GUIDEBOOK FOR FIELD TRIPS

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GUIDEBOOK

Twenty-eighth Annual Meeting of the

NEW YORK STATE GEOLOGICAL ASSOCIATION

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Host

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INTRODUCTION

The area encompassing the field trip routes extends from the southern shore of Lake Ontario about 50 miles southward to the town of Portageville, Livingston County, which lies at the head of the upper gorge of the Genesee River, and from the longitude of Batavia in the west to that of Phelps, about 60 miles to the east. Within this region are diverse geological features which have been the subject of the attention of some of New York's famous geologists from the days of the early surveys down to the present. The phases of the local geology which constitute the principal objectives of these field trips are the following:

1. The history of the Genesee River. The story of the Genesee, the largest northward flowing river in eastern North America, involves a long preglacial history including a major period of stream capture, followed by dramatic glacial and postglacial events which resulted in conspicuous changes in river course and the carving of two spectacular gorges in the bedrock.

2. A survey of Silurian-Devonian stratigraphy in central western New York. Excellent exposures through some 3200 feet of sediments are provided where the Genesee cuts across the strike of belt after belt of gently inclined Middle Paleozoic sediments as the river drops 850 feet in elevation.

3. Exposures near Batavia and Phelps, respectively to the east and west of Rochester. These provide, on the one hand, unmatched fossil collecting in strata of the Middle Devonian Hamilton group, and, on the other, an intimate view of disconformable contact relations between the Upper Silurian and late Lower Devonian calcareous rocks.

4. The glacial history of the region. Glacial features which can be seen include recessional moraines, kames, kettles, eskers, drumlins, and ancient lake shorelines.

5. Mineral collecting in the Lockport dolomite. This Middle Silurian formation in certain localities is replete with a variety of minerals characteristic of low temperature deposition in calcareous rocks.

Part I of this guidebook provides a discussion of information pertinent to some of the major topics indicated above. The aim of this section is to present a background picture which will contribute to fuller appreciation of the geologic features to be seen in the field. This is supplemented by remarks in more detail at appropriate points in the itineraries for the individual trips, which constitute Part II.

A chart showing the sequence of formations in the Genesee Valley will be found on page 68.

PART I — GENERAL GEOLOGY

A. GEOMORPHOLOGY

The area in which the field trips are planned has maximum dimensions of about 60 miles east-west and 50 miles north-south. It reaches from the southern shore of Lake Ontario across a portion of the Central Lowlands physiographic province into the highlands of the Glaciated Allegheny Plateau section of the Appalachian Plateaus province. Throughout the area geologic phenomena recorded in observable features represent two widely separated phases of development: (1) the bedrock geology dating to the Middle Paleozoic and (2) the period of Pleistocene glaciation and post-glacial developments. The gap between these two is bridged only by the obscure and not too spectacular tectonic development of the area and by the more easily interpreted stages in the evolution of the surface of the land itself.

The area between Lake Ontario and the Allegheny Plateau is the far eastern attenuation of the great Central Lowlands province, which, as a whole, includes an area of over half a million square miles, comprising a part, or the entire portion, of the land within sixteen states. Within this large area the variation in essential morphologic form is no greater than in the smaller physiographic provinces, lack of major distinctions being partly a result of the nearly flat-lying strata. The most dominating characteristic in the local area is the effect produced by glaciation.

Similarly, if it were not for the glaciation in the northern part of the Allegheny Plateau section, the glaciated and unglaciated portions of that section would probably not be considered distinct, since the extent of dissection and the amount of relief of both areas are comparable.

Throughout the area to be visited, bedrock consists of Middle Paleozoic sedimentary formations virtually undeformed except for imposition of a regional southward dip which averages about 60 feet per mile, with local variations. The land surface slopes gently toward the north, declining from a hilltop level of nearly 1600 feet at the southern limit of the area to 246 feet at the shoreline of Lake Ontario. Outcrop belts are thus east-west in extent across the area and those of the more resistant formations are marked by low, but in places abrupt escarpments. Largest of these are the Onondaga escarpment (generally taken as the dividing line between the Central Lowlands and the Allegheny Plateau), which extends with slight interruptions nearly from Lake Erie to the Hudson River, and the Niagara cuesta (on the Lockport dolomite), which is best developed from somewhat west of Rochester westward to the Niagara River. Between the two lie the thick and weak Salina shales of the Upper Silurian. South of the Onondaga escarpment the land rises at first gradually over the calcareous shales of the Middle Devonian and then more rapidly over the more resistant shales and sandstones of the Upper Devonian. Although none of these outcrops is highly resistant, the difference between firm sandstones and weak shale is reflected in places by a noticeable change in altitude and style of surface. In the vicinity of the boundary between the two provinces, dips of beds are a bit steeper than average and the northward slope of the surface is pronounced. Therefore, the outcrops of the formations near the boundary are narrow in comparison to outcrops of formations of equal thickness farther from the boundary.

Physiographic History

Near the end of the Devonian period the western part of New York was lifted out of the Paleozoic sea. Evidences of the drainage systems which followed, throughout the remainder of the Paleozoic and the entire Mesozoic eras, have been much obscured by subsequent Tertiary erosion; however, the earliest drainage was undoubtedly consequent and paralleled the south slope of the land. It is believed that since Devonian time the streams have removed at least 2000 feet of bedrock above Rochester and vicinity.

Since the most primitive drainage system was first established, across New York from Canada, streams have been affected by at least two periods of great continental uplift and one epoch of continental glaciation. The first great uplift was caused by the Appalachian Revolution in Permian time which, without much crushing or folding in this area, raised and created for the first time a broad and high Allegheny Plateau. The crustal folds of northern Pennsylvania were continued into New York as very weak anticlines and synclines but the elevation of the Plateau in New York was probably sufficient to keep the enlivened or rejuvenated streams in their southward courses.

Succeeding the Appalachian Revolution came the long era of the Mesozoic during which New York appears to have experienced a period of relative rest from extensive epeirogenic movements. During this era western New York was subjected to continuous erosion and ultimately transformed to a low-altitude peneplane, as evidenced by the near-constant elevation of hill tops in southwestern New York. Probably the streams were mostly held in their old courses in the lowering land surface.. The oldest valleys in central and western New York indicate a direction of stream flow to the south and southwest.

The very thick and weak shales of the Ordovician and Silurian, along the belt of the present Mohawk and Ontario valleys, encouraged the production of subsequent valleys by the deepening of east-west streams tributary to the great south-flowing trunk streams. It is possible that these dominating valleys were initiated during Cretaceous time, but their great development dates from Tertiary time.

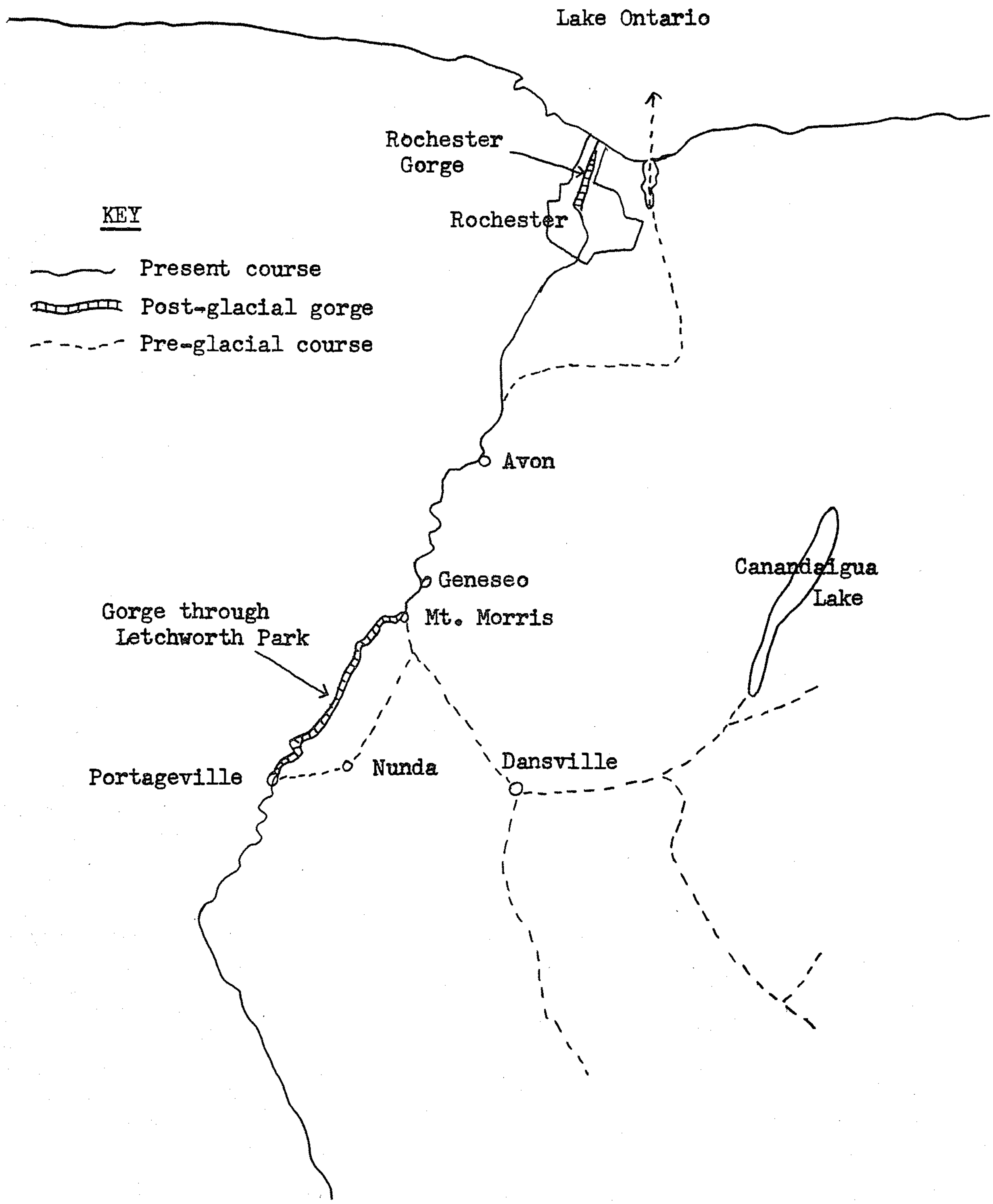
Following the long standstill with erosion and base leveling of Cretaceous time, came the second long epoch of continental uplift in the Tertiary. It is probable that the great rise in the Tertiary was not a single lift but intermittently gradual and oscillatory with possibly long erosional intervals. With the uplift, the streams revived and deeply intrenched their valleys in the elevated Allegheny Plateau, producing high relief and anomalous drainage.

This enlivening of the drainage in early Tertiary time gave expression to the different resistances of the rock strata. Previously the direction of stream flow seems to have been governed primarily by the south slope of the land. At this time, however, the resistance to south-flowing waters effected by east-west outcrops of competent beds, such as the Lockport or Onondaga limestones, gave rise to a gradually expanding subsequent stream pattern. Tributary and subsequent streams flowing east-west, which happened to be fortunately situated on weak rocks, deepened their channels more rapidly than even large south-flowing trunk streams. The Ontario Basin was cut by such a subsequent stream into the soft Upper Ordovician Queenston shale. This stream, the mighty Ontarian River, found an outlet to the sea either by way of the Mississippi River or the St. Lawrence depression. Its tributaries from the south captured great amounts of water from the old south-flowing system, making possible rapid and extensive deepening of some of the old river courses.

In tracing the development of present-day topography, it is necessary to consider the effects of Pleistocene glaciation. The Tertiary drainage system was

Pre-glacial and Present Courses of the

Genesee River



completely disrupted by the sea of ice which, at the time of its greatest extension, had moved in a great mass southward over New York State and into Pennsylvania. There are no continuous moraines near the limit of the ice advance along the New York-Pennsylvania border and scarcely even glacial debris on the uplands, although valleys seem to be well supplied with outwash material.

It was not until the ice front had retreated almost to the southern ends of the present Finger Lakes that a long halt occurred and substantial moraines were built. These are known collectively as the Valley Heads Moraine, and it marks approximately the present divide between the Ontario and the Susquehanna drainage except for the Genesee River. North of this line of moraines the time of ice occupation was much longer than south of it and the ground moraine becomes a more important topographic feature.

The constructional effects of the glacial ice are evident in the variety of morainal deposits which abound through the area. Opinions differ, however, as to the erosive power of the ice sheet. Fairchild, sage of an earlier generation of glacial geologists, felt that the glacier did not have great eroding powers, but that there was a "sort of sandpapering of the land surface" with the greatest work being that of transporting weathered debris. Others, especially more recent workers, have felt that the erosional effects of the glacier are very striking, attributing to this many features of the Finger Lakes region: hanging valleys, steepened lower valley slopes, smooth and straight valley walls, and the absence of projecting spurs.

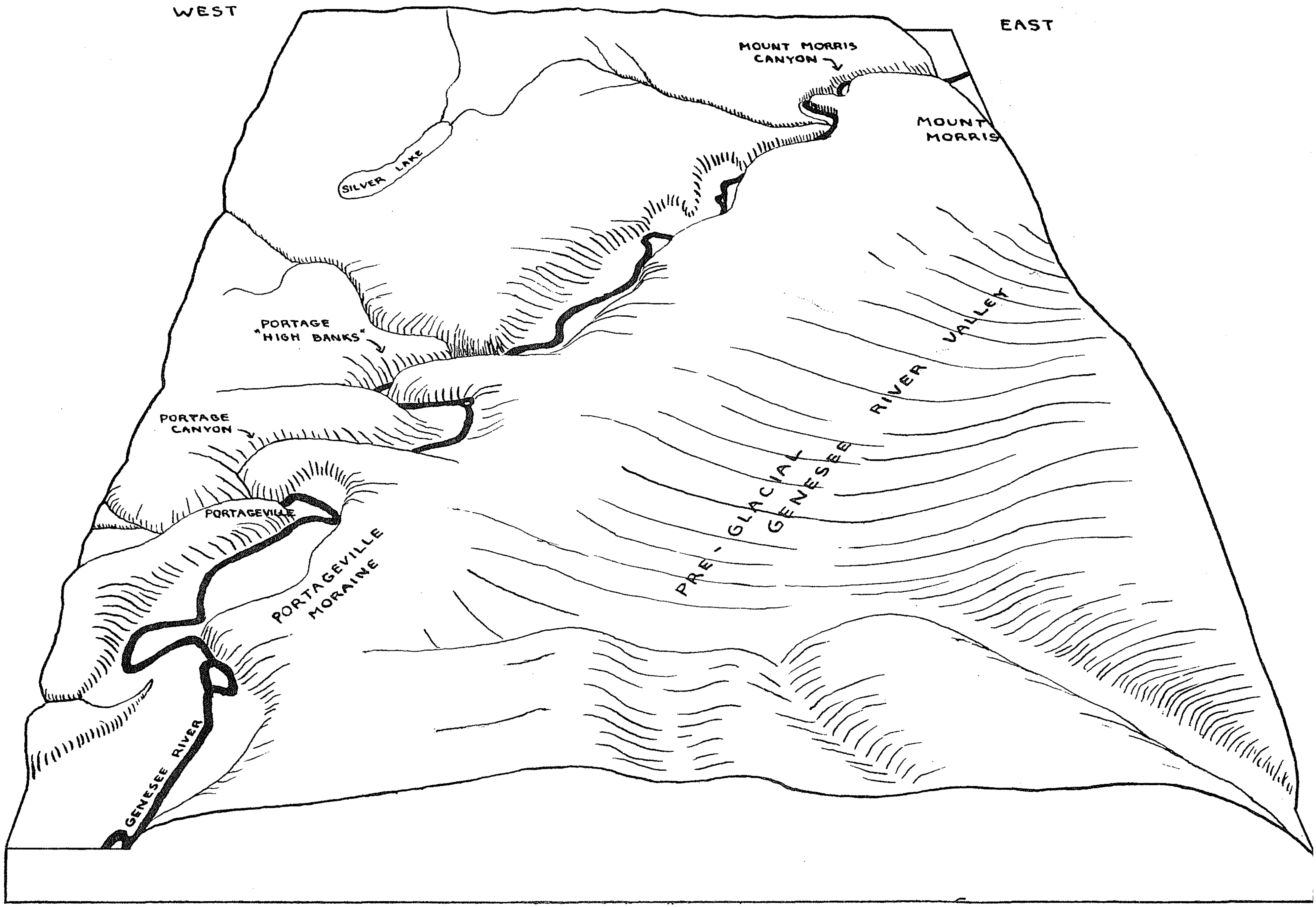
History of the Genesee River

The oldest of the stream valleys tributary to the Genesee were originally a part of the pre-Tertiary southward drainage discussed in the preceding section. The inception of the Genesee as a north-flowing stream in the midst of the early Tertiary south-flowing systems was brought about by the development of the Ontarian River, which was largely responsible for the pre-glacial excavation of the Ontario Basin. The original mouth of the Genesee, at its junction with the Ontarian, was probably somewhere north of what is now Irondequoit Bay. Aided by a steep northward gradient into the Ontarian Valley, the Genesee actively extended itself southward through headward erosion and, in so doing, captured the waters from the older south-flowing system.

The ancient Genesee had two main branches. The western branch followed the course of the present river south of Portageville. The eastern and larger branch, called the Dansville branch, was entirely extinguished by the glacier. It appears to have derived its main source of water from the valley now occupied by Canandaigua Lake, and its flow carved a wide valley through the sites of the present towns of Naples, North Cohocton, Wayland, and Dansville.

Before the ice age, the western branch probably flowed northeast from Portageville through the valley at Nunda and joined the Dansville branch somewhere in the neighborhood of Sonyea. The united branches continued northward as the main trunk to about five miles north of Avon where it turned east along the outcrop of the soft Salina shales for some 13 miles to the vicinity of Fishers. From Fishers the river flowed northward through the deep Irondequoit Valley.

Judging from the present form of the eastern and western branches, the Dansville one must have carried the principal stream and the western one a tributary.



6. THE GENESEE RIVER FROM THE PORTAGEVILLE MORAINE TO MOUNT MORRIS

The advance of the Pleistocene glacier obliterated the drainage pattern. Upon recession of the ice, stream channels had become so disrupted by fillings of glacial debris that important changes resulted in the course of the Genesee as it began again to flow through the area.

One effect was the extinction of the entire Dansville branch from Naples to Sonyea. There may be well over a thousand feet of glacial debris in most of the old river bed east of Dansville and as much as 600 feet north of Dansville to Lake Ontario. Three miles north of Dansville a drill penetrated 450 feet of glacial material without striking bedrock.

Another effect was the blocking of the course of the western branch through the old Nunda valley. This was accomplished by the Portageville moraine, a local development of the Valley Heads Moraine mentioned above. Downstream from Portageville the western branch was forced to cut a new course until it plunged down the western slope of the old pre-glacial valley near the present town of Mt. Morris. This 20-mile post-glacial portion of the Genesee lies mostly within the limits of Letchworth State Park and comprises a gorge that has been aptly termed the "Grand Canyon of the East."

From Mt. Morris, the Genesee flows in its old valley northward to a point beyond Avon where it had previously swung east along the belt of soft Upper Silurian shales. Here another effect of morainal filling is evidenced; the river was blocked from its former course and flowed directly northward to Lake Ontario. The upstream portion of this stretch is a gently meandering passage across a surface with low gradient, composed of ground moraine and a veneer of glacial lake sediments. The portion of the course now running through the city of Rochester is another gorge cut deeply into bedrock.

Upper Gorge — Portageville to Mt. Morris.-- At Portageville there is a striking contrast between the physiographically old valley of the Genesee and the very young valley which cuts the Portage Canyon. From a broad open valley with cultivated slopes the river swings suddenly into a narrow steep-walled chasm. Within 3 miles after entering this Portage Canyon the water drops a total of 317 feet (from 1077 feet to 760 feet above sea level) over three major falls and a series of rapids. The upper and lower falls produce a drop of about 70 feet each, while the middle falls drops 107 feet. Fall maker for the upper falls is the Nunda sandstone; the middle and lower falls are over resistant sandstones in the Gardeau formation. All rocks exposed in the canyon are Upper Devonian in age.

For a mile and a half beyond the Portage Canyon the river flows in an open valley from which it plunges into another deep, steep-sided ravine which is called the Portage High Banks. In dimensions this ravine is superior to the Portage Canyon upstream, being 500 feet in depth. It has no cataracts, although the steep rocky slope of the river bed produces a swift tumbling current. This ravine extends for about three miles. The valley then opens again for about a 5-mile stretch and finally narrows into a third gorge, the Mt. Morris Canyon, through which the river flows 7 miles before returning to its pre-glacial valley. Near its north end, the Mt. Morris Canyon is spanned by a large flood control dam (see Trip 2, stop 2).

Leaving the Mt. Morris Canyon the river flows again into its preglacial valley. From this point the abandoned Dansville branch of the valley extends off to the southeast.

Mt. Morris to Irondequoit Bay.-- The preglacial course of the Genesee from Mt. Morris north to Avon is a broad, flat-bottomed valley with high, but rounded slopes to the sides. The valley was probably deepened by action of glacial ice;

beneath the valley floor today, are thin flood-plain deposits and glacial lake beds, and then a filling of glacier-transported rock debris to an unknown depth (at least several hundred feet). Along the valley floor the river flows sluggishly through elaborate meanders.

The preglacial channel eastward from Avon to Fishers and thence north to Irondequoit Bay is nowhere evidenced on the surface south of Irondequoit Valley itself. The channel was entirely filled in with glacial debris but its course has been established with reasonable certainty from records of water wells. This old filled valley, which continued northward out into Lake Ontario beneath the valley re-excavated by Irondequoit Creek and bearing Irondequoit Bay, carries a strong flow of subsurface water which has been important in supplying both municipal and industrial developments in the area immediately east of the city of Rochester.

Avon to Rochester.-- The portion of the post-glacial course from Avon to Rochester is transitional in aspect between the maturity of the old valley to the south and the obvious youth of the Rochester gorge. The low gradient of the post-glacial surface on which the river flows here is responsible for an apparent physiographic age in excess of that indicated by other criteria.

In Rochester the river descends over three major falls dropping a total of 235 feet to the level of Lake Ontario. The fall makers and drops at the three falls are: upper (Lockport dolomite), 90 feet; middle (Reynales limestone), 42 feet; lower (Thorold sandstone), 97 feet. Exposures in the gorge walls constitute one of the classic sections of sedimentary rocks in the country, extending from the Queenston shales at the base up through the Lower and Middle Silurian to the Lockport dolomite. Unfortunately access to much of the section is difficult, but new exposures from the Queenston up into the Clinton group will be visited (see Trip 1A, Stop 1).

B. STRATIGRAPHIC SUCCESSION

ORDOVICIAN SYSTEM

Upper Ordovician

Queenston Shale

The oldest formation exposed in the Rochester area is the Queenston shale of Upper Ordovician (Cincinnatian) age. The Queenston is about 1000 feet thick and underlies much of the Ontario basin to the north; only the upper 55 feet are exposed in the Genesee Gorge.

Lithology.--The Queenston shale in western New York is made up predominantly of thin-bedded, earthy red shale, breaking up readily into angular fragments and weathering finally to red clay. At some horizons, notably near the top of the formation, heavy red sandstone layers occur, varying from a few inches to a few feet in thickness, often resistant, but weathering into shaly fragments.

The red color is caused by thin coatings of ferric oxide on detrital grains. Where iron oxide is absent, or ferrous, rather than ferric iron prevails, gray, green, or white blotches or layers result. Among the red shale layers are thin bands of green shale, usually one or two inches in thickness, of the same appearance, aside from color, as the red shale in which they occur. These bands are fairly continuous within a single outcrop and may extend for many feet, but cannot be traced over great distances.

The texture of the shale is rather fine and earthy, some of the particles, however, being visible to the naked eye. The sandstone layers are also fine grained, being clearly distinguishable from the typical Grimsby sandstone, which, although almost identical to the Queenston in color, is coarser, frequently quartzitic, and sometimes oolitic in appearance.

Depositional environment and regional relations.-- The Queenston of New York is correlated with the Juniata of the Appalachian area. Both represent deposits laid down on partly subaerial deltas built up by streams eroding highlands to the east, which were elevated toward the end of Ordovician time. To the west this red-bed facies graded into normal marine facies now represented by the fossiliferous Richmond strata exposed in the Cincinnati area in Ohio-Indiana-Kentucky.

Ordovician-Silurian Boundary

The placement of the contact between the Ordovician and Silurian systems has been widely discussed and hotly debated in stratigraphic literature for many years by some of America's foremost geologists. Specifically the problem in eastern North America is to determine whether the beds of Richmond age belong to the Silurian or to the Ordovician. The temper of current times favors placing the Richmond in the Ordovician. In the Niagara gorge section, the red Queenston is overlain by the white Whirlpool sandstone. There the marked lithologic contrast between the two provides a readily recognized horizon at which to locate the systemic boundary. In the Rochester gorge, the red Queenston is overlain by equally red Grimsby sandstone and the boundary has been more arbitrarily determined to lie at the base of the first heavy-bedded siltstone layer. From what can be seen in the field and under the microscope, sedimentation here was fairly continuous across the boundary.

SILURIAN SYSTEM

Lower Silurian

Grimsby Sandstone

Lithology and fossils.--The Grimsby sandstone (55 feet thick in the Rochester gorge) is made up mostly of heavy-bedded red siltstones, but contains in addition heavy-bedded gray siltstones, red graywackes, thin-bedded to fissile, red, argillaceous shaly partings, and thin, fissile, green argillaceous rocks. In terms of total composition, the Grimsby has slightly less clay and more quartz than the Queenston. The Lower Silurian rocks of westernmost New York reflect two major facies: a red continental facies, the Grimsby, to the east, and a marine facies to the west. Only the red siltstone facies is represented at Rochester.

The Grimsby is dominantly red in color, but, especially in the upper 20 feet are found spots and blotches and even thin layers of a peculiar light green color similar to those in the Queenston. In some places the green blotches seem to follow the bedding very closely, but in the majority of cases they are irregular, crossing bedding planes, and passing from one layer to another. As a whole the green blotches seem to be confined to the more sandy layers. Cross-bedding, which is prominent in the red sandstone, is either very indistinct or loses its identity entirely in the green blotches.

Fossils are scarce in the Grimsby. *Arthrophycus alleghaniensis* and *Daedalus archimedes*, variously attributed to worms or seaweeds, are the only common evidence of past life.

Substantial evidence has been offered to show that the Grimsby is of beach origin, at least the part which outcrops at Rochester. Such evidence as ripple marks and mudcracks is plentiful. The cross-bedding shows no apparent orientation and several different types can be observed. Furthermore, the sediments composing the Grimsby are not uniform in size or weight. Small pieces of shale are found even in the conglomeratic layers. The deposit is poorly sorted. Several layers of arkosic conglomerate occur in the section, especially near the top. The sand grains and pebbles which comprise the major part of the unit show a variety of shapes: the constituents in some layers are rounded and spherical, in others, angular and non-spherical, and in still others there is a mingling of the two types.

Correlatives east and west.--In the Niagara gorge, the basal Silurian white Whirlpool sandstone, already mentioned, is separated from the red Grimsby by an eastwardly extending tongue of the marine sequence which is still better developed farther west in Ontario. In southeastern New York and in eastern Pennsylvania the Grimsby is represented by the Shawangunk conglomerate, and by the Tuscarora in central Pennsylvania and through the Appalachians southward to Tennessee.

Middle Silurian

Clinton Group

Thorold Sandstone

Lithology and age.--The Thorold sandstone in the Genesee Gorge is a light gray-green, fine-grained resistant siltstone, with a maximum thickness of 5 feet.

Its resistant character makes it stand out; it is the fall maker for the lower falls of the Genesee. In color it is an easily recognizable unit, being referred to locally as the "grayband". Through western New York the formation retains its dense, compact character which, together with its light gray color, sets it off from the underlying Grimsby, with which it is gradational.

Argillaceous material is abundant in the form of thin shale partings. The sand grains range from angular to semiangular. The quartz of the Thorold is, on the whole, slightly smaller in grain size and less rounded than that in the underlying Grimsby. The cementing material is both siliceous and calcareous, with silica having the dominant role. The Thorold contains many thin shale breaks similar to the shale of the overlying Maplewood, but with a higher percentage of quartz.

A red band or lens a tenth of a foot thick occurs slightly over a foot above the base of the Thorold in the Genesee gorge. This has proved to be a Clinton-type "iron ore", more siliceous than the younger Furnaceville, but essentially a limestone which has experienced considerable replacement by hematite. As there is no characteristic so typical of the Clinton as the "iron ores," this ties the Thorold, at Rochester, to the Clinton group.

It has been suggested that the Thorold represents reworked Grimsby. At any rate, it surely marks the beginning of a readvance of marine conditions from west to east over the greater Queenston delta. It is, therefore, a transgressive unit, and, along with some of the succeeding thin stratigraphic units of the lower Clinton, decreases slightly in age from west to east. Fisher (1954) indicates that it is properly a part of the lower Silurian in the west and of the Middle Silurian in the east.

Fossils.--For the most part the Thorold contains very few fossils. *Arthrophycus alleghaniensis* has been found, and a small form of *Daedalus*.

Maplewood Shale

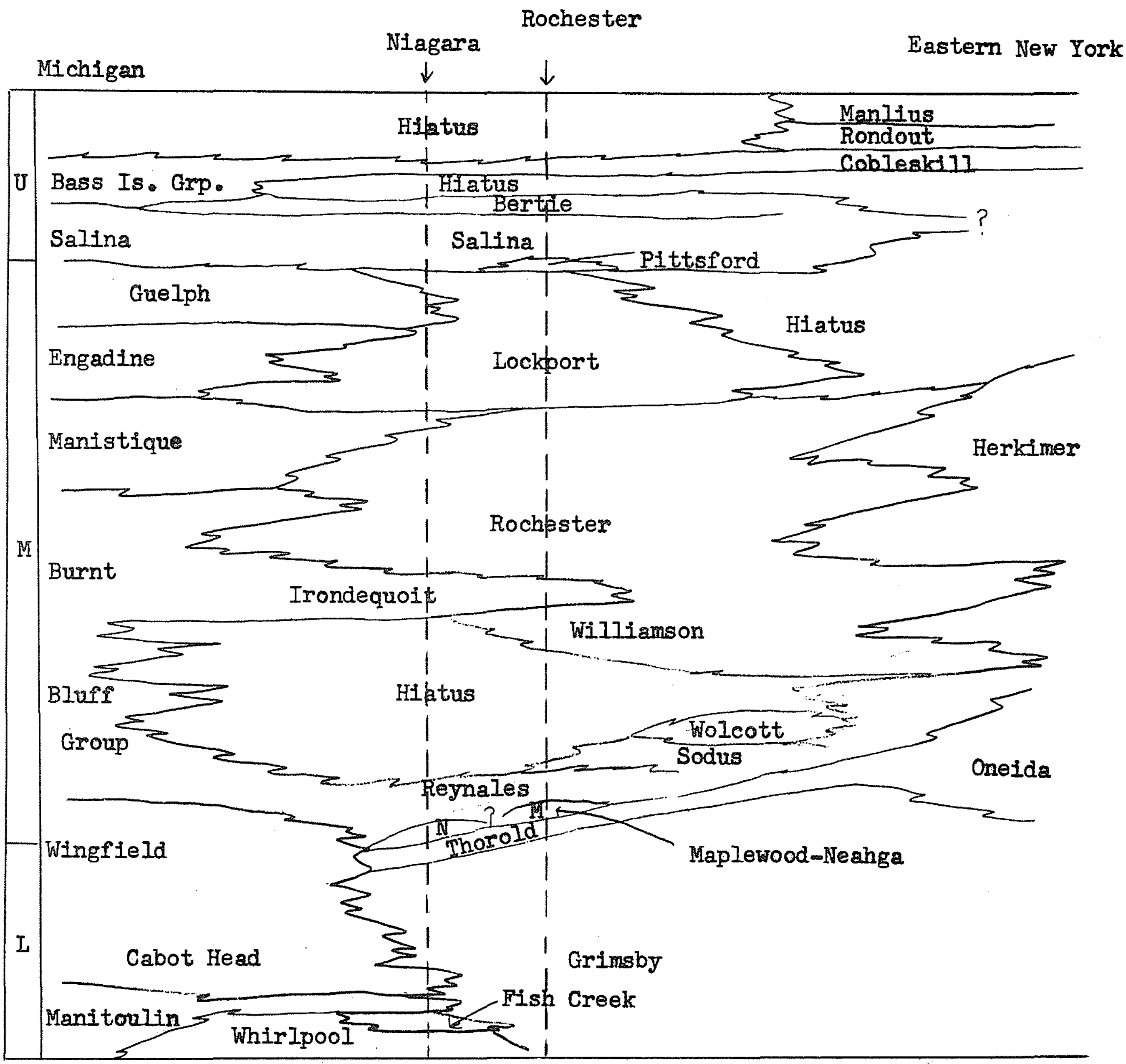
Lithology and origin.--The Maplewood shale (21 feet thick in the Genesee gorge) gradationally overlies the Thorold. It is a smooth, slightly calcareous, green, platy shale, the lower 3 feet being sandy and much more calcareous than the rest. At the lower contact, silt to very fine sand makes up over 50 percent of the matrix. An abundance of phosphatic nodules is characteristic of this lower Maplewood in Monroe County. Several thin limestone beds, all under one inch in thickness, occur in the Maplewood. They are fairly continuous for many feet within a single outcrop, but it is doubtful if they are reliable horizon markers over long distances. Individual bedding planes of the shale generally cannot be traced, due to jointing, fracturing, and the intense hackly weathering. Interesting swirls of uncertain origin, can be seen on some of the bedding planes.

The upper portion of the Maplewood contains interesting flattened calcareous pellets, many of them about the size and thickness of a dime. These may be either clay pellets with a coating of calcite acquired by being rolled around in a lime mud and flattened by compaction, or the result of deposition of the calcite by solution waters moving along joints and fractures which occur in abundance in the formation. There appears to be a concentration of these calcite spots along joint planes.

Generalized Diagram Suggesting Relationships of

Major Silurian Rock Units East and West of

the Rochester Area



The origin of the rather homogeneous, fine green Maplewood is not clear. It has been suggested that it represents a winnowing of the red Grimsby, being the finer material, whereas the Thorold is the coarse material left behind.

Extent and fossils.--From its known maximum thickness of 21 feet in the Genesee gorge, the Maplewood thins to the east and west. It is correlative with the lithologically similar Neahga shale of the Niagara section and may be continuous with it.

Fossils are rare in the Maplewood, with most of the reported forms coming from the lower 3 feet. Fisher (1953) has described a microfauna from the Maplewood.

Reynales Formation

The Reynales limestone (17 feet) in the Genesee gorge consists of three members: the Brewer Dock member (3 feet), the Furnaceville iron ore or hematitic limestone (8 inches to 2 feet), and the upper Reynales limestone (13 feet).

The Brewer Dock is a local member in the Genesee gorge, consisting of 3 feet of gray calcareous beds with shaly partings, lying between the green Maplewood and the red Furnaceville. Heavy mineral studies indicate that the dark argillaceous layers are very like those of the Maplewood, differing principally in color and a greater carbonate content. The Brewer Dock is gray when fresh and buff when weathered. The crystalline, medium gray limestone is like that of the upper Reynales. The characteristic fossil is a minute gastropod of the genus Cyclora; the brachiopod Hyattidina congesta is also found. Small phosphate pebbles also occur in the formation, particularly in the basal limestone bed; some are fossil molds.

The Furnaceville iron ore is one of the many lenslike, hematite-rich layers which characterize the Clinton group. This bed thins to the east and is absent a few miles from the Rochester gorge at Irondequoit Bay. A few miles still farther to the east the Furnaceville is again found, but here it occupies a position at the base of the Reynales. The unit can be traced as far west as western Monroe County.

The Furnaceville is a thin, highly variable, hematitic limestone. The variation in hematite content results largely from the presence of thin shale breaks and layers of non-hematitic limestone. The Furnaceville is dominantly a fossiliferous ore, the hematite having replaced brachiopods, bryozoans, crinoids, ostracods, etc. Both contacts of the Furnaceville are sharp, although there are indications that there was a transition from the hematite-forming conditions to those of the typical Reynales. The origin of the Furnaceville is discussed under Economic Geology.

Above the Furnaceville in the Genesee gorge are over 13 feet containing layers replete with shells of the brachiopod Pentamerus, interbedded with crystalline dolomitic limestone. Some of the crystalline limestones are fossiliferous, but most of them are barren. A few argillaceous unfossiliferous limestone layers are also present. Thin shale partings are found throughout, but are concentrated in the lower two-thirds of the unit. Cherty beds occur in the same portion. The beds of the upper Reynales are thicker, with less shale toward the top of the formation. Unusual cross-bedding occurs in the limestone layers in the upper 7 feet.

Westward the Reynales is continuous into Ontario and probably has correlatives in Michigan. To the east it grades into shale and finally it and the overlying Sodus shale become inseparable.

Fossils.--The Reynales contains a moderately large and variable fauna. To the west, in the Niagara area, it is nearly barren, while in the Rochester area, numerous species have been collected. Most typical is Pentamerus laevis (P. oblongus of authors). Other common forms are Coelospira hemisphaerica, Rhynchotreta robusta, and Stropheodonta corrugata. Eastward, the fauna of the Reynales becomes quite varied, with bryozoans and pelecypods showing up in appreciable numbers.

The upper layers of the formation are made up almost entirely of the large brachiopod Pentamerus laevis (=Pentamerus oblongus of authors). Gillette (1940, p. 51) has pointed out that there are six Pentamerus layers in the Genesee gorge. However, they are not traceable from section to section, even in the gorge, but merely represent recurrence of similar ecological conditions.

Sodus Shale

Lithology.--In the Genesee gorge the Reynales is overlain sharply but conformably by the Sodus shale (11-18 feet thick). The Sodus is principally a green to greenish gray, calcareous, slightly silty, fossiliferous shale with thin limestone layers. Dark gray to "purple" shale layers are interbedded with the green. These dark layers increase downward and the basal 4 to 5 feet is dominated by that color. The "purple" layers are less calcareous. The limestone layers vary from a fraction of an inch to 3 inches in thickness. In the upper 3 feet of the formation there are three prominent layers which contain over 95% calcareous material. These are composed almost entirely of the brachiopod Coelospira hemisphaerica, and are locally referred to as the "pearly layers." These represent current-sorted accumulations of brachiopod shells, practically all of the shells resting with the convex side upward.

Upper contact.--Only the lower Sodus is present in the Genesee gorge and, even this is not present a short distance west of the Monroe County line. In the Genesee gorge the lower Sodus is immediately overlain by the Williamson shale of the upper Clinton. The boundary is marked in some places by a shell rubble which attains a maximum thickness of 3 inches. At other places a more or less sharp break in the stratigraphic sequence is the only evidence for the erosional unconformity. At still other places small pebbles up to a centimeter in diameter are found lying on the upper surface of the lower Sodus. To the east this hiatus between the lower Sodus and Williamson is filled by the upper Sodus and the Wolcott limestone.

