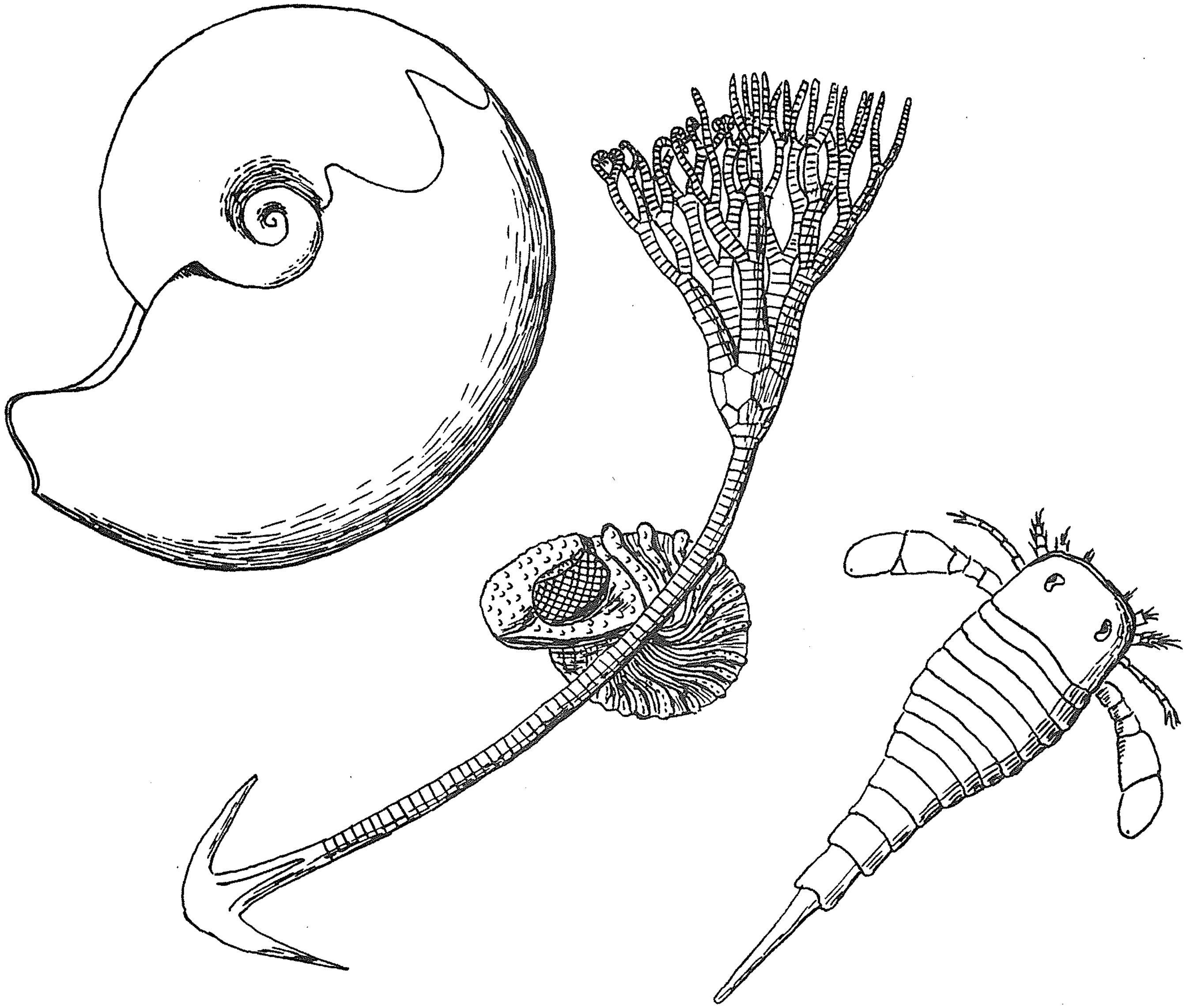
GUIDE BOOK

GEOLOGY OF THE CAYUGA LAKE BASIN



NEW YORK STATE GEOLOGICAL ASSOCIATION

31ST ANNUAL MEETING

CORNELL UNIVERSITY, MAY 8-9, 1959

GEOLOGY OF THE CAYUGA LAKE BASIN

A Guide for the 31st Annual Field Meeting of the

New York State Geological Association

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prepared by

Staff and Students of the Department of Geology

Cornell University

"..... We must especially collect and describe all the organic remains of our soil, if we ever want to speculate with the smallest degree of probability on the formation, respective age, and history of our earth."

------ C. S. Rafinesque, 1818

Second (Revised) Edition

Ithaca, New York

May, 1959

PREFACE

Ten years have passed since Cornell was host to the New York State Geological Association. In the intervening years we have attended the annual meetings and field trips at other places with pleasure and profit. Therefore, we take this opportunity to express our appreciation and thanks to all of those who have made these meetings possible. We not only welcome you to Cornell and the classic Cayuga Lake Basin, but we sincerely hope you will enjoy and profit by your brief excursions with us.

This guide is a revision of one prepared for the 1949 annual meeting. Professor John W. Wells assumed most of the responsibility for its preparation, ably assisted by L. R. Fernow, F. M. Hueber and K. N. Sachs, Jr. Without their efforts in converting ideas into diagrams and maps this guidebook would have been sterile.

We hope that before you leave us, you will agree with Louis Agassiz, who said in one of his lectures during the first year of Cornell, "I was never before in a single locality where there is presented so much material in so many branches of Natural History as here in this beautiful valley."

Let us go and observe!

W. Storrs Cole

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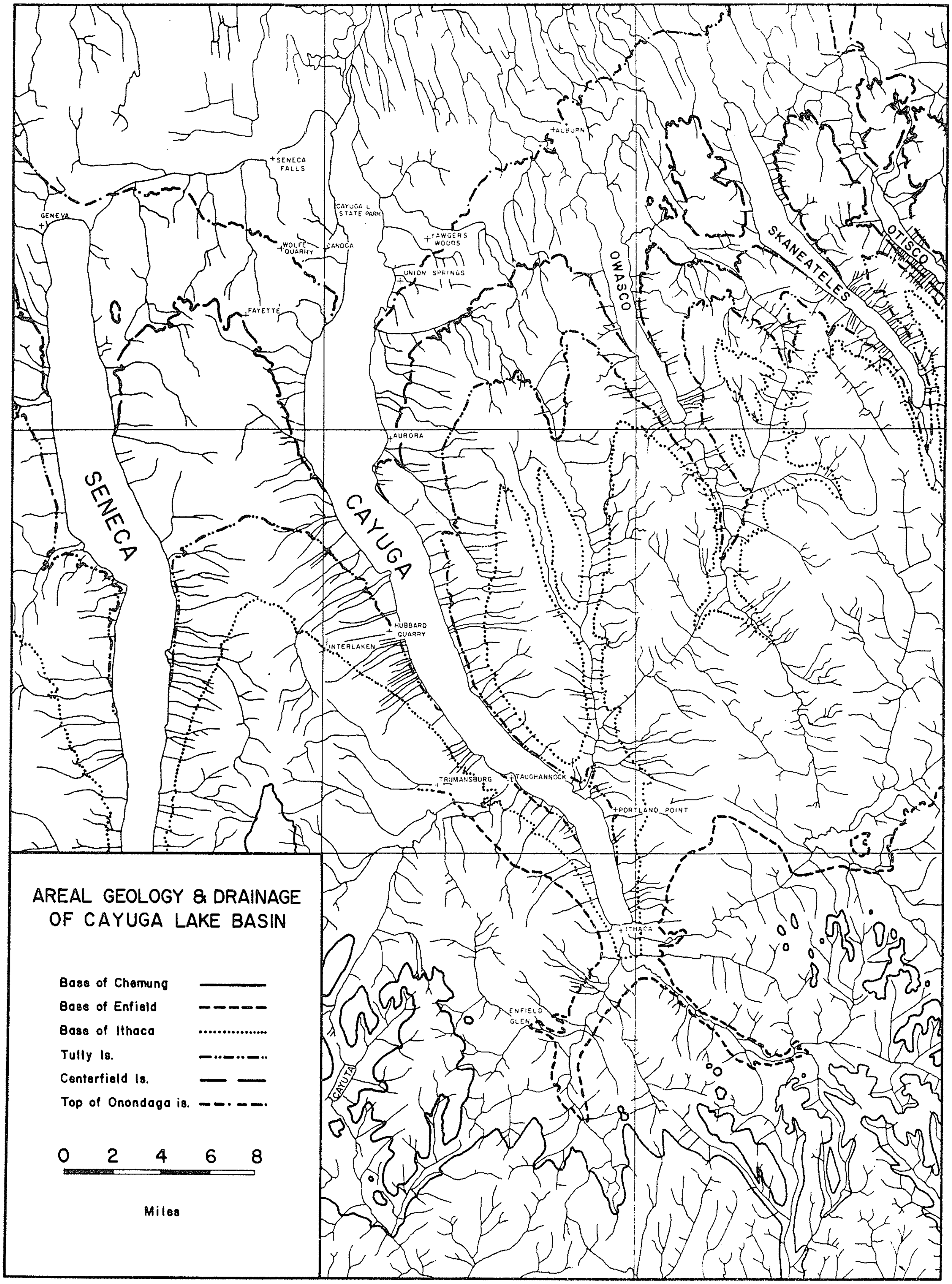

AREAL GEOLOGY & DRAINAGE
OF CAYUGA LAKE BASIN
Base of Chemung
Base of Enfield
Base of Ithaca
Tully ls.
Centerfield ls.
Top of Onondaga ls.
0 2 4 6 8
Miles
SENECA
CAYUGA
OWASCO
SKANEATELES
OTISCO
AUBURN
SENECA FALLS
GENEVA
CAYUGA L. STATE PARK
WOLFE QUARRY
CANOGA
YAWGERS WOODS
UNION SPRINGS
FAYETTE
AURORA
HUBBARD QUARRY
INTERLAKEN
TRUMANSBURG
TAUGHANNOCK
PORTLAND POINT
ITHACA
ENFIELD GLEN
CAYUTA

SUMMARY OF GEOLOGICAL HISTORY

of the

CAYUGA LAKE BASIN

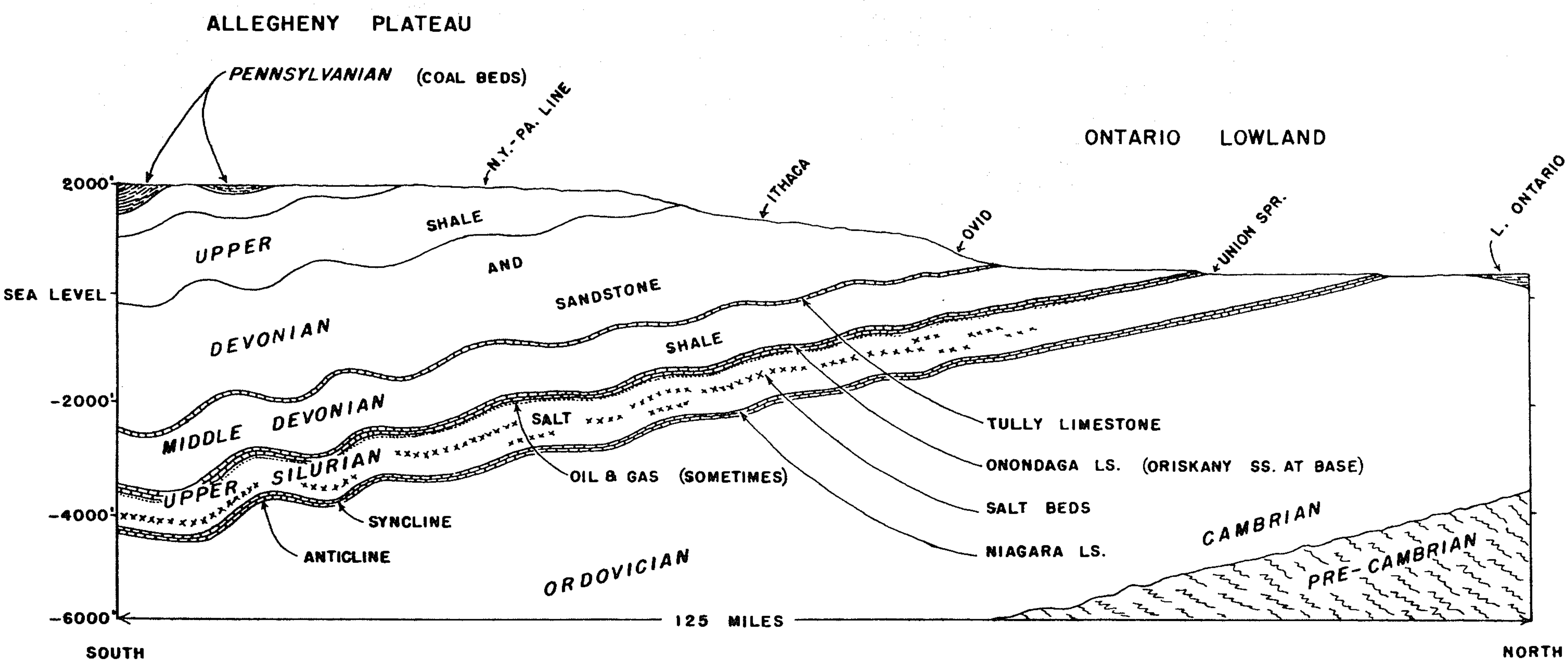
During the Paleozoic Era this region lay in the western part of the Appalachian geosyncline (Miogeosyncline: Cambrian-Ordovician; exogeosyncline: Silurian-Devonian) and was more or less continuously covered by a shallow sea into which sediments were carried from the tectonic and volcanic lands ("Appalachia") to the east. The sediments were dominantly clastics with lesser accumulations of carbonate muds and oozes. Clastics dominated during the Cambrian, carbonate during the Early and Middle Ordovician, clastics during the Late Ordovician and Early Silurian, carbonates and evaporites during the Middle and Late Silurian, carbonates during the Early Devonian, and clastics during the Middle and Late Devonian, depending on the rates of subsidence of the seaway and elevation of the sources to the east. The total thickness of Paleozoic rocks (Cambrian-Devonian) in the basin is about 9000 feet, but only some 4000 feet of the Latest Silurian and Devonian rocks are now exposed, outcropping in order from north to south (see geological map opposite, and section on page 2), following the southerly regional dip of about 50 feet per mile. In places, especially in the southern part of the basin, low folds whose axes trend northeast-southwest, interrupt the otherwise simple structure. These are the outermost of the Appalachian folds.

