake George region during Colonial times has been briefly summarized by Newland and Vaughan (1942) and is of sufficient interest to be quoted here:

"The village site was of great strategic importance during the Revolutionary period and earlier Colonial times. Along with Ticonderoga at the north end of the lake it was regarded as a key point for the control of the water route from the St. Lawrence to the Hudson. A nine-mile carry between the head of the lake and the Hudson near the present Glens Falls was the only important interruption to communication by water from the principal settlements in lower Canada and those within the Hudson Valley. Before Colonial times even, there is reason to believe the Indians had followed this route for purposes of war and trade. The Algonquians on the north and the Iroquois who inhabited the main part of what is now New York State were hereditary enemies, given to warlike incursions on each other's territory; but there were times when peaceful pursuits of trade were in order in all probability.

As witness to the military value in which this place was held during the time of early white settlement we have the series of fortifications here erected. Fort William Henry, the first to have been built was constructed by Sir William Johnson in 1755. It was on the terrace between the present railroad station and the Fort William Henry Hotel. It was captured and destroyed by the French under Montcalm in 1757. At present the most interesting relic remaining on the site seems to be the old well which lay within the earthworks, dug in sand and curbed with small stones.

The second fortification to have been erected at the head of the lake was Fort George, half a mile southeast of Fort William Henry on somewhat higher ground, with rock foundation. This was the work of General Amherst (1759) and used by him as a base from which to conduct operations against Ticonderoga then in possession of the French. It was later captured (1775) and its stores seized by a party from Ethan Allen's forces who took Fort Ticonderoga in the same year. There are enough of the entrenchments and building foundations still left on the site to afford a basis for inferring the outlines and general plan of this Colonial and Revolutionary fort. Interesting is the quarry excavation near-by from which stone was obtained for use in building and lime-making; the exposed rock in the open cut consists of a few beds or layers of dolomite, or magnesian limestone, hard and dense.

The last fortification erected here was Fort Gage, named for a British officer of Amherst's army, on the sand terrace back from the lake and some 200 feet above it. It was designed apparently to command the approach to the lake from the south. There are few marks of the fort now visible."

SELECTED REFERENCES

Broughton, J. G., & Fisher, D.W., Isachsen, Y.W., and Rickard, L.V., 1962, The Geology of New York State, N.Y.S. Mus. and Sci. Serv. Map and Chart Series 5 (a revised text plus geologic-physiographic map of the State is in press).

Bruehl, Donald, 1965, Bedrock contour map of Capital District area, 1:24,000, N.Y.S. Dept. of Public Works, Bur. Soil Mech. open-file map.

Buddington, A.F., 1939, Adirondack igneous rocks and their metamorphism, Geol. Soc. Am. Mem.7, 354 p.

_______________, 1952, Chemical petrology of some metamorphosed Adirondack gabbroic, syenitic, and quartz syenitic rocks, Am. J. Sci. Bowen Volume, p. 37-84.

_______________, 1963, Isograds and the role of H_2O in metamorphic facies of orthogneiss of the northwest Adirondack area, New York, Geol. Soc. Am. 74: 1155-1182.

Cook, J.H., 1930, The glacial geology of the capital district, p. 181-199 in R. Ruedemann, Geology of the Capital District, N.Y.S. Mus. Bull. 285.

Engel, A.E.J., & Engel, Celeste G., 1958, Progressive metamorphism and gravitization of the major paragneiss, northwest Adirondack Mountains, New York, Part I: Total rock, Geol. Soc. Am. Bull. 69: 1369-1414

Fisher, D.W., 1965, Mohawk Valley strata and structure - Saratoga to Canajoharie: in Guidebook for annual meeting of the N.Y.S. Geol. Assoc. (available as separate from N.Y.S. Mus. & Sci. Serv., Albany).

Fisher, D.W., & Isachsen, Y.W., Rickard, L.V., Broughton, J.G., and Offield, T.W., 1961, Geologic Map of New York, N.Y.S. Mus. and Sci. Serv. Map and Chart Series 5 (especially Adirondack and Hudson-Mohawk sheets).

Isachsen, Y.W., 1962, Geological history of the Adirondack Mountains, The Conservationist, June-July 1962, p. 27-31.

_______________, 1963, Geochronology of New York State, The Empire State Geogram 1:3:1-9.

Katz, Samuel, 1955, Seismic study of crystal structure in Pennsylvania and New York, Seismol. Soc. Am. Bull. 45: 303-325.

Kay, G.M., 1942, Development of the northern Allegheny synclinorium and adjoining regions, Geol. Soc. Am. Bull. 53: 1601-1657.

Miller, Wm. J., 1914, Geology of the North Creek Quadrangle, Warren County, New York, N. Y. S. Mus. Bull. 170, 90p.

Newland, D.H., & Vaughan, 1942, Guide to the geology of the Lake George Region, N.Y.S. Mus. Hdbk. 19, 234p.

Silver, Leon T., 1963, Isotope investigations of zircous in Pre-cambrian igneous rocks of the Adirondack Mountains, New York, Geol. Soc. Amer. Sp. Paper :105A.

Simpson, E.S., 1949, Buried preglacial ground water channels in the Albany-Schenectady area in New York, Econ. Geol. 44: 713-720.

Stoller, J.H., 1911, Glacial geology of the Schenectady quadrangle, N.Y.S. Mus. Bull. 154, 44p.

______________, 1920, Glacial geology of the Cohoes quadrangle, N.Y.S. Mus. Bull. 215, 216, 47 p.

deWaard, Dirk, 1964, Notes on the geology of the south-central Adirondack Highlands, N.Y.S. Geol. Assn. 36th Ann. Mtg. Gdbk., p. 3-24.

______________, 1965, The occurrence of garnet in the granulite-facies terrane of the Adirondack Highlands, J. Petrol., Vol. 6, No. 1, p. 165-191.

Waldbaum, D.R., 1965, Thermodynamic properties of mullite, andalusite, kyanite, and sillimanite, Amer. Min. 50: 186-195.

Walton, Matt, 1953, Differential metamorphic mobilization and the Adirondack eruptive sequence. Trans. Amer. Geophys. Union abs. 34:350.

Walton, Matt, & deWaard, D., 1963, Orogenic evaluation of the Pre-cambrian in the Adirondack Highlands, a new synthesis, Proc. Kon. Ned. Akad. Wetensch., Amsterdam, B, 66: 98-106.

Woodworth, J.B., 1905, Ancient waterlevels of the Champlain and Hudson Valleys, N.Y.S. Mus. Bull. 84, 265 p.

TRIP C

GLACIAL LAKE SEQUENCES IN THE EASTERN MOHAWK-NORTHERN HUDSON REGION

by

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INTRODUCTION

The Mohawk-Hudson Lowland has long been a subject area for historical syntheses dealing with various aspects of Wisconsin deglaciation. Following the original investigations of Peet (1904) and Woodworth (1905), considerable attention was focused here, and much of it led to controversy. Of particular interest were the demonstration of post-glacial crustal uplift of eastern North America, the character of the deflection, and its influence on drainage evolution.

Concerning the manner of ice disappearance, two schools of thought developed, each attempting to relate topographic and field evidence to its favored mechanism of ice withdrawal.

Fairchild (1912) emphasized receding, well-defined ice margins defending sequential glacial lakes, and proposed, in chronological order, Lakes Herkimer, Schoharie, and Amsterdam for the Mohawk Lowland and adjacent side valleys. Following the original definition by Woodworth (1905), he continued the concept of a northward-expanding Lake Albany in the Hudson Lowland. In 1918 Fairchild abandoned usage of Lake Albany in favor of a marine strait connecting the Atlantic Ocean at New York City with the St. Lawrence Lowland. Stoller (1918), after mapping the Cohoes quadrangle (1918), rejected this concept, as did others who followed.

Cook (1924) (1930) proposed that the ice overlying eastern New York was thicker than elsewhere and therefore in stagnation

* Contrib. No. 65-4

lingered both in Hudson Lowland valleys and on uplands for the duration of the glacial lakes. Brigham (1929, p. 72-82) lent support to this hypothesis from his study of the Mohawk Lowland. Actually the Fairchild and Cook-Brigham viewpoints need not be mutually exclusive and there is some evidence in support of each. In essence the argument involved the degree to which lake waters were free of ice, and whether wasting upland ice maintained a discernable sequential series of ice margins.

ICE FLOW AND DRIFT BORDER

Ice-molded topography indicating diverging (Cary) ice flow was observed by Rich (1914), Brigham, and Cook (1930) in the Berne quadrangle. The E-W trend of drumlins produced by the Mohawk lobe is in sharp contrast to the S 10 E trend of Hudson lobe flow indicated by drumlins east of the Hudson River in the Troy quadrangle. In the Mohawk Lowland, westward ice flow is topographically indicated as far as western Herkimer County where the Mohawk and Ontarian lobes joined (Brigham, 1929). In the Hudson Lowland, the southern limit (Valley Heads equivalent) has been placed at the Hudson Highlands by Flint (1953) and by MacClintock (1954), but at Long Island (Harbor Hill moraine) by Denny (1956). The younger Catskill drift border of Rich (1935) is acceptable as Valley Heads equivalent. The area covered by Figures 1-6 is well within the Valley Heads border and the deposits throughout indicate only one cycle of glacial advance and stagnation.

DEGLACIATION

The (Cary) deglaciation of the Mohawk Lowland, according to Fairchild, was accomplished by nearly simultaneous recession of the Mohawk block eastward, and the Ontarian block westward. In the uncovered valley areas between the blocks, lake waters supposedly replaced the ice. Lake levels were controlled in early, high-level phases by spillways connecting southward with the Chenango, Susquehana, and Catskill watersheds, and in later phases by spillways and channels leading southeastward along the Helderberg escarpment as the Hudson ice block deteriorated. There is little alternative to the requirement of southward overflow for these glacial drainages but the degree of replacement of ice by open lake waters in upland areas requires further investigation.

The "overthickened stagnant ice" concept of Cook is pertinent here and the reader is referred to the original paper (1924) for details. Cook was impressed, in the Berne quadrangle particularly (1930), for the lack of evidence of water-worked deposits marking, even occasionally, a well-defined, "withdrawing" ice margin. He was also encouraged, by examination of the depressions now occupied by Round and Saratoga Lakes, to promote Woodworth's (1905) and Stoller's (1918) concept of an ice-choked Hudson Lowland through the close of Lake Albany. He further suggested the deltas of the Hoosic River and Batten Kill were laid as kame terraces against ice, rather than into open lake water. [For a discussion of the sedimentary evolution of kame terraces in the Connecticut and Hudson Lowlands the reader is referred to Jahns and Willard (1942) and to LaFleur (1961b, 1963, 1965a).]

The evidence to date indicates a single episode of ice stagnation, with frequent lacustrine accompaniment, through the area north of the Catskills and throughout the easternmost Mohawk and northern Hudson Lowlands, which involved eventually both Lake Albany and Lake Vermont. On the basis of this hypothesis, Figures 1-6 have been drawn to summarize the literature and some recent work by the writer.