Fossils.--The Sodus is a highly fossiliferous formation, although the actual number of individual species is not great, and not a single species collected from the locally exposed part of the Sodus is confined to that formation. It contains a typical brachiopod fauna. The most common forms are the brachiopods Coelospira hemisphaerica, Stropheodonta corrugata, the bryozoan Phaenopora ensiformis, and the pteropod (?) Tentaculites minutus. Pelecypods, abundant in the darker shale beds are represented commonly by Ctenodonta machaeriformis, Pyrenomoeus cuneatus, and others.

Williamson Shale

Lithology.-- The Williamson shale, which overlies the lower Sodus at Rochester, is about 6 feet thick and is a dark green to black, calcareous to slightly calcareous, fissile, graptolite-bearing shale. The upper part, which is predominantly dark green, contains a few thin limestones, particularly evident near the contact with the overlying Irondequoit. Most of the truly black graptolite-bearing layers are in the basal portion. Some, but not all, of them have a central waferlike layer which is highly calcareous. The black argillaceous material which gives its color to the whole thin layer, appears to be firmly pressed into both the upper and lower surfaces of the central calcareous matrix. Ellipsoidal limestone concretions, flattened on the bottom, occur in the basal portion of the formation. These concretions range up to $4\frac{1}{2}$ inches in diameter and have slickensided surfaces on the upper side. Associated with the remains of the graptolites, are small grains and aggregates of pyrite. Some of the layers are almost quartz siltstones. There are some pebbly beds which have been called conglomerate and some beds showing ripple marks. The Williamson apparently represents an unstable phase of sedimentation, with rapid oscillations.

The Williamson, like the lower Sodus, disappears a short distance west of the Genesee gorge; it thickens to the east. Both the Williamson and the overlying Irondequoit, into which it grades, lose their identity to the east and their eastern equivalent is the Willowvale shale.

Fossils.--The Williamson shale is characterized by its graptolite fauna, with *Monograptus clintoni* being by far the most common, although *Retiolites venosus* is also fairly abundant. Brachiopods form another important faunal element, with *Sowerbyella transversalis* most common. Others are *Atrypa* "*reticularis*", *Chonetes cornutus*, *Dicoelosia* /*Bilobites*/ *biloba*, and *Coelospira sulcata*.

Irondequoit Limestone

Lithology.--The Irondequoit in the Rochester area has a uniform thickness of about 18 feet and exhibits a variety of lithologies. In the lower half of the formation are massive argillaceous limestone layers separated by thin dark gray calcareous shales. The argillaceous content reaches a maximum at and immediately above the contact with the Williamson. The upper part of the formation is a light gray, coarsely crystalline, crinoidal limestone; many of the large crystals have a pinkish cast when fresh. Pyrite is a prominent mineral occurring throughout the formation, particularly abundant as disseminated cubes in the coarse crystalline layers. Stylolitic structures are common throughout.

Fossils and reef structures.--The crystalline limestones of the Irondequoit are very often made up almost entirely of crinoid fragments. Other fossils associated with these are not abundant, but some cup corals and brachiopods may be found. Some of the more common brachiopods are *Atrypa* "*reticularis*", *Leptaena* "*rhomboidalis*", *Whitfieldella cylindrica*, and *Eospirifer radiatus*. The thin shale bands in the upper portions of the Irondequoit contain a more varied fauna. In addition to those species listed above, *Schuchertella subplana*, *Sowerbyella transversalis*, *Dictyonella coralifera*, and *Parmorthis elegantula* are common. The basal shaly portions of the Irondequoit contain, in addition to many of the above brachiopods, abundant trilobites, the more common ones being *Liocalymene clintoni*, *Encrinurus ornatus*, and *Phacops trisulcatus*. As a whole, the fauna of the Irondequoit is transitional between that of the underlying Williamson and the overlying Rochester. The fauna of the basal shaly portion resembles that of the Williamson, while that of the thin shaly partings in the upper portion is similar to that in the Rochester.

Of special interest are small biohermal masses in the upper portion of the formation. These arch up the overlying topmost beds of the Irondequoit and the basal beds of the Rochester as well. One reef examined was composed almost entirely of the bryozoans *Fistulipora tuberculosa* and *F. crustula*.

Rochester Shale

Lithology.--The Rochester at its type locality in the Genesee gorge is about 85 feet thick. The formation is considered to be the highest member of the Clinton group. Except for the basal 10 feet, which is brownish gray, it is dark bluish gray in color. In all but these lower 10 feet limestone layers are plentiful. The lower 25 to 30 feet of the formation is a weak shale, which, upon being exposed, quickly disintegrates into a blue to brown clay. The upper 20 to 25 feet is more massively bedded and slightly dolomitic. To the east it thickens and becomes more clastic and is equivalent to the Herkimer sandstone in large part.

Upper contact.--The relationship between the Rochester and the Lockport has been subject to dispute. In some places there is a decidedly sharp lithologic change, while in others there is an interbedded gradation. Some authors, on the basis of faunal correlations with the mid-continent area, have suggested a considerable break between the two; others have postulated continuous deposition. In the Rochester area the Rochester grades into the Lockport without sign of a physical break of any consequence.

Fossils.--The lower few feet and the upper 15 feet are relatively unfossiliferous, but the rest contains an abundance of fossils.

The Rochester shale contains by far the most varied fauna of the Clinton group in this area. Brachiopods form the dominant element. Some of the more common forms are: Parmorthis elegantula, Sowerbyella transversalis, Stropheodonta profunda, Schuchertella tenuis, Atrypa "reticularis", Leptaena "rhomboidalis", Whitfieldella nitida, Camarotoechia neglecta, Rhipidomella hybrida, and Dictyonella coralifera. Bryozoans are also common, with Mesotrypa nummiformsis, Ceramopora imbricata, and Chasmatopora asperatostriata most abundant. The cephalopod Dawsonoceras annulatum, and the trilobites Dalmanites limulurus, Trimerus delphinocephalus, and Arctinurus nereus also occur in appreciable numbers.

Lockport-Guelph Group

Lockport Dolomite

Lithology.--The Lockport is a sugary, gray, massive dolomite, in places sandy. The sugariness in some places is due to the coarse dolomite grains, although to the east it actually becomes quite sandy. The formation commonly contains small cavities lined with dolomite and other crystals.

In outcrop it ranges up to 150 feet thick, while in wells to the south it is reported to be about 300 feet thick. Its lithology is distinctive and the formation is a resistant unit, forming the crests of Niagara Falls and the upper falls of the Rochester gorge. Between these two areas it is responsible for the Niagara cuesta. The Lockport has been traced as far east as Utica.

Guelph facies.--West of Rochester, into Ontario and the Michigan Basin, the upper part of the typical Lockport gives way to a different facies, the Guelph dolomite, which has one of the most striking lithologies in eastern North America. It is a sugary dolomite of a very light tan to almost white color. It is very fossiliferous in places, with an unusual fauna. The Guelph facies is not clearly represented in the Rochester area.

Fossils.--Two faunas are present in the Lockport dolomite in western New York. The lower or "normal" Lockport fauna, although not abundant, is derived from the underlying Rochester shales, and is found best developed in the more argillaceous portions, while the crystalline limestone portions contain numerous crinoid fragments. The upper, or Guelph fauna, is derived from Canada to the west. Some of the faunal elements of the Guelph are present near the top of the formation, although the lithofacies is not of typical Guelph aspect, but rather resembles the rest of the Lockport. Fossil collecting is not generally good in the Lockport.

Upper Silurian

The stratigraphic terminology applied to the Upper Silurian has had a long and complex history which was thoroughly reviewed by Rickard (1953). The scheme followed here differs slightly from the terminology of the Silurian correlation chart (Swartz et al., 1942): the Salina is considered a formation with two major facies (Vernon and Camillus) lying above the Pittsford (a local formation) or the Lockport. The Salina is, in turn, overlain by the Bertie formation which is thus excluded from the Salina [of authors].

Pittsford Shale

Lithology.--The Pittsford (10 to 20 feet thick) is a black shale, which occurs only locally in the Rochester area. At its type locality, near the village of Pittsford southeast of Rochester, it consists of 20 feet of thin layers of black and green mottled shale with some thin layers of dolomite. No good exposures are accessible at present.

Salina Formation

Lithology.--The 600-900 feet of sediments which lie between the Pittsford (or the Lockport where the Pittsford is absent) and the overlying Bertie formation consist of a variety of lithologic types which customarily have been allotted two or three formation names: Vernon shale, Camillus shale, and sometimes Syracuse salt. Two major facies are represented, a red and green argillaceous facies, and a gray to brown more calcareous facies with evaporites. These have a complex interrelationship which is more realistically reflected by using the names Vernon and Camillus for the red and gray facies respectively, than by recognizing these two as distinct formations, the Vernon below the Camillus, even though most of the red beds occur in the lower part of the sequence. Alling feels that the salt of the Upper Silurian is too universally associated with what is here called the Camillus facies to warrant recognition as a separate unit. Salt, gypsum or anhydrite account for up to 300 feet in some subsurface sections; all of these evaporites have been removed by leaching from surface exposures. (See discussion of salt under Economic Geology).

Both the Camillus facies and the overlying Bertie formation thin to the east and disappear along the Mohawk Valley, where they change facies and are represented by the Brayman shale (Fisher and Rickard, 1953).

Fossils.--The fauna of the Vernon facies is even more impoverished than that of the underlying Pittsford. The eurypterids *Pterygotus vernonensis* and *Hughmilleria phelpsae* are characteristic, but not common. The Camillus facies is nearly barren; almost no megafossils, other than rare specimens of *Ctenodonta salinensis* appear to be present.

Bertie Formation

Lithology.--The Bertie formation is 50-60 feet thick in this region and is composed of drab or gray limestone, dolomitic limestone and dolomite. In western New York the formation has been divided into four members which are, in ascending order: O-atka shale, Falkirk dolomite, Scajaquada shale and dolomite, and Williamsville dolomite. The identity of the basal member is poorly established. The Falkirk consists of massive beds of dark dolomite weathering yellow-brown and characterized by a large-scale conchoidal fracture. The Scajaquada consists of medium-bedded dark dolomite with considerable argillaceous content. The Williamsville is a dark brownish-gray dolomite with pronounced conchoidal fracture; the rock is laminated and weathers light gray. The upper two members are exposed at Oaks Corners (Trip 3A).

Fossils.--The Bertie is noted for its eurypterid fauna, of which the more common forms are: Eurypterus lacustris, E. remipes, Eusarcus scorpionis, and Pterygotus buffaloensis. Fragments of these fossils are occasionally found, but specimens anywhere nearly approaching whole individuals are exceedingly rare.

Cobleskill Formation (Akron dolomite facies)

Lithology.--The Cobleskill formation as defined herein (following Rickard, 1953) consists of two facies: an eastern fossiliferous limestone facies and a western dolomitic facies known as the Akron dolomite. The change from the limestone facies to the dolomite facies is not abrupt. At Oaks Corners the Cobleskill is a fine-grained brownish-gray dolomite in massive layers having stylolites, irregular fracture, and occasional geodes. Farther west the dolomite becomes quite mottled, thin bedded, and presents a banded appearance. The Cobleskill is unconformably overlain by the Onondaga limestone and gradationally underlain by the Bertie formation. The thickness of the Cobleskill ranged from 8 to 20 feet.

Fossils.--To the east the limestone facies of the Cobleskill is abundantly fossiliferous. The western dolomite facies has a much more limited fauna which at Oaks Corners is represented solely by silicified stromatoporoids.

Silurian Depositional History

There was no sharp change in conditions at the end of the Ordovician. The Silurian began with a continuation of continental deposition in the east (Taconic disturbance), with a widespread shallow sea over most of the Interior Lowlands. The Lower Silurian is marked by coarse clastics to the east and fine clastics to the west. Like the Queenston (Ord.), the Medina sandstone represents deltaic deposition in parts and marine in other minor parts. In the east the Lower Silurian is represented by the Shawangunk conglomerate and to the south and east by the Tuscarora sandstone. In the Niagara gorge, the lowermost Silurian is represented by the white Whirlpool sandstone, thought by some to represent a dune sand. Farther to the west, in Ontario, the Lower Silurian is represented by a marine sequence, the Cabot Head shale, while still farther to the west it grades to the calcareous Manitoulin and Mayville formations. The shoreline was located in extreme western New York, getting as far as Ontario at times.

The same gradation of facies exists in the Middle Silurian, but the facies all shifted markedly to the east. Continental deposits are found only in eastern New York, with marine shale from eastern New York to western New York, while calcareous facies extended as far east as Rochester, and a little beyond at times.

There were also widespread seas in the Central Stable Region during the Middle Silurian. However, there is a contrast with the Lower Silurian in that there was a lack of the tremendous thickness of clastics to the east. The general shift of facies to the east was probably due to the reduction in the supply of clastics while subsidence continued. The facies shifted back and forth, however, with a few tongues of the calcareous facies extending east beyond Rochester (Irondequoit, Reynales), while the clastic tongue extended from the east to the west (Rochester).

In the Niagara gorge, the entire Middle Silurian is represented by about 100 feet; in the Rochester gorge, it is 165 feet; it is thickest near Syracuse where it is 315 feet. The difference in thickness is due to the appearance of more clastics to the east, and also to the fact that some of the section is missing in the western part.

The Thorold sandstone probably represents a reworking of the upper layer of the red Grimsby. The Thorold becomes progressively younger to the east, due to a transgression of the sea in that direction.

The Maplewood is thought by some to represent a winnowing of the red Medina, being the finer material, while the Thorold represents the coarser material. East of Rochester it disappears, due either to subaerial erosion or exhaustion of clastics.

After deposition of the Maplewood, the depression of the geosyncline continued and marine waters became clear and spread wider, forming the Reynales limestone. The Reynales becomes argillaceous to the east and is lost in the longitude of Syracuse in a shale. Near the base of the Reynales in the Genesee gorge is the Furnaceville iron ore. There are other iron ores in the Silurian, but this is the most extensive.

A break between the lower Sodus and the Irondequoit in the Rochester area represents a time when this area probably was above sea level, although a basin of deposition existed to the east in which middle Clinton deposits accumulated in central and eastern New York.

Upper Clinton time is indicated in the Rochester area by Williamson and Rochester shales, separated by the Irondequoit limestone which feathers in from the west. All three formations are lost in the east in the Herkimer sandstone. The termination of the Clinton brought about a widespread general submergence which produced conditions necessary for Lockport sedimentation.

In the Upper Silurian, there was a gradual change to hypersaline conditions, resulting in thick deposits of evaporites in Michigan and western New York. The lower Upper Silurian is marked by the greatest restriction of the Paleozoic seas. The areas of deposition were restricted to the Michigan and the western New York - north-central Pennsylvania basin. For a large part of the early Upper Silurian, these basins may have been connected. They were slowly depressed and vast thicknesses of fine clastics, dolomites and evaporites accumulated in them.

Silurian-Devonian Hiatus

In the Rochester area the uppermost Silurian and a large portion of the Lower Devonian are represented by a major disconformity between the Cobleskill and the Onondaga formations. At the close of the Silurian, marine waters withdrew from the mid-continent area and were limited to the eastern portion of the Appalachian geosyncline. The uppermost Silurian (Rondout, Manlius) and lowest Devonian (Helderbergian) formations are restricted to eastern New York, forming a wedge of sediments which thins and disappears to the west. The Oriskany sandstone, representing the Deerparkian stage, is the first Lower Devonian formation which extended much beyond the axial portion of the geosyncline. It is not distinctly represented in outcrops in the Rochester area, but in the subsurface to the south it is fairly extensively developed and is one of the significant gas-bearing horizons. The Onondaga was the first really widespread Devonian formation, representing the initial phases of the principal marine inundation of the Devonian.

The erosion interval beneath the Onondaga had considerable duration in the Rochester area. It involved not only pre-Onondaga erosion, which brought about partial removal and reworking of the Oriskany sandstone, but also pre-Oriskany erosion which removed parts of the underlying limestones.

DEVONIAN SYSTEM

Lower or Middle Devonian

Onondaga Limestone

Refer to Oliver, 1954, for thorough discussion.

Extent and thickness.--In New York the Onondaga extends, with remarkable constancy of lithology, from Albany to Buffalo and then continues westward through the greater Great Lakes region. In Pennsylvania, Maryland, and northern Virginia, it is represented by a calcareous shale.

In the Livonia salt shaft, 25 miles south of Rochester, the Onondaga is 140 feet thick, but no complete section outcrops in the Rochester area. Extensive quarries, however, afford excellent exposures of parts of the formation.

Base of the Onondaga.--The unconformity between beds of Onondaga age and older strata has been recognized as continuous over about 700 miles from eastern New York to central Indiana. Westward across New York State the Onondaga rests successively on older formations. In the Albany-Schoharie area, and in southeastern New York in general, the contact with underlying rocks is gradational and there is a facies relationship between the Onondaga limestone and the Schoharie grit. The fine grits of Schoharie age appear to pass very gradually into the impure limestone beds at the base of the Onondaga without any indication of a physical break.

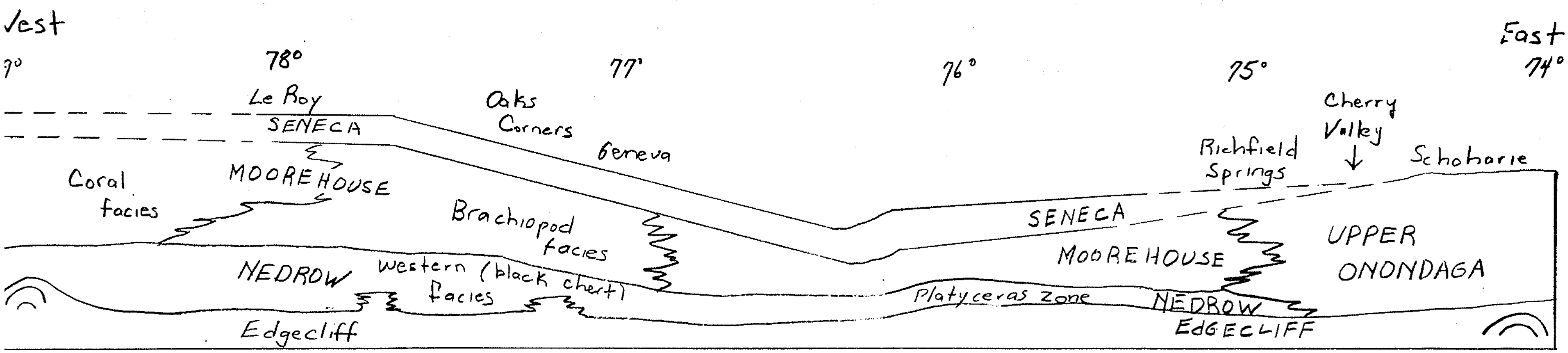
In central and western New York and in portions of eastern New York, there is conclusive evidence that the Onondaga was deposited on an old erosion surface which was emergent until shortly before Onondaga time.

The physical evidence for the disconformity in this region includes both an irregular contact surface between the Onondaga and underlying beds, and a basal sandy zone or conglomerate which is not present at all basal exposures of the Onondaga. Where these basal clastics occur, they are usually less than a foot thick and frequently grade upward into the limestone, gradually merging with it. It was thought at first that this sandy zone represented the Oriskany. It is now thought that this sandy zone, at least in most instances, was formed by the reworking of Oriskany deposits in the early Onondaga sea.

Twenty-five miles south of Rochester, in the Livonia salt shaft, there is, at the base of the Onondaga, 5 feet of coarse green and gray conglomerate containing eight species of brachiopods, suggesting a mingling of the faunas of the Oriskany sandstone and Schoharie grit of the eastern part of the state. At Honeoye Falls, 10 miles north of Livonia and 15 miles south of Rochester, the basal clastic unit is represented by 8 inches of gray calcareous sandstone without fossils.

At Oaks Corners, 41 miles southeast of Rochester, an excellent quarry exposure of the contact shows the coralliferous basal member of the Onondaga resting directly on the irregular surface of the Upper Silurian Cobleskill, with only occasional lenses of sand.

Members of the Onondaga.--Oliver (1954) has divided the Onondaga of central New York into four members. In ascending order, these are the Edgecliff, Nedrow, Moorehouse, and Seneca members. Oliver divides the outcrop belt of the Onondaga



Generalized Cross Section of the Onondaga
from vicinity of Buffalo to vicinity of Albany
(after Oliver, 1954)

into three areas: a western area, between Buffalo and Seneca Lake; a central area, between Seneca Lake and the town of Cherry Valley, about 50 miles west of Albany; and an eastern area, between Cherry Valley and the Albany region. The following discussion follows the scheme of Oliver. Rochester lies north of the western area, with the north end of Seneca Lake about 35 miles to the southeast.

Edgecliff Member: This unit forms the basal member of the formation and is generally massive, light gray, very coarsely crystalline, and characterized by a profusion of tabulate and large rugose corals, and crinoid columnals. It has been referred to as a true biostrome. This character applies especially to the lower half of the member. The name comes from exposures at Edgecliff Park, southwest of Syracuse. At Oaks Corners it is 10 feet thick.

From Seneca Lake westward the unit thickens and light gray chert becomes more abundant. In this western area, the Edgecliff presents some striking biohermal growths. Near Buffalo, there is at least one bioherm which is about 35 feet thick and several hundred feet in diameter. Small mounds or "micro-reefs" are found commonly in this area.

From Seneca Lake eastward to Cherry Valley the member ranges in thickness between 8 and 25 feet. The basal sand is abundant in most places, ranging from a fraction of an inch to 4 feet in thickness. This zone usually contains an Onondaga fauna. Light gray chert here is found widely and irregularly spaced and its presence is more characteristic of the upper half of the member.

Eastward from Cherry Valley the Edgecliff thickens and sections from 20 to 39 feet have been reported. Light gray chert occurs irregularly distributed in the upper half of the member. The lower half exhibits especially strong biostromal characters and commonly grades into the underlying Schoharie grit. Bioherms are developed in the eastern area.

Nedrow Member: West of Cherry Valley this member consists of thin-bedded, medium gray, very fine-grained, shaly limestone. The type locality is a quarry 1 mile south of Nedrow.

West of Seneca Lake the member thickens rapidly to a maximum of about 45 feet. At Oaks Corners the Nedrow is 16 feet thick. In the western area chert forms nearly half the bulk of the member at all localities. In general, fossils are rather rare. No macrofauna is evident in the chert.

East of Seneca Lake and west of Cherry Valley the member ranges in thickness from 10 to 14 feet. The amount of chert decreases rapidly eastward from Seneca Lake so that chert is not common here. Fossils become abundant, with Platyceras, a gastropod, dominating. The lower half of the member is more shaly than the upper half. The shaly nature of the unit can be recognized as far east as Cherry Valley.

East of Cherry Valley the time equivalents of the Nedrow become less distinguishable and bear the same fauna as the Moorehouse member above. Except for the relative abundance of chert, the entire Onondaga formation in the most eastern parts is lithologically similar to the biostrome of the Edgecliff member as it occurs to the west.

Moorehouse Member: The unit is generally medium gray, very fine-grained, and contains some thin shaly partings. Beds are about 2 inches to 5 feet in thickness. The name comes from exposures at the Onondaga County Prison quarry southwest of Moorehouse Flats.

West of Seneca Lake dark gray chert occurs throughout the member, which ranges in thickness from 50 to 65 feet. Corals are abundant to the west. East of Seneca Lake the limestone is somewhat lighter in color and thickness decreases, ranging from 20 to 25 feet. Chert becomes more restricted to the upper half of the member, forming beds 1 to 5 inches thick. Faunal distinctions become more pronounced, with brachiopods dominating. At Oaks Corners 36 feet of the Moorehouse are exposed.

The Moorehouse member is recognizable as far east as Babcock Hill, 12 miles south of Utica. East of this locality it cannot be differentiated from the underlying Nedrow member.

Seneca Member: Ecologically, the Seneca member marks a decline in the generally favorable conditions of the Onondaga sea. The lowest zones are most fossiliferous; each succeeding zone contains fewer fossils. Scattered nodules of dark chert occur throughout the member, and limestones are somewhat darker than those of the underlying member. Conditions improve toward the west, with facies becoming similar to those of the underlying Moorehouse member, although west of Canandaigua Lake little is known about the stratigraphy of the Seneca member.

Between the Seneca and Moorehouse members there is a remarkably uniform bed of clay more or less 6 inches thick. It is ochre colored on the fresh surface and dull gray on the weathered surface. This is the Tioga bentonite. It has been recognized in the subsurface throughout Pennsylvania and adjacent areas of West Virginia, Ohio, and southwestern New York, and is thought to be a good time marker. The bentonite has been found in quarries near Buffalo. Faunal studies have not been made to determine the character of the Seneca in this area.

West of Seneca Lake, the contact between the Seneca and the overlying Marcellus shale, where observed, is abrupt. East of Seneca Lake the contact is usually gradational.

The most easterly known exposure of the Seneca occurs at Cherry Valley. Beyond this locality to the east it has not been recognized.

The upper contact.--In general, the contact between the Onondaga limestone and the Marcellus shale (Hamilton group), especially in the east, is considered gradational. Certain species persist from the Onondaga into the overlying shale and others are thought to be definitely related.

Most authors subscribe to the theory of contemporaneous overlap. This produced a westward regression of Onondaga conditions so that the Seneca member thins to the east and younger beds of the Seneca are restricted to the west. There is a corresponding thinning of the lower Marcellus shale beds toward the west. It has been stated that the upper 50 feet of the Onondaga limestone in the west may be the time equivalent of the Union Spring shale (lower Hamilton) which appears as far west as Cayuga Lake.

The Tioga bentonite has not been located in the eastern area. Oliver suggests that further surface work in eastern New York might show the bentonite in the Lower Marcellus.

Chert in the Onondaga.--The Onondaga of central New York contains notable quantities of chert at many exposures. At its greatest concentration, chert composes up to about one-half of the volume of the Nedrow member west of Seneca Lake.

Throughout central New York there is an eastward stratigraphic rise of dark chert accompanied by thickening of the non-cherty interval to the east. The facies relationship of the Edgecliff (light chert) and Nedrow (dark chert) west of Seneca Lake indicates that the type of chert is intimately connected with the limestone lithology. Dark chert is attributed to an excess of carbonaceous matter. This relationship between limestone and chert lithologies indicates that the causative agent in the chert formation existed during rather than after deposition of the enclosing limestone (Oliver, 1954, p. 649).

Chert occurs in all members exposed at Oaks Corners. It is not abundant in the Edgecliff, where it appears in light gray nodules in the upper half of the member. Chert composes upward to one-half of the Nedrow member here. The Nedrow and Moorehouse members are argillaceous; the Moorehouse presents a brachiopod facies wherein fossils can be found enclosed in chert, and in a condition of at least partial silicification. Chert of the Nedrow and Moorehouse members at Oaks Corners is characteristically dark. The stratigraphy of the Onondaga 20 miles southwest of Rochester at LeRoy (where large quarries in the Onondaga are operated by the General Crushed Stone Company) is similar to that at Oaks Corners except that chert at LeRoy does not occur in the Edgecliff; the Nedrow may contain a little more chert; the Moorehouse is less argillaceous and contains corals.

The megascopic appearance of the chert at LeRoy and Oaks Corners can be described in terms of size, external shape and spatial distribution, color and diaphaniety, and internal structure.

Most nodular masses of chert rarely exceed 3 inches in diameter. Usually they are highly irregular in outline where they are this large. However, a few nodules up to 4 inches in diameter can be noted. Nodules are usually less than 2 inches in diameter, grading down in size to small blebs. Beds of chert range usually between 1/2 and 8 inches in thickness, and between several inches and 2 or 3 feet in length. Most beds of chert are between 2 and 4 inches in thickness, and 6 inches and 1-1/2 feet in length.

External shape of the chert can be classified as follows: nodular (traced as a distorted ellipse with no re-entrants or protuberances), compound nodular (formed by coalescence of nodules), bedded (masses with large dimensions parallel to bedding, in relation to thickness), irregular (masses which present many protuberances), and brecciated (parted due to slumping before consolidation). All of these forms are arranged very commonly in zones of varying thickness parallel to bedding. Nodules may occur isolated in massive limestone beds with no apparent concentration parallel to bedding.

Chert at both LeRoy and Oaks Corners for the most part appears medium dark gray to dark gray. A very small amount of chert is light gray. Brown tints in fresh chert can be noted in chertiferous limestones which are argillaceous. In general, the darkest and lightest chert is opaque. Chert which ranges from medium light gray to medium dark gray is, in general, more or less translucent.

Among internal structures in chert, perhaps the type observed most commonly is the chert conglomerate. These occurrences present well-rounded chert pebbles enclosed in a chert matrix. Fossils are not abundant in the chert. Where fossils are particularly numerous in the limestone, associated chert may envelop some of them. Other structures which occur in the chert are geodes up to 1/2 inches in diameter, which are usually filled or lined with either secondary quartz or calcite; irregular pits usually less than 1/8 inch in diameter, which result from the weathering of limestone inclusions in the chert; fractures which originated, for the most part, at the time the chert was deposited or during lithification of the chert. Many fractures are filled with secondary quartz or calcite.

In reference to chert at Oaks Corners and LeRoy, among evidences in support of the hypothesis of primary origin are: the concentration of most of the chert along planes parallel to limestone bedding; the presence of elliptical chert forms, which are more readily explained by a colloidal precipitation theory; the occurrence of chert conglomerate; the occurrence of cracks in some chert, which are filled with limestone similar to enclosing limestone; the presence of well-preserved fossils only partially silicified in some chert masses; the absence of evidence of growth in chert since the period of deposition; the disposition of limestone laminae above and below some chert masses.

Among evidences in support of the hypothesis of replacement are: the irregular shape of some chert masses; the presence of irregular inclusions of limestone in some chert masses; the association of silicified fossils and chert in some limestones; the preservation of limestone structures in some chert masses; the occurrence of silicified oolites in some limestone.

The chert under discussion here can best be explained as having formed penecontemporaneously with limestone deposition.

Fossils.--The fauna of the Onondaga in western New York is large and varied. The dominant group of animals were the corals which, in parts of the basal Edgecliff member form biostromes some 20 feet in thickness. The Nedrow member overlying the Edgecliff is the least fossiliferous, whereas the Moorehouse above it has a great abundance of corals in the Rochester area. To the east, however, these corals give way to a dominant brachiopod fauna near Canandaigua Lake. Some of the more common fossils found in the Onondaga are the corals Heterophrentis prolifica, Bethanyphyllum robustus, Cystiphylloides americanum, Synaptophyllum simcoense, and Cylindrophyllum elongatum; brachiopods Atrypa "reticularis", Chonetes mucronatus, C. lineatus, Levenia lenticularis, and Leptaena "rhomboidalis". The gastropod Platyostoma lineata is also quite common.

Many of the fossils have been silicified and, therefore, readily weather free from the enclosing carbonate matrix, or can be recovered by etching blocks in hydrochloric acid.

Middle and Upper Devonian

Facies and Faunas

Following the widespread covering of lime-depositing waters which characterized New York through most of Onondaga time, there was a basic change in the pattern of sedimentary conditions. This was primarily the result of disturbance and uplift in the east, which elevated the land area bordering the sedimentary basin, thus providing a fresh supply of clastic materials. The uplift culminated in the Acadian Disturbance which had its most intense effects in late Devonian time, but its beginnings were reflected in the sedimentary record as early as the time of deposition of the uppermost Onondaga in western New York. As noted above, the upper Onondaga is thought to grade eastward into clastics of the lower Hamilton group.

The Middle and Upper Devonian of New York are dominated by a complex series of facies. These interfinger intricately in detail, but in gross aspect they have about the relationships outlined below and indicated on the diagram. From east to west across the area at any one time the succession of facies was:

1. Continental red beds

2. Nearshore marine coarse clastics

3. Non-calcareous shales and fine sandstones

4. Calcareous shales and impure limestones

5. Black shales

6. Pure limestone (only to the west of New York State)

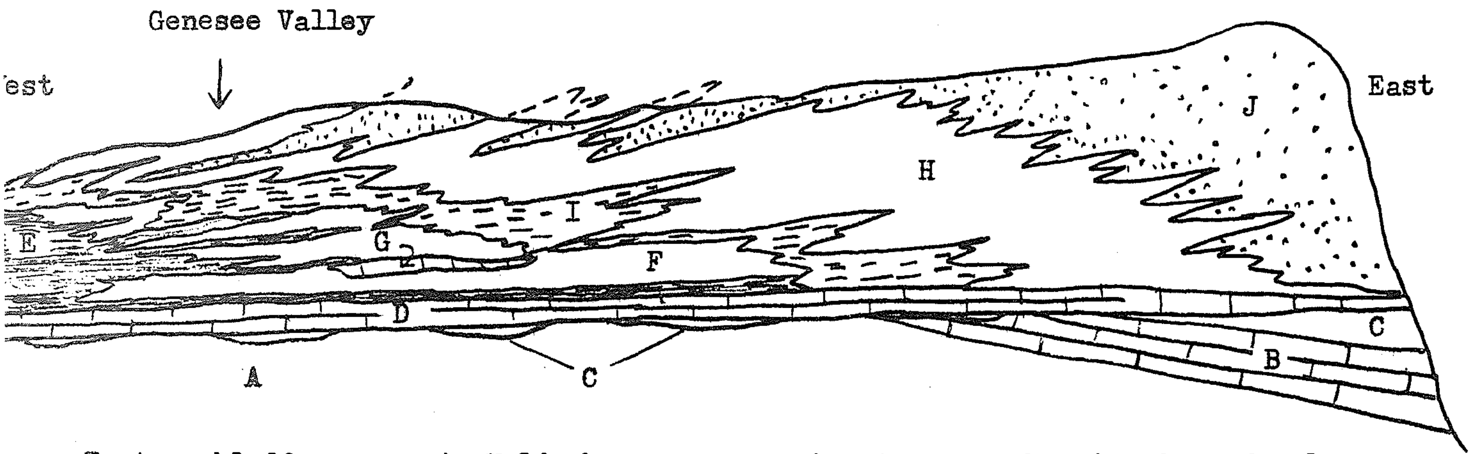
As time progressed, elevation of the land source in the east continued and the sedimentary facies migrated farther and farther westward as more and more clastics built out the great Catskill Delta from the east. Eventually (in the Late Devonian) the continental red bed facies reached to western New York and northwest Pennsylvania. Because of this westward migration of facies with time, a vertical section through the Middle-Upper Devonian sequence tends to show (from the base upward) the same succession of major facies as were disposed with increasing distance from the shoreline. Except for the easternmost red bed facies, marine conditions prevailed and the environment was favorable to abundant animal and plant life in many areas.

Occupying a somewhat anomalous position in the midst of this great mass of sediments is the Tully formation, which includes some conspicuously pure and massive limestone beds. The sedimentary and paleogeographic setting associated with Tully deposition are not wholly understood in detail. The area of Tully outcrop lies entirely to the east of the Genesee Valley.

The highly fossiliferous strata of the Middle and Upper Devonian have long attracted paleontologists. As might be expected, detailed study has shown that the variety of lithologic types in the sequence — reflecting contrasting environments as they do — are accompanied by a variety of faunal assemblages. Also, since the vast Catskill Delta required many millions of years abuilding, even the same lithofacies may contain distinctive faunas in portions which are of considerably different age. The diagram shows in very schematic fashion the approximate relationships of the lithofacies and named faunas, and suggests the derivation of later faunas from earlier ones. The names of faunas have been placed in quotes to distinguish them from rock-unit names.

The "Hamilton" (or "Skaneateles") fauna is the most prolific of the Middle Devonian. It shows some east-west modification depending upon the lime-clastic ratio. It is essentially a brachiopod fauna (also referred to as the Tropidoleptus fauna) with corals and crinoids abundant (westward) where the lime content is appreciable, and pelecypods added (eastward) where lime is lower and more clastics are present. The Upper Devonian "Ithaca" fauna is a recurrent "Hamilton" fauna and the "Chemung" fauna, derived from the "Hamilton", represents a near shore facies in coarse sediments and is rich in glass sponges, pelecypods and brachiopods. The "Naples" fauna includes pelecypods as the most striking element in a large and diversified assemblage with distinctive Upper Devonian forms (e.g. goniatites). The fauna of the Tully limestone is made up essentially of the lime-loving Hamilton species (but without such abundant corals) with the addition of several exotic forms whose close affinities are with European species of about the same age. The Middle Devonian "Marcellus" fauna of the black shale facies is decidedly limited in number

Highly schematized cross section with extreme vertical exaggeration suggesting major pattern of distribution of Devonian rock types across New York State



Eastern bluff represents Helderberg escarpment. Upper surface has been deeply eroded.

A - Underlying Silurian

B - Lower Devonian carbonate rocks of Helderberg area

C - Oriskany sandstone with remnants in west

D - Onondaga limestone

E - Black shale facies

F - Calcareous shale facies

G - Tully limestone

H - Marine sandstone facies

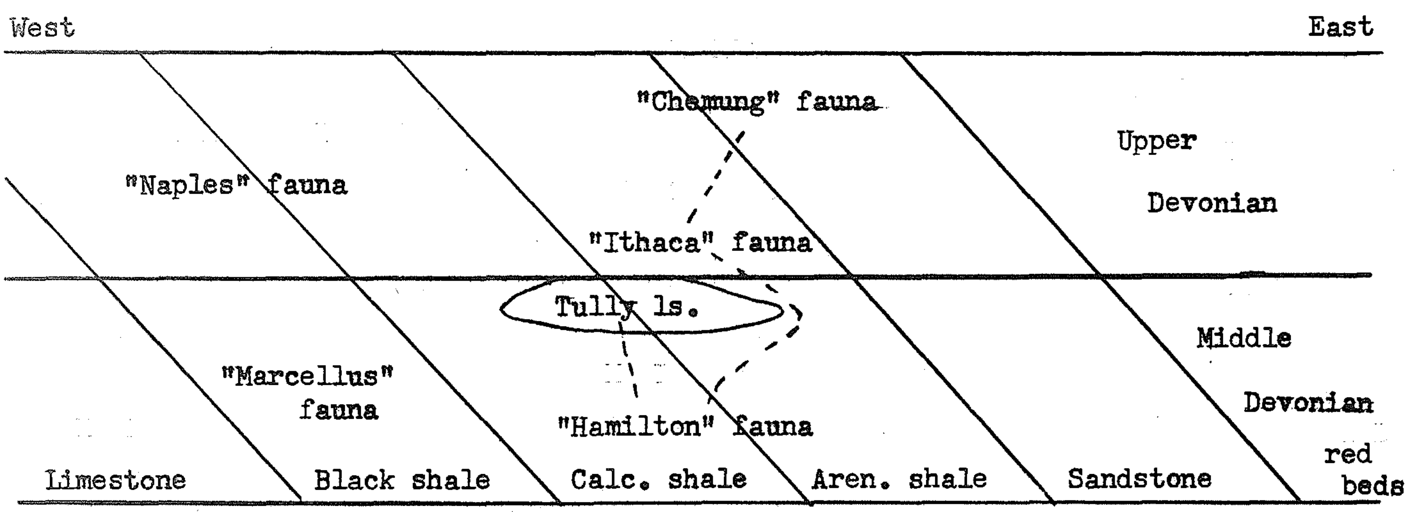
I - Sandstone, siltstone, shale facies

J - Red bed continental facies

Limestone facies <u>of mid-continent area</u> not indicated in west.