At the close of the Paleozoic the Appalachian Revolution, with its lateral pressures from the southeast, produced the gentle folds, small faults, joint systems, and regional dip. It is likely that the igneous dikes of the region were intruded at the same time.

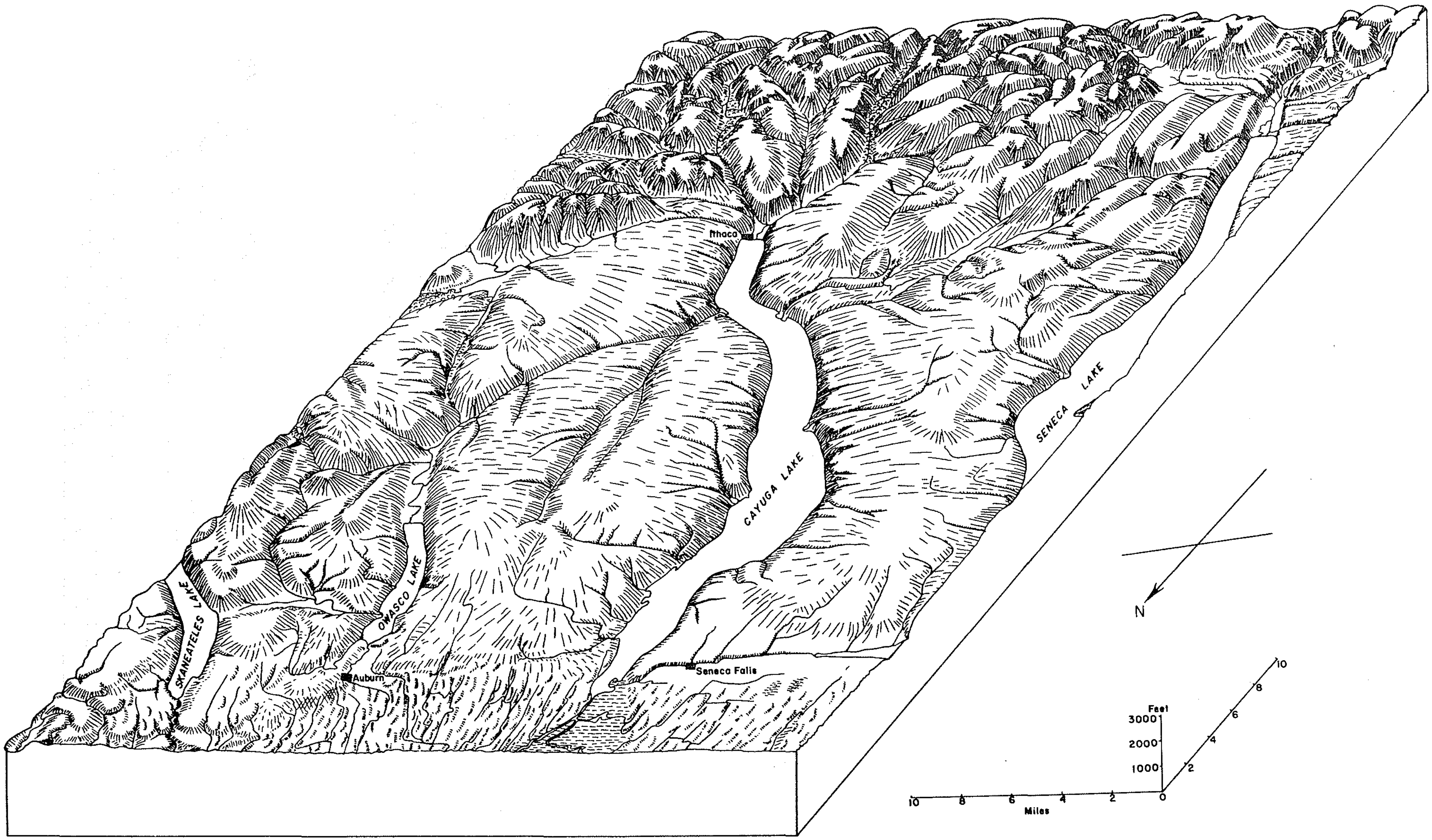
During the succeeding long period of relative quiet the streams, aided by various weathering agencies, slowly wore away the rock. This condition continued long enough for the whole region to be eroded to an essentially flat plain near sea level, called a peneplain. It was probably completed sometime during the early or middle part of the Cenozoic era.

Crustal disturbances then elevated the peneplain, probably very slowly, several hundred or a few thousand feet. Streams flowing over this plateau-like country developed valley systems which dissected the uplifted peneplain. Those portions which escaped destruction may be recognized today as a succession of hilltops at about the same elevation.

One of the streams on the peneplain followed approximately the course of the present Cayuga Lake and is referred to as the Cayuga river. The bottom of this pre-glacial valley was at about the elevation of the Cornell campus. The river was fed by many tributaries whose courses are indicated by the upper portions of such streams as Fall, Cascadilla, Six Mile, Buttermilk, Enfield, and Taughannock creeks. At that time there were no waterfalls and gorges, the streams being well graded.



NORTH - SOUTH SECTION IN CENTRAL NEW YORK



PHYSIOGRAPHIC DIAGRAM, CAYUGA LAKE BASIN

At the beginning of the Pleistocene, a great ice sheet began to move slowly southward from its center in eastern Canada, overwhelming the northern part of this country and extending as far south as New York City and into Pennsylvania. Its thickness, although unknown, was sufficient to cover the highest hills in this region. The slowly moving glacier found the Cayuga river valley a convenient course. The flow was therefore concentrated in the valley and resulted in about 1000 feet of erosion, so that the valley bottom is now below sea level. This valley has the U-shaped cross section typical of all glacial valleys. The tributary streams, being crosswise to the direction of ice movement, were not greatly eroded. When the ice ultimately melted they were left isolated far above the new bottom of the main valley, so that they are now hanging valleys. As the streams in these valleys reached the steep slopes of the deepened main valley they formed a series of rapids and cut into the rock, developing waterfalls and gorges (Fall and Cascadilla Creeks, the north and south boundaries of the Cornell campus).

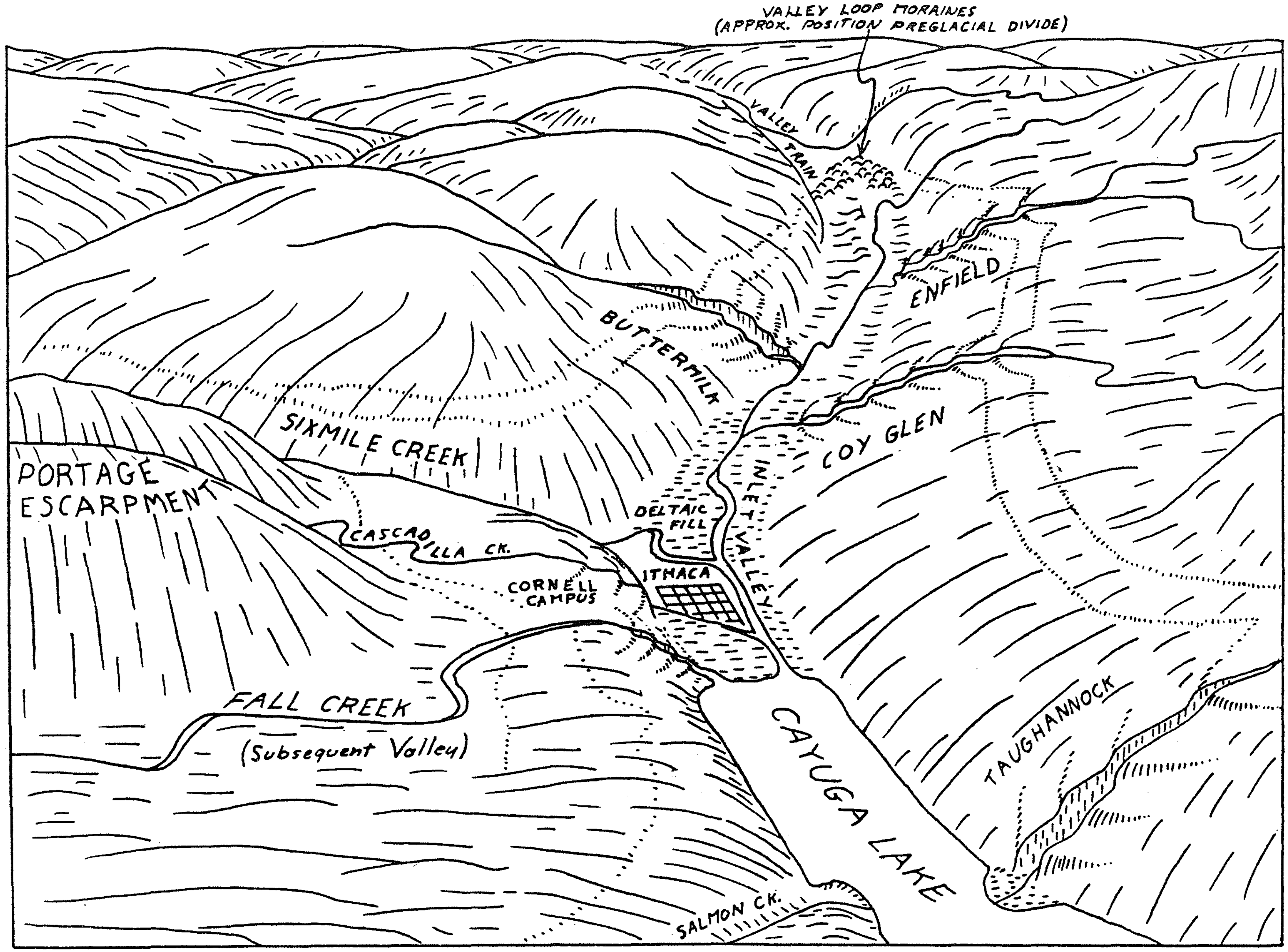
In this region the ice age was interrupted by at least one warm inter-glacial period which was of much longer duration than our present post-glacial warm period. Gorges cut by the inter-glacial streams are generally broader and with more gently sloping sides than those cut since the melting of the last glacier. The inter-glacial valleys are largely filled with glacial till left by the last ice sheet and are exposed only locally where the post-glacial streams have partially re-excavated them. The post-glacial gorges and waterfalls have been formed within the twenty or thirty thousand years since the last ice sheet disappeared. Because the valleys were irregularly filled with moraine material, the new streams had to pick their way from one low point to another over the rough surface, and their courses only locally correspond with the inter-glacial gorges (Enfield Gorge, southwest of Ithaca).

The general slope of the land in this region is to the north. As the ice front melted back, the glacial waters were ponded between the ice to the north and the high land to the south, and overflowed southward into the Susquehanna river. As the ice continued to melt northward, it uncovered lower outlets and allowed the lake to drop to successively lower levels. At each level the incoming streams built deltas with the loose material which they were removing from the land surface. These abandoned high level deltas are called hanging deltas. The flat on which the city of Ithaca has been built is a delta which has been formed at the present lake level by material brought there by such streams as Cascadilla, Fall, Six Mile and Inlet creeks.

GEOMORPHOLOGY

The Cayuga Lake Basin (see physiographic diagram opposite) lies chiefly within the Southern New York section of the Appalachian Plateaus Province which Fenneman (1928) characterizes as a mature, glaciated plateau of moderate relief. A more complete statement of the topographic stage would be:

> A mature plateau region of cuestaform type in an n + 1 cycle of erosion with features of topographic youth superimposed on it by the accident of continental glaciation.



DIAGRAMMATIC SKETCH OF ITHACA REGION LOOKING SOUTH

The uplands are beveled by the Allegheny (Schooley) erosion surface (Fridley, 1929; Cole, 1938) below which occur straths of the Niagara (Harrisburg) erosion surface and into which were carved the floors of the preglacial valleys. The preglacial valleys in turn have been modified variously by glaciation and locally by postglacial erosion.

Two fundamental topographic types are seen with clarity in any comprehensive view of the region: (1) the preglacial features, of which an outstanding example is the east-west trending Portage escarpment dominating the uplands, whereas (2) the glacially modified terrains, of which the overdeepened and steepened trough of the Cayuga valley is a classic example, are characteristic of the lowlands. A combination of pre-, inter-, and post-glacial features is found in the valley of Fall Creek which flows along the base of the Portage escarpment for the last few miles of its course.

This is a subsequent valley of preglacial origin and retains in the large view its original configuration, but in detail it has been modified by a masking of glacial deposits and by the development within its confines of inter- and post-glacial valleys. Although the large subsequent valley must be viewed from a distance, the development of the various gorges is displayed on the Cornell campus in the vicinity of Beebe Lake which occupies a portion of the inter-glacial gorge which has been re-excavated post-glacially. Another inter-glacial gorge can be traced at Enfield Glen.