LAKE CHRONOLOGY

In the northern Catskills, Grand Gorge Lake (1640' maximum) spilled southwestward through Grand Gorge until the ice margin receded 18 miles northward to Middleburg and uncovered the col at the head of the present Catskill Valley near Franklinton. At this point the Grand Gorge Lake waters were lowered to 1200' and diverted into the Franklinton channel (Rich, 1935). After the ice margin receded northward an additional 12 miles, defending expanding Lake Schoharie, the east-facing outlet at Delanson was made available, and lake levels fell to about 860'. Figure 1 illustrates this lake phase.

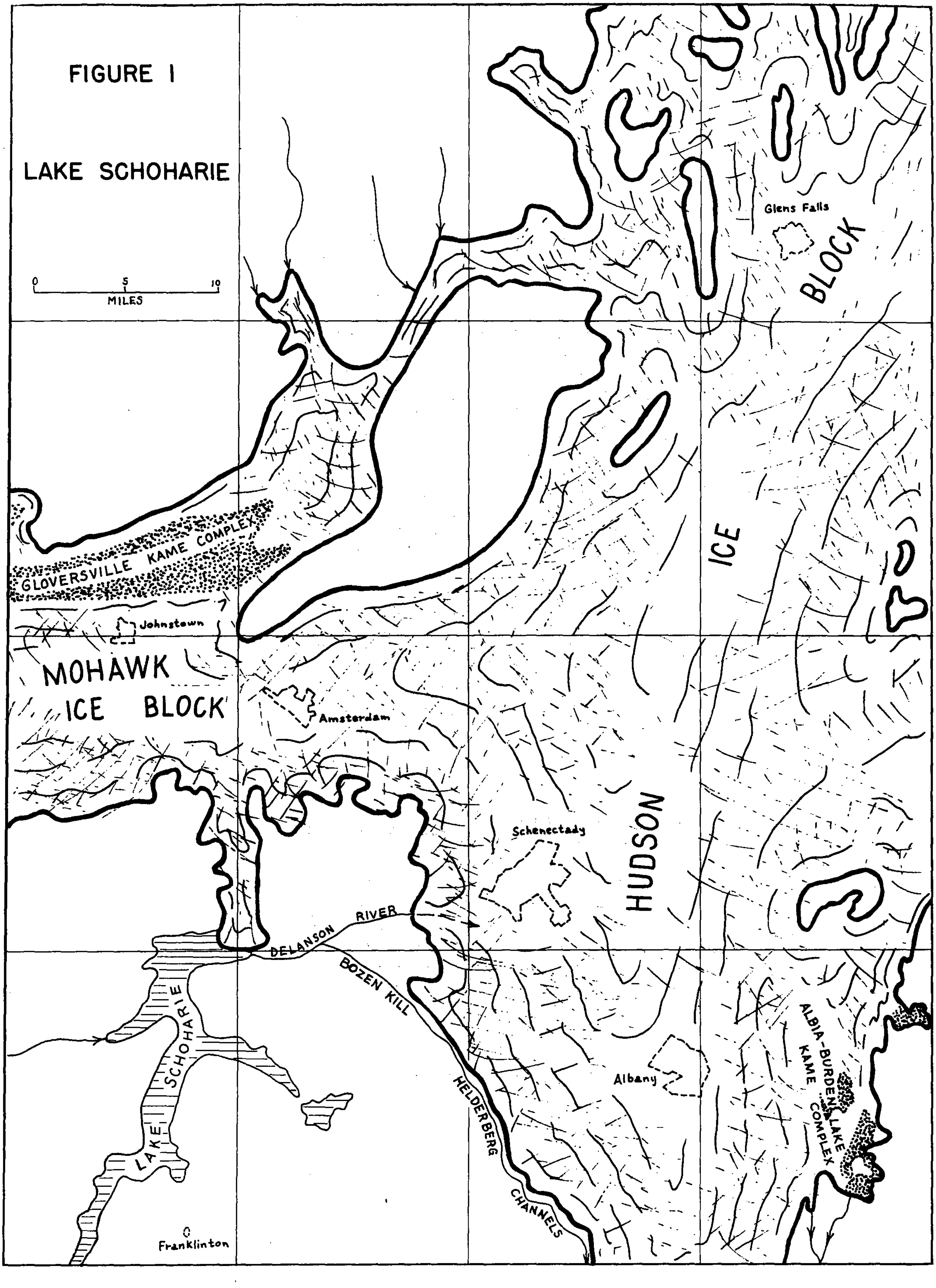


FIGURE I
LAKE SCHOHARIE
0
5
10
MILES
Glens Falls
BLOCK
GLOVERSVILLE KAME COMPLEX
Johnstown
MOHAWK
ICE BLOCK
ICE
Amsterdam
Schenectady
HUDSON
RIVER
DELANSON
BOZEN KILL
LAKE SCHOHARIE
HELDERBERG
CHANNELS
Albany
ALBIA-BURDEN LAKE
KAME COMPLEX
Franklinton

The validity or extent of Lake Herkimer has not been evaluated in the eastern Mohawk region but it must have been equivalent to part of the Grand Gorge-Schoharie lake sequence. West of this area, in Herkimer County, spillways at 1360' and 1220' are cited by Fairchild as controls for Herkimer lake waters at Summit Lake north of Springfield Center and at Cedarville, respectively.

Lake Schoharie

The clays of the Schoharie Valley imply the existence of lacustrine conditions there and Fairchild proposed Lake Schoharie, with overflow to the east at Delanson at an elevation of about 860'. Figure 1 shows the ice dam at the northern end of Schoharie Valley, which required eastward flow initially through the valley now more completely dissected by the Bozen Kill and southward along the face of the Helderberg escarpment. Upon slight recession of the ice northward, the Delanson River (Fairchild, 1912) became established. The underfit headwaters of the Normans Kill now occupy the large Delanson outlet.

The kame complex at 900' to 1200' mapped by Brigham (1929) near Gloversville probably dates in part from this episode and reflects continuity of the Mohawk and Hudson ice blocks through the Sacandaga Valley.

East of the present Hudson River in the Troy quadrangle, southward drainage between the ice and the edge of the Rensselaer Plateau became established as the ice thinned and exposed the plateau as a broad nunatak. Some early elements of the Albia-Burden Lake kame complex with summits at about 800' may date from this episode (LaFleur, 1965a). The Hudson ice block extended perhaps as far south as the village of Catskill, precluding Lake Albany waters from the central Hudson region.

Early Lake Amsterdam and Lake Sacandaga

After recession of the Mohawk ice block to the north end of the Schoharie Valley near Minaville, 860' Lake Schoharie was lowered. This new Lake Amsterdam, beginning with a level of about

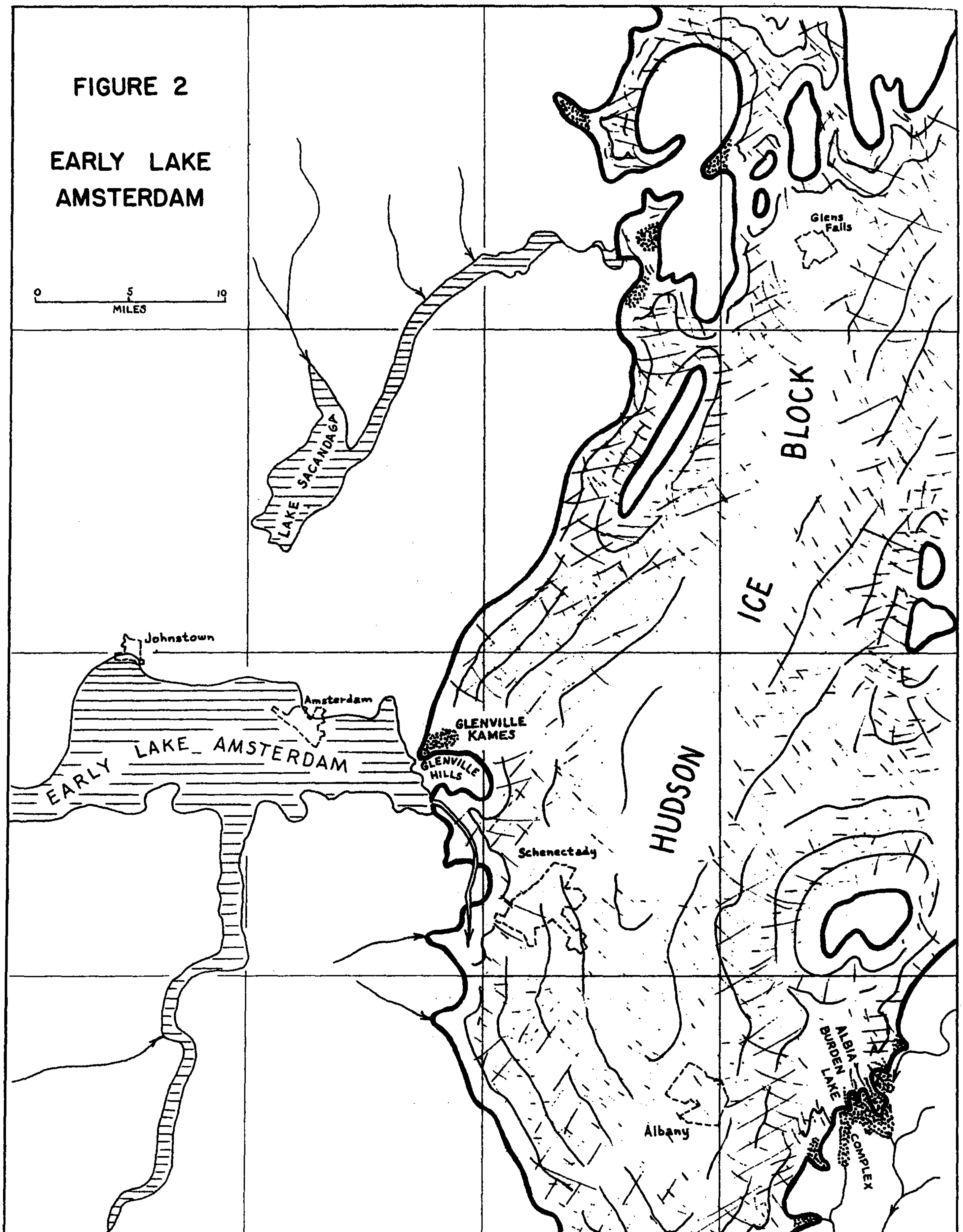


FIGURE 2

EARLY LAKE AMSTERDAM

700' drained eastward through the Mohawk Valley as downwasting progressed through the site of the present gorge of the Mohawk at Rotterdam Junction. See Figure 2. A well-defined channel 2 miles due south of Wyatts indicates one of the south-leading outlets.