* * * * * * *

Schematic representation of distribution of major named faunas and rock types



of species and is typified by the brachiopod <u>Leiorhynchus</u>.

Of course, field relationships are never so simple as can be shown on a diagram. This is especially so in the case of the Middle-Upper Devonian facies because of the vast scale and complexity of their interrelationships. Thus, individual "fingers" of a facies may be of such magnitude as to be accorded formation rank, and the vertical sequence of facies in one exposure or series of exposures may differ greatly from the diagrammed one. However, a concept of the gross arrangement of major facies may assist in understanding the stratigraphic section in the Genesee Valley and its relation to the larger regional picture.

Just as subdivisions of the lithologic facies become meaningful upon detailed study, so do subdivisions of the faunal assemblages have value. Some of the faunal groupings are discussed in the following section on the Hamilton group.

Hamilton Group and Tully Formation

Introduction

The Hamilton group consists of a huge wedge of Middle Devonian sediments, which are dominantly subaerial and nearshore clastics in eastern New York, changing over to mixed clastics and limestones in central and western New York, and finally grading into marine limestones and shales in Michigan. The rocks thin appreciably from 4,500 feet to 5,000 feet in eastern New York to about 285 feet at Lake Erie. In the Genesee Valley area, the Hamilton is 475 to 510 feet thick.

In New York the Hamilton group represents a fascinating example of intertonguing facies with unusual and rapid changes in lithology both along the strike and vertically. Coupled with the complex lithologic pattern is the bewildering number of fossils found in these rocks. Regretably, most of the fossils have an extended stratigraphic range and, therefore, are of little value for detailed correlation. On the other hand, certain particular faunal assemblages have been used for correlation with moderate success. The more arenaceous eastern facies contain an unusually large pelecypod fauna, whereas the argillaceous and calcareous western facies have a dominantly brachiopod fauna with an occasional coral horizon.

The Tully formation does not extend into the Genesee Valley area. Its most western exposure is approximately one mile east of the east shore of Canandaigua Lake. At that locality, the Tully is a dense, dark gray limestone about 2 feet thick. This formation thickens to the east to about 30 feet in the Chenango Valley and the limestones grade into arenaceous shales and calcareous sandstones. The relationship of the Tully formation to the Leicester marcasite (formerly Tully pyrite) is discussed on page 35.

The term Hamilton was proposed by Vanuxem (1840) for a series of shales near Hamilton, New York, that lie between the Skaneateles below and the Moscow above. This sequence is now recognized as the Ludlowville formation. Later Vanuxem used the term Hamilton to include all the rocks from the top of the Marcellus formation to the base of the Tully limestone. J. M. Clarke realized the need for dividing the Hamilton, and revived the terms Skaneateles, Ludlowville, and Moscow. This usage was followed until 1930 when G.A. Cooper included the Marcellus in the Hamilton. Currently, the group consists of four formations; in ascending order they are: Marcellus, Skaneateles, Ludlowville, and Moscow.

The base of the Hamilton rests on the Onondaga limestone. The nature and significance of this contact was discussed in the preceding section on the Onondaga. From Canandaigua Lake eastward to the Schoharie Valley the Hamilton is disconformably overlain by the Tully formation, whereas, westward from Canandaigua Lake to Lake Erie it is disconformably overlain by the Geneseo formation. Evidence of this break is the successive westward disappearance of the three top faunal zones in the Hamilton and the sharp lithologic break between the Moscow and Tully formations. In addition, the magnitude of the break increases to the west as noted by the absence of all of the Moscow and part of the Ludlowville formations in Ohio and Ontario.

Previous Work

The early reports of the New York Survey (1837-1843) were confined largely to descriptions of the prolific Hamilton faunas with brief discussions or comments on the stratigraphy. Later workers (1848-1906) continued the paleontologic studies and together with others, made embryonic attempts to correlate the various formations of the Hamilton across the state and in adjacent areas (1890-1917). Field mapping of several quadrangles which cross the Hamilton outcrop belt was undertaken by Clarke and Luther (1901-1914) either singly or together; they also described the sequence from the Livonia salt shaft (1894). Unfortunately, their quadrangle reports are too brief to be used for detailed correlation. From 1915 to 1930, little was added to our understanding of the stratigraphy of the Hamilton until the appearance of the classic paper by G. A. Cooper (1930). In this paper, Cooper redefined the formations in the Hamilton, subdivided them into members, and correlated the units across the state. Subsequent work in western New York includes accurate quadrangle mapping, detailed paleontologic studies, and paleontologic-stratigraphic investigations (1939-1956).

Descriptions of Formations and Members

All of the formations of the Hamilton group outcrop in the Genesee Valley area. The Marcellus formation consists of the Oatka Creek member, which rests directly on the Onondaga limestone, and the Stafford limestone member. Overlying the Marcellus is the Skaneateles formation composed of only one member, the Levanna black shale member. The Ludlowville formation follows the Skaneateles and is divided into the following members: Centerfield limestone, Ledyard-Wanakah shale, Tichenor limestone and shale and Deep Run shale. The youngest Hamilton formation is the Moscow which is made up of the Menteth limestone member, Kashong- and Windom shale members and the Leicester marcasite member.

The Hamilton beds consist of black shales, dark grey to blue-grey, calcareous and argillaceous shales and interbedded thin limestone layers and lenses. The older formations are characterized by black and dark grey shales with few limestone layers which grade imperceptibly into light grey and blue grey shales with numerous limestone layers in the upper formations. The upper part of the Moscow formation consists of dark grey to black shales and unique marcasite lenses. It is fortunate that the otherwise monotonous expanse of nearly homogeneous shales are interrupted by a few remarkably persistent limestone beds which serve as valuable key horizons across central and western New York.

Marcellus Formation

In the Genesee Valley, the Marcellus formation is represented by approximately 10 feet of black, bituminous, fossiliferous shale followed by 20 feet of dark grey fissile shale with concretionary layers and abundant pyrite. These 30 feet are represented by the Oatka Creek member. Fossils are most abundant in the upper few feet.

From its type section at LeRoy, New York, the Oatka Creek member thickens to about 50 feet at Lake Erie and to 60 feet at Cayuga Lake. The member loses its identity between Marcellus, New York, and the Onondaga Valley where it intertongues with and grades into the Cardiff shales and siltstones and the Chittenango black shale. Still farther east in the Chenango and Unadilla Valleys the Cardiff unit is divided into the Bridgewater, Solsville and Peckport members. Underlying the Chittenango shale are the Union Springs and Cherry Valley members; both pinch out before reaching the Genesee Valley.

The top member of the Marcellus is the Stafford limestone, a massive, dark grey limestone about 2 feet thick with shaly partings in the middle. Traced westward, the member thickens to 15 feet at Lake Erie, but eastward it thins to approximately 6 inches in the Canandaigua quadrangle. The Stafford is believed to correlate with the Mottville sandstone and limestone member to the east, but insufficient exposures prevent continuous lateral tracing of one unit into the other. Cooper (1930) formerly placed the Mottville and Stafford members at the base of the Skaneateles formation, but in 1942 Cooper, et al. transferred them to the Marcellus formation because of the presence of *Paraspirifer* in the Mottville and its abundance below the Mottville in eastern New York. In general, the Stafford limestone contains fewer species of fossils than younger Hamilton limestones.

Skaneateles Formation

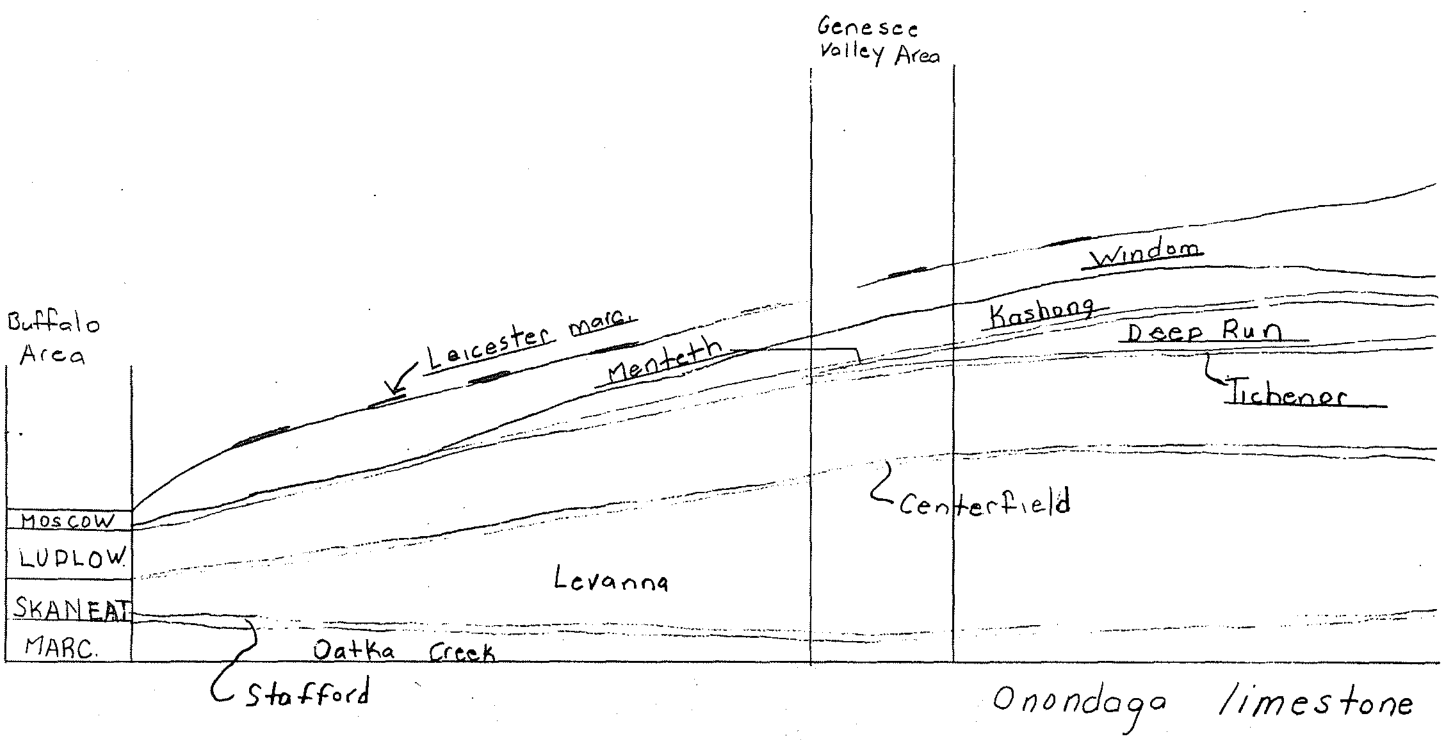
This formation consists of 190 to 214 feet of undifferentiated black and grey shales, intercalated in the upper part by a few limestone and concretionary layers. The basal part consists of black shale, very similar to the Oatka Creek shale below. The black shale sequence is terminated by a grey limestone 1.5 feet thick. The succeeding 140 to 170 feet are composed of dark grey to medium grey shale overlain by 15 to 25 feet of dark grey to black interbedded shales with a few dense limestone bands and concretions at the top. East of Cayuga lake the Skaneateles formation is divided into three members, but west of Cayuga the entire formation is represented by the Levanna member. The formation thins to the west to about 43 feet at Lake Erie. Eastward it thickens to 225 feet at Canandaigua Lake and is over 400 feet thick in the Chenango and Unadilla Valleys. The members recognized east of Cayuga Lake are the Delphi Station, Pompey and Butternut; in the Chenango Valley, the Chenango member wedges in between the top of the Butternut member and the base of the Ludlowville formation.

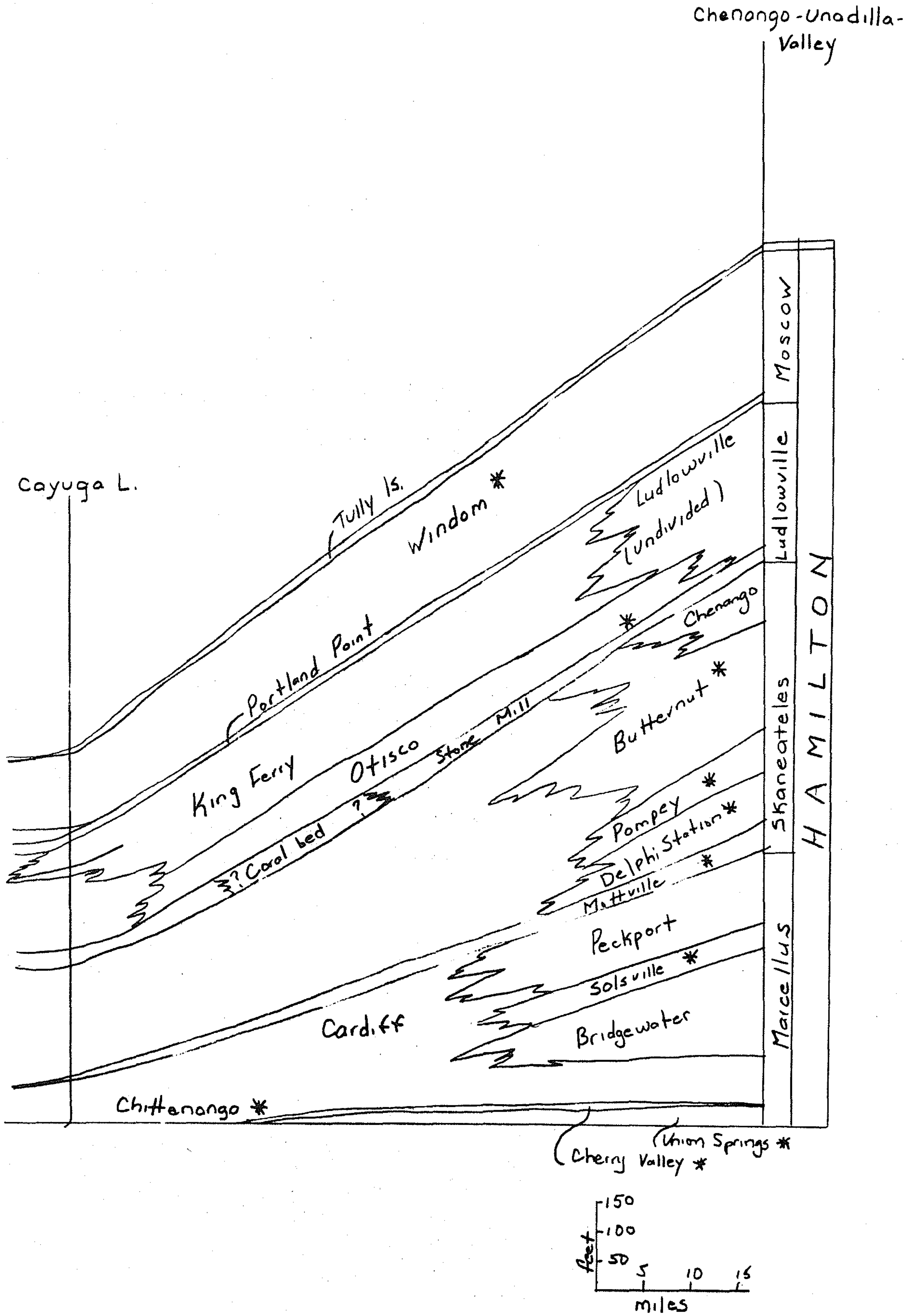
Ludlowville Formation

In the Genesee Valley the Ludlowville formation is 115 to 130 feet thick. The base is marked by several very fossiliferous limestone beds. Above the limestones, the shale is very dark, but gives way to lighter shales and a few thin limestone beds in the upper part. Four members are recognized in this area. They are, from the oldest, the Centerfield, Ledyard-Wanakah, Tichenor and Deep Run.

Centerfield limestone member.--This unit consists of from 8 to 11 feet of five to seven dense, crystalline, extremely fossiliferous limestone beds separated by several inches of blue grey shale. The Centerfield is famous for its huge and varied fossil assemblage; of particular importance are its vast coral colonies. This member thins westward to 4.5 feet at Blossom, New York, and is believed to correlate with the Pteropod zone of Grabau along Lake Erie. At Skaneateles Lake, it is 50 feet thick. The Centerfield becomes homogeneously arenaceous and crossbedded east of the Finger Lakes and loses its identity in the Chenango Valley. The Centerfield is tentatively correlated with the Stone Mill limestone to the east.

<u>Underscored</u> <u>Name</u>	=	Scheduled to be seen on trips of this field conference
Starred Name*	=	Scheduled stop or seen on field trip from Colgate, 1955
Note	=	Thicknesses of units less than 20 feet slightly exaggerated to permit representation on diagram.





Chenango-Unadilla-Valley
Cayuga L.
Tully ls.
Windom *
Ludlowville (undivided)
Portland Point
King Ferry
Otisco
Stone Mill
?Coral bed
*
Chenango
Butternut *
Pompey *
Delphi Station *
Mottville *
Peckport
Solsville *
Cardiff
Bridgewater
Chittenango *
Cherry Valley *
Union Springs *
Moscow
Ludlowville
Skaneateles
Marcellus
HAMILTON
150
100
50
feet
5
10
15
miles

Ledyard-Wanakah shale member.--Cooper (1930) divided this interval into two members separated near the middle by the "Strophalosia" (= Productella) bed. Sutton (1951) working in the Batavia quadrangle found that the "Strophalosia" bed does not maintain a constant stratigraphic position with respect to the overlying Tichenor limestone, lying there only 15 feet below the Tichenor. Aside from the "Strophalosia" bed there is little on which to separate the Ledyard and Wanakah.

The member is 105 to 112 feet thick in this region. The lower 90 feet is composed of dark grey shales interfingered with grey to black fissile shales, thin, fine-grained limestones and concretions. This sequence is overlain in the Batavia quadrangle by a light grey argillaceous limestone 0.5 to 1.0 foot thick, which contains abundant Productella truncata (formerly Strophalosia truncata). Above the "Strophalosia" bed, the shales are light to medium grey and intercalated with numerous thin limestone layers and lenses. Fossils are only moderately common in the shales below the "Strophalosia" bed and are confined to a relatively few species. In contrast, the shales above that bed are generously fossiliferous and contain a greater variety of species. This is the first occurrence of what Cooper terms "the typical Hamilton fauna".

Tichenor limestone member.--The Tichenor is made up of 8 to 11 feet of alternating semi-crystalline blue grey limestones and calcareous medium grey shales. Both are highly fossiliferous and corals are particularly abundant.

Deep Run shale member.--The Deep Run member is represented by about 9 feet of brittle blue to blue-grey shale. These rocks carry a fauna quite distinct from the underlying Tichenor member by having pelecypods and brachiopods in abundance but by almost lacking corals and Bryozoa.

Post-Centerfield correlations.--All of the Ludlowville members recognized in the Genesee Valley thin to the west. At Lake Erie, the Ledyard-Wanakah is 75 feet thick and the Tichenor less than 2 feet. The Deep Run is not known west of the Batavia quadrangle. To the east, the members thicken; the Ledyard-Wanakah is 130 feet at Cayuga Lake, the Tichenor is 11 feet at Canandaigua Lake but thins to 1 foot at Seneca Lake. The Deep Run is 55 feet at Canandaigua Lake but thins to 49 feet at Seneca Lake. The lower part of the Ledyard-Wanakah sequence grades into the Otisco member, and the upper part of the Ledyard-Wanakah, the Tichenor and Deep Run members grade into the King Ferry arenaceous shale in the Cayuga Lake region. In the Chenango and Unadilla Valleys, the Ludlowville is undifferentiated.

Moscow Formation

The Moscow formation in the Genesee Valley consists of 95 to 105 feet of blue-grey to dark grey shales intercalated with numerous limestone bands and concretionary layers. Four members are recognized within the formation. These are, in ascending order, the Menteth limestone, Kashong and Windom shales, and the Leicester marcasite.

Menteth limestone member.--This member is a 0.5 to 1.0 foot dense, coarsely crystalline, crinoidal limestone. It is abundantly fossiliferous. At some exposures the member is corniferous, and some of the fossils are silicified. In addition, the fossils and matrix frequently have a pinkish sheen. This member thins to the west and terminates in the western part of the Batavia quadrangle. To the east, it is correlated with the basal beds of the Portland Point member.

Kashong shale member.--The Kashong member is composed of 45 to 55 feet of blue and blue-grey shale, very similar to the Deep Run shale, with concretions and limestone layers in the upper part. The lower 10 feet consists of blue-grey shale with numerous crinoid fragments and Bryozoa. In this interval the fossils decrease in abundance toward the top. The succeeding 26 to 36 feet of shale is blue or blue-grey and contains a varied fauna, but specimens are not abundant with the exception of Tropidoleptus carinatus and Phacops rana. The remaining 9 to 10 feet is distinguished by three limestone-concretionary beds, each separated by approximately 4 feet of blue shale which commonly contains small pyrite nodules and oddly shaped concretions.

The top of the upper limestone layer is regarded as the Kashong-Windom boundary in this area, rather than the Ambocoelia-Chonetes zone as proposed by Cooper (1930). The reason for this is explained in the discussion of the Windom shale. The Kashong member is a large lenticular mass that thins east and west of the Genesee Valley, and extends from slightly east of Cayuga Lake to the eastern part of the Depew quadrangle.

Windom shale member.--The Windom member is made up of 45 to 48 feet of shale and thin interbedded limestones. The lower 12 feet of shale is fine grained and medium grey. The rocks in the upper 5 feet of this interval contain enormous numbers of the small brachiopod Ambocoelia umbonata. The following 8 to 12 feet of shale is darker, and carries a more varied fauna. Above this is a short interval of dark grey shale that contains Leiorhynchus laura and Ambocoelia praeumbona. The succeeding 20 feet consists of interbedded thin coquinoid limestones and very fossiliferous medium grey shales. Numerous concretions are imbedded in the shales. The upper 4 to 5 feet of shale is dark grey to black and carries few fossils except Leiorhynchus laura and Lingula sp.

Cooper (1930) considered the Ambocoelia umbonata-Chonetes mucronatus zone as the base of the Windom. Recent studies indicate that west of Canandaigua Lake there is not one, but several layers in the Windom that contain abundant Ambocoelia umbonata and Chonetes mucronatus. In addition, these very fossiliferous layers do not maintain a constant stratigraphic position with respect to the top of the formation. Sutton (1951) suggested that the first limestone below the lowest occurrence of Ambocoelia-Chonetes be used as the division between the members in this area. This limestone is recognized in the Batavia and Attica quadrangles, and is tentatively correlated with the limestone layer below the Ambocoelia-Chonetes zone at the type section of the Moscow.

The Windom member is 15 feet thick along Eighteen Mile Creek, 135 feet at Cayuga Lake and 265 feet in the Unadilla Valley.

Leicester marcasite member.--From Canandaigua Lake to the western edge of the Depew quadrangle the Windom is usually separated from the Geneseo black shale by thin lenticular masses which consist chiefly of marcasite and pyrite with minor amounts of calcium carbonate. They average 5 inches at their thickest part, and from 20 to 30 feet in length. These unusual rocks contain a dwarfed fauna which is difficult to free from the dense, hard matrix.

In earlier reports this unique horizon was referred to as the "Tully" pyrite because of its stratigraphic position. As the name implied, it was regarded as the western equivalent of the Tully limestone. Cooper and Williams (1935), however, correlated the "Tully" pyrite with the Spirifer tullius-Vitulina (now Pustulina) zone, i.e., the highest faunal zone in the Hamilton in central New York. To remove any suggestion of correlation with the Tully, Sutton (1951) proposed the name Leicester marcasite member for the lenses, and considered it the youngest member of the Moscow formation. More recent work in the Canandaigua Lake area

Grp.	Fm.	Member and Thickness	Lithology	Fauna
HAMILTON	MOSCOW	Leicester 0 - 6"	2.	B
		Windom 45' - 48'	3.	C
			3. & 5.	C & E
		c. <u>Leiorhynchus</u>-<u>Ambocoelia praeumbona</u>	2.	B
		b. <u>Ambocoelia-Chonetes zone</u>	3.	C
		Kashong 45' - 55'	4.	D
			4.	
		Gap	4.	D
		Menteth 0.5' - 1.0'	5.	E
	LUDLOWVILLE	Deep Run 3' - 11'	4.	D
		Tichenor 8' - 11'	5.	C & E
		Ledyard-Wanakah 115' - 130'	3.	C
		a. "<u>Strophalosia</u>" bed		B
			2.	
		Gap		B
			2.	
			3.	B
		Centerfield 8' - 11'	5.	E
	SKANEATELES	Levanna 190' - 214'	2.	B
			2.	B
			1.	A
		Gap		
	MARCELLUS	Stafford 2'	1.	A
		Oatka Creek 30'	2.	B
			1.	A
			1.	

suggests that the marcasite lenses may be post-Hamilton - pre-Tully in age, and there is a possibility that they may even be post-Tully in age. However, a detailed study of the marcasite over a larger area is required before a more definite age determination can be made.

Lithologic-Paleontologic Relationships

Within the rocks of Hamilton age in the Genesee Valley five more or less distinct lithologies are recognized. These are: (1) fine grained black shales, fissile, and with abundant pyrite, (2) interbedded black and dark grey shales, (3) medium grey shales and thin limestone layers, (4) blue to blue-gray shales and limestones with concretions, (5) grey, dense, coarse to medium grained conquinoid limestone beds and lenses with interbedded shales. With each lithology there is also a corresponding faunal association. The faunal assemblages are (A) *Leiorhynchus* fauna, (B) modified *Leiorhynchus* fauna, (C) Hamilton fauna, (D) *Tropidoleptus*-pelecypod fauna, (E) Encrinal-coral fauna.

A. *Leiorhynchus fauna*.--This association is characterized by *Leiorhynchus limitare*, *L. laura*, *Orbiculoidea minuta*, *Chonetes lepidus*, *Styliolina fissurella* and *Nuculites triqueter*.

B. *Modified Leiorhynchus fauna*.--This assemblage contains most of the species listed above and, in addition, a few of the species more common in the Hamilton fauna. Modification may be by substitution, e.g., *Orbiculoidea minuta* may be replaced by *O. lodiensis*; *Ambocoelia praeumbona* may be added to the assemblage.

C. *Hamilton fauna*.--The Hamilton fauna is recognized by its large number of species and genera, of which the dominant group is the Brachiopoda. Other groups are usually well represented, but most have their greatest development in another association. Typical species from the Hamilton fauna are:

Ambocoelia unbonata
Athyris spiriferoides
Atrypa "reticularis"
Chonetes coronatus
Chonetes mucronatus
Douvillina inaequistriata
Mucrospirifer mucronatus
Nucleospira concinna
Rhipidomella vanuxemi
Spinocyrtia granulosa
Craniops hamiltoniae

Cypricardella bellistriata

Amplexiphyllum hamiltoniae
Stereolasma rectum
Heliophyllum halli
Pleurodictyum americanum

Sulcoretepora incisurata

Phacops rana
Greenops boothi

Platyceras lineata
Loxonema hamiltoniae

D. *Tropidoleptus-pelecypod fauna*.--This assemblage is readily recognized by the occurrence of the brachiopod *Tropidoleptus carinatus* in large numbers and the presence of pelecypods with *Tropidoleptus*. Typical forms from the Hamilton fauna are usually present, but in small numbers. The most abundant species are:

Tropidoleptus carinatus	Orthonota undulata
Mucrospirifer mucronatus	Cypricardella bellistriata
Chonetes mucronatus	Paracyclas lirata
Camarotoechia sappho	Grammysia bisulcata
Actinopteria decussata	Platyceras lineata
Aviculopecten princeps	

E. Encrinal-coral fauna.--Abundant in this association are the various parts of crinoids and several species of tabulate and rugose corals. Brachiopods are also common, but are usually represented by a large number of specimens of a few species. Bryozoa, Gastropoda and Ostracoda are common to abundant, whereas pelecypods and trilobites are rare. The more common genera and a few of the species are listed below:

Aulopora sp.	
Amplexiphyllum spp.	Ambocoelia umbonata
Craspedophyllum spp.	Brachyspirifer audaculus
Favosites arbuscula	Chonetes coronatus
Favosites placenta	Douvillina inaequistriata
Favosites spp.	Mucrospirifer mucronatus
Heliophyllum halli	Rhipidomella vanuxemi
Streptolasma rectum	
Drymopora spp.	Sulcoretepora incisurata
Trachypora sp.	Taeniopora exigua

Crinoid calyces, plates, columnals, cirri, etc.

Briefly, the lithologic-faunal associations are as follows: The Leiorhynchus fauna is a black shale assemblage which has its greatest expression in the Oatka Creek and Levanna members. When black and grey shales are interbedded, the Modified Leiorhynchus is usually present as evidenced in the upper Skaneateles and most of the Ledyard-Wanakah below the "Strophalosia" bed. Medium grey shales with thin limestone beds generally carry a typical Hamilton fauna. This fauna first appears in the shales above the "Strophalosia" bed, but has its best development in the Windom member. Blue to blue-grey shales with limestones were found to abound in Tropidoleptus carinatus, and pelecypods are common. The Deep Run and Kashong members are characterized by this association. The Encrinal-coral association is found in the dense, grey crystalline limestones such as the Centerfield, Tichenor, and Menteth. These lithologic-faunal associations are depicted in the accompanying diagram.

It is to be understood that the relationships described above are not absolute, for there are many exceptions. In most sequences minor amounts of rock with a different lithology and fauna will be interbedded with the dominant types. However, the general picture is correct. Besides the lithologies and paleontologic associations described above, there are several zones in the Hamilton to which specific or fixed names have been assigned, either because of their unusual fauna or the extreme abundance of one specific fossil or group of fossils. These are also indicated in the diagram. Specific information concerning these zones may be obtained by consulting the literature.

Upper Devonian

Genesee Group

History of Nomenclature

In 1842 Vanuxem used the term Genesee slate in writing about the strata overlying the Tully limestone and extending to the base of the sequence now included in the Naples group. The term gradually came to include different parts of the lower Upper Devonian section as various workers used Genesee shale, Genesee Group, and simply Genesee beds. Some times Vanuxem's original description was followed while other times the term was redefined to include more or less of the original stratigraphic section. The confusion which resulted was probably due to the very nature of the Upper Devonian rocks. Contacts are gradational more often than not.

Arbitrary boundaries and definitions were the rule until J. M. Clarke in 1903 systematically defined several of the black shales on a lithologic and paleontologic basis. In 1904 Clarke and Luther established a Genesee group which included the Standish flags and shales (abandoned term), the West River shale, the Genundewa limestone, and the Genesee black shale.

The Genesee black shale was renamed by Chadwick in 1920 as the Geneseo black shale. This ended the confusion which had resulted from the formation having the same name as the group. For a time the Genesee group was a well established group of formations.

In the Devonian Correlation Chart (Cooper, et al., 1942) the Genesee group was once again rearranged. The Tully limestone and the Geneseo shale were placed in the Taghanic stage (uppermost Middle Devonian). The Genundewa limestone and the West River shale make up the Genesee group according to the Devonian Correlation Chart.

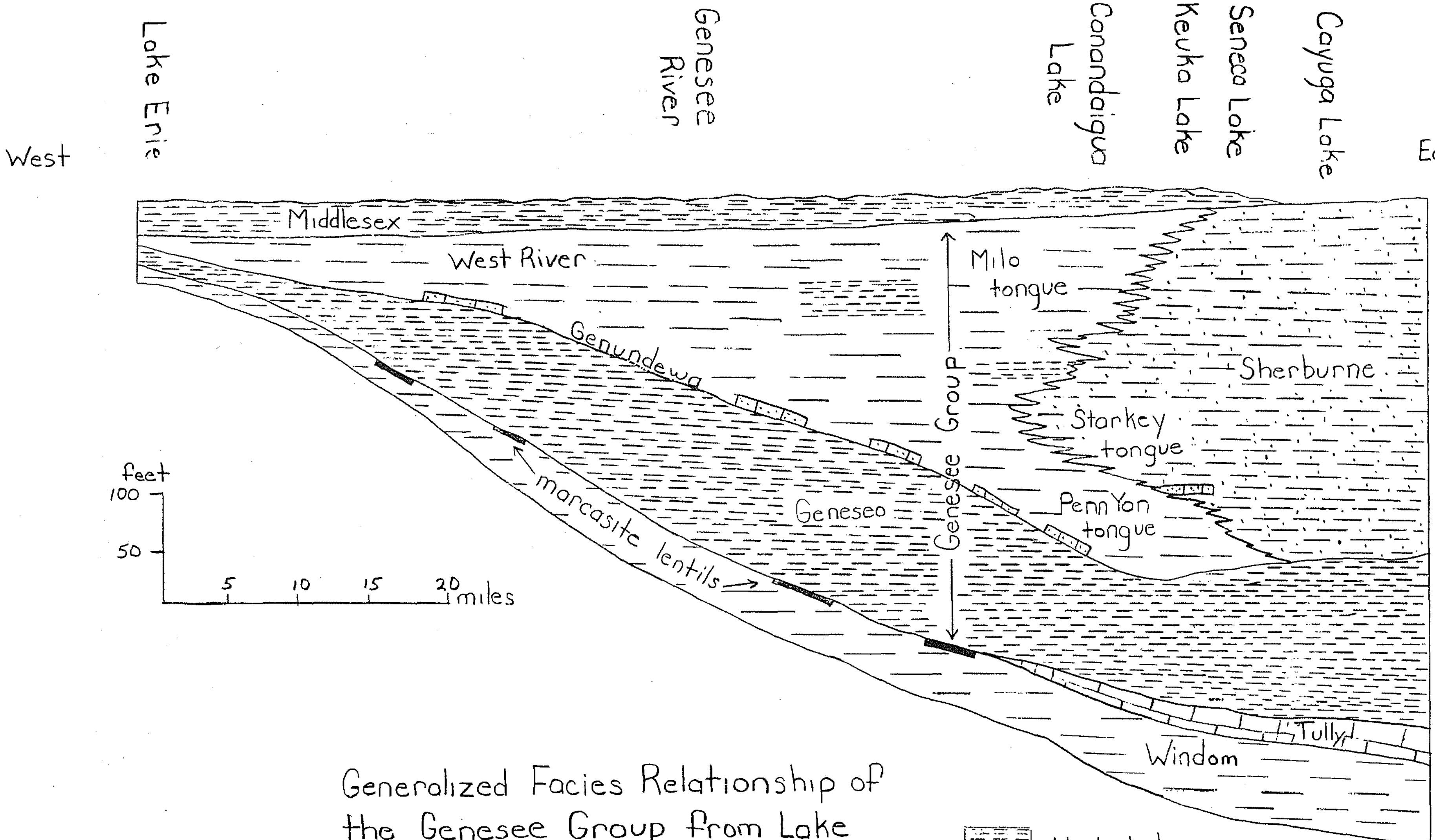
Grossman (1944) in his definitive paper on the Genesee group of New York includes the Geneseo shale as the basal formation of the Genesee group. In writing about the Genundewa limestone, Grossman (p. 61) suggests that the term be abandoned and that the *Styliolina* layers be included as the basal member of the West River shale. He states further (p. 58) "The significance of these lentils [Genundewa] in defining a continuous break in western New York is doubtful, because of the highly irregular and only local occurrence of the pteropod lenses."

Geneseo Black Shale

As outlined above, the Geneseo shale is considered to represent the basal formation of the Genesee group, which is lowermost Upper Devonian in age.

The lower part of the formation consists of black, finely laminated shale. The fresh rock is massive but upon exposure fissility is developed. Upon breaking open a fresh block of this shale the observer is at once aware of a strong petroliferous odor. Overlying these beds is a series of dark grey, irregularly bedded shales, thin limestones, and concretions. To the east, at Cayuga Lake, the upper portions contain thin, cross-bedded, light-colored siltstones.

At Lake Erie the Geneseo is 2 to 8 inches thick. There are 84 feet of the formation at Fall Brook (type section: 1.75 miles south of the town of Geneseo on the east side of the Genesee Valley). At Canandaigua Lake 115 feet of Geneseo has been measured, while at Cayuga Lake 125 feet is reported (Grossman, 1944, p. 54).



Generalized Facies Relationship of the Genesee Group from Lake Erie to Cayuga Lake — in part after Grossman 1944

"Correlation of Genesee equivalents east of Cayuga Lake is largely conjectural" (Grossman, 1944, p. 71). This statement applies to the Geneseo black shale as well as the other parts of the Genesee group because of the lack of adequate guide fossils and marker horizons to the east. East of Cayuga Lake interfingering of siltstones and red beds gradually obscure the Genesee formations of western and central New York.

Fossils.--The fauna of the Geneseo black shale includes no diagnostic forms and is extremely impoverished as compared to that of the underlying Hamilton group. Grossman (1944, p. 57) lists several of the common forms. Included are pelagic forms like Styliolina fissurella, and benthonic forms which thrived on a muddy bottom, such as Leiorhynchus quadricostatus, Lingula spatula, and Pterochaenia fragilis.

Genundewa Limestone Lentil of the West River Shale

The Genundewa limestone was named by J. M. Clarke in 1903. He chose as the type section the cliff-shore exposures at the foot of Bare Hill (formerly Genundewa Hill) on the east side of Canandaigua Lake.

The Geneseo black shale is separated from the main part of the West River shale by a series of thin limestones and shale beds referred to as the Genundewa limestone. Sass (1951, p. 67) defines the base of the Genundewa as the first pteropod limestone in the Geneseo-West River sequence which contains the pelecypod Paracardium doris and/or the goniatites Manticoceras sp. and Tornoceras cf. T. uniangulare. The top of the Genundewa cannot be defined because the characteristic thin limestones are found at varying distances (up to 46 feet) above the base of the West River shale. Variations in thickness are due to the intervening shale. Because of the vagueness of the upper boundary of the member, Grossman (1944, p. 60) prefers to abandon the term Genundewa. He calls these limestone lentils the Styliolina beds and considers them a facies of the West River.

The Genundewa consists of dark to light brownish gray, lenticular, nodular and concretionary limestones which contain an abundance of the shells of Styliolina fissurella. This tiny, needle-like pteropod may be seen by a close look at most Genundewa specimens. The thin limestones are separated by irregularly bedded, dark grey shales which have a typical West River aspect.

The Genundewa extends from Lake Erie where it is only a few inches thick to the vicinity of Gorham, Ontario County, or possibly to Seneca Lake.

The fauna of the Genundewa represents the first appearance of the Naples fauna which characterizes the formations above the West River shale. Clarke and Luther (1904, p. 59) list 43 forms in the Genundewa limestone. The abundance of the pteropod Styliolina fissurella has been mentioned. The other common forms include the ammonoid cephalopods (e.g., Manticoceras sinuosus and Tornoceras uniangulare), thin-shelled pelecypods (e.g., Paracardium doris), and plant remains.

West River Shale

Clarke and Luther in 1904 named the West River shale for the sequence of shales above the Genundewa and below the Middlesex black shale. Favorable exposures in the West River valley of Yates County were chosen as the type section.