The major erosive work of the ice occurred along north-south lines in the area, and was selective. Pre-glacially, the Cayuga trough was occupied by a stream which carved a valley that was north-sloping. The continental ice crowding down through this valley eroded it to such a degree that the present floor of the trough is at least 54 feet below sea-level, whereas the ice rode over the east-west valleys and intervening uplands with slight, if any, erosion (see diagram, p. 6).

In consequence of this selective activity, the valleys joining the Cayuga trough show progressive degrees of hanging. Inlet valley which is in the southern continuation of the Cayuga trough had its floor reduced in level so that it joins the Cayuga trough at an accordant level.

Six-Mile valley which trends southeast from the Cayuga trough was eroded moderately, whereas Cascadilla and Fall Creek valleys were largely undisturbed. Therefore, from south to east there is a progressively greater hanging relationship as these valleys join the Cayuga trough.

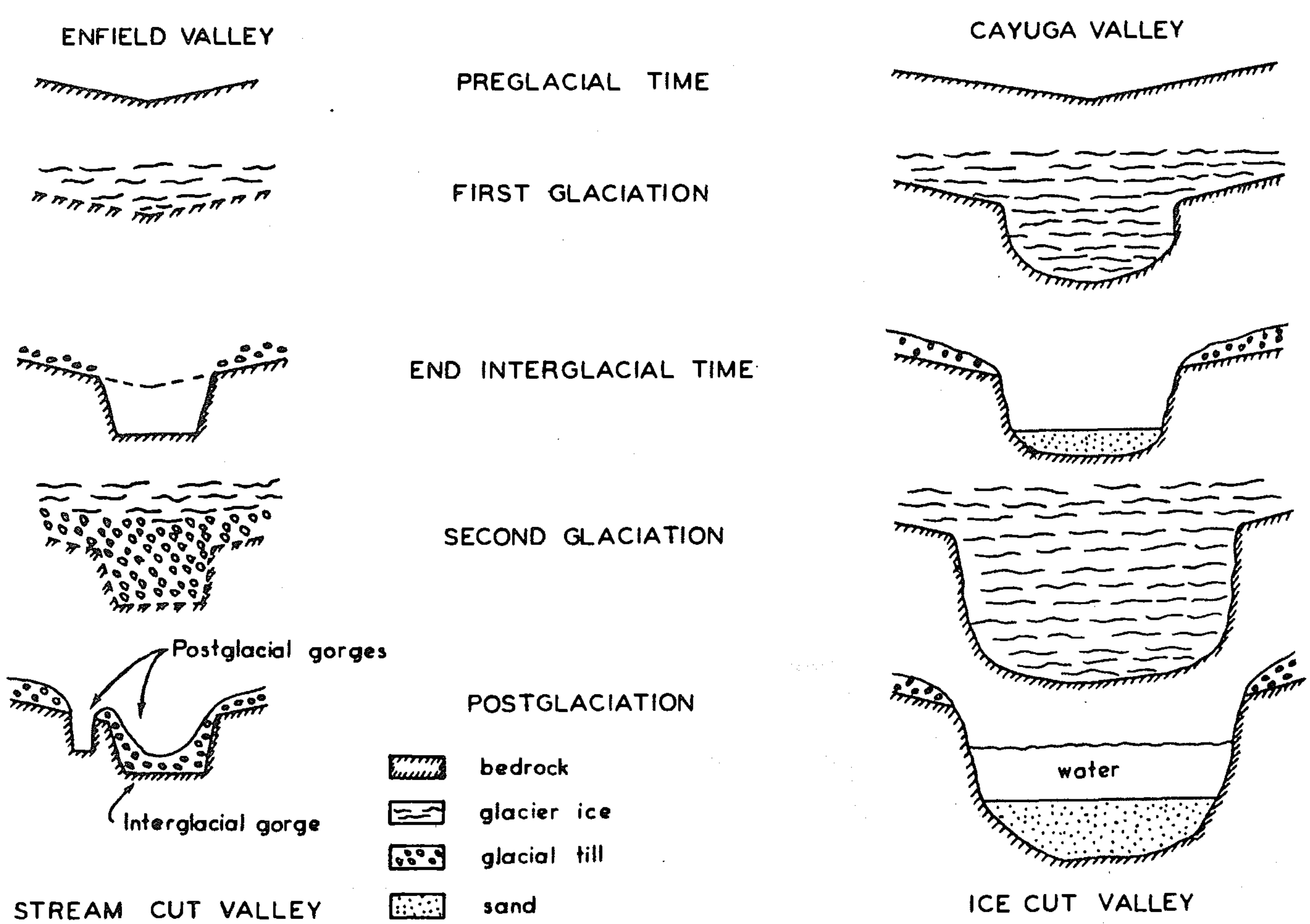
Cayuga Lake is the final (for the moment) lake in a long series of lakes which developed as the ice retreated northward (Fairchild, 1934). After the recession of the ice over the divides at the heads of Inlet and White Church valleys, lakes were formed in front of the ice. With progressive retreat of ice, successively lower outlets for the lakes became available. However, after a new outlet developed, the lake became stabilized for a period of time before a new outlet formed.

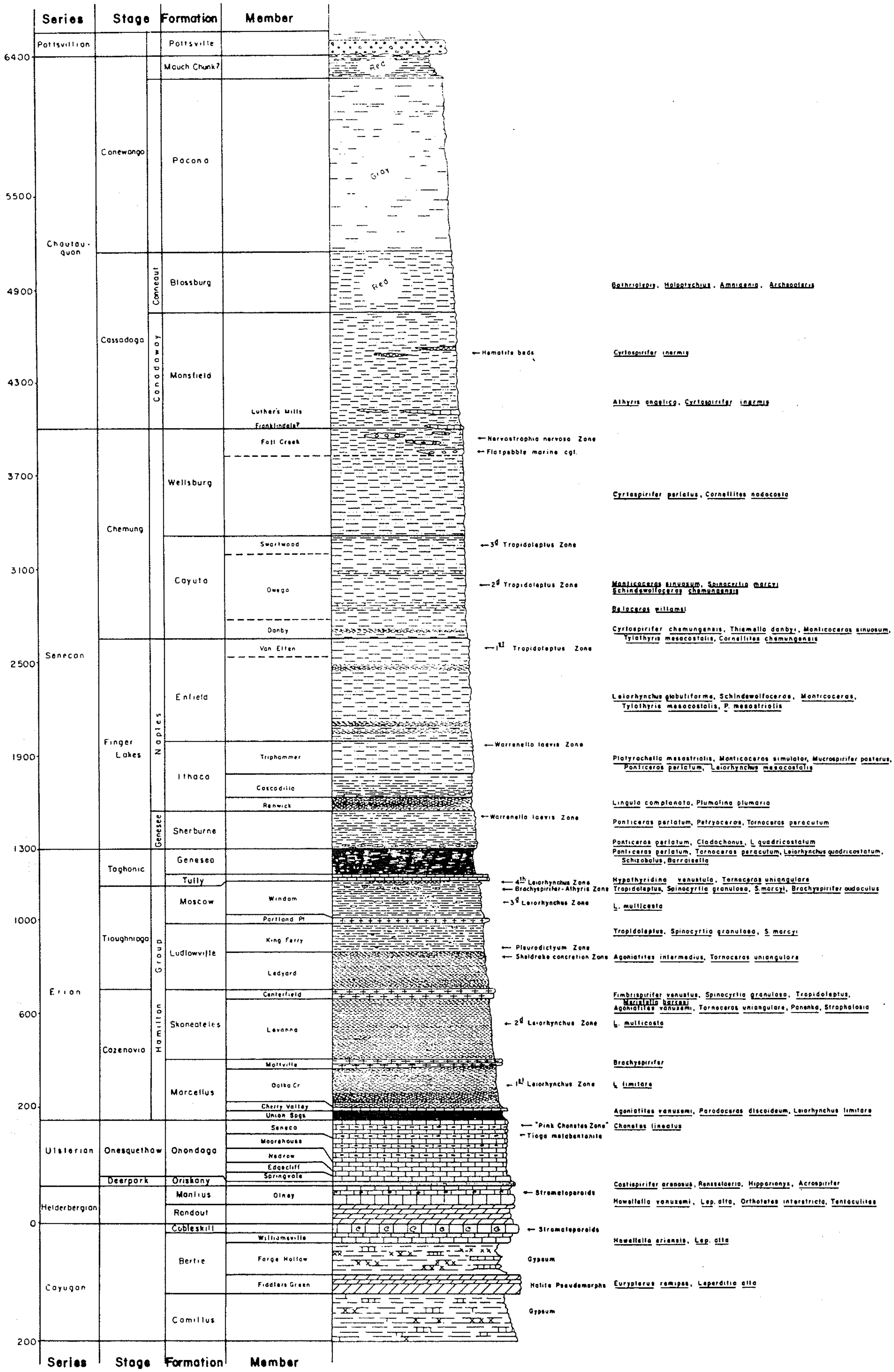
At each stand of the lakes, the inflowing streams built deltas similar in every respect to the modern delta at the mouth of Taughannock (Taghanic) Creek. Every time the lake level dropped the deltas of that lake would be trenched by the stream which had formed it and a new delta would be formed at the new and lower stand of the lake. Therefore, each stream has built and partially destroyed a series of deltas in post-glacial times (see diagram, p. 4).

The most clearly defined set of hanging or fossil deltas (good sources of gravel) are those associated with Coy Glen which is on the west side of the Cayuga trough about 1.5 miles south of Ithaca (Cole, 1930). However, high-level deltas may be observed at Taughannock Gorge and on the Cornell campus. The chemistry building, Baker Laboratory, is built on such a delta.

Since Cayuga Lake attained its present surface level of 382 feet above sea-level, the streams discharging into the south end of the lake have built a vast delta from about the vicinity of Buttermilk Falls to the present south end of the lake, and it is still being extended. These delta deposits have been covered by floodplain materials, and it is upon these that the main section of Ithaca developed. Later, the city spread to the valley walls, and at present is expanding to the uplands.

VALLEY FORMATION ITHACA REGION





DEVONIAN SECTION, CAYUGA LAKE MERIDIAN

STRATIGRAPHY

The general stratigraphic section of the Cayuga Lake Region is shown on the section opposite this page. Analysis of the distribution of fossils throughout the Devonian indicates that the faunal succession is not at all simple: throughout there are different faunas, some of them apparently disappearing and reappearing in a perplexing manner. Further, from the section it is apparent that the lithology of the rocks varies, with different kinds appearing and disappearing, often reappearing again higher up. The lithology of a sedimentary rock unit reflects, of course, the sedimentary and aqueous environment in which it was laid down. Similarly, the fauna living where a certain type of sediments is being deposited is closely adjusted to that particular environment. Once this is understood, similarity of faunas in different formations having the same lithology is to be expected, and the differences in such faunas in the same rock types up and down the column are due primarily to the effects of evolution with time and intermingling. Because of this complexity of fossil faunas, the Devonian stratigraphy of this region is still, after 120 years of study, not thoroughly worked out. Here only the broad features of the interrelationships of the lithologies and faunas can be outlined.

The upward continuation in time and in the geologic column of the same lithology containing similar fossil faunas is a phase. Thus, referring to the chart of New York Devonian relationships opposite p. 8, the similar lithologic and overall faunas of the eastern part of the Hamilton-Tully-Ithaca-Enfield succession represents a phase. At any one time in the column two or more phases may exist side by side in the area of deposition, as for instance during Ithaca time, when the Naples Fauna with its characteristic lithology occupied the area to the west, the Ithaca Fauna to the east, and still farther eastward was the continental Catskill Fauna and Flora. Each of these segments of three phases is a <u>facies</u>. Diagrammatically the relations of phases and facies may be represented as follows:

Phase	facies	Phase	facies	Phase	facies
	facies		facies		facies

The relations actually are never so neatly defined as shown above and in the Cayuga Lake Basin they are more nearly as shown in the diagram, p. 9. Here only the east-west relations are indicated. A more complete picture could, of course, be prepared if the north-south relations were known. Further, it is found that each of the phases and facies can be divided into subphases and subfacies reflecting slightly different environments within each. The problem of nomenclature for these relations is complex and only broad terms are used here. There is yet work to be done.

Lower Devonian

Only a few feet of Lower Devonian (Helderbergian) rocks exist in this region, where the nearly unfossiliferous Rondout and the overlying sparsely fossiliferous Manlius limestones, totalling about 50 feet, represent the western edge of the thicker rocks to the east, and rest with slight unconformity on the Cobleskill limestone, the latest Silurian formation. The Cobleskill-Rondout-Manlius sequence represents the slow and incomplete return to normal marine conditions following the salt-gypsum depositional environment of the Late Silurian (for brief summary of latest views, see Rickard, 1955).

The Manlius fauna is sparse and when found consists of large numbers of individuals representing a few species, a condition suggestive in this case of still higher than normal salinity. Typical forms are the brachiopods Howellella vanuxemi and Orthotetes interstriata, the ostracod Leperditia alta, and the "pteropod" Tentaculites.