One need not presume the Mohawk Valley was thoroughly deglaciated by this time. Lake Amsterdam may actually have been in part a stagnant ice block segregated from the Hudson block by the bedrock promontory hills overlooking Glenville and Rotterdam Junction. But how slowly or erratically the ice may have downwasted locally, the drainage sequence remains largely the same - imponded Mohawk waters find lower and lower outlets as the Hudson ice block thins.

Deglaciation and imponding of the Sacandaga Valley produced Lake Sacandaga, standing near 760', confined on the south by the Gloversville kame complex and on the northeast by ice or drift near Luzerne. Construction in 1930 of the Conklingville dam and filling of the Sacandaga Reservoir as a flood control for the modern Sacandaga and Hudson Rivers has restored this former glacial lake.

The duration of Lake Sacandaga is unknown, but the relatively slight incision of bottom sediments by the modern Sacandaga River and the rock canyon constriction at Conklingville suggest a relatively long life. A temporal lake condition is suggested into modern times by the (pre-reservoir) flood-plain character of the Sacandaga Vly, west of Northampton.

In the Troy quadrangle, the Albia-Burden Lake complex continued to accumulate and the Schodack kame terrace also developed alongside the Hudson ice block.

Later Lake Amsterdam

Prominent deltas and terraces near 420' along the present Mohawk River record the lowest level of falling Amsterdam waters, by that time restricted to a narrow valley not more than a mile

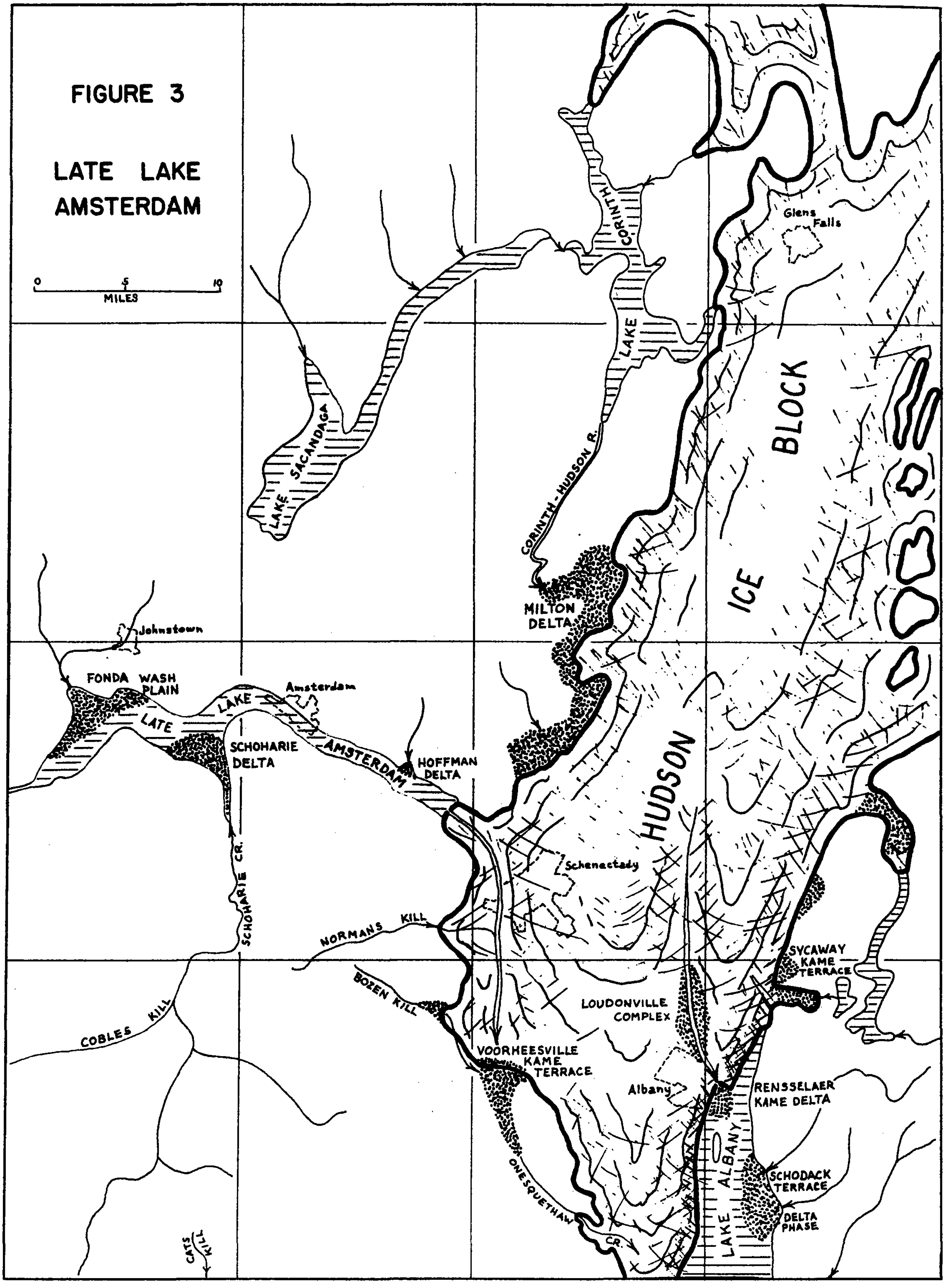


FIGURE 3

LATE LAKE AMSTERDAM

or two across. See Figure 3. The Fonda wash plain, the Schoharie delta, the smaller deltas at Hoffmans and Cranesville record this level. Lake Sacandaga at 760' - 740' continued to be drained northeastward by a short Sacandaga River.

The first of several diagrams by Chadwick (1928) appears to correlate with late Lake Amsterdam. Lake Corinth filled the lower, eastern valley of the Sacandaga and, imponded by the ice at Palmertown Mt., found exit southward through the Corinth-Hudson River. The 420' Milton delta is the terminus of this system against the Hudson ice block.

The Voorheesville kame terrace appears to lie in the path of escaping Lake Amsterdam waters, which ultimately found their way through the Onesquethaw Valley into Lake Albany, south of the map area. The Loudonville complex similarly lies immediately upstream from the kame delta at Rensselaer in the path of drainage derived from the Hudson ice block. These drainage systems built at an ice margin of slightly later time the esker and kame complex at Mohawk View (SE corner of Schenectady 15' quadrangle), and the Guilderland kame terrace (Voorheesville 7.5' quadrangle).

On the Cohoes and Troy quadrangles, the ice margin bordered the 400' kame terraces at Spiegletown and Sycaway, with the kame delta at Rensselaer indicating the ice margin defending 350' Lake Albany. The Albia-Burden Lake kame complex had been completed and (Lake Albany) lacustrine conditions spread northward through the Capital District area. For local details see LaFleur (1961b) (1965a).

Mohawk Delta and 350' - 330' Lake Albany

As the wasting Hudson block cleared the eastern end of the Mohawk Valley at Schenectady, the westward enlargement of Lake Albany began to receive a large delta of Fairchild's Glaciomohawk River. See Figure 4. Although the delta appears to have been built largely into open water, at some localities southwest of Albany the more distal, deeper water sands were laid down apparently

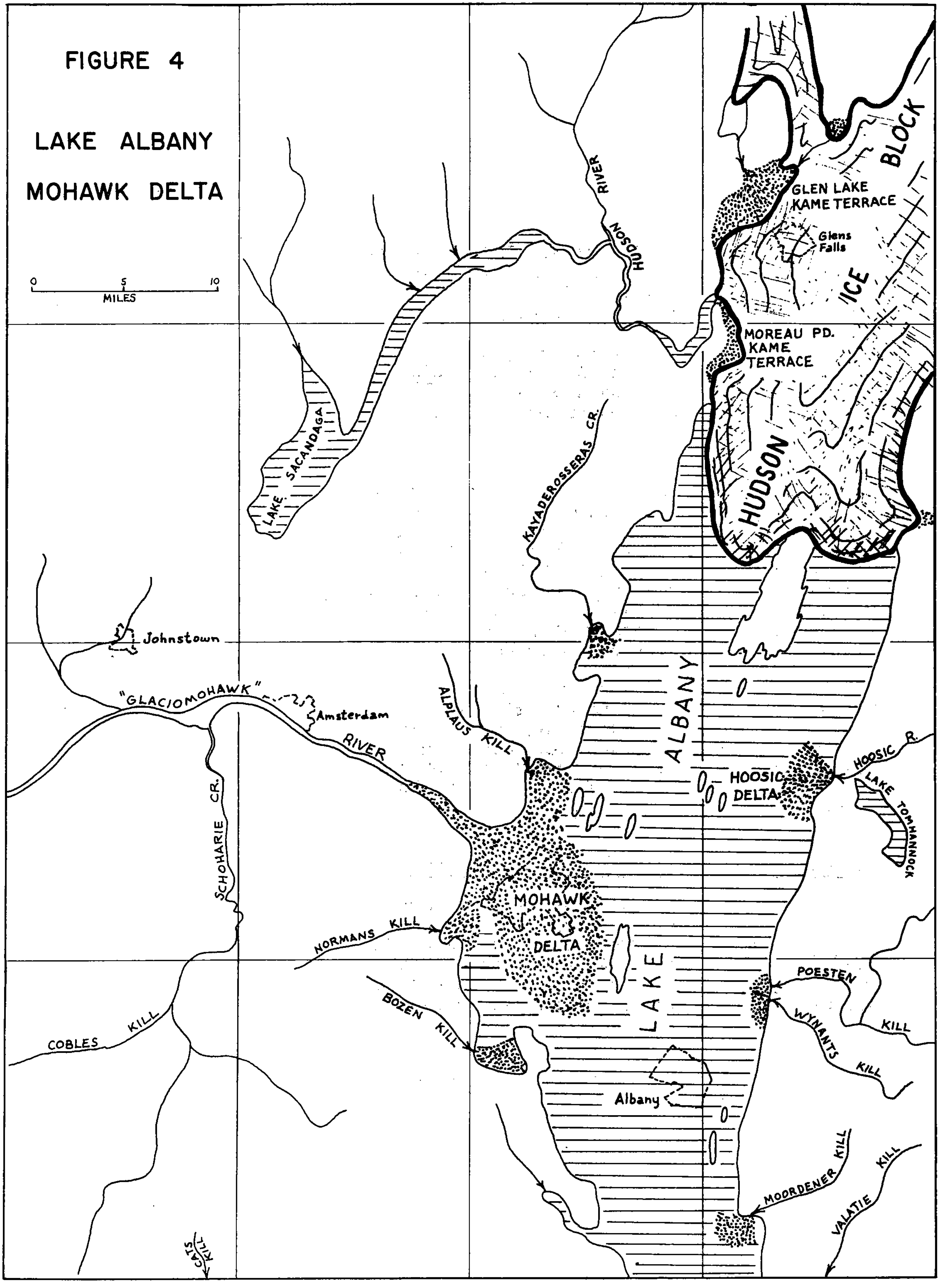


FIGURE 4
LAKE ALBANY
MOHAWK DELTA
0 5 10
MILES
HUDSON RIVER
GLEN LAKE KAME TERRACE
Glens Falls
BLOCK
ICE
HUDSON
MOREAU PD. KAME TERRACE
LAKE SACANDAGA
KAYADEROSSERAS CR.
Johnstown
"GLACIOMOHAWK"
Amsterdam
RIVER
ALPLAUS KILL
LAKE ALBANY
HOOSIC DELTA
HOOSIC R.
LAKE TOMHANNOCK
SCHOHARIE CR.
MOHAWK DELTA
NORMANS KILL
BOZEN KILL
COBLES KILL
POESTEN KILL
WYNANTS KILL
Albany
MOORDENER KILL
VALATIE KILL
CATS KILL

in the presence of sunken dirty ice. Severe deformation structures are found in sand hills resembling dunes along the present Normans Kill about 200' above present sea level. The dune origin of other sand hills west of Albany may also be suspect. Chadwick (1928) implied the existence of buried ice beneath the "Malta Lake" sand plain of the same age in Saratoga County.