The major portion of the West River consists of interbedded dark grey and black shales. The dark grey units are irregularly bedded and often calcareous. The black shales are fissile and have the appearance of the Geneseo black shales.

At Lake Erie the West River as a whole (including the basal Genundewa limestone lentils) is 8.5 feet thick. At the Genesee Valley it is 60-70 feet thick and at Canandaigua Lake it is 175 feet thick. Between Canandaigua Lake and Cayuga Lake the West River thins to 36 feet. In the Canandaigua Lake area the West River is penetrated by the Starkey tongue of the Sherburne sandstone and is divided by Grossman (1944, p. 64-66) into the Penn Yan tongue (lower) and the Milo tongue (upper). The Penn Yan tongue is the part of the West River which extends to Cayuga Lake; the Milo tongue is replaced by the Starkey prior to reaching the east side of Seneca Lake. In the Canandaigua Lake-Seneca Lake area the Starkey tongue consists of thin, light colored, cross-bedded siltstones interbedded with the dark grey shales of the West River.

The first continuous sequence of black, fissile shale above the West River defines the base of the Middlesex black shale.

The West River is not abundantly fossiliferous; thin-shelled pelecypods and brachiopods are its most common fossils. The pelecypod *Pterochaenia fragilis* is one of the most abundant of these.

Sedimentary Structures in the Genesee Group

Concretions and septaria are of particular interest in the West River shale and Geneseo black shale. They consist of dark grey to greyish black, argillaceous limestone and in many places occur in rows. They are commonly spheroidal in shape but may be quite elongated and irregular. Bedding may be continuous from the surrounding grey shale through the concretion. Most commonly the concretions contain concentric layers. Peripheral haloes of finely disseminated pyrite have been observed in the Geneseo concretions. Often the concretions contain a pyritized nucleus, a fossil animal or plant fragment, with the shape of the concretion influenced by the shape of the nucleus. Solid limestone concretions may contain a single thin crack-wedge filled with crystalline mineral material. By an increase in the number of these cracks concretions grade into septaria.

Septaria are most commonly found in the West River shales. Contained in the wedge-shaped cracks of these rounded bodies are crystalline mineral suites which occur in vugs in some of the thick limestone and dolomite formations of the Silurian (Lockport dolomite is an example). Small euhedra of pyrite, ankerite, sphalerite, galena, selenite, and, most commonly, calcite are often found lining the V-shaped fractures. The origin of this very interesting sedimentary structure is not completely understood. The concentration of a metallic mineral suite in a ball of impure lime mud and the concentration of the lime mud into spherical shapes is an unsolved problem in sedimentation which may be intimately related to the origin of limestone.

The shales surrounding concretions and septaria are commonly bent around these structures. This strongly suggests a contemporaneous time of deposition for the shales and the concretions.

Lobate flow markings on the base of siltstone beds are commonly found in the West River shale. Parallel flow markings are found on siltstones in the Geneseo black shale. These two structures are very common in the Naples group.

Naples Group

Introduction

The Naples group consists of four formations, in ascending order: the Middlesex black shale, Cashaqua formation, Rhinestreet black shale, and Hatch formation. The group extends from Seneca Lake to Lake Erie and thins from east to west. Sandstones, siltstones, and gray shales predominate in the eastern part. In the west, dark gray and black shales are characteristic (see accompanying diagram).

The name Naples was first used by Clarke (1885) for the strata above the Genesee shale. Chadwick (1935) modified the usage of the term, limiting it to the rocks between the West River (below) and the Grimes sandstone (above). The Naples group is approximately 500 feet thick in the Genesee Valley. Westward, it thins to 170 feet at Lake Erie. Eastward, it thickens to over 800 feet at Seneca Lake and beyond its identity is lost where it interfingers with the Ithaca and Enfield formations at Cayuga Lake.

Middlesex Black Shale

Clarke (1903, p. 23) applied the name "Middlesex" to the black shales at Middlesex, New York. The formation is 30 feet thick in the Genesee Valley and is composed of black shale with a few thin beds of gray shale. Fossils are very rare. The formation is exposed just above the base of the dam at Mount Morris. It may be recognized by its dark gray color, blocky jointing, and resistant character.

Cashaqua Formation

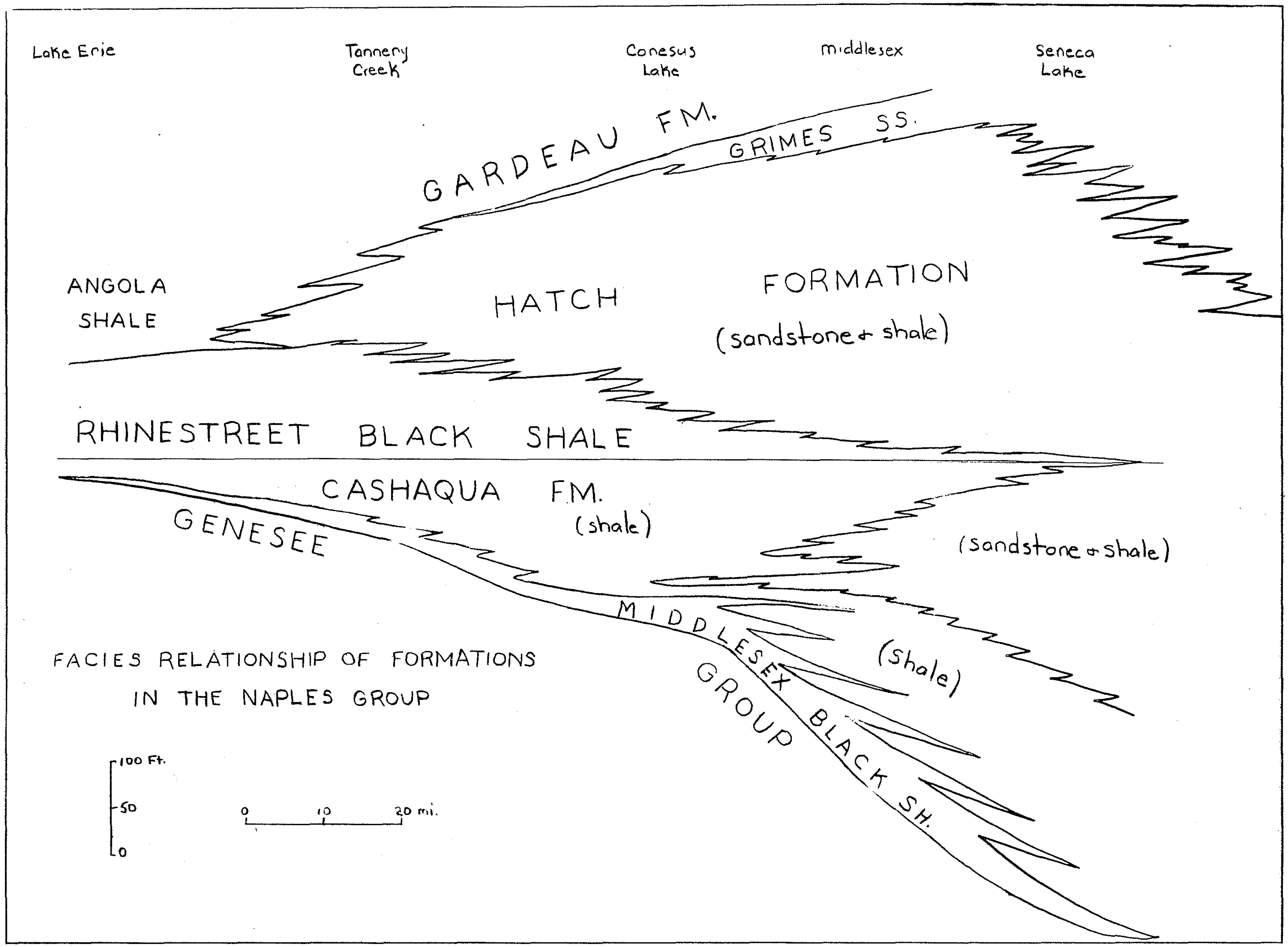
The name, Cashaqua, was given to the shales overlying the Middlesex black shale by Hall (1840, p. 390 ff.). The type locality is Keshaqua Creek (formerly Cashaqua Creek), southeast of Mount Morris. The formation thins from east to west, measuring 480 feet at Seneca Lake, 166 feet at Mount Morris, and 28 feet at Lake Erie. Bluish gray shale (weathering to olive-gray) predominates in the Genesee Valley-Lake Erie region. The formation becomes more sandy toward the east. At Seneca Lake, it is composed of 40 percent sandstones and siltstones and 60 percent arenaceous shales. The Cashaqua forms most of the gorge wall at the Mount Morris dam. The upper contact may be observed a short distance below the top of the cliff.

Fossils are common. Thin-shelled pelecypods, cephalopods, and gastropods predominate. Brachiopods, arthropods, crinoids, and fish are rare.

Rhinestreet Black Shale

Clarke (1903, p. 23) gave the name "Rhinestreet" to the black shales overlying the Cashaqua formation. The type locality is just north of Naples, New York. The formation is composed of black shale interbedded with small amounts of dark gray shale and thin siltstones. It thickens from east to west and measures over 100 feet in the Genesee Valley.

Fossils are rare in the black shale but a Cashaqua fauna may be found in some of the dark gray shale beds in the lower part of the formation.



FACIES RELATIONSHIP OF FORMATIONS IN THE NAPLES GROUP

Hatch Formation

The Hatch formation was named by Clarke (1904) and the type locality designated as the lower part of Hatch Hill, near Naples. The formation extends from Attica, New York, to Keuka Lake. In that distance, it thickens from 150 feet (west) to over 400 feet (east). At Letchworth State Park it measures 186 feet. Thin-bedded siltstones, gray and black shales comprise the formation in the Genesee Valley. Shales are more abundant to the west, whereas siltstones predominate in the east. The Hatch is exposed north (downstream) of the lower falls in Letchworth Park.

Fossils are not common in the Hatch. A modified Cashaqua fauna is present but in greatly reduced numbers.

Formations above the Naples Group

Grimes Sandstone

The Grimes sandstone was named by Luther (1902) from exposures in Grimes Gully at Naples, New York. The formation is 25 feet thick in the Genesee Valley and is composed of bluish gray sandstones, siltstones, and arenaceous shales. It may be observed just below the lower falls at Letchworth State Park.

The Grimes carries a Chemung fauna (Clarke and Luther, 1904) with brachiopods predominating. A well-defined faunal break marks the Hatch-Grimes boundary.

Gardeau Flags and Shales

The name was first used by Hall (1840) for exposures on the Gardeau reservation, south of Mount Morris, New York. It included the rocks from the base of the Rhinestreet to the top of the Nunda sandstone. Luther (1902) restricted its usage to the strata between the Grimes and Nunda sandstones. His definition is followed here. The formation consists of bluish gray sandstone, siltstone, and gray and black shale. The Gardeau measures 344 feet in Letchworth Park and is exposed in the river from the base of the lower falls to a point just below the crest of the upper falls. The Gardeau and the Hatch form the walls of the gorge north of the lower falls.

Fossils are uncommon. Thin-shelled pelecypods, cephalopods, and gastropods occur in some shale beds (see Clarke and Luther, 1908, p. 60-61).

Nunda Sandstone

The name "Nunda" was proposed by Clarke and Luther (1908) for the thick beds of bluish gray sandstone and thin beds of gray, arenaceous shale that overlie the Gardeau. The greater thickness of the sandstone beds (up to 15 feet) distinguishes the Nunda from the Gardeau below. The formation is approximately 200 feet thick in the Genesee Valley and forms the cap rock of the upper falls at Letchworth Park.

Fossils are rare. A few cephalopods (*Manticoceras*), *Aulopora*, *Orbiculoidea*, and crinoid stems have been reported. *Scolithes verticalus* (a worm tube?) is very abundant.

Wiscoy Flags and Shale

The Wiscoy was first named by Clarke (1899) for the soft shales that overlie the Nunda sandstone. The type locality is Wiscoy Creek, Allegheny County. The formation is 170 feet thick in the Genesee Valley and contains a black shale in the lower part called the "Pipe Creek member" by Chadwick (1933). Gray shales and thin siltstones comprise the remainder of the formation.

A thin-shelled cephalopod and pelecypod is present in the gray shales.

C. GLACIAL GEOLOGY

Chronological Wastage of Ice in New York State

The Wisconsin glaciation is the major and only important glacial stage represented in New York State. Aside from the terminal moraine, all morainal deposits here are recessional, thereby indicating periods of stagnation as the ice retreated northward across the state.

Terminal, or Olean-Salamanca moraine.--The farthest advance is evidenced by the massive terminal moraine or Olean-Salamanca moraine which at its eastern end extends from Long Island westward through New Jersey and Pennsylvania. It swings northwest from Pennsylvania into southwestern New York in the Olean-Salamanca districts, then turns southwest again back into Pennsylvania. That portion of the terminal moraine in New York State represents an ice front re-entrant. Patches of Illinoian drift have been found just south of the moraine in the Salamanca district (MacClintock, 1954).

Binghamton moraine.--The Binghamton moraine extends southwestward from the northern tributaries of the Susquehanna Valley and the Chenango River Valley to the Binghamton area, then swings northwestward to just north of Franklinville, where it turns to the southwest and continues on into Pennsylvania.

This moraine has been placed by MacClintock (1954) in the Cary substage of the Wisconsin.

Valley heads moraine.--An uneven recession of the ice front from the terminal moraine to a line of stagnation just below the southern extremities of the Finger Lakes, or on a line along the heads of the present north-trending valleys, permitted an abundance of glacial drift to be deposited. Drift accumulation in the valleys exceeded that on the intervening ridges and lines of drift across the ridges are poorly developed and difficult to trace.

In the Genesee Valley this drift is responsible for shunting the river from its preglacial channel and consequent excavation of the upper Genesee gorge.

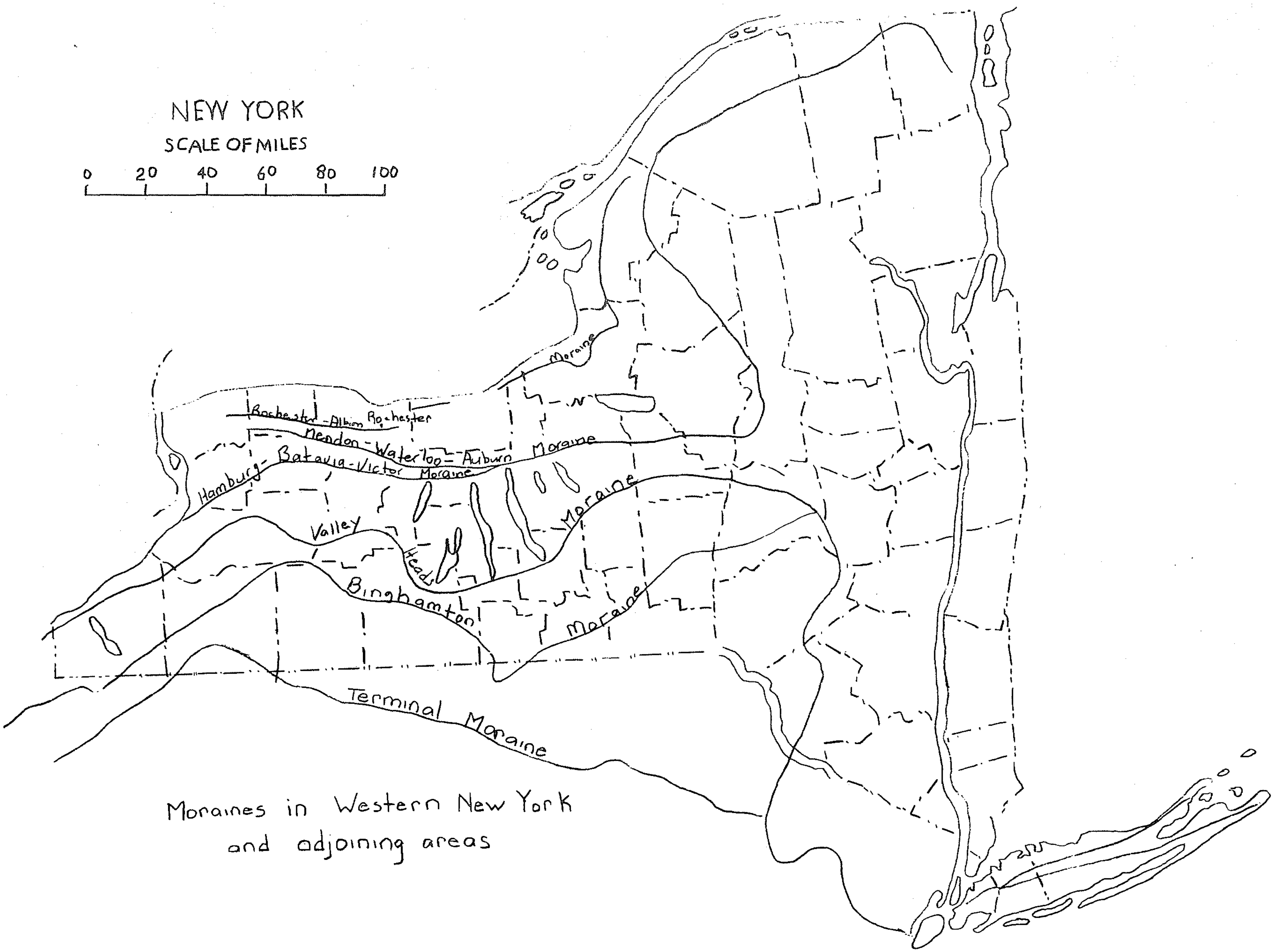
The Valley Heads moraine constitutes the present divide between north and south drainage, except for the major flow of the Genesee River.

Like the preceding Binghamton moraine, this moraine has been dated as Cary (MacClintock, 1954).

Hamburg-Batavia-Victor moraine.--Another recession and period of stagnation caused considerable drift deposition extending northeast from Hamburg to Batavia, where the belt turns southeast and on to Victor. The moraine continues to the east at approximately the northern ends of the Finger Lakes in the central portion of the state.

An outstanding kame area to the southwest of Victor occupies about 20 square miles and attains summit elevations up to 1000 or 1100 feet (Fairchild, 1932)

Along the line of the moraine the intervalley ridges show a paucity of drift and no definite lines of ice front accumulation (Fairchild, 1932).



Moraines in Western New York and adjoining areas

Fairchild (1932) put forth the idea that the Batavia deposits mark a point of turning or pivot of the Ontarian ice bodies (see below, under glacial lakes).

Mendon-Waterloo-Auburn moraine.--This morainal belt intersects the preceding one at Waterloo; to the west it lies subparallel to and a few miles north of the earlier one.

The Mendon kame area is about 10 miles south of Rochester. Westward from the Mendon kames the moraine stretches to the northwest in a series of moderate knolls and short ridges interrupted only by the Genesee River.

The Turk-Baker Hills, 7 miles east of Mendon, and the Junius kames, between Lyons and Geneva, are included in this moraine. To the east of Seneca Falls and Cayuga Lake the moraine follows on line to Auburn.

Significantly, the moraine is apparently contemporaneous with attenuated drumlin flutings to the north. A similar relation is described east of Cayuga Lake in the Auburn moraine (Fairchild, 1932).

The age of the drift is Mankato (MacClintock, 1954).

Rochester-Albion moraine.--The Rochester-Albion moraine extends west from Rochester, then curves northwestward and again westward through Albion and Medina. Along much of its course this moraine is a belt of subdued, irregular knolls and ground moraine. The line of prominent kames which constitute the Pinnacle Range in Rochester is the eastern part of the Rochester-Albion moraine. This conspicuous ridge extends about four miles eastward from the Genesee River along the southern edge of the city.

The abrupt eastern termination is imperfectly understood. There may be correlation between this belt and another one east of the Irondequoit Valley, but no direct connection exists. The Rochester-Albion moraine represents a period of recession and stagnation of the Mankato ice mass.

Oswego moraine.--Near the shore of Lake Ontario a prominent ridge of water-laid deposits extends from Fairhaven to Oswego, except for a break across the deep embayment of Sodus Bay. The moraine strikes essentially parallel to the shore of Lake Ontario. It was deposited in front of Mankato ice.

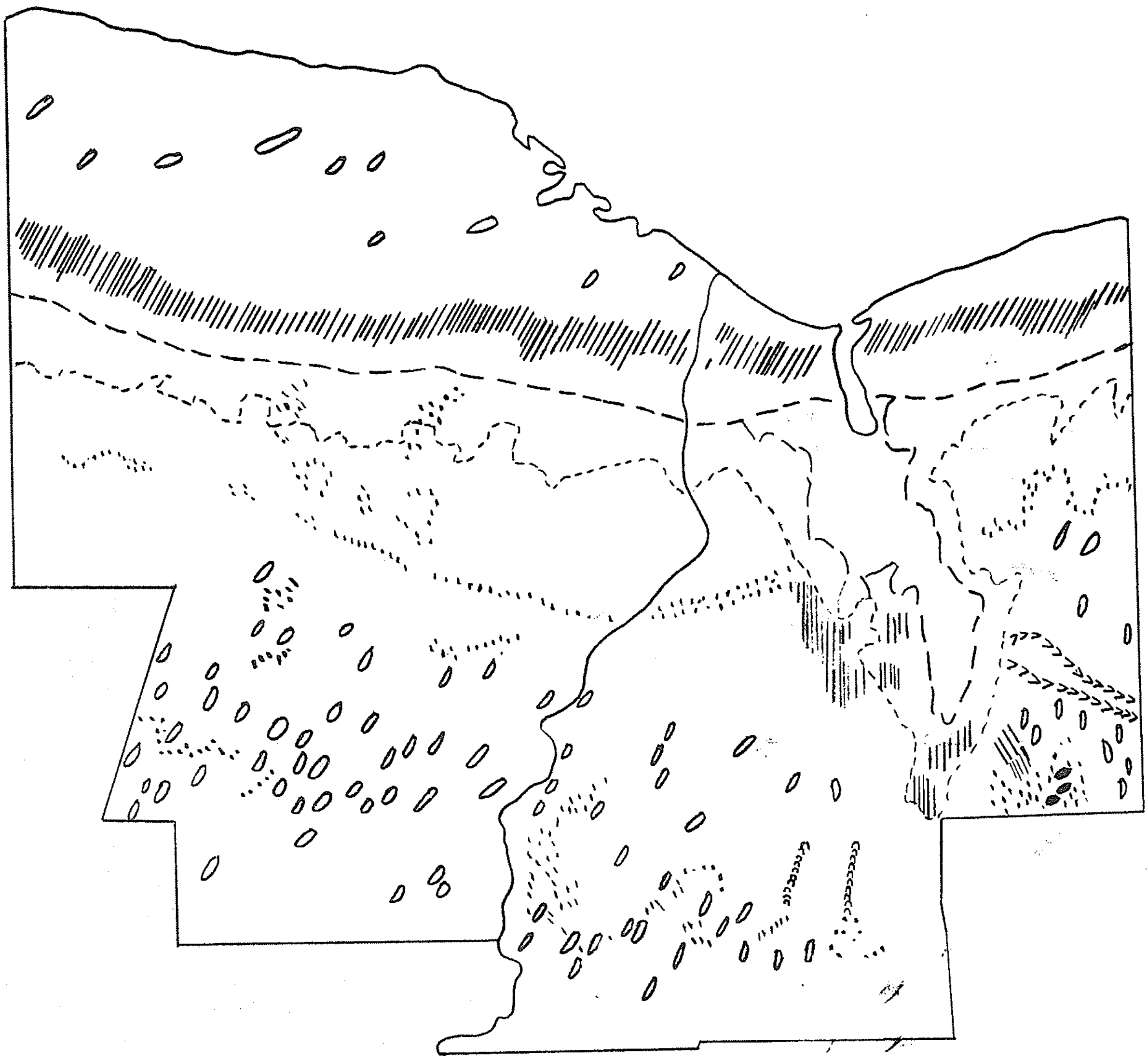
Glacial Lake Development in Western New York

As the ice sheet retreated from the higher elevations of its farthest southward advance to lower and lower elevations toward the north, glacial meltwater and north-flowing streams became imponded between the highlands to the south and the massive ice dam to the north.

The ice mass of western New York was manifested as tongues or lobes which flowed along paths of least resistance, filling and modifying valleys and leaving intervening ridges either exposed to the atmosphere or under a relatively thin sheet of ice. As the ice retreated northward, the major pre-existing north-trending valleys were uncovered, becoming the loci for the accumulation of glacial meltwater and debris.

The withdrawing ice uncovered lower and lower outlet channels that allowed waters to flow east or west contiguous with the front of the ice, cutting prominent east-west channels. The east-west channels are especially well developed in the

GLACIAL FEATURES OF MONROE COUNTY, NEW YORK



Lake Iroquois shoreline

Lake Iroquois sand plains

Lake Dawson shoreline

Lake Dawson sand plains

Lake Dawson outlet channel

Lake Dana delta plains

Lake Warren wave smoothed areas

Morainal belts

Eskers

Drumlins

intervening ridges between the major drainage systems and lakes of west and central New York State. The ice front channels are readily seen in the field and are just as important as the moraines, in defining the position of the ice front. Many have been mapped by Fairchild (1909), and have been used for correlation purposes where morainal material is absent. Such ice-border drainage was responsible for the dissipation and removal of much glacial drift.

The succession of glacial lakes in western New York is denoted by elevations of channel outlets, terraces, beach deposits, and deltas, the last being built by streams flowing in from the east or west off the inter-valley ridges.

As previously stated, early glacial lake formation in the southern portions of the state was confined to the major valleys. The recession of the ice to parallels between the Valley Heads moraine and the Hamburg-Batavia-Victor moraine was accompanied by a gradual merging of the confined lakes into a large glacial lake extending many miles east and west.

The following discussion outlines the succession of major glacial lakes from the time when the ice was at the latitude of the Finger Lakes to the time of its retreat to the Ontario basin and Canada, encompassing Cary and Mankato time.

The southerly, higher, and more local glacial waters were confined to the major depressions of the Genesee Valley and the Cayuga basin. Early outflow was to the south. At a later stage when the ice was at or near the northern end of the Finger Lakes, the waters collected mainly into two large lakes, which later merged to form Lake Newberry.

Lake Newberry.--Lake Newberry occupied the central valleys of Seneca, Cayuga, and Keuka and discharged southward through the site of the community of Horseheads (900 feet elevation) to the Chemung and Susquehanna Rivers (Fairchild, 1909).

The other main lake in the Genesee River valley escaped at different times and levels via the Susquehanna-Alleghany-Ohio-Mississippi drainage (Fairchild, 1909).

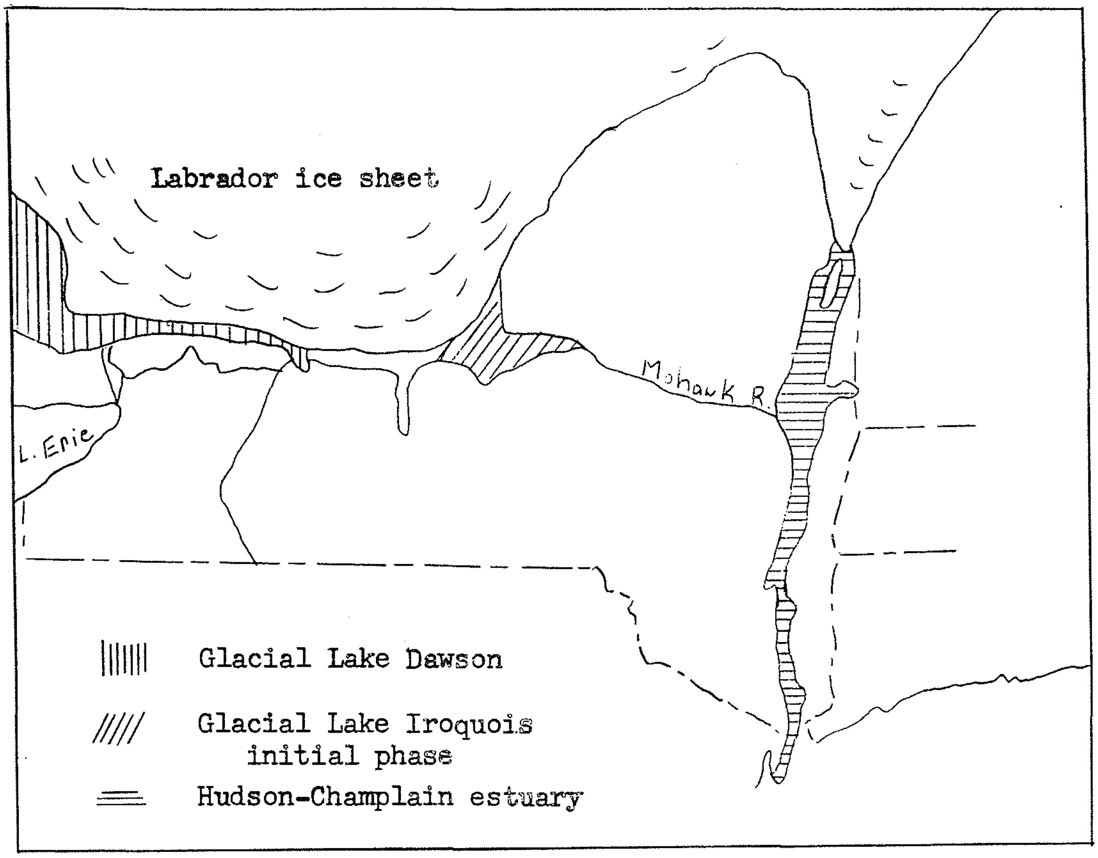
When the ice front receded to the parallel where the Hamburg-Batavia-Victor moraine now lies, at the northern end of the Finger Lakes, the two lakes merged to be called, collectively, Lake Newberry. The lake waters had a surface elevation of 1000 feet (Fairchild, 1909).

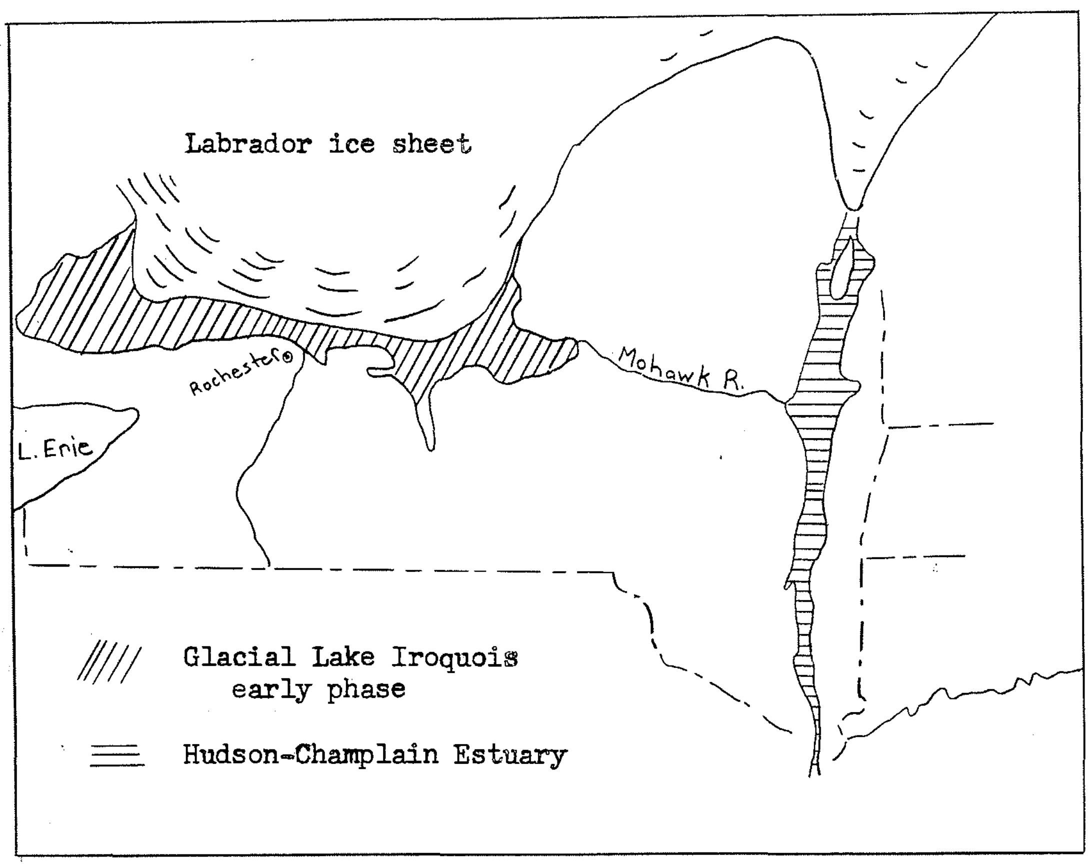
Lake Hall.--It was mentioned under the discussion of moraines that the Batavia portion of the Hamburg-Batavia-Victor drift belt marked a point of "pivot" in the retreat of the ice front. While the ice at Batavia remained stationary, the eastern extremity of the ice front retreated and permitted Lake Newberry to drain eastward via the Mohawk Valley. This caused lake levels to drop from 1000 to 900 feet. Glacial waters at the interval between 1000 and 900 feet were called Lake Hall (Fairchild, 1909).

Lake Warren I (Lake Vanuxem I).--After a time the ice front at the longitude of present Batavia receded to the Onondaga escarpment and the surface elevation in the lake dropped to just below 900 feet. This allowed the Warren waters in the Erie basin, previously trapped by the Batavia salient, to flow eastward via the Mohawk Valley. The new lake was called Lake Warren I (Vanuxem I) (Fairchild, 1909).

Period of free drainage or deglaciation.--The ice at this time apparently receded some distance to the north, a period of "free drainage" (Fairchild, 1909) ensued, and Lake Warren I disappeared.

TWO STAGES IN GLACIAL RETREAT, SHOWING LAKES DAWSON AND IROQUOIS





Lake Warren II (Vanuxem II).--A subsequent advance of the ice to the south following the period of "free drainage" blocked off the Syracuse channels on the east resulting in the formation of a new lake, Lake Warren II (Vanuxem II) (Fairchild, 1909).

This readvance of the ice is marked by the Mendon-Waterloo-Auburn moraine which shows the wave work of Lake Warren II at 880 feet.

The Bristol Hills, south of Mendon Ponds Park, mark the beginning of the Appalachian Plateau, rising up from the Interior Lowland. The hills were the southern shores of Lake Warren II as evidenced by terraces and delta deposits at 880 feet.

A study of the depth of leaching in glacial gravels near Syracuse revealed anomalous data which have been attributed to an advance and over-riding by the Mankato ice sheet over a pre-existing drift (MacClintock, 1954). This information tends to corroborate the ice advance to establish Lake Warren II.

Lake Dana.--During the recession of the ice front to the parallel of Rochester, water levels dropped as lower channels were uncovered. When the ice front stagnated along the Rochester parallel, glacial Lake Dana (Lundy) came into existence. The lake was dammed on the south by the Bristol Hills with the Mendon Ponds kames projecting above water level as numerous local islands. Dana lake levels have been recorded at 700-725 feet (Fairchild, 1932).

The southwestern flanks of the Turk-Baker Hills, 7 miles east of Mendon Ponds Park, show delta plains at an elevation of 720 feet that were built in Lake Dana.

Debris-laden melt waters flowing from the ice front into Lake Dana were responsible for building the Pinnacle Range of kame deposits in present Rochester. Great quantities of fine sediment were deposited farther out into the lake, developing the present large clay plain south of the Pinnacle Range. Excavations for buildings for the University of Rochester River Campus and the Strong Memorial Medical Center revealed great thicknesses of silts and clays.

The Marcellus-Cedarville channel in the Otisco Valley far to the east is the only prominent channel that can be correlated with the Dana lake level (Fairchild, 1909).

Lake Scottsville.--Lake Scottsville was the successor to Lake Dana and contemporaneous with the initial stages of Lake Dawson (see below). This small, shallow, and local lake was located south of the Pinnacle moraine and west of a drift ridge (East Henrietta ridge) extending to the south along South Avenue and the East Henrietta Road.

The outlet was northward through the moraine where the Genesee River now flows. It is assumed that the lake waters cut through the lowest point of the Pinnacle Range. A contour map shows that the breach across the moraine could not have been much above 540 feet, otherwise the cut would have been made towards the west across Brooks Avenue (Fairchild, 1923).

Lake Scottsville extended south up the Genesee Valley past Scottsville toward Avon at an elevation of 540 feet. This lake furnished a basin for the accumulation of sediments brought down by the Genesee River. The expansive valley plains from Rochester to Avon are lake sediments topped by silts left by river floods.

The Lake Scottsville waters discharged northward through the Pinnacle Range into the beginning stages of Lake Dawson. Drops in the level of Dawson caused Scottsville waters to cut a rather prominent channel through which the Genesee River now flows.

Lake Dawson.--Lake Dawson followed Lake Dana in the sequence of temporary glacial lakes and existed for a relatively short period of time. The lake occupied the west end of the Ontario basin and flooded the Irondequoit Valley. A portion of the ice front along the east side of Irondequoit Bay and along the parallel of Penfield was responsible for the western restriction of the lake.

Lake Dawson drained to the east via a capacious channel commencing at Fairport and passing through Palmyra, Newark, Lyons, and Clyde. The lake ultimately discharged into the incipient stage of Lake Iroquois then inundating the districts from Rome to Syracuse and the eastern Ontario basin (Fairchild, 1919) (see page 52.

The extinction of Lake Dawson took place when the ice, lying along the parallel of Penfield, receded and allowed the waters of Lake Dawson and the early, eastern Lake Iroquois to merge, forming greater Lake Iroquois.

The pro-glacial lakes of Dawson and Iroquoit completely filled and overtopped the ancient Irondequoit Valley. This resulted in a copious and almost complete filling of the valley by sediments which in turn lie over a considerable accumulation of till (Chadwick, 1917).

The elevation of Lake Dawson has been placed at 480 feet. This figure was reached by considering a 460 foot elevation at the Fairport channel, a 15 foot allowance for depth of water in the channel, and a 5 foot difference of land uplift between Fairport and Rochester (Fairchild, 1919).

During Lake Dawson time, Niagara Falls and Lake Erie came into existence.

Lake Iroquois.--The long duration of Lake Iroquois resulted in a well-defined shoreline and conspicuous wave-cut cliffs. The lake level was determined by the elevation of a pass at Rome leading into the Mohawk Valley (Fairchild, 1919). In the Rochester district, the Iroquois shoreline is found along the 440 foot contour. Ridge Road runs along a prominent Iroquois beach just to the north of the city proper. The lake inundated the Irondequoit Valley as far south as Pittsford.

Processes of sedimentation in the Irondequoit Valley were extensive during Lake Dawson and Lake Iroquois times, thereby filling the depression to within 30 or 35 feet of the water surface (Fairchild, 1906). More recently Irondequoit Creek and its tributaries have contributed to fill in the deeper parts of the valley, while, at the same time, partially removing some of the lake deposits from higher levels.