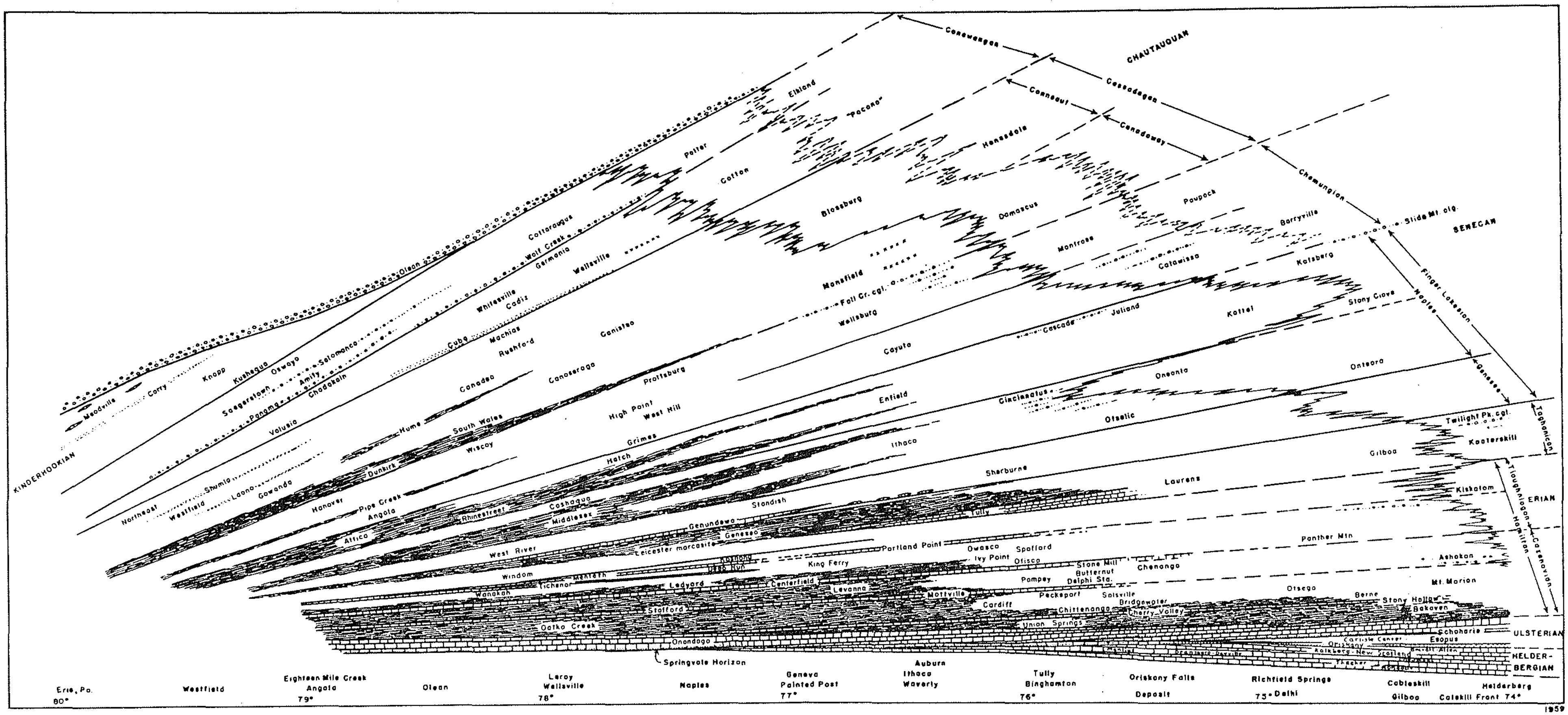
Uplift at the close of the Helderbergian resulted in extensive erosion of these limestones before renewed subsidence began in the Middle Devonian (Ulsterian). The weathering products of the limestones presumably supplied the material for the transgressive Oriskany sandstone.

Middle Devonian

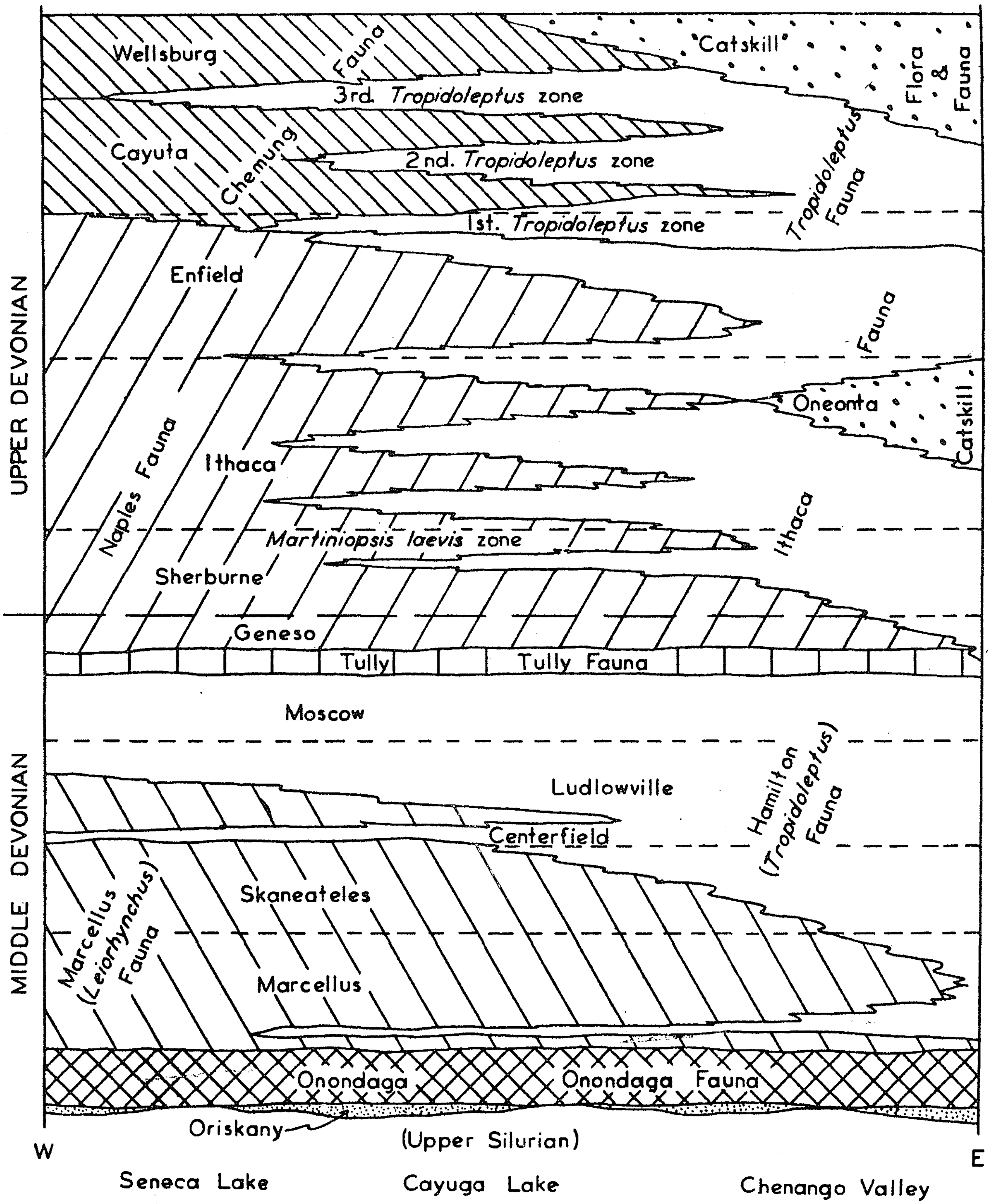
The Oriskany sandstone, representing the deposits of a renewed advance of the sea at the commencement of Middle Devonian time, is marked in the Cayuga Lake Region by its fauna of mostly large brachiopods, Rensselaeria, Meristella, Costispirifer, Acrospirifer, Hipparionyx, Costellirostra, and Chonostrophia. Other types are rare: Platyceras, Cyrtolites, Tentaculites, Modiomorpha, and Pterinea. Few of the genera and species continue upwards in this area into the overlying Onondaga limestone.

The faunas of the Onondaga limestone and overlying Hamilton group include facies faunas of three phases: Onondaga normal limestone phase, Hamilton normal shale phase (Tropidoleptus-Mucrospirifer Fauna), and the Marcellus dark to black shale phase (Leiorhynchus Fauna). The Onondaga is characterized by the abundance of corals (rugose, tabulate, and stromatoporoid), crinoids, brachiopods (Paraspirifer, Fimbrispirifer, Leptaena, Meristella, Pentamerella, Atrypa, Megastrophia), rare pelecypods, gastropods, often large (Platyceras, Pleuronotus, Platyostoma), cephalopods (Spyroceras, Ryticeras, Goldringia) and trilobites (Anchiopsis, Calymene, Coronura, Odontocephalus, Phacops, Proetus). This is the clear water, shelf phase of the Middle Devonian in areas distant from the influx of clastics from landmasses where life conditions were at the optimum. In places coral-reefs are developed.

The Hamilton Fauna represents, on the other hand, the nearshore phase with muddy bottoms and less favorable conditions for many groups, especially corals and pelmatozoans (stromatroporoids, for instance, are unknown in the Hamilton in this region, but are common farther to the west in Michigan where ecologic conditions similar to those of the Onondaga continued into Hamilton time). For some groups, such as pelecypods, the Hamilton conditions were more favorable than in the Onondaga.



GENERALIZED EAST-WEST SECTION, DEVONIAN OF NEW YORK (ADAPTED FROM CHADWICK).



DEVONIAN FAUNAL RELATIONS IN
CENTRAL NEW YORK
(DIAGRAMMATIC)

Characteristic of the Hamilton faunal facies are the brachiopods: Tropidoleptus, Mucrospirifer, Spinocyrtia, Brachyspirifer, Rhipidomella, Pustulina, Camarotoechia, Eunella, Ambocoelia, Athyris, Stropheodonta, Protoleptostrophia, Douvillina; pelecypoda: Modiomorpha, Cypricardella, Cornellites, Aviculopecten, Goniophora, Grammysia, Orthonota, Panenka, Nucula, Palaeoneilo, Glyptodesma, Actinopteria; gastropods: Bembexia, Loxonema, Platyceras, Platyostoma; cephalopods: Michelinoceras, Spyroceras, Nephriticeras, Tornoceras; trilobites: Dechenella, Phacops, Dipleura, Greenops; bryozoa, tabulate and rugose corals (but rarely in any such abundance as in the Onondaga); echinoderms: crinoids (Gennaeocrinus, Ancyrocrinus, Dolatocrinus, Taxocrinus), blastoids (Devonoblastus); and other groups.

The Marcellus Leiorhynchus facies fauna, composed of few species and sporadic occurrence of large numbers of individuals, occurring in fine-grained dark to black, rarely calcareous muds, was contemporaneous with the Onondaga and Hamilton faunas but represents a phase of environment where bottom conditions were unfavorable, even for mud-loving types. Such areas were probably well off-shore with poorly oxygenated water. Characteristic forms are Leiorhynchus, Orbiculoidea, Pterochaenia, Panenka, Styliolina, and occasional wanderers from more favorable sites.

After the close of Onondaga time the Cayuga Lake Basin was occupied alternately during the ensuing Hamilton time by the Tropidoleptus and Leiorhynchus facies faunas, whenever the conditions for either existed (see chart of faunal relations), with a tendency for the Tropidoleptus fauna to extend its area of occupancy farther and for longer periods as time went on.

At the close of Hamilton time, conditions for deposition of more nearly normal limestone developed with the deposition of the Tully limestone (Trainer, 1932; Cooper and Williams, 1935). During this time the Hamilton fauna continued to occupy the region but it was modified slightly but very distinctly by immigration of Eurasiatic elements from the west or northwest where these elements had existed, during the latter part of Hamilton time, as part of the well-known Stringocephalus provincial fauna of Europe, Asia, and northwestern North America. Genera indicative of this minor and first invasion of "foreign" forms into the Tully sea are: Hypothyridina, Scutellum, and Sphaerospongia. These elements, however, disappeared at the close of Tully time, when the Hamilton fauna also moved elsewhere from the Cayuga Land and New York Region, as the old Marcellus fauna, now considerably modified and reappearing as the "prenuncial" Naples facies fauna, marked by an influx of "foreign" pelagic goniatites such as Ponticeras, returned during Geneseo time at the beginning of the Late Devonian.

Upper Devonian Faunas

The Ithaca facies fauna is a modified, less varied Hamilton facies fauna adapted to slightly less favorable conditions, and lacking many common Hamilton forms such as corals and trilobites, and some brachiopods, notably Tropidoleptus, but with a few new types such as Platyrachella mesastrialis, Mucrospirifer posterus, Schizophoria impressa, Cryptonella eudora, etc. In turn the Chemung fauna is a modified Ithaca fauna with new forms such as Cyrtospirifer chemungensis, C. perlatus, Cornellites chemungensis and C. nodocosta, while the Canadaway is marked by diminished and modified Chemung species and the appearance of Cyrtospirifer inermis and Athyris angelica. At several horizons in the upper Enfield and Chemung formations there are recurrences of the earlier Tropidoleptus fauna, modified by time and an excursion elsewhere since the end of Tully time with Tropidoleptus, Cypricardella, Rhipidomella, Spinocyrtia marcyi, Phacops, etc.

The Naples facies fauna, dominant in the lower Upper Devonian to the west, appears in the Cayuga Lake Basin at several horizons in the Geneseo ("prenuncial"), Sherburne, Ithaca, and Enfield, and interfingers with the Ithaca fauna. It is characterized by its largely pelagic and occasional benthonic elements, such as Manticoceras, Honeyoyea, Buchiola, Paracardium, Orbiculoidea, Leiorhynchus, Styliolina, Pterochaenia, etc. It is similar to, and a modified version of the earlier Marcellus Leiorhynchus facies fauna, with immigrant Eurasiatic elements and generally adapted to less rigorous conditions than the dark-black shales. Eastward the Warrenella ("Martiniopsis", "Reticularia") laevis subfauna, with more benthonic types, including Plumalina plumaria, the curious feather-like hydroid is developed, especially in the Cayuga Lake Basin.