Along the eastern shore, Lake Albany received delta sands from the Moordener Kill, Wynants Kill and Hoosic River and a prominent beach began to form. The 380' kame terrace of the Batten Kill appears to correlate with the 360' Hoosic delta, as other more extensive Batten Kill deltas are inferior to the Hoosic delta summit. Chadwick's diagram of the ice margin of this episode includes the Glen Lake and Moreau Pond kame terraces. The latter is the sedimentary product of the early post-glacial Hudson River, which at this time drained a dwindling Lake Corinth eastward.

Quaker Springs Lake Vermont and 300' - 240' Lake Albany

Upon lowering of Lake Albany level from 350' to about 300', the Mohawk was forced to turn northward at Alplaus and cut a series of channels, the earliest of which is indicated on Figure 5. Throughout the Hudson Lowland, earlier, higher deltas and kame terraces were similarly incised during this episode with a particularly complete record of falling lake levels indicated by the terraces in the Hoosic delta. (Woodworth, 1905), (Stoller, 1918).

The Hudson River continued its delta building at lower levels at Glens Falls, as did the Batten Kill and other streams along the eastern shore. Lake Bolton, predecessor to Lake George, occupied that basin (Chadwick, 1928). The Iromohawk River of Fairchild supposedly drained Lake Iroquois through large outlet channels, well shown on the Schenectady quadrangle, into a dwindling Lake Albany. The Ballston-Mourning Kill channel appears to be the earliest, followed shortly by the Ballston-Drummond Creek channel.

(If the disturbed clays northeast of Hudson Falls are the result of an ice readvance in early "Quaker Springs" time (or before) into lake waters of the northernmost Hudson Lowland, there would be no incompatibility with the later lake history. Chadwick (1928) placed a buried ice block east of Hudson Falls at this time, but did not relate it to a readvance.)

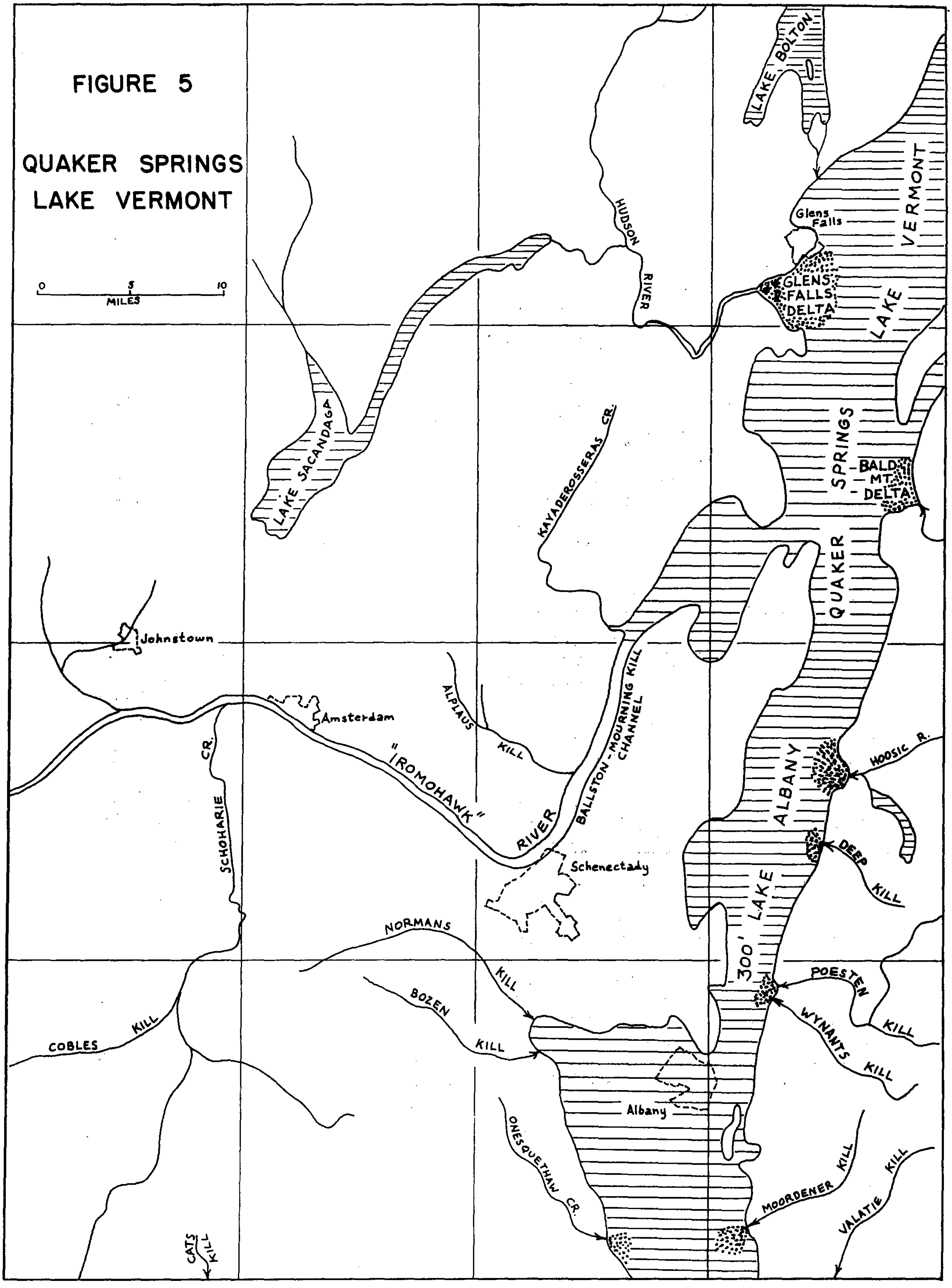


FIGURE 5

QUAKER SPRINGS LAKE VERMONT

Coveville Lake Vermont and 190' Lake Albany

A time of stability of falling water levels is indicated by the terraces along the Hudson at about 200' south of Schuylerville and by the 240' delta of the Hudson River at Hudson Falls (Chadwick, 1928). This Vermont lake phase is represented south of Schuylerville by a greatly reduced "Lake Albany" which is by this time only a broad river. See Figure 6. The tributary Iromohawk occupied both the Round Lake channel and the Alplaus-to-Waterford channel (now the present Mohawk course) as indicated by the terrace at 190' at Mechanicville and also by scour of clays to that level at Waterford (Schock, 1963). The Kayaderosseras-Fish Kill system entered the lake at Coveville and continued to fall over the rock sill at that point until the system was captured by the short tributary to the Hudson at Victory Mills. All of the Mohawk was eventually captured at Alplaus upon erosion there of a rock sill and the river presently enters the Hudson at Cohoes. Ballston, Saratoga, and Round Lakes now occupy parts of the abandoned Mohawk channels.

The origin of the basin of Round Lake and the reason for its position in the middle of an outlet channel remain enigmatic. The elbow of capture at East Line is also curious, considering the then-existing well-developed Ballston-Drummond channel. The thaw of a buried ice block at Round Lake combined with headward erosion westward from the basin so produced might have provided a mechanism for capture of a well-established channel. One must also take into account the lessening of channel gradient in the north direction caused by progressing crustal uplift. (The reader is referred to Chadwick (p. 917, 1928) for discussion of the "wave of uplift" and other hypotheses, and to LaFleur (1965a) for a comparison of Lake Albany and Lake Vermont data which indicate crustal uplift.)

Fort Ann Lake Vermont (not illustrated) then drained through the present Hudson Valley, confined to approximately the present strath of the Hudson River. Its record in the Capital District is insignificant in comparison to earlier lake phases.