When removal of the ice opened the St. Lawrence River Valley, Lake Iroquois was slowly drained to sea level. The ephemeral sequence of falling Iroquois waters left behind a series of terraces which can be readily observed in the Irondequoit Valley. These have been modified by more recent erosive effects of the Irondequoit Creek and its tributaries.

Gilbert Gulf.--Draining of Lake Iroquois ultimately reduced its surface elevation to sea level. The name applied to the ocean level water in the basin of Lake Ontario is Gilbert Gulf. Since Gilbert Gulf time isostatic uplift has caused the rise of the surface of Lake Ontario to its present 246 feet above sea level.

Mendon Ponds County Park

The Mendon kame district is approximately 10 miles south of Rochester. It is the third highest point in Monroe County, with a maximum altitude of 840 feet. It is bounded on the west by Clover Road and on the east by Pittsford Road. The park covers 4 square miles. Here is an excellent example of a kame-kettle topography, similar to the western extremity of the Pinnacle Hills at Mount Hope Cemetery.

The map of Mendon quadrangle shows the district to have a three-fold east-to-west division. The central division is an area of imponded drainage exemplified by four major lakes or kettles. The eastern and western divisions each contain a well developed esker flanked by prominent kames.

The esker along the western tract is approximately 2 miles long and reaches a height of 100 feet at several places. It abruptly broadens into an esker fan at its southern termination west of Deep Pond.

The esker extending north-south along the eastern division is one of the best esker forms in New York State. It possesses a typical hummocky profile and assumes a serpentine course. The esker is bordered on both sides by kames, and extends in a northeast to southwest direction for a distance of 2-1/2 miles. A succession of numerous kettles occurs along its base, which may contain water forming small ponds or swamps. The northern end of the esker is one of the highest points in Monroe County. The esker becomes conspicuously subdued at its southwestern terminus.

The Turk-Baker Hills 7 miles east from Mendon Ponds Park are also kame deposits and attain an altitude of 930 feet. The Turk-Baker Hills display wave work done by Lake Warren II at just under 900 feet. On the southwest flanks of the hills are delta plains built in Lake Dana at 700 feet (Fairchild, 1926).

The higher kames at Mendon display some inconspicuous leveled or smooth tracts on the east and west side of the kame areas where Dana waves had greater force.

The Junius kame moraine 20 miles southeast of the Turk-Baker Hill kames is correlated with the Mendon and Turk-Baker Hill localities. The Junius kames occupy lower ground and show less relief. They are piled on drumlin territory so that kames and drumlins are often confused.

The Waterloo and Auburn moraines show contemporaneous relationships with attenuated drumlin fluting on the north (Fairchild, 1926).

It appears that the entire extended moraine was contemporaneous with the final shaping of the drumlins in the adjacent territory to the north. Another interesting fact in this connection is the relative weakness of the moraines lying in front of the drumlins with stream outwash largely concentrated in the kame areas. Fairchild (1932) suggested that the greater load of drift borne by the ice was mostly incorporated in the drumlins.

This belt of kames represents a great volume of drainage which has no apparent genetic relation to the topography. Conditions of the ice, surficial or internal, seem to have determined the concentrated stream flow.

At Mendon Ponds there is an intimate genetic relation between kames and esker, both apparently being a product of the same stream. The kame knolls are outwash detritus deposited where the glacial streams emerged from the fluctuating edge of the ice. The esker comprises the coarse material dropped by the glacial stream in its bed when the volume and velocity of the flowing water was unable to carry all the load (Giles (1918).

The Pinnacle Hills

Location and extent.--The Pinnacle Hills (or Pinnacle Range) lie at the eastern portion of the Rochester-Albion moraine. The range consists of an irregular but linear belt of kame deposits extending about 4 miles from the town of Brighton, adjoining Rochester on the southeast, westward to the Genesee River.

The range attains a maximum elevation of 749 feet at the Pinnacle Hill high point, and projects above the Rochester plain about 240 feet. The line of hills displays some curvature with a convexity towards the south. The moraine continues beyond the Genesee River northwest toward Spencerport, continuing past Brockport, Holly, and Albion. This western extension of the Rochester-Albion moraine is essentially a belt of subdued hills, knolls, and ridges. In some cases it is present only as ground moraine. East of the Irondequoit Valley is one of the largest drumlin fields in the United States upon which is believed to lie an eastern extension of the moraine. In the drumlin area it is represented by scattered and inconspicuous morainal material (Fairchild, 1923).

The earliest description of the Pinnacle Range was made by Dryer (1890) in which he correctly described the hills as a large kame deposit. In 1893, Upham recorded the Pinnacle Range as an esker deposited in a "deep ice-walled gorge". H. L. Fairchild studied the range in detail and described its features voluminously. He described the Pinnacle kames as ice-contact deposits laid down by streams discharging from the ice front into glacial Lake Dana. In 1924, Taylor put forth the hypothesis that the Pinnacle Range is an interlobate moraine. This interpretation will be discussed below.

The Pinnacle Hills have been divided into three main groups (Fairchild, 1923) which are briefly characterized as follows:

Brighton-Cobbs Hill:

This division encompasses that portion of the range east of Monroe Avenue, including Cobbs Hill. The maximum elevation for this division is 663 feet.

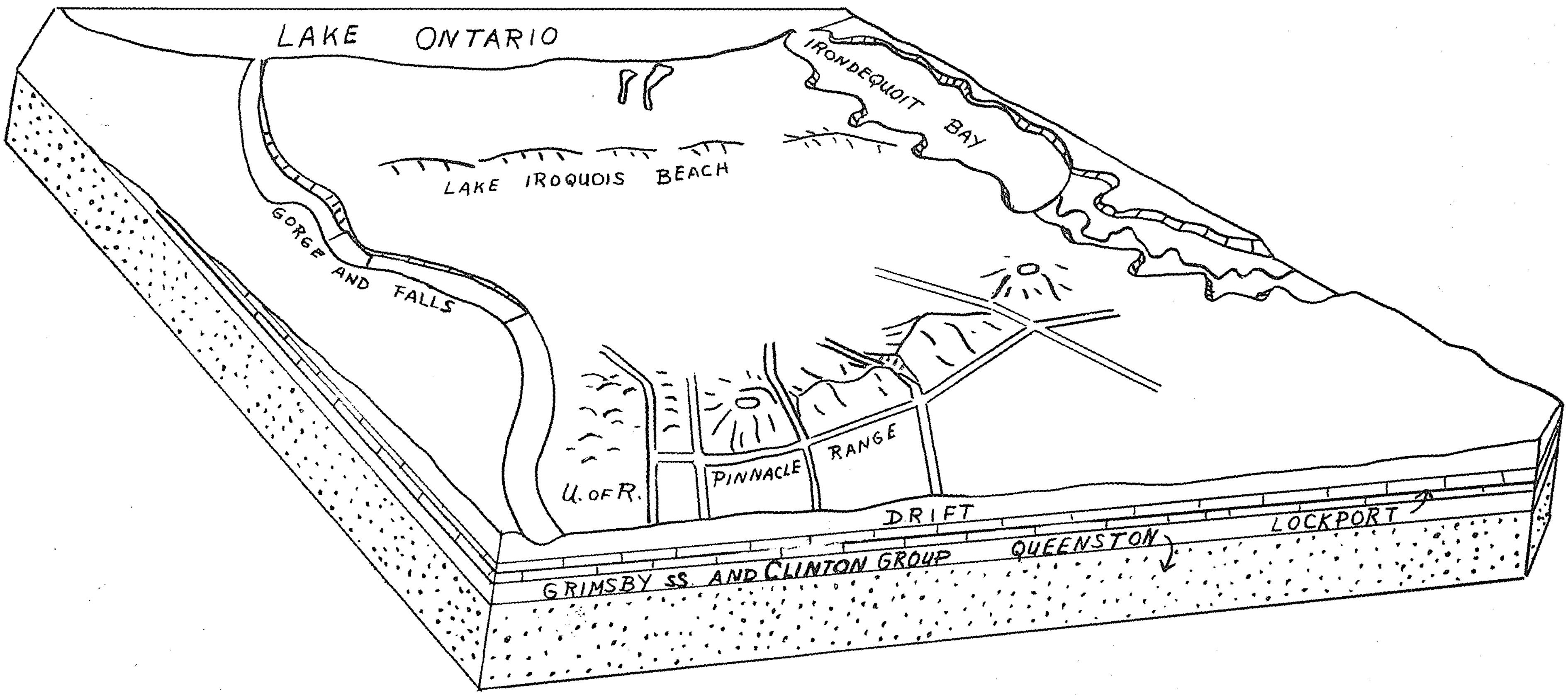
The Pinnacle Hill:

The second division is more restricted laterally and extends from Monroe Avenue to about 1/4 mile west of South Clinton Street (see block diagram). It contains the Pinnacle Hill high point at an elevation of 749 feet, approximately 240 feet over the Rochester plain.

Divinity-Highland-Mount Hope-Oak Hill:

The remainder of the range to the Genesee River is included in the third division. It embraces the knoll east of Goodman Street (on which the Colgate-Rochester Divinity School is located), Highland Park between Goodman and South Avenue, Mount Hope Cemetery, and Oak Hill. The latter is the site of The University of Rochester. Summits in the cemetery attain a maximum elevation for this division of 675 feet.

BLOCK DIAGRAM SHOWING RELATIONSHIP OF MAJOR TOPOGRAPHIC FEATURES IN IMMEDIATE VICINITY OF ROCHESTER



The third division differs from the first two in having a greater width and an outstanding irregular kame-kettle topography similar in form to the Mendon kames and kettles. The dissimilarity between the eastern and western ends may be attributed to different relations between melt water discharge and the configuration of the ice front.

General Description.--The northern slopes of the range are steep and irregular probably as a result of both erosion and the direct effects of ice contact. Extensive real estate development and large man made excavations have contributed to the removal or concealment of great quantities of material. Southern slopes are generally less steep and merge into the Lake Dana plain with gentle acclivity.

Water-laid deposits:

The Pinnacle Range is composed largely of sand and gravel deposits which display abrupt changes both vertically and laterally. Stratified deposits trend across the range, rather than along its length as would be the case with an esker.

Work done by Fairchild (1923) and Anderson shows that beds dip to the southeast, south, and southwest, the latter taking a slight precedence over the other directions.

Fine sands are found in the eastern and western extremities of the moraine. Fine sands are also found on the north and south slopes with greater abundance of coarser material on the north side.

The coarse water-laid materials are of pebble and cobble size. These size ranges are made up of about 50 to 60 percent red Medina sandstone, and 20 to 30 percent Lockport dolomite. The remainder is composed of Silurian-Ordovician limestones and exotic crystallines. Well rounded pebbles and cobbles of Medina sandstone and Lockport dolomite indicate only a short distance of transport was necessary to produce a well rounded rock.

Till:

An important feature of the Pinnacle Range is the till capping which overlies the stratified sediments and varies in thickness from 3 to 20 feet. The overlying till indicates a moderate southward oscillation of the ice which overrode the kames and coated the hills. Upturned and vertical bedding planes in the stratified material are present on the north side of the hills. High angle faulting in both the till and stratified deposits have been attributed to subsequent slumping after the ice backed away to the north (Fairchild, 1923). The south slopes show little distortion in comparison to the northern slopes.

A recent till fabric study by Anderson shows that the orientation of the long axes of pebbles incorporated in the till varies between southeast and southwest, with the southwest direction showing slightly the greater concentration.

Poorly rounded, striated, and polished pebbles and cobbles of Lockport dolomite constitute 60 to 70 percent of the rock fragments in this size range. Lesser and varying amounts of Medina sandstone, Ordovician-Silurian limestones and crystallines make up the other rock types. Large Lockport and crystalline erratics are moderately numerous in the upper till zone.

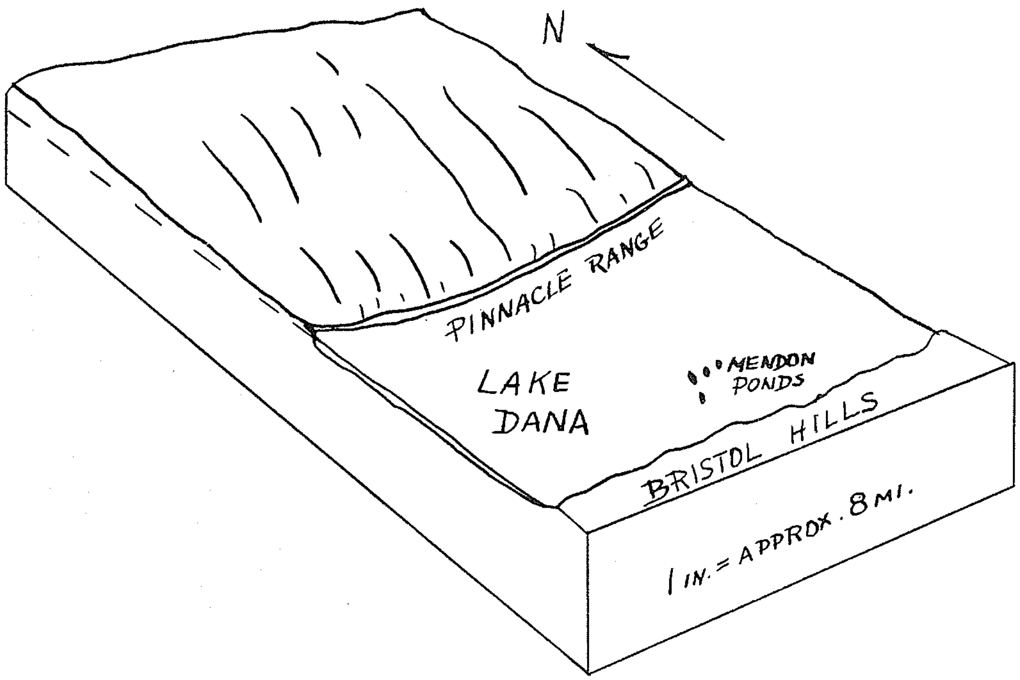
Till matrix varies between hard compact clays and fine clayey sands or silts. The compact clay matrices are found on the lower northern slopes and, perhaps, represent basal packing beneath the ice mass (Flint, 1949). Tills on the upper slopes show a sand-silt matrix with lesser quantities of clay. The pebbles and cobbles in the upper tills generally show a higher degree of rounding than those of the basal till. Apparently the till in the upper reaches of the range was not subjected to the pressures of a thick ice packing but was reworked to some extent by minor melt water action (Flint, 1949).

Glacial striae:

Glaciated surfaces of the bedrock in the Rochester plain show two sets of striae (Fairchild, 1923). The direction of the most prominent set varies between S 40° W to S 60° W. Another and less outstanding set of glacial markings display a radiating direction perpendicular to the Pinnacle Range. West of the Genesee River the latest ice movement was S 5° W to S 15° W as shown by the striations (Fairchild, 1923). Striations recently observed in a new exposure in the city of Rochester (see Trip 1A, Stop 1) have the unexplained and anomalous bearing of S 70° E.

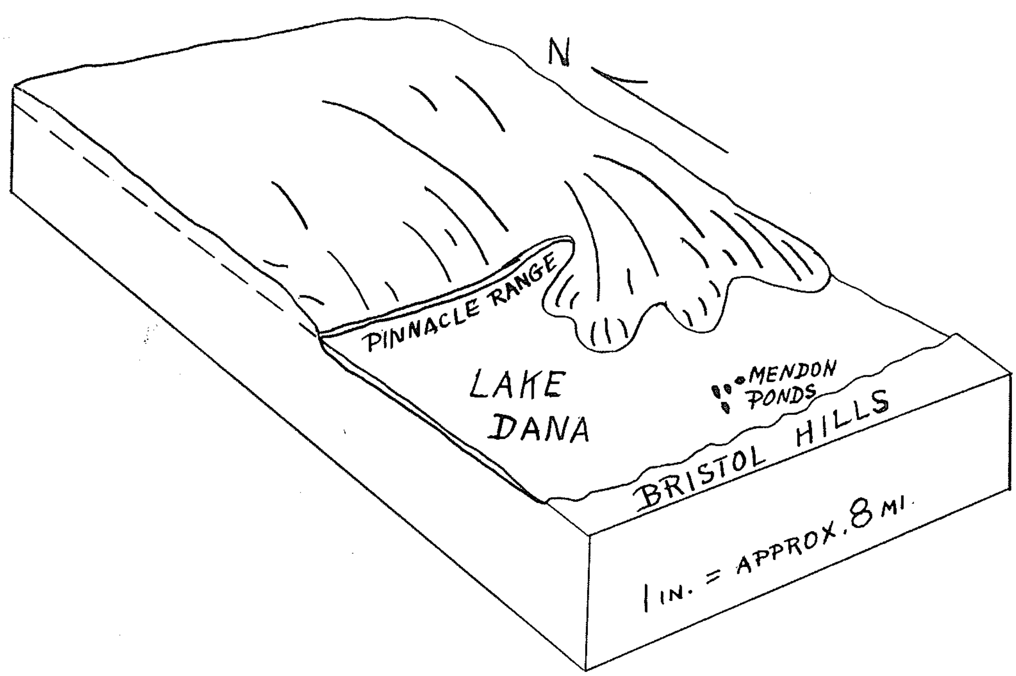
The two-lobe or interlobate hypothesis.--Close to Mount Hope Cemetery a subdued till ridge extends in a direct course south to Henrietta. Taylor (1924) indicates the ridge as the marker for the ice border which protruded as a lobe south-southwest out of the Irondequoit Valley (see accompanying diagram). According to Taylor (1924) the Irondequoit lobe formed a southern ice wall to the Pinnacle Range. Although the till ridge does exist, there is some question as to when it was built relative to the formation of the Pinnacle moraine. Thick clays and silt deposits behind and in front of the ridge are attributed to Lake Dana deposition.

The interlobate interpretation has been put forth on the basis of the form and distribution of the hills, the ice contact deposits on both sides of the range, the considerable height of the range relative to its width, and the drift ridge which extends southward from the west end of the Pinnacle Hills (Taylor, 1924). It is hoped that sedimentological studies now under way may throw additional light on the origin of the hills.



FORMATION OF PINNACLE RANGE

SINGLE LOBE THEORY



FORMATION OF PINNACLE RANGE

INTERLOBATE THEORY

D. ECONOMIC GEOLOGY

SALINA SALT

History.--Salt production in New York State is known to have begun soon after the Revolution. In 1788 operations began at Salt Point (now the village of Salina) for evaporating salt from brine secured from a shallow excavation. The first operations involving the mining of rock salt were begun in 1881 at Wyoming, Wyoming County. The deposits of salt in this locale are reported to have been 70 feet thick, below 1270 feet of rock cover. In short succession rock salt was found at Warsaw, Rock Glen, Silver Springs, Gainesville, and Bliss. In the Genesee Valley the original well was drilled in 1882 near the present location of the Retsof Mining Company's operations.

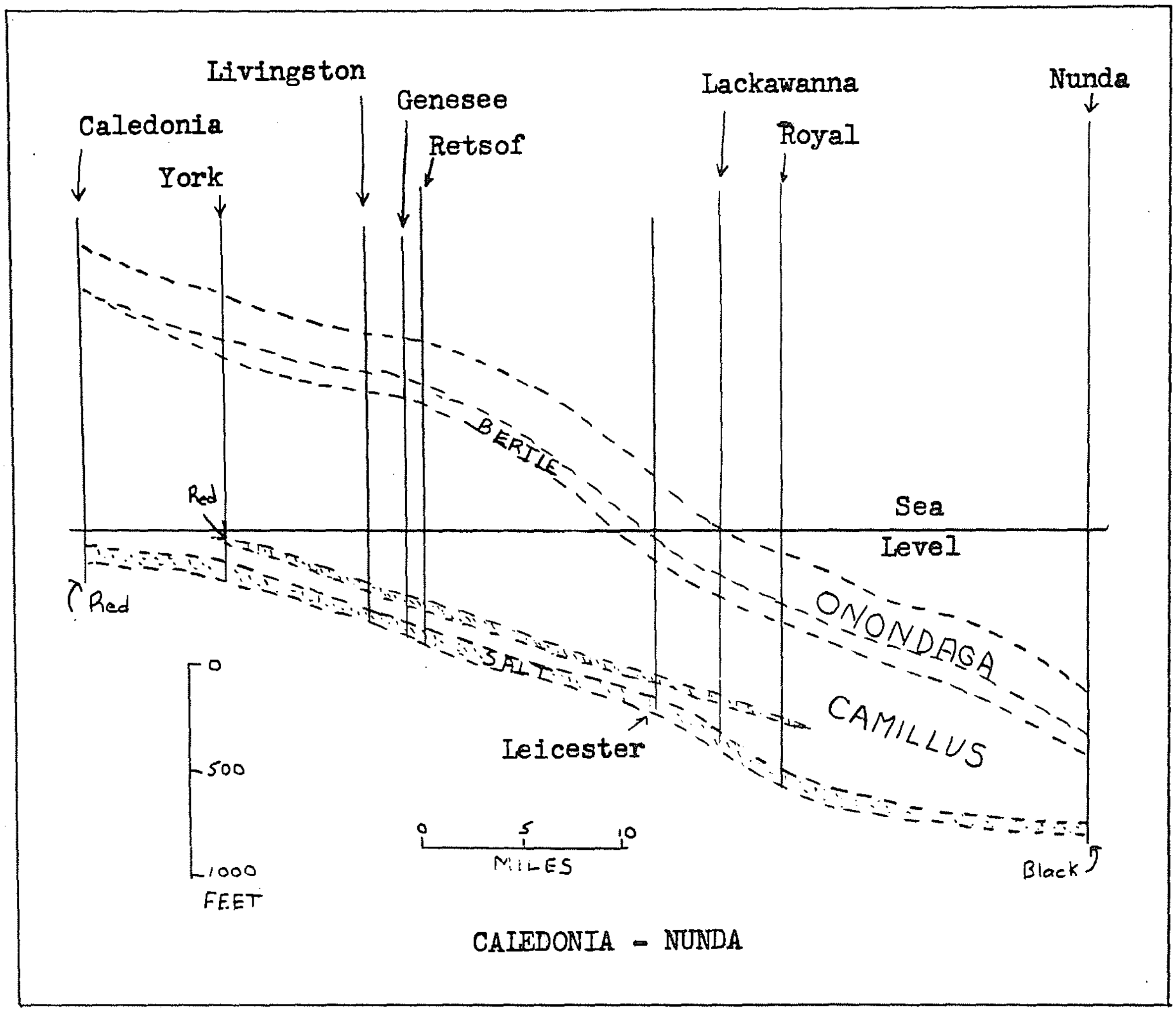
Subsurface mining of salt began in the Genesee Valley in 1888 under the supervision of the Retsof Mining Company, about 20 years after the discovery of the first occurrence of rock salt was reported in New York. The original shaft at Retsof was begun in 1884, completed in 1885, and put down to a depth of 1063 feet. Other mines were soon opened at Greigsville just west of the Retsof shaft by the Greigsville Mining Company; south of LeRoy by the Lehigh Mining Company; by the Livonia Mining Company at Livonia, Livingston County; all of these were in operation for a time but are now abandoned. The last mine to be opened was at Portland Point, Tompkins County, in 1917.

The past 50 years has witnessed a general readjustment of the business through the abandonment of those operations that were less favorably situated with respect to production, markets, and shipping facilities. In 1939 the list of manufacturers included only six companies as compared to 30 or more that were in operation in 1905.

Lithology and distribution.--Halite, gypsum, and anhydrite are known to occur in the Salina beds of New York and Michigan. In New York the width of outcrop of the Salina beds at Niagara is 12 miles. The belt extends eastward across the state and at the foot of Cayuga and Seneca Lakes is about 20 miles wide. The salt mines and brine plants are located south of this belt. As the salt is very soluble it can not be found in surface exposures and can be reached only by shafts and wells.

At Vernon, the type locality of the Vernon shale, the formation is a purple-red shale with occasional gray-green layers and spots. The base of the formation is decidedly greener, containing alternating beds of bright green, purple-red, and mottled green and red shales. The New York Geological Survey places the rock salt at the top of the Vernon and includes the salt in this formation. However, Alling (1928) has demonstrated that the salt at the top of the Vernon occurs in several distinct layers and is interbedded and closely associated with the Camillus type of sediment. Due to lack of precise paleontologic evidence, Alling has concluded: "that when the sediments become anhydritic magnesian lime mud rocks or marlites of brownish to grayish color with veinlets of saline material, we pass from the Vernon into the Camillus phase of sediments" (p. 23).

The crude rock salt that occurs at or near the contact between the Vernon and the Camillus formations is composed of 96 to 98 percent of well crystallized halite. Impurities in the rock salt are anhydrite, sylvanite, polyhalite, carnallite, pyrite, quartz, feldspar, hornblende and leucoxene. Above and below



Geologic cross section of the New York State salt field, south from Caledonia to Nunda. After Alling, 1928, p. 69.

the mine horizons the rocks become more anhydritic and pass into magnesian lime-mud rocks streaked with veins of halite. It is in these beds that the rare saline minerals are concentrated.

The name Syracuse salt has been used by the New York State Survey as a formational unit to denote the salt horizons between the Vernon and the Camillus. Alling (1928, p.26) has proposed that: "...the multiplicity of salt beds, their lithological and probable genetic association with the Camillus type of rock render(s) the name of doubtful value in any detailed stratigraphic discussion." He goes on to place the Syracuse salt in the Camillus formation.

All through the Camillus, calcium sulphate occurs in veins and plumose masses. Beneath the surface the calcium sulphate takes the form of anhydrite. At the outcrop it is always the hydrous form, gypsum. The mineable anhydrite zones are from 50 to 150 feet below the base of the Bertie. The calcium sulphate occurs as lenses and not as distinct beds. The lenses may be as large as 1 mile along the strike and invariably pinch and swell.

The accompanying diagram is a geologic section of the New York field south from Caledonia to Nunda. This section illustrates some of the more interesting aspects of Salina stratigraphy and affords a closer look at some of the more important wells and mines.

Immediately beneath the Onondaga are anhydritic shales of the Camillus formation which illustrate the Onondaga-Bertie unconformity. In the York well the Bertie is present and a 10-foot bed of red shale is found at the base of the Camillus, illustrating Alling's contention that red beds in the Camillus are more common than generally believed.

Most reliable data have constantly been derived from the Retsof shaft. Here, beneath the Bertie, is an anhydritic layer 47 feet thick while in the Greigsville shaft just west of Retsof, the corresponding layer is 75 feet thick. This, very nicely, illustrates the lenticular nature of the anhydritic masses. A single bed of halite in the Caledonia well, 25 feet thick, becomes two beds in the wells to the south. The uppermost bed in the Retsof shaft is the only bed that has ever been worked in the Retsof mine, and is only 9 feet thick. In the abandoned Leicester well, the upper bed is 4 feet thick and the lower bed is 28 feet thick. The two beds are separated by 3 feet of shale.

The relations change markedly at the Royal and Nunda wells. Only one bed of salt is recorded, 35 feet thick. It is assumed that this is the upper bed. The salt is underlain by 85 feet of black shale — a most interesting fact when the red Vernon shale was believed to directly underlie the salt.

Origin.--Usiglio has demonstrated in the laboratory (fide Alling, 1928) that the simple evaporation did not reproduce salt deposits similar to those found in New York. Experiments of this nature lack three important constituents: (1) long periods of time, (2) extensive changes in temperature during deposition, and (3) pressure and heat due to overburden. This pressure and heat would furnish the conditions for reactions between the original salts. Two salts placed in solution may yield, upon crystallization, double salts in addition to four simple salts. The list of salts that can possibly be derived from the evaporation of sea water and subsequent changes due to heat and pressure is accordingly very great. Alling (1928) furnishes the evidence to verify these theoretical considerations by indicating that there may be as many as 40 salts present in the New York Salina.

Many thories have been postulated to explain the origin of these deposits. Among these are: (1) the complete evaporation of an arm of the sea, (2) the partial evaporation of an isolated arm of the sea, (3) a desert basin isolated from the sea, and (4) a desert basin periodically refilled by the influx of the sea through a narrow channel. Grabau (1909) does not favor theories involving the complete evaporation of a body of sea water cut off from the ocean. He reasons that this would result in a series of deposits that would contain gypsum beneath the halite and that in order to explain the extreme thickness of New York salt deposits there would have to be periodic influxes of sea water which would carry normal marine faunas (or at least their remains) and they would be preserved.

The following is proposed as a possible series of events which would lead to Salina deposits as now observed (after Alling, 1928):

The Michigan and New York basins are separated by a lack of continuity of the salt and the Camillus is thinner where it rests upon the Ontario barrier between the two basins. The Vernon is interpreted as river-accumulated clays and muds. Above the salt the Camillus muds were deposited in shallow lagoons and extensive playa lakes with an occasional influx of sea water.

The two basins became separated through tilting and uplift. Salt and associated saline minerals were deposited toward the base of the Camillis under desert conditions. The salt itself may have had a number of sources: (1) influx of sea water over a bar, (2) influx of sea water through a narrow channel in such a barrier, and (3) from rivers carrying salt in solution. The order of precipitation of these deposits was interrupted by new and periodic supplies of sea water. As the two basins were filled by the Camillus, the barrier between the two basins was covered and the Camillus was deposited as a continuous series of sediments in the two basins.

CLINTON IRON ORE

History.--While the hematite ores of the New York Clinton are not now of economic importance as a source of either iron or paint pigment, they were worked with only a few interruptions since the early part of the nineteenth century. A mining lease was granted in Oneida County as far back as 1797 and a small quantity of ore was shipped from Wayne County for use in the War of 1812.

At the turn of the last century production averaged about 75,000 tons per year. The aggregate at the time was placed at from 4,000,000 to 5,000,000 tons by Newland and Hartnagel (1908). The ore has been removed exclusively by open pit mining except at Clinton, New York. The mines at Clinton furnish the only example of underground exploitation of hematite in the state. The ore seams at these mines are from 30 to 36 inches thick.

Distribution.--The eastern and western limits of the several beds of hematite, which occur at a number of horizons through the Clinton group, are somewhat indefinite. At Rochester, the extreme westerly point where the ore is known, there is a single bed of hematite 14 inches thick, the Furnaceville iron ore member of the Reynales formation. This bed is a continuation of the bed which stretches across Wayne County and was formerly mined at Ontario Center, 15 miles northeast of Rochester. West of Rochester, there are not many good exposures of the Clinton until the Niagara gorge is reached. Here the ore is missing and the entire Clinton thins to approximately 40 feet.

To the east the hematite ore can be traced as far as the Oneida-Herkimer County border. From Clinton to the town of Frankfort, Herkimer County, a distance of only 9 miles, the ore body thins from 36 inches to 10 inches. The bed disappears entirely following the strike to the southeast across Herkimer County. The ore either lenses out or else grades into a non-commercial ferruginous sandstone.

The area around Clinton has been the principle source of ore in the past. There are two seams here: an upper fossiliferous layer and a lower oölitic bed. The fossiliferous seam is not used as ore for it is considered too lean to be used in the furnace. The oölitic body has an average content of 40 percent.

Origin.--Hall (1843) recognized that the hematite at Rochester replaced a multitude of fossil types. He postulated that the iron was derived from pyrite, which in turn replaced the fossils. Other workers advocating a replacement origin for the ore have suggested (a) replacement by hematite, (b) replacement of oölitic limestone by siderite which was then converted to hematite, (c) replacement by limonite which in turn was converted to hematite, and (d) replacement by pyrite which later altered to hematite. The replacement hypothesis usually implies that concentration of iron compounds in the original sediment was not marked but that ground water circulation was responsible for the concentration and enrichment of the iron and the replacement of an original calcareous deposit.

Still other possibilities have been proposed for the origin of these ores. The ore bodies may represent original hematitic deposition. McCallie (1908) postulated an original chamosite or glauconite deposit subsequently oxidized to hematite. Smyth (1911) proposed a primary deposit of limonite which by dehydration and oxidation was changed to hematite.

The ore bodies extend for approximately 150 miles across the state of New York. In the west the beds are associated with limestones and are termed "fossil ores". In the east the slightly more siliceous ores are associated with siliceous limestones and calcareous siltstones, and are called "oölitic ores". The two rarely occur together, but as indicated above, the two do occur at Clinton and here the "oölitic" ore is used in preference to the "fossil" ore. In Rochester the Furnaceville iron ore is essentially a "fossil ore" and contains sufficient calcite to effervesce with dilute hydrochloric acid.

An intensive study of the origin of the Clinton iron ore was made by Alling (1947). He found that hematite was the principal mineral constituent and that turgite and goethite are also present in small amounts. Hydrotroilite, melrikovite (ferrous sulphides), chamosite and pennite, glauconite and francolite are other minor constituents. Calcite and quartz are the important cementing minerals and the latter has "enlarged" the clastic quartz grains.

Alling also refines the miners' terms "fossil" and "oölitic" ores. He defines three types of ore: the western type, characterized by a high calcite content; the eastern type or "oölitic" ore; and a western oölitic ore. The carbonate in the western oölitic ore is partly fossil fragments which form the nuclei of the oölites. In the eastern oölites the nuclei are well rounded quartz fragments which Alling believes are partially rounded by chemical attack of the iron bearing solutions.

According to Alling the ores are primary and were formed during the diagenesis of marine limestones in the presence of solutions containing abundant iron compounds. The ferrous iron compounds that may have been so formed were subsequently oxidized to the ferric condition and largely dehydrated. The oölitic structures are related to an end stage introduction of siliceous compounds that formed chamosite. The chamosite and the hematite formed the oölites in "thin onion skin layers". If the nuclei of the oölites were fossil fragments the "western type" of oölite was formed. If the nuclei were quartz grains, then the "eastern" type of oölite resulted.

OIL AND GAS

The oil pools in New York State cover about 60,000 acres and are found in an area some 54 miles long and 12 miles wide, extending along the New York-Pennsylvania line. Parts of Allegany and Steuben counties are included, with the largest number of wells in Allegany County. The Bradford and Chipmunk pools have been the most productive in the state.

There has been no production of petroleum in Monroe County; however, potential source beds of petroleum and natural gas are important rock types in the area. Moreover, the shales which could conceivably serve as source beds are often closely associated with porous and permeable sandstones, limestones, and dolomites.

The northward up-dip migration of petroleum has been demonstrated in many of the formations in the region. At the Williamsville Quarry, Erie County, the Oriskany sandstone contains hydrocarbon-saturated Favosites (Hamilton, 1937). The residual content of this material is approximately the same as that of the Oriskany oil found in Allegany County. Platt (1949) describes a "strong bituminous" odor in the higher stratigraphic horizons of the Lockport dolomite. Examination of core samples extending in a 15 foot zone from 45 feet below the top of the formation indicates that this is the area of greatest concentration of the petroliferous residues. In this zone the core takes on a more porous character as seen in the development of solution cavities. This same horizon is also much more fossiliferous, containing Bryozoa and brachiopods replaced by silica and dolomite. Platt suggests that this porous and permeable horizon of the Lockport served as a reservoir bed for petroleum and that some, if not all, of the petroleum has been lost by the northward, up-dip migration to the surface. The Canadian partial correlative of the Lockport, the Guelph dolomite, has produced oil (Williams, 1919) and the possibility exists that there may still be sufficient petroleum in the Lockport to warrant further investigation.

The Geneseo black shale has long been known for its strong petroliferous odor. The black shales of the Hamilton and the Portage groups of Middle and Upper Devonian age, respectively, are postulated to be the most likely source beds in the area by Willard and Stevenson (1950). The thick section of Upper Devonian clastics could conceivably act as excellent reservoir beds.

There has been some gas production in Monroe County. The Churchville gas field in the town of Riga, Monroe County, produced gas for a number of years from shallow wells in the Medina at depths of 400 to 500 feet. In the town of Chili a test well was drilled into the Medina in 1932 by the Hammondsport Natural Gas Company. The well had a flow of 12,000 cubic feet daily at a depth of 540 feet. A deep well, sunk in the city of Rochester, at the turn of the century, was drilled for a depth of 3000 feet into the Precambrian basement but did not find gas or oil. Another well drilled in nearby Henrietta in 1933 reached a depth of 2025 feet without finding gas or oil.

GROUND WATER

By far the best quality and largest quantity of ground water in Monroe County is derived from the stratified drift that occurs in the buried preglacial stream valleys. A number of test wells in the buried preglacial Genesee Valley have yielded from 150 to 600 gallons of water per minute. This water averages less than 200 parts per million in hardness and is a calcium carbonate water. Some of the shallow wells in the drift may contain as much as 400 parts per million of calcium sulphate.

Upper Devonian clastics cropping out south of Monroe County yield moderate amounts of water. The youngest formation that is exposed in Monroe County, the Marcellus shale, is of little importance as a source of water. The underlying Onondaga, on the other hand, yields moderate quantities of water to wells on the Onondaga escarpment. It is often high in calcium carbonate content, with an average of 405 parts per million.

In the Salina group the Akron dolomite facies of the Cobleskill is unimportant as a source of water; moderate supplies are obtained from the underlying Bertie. The shaly layers of the Camillus are impermeable, but the salt bearing layers near the surface have been leached and the resultant cavities provide good opportunity for the accumulation and circulation of ground water. The Vernon shale also yields moderate supplies of ground water, ~~but~~ as is generally the case with the Camillus, the water is often of poor quality, salt and sulfur reported in most of the supplies derived from these formations. The Pittsford shale is of no importance as a water-bearing horizon.

Joints, enlarged bedding planes, and solution cavities permit circulation and the storage of ground water in several horizons in the Lockport dolomite. Other than the glacial drift, the Lockport is the best water bearing horizon in Monroe County. Sandstone beds at the top of the Rochester shale or at the base of the Lockport are important water bearing horizons. The lower shaly facies of the Rochester is generally barren.

The Clinton beds below the Rochester shale as a rule are not good sources of water. However, in some wells the Irondequoit and the Reynales have been identified as water bearing horizons.

The sandstone layers in the Medina sandstone, as well as some of the sandstone layers in the Queenston shale, have produced some water of poor quality. Both formations contain small amounts of salt and deep wells ending in either of the formations often produce salt water.

STRATIGRAPHIC SUCCESSION — GENESEE VALLEY

	Series	Group	Formation	Member
DEVONIAN	Upper		Wiscoy flags and sh. Nunda ss. Gardeau flags and ss. Grimes ss.	
		Naples	Hatch ss. and sh. Rhinestreet bl. sh. Cashaqua sh. Middlesex bl. sh.	
		Genesee	West River sh. Genundewa ls. at base Geneseo bl. sh.	
	Middle	Hamilton	Moscow formation	Leicester marc. Windom sh. Kashong sh. Menteth ls.
			Ludlowville formation	Deep Run sh. Tichenor ls. Ledyard-Wanakah sh. Centerfield ls.
			Skaneateles formation	Levanna ls.
			Marcellus formation	Stafford ls. Oatka Creek bl. sh.
	Lower or Middle		Onondaga limestone	Moorehouse member Nedrow member Edgecliff member
SILURIAN	Upper		Cobleskill formation	Akron dol. fac.
			Bertie waterlime	
			Salina formation	Camillus facies Vernon facies
			Pittsford shale	
	Middle	Lockport-Guelph	Lockport dol.	
		Clinton	Rochester sh. Irondequoit ls. Williamson sh. Sodus sh.	
			Reynales ls.	Upper member Furnaceville iron ore Brewer Dock. ls. mem.
			Maplewood sh. Thorold ss.	
	Lower		Grimsby ss.	
ORD	Upper		Queenston sh.	