The Catskill phase of continental or subcontinental deposits, with land plants, freshwater fishes, and freshwater mussels, is more or less continuously developed to the east of the Cayuga Lake Basin, but enters the area only in the Late Devonian to the south near the Pennsylvania line. Fragments of plants and fish of the Catskill phase are occasionally found in the Middle and Upper Devonian marine beds into which they were washed or drifted from the east.

STRUCTURAL GEOLOGY

Folds and Faults

The folds in the Cayuga Lake Basin are diminished Appalachian foreland folds. They have a more or less east-west trend and are superimposed on the regional dip (see structure map opposite). According to Bradley and Pepper (1938, p. 29) the arrangement of the folds "is characterized more by lack of system than by any clearly defined system. Folds that are plainly traceable across the area are exceptional; most of them are rather short and almost haphazard in their arrangement." In general, however, the axes trend northeastward to eastward and plunge gently southwestward to westward. The most northerly fold in the Cayuga Lake Basin is the Portland Point anticline. Another lies a few miles south of Ithaca, its axis running nearly through Danby. Ithaca lies above the deep syncline between the two.

The crest of the Portland Point anticline is marked by a low-angle thrust fault, visible in the competent Tully limestone in the southwest corner of the cement quarry. In the incompetent Windom shale (Moscow fm.) below it is scarcely traceable. On the opposite side of the lake, at the foot of Taughannock Falls, is another thrust fault, perhaps a continuation of the quarry fault. In both cases the thrust came from the south, with displacements of 30 to 100 feet.

Joints

This region is classic ground for the study of joint phenomena. First illustrated in 1843 by James Hall, the magnificently exposed joints in the Sherburne formation on the east shore of Cayuga Lake a few miles north of Ithaca are familiar features of many geology textbooks.

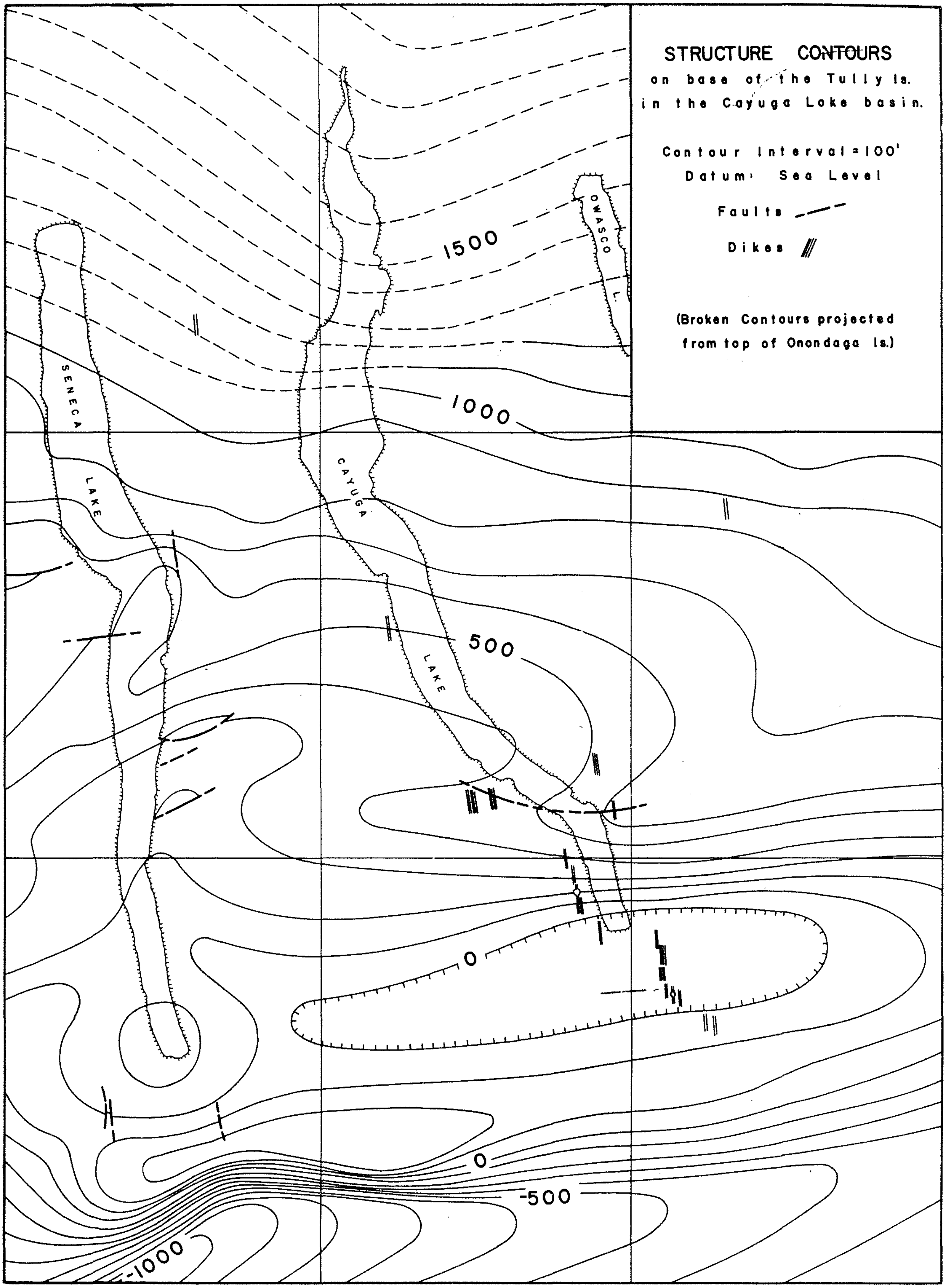
There are three joint sets in the region (see map of joint pattern, p. 13), and Sets I and II constitute a system:

Set I. The master or dip joints, composed of two conjugate shears intersecting at very acute angles (10°-30°) arranged with their mean direction swinging progressively from N 15-30 E eastward from Cayuga Lake to N 40-50 W to the west.

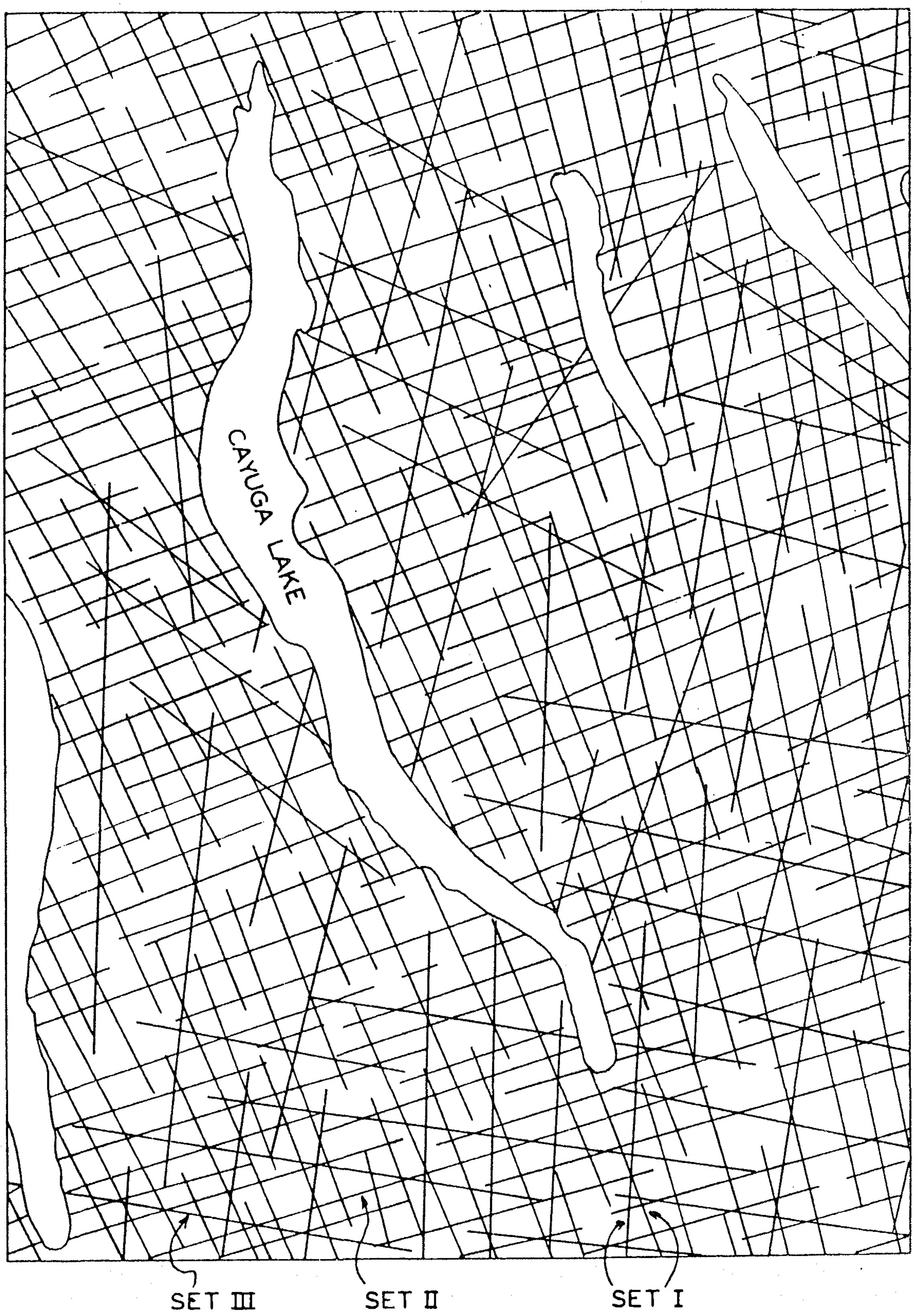
Set II. The strike joints, about perpendicular to the master joints of Set I. In plan, a series of slightly sinuate concentric arcs. To the westward the direction is about N 60 E, shifting centrally to N 70 E. They are better developed than Set III.

Set III. Tension joints arranged concentrically with a strike in the south of about N 84 W, and well-developed only in the southwestern part of the Cayuga Lake Basin. They are tentatively attributed to later tension effects than Set II.

The master or dip joints of Set I are believed to have resulted from simultaneous compression and tension (shearing), at right angles, and were the earliest formed. Those of Set II, the strike joints, developed


STRUCTURE CONTOURS
on base of the Tully ls.
in the Cayuga Lake basin.
Contour Interval = 100'
Datum: Sea Level
Faults
Dikes
(Broken Contours projected
from top of Onondaga ls.)
SENECA
LAKE
CAYUGA
LAKE
OWASCO
L.
1500
1000
500
0
0
-500
-1000

JOINT PATTERN IN CAYUGA LAKE REGION



progressively in areas of local weakness as a result of tension transmitted through the basement rocks. Their local departures from right angles to Set I show the influence of local plunging folds and variations from regional dip. These joints are not the result of Appalachian folding but may have resulted rather from the same stresses before folding began-- the first effects of the stresses. Set III may be a later effect of the folding.

En Echelon Fractures

In the lower part of Taughannock Gorge, where the upper surface of the Tully limestone has been swept clear of the overlying Geneseo shale and debris, there is exposed a beautiful set of short, open, en echelon tension gashes and long shear planes, in a thick stratum of this competent formation. These suggest local rotational stress. The tension gashes trend N 60 W and the shears N 50 W. This occurrence is on the north flank of the Portland Point anticline just north of the axis which here is nearly east-west in trend. Torsional stresses resulting from development of this fold may have been responsible for the gashes and shears, after the manner described by C. M. Nevin (1942, p. 114). The local operation of such stresses may have opened the first-formed dip joints (Set I) into which the dikes of the region were shot upwards from deep reservoirs, in places so abruptly as to be accompanied by explosive ascents (diatremes).

IGNEOUS ROCKS

The dikes referred to above are intrusions of alnoite ("peridotite", "kimberlite") (Martens, 1924). They occur in many places in the Cayuga Lake Basin (map, opposite p. 12) and are similar to those of Clintonville and Syracuse to the northeast. They are part of a system extending from the Monteregian hills near Quebec, across New York, western Pennsylvania, eastern Kentucky, western Kentucky, southern Illinois, and eastern Missouri to eastern Kansas, - a 1500 mile arc, referred to as the "Chestnut Ridge Disturbance." Washington (1922) remarked that these dikes appear to be surficial extensions of a general body of magma which underlies the greater part of this area."

At least 65 dikes are known to occur around the head of Cayuga Lake (Filmer, 1939-40), and those near Ludlowville were known in 1839 (Vanuxem, p. 260). All strike in the same direction, approximately north-south and follow either east or west components of the N-S conjugate shear joint set (Set I). None has a known linear extent of more than half a mile (Portland Point Quarry) and all soon pinch out in both directions. Their thickness ranges from literally paper-thin (especially at foot of Taughannock Falls) to about 12 feet (Williams Brook). Usually they are about 6 inches thick. At two sites they give way to modest-sized "pipes" or diatremes where the intrusive mass is a highly-altered, calcite-seamed mass with a roof of shattered country rock and containing xenoliths of underlying rocks, some of them derived from the deep-lying Pre-Cambrian basement 6000-8000 feet below.