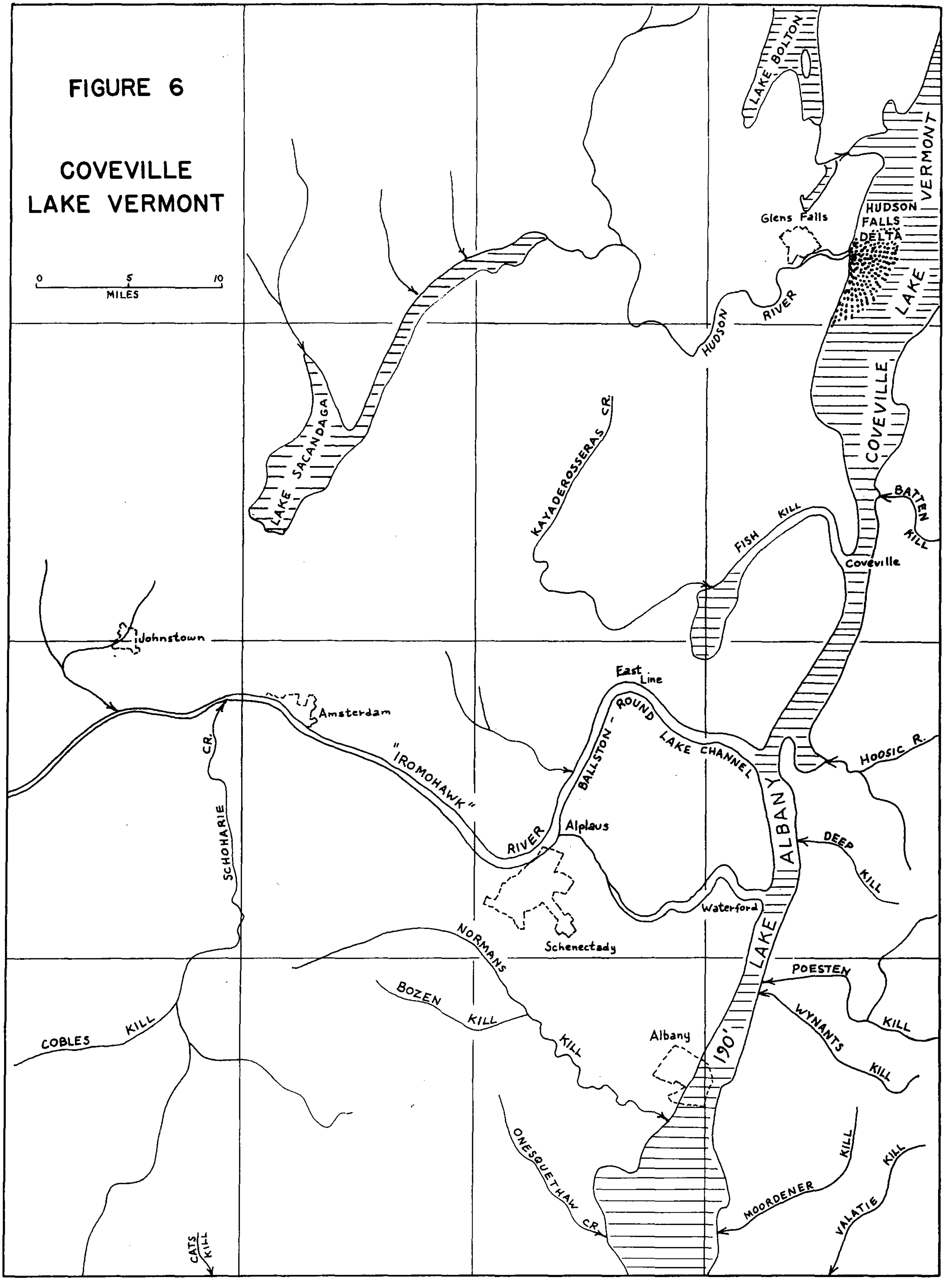


FIGURE 6

COVEVILLE LAKE VERMONT

PROBLEMS IN CORRELATION OF THE LATER LAKES

Previous Work

By careful study of spatial relationships between features which indicate temporary base levels, such as beaches, deltas, kame terraces, and the drainage systems necessary for their formation, one can arrive at a meaningful grouping of successive ice-contact and proglacial lake deposits. The first such attempt was made by Chadwick (1928) who diagrammed a sequence of ice margins defending expanding Lake Albany in the area between Saratoga and Glens Falls. Chadwick distinguished younger Lake Vermont from Lake Albany and restricted the former, largely on geographical grounds, to the Hudson Lowland north of Schuylerville. Through reference to the supposed southern spillway for Lake Vermont into a drained Lake Albany basin at Coveville, he continued to promote the Coveville phase originally named by Woodworth (1905). Chadwick also cited the pot-holed sill in the Precambrian rocks at Fort Ann as a Lake Vermont outlet to be preferred to the Fort Edward channels. From this reference Chapman (1937) coined the final Fort Ann phase of Lake Vermont.

At Quaker Springs, a location on the Schuylerville quadrangle 2 miles southwest of Coveville, Woodworth (1905) recognized a temporary lake level at about 300' above present sea level, inferior by 50' to the Lake Albany maximum. He applied this name to the earliest phase of Lake Vermont. The Quaker Springs phase was totally ignored by Chadwick (1928) and was not given regional significance in the Champlain Valley by Chapman (1937). Rather the evidence for its existence there was attributed to the effects of local, high-level lakes. Stewart (1961) revived usage of the name Quaker Springs as the earliest phase of the Lake Vermont succession, followed by the inferior Coveville and Fort Ann phases.

Current Concepts

Much of the difficulty in relating Lake Albany to Lake Vermont is nomenclatural. "Quaker Springs", however valid its application might be to Champlain Lowland history, is clearly in the middle of the classical Lake Albany sequence of falling lake levels and geographically is well south of and topographically superior to the "outlet" at Coveville.

Still to be evaluated is the postulated readvance of ice to Glens Falls and the degree of Late Cary deglaciation (if any) in the Champlain Lowland, between the time of Lakes Albany and Vermont. Flint (1953) suggested that the evidence of Mankato ice override west of Glens Falls might be obscured by the later development of the Glens Falls delta of the Hudson. But Chadwick had assigned, in a reasonable way, most of that delta to the latest phase of Lake Albany, as receding ice cleared the Hudson Lowland at Palmertown Mountain for influx of Sacandaga-Hudson drainage. Chadwick accepted an orderly succession of ice-margin and lacustrine deposits dating from Lake Albany through Lake Vermont. His hypothesis has not been contradicted by recent mapping in the Troy area (LaFleur, 1965a). There is so far no evidence to suggest a draining of the Mohawk-Hudson Lowland following Lake Albany and later filling by Lake Vermont waters.

Coveville Outlet

The word "Coveville" has unfortunately been applied erroneously to identify a spillway which never controlled a lake level, in contradiction to traceable superior and inferior terraces north and south of Schuylerville along the present Hudson. But the name has been firmly entrenched in the literature and its removal is not suggested here - rather the relation of the spillway to Mohawk and Kayaderosseras-Fish Kill drainage is to be emphasized.

The writer (1965a) has drawn some conclusions regarding the partial synonomy of Lakes Albany and Vermont. Figures 5 and 6 indicate the proposed relationships between early Vermont phases and late Albany phases.

SELECTED EXPOSURES

See Figure 7 for numbered locations.

1. Long, narrow drumlins with east-west trend, 2 miles west of Mariaville Lake. (Duanesburg 7.5 min. quad.)

2. Flaggy boulders of Schenectady Formation predominate drift north of Duanesburg; well exposed along Duanesburg Churches Rd. Excellent view of drumlin terrane north from Highland Park Rd.

3. Overlook of Duanesburg channel (of Delanson River) at Duane, Rt. 7 one mile south of Duanesburg.

4. Drumlins north of Rt. 20, 1 1/2 miles east of Duanesburg. Roadcut exposes till. Good view north across Normans Kill Valley.

5. Overlook of lower Mohawk Valley from hill one mile northwest of Rotterdam; 350' terrace remnant of Mohawk delta; river gravels; islands in the Mohawk River at Scotia.

6. Outlet channel of Early Lake Amsterdam now occupied by NYS Thruway; 1/2 miles west of exposure no. 5.

7. Delta in Late Lake Amsterdam at Hoffmans; Wolf Hollow gorge of Chaughtanoonda Creek has formed along the Hoffmans Fault, accentuating a striking topographic lineament traceable for 3 miles to the north. (Pattersonville 7.5 min. quad.)

8. Glenville kames along the West Glenville Rd.; suggesting the location of the ice margin which defended Early Lake Amsterdam.

9. View from Potter Rd., one mile north of Glenville, south to rock benches of the Glenville Hills.

10. View from Ostrander Rd., one mile east of Guilderland Ctr., southwest to Helderberg escarpments. (Voorheesville 7.5 min. quad.)

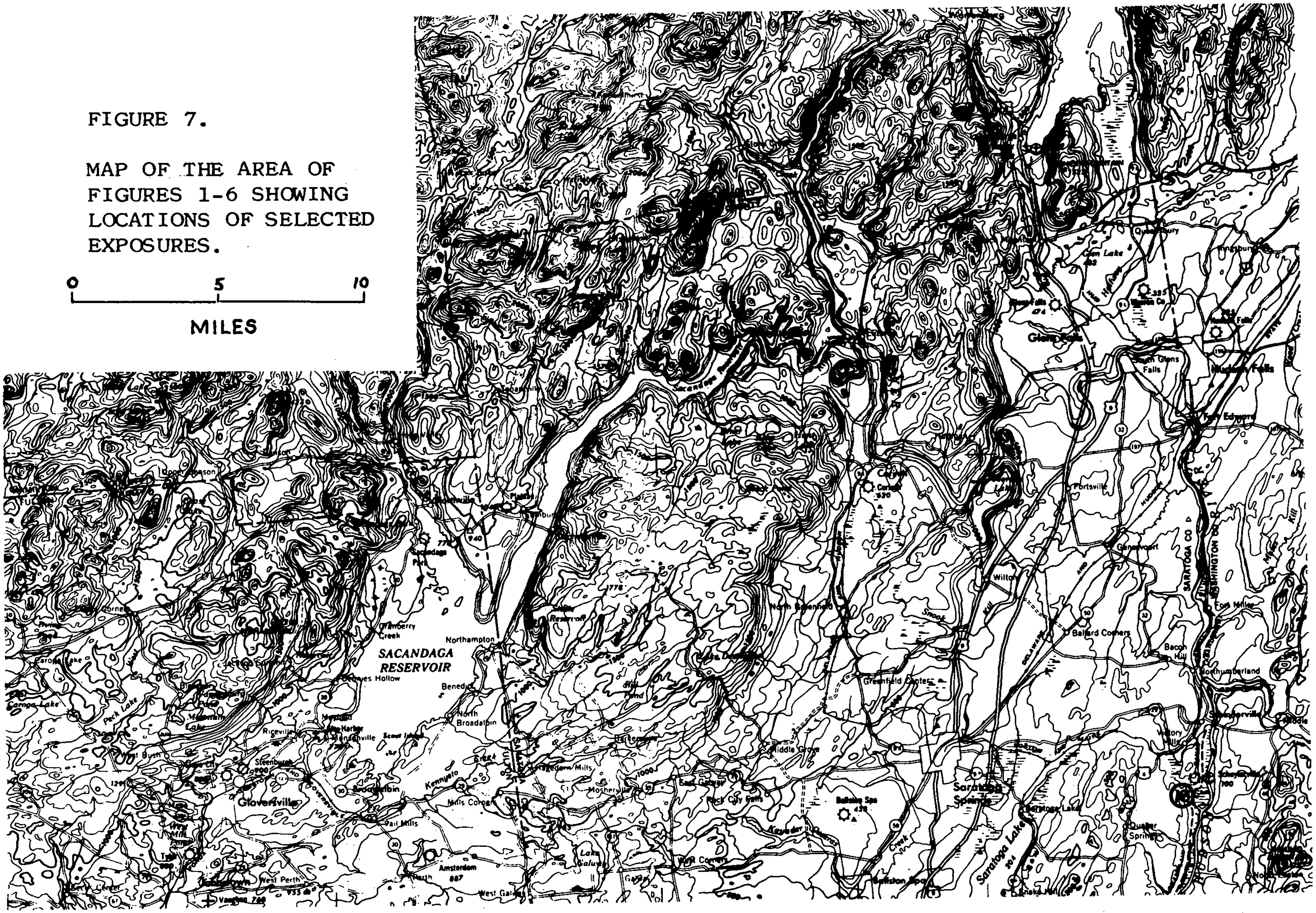
11. Along Grant Hill Rd., one mile southeast of exposure no. 10; dissection of the south (lee) side of a drumlin by the Normans Kill exposes 100 feet of bouldery till.