PART II - ITINERARIES

Friday, May 4, 1956

FIELD TRIP NO. 1A -- Silurian Stratigraphy; Geomorphology.

Trip 1A-1 begins at U of R River Campus and ends at Seneca Park. Turn to page 75 for beginning of detailed itinerary.

Trip 1A-2 begins at Seneca Park and ends at U of R River Campus. Turn to page 79 for beginning of detailed itinerary.

Both trips travel the same route and will make the same stops, but in reverse order.

The two stops on this trip will afford an opportunity to study the classic Lower and Middle Silurian stratigraphic section of the Rochester area. The route to and between the stops passes many features related to the glacial history of the region (see pp. 47-60) and to the history of the Genesee River (see pp. 5-8).

Penfield Quarry of the Dolomite Products Co.

Stop 1 of Trip No. 1A-1 -----------Stop 2 of Trip No. 1A-2

The Lockport dolomite is a hard, dark gray, dolomitic limestone, with considerable quantities of disseminated argillaceous matter. A fine to coarse sugary texture and strong petroliferous odor when struck with a hammer are characteristic. The formation is about 180 feet in total thickness, of which about 42 feet are exposed in the quarry wall. The Lockport underlies much of the city of Rochester. It has been used as a building stone but weathers with moderate rapidity. The sometimes fantastically shaped and sculptured blocks resulting from solution by subsurface water are commonly used for ornamental stonework in local gardens. Commercially the rock finds its greatest value today as crushed stone, for which it is quarried in two large quarries operated by the Dolomite Products Company just outside of Rochester, and by smaller concerns at other localities along its outcrop belt.

Bedding is massive; fossils occur in some layers but are not usually well preserved. Solution cavities and stylolites are common. In the upper levels of the Penfield quarry many of the secondary cavities are filled with crystallized dolomite and other minerals; small fissures may be filled with sphalerite, gypsum, or galena, and residual hydrocarbons occur. For greater detail see comments under Field Trip No. 3C; on that trip there will be opportunity to collect from blocks of the mineral-bearing strata.

Rochester Gorge of Genesee River

Stop 2 of Trip 1A-1 ----------- Stop 1 of Trip No. 1A-2

Exposures along private road to Rochester Gas and Electric Company power plant, and in banks of Genesee Gorge.

Bedrock.--Exposures in the new road cut extend from the Queenston shale to the Reynales limestone (Clinton group). Strata above the Reynales, up to the basal few feet of Rochester shale are exposed in the gorge wall below the Hawk-Eye plant of Eastman Kodak Company.

The contrasting lithologic types exposed in the road cut exhibit a variety of sedimentary features reflecting diverse environments (see pp. 9-15). The accessible section here is not generally fossiliferous; beds of Pentamerus coquina provide the best collecting possibilities.

The thin Thorold sandstone forms the lower falls of the Genesee at the power plant, just south of Driving Park Avenue bridge. The middle falls, a short distance farther upstream is formed by the Reynales limestone. The upper falls, not visible from this locality, is over beds in the lower part of the Lockport dolomite.

The accompanying stratigraphic section is based on exposures in this vicinity.

Gorge.--The river gorge here (200 feet deep at this point) is a result of post-glacial erosion. The pre-glacial course at this latitude lay several miles to the east in what is now the valley of Irondequoit Bay and Creek. See page 5 for river history.

Unconsolidated material.--Above the Silurian strata in the upper portion of the road cut are exposed four distinct types of unconsolidated materials with a cumulative thickness of approximately 25 feet and length of exposure of 200 feet. The exposure of these deposits is bounded on the northeast by a graded slope and on the southwest by an undisturbed vegetative covering. The exposure strikes N60°E.

N.85°E.

Lowermost of these unconsolidated units at the heads of the road cut is a 4- to 5-foot layer of reddish till lying on striated and highly polished Reynales limestone. Striations on the limestone surface strike S75°E, an anomalous direction for this region. The red till contains striated and well worn pebbles with relatively little sharply angular material. Components of the till range in size from small boulders to clay sized particles; no stratification is apparent. The materials are extremely fresh without visible alteration of any type. Fabric studies of this till show a distinct northwest-southeast preferred orientation of the long-diameter of pebbles.

This unit of unconsolidated sedimentary material extends from the head of the road cut for a distance of 120 feet toward the southwest. At this point it terminates abruptly against Sodus shale, the next stratigraphic unit above the Reynales Formation.

Immediately overlying the red till and in marked contrast to it in the northwest portion of the sequence is approximately 10 feet of highly modified, bouldery material in a jumbled mass. Percolating ground water solutions have altered or disintegrated all types of rock and material, coating and replacing material with various iron oxides. Contained within this unit at a point 100 feet from the head of the cut is a lens or nest of stratified sand 8 feet wide and with a maximum thickness of 2 feet. Any other primary textural or structural modifications within this unit have been destroyed by the alteration of the material. This altered material bevels across the red till-shale contact and, in part, lies directly on the Sodus shale.

At a point about 110 feet southwest along the exposure another type of material wedges in below the highly weathered sediment and overlies the Sodus shale. This is a brown sandy unit containing blocks of limestone and other coarser material along with small lenses and stringers of sand. Weathering of this material has been limited to various stages in the alteration and disintegration fragments into patches of yellow-brown residium. Thickening of this member increases to the southwest at the expense of the highly altered material which correspondingly pinches out in the same direction.

Lying above and again sharply contrasting with the underlying material is 10-15 feet of ashy rubbish exposed throughout the cut. This represents the remains of a city dump. The thickness of this material lessens to the southwest; solutions from it may, in part, account for the alteration of the underlying material.

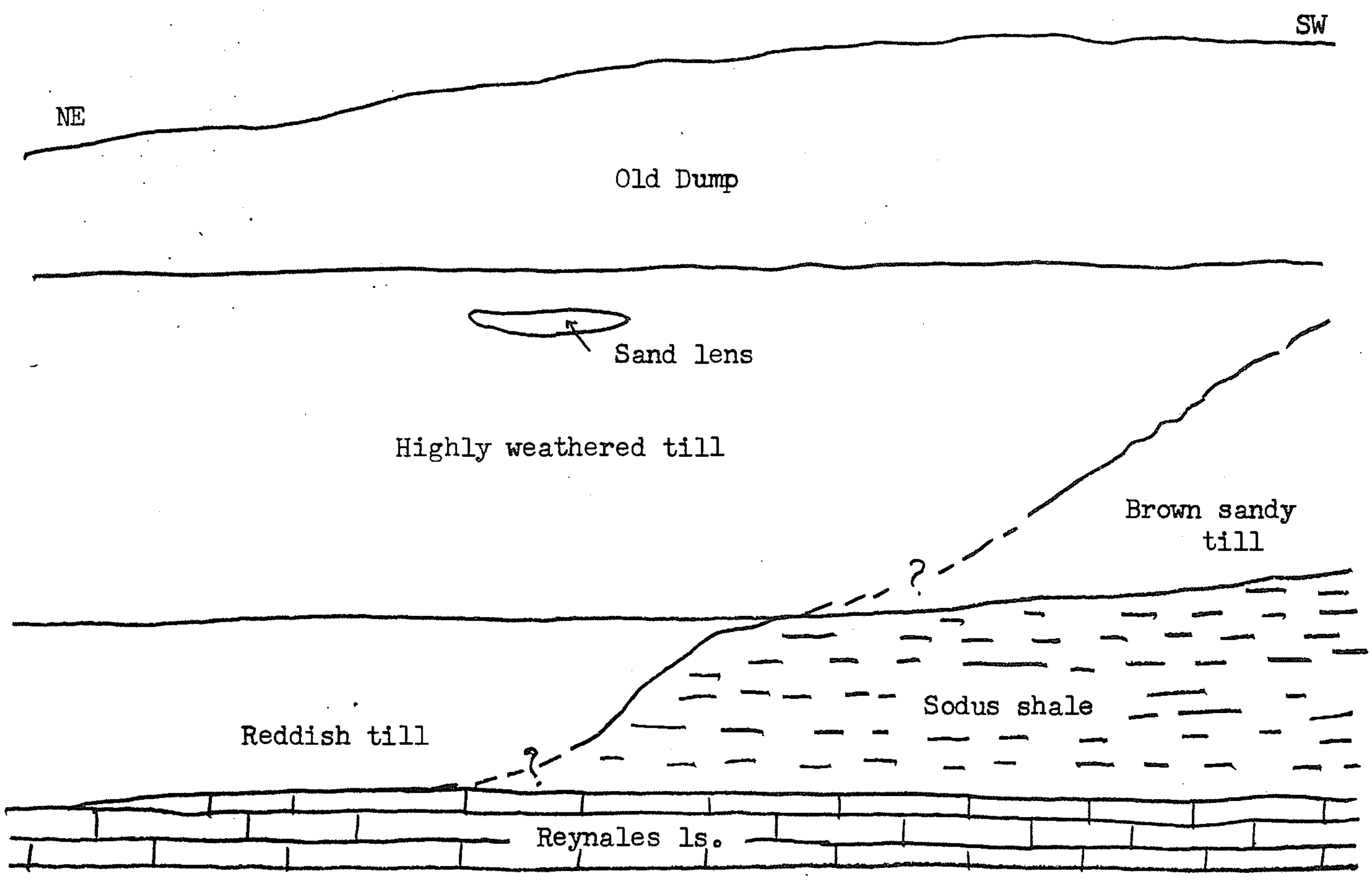
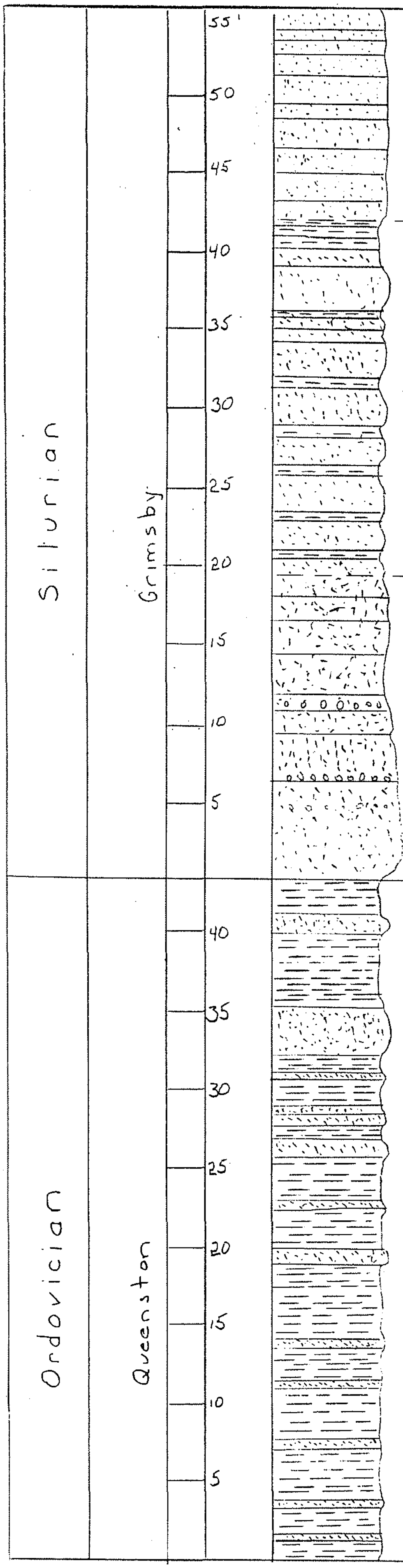


Diagram showing relationships of bed rock, till, and recent dump material at uphill end of exposed section along Rochester Gas and Electric Company road

Measured Section — Rochester Gorge



Thick-bedded, mottled, red and gray alternating sandstones and siltstones with minor shale layers.

Rapidly alternating thin-bedded red and gray sandstones and siltstones with more prominent red and green shale layers than above. Arthrophycus and Daedalus.

Thick-bedded coarser red and gray sandstones, with minor siltstones and shale.

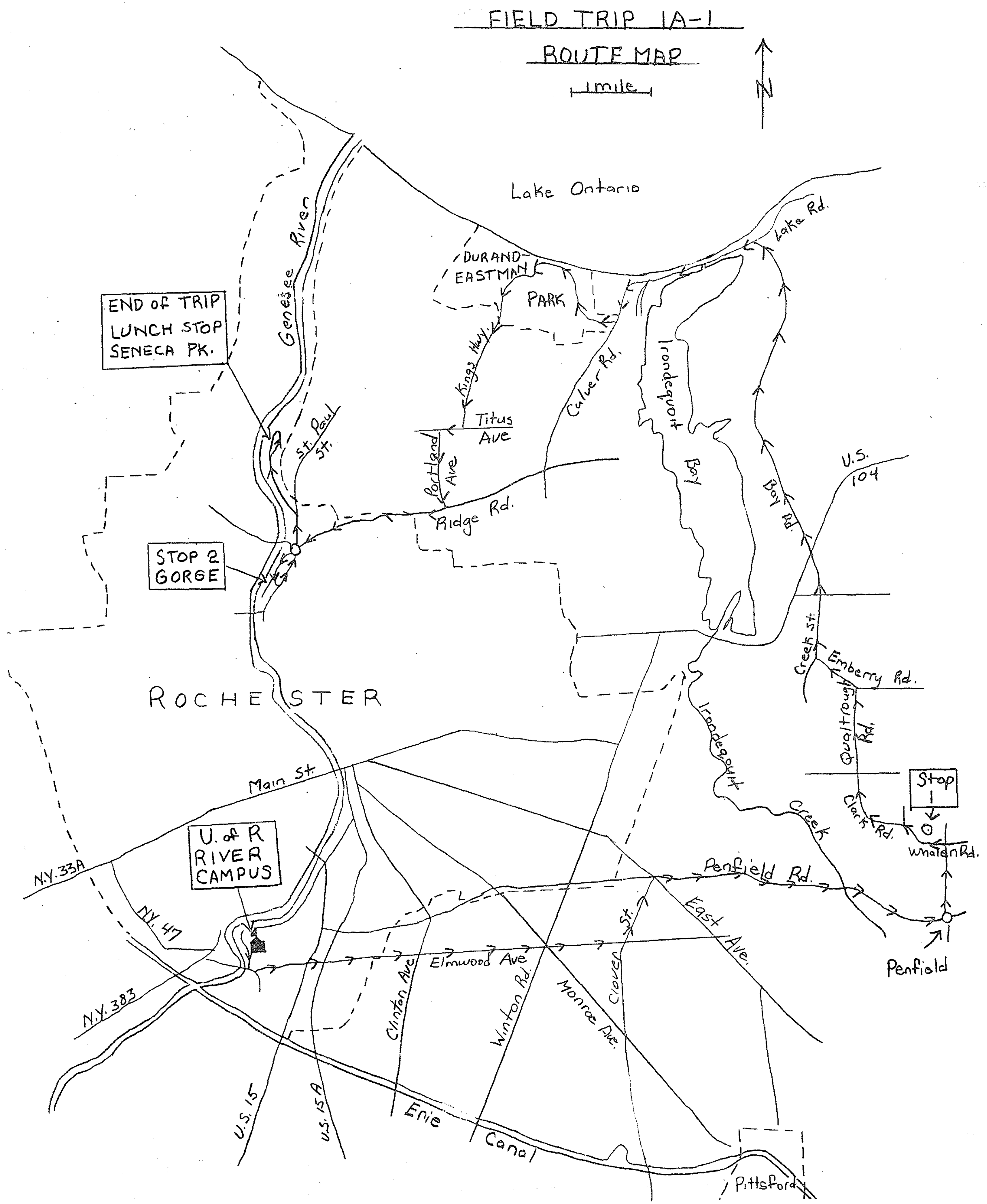
Alternating thin-bedded, earthy, red shale and siltstone. Some heavy red sandstone layers near the top. Several thin green shale layers. Ripple marks, mud cracks, and ice-crystal imprints present.

Base of section

Measured Section — Rochester Gorge

Top of section

System	Formation	Thickness	Scale	Remarks	Description
Silurian	Lockport	180'			Sugary, gray, massive dolomite, in places argillaceous.
	Rochester	85'			Dark bluish-gray shale. Basal 10 feet brownish-gray. Some very calcareous layers. Fossils very abundant.
	Irondequoit		15', 10'		Light-gray crystalline limestone with few shale partings. Upper part contains reef-like bodies.
			5'		Crystalline ls. interbedded with dark grayish-green shale layers. Limestone layers thicker at top.
	Williamson		5'		Dark grayish-green fissile shale. Basal 2 feet of thin black layers containing abundant graptolites.
				hiatus	
	Lower Sodus		10', 5'		Greenish-gray shale with many thin <u>Coelospira</u> limestone layers. Dark gray or purple shale with green increases toward base. Contact sharp.
	Upper Reynales		10', 5'	← Limit of exposure in new road cut	Light-gray crystalline limestone, lower part thinner bedded. Many shale partings increasing in thickness toward base. Several argillaceous limestone layers containing chert. Several <u>Pentamerus</u> layers.
	Furnaceville		1'		Furnaceville iron ore
	Brewer Dock		2', 1'		Light and medium gray limestones separated by shale partings.
	Maplewood		15', 10', 5'		Smooth, platy, green, in part calcareous shale. Few thin limestone layers. Phosphate zone at base.
	Thorold				Gray sandstone. Very hard and well cemented.


FIELD TRIP IA-1
ROUTE MAP
1 mile
N
Lake Ontario
Genesee River
DURAND-EASTMAN PARK
Lake Rd.
END of TRIP LUNCH STOP SENECA PK.
Kings Hwy.
Titus Ave
Portland Ave
St. Paul St.
Culver Rd.
Irondequoit Bay
Bay Rd.
U.S. 104
Ridge Rd.
STOP 2 GORGE
Creek St.
Emberry Rd.
Qualtrough Rd.
ROCHESTER
Irondequoit Creek
Main St.
Stop 1
Clark Rd.
Whalen Rd.
U. of R RIVER CAMPUS
N.Y. 33A
N.Y. 47
Penfield Rd.
East Ave.
Clover St.
Elmwood Ave
Penfield
N.Y. 383
Clinton Ave
Winton Rd.
Monroe Ave.
U.S. 15
U.S. 15A
Erie Canal
Pittsford

TRIP 1A-1

U of R River Campus — Penfield Quarry — Rochester Gorge — Seneca Park

Miles	
0.0	Zero mileage (headed south) at River Boulevard entrance to main quadrangle of U of R River Campus. Erratic anorthosite boulder opposite entrance, with polished and striated surfaces, bears bronze tablet inscribed with "The Genesee", alma mater of the University of Rochester. Proceed south on River Boulevard. River here is in post-glacial course (see p. 8).
0.25	Elmwood Avenue (N.Y. 47). Turn left and pass under tracks of Lehigh Valley and Erie railroads.
0.35	Road fork. Bear left on Elmwood Ave. (N.Y. 47). For first 3.5 miles, route nearly parallels the Pinnacle Range (see p. 56) of kame moraine hills. Route is on outwash plain and lake beds. U of R Campus is on west end of range.
0.5	U of R Atomic Energy Project building to left (N); U of R Medical Center to right (S).
0.9	Mt. Hope Cemetery to left (N). Northwestern portion of cemetery, adjoining campus, is an area of spectacular kame and kettle topography.
1.1	Mt. Hope Ave. (U.S. 15). Keep straight.
1.4	View to left (N) of Pinnacle Range, now about a half-mile to the north.
1.8	Enter town of Brighton. Colgate-Rochester Divinity School on crest of Pinnacle Range to left (N).
2.3	Clinton Ave. Keep straight. Highest point on Pinnacle Range (749 feet) is just west of radio and telephone towers visible here to the left (N).
3.7	Winton Rd. (N.Y. 47 turns left). Keep straight.
3.8	Monroe Ave. (N.Y. 31). Keep straight. This is Twelve Corners, business center of Brighton.
4.45	Pass over Rochester subway, in abandoned bed of early Erie Canal.
4.75	Clover St. (N.Y. 65). Turn left (N).
5.5	Bear right (E) before intersection. Turn right (E) onto East Av. (N.Y. 64 and 96) and get in left lane.
5.6	Road fork at traffic light. Penfield Rd. (N.Y. 441). Bear left.
6.0	Pass under New York Central main line. Outcrops are Lockport dolomite showing characteristic pitted and pocketed surface weathering.
6.8	Enter Town of Penfield.
7.4	Begin descent into Irondequoit Valley.
7.8	Cross Irondequoit Creek.

Miles	
7.9	Flat bottom of Irondequoit Valley (elev. 270 feet). Valley is part of pre-glacial Genesee Valley (see p. 7) which here was filled with morainal debris and Lake Iroquois (see p. 54) sands, then re-excavated by post-glacial Irondequoit Creek. Bedrock, till and lake deposits are exposed at places along valley sides; local sand and gravel workings in glacial material and lake beds. Valley slopes marked by several terraces representing levels of Lake Iroquois. One terrace (at 400 feet) visible here forms flat valley rim.
8.75	Enter Village of Penfield.
9.0	Top of hill.
9.1	N.Y. 253. Turn left on Five Mile Line Rd.
9.6	View to left (W) to Rochester over Irondequoit Valley and in line with Pinnacle Range which is prominent elevation.
10.0	Stop sign, Whalen Rd. Turn left (W).
10.3	East entrance Penfield Quarry of the Dolomite Products Co. Turn in (right).
	STOP 1. --- Penfield Quarry. See page 69.
10.4	Leave west entrance Penfield Quarry. Turn right (W) on Whalen Rd.
10.6	Clark Rd. Turn left (W).
11.2	View to west of Rochester and Pinnacle Range.
11.3-17.3	Orchards here are part of extensive apple and peach belt south of Lake Ontario.
11.6	Stop sign. Browncroft Blvd. (N.Y. 286). Straight across onto Qualtrough Rd.
12.6	End of Qualtrough Rd. Turn left (W) on Emberry Rd.
13.2	Junction. Bear right on Creek St.
13.9	Stop sign. Plank Rd. Keep straight.
14.45	Empire Blvd. (U.S. 104). Cross obliquely onto Bay Rd.
15.0	Enter Town of Webster.
15.7	Ridge Rd. goes to right (E) on Lake Iroquois bar which is inconspicuous here. See mileage 25.5.
18.4	Stop sign. Lake Rd. (N.Y. 18). Turn left (W).
18.5	East end of barrier bar carrying road across mouth of Irondequoit Bay which occupies part of re-excavated pre-glacial Genesee Valley.

19.4 Cross outlet of Irondequoit Bay. Enter Town of Irondequoit.

19.5 Road fork, bear right, leave N.Y. 18. West end of barrier bar. Road becomes Culver Rd. at top of hill.

20.4 Traffic light. Turn right (W) on Durand Blvd. Enter Durand-Eastman Park. Enter City of Rochester.

Durand-Eastman Park, Rochester's largest public park, is in an area of glacial till veneered with Lake Iroquois deposits. The terrane has been dissected deeply by a number of small and closely spaced post-glacial streams which flow directly into Lake Ontario or into narrow inter-divide lakes now sealed from Lake Ontario by massive barrier bars. The Lake Ontario surface is at 246 feet. The crests of the divides increase gradually in elevation southward from about 300 feet a little south of the lake shore to 375 feet two miles farther south.

21.3 Road to left. Keep straight.

21.4 Public bath house to right (N). Two barred lakes south of road.

21.8 Road to left. Keep straight.

22.0 Two roads to left. Pass first, turn left (S) on second one (at top of hill).

22.6 Road fork. Bear left on Kings Highway.

22.6-24.0 Route follows narrow divide between steep-sided valleys. Note accordant divides (Lake Iroquois bottom) at about 375 feet.

22.8 Enter Town of Irondequoit.

24.3 Titus Ave. Turn right (W). Irondequoit town hall to right.

24.55 Portland Ave. Turn left (S).

24.55-25.5 Cross near-shore bottom of Lake Iroquois.

25.5 Ridge Road (U.S. 104). Turn right (W). Road is atop offshore bar of Lake Iroquois.

26.3 Hudson Ave. Keep straight.

26.6 Note lower ground to left (S), lagoon behind barrier bar.

26.7 Enter City of Rochester.

26.8 Seneca Ave. Keep straight.

27.0 Clinton Ave. Keep straight.

27.3 Stop sign. Traffic circle. Take third street to right (first one past bridge) where sign says "Norton St. Traffic Turn Here".

Miles	
27.75	Gateway to entrance to Rochester Gas and Electric Company private road to power plant. Park.
	STOP 2 --- Rochester Gorge. See page 69.
27.8	St. Paul St. Turn left (N).
28.2	Traffic circle. Keep on St. Paul St. (third street to right).
28.6	Turn left into Seneca Park. Bear right at road forks.
29.3	Parking area for Seneca Park Zoo.
29.6	Road fork. Bear right.
30.0	LUNCH STOP at park pavilions. END OF TRIP 1A-1.

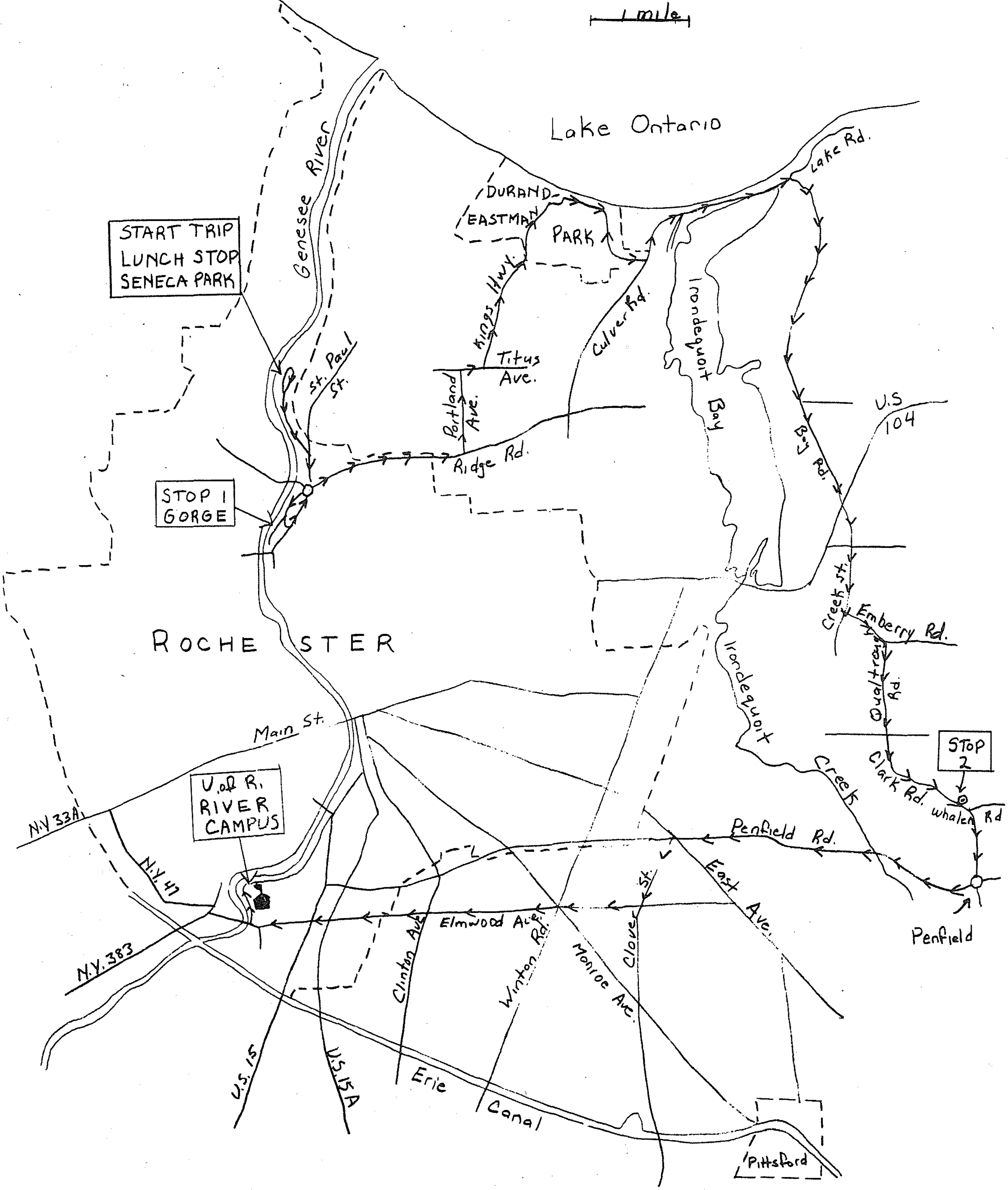
TRIP 1A-2

Seneca Park — Rochester Gorge — Penfield Quarry — U of R River Campus

Miles	
0.0	Leave lunch stop at Seneca Park pavilion area and proceed out of park, continuing south on St. Paul St. to traffic circle. Zero mileage at intersection with traffic circle. Take second street to right (first is bridge over gorge).
0.45	Gateway at entrance to Rochester Gas and Electric Company private road to power plant. Park.
	STOP 1 --- Rochester Gorge. See page 69.
0.5	St. Paul St. Turn left (N).
0.9	Traffic circle. Take second street to right, Ridge Rd. (U.S. 104). Road is atop ridge formed by barrier bar in glacial Lake Iroquois (see p. 54).
1.3	Clinton Ave. Keep straight.
1.5	Seneca Ave. Keep straight.
1.6	Enter Town of Irondequoit.
1.7	Note lower ground to right (S), lagoon behind barrier bar.
2.0	Hudson Ave. Keep straight.
2.8	Portland Ave. Turn left (N).
2.8-3.75	Cross near-shore bottom of Lake Iroquois.
3.75	Titus Ave. Turn right (E).
3.95	Irondequoit town hall to left (N).
4.0	Kings Highway. Turn left (N).
	Approaching Durand-Eastman Park, Rochester's largest public park. This is an area of glacial till veneered with Lake Iroquois deposits. The terrane has been dissected deeply by a number of small and closely spaced post-glacial streams which flow directly into Lake Ontario or into narrow inter-divide lakes now sealed from Lake Ontario by massive barrier bars. The Lake Ontario surface is at 246 feet. The crests of the divides decrease gradually in elevation from about 375 feet at Titus Ave. to about 300 feet a little south of the lake shore, in a distance of two miles.
4.3-5.7	Route follows narrow divide between steep-sided valleys. Note accordant divides (Lake Iroquois bottom) at about 375 feet.
5.5	Enter City of Rochester and Durand-Eastman Park.
5.7	Road enters from left. Keep straight.

FIELD TRIP IA-2

ROUTE MAP



Miles	
6.1	Road fork. Bear left.
6.3	Durand Boulevard. Turn right (E).
6.5	Road to right. Keep straight.
6.9	Public bath house to left (N). Two barred lakes south of road.
7.0	Road to right. Keep straight.
7.3	Road fork. Bear left.
7.9	Culver Road. Turn left. Enter Town of Irondequoit, leave Durand-Eastman Park.
8.8	After curving down hill, merge with N.Y. 18 which joins from right rear. For next mile route is on barrier bar across mouth of Irondequoit Bay which occupies part of re-excavated pre-glacial Genesee Valley. Enter Town of Webster.
8.9	Cross outlet to Irondequoit Bay.
9.8	East end of barrier bar
9.9	Bay Road. Turn right (S) up hill.
11.0-17.0	Orchards here are part of extensive apple and peach belt south of Lake Ontario.
12.6	Ridge Rd. goes to left (E) on continuation of Lake Iroquois bar east of Irondequoit Bay.
13.3	Enter Town of Penfield.
13.8	Empire Blvd. (U.S. 104). Cross obliquely onto Creek St.
14.4	Stop sign. Plank Rd. Keep straight.
15.1	Road junction. Emberry Rd. Turn left (E).
15.7	Road junction. Qualtrough Rd. Turn right (S).
16.7	Stop sign. Browncroft Blvd. (N.Y. 286). Straight across onto Clark Rd.
17.1	View to west of Rochester and Pinnacle Range of kame moraine hills (prominent hill above level skyline) across Irondequoit Valley. See page 56.
17.7	Whalen Rd. Turn right (S).
17.9	West entrance Penfield Quarry of the Dolomite Products Co. Turn in (left).

STOP 2 --- Penfield Quarry. See page 69.

Miles	
18.0	East entrance Penfield Quarry. Turn left (E) on Whalen Rd.
18.3	Five Mile Line Rd. (N.Y. 253). Turn right (S).
18.6	Enter Village of Penfield.
18.7	View to right (W) of Rochester and Pinnacle Range (prominent hill).
19.2	N.Y. 441. Turn right (W).
19.3	Begin descent into Irondequoit Valley.
20.4	Flat bottom of Irondequoit Valley (elev. 270 feet). Valley is part of pre-glacial Genesee Valley (see p. 7) which here was filled with morainal debris and Lake Iroquois sands. Then re-excavated by post-glacial Irondequoit Creek. Bed rock, till and lake deposits are exposed at places along valley sides; local sand and gravel workings in glacial material and lake beds. Valley slopes marked by several terraces representing levels of Lake Iroquois. One terrace (at 400 feet) visible here forms flat valley rim.
20.5	Cross Irondequoit Creek.
20.9	Top of hill after climbing out of valley.
21.5	Enter Town of Brighton.
22.3	Pass under New York Central main line. Outcrops are Lockport dolomite showing characteristic pitted and pocketed surface weathering.
22.7	Merge with East Ave. (N.Y. 64 and 96) at traffic light. Get in left lane to turn at next light.
22.75	Turn left (S) onto Clover St. (N.Y. 65).
23.55	Elmwood Ave. Turn right (W).
23.85	Pass over Rochester subway, in abandoned bed of early Erie Canal.
24.5	Monroe Ave. (N.Y. 31). Keep straight. This is Twelve Corners, business center of Brighton.
24.6	Winton Rd. (N.Y. 47 enters from right). Keep straight.
25.8-28.3	For last 3.5 miles, route nearly parallels the Pinnacle Range. Route is on outwash plain and lake beds. U of R River Campus is on west end of range.
26.0	Clinton Ave. Keep straight. Highest point on Pinnacle Range 749 feet) is just west of the radio and telephone towers visible here to the right (N).

Miles

26.5 Enter City of Rochester. Colgate-Rochester Divinity School on crest of Pinnacle Range to right (N).

27.2 Mt. Hope Ave. (U.S. 15). Keep straight.

27.4 Mt. Hope Cemetery to right (N). Northwestern portion of cemetery, adjoining campus, is an area of spectacular kame and kettle topography.

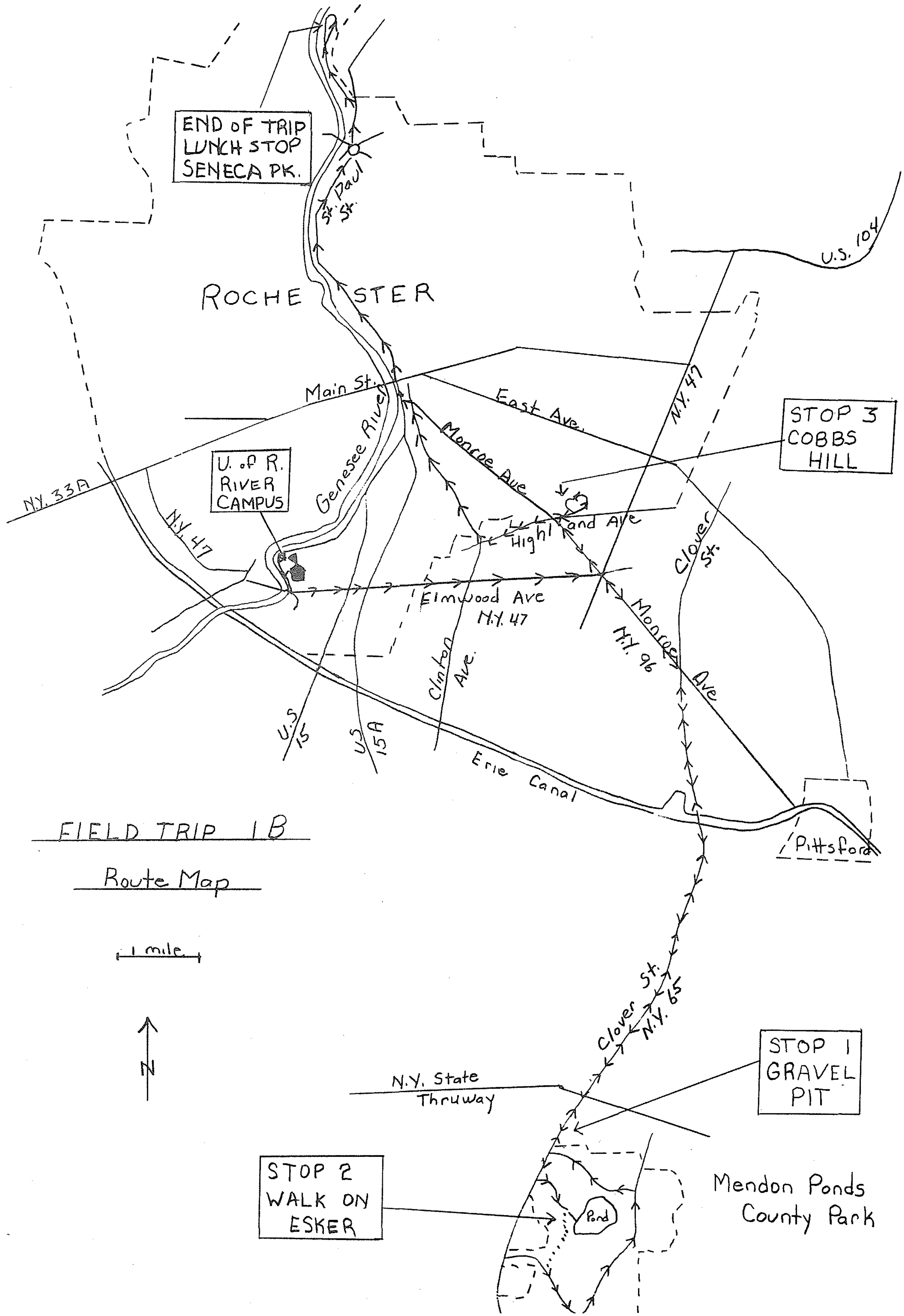
27.8 U of R Atomic Energy Project building to right (N); U of R Medical Center to left (S).

27.95 Bear right beneath tracks of Lehigh Valley and Erie railroads.

28.05 River Blvd. Turn right. Genesee River here is in post-glacial course.

28.3 Entrance to main quadrangle of River Campus. Erratic anorthosite boulder opposite entrance, with polished and striated surfaces, bears bronze tablet inscribed with "The Genesee", alma mater of the University of Rochester.