The fresher dike rock is black to dark green and dense (Williams Brook, Cascadilla Creek) and shows brown mica prominently and fresh light green olivine, but the latter is usually serpentinized. With alteration the rock becomes lighter green (Portland Point Quarry) or greenish gray (Taughannock Falls), and weathers to an orange-brown soil (above Taughannock Falls). Originally the rock is presumed to have been composed of abundant phenocrysts of olivine and brown mica in a fine-grained groundmass of magnesia mica, melilite (only in freshest rock), perofskite, apatite, and magnetite. The principal secondary minerals are serpentine, chlorite, calcite, and pyrite. Minor minerals present in very small amount are: chromite, picotite, graphite, red garnet (pyrope), bright-green diopside, and enstatite. All of these minerals have been found in the diamond-bearing kimberlite of South Africa, but no diamonds have yet been found in the Cayuga Lake Basin dikes or in others of the same system.

The date of the intrusions is not definitely known. The youngest rocks intruded along the line of disturbance are Pennsylvanian, and there is no reason to suppose they are other than an effect of the Appalachian Revolution. Sheldon (1927, p. 366) summarized the data for the Cayuga Lake Basin:

"Fault stresses began early in the Appalachian Revolution and continued until after the joint planes and dikes were formed. The joint planes formed early in this time. The dikes were intruded later possibly at the climax of activity, but still before the end of fault movements."

ECONOMIC GEOLOGY

Salt

The Upper Silurian beds (Camillus formation) south of their outcrop to the north contain numerous beds of rock salt. At Portland Point, on the crest of the anticline, the salt is reached at depth of about 1800 feet by two shafts and is mined. A short distance to the north at Myers Point, the salt is procured in the form of brine from wells. The location of the salt works is determined partly by the uplift due to the anticline (less distance down to the salt) and partly due to immediate proximity of a railroad.

Gypsum

Gypsum occurs in considerable quantity in the upper part of the Camillus formation and in the Forge Hollow member of the Bertie formation, at the north end of the Cayuga Lake basin. It was formerly quarried extensively in the 19th century and exported by barge, largely to be used as "land plaster".

Limestone

At Portland Point, on the crest of the anticline, the Tully limestone has been quarried for many years for the manufacture of cement at a large plant located on the lake shore, to which the rock was transported from the quarry above by aerial cableway. The plant has been closed since June, 1948. Quarries scattered along the outcrop of the Tully provide small amounts of locally used road metal.

The Onondaga limestone was formerly extensively quarried for building stone and lime along its outcrop in the northern part of the area, but today only a few quarries are still worked for road metal. Outside the area, to the east and to the west, the Onondaga is a very important source of lime.

Building Stone

Since early days, the sandstone layers in the Ithaca and Enfield formations of the Upper Devonian have provided flagstone and building stone. A large quarry (now covered over, alas) about 150 yards down the slope to the northwest of McGraw Hall, and others nearby, provided the stone, except for the trim (which is Onondaga limestone from the Union Springs region 40 miles down the lake), for the first three Cornell Buildings: Morrill, McGraw and White. In the course of working these quarries, many fossils were obtained, some of them new species described by James Hall, H. S. Williams, and others.

At present the only operative quarries are in the Enfield formation in the Cascadilla Creek valley (Ellis Hollow) about 3 miles east of the campus. One is owned by the university and provided the stone for Willard Straight Hall, Barton Hall, and Balch Hall.

Natural Gas

Natural gas springs, detected by gas bubbling up through joint planes in the beds of creeks, are not uncommon in this region. The gas comes from the black shales of the Marcellus, and has been used locally for small domestic supply.

In the latter part of the last century, enough gas was supplied by shallow wells in the Lower Silurian Medina sandstones to provide most of the village of Seneca Falls for about 20 years.

The Portland Point anticline has been tested several times to the Oriskany sandstone but little more than a show of gas has been found. But on the next anticline to the south of Ithaca, several wells drilled to the Oriskany in the vicinity of Danby produced marketable quantities (2,000,000-5,000,000 cu. ft. per day). However, by the time a pipe-line was laid, the pool was virtually exhausted. Test drilling continues hopefully and sporadically in this region.

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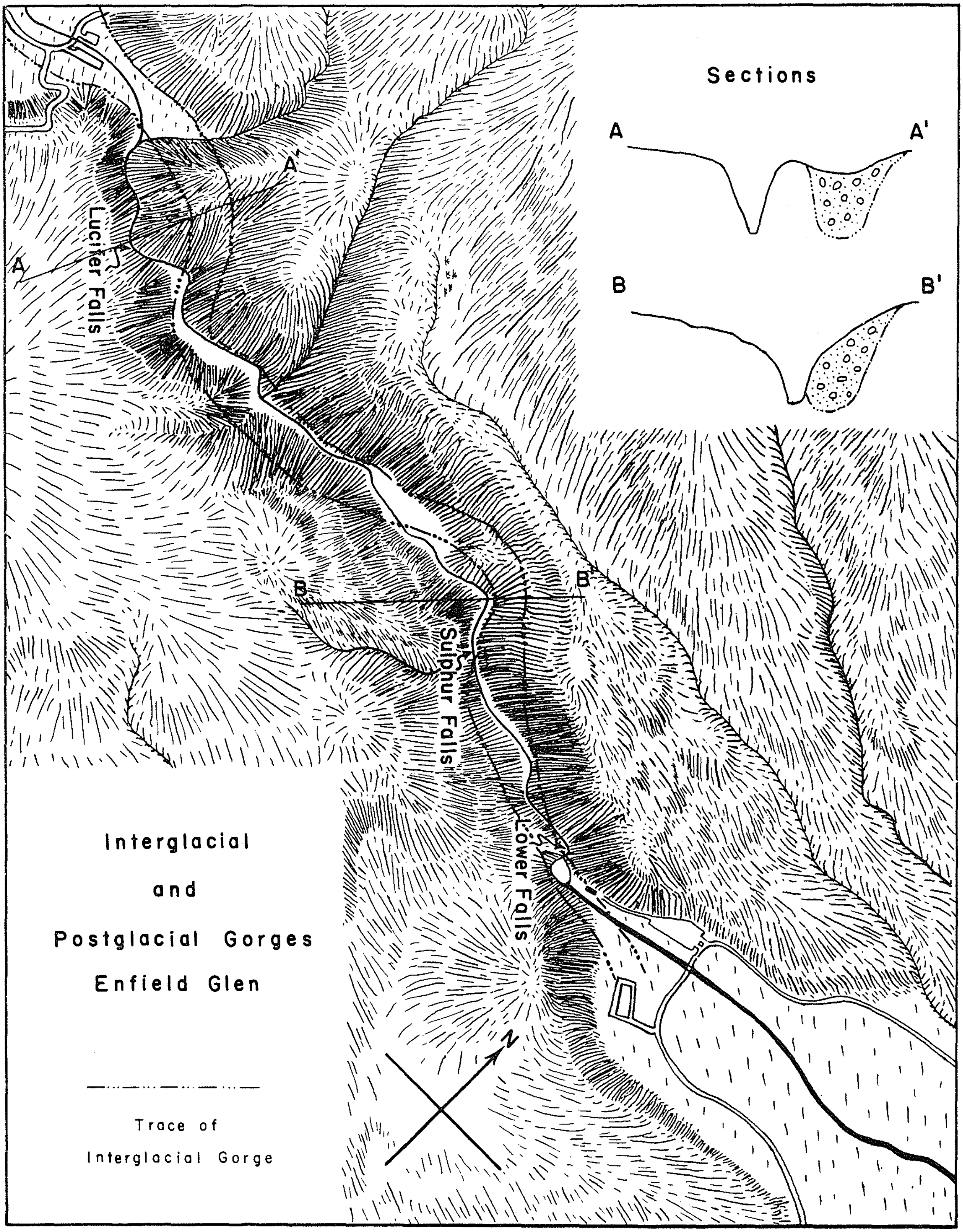

Sections
A
A'
B
B'
Lucifer Falls
A
A'
B
B'
Sulphur Falls
Lower Falls
Interglacial
and
Postglacial Gorges
Enfield Glen
N
Trace of
Interglacial Gorge

TRIP A. ENFIELD GLEN (ROBERT H. TREMAN STATE PARK)

FRIDAY AFTERNOON, 8 MAY, 2:00 P.M.
(See diagram opposite page)

Leave McGraw Hall. Down the eastern wall of the Cayuga trough, and west across the delta-plain to Albany street, turning south. Soon after crossing Six-mile creek the road (Rte. 13) turns toward the southwest. Excellent views west from this stretch of road of the surface of the delta-plain and the sequence of hanging deltas through which the Coy Glen stream has cut its gorge.

Railroad underpass. Just south of this underpass the end of the interglacial Buttermilk gorge may be seen on the east to be followed slightly to the south by the hanging valley waterfalls made by the post-glacial Buttermilk stream as it descends the oversteepened eastern wall of the Cayuga trough. The large gravel pit to the south of the Buttermilk Falls was excavated in the hanging delta sequence made by Buttermilk creek.

The bed-rock exposed in Buttermilk Falls is the Ithaca formation. The upper member of the Ithaca shale begins at about the top of the first cascade.

Junction of Routes 13 and 13A. The road crosses the delta-plain to the west side of the valley and continues southward on glacial deposits to

State Route 327. From the floor of the Cayuga trough the road climbs the west wall. Small hanging deltas may be observed in several of which gravel pits have been opened.

Upper or western entrance to Treman State Park. The parking area is in a post-glacial, excavated part of an interglacial gorge (see diagram for details). (The buses will leave the parties and later meet them at the lower or eastern entrance.) From the parking area, walk to the entrance of the post-glacial sector of the gorge. This post-glacial gorge is nearly at right angles to the drift-filled interglacial gorge which swings around the rock island which forms the north wall of the post-glacial gorge. The outstanding feature of the post-glacial gorge itself is the perfection of joint-plane control of the stream course.

Lucifer Falls at the eastern end of the upper gorge is slightly upstream from the main southern wall of the interglacial gorge which has been excavated by the post-glacial stream. The upper gorge is cut in the Enfield shale. The base of the Enfield formation is about at the top of Lucifer Falls. The lower sector of Enfield Glen is in the Ithaca formation.

Several sedimentary features are well developed in the rocks in the vicinity of Lucifer Falls, including current ripple marks that demonstrate that the general current direction was from northeast to southwest. Moreover, there is a submarine erosion channel which shows well in the south wall of the gorge above Lucifer Falls.

View eastward before descending into the interglacial part of the Enfield Glen the eastern, oversteepened slope of the Caguya trough.

Eastward from Lucifer Falls. The trail follows down the drift-filled interglacial valley and thence along the excavated part of interglacial valley. Sulphur falls and the Lower falls represent spurs of the interglacial valley upon which the post-glacial stream was superimposed.

Return to Ithaca via Rte. 13.

TRIP B. CAYUGA INLET TROUGH

FRIDAY AFTERNOON, 8 MAY, 2:00 P.M.

Glacial and proglacial features of the southern part of Cayuga trough, between Ithaca and North Spencer, returning by way of Michigan Hollow and Danby. Includes hanging deltas, kame and kettle topography, marginal meltwater channels, end moraine, outwash plain, stream diversion and the upland surface.

Route. From Cornell Campus descend into Cayuga trough to downtown Ithaca built on compound delta of four creeks. Valley fill more than 400 ft. thick. Bottomlands subject to flooding. South via Routes 13 and 34,

leaving Ithaca city limits at	0.0 miles
Turn left into Buttermilk Falls State Park at	1.3 miles

Stop 1. Buttermilk Falls. Lower portion of Enfield and upper portion of Ithaca formation exposed. Representative of notched lower reaches of hanging valleys of Cayuga trough but contrasts with gorges initiated prior to last glaciation. Buttermilk Creek was diverted by glacial deposition in its interglacial gorge. Hanging deltas exposed in gravel pits 150 yards south.

Continue southwest on Route 13 to Inlet Valley School at	1.9 miles
Turn sharply right (north) on Route 13A; proceed to Coy Glen at	2.7 miles
Turn left (west) on Coy Glen Road and enter upper gravel pit at	3.1 miles

Stop 2. Coy Glen hanging deltas. Excavations by Rumsey Ithaca Corporation expose structure of massive deltas built into proglacial Lakes Warren and Dana during recession of the continental ice sheet in late Wisconsin time. Coy Creek in incising a meander initially developed across the main Dana delta has imposed on it second order meanders controlled by bedrock joints. Meet bus at lower pit.

Return south on Route 13A to Inlet Valley School at	4.4 miles
Continue south on Route 13 over kame and kettle topography. Contrast steep southeast wall with gentler northwest wall of Cayuga trough.	
Pass Enfield Glen and entrance to Robert H. Treman State Park at	6.0 miles
Continue south on Route 34 to Newfield Station (Nina) at	8.1 miles
Turn right (west) following West Branch .8 mile toward Newfield to	8.9 miles
Turn left and immediately bear right at fork, climbing due south up the southwest wall of Cayuga trough to intersect Shaffer Road at	9.5 miles

Stop 3. Shaffer Road overlook. Meltwater from a proglacial lake briefly imponded near Newfield flowed through ice-walled channels, cutting the bench followed southeastward by Shaffer Road and debouching across kame terrace to the southeast. View across stagnant ice deposits which fill the southern end of Cayuga trough.

Continue south on Shaffer Road, turning left (east) on Piper St. at — 10.7 miles

Descend into Cayuga trough over kame complex, via Piper St. to Stratton — 13.0 miles

Turn right (south) on Route 34 at Stratton, riding across complex of stagnant ice deposits which mark minor glacial oscillations during downwasting of the Cayuga ice tongue in recession from the Valley Heads terminal moraine

Route 34 climbs to 1130 feet, about 750 feet above Cayuga Lake at — 18.9 miles

Tributaries to Cayuga trough have entry angles pointing north, whereas tributaries to the through valley south of this point have entry angles pointing south, suggesting that the present depositional divide between St. Lawrence and Susquehanna watersheds corresponds approximately with an interglacial or preglacial bedrock divide.