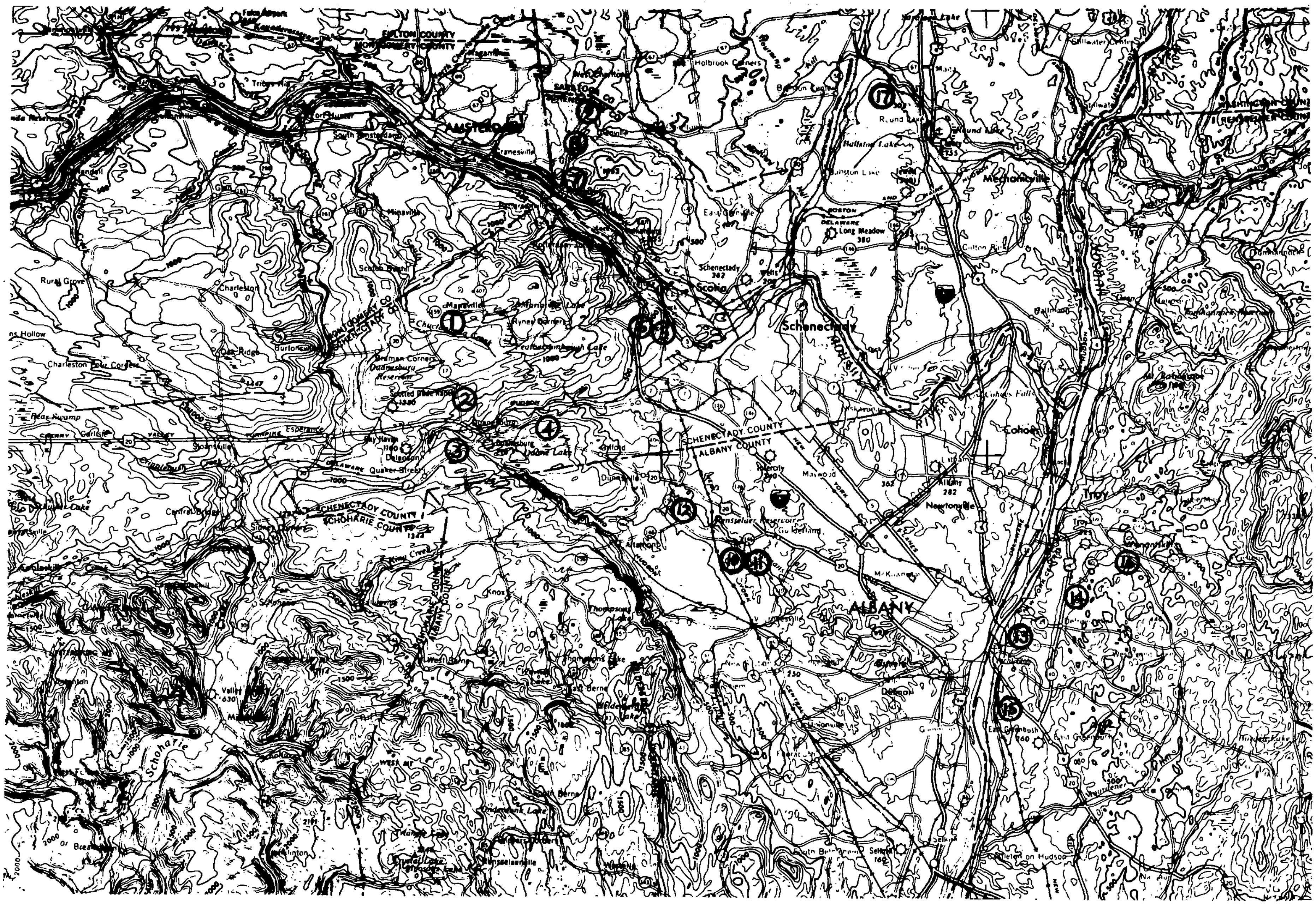
FIGURE 7.

MAP OF THE AREA OF FIGURES 1-6 SHOWING LOCATIONS OF SELECTED EXPOSURES.

0 5 10

MILES




ALBANY
Schenectady
SCHENECTADY COUNTY
ALBANY COUNTY
SCHOHARIE COUNTY
Mechanicville
Cohoes
Troy
Delmar
Altamont
Knox
Charleston
Long Meadow
Newtonville
Esperance
Schoharie

12. Guilderland kame terrace along southwest shore of the Watervliet Reservoir (Voorheesville 7.5 min. quad). Several gravel pits expose southwest-dipping gravels and sands; also isolated pockets of rhythmic clays. A solitary kame is located at the intersection of Routes 158 and 146. The Lake Albany 330' beach has modified the northeast (ice-contact) side of the kame terrace.

13. Rensselaer (Lake Albany) kame delta, east of city limits of Rensselaer. Turbidite sands in delta bottomset beds; graded bedding, sole markings. (Troy South 7.5 min. quad.)

14. Lake Albany beach ridge with gravel pit excavation; one mile north of Defreestville on Bloominggrove Rd. (Troy South 7.5 min. quad.)

15. Teller Hill promontory, one-half mile west of Sherwood Park (E. Greenbush 7.5 min. quad.) Panorama of Hudson Valley, the Hampton Park kame delta, and the Hudson flood plain.

16. Eskers of the Albia-Burden Lake complex, exposed in several large gravel pits on Route 66 east of Wynantskill. (Averill Park 7.5 min. quad.)

17. Panorama from East Line Rd., 3 miles north of Jonesville (Round Lake 7.5 min. quad.); Ballston outlet channel capture at East Line; Round Lake depression and channel, Malta sand plain. Round Lake channel also shown where it is crossed by the Northway one mile east of exposure no. 17.

18. Coveville outlet and plunge pool three miles south of Schuylerville on west side of Hudson River. (Schuylerville 15 min. quad.)

REFERENCES

Brigham, A. P., 1929, Glacial geology and geographic conditions of the lower Mohawk Valley: N.Y. State Mus. Bull. 280

Chadwick, G. H., 1928, Ice evacuation stages at Glens Falls, N.Y.: Bull. Geol. Soc. Amer. v. 39, p. 901-922

Chapman, D. H., 1937, Late-glacial and post-glacial history of the Champlain Valley: Am. J. Sci., v. 34, No. 200, pp. 89-124

Cook, J. H., 1924, Disappearance of the last glacial ice-sheet from eastern New York: N. Y. State Mus. Bull. 251

__________, 1930, Glacial geology of the Capital District: in N.Y. State Mus. Bull. 251

__________, 1935, Glacial geology of the Berne Quadrangle: in N.Y. State Mus. Bull. 331, pp. 222-230

Denny, C. S., 1956, Wisconsin drifts in the Elmira region, N. Y., and their possible equivalents in New England: Am. J. Sci. v. 254, pp. 82-95

Fairchild, H. L., 1909, Glacial waters in Central New York: N. Y. State Mus. Bull. 127

__________, 1912, Glacial waters in the Black and Mohawk Valleys: N. Y. State Mus. Bull. 160

__________, 1914, Pleistocene marine submergence of the Connecticut and Hudson Valleys: Bull. Geol. Soc. Amer., v. 25, pp. 219-242

__________, 1917, Post glacial features of the Upper Hudson Valley: N. Y. State Mus. Bull. 195

__________, 1918, Pleistocene marine submergence of the Hudson, Champlain, and St. Lawrence Valleys: N. Y. State Mus. Bull. 209-210

__________, 1932, Closing stage of New York glacial history: Bull. Geol. Soc. Amer., v. 43, pp. 603-626

__________, 1932, New York Moraines: Bull. Geol. Soc. Amer., v. 43, p. 627-662

Flint, R. F., 1953, Probable Wisconsin substages and Late-Wisconsin events in northeastern United States and southeastern Canada: Bull. Geol. Soc. Amer., v. 64, pp. 897-920

Jahns, R. H. and Willard, N. E., 1942, Pleistocene and recent deposits in Connecticut valley, Massachusetts: Am. J. Sci., v. 240, pp. 161-191, pp. 265-287

LaFleur, R. G., 1961a, Pleistocene geology of the Troy, N. Y. quadrangle: Ph.D. diss., R.P.I., Troy, N. Y.

____________, 1961b, Glacial features in the vicinity of Troy, N. Y. : Guidebook to Field Trips, N. Y. State Geol. Assn., p. 1-21

____________, 1963, Origin of sand and gravel deposits in New York: First Ann. Sand and Gravel Symposium; Empire State Sand, Gravel, Ready-Mix Assn.

____________, 1965a, Glacial geology of the Troy quadrangle: N. Y. State Museum Map and Chart series

MacClintock, P., 1954, Leaching of Wisconsin glacial gravels in eastern North America: Bull. Geo. Soc. Amer., v. 65, pp. 369-384

Moss, J. H. and Ritter, D. F., 1962, New evidence regarding the Binghamton substage in the region between the Finger Lakes and the Catskills, New York: Am. Jour. Sci., v. 260, pp. 81-106

Peet, C. E., 1904, Glacial and post-glacial history of the Hudson and Champlain Valleys: Jour. Geol., v. 12, pp. 415-469, 617-660

Rich, J. L., 1914, Divergent ice-flow on the plateau northeast of the Catskill Mountains as revealed by ice-molded topography: Bull. Geol. Soc. Amer., v. 25, pp. 68-70

____________, 1935, Glacial Geology of the Catskills: N. Y. State Mus. Bull. 299

Schock, R. N., 1963, Geology of the Pleistocene sediments, Troy North quadrangle, N. Y.: M. S. Thesis, Rens. Poly. Inst.

Stewart, D. P., 1961, Glacial geology of Vermont: Bull. No. 19, Vermont Geol. Survey

Stoller, J. H., 1911, Glacial geology of the Schenectady quadrangle: N. Y. State Mus. Bull. 154

____________, 1916, Glacial geology of the Saratoga quadrangle: N. Y. State Mus. Bull. 183

____________, 1918, Glacial geology of the Cohoes quadrangle: N. Y. State Mus. Bull. 215

_______________, 1919, Topographical features of Hudson Valley and question of post-glacial marine waters in Hudson-Champlain Valley: Bull. Geol. Soc. Amer., v. 30, pp. 415-422

_______________, 1922, Late Pleistocene history of the lower Mohawk and middle Hudson region: Bull. Geol. Soc. Am., v. 25, pp. 515-526

Woodworth, J. B., 1905, Ancient water levels of the Champlain and Hudson Valleys: N. Y. State Mus. Bull. 84, pp. 63-265

FIELD TRIP D
GEOLOGIC PHENOMENA IN THE
SCHENECTADY AREA

by
P.C. Hewitt, Wm. E. McClennan Jr. & Harold Nilsson

Stop 1 -- THE CLIFTON PARK ANTICLINE

Location

The outcrop is located at the top of a hill in the town of Clifton Park on N.Y. Rt. 146, 1.7 miles east of the intersection of Rts. 9 and 146. If approached from the east the outcrop lies 0.5 miles west of the intersection of Rts. 146 and 236.

Description

The Clifton Park anticline is an excellent outcrop for teaching purposes. At the one locality many structural and sedimentological features may be observed. It also is a prime example of the thrust faulting in the eastern part of the lower Mohawk Valley. There are only a few faults of this type in the area and they probably represent only small scale thrusting. Though associated with Taconic thrusting they are not part of the Taconic region itself but are west of the westernmost zone of that much discussed area.