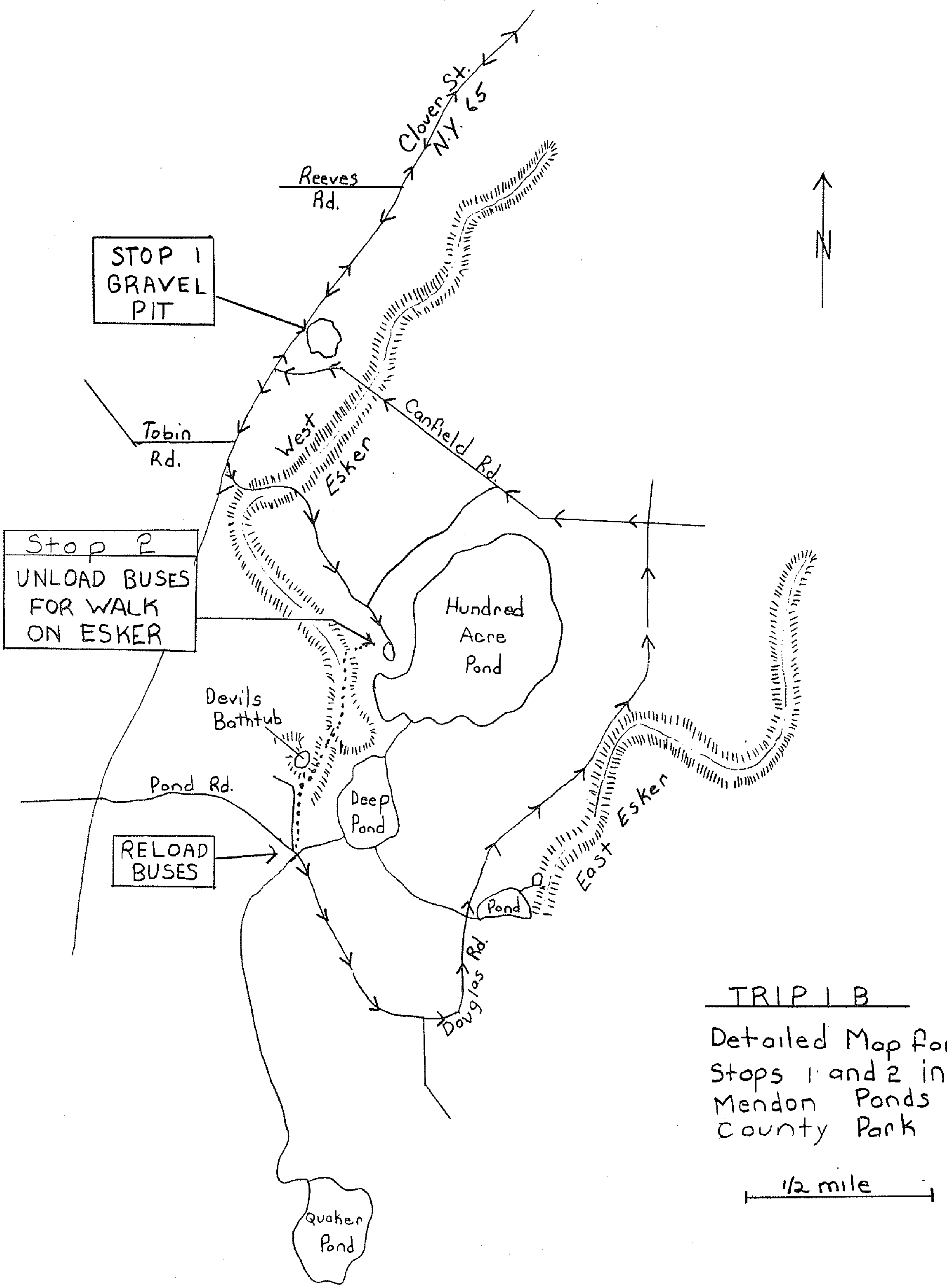
END OF TRIP 1A-2.


END OF TRIP
LUNCH STOP
SENECA PK.
St. Paul St.
ROCHESTER
U.S. 104
Main St.
East Ave.
N.Y. 47
STOP 3
COBBS
HILL
Monroe Ave
Genesee River
U. of R.
RIVER
CAMPUS
N.Y. 33A
N.Y. 47
Highland Ave
Clover St.
Elmwood Ave
N.Y. 47
Monroe Ave
N.Y. 96
Clinton Ave.
U.S. 15
U.S. 15A
Erie Canal
Pittsford
FIELD TRIP 1B
Route Map
1 mile
N
Clover St.
N.Y. 65
N.Y. State
Thruway
STOP 1
GRAVEL
PIT
STOP 2
WALK ON
ESKER
Pond
Mendon Ponds
County Park

TRIP 1B ----- Glacial Geology

Stops on this trip will be in the Mendon Ponds kame and kettle area (see p. 55) and on the Pinnacle Range of kame moraine hills (see p. 56). The trip ends adjacent to the post-glacial lower gorge of the Genesee River.

Miles	
0.0	Zero miles at River Boulevard entrance to main quadrangle of River Campus. Proceed south on River Blvd. River here is in post-glacial course.
0.25	Elmwood Ave. (N.Y. 47). Turn left and pass under tracks of Lehigh Valley and Erie railroads.
0.35	Road fork. Bear left on Elmwood Ave. (N.Y. 47). For first 3.5 miles, route nearly parallels the Pinnacle Range (see p. 56) of kame moraine hills. Route is on outwash plain and lake beds. U of R River Campus is on west end of range.
0.5	U of R Atomic Energy Project building to left (N); U of R Medical Center to right (S).
0.9	Mt. Hope Cemetery to left (N). Northwestern portion of cemetery, adjoining campus, is an area of spectacular kame and kettle topography.
1.1	Mt. Hope Ave. (U.S. 15). Keep straight.
1.4	View to left (N) of Pinnacle Range, now about a half-mile to the north.
1.8	Enter Town of Brighton. Colgate-Rochester Divinity School on crest of Pinnacle Range to left (N).
2.3	Clinton Ave. Keep straight. Highest point on Pinnacle Range (749 feet) is just west of radio and telephone towers visible here to the left (N).
3.7	Winton Rd. (N.Y. 47) turns left. Keep straight.
3.8	Monroe Ave. (N.Y. 31). Turn right (SE).
5.2	Clover St. (N.Y. 65). Turn right (S).
5.5	Enter Town of Pittsford.
6.7	Erie Canal Lock 32.
6.8	New York Central railroad branch line.
7.0	Jefferson Rd. (N.Y. 252). Keep straight; at fork beyond, bear right on N.Y. 65.
8.3	N.Y. 253 joins from left (E).
9.2	N.Y. 253 leaves to right (W). Note drumlins elongated parallel to N.Y. 65 both east and west of route.
10.3	Pass over New York State Thruway.



TRIP 1 B

Detailed Map for Stops 1 and 2 in Mendon Ponds County Park

Miles

10.6 STOP 1.— Gravel pit in kame moraine, exposing features typical of such deposits in this area. Lenses of sand and gravel show great variety of sedimentary features. The sediments are displaced along small normal faults in places. The gravel lenses tend to be cemented with calcareous material probably derived from pebbles and cobbles of Lockport dolomite. Most abundant pebbles are of red Grimsby sandstone; however, representatives of all formations of the local Lower and Middle Silurian section can be found. In addition there are Ordovician limestones (some fossiliferous) and crystallines from Canada.

10.9 Mendon Ponds County Park, Canfield Rd. entrance. Keep straight.

11.2 Mendon Ponds County Park, entrance. Turn left (E).

11.8 Road to left. Bear right.

12.0 Parking area. Buses will meet group on Pond Rd., at mile 14.2.

STOP 2 — In Mendon Ponds County Park are to be seen excellent examples of kame hills, kettles, eskers, and lakes and swamps in poorly drained morainal ground. For general glacial history see pages 47-60; for more specific comments on this park, see page 55.

There are two prominent eskers in the park, one east and one west of Hundred Acre Pond which is the largest of several ponds. The recognizable portion of the western esker extends, with only slight interruptions, for a little over two miles. The group will walk along about 0.3 mile of this esker, from a point behind (S) of the park buildings to a conspicuous kettle known as Devil's Bathtub, at which point the esker deposits fan out, apparently at the mouth of the stream responsible for the deposit.

12.2 Road to right. Bear left.

12.8 Clover St. Turn left (S).

13.7 Mendon Ponds County Park, Pond Rd. entrance. Turn left (E).

14.2 Dirt road up hill to left (N) to Devil's Bathtub.
Group will reboard buses here.

14.7 Swamp-filled depression to left (N) here continues north to Hundred Acre Pond.

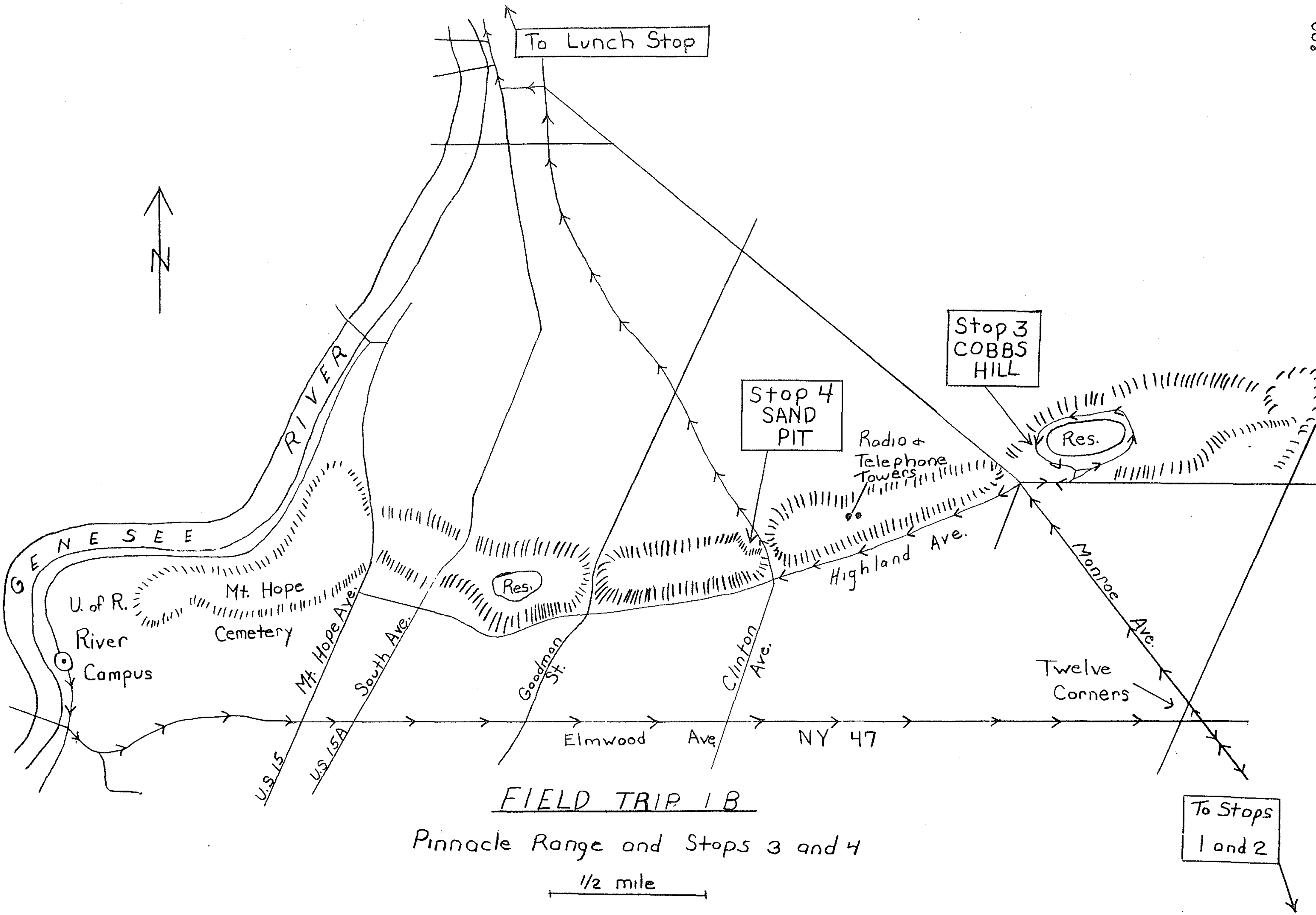
14.9 Pond Rd. turns to right. Keep left on Douglas Rd.

15.0-16.2 At sharp left curve begins extensive kame-kettle area east of Hundred Acre Pond depression.

15.3 Prominent water-filled kettle to right (E) of road.

16.0 Steep slope east (right) of route is eastern esker. Hundred Acre Pond to left (W).

16.6 Canfield Rd. Turn left (W).



FIELD TRIP 1B

Pinnacle Range and Stops 3 and 4

1/2 mile

Miles

17.5 Road crosses small swampy area here, then rises abruptly, cutting through the western esker at point about 0.8 mile north of where group climbed upon it at Stop 2.

17.7 Clover St. (N.Y. 65). Turn right. Follow N.Y. 65 to Monroe Ave. (N.Y. 31) retracing part of earlier route.

23.3 Monroe Ave. (N.Y. 31). Turn left (NW).

24.7 Elmwood Ave. Keep straight.

24.8 Winton Road (N.Y. 47). Keep straight.

25.6 Highland Ave. Turn sharply right (E).

25.7 Turn obliquely left up hill to Cobbs Hill Reservoir. Circle reservoir.

26.4 West end of reservoir.

STOP 3 — Cobbs Hill is the easternmost prominent hill of the Pinnacle Range (see p. 56). In clear weather an excellent view may be obtained from here. Water elevation 633 feet, about 130 feet above plain to north and south. Water in reservoir is from Hemlock Lake, about 30 miles south of Rochester. To south lie outwash plains and glacial lake beds, with occasional drumlins. Bedrock hills (Bristol Hills, Middle Devonian) rise in distance; Onondaga escarpment not prominent here. To north lies city of Rochester on thin veneer of lake beds and till above Lockport dolomite and Rochester shale. Lake Ontario in distance. To west Pinnacle Range continues toward U of R River Campus. Radio and telephone towers are on the Pinnacle, highest of the Pinnacle Hills, just east of summit.

26.7 Stop sign. Highland Ave. Turn right (W)

26.8 Monroe Ave. (N.Y. 31). Keep straight. Route follows along south foot of Pinnacle Range.

27.6 Clinton Ave. Turn right (N) up hill.

27.8 Turn left into ball park.

STOP 4 — Sand and gravel quarry in Pinnacle Range kame moraine. The lower part of the cut exposes uniform, well-sorted and stratified sands; bedding southwest at 25-28 degrees. At the upper part of the cut there is a thin covering of till, evidencing brief ice readvance after kame formation. Fabric studies of the orientation of the long axes of pebbles in the hill show, at the east end of the exposure, an 11% concentration with a plunge of 10 degrees and a southward strike, and at the west end, a dominant plunge of 20-25 degrees and strike concentration in the sector from S30°W to S15°E. The low ridge bordering the ball park on the northwest (old cemetery beyond the concessions stand) is also composed of till.

29.0 Cross Rochester subway in old Erie Canal bed.

Miles

29.2 Howell St. Keep straight.

29.3 Monroe Ave. Turn left (W).

29.4 South Ave. Turn right (N) and keep in right lane to go straight through next intersection.

29.7 Main St. Keep straight. South Ave. becomes St. Paul Street north of Main St.

30.1 Cross Cumberland St., bear left to go under New York Central overpass.

30.7 Pass between two major buildings of Bausch and Lomb Optical Company.

31.8 Avenue E. Hawk-Eye Works (camera mfgr.) of Eastman Kodak Company.

32.7 Traffic circle. Keep on St. Paul St. (third street to right).

33.1 Turn left into Seneca Park. Bear right at road forks.

33.8 Parking area for Seneca Park Zoo.

34.1 Road fork. Bear right.

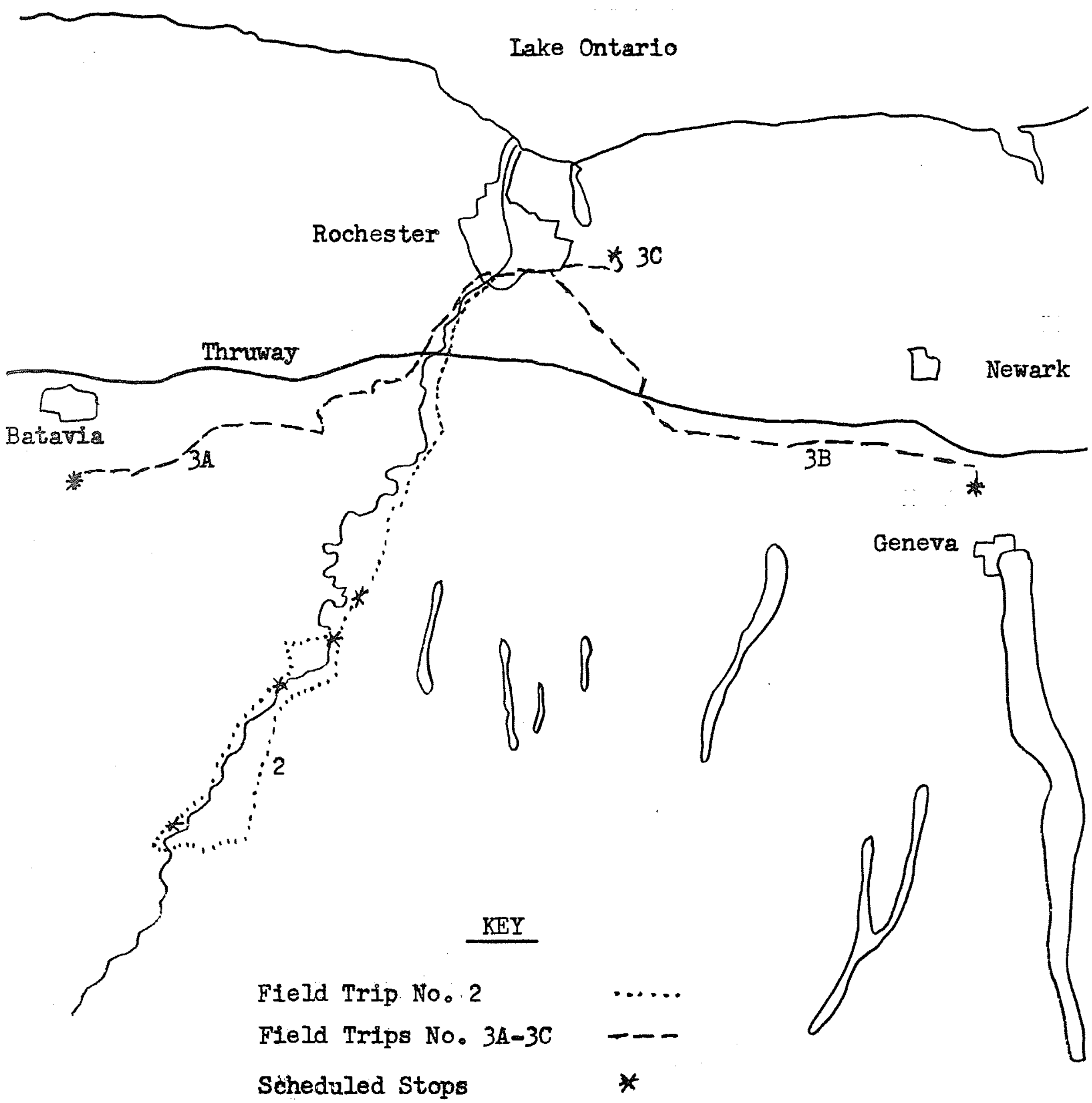
34.5 LUNCH STOP at park pavilions. Park is on east bank of lower gorge (post-glacial) of the Genesee River downstream from lowest falls. See pages 4-8.

END OF TRIP 1B

FIELD TRIP NO. 1C - TOUR OF KODAK PARK

Kodak Park, the main plant of the Eastman Kodak Company, is located at Ridge Road and Lake Avenue, a short distance west of the Genesee Gorge opposite Seneca Park. Buses will proceed from the lunch stop directly to Kodak Park via the Veterans' Memorial Bridge (Ridge Road, U.S. 104). After the tour, buses will return directly to the U of R River Campus.

ROUTES OF FIELD TRIPS NO. 2 AND 3A-3C



FIELD TRIP NO. 2 —— Devonian Stratigraphy; History of Genesee River

The route of this trip extends from the U of R River Campus southward, up the Genesee River Valley, about 50 miles to Letchworth State Park and return. The Genesee River will be seen in both its pre-glacial and post-glacial valleys, including the scenic gorge through Letchworth Park and its history reviewed (see pp. 4-8). Middle and Upper Devonian strata (see pp. 26-46) will be seen at four stops, with opportunity for fossil collecting in rocks of the Hamilton group at two of them. One stop will be a visit to the Mount Morris flood control dam.

Miles	
0.0	Zero mileage (headed south) at River Blvd. entrance to main quadrangle of U of R River Campus. Erratic anorthosite boulder opposite entrance, with polished and striated surfaces, bears bronze tablet inscribed with "The Genesee", alma mater of the University of Rochester.
0.25	Elmwood Avenue (N.Y. 47). Keep straight, enter Genesee Valley Park.
0.7	Bridge over Erie Canal. Junction of canal and Genesee River is 0.25 mile to the west.
0.8	Road fork. Bear left.
1.1	Road fork. Turn left out of park and then sharply right on East River Rd.
2.3	Road swings next to Genesee River. Enter Town of Brighton.
3.8	New York Central Railroad crossing and bridge.
4.2	Stop sign. Jefferson Rd. (N.Y. 252). Keep straight.
4.4	Drumlin to left. Route leaves river bank and crosses drumlin at 4.9 miles. A number of the drumlins in this area have wave-cut northern ends developed while partly submerged in glacial lakes (see p. 49).
6.3	Top of drumlin.
6.9	Top of drumlin
7.9	Pass over New York State Thruway.
8.1	N. Y. 253 joins from left (E).
8.3	N. Y. 253 leaves to right (W). Keep straight.
8.8	Erie Railroad crossing.
10.4	Two prominent drumlins to right (SW), one wooded.
10.7	Stop sign. Telephone Rd. Bear right.
10.8	Stop sign. Scottsville-Rush Rd. (N.Y. 251). Keep straight.

Miles

12.0 Railroad crossing.

12.7 Bridge over small stream.

12.8 Rush-West Rush Rd. joins from left. Turn right.

13.5 Road fork. Bear right.

15.7 Meander bend of Genesee River adjacent to road (right). Here route begins to follow pre-glacial valley of Genesee, now with broad flood plain developed on partial filling of glacier-transported debris. Just north of this point, pre-glacial course swung eastward along outcrop belt of soft Upper Silurian shales, and eventually turned northward again in line with present Irondequoit Valley (see pp. 5-8 and map on p. 4). Except for Irondequoit Valley, the pre-glacial valley north of this point is entirely filled with debris and is without surface expression; the course has been fairly accurately traced through water well records.

16.1 Enter Town of Avon.

16.6 Bridge across stream with outcrops of Onondaga limestone about 150 feet east of road. The Onondaga escarpment has no particular expression at this point because of local prominence of slopes into Genesee Valley.

17.1 Road fork. Bear right.

17.3 Enter Village of Avon.

18.15 Stop. Main St. (U.S. 20, N.Y. 5). Turn right (W). Cross Erie Railroad. Get in left lane for left turn.

18.2 Wadsworth Ave. (N.Y. 39). Turn left (S).

19.7 Bridge over Conesus Creek, outlet for Conesus Lake.

20.0 Begin ascent of east side of Genesee Valley. Good views to west (right) across valley. This is pre-glacial section between Mt. Morris and Avon (see p. 7).

24.1 Small bridge across north branch of Jaycox Run (Wheeler Gully). Road bends slightly right. Menteth limestone exposed in low falls immediately left (E) of road, also as one-foot bed at top of cut in stream bend to right. Shales in stream bend are Deep Run member, Ludlowville formation.

24.45 Falls, 40 feet high, over one-foot bed of Tichenor limestone about 400 feet west (right) of road.

24.7 Park on right (W) at gate opposite white house with white board fence.

STOP 1 - Jaycox Run.

Section exposed in stream bed 0.25 mile west of road is as follows:

Moscow formation | feet

Menteth limestone member - impure limestone, makes low falls	1

Ludlowville formation

Deep Run shale member - calcareous shale and thin argillaceous limestones	11
Tichenor limestone member - crinoidal limestone, fallmaker	1
Wanakah shale member - calcareous shale with thin limestones and prominent 1-foot limestone bed about 10 feet from top	49

Excellent fossil collecting in Deep Run shale and shales of Wanakah member. Crinoid columns conspicuous in Tichenor limestone; this is one of the "Encrinal" layers of early reports. See pp. 31-38 for stratigraphic details and faunal lists.

26.7 Currently operating shaft of Retsof mine of International Salt Company visible to west across valley.

This is reportedly the largest salt mine in the world. A single 9-foot layer of rock salt (in the Camillus facies of the Salina) is being mined at a level 1000 feet below the surface at the shaft. The face now being worked is about 2½ miles from the shaft. An area about 15 miles in circumference has been mined by the room and pillar system, leaving about 60% of the salt in pillars. Mining began in 1885 at a shaft 3 miles south of Retsof (see mileage 78.3). The shaft at Retsof was opened in 1920.

26.9 Enter Village of Geneseo.

27.3 Bear left onto Main St. at caution blinker.

27.8 South St. (U.S. 20A). Turn right (W).

27.9 N.Y. 63. Turn left. After turn, good overlook of valley to west.

28.7 Road fork. Keep straight on N.Y. 63; U.S. 20A and N.Y. 39 leave to right.

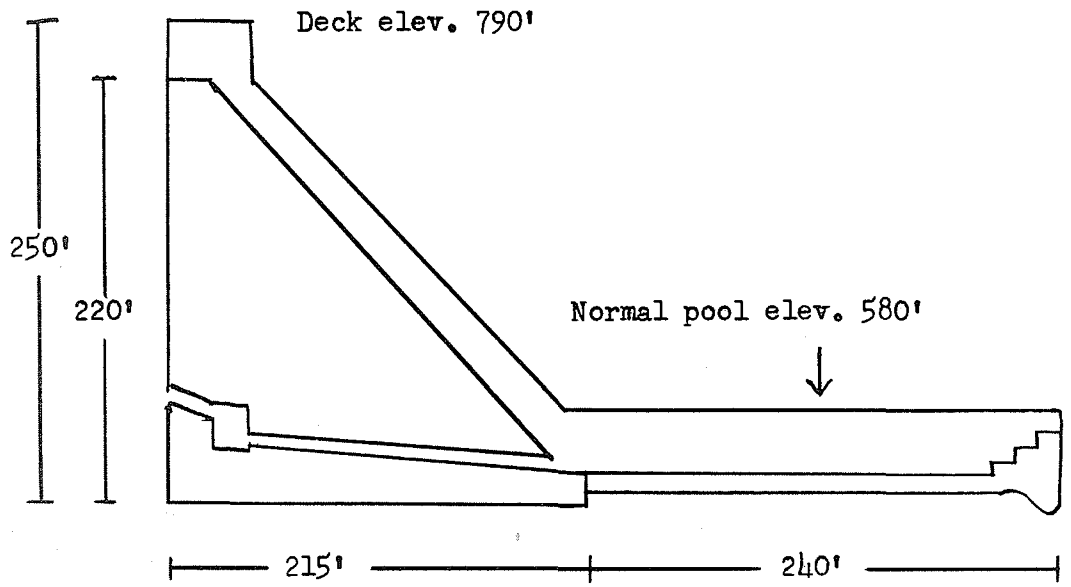
29.3 Fall Brook to right (W). Lower end of valley will be Stop 4, this trip. Falls is over Genundewa limestone at base of West River formation (see p. 41).

30.7 Breech in west wall of Genesee Valley, visible in right (W) distance across valley and just to right of water tower and smokestack, is debouchure of post-glacial Genesee from Mt. Morris canyon (see p. 7).

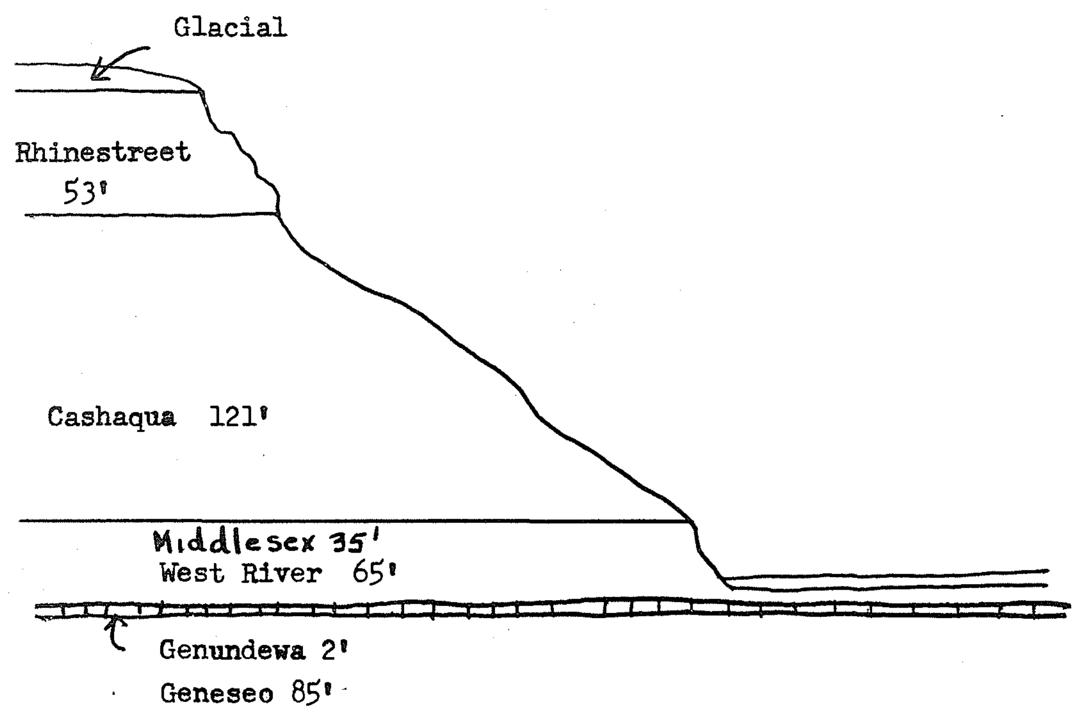
31.6 Road fork. Bear right on N.Y. 408. Sign pointing to Mt. Morris.

32.1 Bridge over Canaseraga Creek, the misfit stream presently occupying wide Dansville Valley (see p. 5). Route here begins to cross wide flat

Diagrammatic Cross Section of Mt. Morris Dam



Stratigraphic Section in Gorge Wall at Dam Site



Middlesex black shale — black shale with a few thin beds of gray shale; resistant, conspicuous blocky jointing; fossils very rare 35

Miles

floor of this valley, originally cut by pre-glacial Genesee, then deepened by ice-gouging and partly filled with rock debris and lake deposits.

33.6 Delaware, Lackawanna and Western Railroad.

33.9 Route climbs from valley floor; cross railroad. Enter Mt. Morris.

34.1 Main St. (N.Y. 36). Turn left, then right again, following N.Y. 408.

36.0 Side road, sign to Mt. Morris Dam. Turn right.

37.1 Overlook of Mt. Morris canyon to left.

37.8 Sharp left turn.

37.9 Circle at dam overlook and turn into parking area.

STOP 2 — Mt. Morris Dam

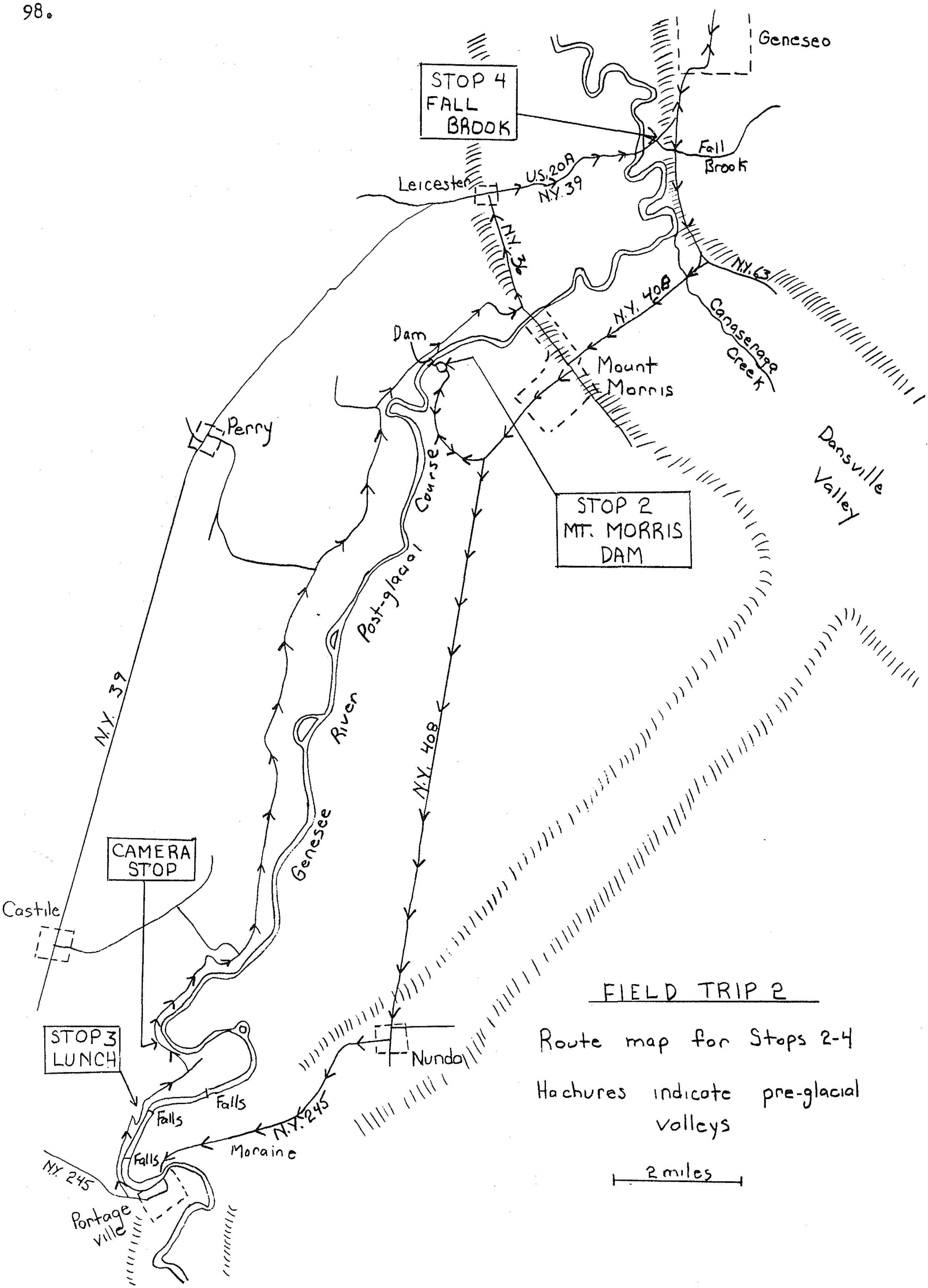
Built by Corps of Engineers, completed 1951. Purpose: flood control. Concrete construction using filler of crushed Onondaga limestone from General Crushed Stone Company quarries at LeRoy (20 miles north) and sand from glacial lake delta just north of gorge (see mileage 73.8). Total length of dam: 1028 feet, length of spillway: 550 feet. Drainage area above dam: 1077 sq. mi., maximum reservoir area: 3300 acres. Capacity at spillway elevation: 337,000 acre feet. The base of the dam rests upon the Genundewa limestone at the base of the West River shale (see p. 41). The section exposed in the gorge is as follows:

	feet
Glacial cover	
Rhinestreet black shale — laminated, fine-grained shale, making buttresses at gorge rim	53
Cashaqua formation — gray-green shales and thin siltstones, easily weathered and making the long slope of the gorge wall	121
West River shale — dark, thin-bedded shale at foot of gorge, only part exposed	65

The Rhinestreet and Cashaqua and the contact between the two are excellently exposed in the cuts of the road leading down to the deck of the dam.

39.9 N.Y. 408. Turn right.

42.2-
42.6,
45.0 To the southeast (left front) can be seen the broad Dansville Valley extending into the distance and, to the right of it, in front of the high ground, the Nunda Valley which was cut by the pre-glacial west



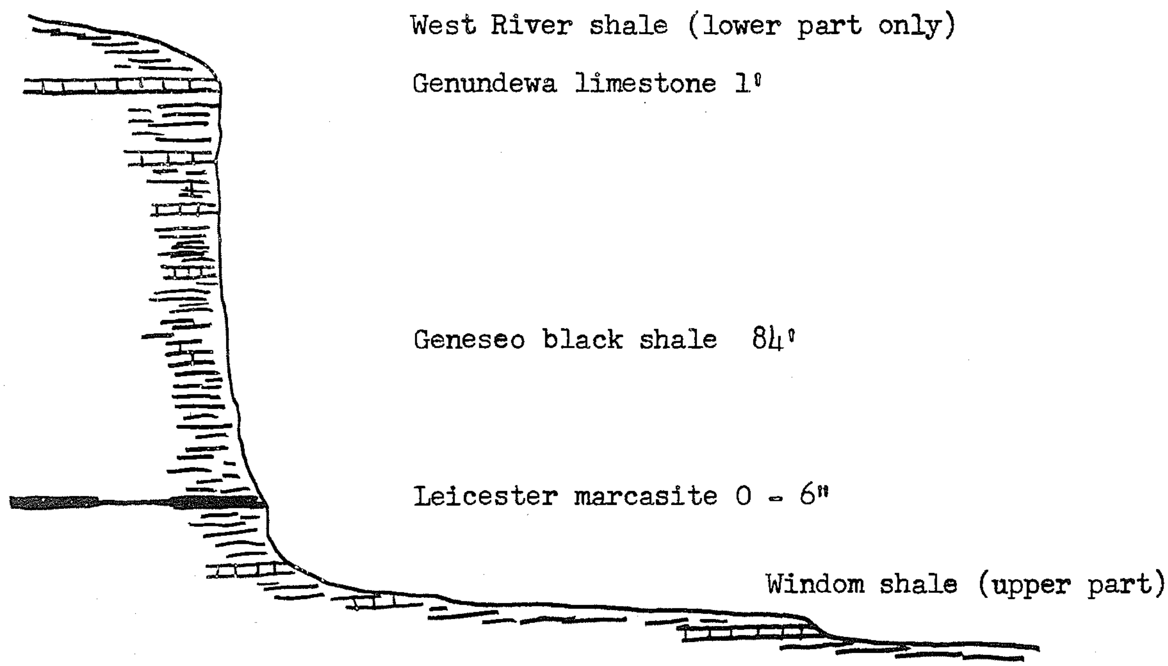
FIELD TRIP 2

Route map for Stops 2-4

Hachures indicate pre-glacial valleys

Miles	
	branch of the Genesee and is now occupied by misfit Keshequa Creek. See pages 4-7.
45.2	N. Y. 258 joins from left (E).
47.0	Begin descent into Nunda Valley.
48.2	Pennsylvania Railroad.
49.0	Enter Village of Nunda.
49.05	N.Y. 245 joins from left.
49.4	Stop sign. Portage St. Turn right, following N.Y. 245.
50.6	Keshequa Creek, misfit stream to left of route.
51.1-51.7	Locks of abandoned canal constructed to carry river traffic from Portageville to Mt. Morris via the Nunda Valley, around post-glacial gorge section of present Genesee River. Canal operated 1852-1877. Lock walls are constructed of Nunda sandstone (see p. 45); typical gray-green flagstone blocks.
51.8	Begin to ascend morainal dam which blocked Genesee from pre-glacial Nunda Valley. Route crosses moraine from here to Portageville.
52.2	Road fork, Junction N.Y. 351. Bear right on N.Y. 245.
54.3	Pass under Erie Railroad.
54.6	Descend slope of Portageville moraine into pre-glacial Genesee Valley. Good view of valley to left (S).
55.2	Bridge over Genesee River. River elevation 1100 feet.
55.3	Enter Village of Portageville. Turn right on N.Y. 245.
55.5	Railroad overpass. To north (R) Genesee River can be seen where it leaves broad pre-glacial valley and enters narrow post-glacial gorge section.
55.6	N.Y. 19A joins from left. Turn right, following N.Y. 245.
55.9	Portageville entrance to Letchworth State Park. Turn right (N).
56.3	Erie Railroad bridge across gorge. Uppermost of three falls in gorge just north of bridge (height 71 feet) fallmaker in basal Nunda sandstone (see p. 7). Roadcut exposures are Nunda.
56.9	Side road. Sharp right turn down hill.
57.1	Parking area. LUNCH STOP. - Stop 3.
	This flat area is a small terrace bench between the middle and upper falls. The middle falls, highest of the three in Letchworth Park, drops 107 feet. Fall maker is resistant layer in Gardeau formation (see p. 45). The lower falls will not be visited.