Highway passes onto outwash where moraine ridge curves southeast at — 19.2 miles

Pitting and large kettle lakes (e.g. Spencer Lake) indicate outwash deposition onto unmelted stagnant ice. Valley Heads terminal moraine about 2.5 miles south of this point is largely buried in outwash.

Turn left (east) on Michigan Hollow Road in North Spencer — 20.5 miles

Cross swampy edge of large kettle lake. Toward east side of Cayuga trough road curves north to parallel low, narrow ridge which separates it from south-flowing Michigan Creek. Continue to Point O'Rocks — 22.8 miles

Stop 4. Point O'Rocks. Ice and ice marginal deposits near the Valley Heads maximum crowded Michigan Creek against the side of its valley, forcing it to cut a bedrock channel around this point. During ice wastage Michigan Creek deposited a fan into which it is now cutting. Kame exposed in borrow pit.

Continue north from Point O'Rocks on Michigan Hollow Road. Moraine deposited by ice moving south down Michigan Hollow crosses valley at — 24.7 miles

Kames exposed in cuts and gravel pits to east near road. Valley bottom widens northward with swamp and ponds, the remnants of a small proglacial lake imponded behind the moraine until drained by Michigan Creek.

Turn left (northwest) on Route 96 in outskirts of Danby at — 28.4 miles

Continue on Route 96 to moraine ridge trending northeast across Danby Valley. At this point turn right (northeast) on Muzzey Road — 30.6 miles

Turn left (north) on Patmore (Troy) Road at — 31.7 miles

Road as here at 1500 feet above sea level on the glacially modified upland erosion surface. View northeast across Hungerford, Snyder and Turkey hills at the edge of the deeply dissected Portage escarpment.

Descending the upper slope of Sixmile trough, cross rock bench at — 33.6 miles

This bench at 1030 ft. is continuous northwest to the abrupt nose on South Hill which marks a former ice-walled spillway.

Here the waters of proglacial West Danby Lake in Inlet trough first escaped eastward into Slaterville Lake in Sixmile trough just before the two joined to form Lake Ithaca with outflow southeast past White Church and Willseyville.

Turn left, (northwest) on Coddington Road at 37.0 miles

Enter Ithaca city limits at 38.3 miles

Return through downtown Ithaca to Cornell Campus.

TRIP C. AROUND CAYUGA LAKE

SATURDAY, 9 MAY, 8:30 A.M. - 5:30 P.M.

This trip is in two sections: Section 1 in a clockwise direction, Section 2 counterclockwise. Both sections will meet at Stop 5 for lunch. Note that Section 2 will make the stops in reverse order, i.e., the first stop will be Stop 7.

Routes

Section 1.

Leave McGraw Hall, crossing downtown Ithaca to Rte. 96. North towards Trumansburg (views of Cayuga Lake trough to right. Note southerly dip of rocks on east shore of lake; prominent datum plane is the Tully limestone), to entrance to

Taughannock State Park. East along upper Taughannock Creek: exposures of middle part of Ithaca formation; under railroad to

Stop 1. Main Falls Lookout. Exposure of Geneseo, Sherburne, and Ithaca formations in gorge walls. Continue down hill to Rte. 89, south across Taughannock Creek and present delta, with view on right of lower falls over Tully limestone. Turn around and north on Rte. 89, with views of Cayuga Lake on right, 9 miles to

Stop 2. Hubbard Quarry. Contact of Geneseo and Sherburne formations, Middle-Upper Devonian boundary. Fossils. Septarian concretions. Continue north of Rte. 89 to Town Line Road. West to junction with Rte. 96. West on Rte. 96 to Ovid, north on 96 to junction with Rte. 414 at Romulus Center. North on Rte. 414 to Fayette. In Fayette, west on Poorman Road 0.25 mile to

Stop 3. Fayette Town Quarry. Upper Skaneateles (Levanna) shale in lower part of quarry; lower part of Centerfield member in upper part. Fossils from both members; septarian concretions. Back to Fayette and north on Rte. 414 to Yellow Tavern Road (Country Rd. 121), thence east to quarry.

Stop 4. Old Wolf Quarry (Warren Bros. Road Co.). Upper Onondaga limestone (Seneca member). Tioga metabentonite. Continue east on Yellow Tavern Road to Seybolt Road; north to first road east to Canoga and Rte. 89. North on Rte. 89 to

Stop 5. Cayuga Lake State Park. LUNCH (1 hour). Continue north on Rte. 89 to junction with Rtes. 5 and 20. East across Montezuma Swamp and Seneca River (State Barge Canal and Cayuga outlet) to junction with Rte. 90. South on Rte. 90 through Cayuga to junction with Rte. 326. East then north to

Stop 6. Yawger's Woods. Walk west from road 0.5 mile to woods, through woods to outcrop of Manlius (Olney) limestone and Oriskany sandstone.

Fossils from Oriskany (sledgehammers useful!). Return via Rte. 326 to Rte. 90, then south through Union Springs, Levanna, and Aurora to King Ferry and junction with Rte. 34B. South on Rte. 34B to road 0.7 mile west of South Lansing leading down to Portland Point. 0.5 mile to quarry entrance.

Stop 7. Portland Point Quarry. Upper Moscow (Windom) shale, Tully limestone, lower Geneseo shale. Fossils. Alnoite dike. Low-angle thrust. Back to Rte. 34B; east to South Lansing, south on Rte. 34 to Ithaca (Cornell Campus).

Section 2.

Leave McGraw Hall, north on Rte. 34 to South Lansing. West on Rte. 34B 0.7 mile to road leading down to Portland Point. 0.5 mile to quarry entrance.

Stop 7. Portland Point Quarry. Upper Moscow (Windom) shale, Tully limestone, lower Geneseo shale. Fossils. Alnoite dike. Low-angle thrust. Back to Rte. 34B, north to junction with Rte. 90 at King Ferry. West then north on Rte. 90 via Aurora, Levanna, and Union Springs to junction with Rte. 326. East then north to

Stop 6. Yawger's Woods. Walk west from road 0.5 mile to woods, through woods to outcrop of Manlius (Olney) limestone and Oriskany sandstone. Fossils from Oriskany (sledgehammers useful!). Return via Rte. 326 to Rte. 90. North on Rte. 90 via Cayuga to junction with Rtes. 5 and 20. West across Montezuma Swamp and Seneca River (State Barge Canal and Cayuga outlet) to junction with Rte. 89. South on Rte. 89 to

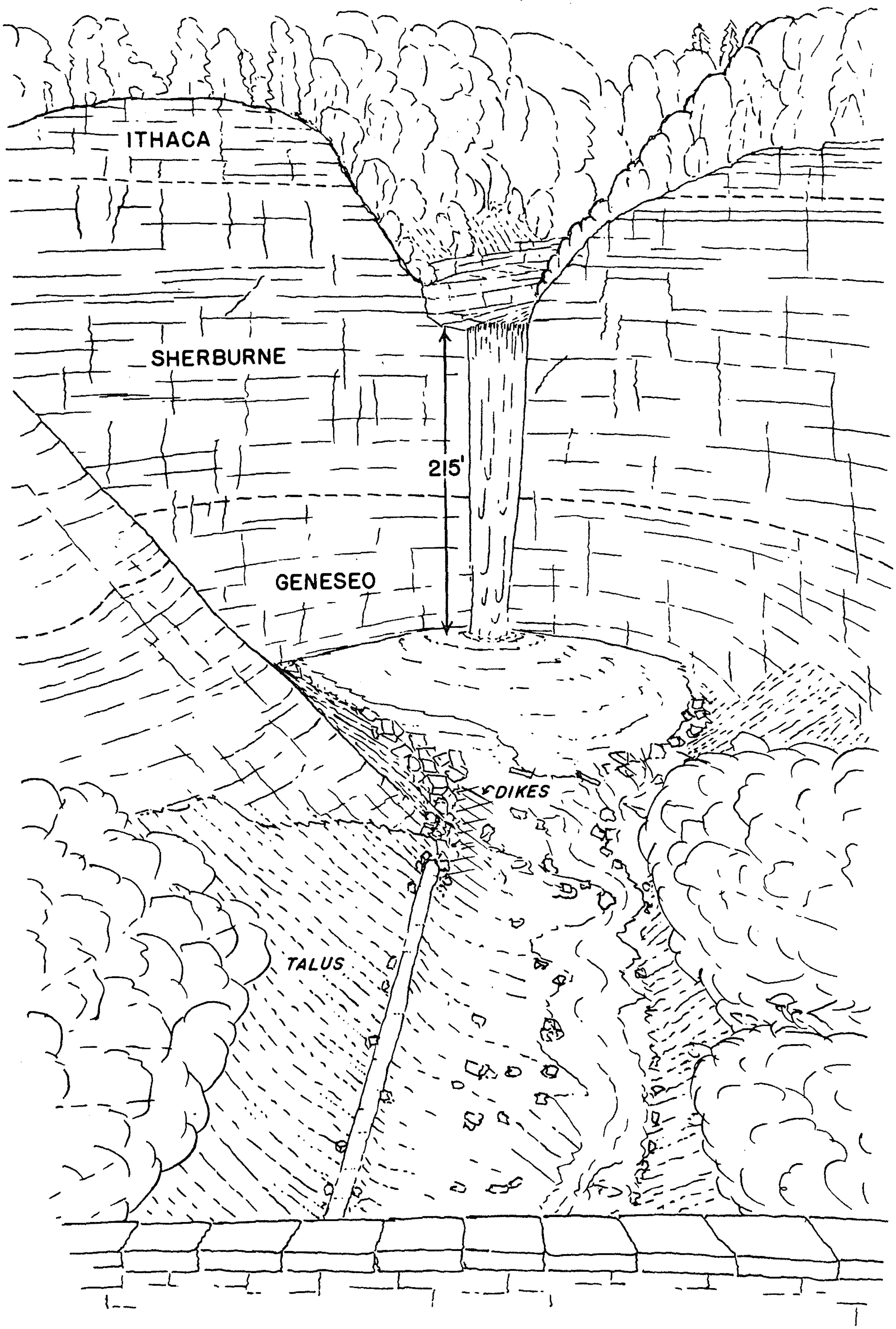
Stop 5. Cayuga Lake State Park. LUNCH (1 hour). Continue south on Rte. 89 to Canoga. West to Seybolt Road. South then west on Yellow Tavern Road to quarry.

Stop 4. Old Wolf Quarry (Warren Bros. Road Co.). Upper Onondaga limestone (Seneca member). Tioga metabentonite. Continue west on Yellow Tavern Road (County Rd. 121) to junction with Rte. 414. South on Rte. 414 to Fayette. West on Poorman Road 0.25 mile to

Stop 3. Fayette Town Quarry. Upper Skaneateles (Levanna) shale in lower part of quarry; lower part of Centerfield member in upper part. Fossils from both members; septarian concretions. Back to Fayette. South on Rte. 414 to junction with Rte. 96 at Romulus Center. South on Rte. 96 to Ovid, then east to Town Line Road, and continuing east 2 miles to Rte. 89. South on Rte. 89 to Lively Run and

Stop 2. Hubbard Quarry. Contact of Geneseo and Sherburne formations, Middle-Upper Devonian boundary. Fossils. Septarian concretions. Continue south on Rte. 89 to Taughannock State Park, crossing bridge over Taughannock Creek (view to right of lower falls over resistant Tully limestone), turning around in parking space and back across creek and up road north side of gorge leading west to

Stop 1. Main Falls Lookout. Exposure of Geneseo, Sherburne, and Ithaca formations in gorge walls. Continue up hill, under railroad bridge and west along Taughannock Creek (exposures of middle Ithaca formation) to junction with Rte. 96. South on Rte. 96 toward Ithaca. Views of Cayuga Lake to left. Note southerly dip of rocks exposed along east shore of lake; prominent datum plane is the Tully limestone. West across Ithaca and up hill to Cornell Campus.



TAUGHANNOCK FALLS

DESCRIPTION OF STOPS, TRIP C

Stop 1. Taughannock Falls, Taughannock State Park, 2.5 miles southeast of Trumansburg, Tompkins County.

(See sketch on opposite page.)

The main falls is at the head of a deep post-glacial gorge one mile long, with walls from 200 to nearly 400 feet high. The falls is determined partly by the superior resistance of the Sherburne-Ithaca sandstones and shales with respect to the weaker underlying Geneseo black shale, and partly by the jointing. The upper 90 feet of the Geneseo is exposed in the gorge walls from the level of the plunge pool to a point, marked by change in lithology and color, about halfway up the falls. The full thickness of the Sherburne (about 150 feet) is exposed above the Geneseo, and about 50 feet of the overlying Ithaca caps the top of the wall on either side of the falls. The contact of the Sherburne and Ithaca is marked by the *Warrenella laevis* zone rather than any significant lithologic change.