The strata exposed at Clifton Park are assigned to the Normanskill formation and represent primarily the Austin Glen Graywacke member. Some black shales are interbedded with the siltstones and graywackes. The mud pebble conglomerate so common in the Normanskill may also be observed at this outcrop. No fossils have been reported from this exposure but the lithology is typical of this Middle Ordovician unit and fossils found in the near vicinity assure this age assignment.

The outcrop extends for about 600 feet on either side of the road. It is apparent from a rapid glance that the strata on the north side of the road do not match those on the south side. To gain the most from this exposure it is best to start your traverse at the west end on either side of the road and to walk toward the east and return in the opposite direction on the other side of the road. A series of thrust faults may be seen on either side of the road.

At the west end of the exposure on the south side of the road is a small thrust which may be observed to blend into a bedding plane fault to the east. Virtually all of the faults show mineralization along the fault plane. The mineralization usually consists of well slickensided calcite. No individual fault can be traced any great distance but there is no difficulty in detecting the faults nor in following them over a distance of several yards or more.

The entire section of strata on the south side appear to be less contorted than on the north. This is more apparent than real, however, for the whole area is part of an anticline plunging to the south.

Structural features on the north side of the road are quite different. Starting at the east end one may see beds dipping about 30° to the southeast followed by a small symmetrical anticline. About 25 ft. further west is a small faulted anticline. The fault here is a small thrust with a strong drag zone. Gouge may be seen in the fault plane itself. Another small but tight fold succeeds the fault to the west. About 75 ft. from the small fault is an interesting overturned anticline with an east limb dipping only a few degrees to the east and a west limb dipping 75° to 80° to the east. As a result the beds on the west limb are up-side-down.

For a distance of about 30 ft. is a zone of shattered siltstone which may represent one of the faults on the opposite side of the road. Still walking westward the last structure to be encountered is a symmetrical anticline whose limbs dip 30°. Jointing is obvious through the section.

In addition to the structural elements there are many sedimentary features to be seen on both sides of the road. Mud-pebble conglomerates, large ripple-marks, graded bedding and other features may be observed throughout. It is also interesting to note the result of unloading of the surface upon the siltstones and graywackes. Here, the beds have fractured and it is possible to see the difference between the beds which are actually several feet thick and the zone in which the beds appear thinner due to unloading.

Furthermore, it is obvious that the beds of siltstone and graywacke do not maintain a constant thickness as one traverses the outcrop.

Discussion

The primary cause of interest at the Clifton park anticline lies in the differences in strata and structural appearance on either side of the road. Some students have suggested that a fault, striking east-west is responsible for the disparity. This seems unlikely and is not needed to explain the exposure. On the contrary, an asymmetrical fold plunging to the southwest which was later cut by faulting seems to provide a simple and more adequate explanation. The explanation lies more in the asymmetry of folding followed by erosion than in any other factor. Certainly there is room for interpretation at this outcrop and we will welcome any comments.

Stop 2 -- GEYSER PARK AND THE "VALE OF SPRINGS"

Location

This area is a portion of the state-owned Saratoga Springs Reservation located just south of the city of Saratoga Springs, between N. Y. 9 on the east and N.Y. 50 on the west. Geyser Park is situated in the western half. Entrance to the Park is via a new road at the southern limits of the reservation which connects with both Route 50 and Route 9. The old entrance and approach to the Park, near the Hall of Springs, has been closed to vehicular traffic making it impossible to approach the park from the north. Visitors may, however, elect to park in that section of the reservation and walk down the hill into the upper section of the Park.

Features and Lithology

This area has the highest concentration of "springs" and "geysers" of any area in or around Saratoga. Altogether four "springs" and three "geysers" will be in operation upon the completion of a multi-million dollar reconstruction program.

The mineral waters discharged by the "springs" and "geysers" are representative of the Saratoga type mineral water; a highly saline water charged with varying amounts of carbon dioxide gas. Occurrences of this type mineral water is restricted to only one other locality in the United States.

The wells in the Park, some almost 1,000 feet deep, continuously discharge large volumes of water. The water is carried up in the well by the release of gas pressure in much the same manner as a warm and well-shaken bottle of soda ejects its contents when opened. This water pressure, passed through a small orifice at the top of some wells, produces the so-called "geysers" to be seen in the Park.

The large proportion of salts in the water, particularly carbonates, produces interesting tufa deposits in the form of cones, flows and terraces.

Geyser Brook, a non-carbonated, non-potable stream winds through the Park from the north, cutting a small valley and exposing the Canajoharie shales in several places. Rather poor specimens of some graptolites can be secured at several horizons in the shale.

Tour and Discussion

The first of three "geysers" to be observed is the Polaris "Geyser." All "geysers" are free flowing, but the force with which they leave the casing is regulated by using a small orifice. All of the "geysers" have been drilled and are actually wells which are allowed to run free. We have placed the word "geyser" in quotation marks since a true geyser is associated with hot water driven from the ground by steam pressure. Part of the cone of the Polaris has been created with stones piled around the casing, but a considerable amount of tufa (travertine) has been deposited since their initial operation.

The Park road eventually reaches a large parking lot, snack bar and comfort station. Further exploration will be on foot. Proceed across the bridge and turn right on the path. Just above the bridge is the Hayes Spring (well). The terminology becomes difficult at this point as both the spring and well apply. The impervious cap rock was pierced by a well in 1909. However, the water flows under its own pressure much as in a spring. Arguments could be collected in favor of an artesian well or spring. The reader is invited to choose one or the other. The Hayes is a pleasant water for those who are native to the area and who have acquired a taste for Saratoga type mineral water. It is well carbonated and moderately saline and popular with mineral water enthusiasts. A hole on the upstream side of the Fountain permits people to inhale the excess gas from the well and it is guaranteed to "clear your head." An analysis of the Hayes Well is appended for people with geochemical interests or for those who are just plain curious about what they are drinking. It is only fair to warn the drinker that many of the dissolved salts have had a reputation as "diuretics and cathartics," and they seldom fail to achieve this result when taken in any quantity.

The "geyser" a hundred feet or so upstream is appropriately named the Island Spouter "Geyser." Its waters ascend in a graceful flow to heights of thirty feet or more and is a much photographed object. The tufa cone and surrounding terrace is no more than 40 years old but in that time it has acquired a considerable thickness. The terrace is very slippery and the water tastes the same as the Hayes. Since another terrace is more accessible, it is not necessary at this point to get any closer to it than you are.

A much larger and more impressive tufa flow occurs a few hundred yards upstream where the overflow from the Orenda "spring" cascades over the bank and enters the brook below. This action results in a vertical structure approximately thirty feet high and two to five feet thick. This tufa flow is, in a sense, a miniature Yellowstone of the east, with the notable exception that it is almost 93 percent carbonates from cold water rather than siliceous matter (silicates) from hot water. According to Strock, the travertine is built up at the rate of 0.5 gram/liter of water. Literally translated to English units, it works out to be one pound in 240 gallons, or a potential two tons per million gallons.

The terrace is an interesting physical structure but the tufa itself has a few singular features. First of all, it is radioactive. Minute amounts of radon and other radioactive materials dissolved in the water become highly concentrated in the tufa. The tufa also affords an open-air, above ground exhibition of cave type travertine formation. The rapidity with which it forms causes it to be more coarse and granular but the laminations are readily visible. The rapid formation of tufa gives rise to a sort of "instant fossilization" process. Twigs and leaves are quickly coated with the carbonates and become a part of the fossil record. Loose pieces of tufa show excellent imprints and faithfully record the botanical activity near the terrace. With some luck one can occassionally find an insect accumulating a calcareous overcoat.

Some of the shales on either side of the terrace have a few graptolites. These would be Ordovician but identification is difficult because of an absence of detail. The best horizons seem to range from two to five feet above the level of the path.

Further upstream the path terminates at a bridge which crosses Geyser Brook as it emerges from a stone culvert which once carried the water beneath the now abandoned roadbed of the Delaware and Hudson Railroad. This is a very interesting area following a heavy rain; a prime spot to study the Venturi effect on the velocity of liquids.

The pipe discharging water into the stream at the southern end of the bridge is actually the water from the Champion spring (well). The well has sufficient pressure to be a "geyser" and was for a long time, and it may again function as such. The water is noticeably sulphurous in taste and smell, the only water in the Park to have this characteristic. Since this is not typical of Saratoga Mineral Water, we can assume that the casing has been perforated by corrosion and ground water is entering from the shales. Considerable quantities of sulfur water are encountered throughout the Canajoharie and Snake Hill shales much to the consternation of suburban Saratogians. At Saratoga Lake the waters become heavily charged with hydrogen sulfide. Luther's White Sulfur Springs, at one time, was a small spa itself but is unfortunately eclipsed by more famous sulfur springs to the west at Richfield and Sharon Springs. All sulfur water seems to be a product of the Ordovician Shales which outcrop in the Mohawk Valley from Utica eastward.

A second Champion "Spring" flows from the bank about 50 feet beyond the bridge. After crossing the bridge, the path climbs up the west bank and enters a road which passes south along the bank, passing the Orenda "Spring" whose overflow is responsible for the tufa terrace previously inspected. An excellent view of the Island Spouter "Geyser" is obtained along the road just before it descends to stream level at the Hayes Well and the parking lot.

The Karista "Spring" is located a few hundred yards down stream on the west side of the brook from the bridge. Its mineral composition and gas content are much lower than either the Hayes or the Orenda. However, unless the visitor has a special interest in mineral water, it might be well to terminate the tour at the bridge and return to the parking lot.

The Saratoga Mineral Water Mystery

The manner in which this water was produced has excited the interest of many people and the theories seem to be directly proportional to the number of investigators. A few facts seem to have universal acceptance.

First, the water is in limestones and dolomites covered with the impervious layers of Ordovician shales which extend to the north, east and south. The Little Falls dolomite was given the credit for some time until Fisher and Hanson (1951) established the dolomite as Ordovician and renamed it the Gailor dolomite.

The water appeared at Saratoga because of an extensive fault (MacGregor) which forms a scarp north of Saratoga and then bifurcates as it approaches Saratoga. The eastern branch of the fault breached the shale and allowed the water to escape upward along the fault plane. This is graphically displayed at the north end of Saratoga Springs at High Rock Park. Route 9N traverses the top of the scarp and at the base approximately 30 feet of dolomite is exposed. High Rock Park is the site of the High Rock Spring, a true spring, which was known by the Indians long before Jacques Cartier first reported it in 1535. Only the tufa cone of this spring remains but a hundred yards to the north the Old Red continues to flow, having done so since 1774.

The control of the fault is striking. All springs and wells are always on the eastern side and the water issues forth at many places from Wilton, four miles north of Saratoga to Ballston Spa, seven miles to the south. Altogether some 200 springs and wells have produced Saratoga type mineral water, and always on the eastern side of the fault.

The source of the large mineral and gas content of the water has always been the difficult part of the problem.