Fall Brook — Diagrammatic Section



Miles	
57.4	Good view of middle falls as route ascends hill.
57.6	Rejoin main road through park. Keep right.
57.8	Roadcut outcrops of Nunda sandstone. Bronze tablet to James Hall.
57.9	Side road and Civil War obelisk.
58.6	Park administration building to right. Bear left at road fork ahead.
59.3	Gorge overlook. Camera stop. Gorge wall is Gardeau formation.
61.2	Wolf Creek.
61.8	Side road to Wolf Creek entrance.
68.3	Side road to Smoky Hollow entrance.
70.0	Road cut to right exposes glacial lake sands.
71.5	Sharp curve to left.
71.7	Junction. Turn sharply right.
72.9	North overlook of Mt. Morris Dam is to right.
73.8	Excavations in small delta built into glacial lake filling Genesee Valley (elev. about 800 feet). Some of sand for dam concrete obtained here.
74.3	Sharp right turn.
74.6	N.Y. 36. Turn left (N). Genesee River leaves gorge section and re-enters wide pre-glacial valley 0.25 mile south of this point. Road route now follows along west edge of valley to Leicester.
76.0	Pass over Delaware, Lackawanna and Western Railroad.
77.0	Stop sign. U.S. 20 and N.Y. 39. Turn right. Village of Leicester.
77.2	In east bank of stream (Little Beards Creek) a quarter-mile north of here is type section of Moscow formation of Hamilton group.
78.3	Sharp right turn in Cuylerville. To left, after making turn, can be seen abandoned shaft head buildings of the International Salt Company mine. Only a small ventilator shaft operates here now; active shaft is about 3 miles to the north.
	Route now crosses flat floor of broad Genesee Valley.
79.9	Genesee River.
80.3	Park just past abandoned buildings on right.

STOP 4 — Fall Brook.

This is the type section of the Geneseo black shale (village of Geneseo just to the north) and also affords excellent exposures of the overlying Genundewa and West River and the underlying Leicester marcasite and Windom shale members of the Moscow formation. See pages 35, 39.

The more calcareous layers of the Windom are richly fossiliferous; some large concretions occur. The Moscow-Geneseo contact is marked by the thin but unusual Leicester marcasite which has a Hamilton fauna described as dwarfed or interpreted to consist of small fossils as a result of sorting (Loomis, 1903; Tasch, 1953). Where the lenses of Leicester are absent, the contact is marked by iron staining. The conspicuous laminated bedding and smooth jointing of the Geneseo contrast with the less regular structures of the Windom. The Geneseo is almost unfossiliferous. Large blocks of the fall-making Genundewa limestone show its characteristic lithology; most blocks are replete with the pteropod (?) Styliolina fissurella.

80.6 Geneseo black shale with limestone bands and layers of concretions in road cuts.

80.8 Junction N.Y.63. Turn left. Route from here back to U of R campus follows course of start of this trip from 0.0 to 28.7 miles.

81.0 Road fork. Keep straight. N.Y. 63 leaves to left (W).

81.6 Right turn.

81.7 Main St., Geneseo. Turn left, following N.Y. 39.

Continue on N.Y. 39 to Avon.

91.3 Main St., Avon (U.S. 20, N.Y. 5), Turn right; get in left lane for left turn after crossing railroad.

91.35 Turn left at foot of hill.

96.7 Curve to right. Then turn left.

98.7 Stop sign. Scottsville-Rush Rd. Keep straight.

98.8 Road fork. Bear left on East River Rd.

105.3 Stop sign. Jefferson Rd. (N.Y. 252). Keep straight.

107.2 Road swings away from river bank.

108.1 Stream bridge.

108.25 Turn left into Genesee Valley Park. Bear right.

108.8 Erie Canal bridge.

109.2 Elmwood Av. (N.Y. 47). Keep straight.

109.5 Quadrangle entrance, River Campus

END OF TRIP 2

FIELD TRIP NO. 3A — Hamilton Stratigraphy and Fossil Collecting

Exposures of the Ludlowville formation will be visited in an area south of Batavia. The Centerfield member here is prolifically fossiliferous and the relationships of the other Ludlowville members (except the Deep Run) are clearly shown across the Clarendon-Linden monocline.

Miles	
0.0	Zero mileage, River Blvd. entrance to main quadrangle of U of R, River Campus, as for previous trips.
0.25	Elmwood Ave. (N.Y. 47). Turn right over Genesee River bridge.
0.5	N.Y. 383 (Plymouth Ave.) joins from right. Cross railroad tracks.
0.7	Follow N.Y. 383 to left onto Scottsville Rd.
1.1	Erie Canal
1.8	Rochester-Monroe County Airport to right.
3.0	N.Y. 252 joins from right. Bear left.
3.1	Pass over railroad.
3.8	New York Central Railroad branch line crossing and bridge.
4.2	N.Y. 252 leaves to left over steel truss bridge.
6.3	Road swings away from Genesee River. Ascends Dumpling Hill, a drumlin whose northeast end is truncated by the Genesee.
8.8	Pass under New York State Thruway.
9.2	Pass over railroad.
10.1	Turn right (W) on North Rd. at beginning of settlement (Scottsville). Now over Upper Silurian; no exposures.
10.7	Railroad crossing.
11.4	Scottsville-Chili Rd. Keep straight. Several gravel pits in glacial material to left after crossing.
14.0	Wheatland Center Rd. Turn left (S).
14.5	Stop sign. N.Y. 383. Turn right (W). Wooded drumlin at left after making turn. Behind (S of) drumlin is shallow gypsum mine in Upper Silurian. Plant visible at 15.3 miles.
16.9	Turn left (S) at triangular junction. N.Y. 36 joins from right.
17.1	Oatka Creek bridge. Creek here runs west-to-east along south edge of outcrop belt of soft Upper Silurian shales. Rise of ground just south of creek in Onondaga escarpment, here supported by waterlimes above Salina shales and by lower part of Onondaga limestone.

Miles

17.4 Caution blinker at crossing in village of Mumford.

17.7 Pass over railroad. County line. Enter village of Caledonia.

18.5 Pass under Lehigh Valley Railroad.

18.8 Stop sign. Main St. (N.Y. 5). Turn right (W).

19.3 N.Y. 36 leaves to left. Keep straight on N.Y. 5.

21.0 Railroad crossing.

24.4 Quarry and crushing plant of General Crushed Stone Company to right. Operating in Onondaga limestone.

25.2 Enter Village of LeRoy, birthplace of Jell-O!

26.0 Bridge over Oatka Creek. Low dam retains pond to left. To right, just north of bridge, is low falls over Stafford limestone member of Marcellus formation, Hamilton group. Banks below buildings on east (right) side of creek below falls used to expose type section, Oatka Creek black shale member of Marcellus (typical *Leiorhynchus* facies: paper-like black shales with *Leiorhynchus* and *Orbiculoidea*. Bank is now parked and exposures are poor.

26.5 Turn obliquely left (SW) on Gilbert St. (first street to left over brow of hill), marked with sign to Lapp Insulator Company plant.

27.3 Lapp Insulator Company plant.

27.5 Pass over Pennsylvania Railroad branch line. Dangerous bridge.

28.4 Cross Cole Road.

28.7 Road fork. Bear left.

29.7 Outcrops in stream bank to left (SE), adjacent to small bridge on side road, are Levanna shale member of Skaneateles formation.

30.3 Cross Roanoke Rd.

31.6 Cross Transit Rd. Keep on pavement.

32.4 Crossroad. Keep straight.

33.1 Stop sign. N.Y. 63. Turn right (NW). This is village of East Bethany.

33.3 Turn obliquely left (W) on dirt road at edge of settled area.

34.9 Cross Center Rd. (paved). Keep straight.

36.4 Road end. Turn left on Francis Rd.

37.0 Overpass over Delaware, Lackawanna and Western Railroad. Park before reaching overpass.

STOP 1 — Exposures of Hamilton strata along Delaware, Lackawanna and Western Railroad and vicinity, 3 miles west of East Bethany.

This locality is world famous as a collecting ground for Middle Devonian fossils of the typical Hamilton assemblage (see pp. 37-38). The locality is also interesting for structural features, unusual in western New York, which have led to the exposure of over 100 feet of strata in a relatively short, nearly horizontal exposure. The section to be visited extends along railroad cut and hillside exposures for about half a mile east of the bridge carrying Francis Road over the railroad tracks. In this distance the section spans, nearly completely, the Clarendon-Linden monocline, a westward-sloping flexure which displaces the exposed strata about 100 feet. Observable dips at the surface reach a maximum of about 5 degrees. Water and gas well records suggest a greater displacement at depth, and it may be that the monocline evidenced at the surface is but a subdued expression of a major fault at depth.

The stratigraphic section here is as follows (see pp. 30-34):

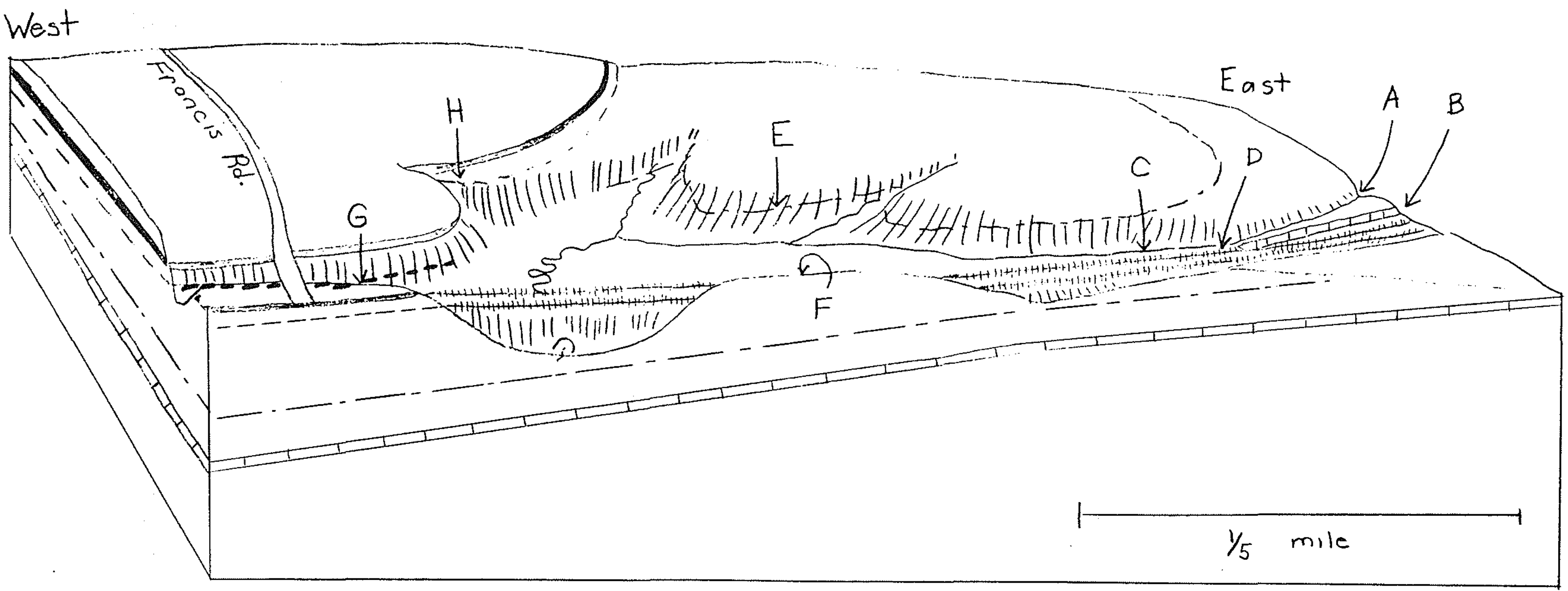
	Thickness
Ludlowville formation	
Tichenor limestone	about 1 foot
Wanakah shale	15 feet
Ledyard shale	88 feet
Centerfield shale	2 feet (+?)
Skaneateles formation	
Levanna shale	portion near top

The accompanying map and perspective sketch indicate the field relations. The letters in the following discussion refer to these illustrations.

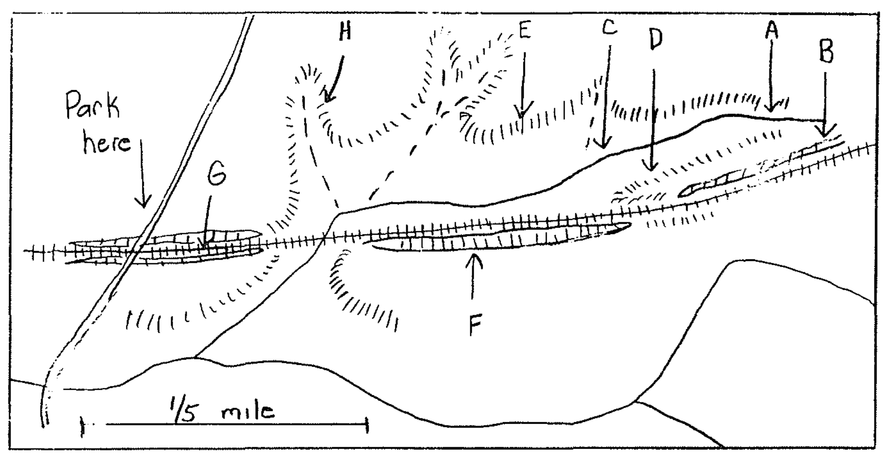
The Levanna shale (A) is in typical black shale, Leiorhynchus facies, exposed in the stream bank. The Levanna-Centerfield contact is covered and the actual thickness of the Centerfield cannot be determined. Unweathered blocks occur in place, with horizontal bedding at B, and from here eastward for more than a mile. Most of the material in this cut is weathered Centerfield residuum rich in fossils. At C fresh Centerfield strata occur in the stream bed about 30 feet lower than at B, and in between the two (D) the ground surface is composed almost exclusively of fossils weathered from the Centerfield and washed clean of matrix. Samples of the finer fraction of material here are rich in microfossils: ostracods, sponge spicules, Foraminifera, Bryozoa, crinoid and echinoid plates and spines, immature specimens of larger forms (and oddly shaped cinders!). The larger specimens are mostly corals, brachiopods, gastropods, and crinoids in great variety, and the trilobite Phacops rana.

Severe weathering of a portion of the Ledyard bearing fossils formerly replaced with marcasite has yielded an interesting assemblage of limonitized specimens at E. Most common are small gastropods and nautiloids, the goniatite Tornoceras, and nuculoid pelecypods.

Section along D.L. & W. RR 3 miles west of East Bethany



Tichenor
"Strophalosia" bed
Marcasite bed
Centerfield



Middle layers of the Ledyard, exposed in the railroad cut F, are poorly fossiliferous. Leiorhynchus and Chonetes occur in some of the laminated black shales in this cut. A rather high angle reverse fault (displacement a few feet, dip east) is visible here.

The upper portion of the Ledyard, and the Wanakah, in cuts on both sides of the railroad at G, typify the calcareous shale facies of the Hamilton. Occurring here are Rhipidomella, Athyris, Atrypa, Mucrospirifer, Ambocoelia, Stereolasma, Pleurodictyum, Styliolina. Microfossils are abundant, also, in washed residues of thoroughly weathered material, but variety is less than in samples from the Centerfield. Some of the more coherent layers contain orthoconic nautiloids, gastropods and pelecypods, along with the trilobites Greenops and Phacops.

The resistant lime-rich layer which descends to track level just west of the bridge abutment is the "Strophalosia" bed, replete with the productid brachiopod Productella truncata (formerly Strophalosia). This has been used as the marker horizon separating the Ledyard below from the Wanakah above. This practice is of questionable validity (although followed here for convenience), for the bed does not occur in a consistent position with respect to the top and bottom of the Ledyard-Wanakah shale interval in different exposed sections (see p. 34). At this locality it is unusually high, thus making the thickness of the Wanakah unusually small and that of the Ledyard correspondingly great. It is probably better to consider the Ledyard-Wanakah a single unit with several contrasting facies between the Centerfield and Tichenor limestones.

An exposure near the top of the Wanakah, at H, is rich in Chonetes, Mucrospirifer and Pleurodictyum. A little higher on the slope in the same area, tetracorals probably weathered from the Tichenor can be found.

FIELD TRIP NO. 3B — Silurian-Devonian Contact Relations,

Oaks Corners Quarry

The highest Silurian strata (Bertie and Cobleskill, see p. 18), the lowest Devonian strata (Onondaga, see pp. 21-26), and the disconformable contact between them will be examined at a locality near Phelps, N. Y.

Miles	
0.0	Zero mileage. River Blvd. entrance to main quadrangle (headed south).
0.25	Elmwood Ave. (N.Y. 47). Turn left (E). Follow route 47 to intersection with N.Y. 31 at Monroe Ave. (for details of this route, see itinerary for Trip No. 1B, miles 0.25-3.8).
3.8	Monroe Ave. (N.Y. 31). Turn right (SE).
5.2	Clover St. (N.Y. 65). Keep straight.
5.3	Enter town of Pittsford. The Spring House on right is old hotel on former course of the Erie Canal.
7.1	Cross Erie Canal and railroad.
7.2	Enter village of Pittsford.
7.5	East Ave. (N.Y. 252, 253, and 264). Keep straight.
7.6	South St. Turn right.
8.1	Stop sign. Keep straight, merging with N.Y. 252.
8.7	Pass under railroad. Erie Canal to left.
9.8	Gravel and sand operation in water-laid glacial material to right.
10.8	Turn left, then right to join N.Y. 96. Follow signs to Victor and Thruway.
11.8	High ground to left is western edge of large kame moraine area (Turk-Baker Hills, see p. 55).
12.2	Gravel pit in kame material to left.
14.8	Thruway entrance to left.
15.1	Pass under New York State Thruway.
16.2	For next few miles route runs along northern margin of Victor channel, cut by waters flowing parallel and close to the ice front. Onondaga limestone caps high ground to south of valley.
16.4	Junction, N.Y. 251.
17.2	Enter village of Victor. Straight through.

Miles

18.6	Pass over railroad.
19.4	Mud Creek.
20.8	N.Y. 332. Keep straight.
23.3-39.1	The route here runs about a mile south of the southern edge of the great Palmyra drumlin field. Some of the southernmost drumlins are visible to the left (N). The high ground to the right (S) is the Onondaga escarpment, rather feebly developed here.
26.0	Pass over Lehigh Valley Railroad.
27.7	N.Y. 21. Keep straight.
27.9	Cross Canandaigua Lake outlet.
30.4	Stone fences are of platy waterlime of Bertie formation.
31.7	Gravel pit to right (S).
32.3	Clifton Springs to right (S). Rise in ground is Onondaga escarpment.
33.5	New York Central Railroad, branch line.
34.0	Slight rise in route elevation marks passage onto Onondaga outcrop belt. Note Onondaga blocks in stone fences.
34.9	N.Y. 88 joins from right.
35.2	Pass over railroad.
36.0	Enter Village of Phelps. Bear right on N.Y. 96 at road fork where N. Y. 88 leaves route to left.
36.9	Cross Flint Creek. Bertie outcrops in stream bed.
37.5	Leave Village of Phelps.
39.5	Preemption Road. Turn right at Snack Bar; follow signs to Oaks Corners and Geneva.
40.4	Cross railroad and immediately turn sharp right into quarry entrance.

STOP 1 — Oaks Corners Quarry and Plant of General Crushed Stone Company. The stratigraphic section exposed here is as follows (measurements from Oliver, 1954):

Onondaga limestone	feet
Moorehouse member -- medium- to thick-bedded limestone with dark chert	36
Nedrow member -- thin-bedded impure limestone with chert . .	16
Edgecliff member -- light gray crystalline coralline limestone, with pebbles of Cobleskill and intermittent sandy zone at base	10±
Disconformity -- Relief up to 5 feet along irregular surface. Contact has been locus of much solution and it is difficult to judge how much of the relief of the contact surface is due to pre-Onondaga erosion and how much to post-depositional solution. Lower Devonian Helderberg-Oriskany sequence missing.	
Cobleskill formation, Akron dolomite facies, unfossiliferous massive dark dolomite, Vugs near top contain secondary minerals: calcite, dolomite, sphalerite, and gypsum	10-14
Bertie formation (in pit in quarry floor)	
Williamsville member -- buff-weathering homogeneous waterlime with conchoidal fracture. A fine, even lamination determines breakage into thin plates. Upper surface makes quarry floor	5
Scajaquada member -- medium-bedded dark dolomitic limestone. Only upper portion exposed	15±

FIELD TRIP NO. 3C — Mineral Collecting

Itinerary same as for Field Trip No. 1A-1 (see p. 75) from U of R River Campus to Penfield Quarry of Dolomite Products Company (miles 0.0 to 10.3).

General geology.--The rock quarried is a hard dense dark gray dolomitic limestone (Lockport dolomite) of Middle Silurian age. Irregular cavities of secondary origin in the upper levels of the quarry are frequently lined with crystallized dolomite and other minerals. Occasional small fissures in the rock are filled with sphalerite, gypsum or galena.

The dolomite rock of the Penfield quarry was permeated, in the geologic past, by petroleum-type hydrocarbons. When the rock is struct with a hammer, it emits a bituminous odor. Residual hydrocarbons, described below, are often found. Some minerals, fossils and some areas of the rock will fluoresce bluish white to orange under long wave ultra violet light. (This fluoresence is typical of many petroleum-type hydrocarbons).

Economic uses.--The crushed dolomite from the quarry is used for concrete aggregate, highway construction, and asphalt pavements.

Minerals.--(Abbreviations: a - abundant; c - common; m - museum quality may be found; o - occasional; r - rare.

Anhydrite	(o)	Gypsum	(c,m)
Aragonite	(r)	Marcasite	(o)
Barite	(r)	Pyrite	(r)
Calcite	(a,m)	Quartz	(o)
Celestite	(c,m)	Residual hydrocarbon	(o)
Dolomite	(a,m)	Sphalerite	(c)
Fluorite	(c,m)	Strontianite	(r)
Galena	(r)	Sulfur	(r)

Notes on minerals.--

Anhydrite - White to light blue in color; finely to coarsely crystalline masses that show 3 pinacoidal cleavages which closely resemble cubic cleavage. All gradations from anhydrite to gypsum may be found.

Aragonite - Found as white crusts.

Barite - Closely resembles celestite. Flame test will distinguish between the two minerals.

Calcite - White to yellow and some smoky scalenohedral crystals are often found with crystallized dolomite. Larger crystals consist of multiple scalenohedral crystals in parallel position.

Celestite - Crystals with very good terminations are occasionally found, sometimes embedded in clear selenite. Fibrous and radiated crystals without terminations are also common.

Dolomite - The rock itself is composed mostly of very fine dolomite crystals. The cavities in the rock are frequently lined with white rhombohedral crystals that are slightly curved and have a pearly luster. Some crystals are pinkish in color.

Fluorite - Individual crystals and groups range up to two inches and more on an edge. Light blue is the common color, yellow and dark blue less common. Zoning of colors is frequent and some crystal faces are highly etched. Occasional crystals have unusual negative cavities that are possibly formed around anhydrite that has been removed by solutions.

Galena - This occurs as thin seams in the rock. Crystal faces are very rare.

Gypsum - This mineral is found in various forms from snow white masses completely filling cavities to clear selenite. All gradations to anhydrite are found. The selenite often encloses other minerals. The best clear selenite is of optical quality.

Marcasite - This mineral occurs as tiny bronze-colored to black bristle-like crystals on dolomite and calcite. The crystals are striated, sometimes having a slight iridescence. This mineral has been erroneously identified in the past as rutile.

Pyrite - Very tiny, highly modified crystals of typical yellow color are sometimes seen.

Quartz - Drusy quartz is common in some parts of the quarry where it may be found forming crusts and sugary masses with dolomite and other minerals.

Sphalerite - Shiny brown, partly transparent crystals up to 3/4 inch may be found, though smaller crystals in small groups are more common. Occasional fissures in the rock are filled with a light brown resinous sphalerite.

Strontianite - This white crystalline mineral is sometimes associated with celestite.

Sulfur - This is usually found as yellow films on rock.

Residual hydrocarbon - This material ranges in consistency and appearance from that of petroleum to heavy lubricating grease and brown or black films and globules in cavities. It is apparently a residual hydrocarbon formed from petroleum-like materials which permeated the rock. It can sometimes be removed by immersing the grease covered minerals in very hot water.

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The notes above were prepared by the Minerals Section, Rochester Academy of Science.

Platt (1949) attempted an evaluation of the three possible modes of origin of the "exotic" minerals in the Lockport, namely, secondary introduction by magmatic emenation, or by meteoric water, or concentration of indigenous materials. Special attention was paid to the lead and zinc. He discounted a hydrothermal origin because of the absence of major structural channelways and the presence of the thick impermeable shale sequence below the Lockport, which would act as a barrier to the upward migration of hydrothermal solutions. Platt reasoned that if meteoric waters were the agent that introduced the minerals, then an eroded source area must be postulated. The nearest such area would be the Canadian shield to the north. If lead and zinc as well as the other "exotic" metals could be shown to be present in zones where no evidences of solution were present, then the hypothesis favoring the concentration of indigenous material would be strengthened. If these metals were not present, then the introduction by meteoric water would be more probable. Spectroscopic analysis of cores by Platt showed that lead and zinc were present without exception in every specimen. Thus, the theory of genesis proposing indigenous lead, zinc, etc., and subsequent concentration by circulating ground water is held to be most probable.

PLATE I

COMMON SILURIAN FOSSILS

Figure

1. Eurypterus remipes; Bertie waterlime. x-1/3

2. Eurypterus lacustris; Bertie waterlime. x-1/3

3. Liocalymene clintoni; Clinton group

4. Dalmanites limulurus; Clinton group. x-1/3

5. Trimerus delphinocephalus; Clinton group. x-1/4

6. Halysites sp.; Silurian. x-1/2

7. Favosites niagarensis; Middle Silurian. x-1/2

8. Pentamerus laevis, brachial valve of an elongate specimen; Middle Silurian. x-1/2

9. Pentamerus laevis, brachial valve of a subquadrate specimen; Middle Silurian. x-1/2

10. Atrypa "reticularis", brachial valve; common throughout Silurian and Devonian. x-2/3

11. Whitfieldella cylindrica, pedicle valve; Clinton group. x-1

12. Whitfieldella cylindrica, lateral view; Clinton group. x-1

13. Stropheodonta corrugata, pedicle valve; Clinton group. x-1/3

14. Leptaena "rhomboidalis"; common throughout Silurian and Devonian. x-1/2

15. Camarotechia neglecta, brachial valve; Clinton group. x-1/2

16. Camarotechia neglecta, anterior view; Clinton group. x-1/2

17. Dictyonella corallifera, brachial valve; Clinton group. x-1

18. Dalmanella elegantula, pedicle valve; Clinton group. x-1

19. Whitfieldella nitida, brachial valve; Clinton group. x-1/2

20. Eospirifer radiatus, brachial valve; Clinton group. x-2/3

21. Dicoelosia biloba, brachial valve; Clinton group. x-1

22. Dicoelosia biloba, pedicle valve; Clinton group. x-1

23. Chonetes cornuta, pedicle valve; Clinton group. x-1

Figure

24. Tellinomya machaeriformis, right valve; Clinton group. x-2/3

25. Pyrenomoeus cuneatus, left valve; Clinton group. x-2/3

26. Tentaculites minutus; Clinton group. Greatly enlarged.

All figures from Hall; Natural History of New York, Part 6.

PLATE II

COMMON DEVONIAN FOSSILS

Figure

1. Sulcoretepora incisurata; Hamilton group. x-5

2. Phacops rana; Hamilton group. x-2/3

3. Spinocyrtia granulosa, brachial valve; Hamilton group. x-1/2

4. Athyris spiriferoides, brachial valve; common throughout Silurian and Devonian. x-1

5. Mucrospirifer mucronatus, pedicle valve; Hamilton group. x-1/2

6. Rhipidomella penelope, pedicle valve; Hamilton group. x-1

7,8. Chonetes coronatus, brachial and pedicle valves; Hamilton group. x-1

9,10. Tropidoleptus carinatus, pedicle and lateral views; Hamilton group. x-1

11,12. Leiorhynchus laura, pedicle and brachial valves; Hamilton group. x-1

13,14. Megastrophia concava, brachial and lateral views; Hamilton group. x-1/3

15. Brachyspirifer audaculus, brachial valve; Hamilton group. x-1/2

16. Mucrospirifer consobrinus, brachial valve; Hamilton group. x-1/2

17. Chonetes mucronatus, brachial valve; Hamilton group. x-1-1/2

18,19. Ambocoelia praeumbona, brachial and lateral views; Hamilton group. x-1

20,21. Douvillina inaequistriata, pedicle and brachial valves; Hamilton group. x-2/3.

22-24. Ambocoelia umbonata, brachial, pedicle and lateral views; Hamilton group. x-1

25. Lingula spatula; Genesee group. x-1

26. Centronella impressa, brachial valve; Hamilton group. x-2/3

Figure

27. Loxonema hamiltoniae; Hamilton group. x-2/3

28. Euryzone lucina; Hamilton group. x-2/3

29. Bembexia sulcomarginata; Hamilton group. x-2/3

30. Nuculites triquiter; left valve; Hamilton group. x-1

31,32. Paracardium doris, left and right valves; Genesee, Naples groups. x-1/2

33. Bellerophon sp.; Hamilton group. x-2/3

34. Euryzone itys; Hamilton group. x-2/3

35,36. Styliolina fissurella; Hamilton, Genesee, Naples groups. Greatly enlarged.

37. Heliophyllum halli; Hamilton group. x-1/2

All figures except No. 37 from Hall; Natural History of New York, Part 6.

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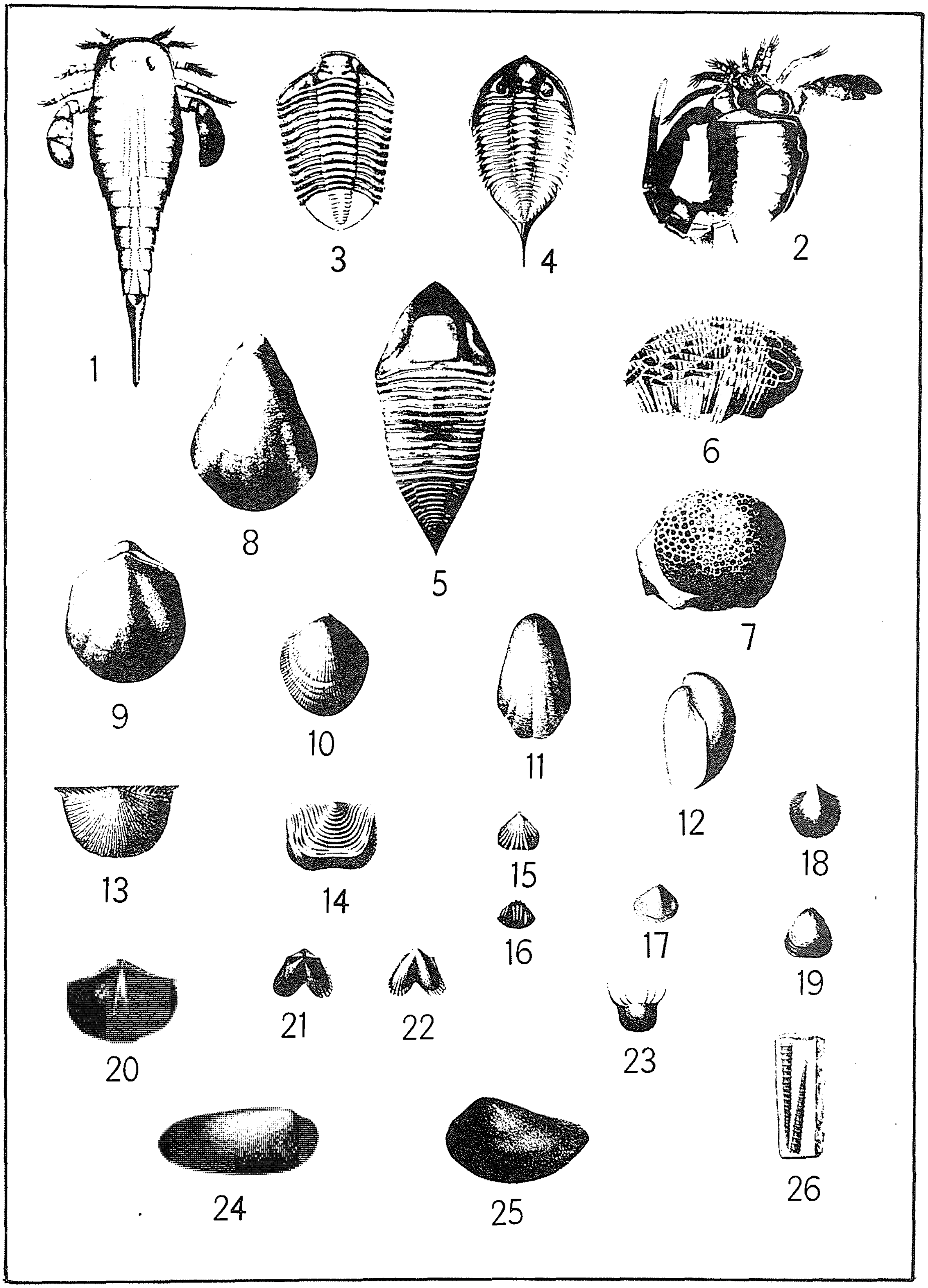
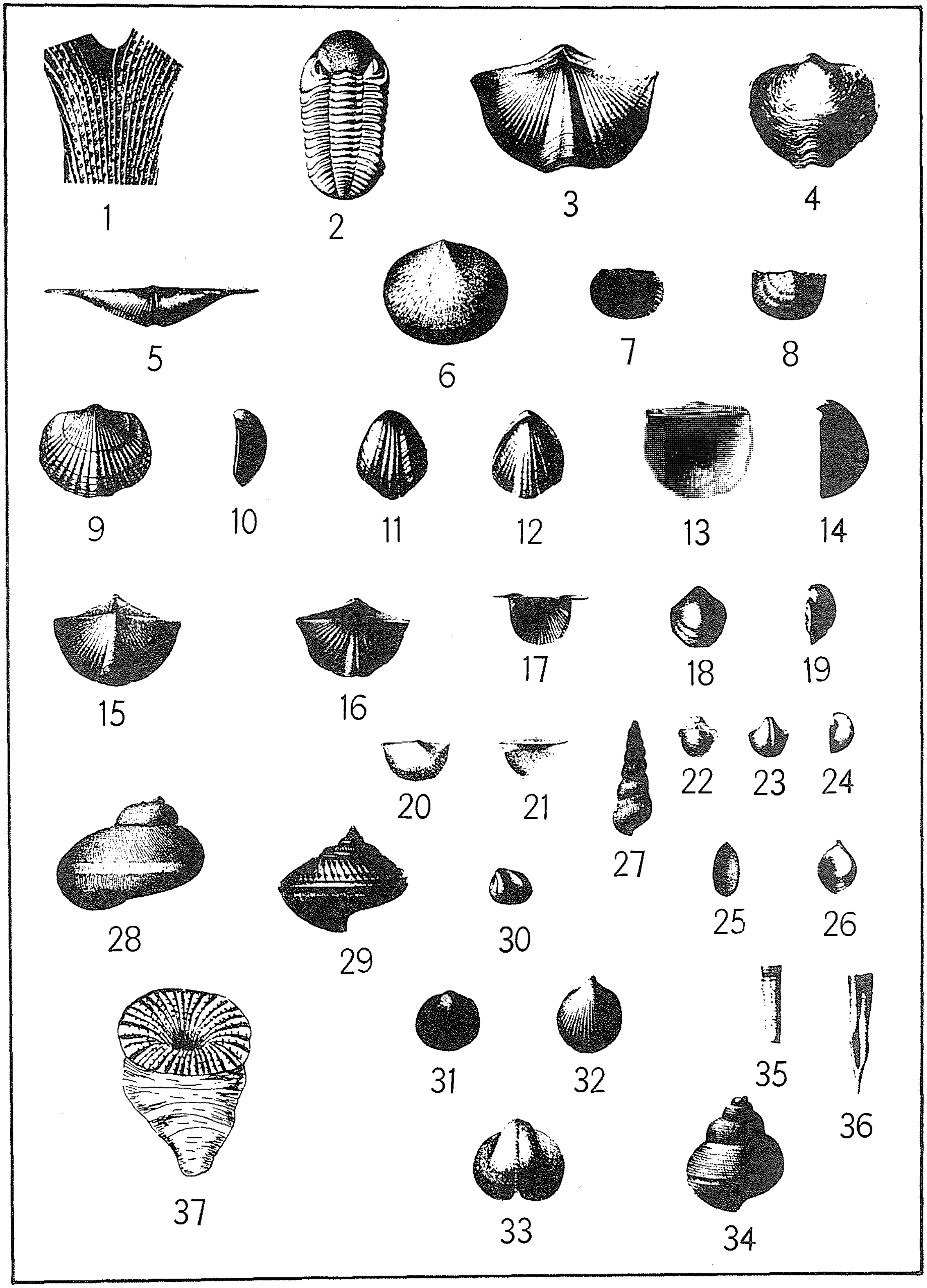


PLATE I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