Kemp (1912) looked to some deep-seated source for CO_2, Cl, Br and Fe. His ideas were deeply influenced by the presence of an old volcanic mass at Northumberland (Stark's Knob) some 15 miles northeast of Saratoga.

Strock (1944) on the basis of geochemical data, felt that the chemical content was in many ways related to sea water. As a result he placed the source in the Salina group, the extensive salt beds of Central-Western New York. Such beds extend eastward into Schoharie county, an area about forty miles to the southwest of Saratoga.

Ruedemann-Cushing (1914) suggested that Saratoga waters originated to the east of the region, aided in their movements up the bedding planes and fractures of the limestones and dolomites by a hydrostatic head established in the Green and Taconic Mountains.

The "volcanic exhalation" would doubtlessly furnish the CO_2 but in all probability furnish other gases as well. It leaves a question as to the mineral matter and overlooks the lack of any thermal activity which in most cases might be associated with deep-seated activity.

The virtual absence of all sulfates in the Saratoga water is difficult to correlate with the average chemical composition of sea water, either ancient or recent. Strock (1944) envisioned the water as coming down the Mohawk Valley and then moving northward. Unfortunately the dolomite outcrops long before it reaches the fault and in all probability would give up the water long before it reached the Saratoga fault. Then, too, it must be remembered that all wells and springs occur on the eastern side of the fault.

The eastern basin theory seems to have fewer "ifs" and more positive evidence. The limestones and dolomites are buried at depth and covered by thick and impervious shales. The upturned edges of these beds, raised in the Taconic disturbance, collects the water. The limestones and shales are reasonably competent and withstood the compression of the Taconic disturbance without difficulty until it grounded out against the crystalline base of the Adirondacks. The north-south lineation of the fault would tend to substantiate this idea. This places the source of the water in the dolomites and limestones. Considerable amounts of sodium, calcium and magnesium salts are available plus the halogens which are noticeably high in the water. The Hoyt limestone beneath the dolomite contains a vast cryptozoon population which suggests shallow seas and possibly intermittent periods of dryness whereupon some elements would crystallize out and into the calcareous material of the sea floor. Any acid bearing ground water introduced into these carbonates would immediately begin an attack on the carbonates which in turn would begin the production of CO_2. This gas, sealed in the acquifer by the shale above and brought up in pressure by a hydrostatic head, would produce a strong carbonic acid system which would increase with further solution until reasonably high pressures were developed. More than ordinary solution would occur, unlike the conventional solution as observed in other limestone areas. The water, driven westward by a hydrostatic pressure, reaches the fault and is carried up the thousand or more feet by the sudden release of the gas pressure.

Colony (1929) in his report to the Saratoga Springs Commission examines all previous ideas and debates them in far more detail. Although the mineral water industry has declined seriously, the controversy as to its source and origin has flourished. Anybody with a new theory??

Selected References

Colony, R. J. 1929 Report to the Saratoga Springs Commission, Restudy of the Geology of the Saratoga Area and the Problem of the Mineral Waters. N.Y.S. Legislative Document #70, 1930.

Fisher, Donald W. and Hanson, George F. 1951 Revisions in the Geology of Saratoga Springs, New York and Vicinity. American Journal of Science, Vol. 249, Nov. 1951, pp. 795-814.

Kemp, James F. 1912 The Mineral Springs of Saratoga. N.Y. State Museum Bull. No. 159, pp. 5-79.

Rudemann, R. and Cushing, H.P. 1914 Geology of Saratoga Springs and Vicinity. New York State Museum Bull. No. 169.

Strock, Lester W. 1944 Geochemical Data on Saratoga Mineral Waters--Applied in Deducing a New Theory of Their Origin. Publications of Saratoga Spa No. 14, 1944.

Analyses of the Hayes Well
Hypothetical combinations of elements in parts per million

Ammonium chloride	38.24
Lithium chloride	24.07
Potassium chloride	465.40
Sodium chloride	5,941.82
Potassium bromide	30.00
Potassium iodide	1.25
Sodium sulphate	trace
Magnesium sulphate	none
Sodium metaborate	trace
Sodium nitrate	trace
Sodium nitrite	trace
Sodium bicarbonate	712.76
Calcium bicarbonate	2,849.13
Barium bicarbonate	30.88
Strontium bicarbonate	trace
Ferrous bicarbonate	10.82
Magnesium bicarbonate	1,626.90
Alumina	.74
Silica	10.80
Total Solids	11,742.81

Stop 3 -- STARK'S KNOB

Stark's Knob is a protuberance of volcanic rock located north of the town of Schuylerville, New York. It was named after General John Stark of the Revolutionary Army that hindered Burgoyne's retreat to the north (Woodward, 1901). It is found 1.2 miles north of Schuylerville just west of New York State Highway #4.

The Knob is a mass of basalt about 200 feet high and is surrounded by Ordovician Normanskill shales. The rock has been quarried for road metal resulting in exposure of the interior of the rock mass. In describing the Knob and locating its features, it will be convenient to refer to the quarried face on the east and the natural face, which is a steep cliff, on the west. Prior to quarrying, the Knob was probably ovoidal or circular. It may be noted that basalt is also found on the south side of the dirt road located south of the Knob.

Standing at the base of the quarried face one can see a mass of dark basalt broken by many fractures and fault planes. A prominent fault or fracture extends upward along the middle of the quarried face. A less obvious fault exists about 50 feet up slope from a small circular well or pool at the base, near the southern corner of the quarried face. One can also see pillow lava or lava ball structure displayed all over the quarried face. The western natural face is almost vertical on its north end and is partially covered by talus on its southern end. The southern portion of the Knob is unquarried and is extensively covered by brush and trees. A foot path extends over the crest of the Knob. At the summit, a plaque offers the history of the area and a presumed explanation of the geology.

Rock Types

The basaltic Knob is surrounded by slaty shales of the Normanskill formation. The shales are blue-gray and weather to buff and locally rusty-red. Cleavage is well displayed, and bedding is obscure.

The shale-basalt contact is exposed on a small hump at the base of the Knob along the dirt road leading to the quarry. The contact is also exposed along the northern end of the Knob at the edge of the quarry where it curves eastward, and in a small patch near the summit along a path leading down the talus slope of the natural face. No apparent macroscopic contact metamorphism of the shales has been observed. Some of the shales at these contacts may be fault slices or inclusions in the basalt.

Where the shales have been faulted, their character changes. This may be seen at the base of the quarry area and on a linear mound or hump which trends east-west at the base of the Knob on its southeasterly side (south of the quarry area). This mound will be discussed in the section on structure. The shales, which apparently have been faulted, do not show such prominent fissility as displayed in shales farther from the Knob. The rock has curved, platy surfaces and weathers rusty-red.

The basalt occurs as pillows, balls or ovoidal structures embedded in a matrix. Both the lava balls and the matrix are liberally penetrated by calcite veins. The pillows range from approximately an inch to four feet along the greatest dimension. They display radial jointing in the outer portions. The lava pillows are surrounded by a dark, foliated, shaly matrix. This matrix concentrically surrounds and winds through the space between the pillows. Some pillows have a dark, glassy coating which in some places appears to be part of the matrix and at others, part of the pillow. Lava balls and limestone inclusions are beautifully displayed on the quarry face. Balls of varied sizes and shapes are randomly grouped. The balls show coarser grained interiors with a fine grained rind on the surface. In rare cases they display characteristic pillow structure including the tail-like feature.

On the southeast unquarried portion of the knob the basalt does not show ball-structure as clearly. This rock is very porous, apparently due to leaching of calcite or some other mineral. There are many large and small holes in which lady bugs may be found hibernating during cold weather. This porous rock crumbles when struck by a hammer. Massive patches of basalt in which faulting is manifested by planes with slickensided calcite also occur on the unquarried portion of the knob. On both the quarried and natural faces the lava pillows contain amygdules. Many pillows, however, show no amygdaloidal structure.

Limestone inclusions may be found readily in the lava balls. The limestone is medium to dark gray and is medium to fine grained. The limestone weathers to buff or tan, surrounded by a darker portion near contact with the basalt. Fracturing along calcite veins may give the appearance of a limestone inclusion. Care must be taken to make sure one is looking at an authentic inclusion.

On the natural face the limestone is especially different from the quarried face. Here the inclusive nature of the limestone is less apparent and the limestone may actually be in the matrix. Locally a limestone matrix with basalt fragments appears as a breccia. The limestone itself is porous and is almost entirely calcite. An extremely small amount of fine, unidentified, insoluble residue was obtained from this limestone.

Structural Geology

The only secondary structures that can readily be seen in the basalt are fractures and faults. On the quarry side there are many ledges, over which one may walk, which exhibit slickensided calcite. Locally, calcite veins offset by fractures can be found. Along the crest over the quarry face there are fractures which are parallel or semi-parallel. Calcite veins occupy some of the fractures. Along this same crest and on the natural face the fractures are closer spaced than on the quarry side. Throughout the knob, calcite and quartz crystals occupy large fractures. Irregular calcite veins pervade the basalt and are not apparently related to fractures.

Faulting is manifested in the slickensides found along the calcite veins. At least some faulting must have taken place after the deposition of the calcite. There is one large fault plane or fracture striking N 50°W and dipping 52° NE on the quarry side. It is covered with talus and vegetation making investigation difficult. Another prominent fault striking N 45°W and dipping 32° NE is exposed above the small well just south of the quarry area. The rock here is crushed, folded and has a peculiar shaly appearance and is probably gouge. There is basalt above the fault and talus below. Intersecting this fault almost perpendicularly is another fault which strikes N 65°W and dips 79° NE. The fault surfaces here have very prominent slickensides.

The linear mound or hump mentioned previously strikes N 55°E and plunges away from the Knob near the bottom of its southeast slope. The hump is about 12 feet across and 70 feet long. The rock exposed here is slaty shale but, as mentioned before, is different from the surrounding Normanskill shales.

Problems of Stark's Knob

This report is, of course, brief, superficial and almost entirely descriptive. It does not propose nor support any genetic theories for Stark's Knob. However, one cannot help but question the origin of this rock, and how it, unlike any other in the State, could have occurred here.

The main question concerning the origin of Stark's Knob is whether it is a volcanic neck, indigenous to this locality, or an allochthonous mass faulted in from some other area.

Cushing and Rudemann (1914) hesitantly support the theory that the knob is autochthonous and was intruded where it stands. Never the less, they acknowledge the apparent lack of contact metamorphism and the absence of any inclusions, especially shale, other than the limestone.

The irregular, fine grained calcite veins contrasted to the coarse, crystalline and slickensided ones may indicate more than one period of calcite precipitation. The pillow-type structure is similar to known subaqueous pillow lavas, hinting at under-sea extrusion of the basalt precipitating calcium carbonate dissolved in the water.

Bibliography

Cushing, H.P., and Ruedemann, R. 1914, N. Y. State Museum Bull. 169, p. 115-135.

Woodward, J. B., 1901, N. Y. State Geol. 21st Rept., p. 17-24.