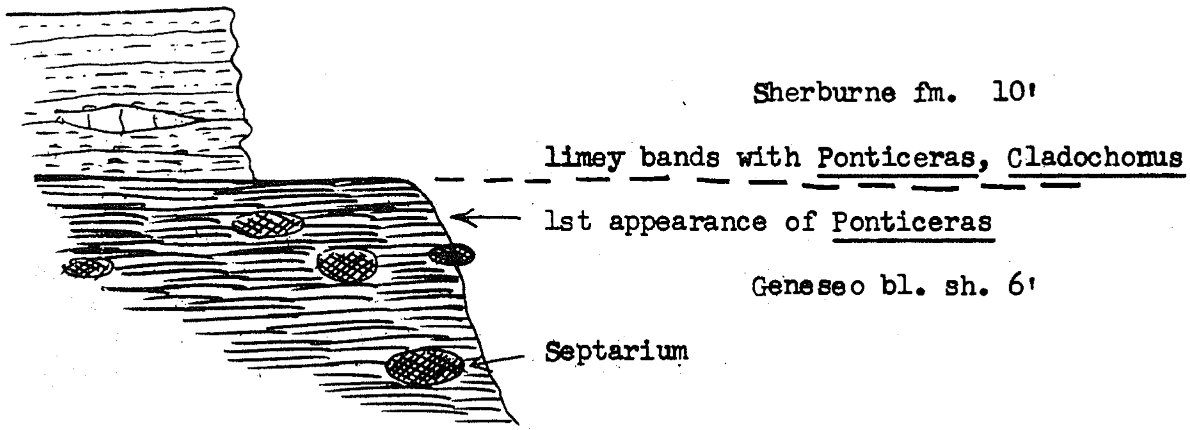
To the left of the base of the falls are several very thin (0.2 to 1 inch) altered alnoite dikes in the N-S joint planes.

At the mouth of the gorge on the lake is the lower falls, 15 feet high, over the resistant Tully limestone (15 feet thick) between the weak basal Geneseo above and the weak shales of the upper Moscow formation below.

Stop 2. Hubbard Quarry, on Rte. 89 at Lively Run, 1.5 miles northeast of Interlaken, Seneca County.

This is one of the few places in this region where the contact of the Geneseo black shale and the Sherburne formation--and the boundary between the Middle and Late Devonian--can be studied at close range.

Section in the Hubbard Quarry:



In the upper few feet of the Geneseo, typical fossils of the black shale phase occur:

Barroisella spatulata	Pterochaenia fragilis
Orbiculoidea lodensis	Ponticeras perlatum
Schizobolus truncatus	Tornoceras peracutum
Leiorhynchus quadricostatus	Fish and plant fragments

P. perlatum and T. peracutum are especially important, for they first appear at this horizon and extend upward through the Sherburne into the lower part of the Ithaca formation. Ponticeras is characteristic of the lower part of the Manticoceras Zone which marks the base of the Upper Devonian throughout the world.

The septarian concretions in the upper Geneseo are almost wholly unfossiliferous but do contain an interesting variety of minerals: barite, calcite, ankerite, quartz, marcasite, sphalerite, and galena, in order of decreasing abundance. They have not been studied since Martens' brief note in 1925.

In the lower Sherburne the following fossils occur:

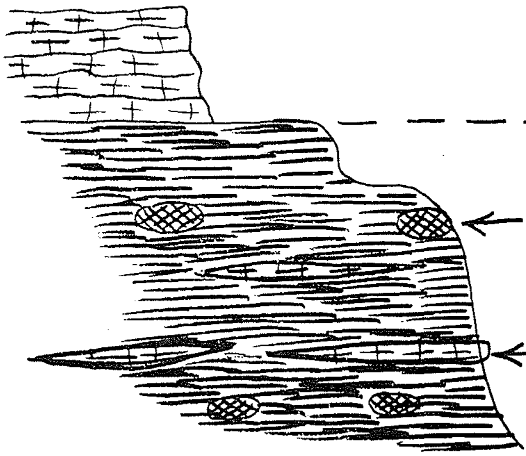
Cladochonus sp.	Panenka sp.
Leiorhynchus quadricostatus	breviconic nautiloids
Loxonema noe	Ponticeras perlatum
Palaeotrochus praecursor	

This fauna of mixed benthonic and pelagic types is similar to the "Naples fauna" of the West River shales farther to the west. The basal zone, exposed in the quarry, has been correlated with the Genundewa limestone to the west but is probably older, and the lower part of the Sherburne is equivalent to the upper part of the Geneseo to the west.

Stop 3. Fayette Town Quarry, 0.25 mile west of Fayette, Seneca County.

This quarry, operated by the town for road material, exposes the upper part of the Levanna member of the Skaneateles formation and the lower 20 feet of the overlying Centerfield member. It is a good collecting site for the dark shale Leiorhynchus fauna of the Levanna and the more normal bottom Tropidoleptus fauna of the Centerfield.

Section in Fayette Town Quarry:



The Levanna is a dark, almost black shale with a typical dark shale fauna of mostly pelagic forms:

Leiorphynchus multicostus
Ambocoelia umbonata
Strophalosia truncata
Chonetes scitula
Orbiculoidea media
Nuculites
Styliolina fissurella
Tornoceras uniangulare
Lyrioceras
Palaeoneilo
Buchiola halli
Panenka
Pterochaenia fragilis
Bucanopsis leda
Euryzone rugulata
Geisonoceroides
Michelinoceras
Spyroceras

Terrestrial plants from the lands to the east drifted into this area and their carbonized remains are not uncommon: Drepanophycus (lycopsid), Hostimella, Loganiella (psilopsids), and macerated pieces of the seed-fern Eospermatopteris. Fish remains, especially fragments of the armor plate of Dinichthys halmodeus, have been found.

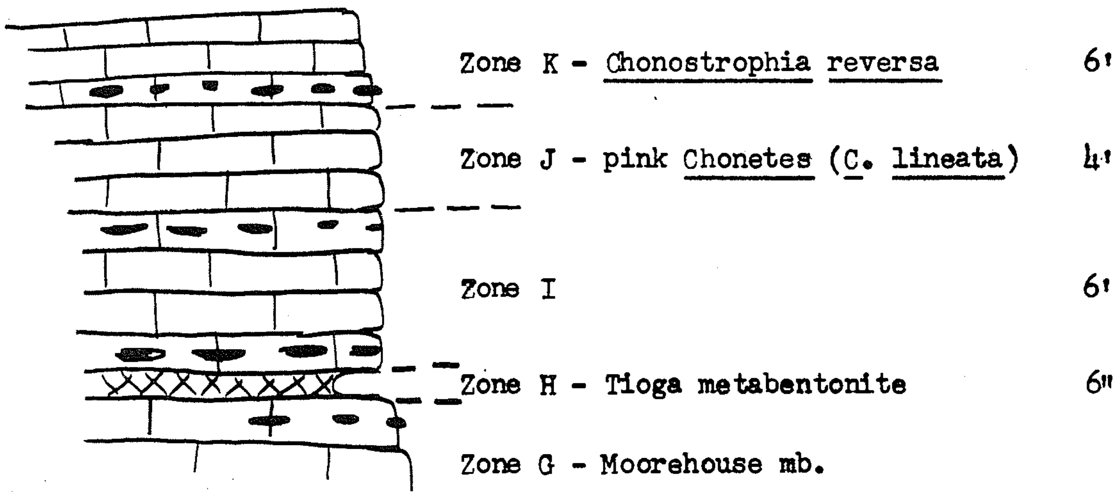
In the lighter-colored, slightly calcareous, worm-riddled bands near the top of the Levanna, a more normal benthonic fauna occurs with Phacops rana, Mucrospirifer, Brachyspirifer, Chonetes coronata. Large specimens of Agoniatites vanuxemi have recently been found in these layers.

The lighter-colored, slightly calcareous, drab-weathering Centerfield in the upper part of the quarry represents the lower part of the member, and is here rich in pelecypods such as Aviculopecten princeps, Actinopteria decussata, Modiomorpha mytiloides, and Leiopteria; and well-preserved brachiopods: Meristella barrisi, Tropidoleptus carinatus, Spinocyrtia granulosus, Fimbrispirifer venustus, and Brachyspirifer audaculus.

Stop 4. Old Wolf Quarry, 1.75 miles west of Canoga, Seneca County.

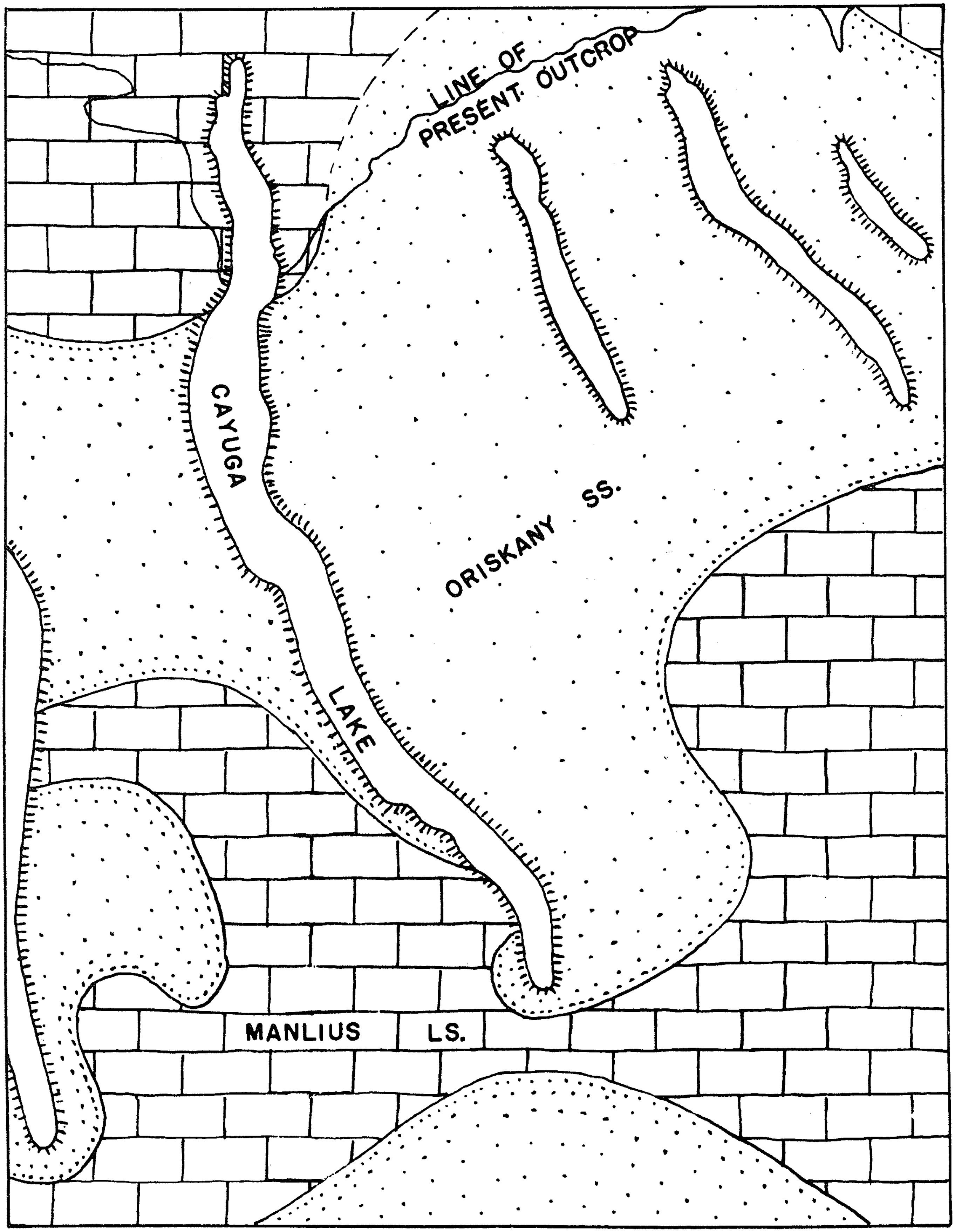
At this locality most of the upper member of the Onondaga, the Senaca, is exposed. The quarry has been worked off and on for at least a century, and recently has been re-opened by Warren Bros. Road Co. to provide crushed stone for bituminous paving.

Section in the Wolf Quarry:



The Tioga metabentonite, a pale greenish-gray clayey ash layer widespread in New York and Pennsylvania, lies about a foot below the floor of the quarry, about 14 feet below the top of the Onondaga formation. Eastward from here it is found progressively nearer the top. At Cherry Valley it is 6 feet below the top, and still farther east both it and the overlying Seneca member must pass laterally into the overlying Marcellus, indicating the time-transgressing nature of the Onondaga limestone--older to the east, younger to the west.

Stop 5. Cayuga Lake State Park. Lunch (1 hour).

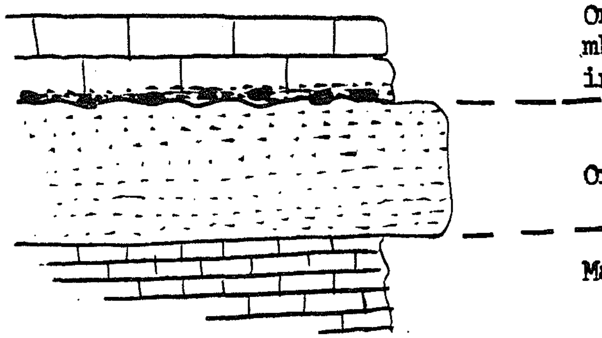


PRE-ONONDAGA PALEOGEOLOGY, CAYUGA LAKE BASIN

Stop 6. Yawgers Woods, 2 miles northeast of Union Springs, Cayuga County

Here the resistant Oriskany sandstone, a single bed 4 feet thick, outcrops in the woods a half mile west of the road, where it forms a low escarpment facing west. A few feet of Manlius (Olney mb.) limestone can be seen below it and one or two feet of the basal Onondaga (Springvale and Edgecliff mbs.) limestone rest on top.

Section at Yawgers Woods:



Onondaga limestone (Edgecliff mb. with Springvale horizon in base)	2'
Oriskany sandstone	4'
Manlius (Olney mb.) ls.	4'

(Concealed)

(In a creek less than 1000 yards to the south the Oriskany is absent and the Onondaga lies directly and disconformably on the Manlius. The Oriskany is absent from the opposite side of the lake westward to Buffalo. The sandy Springvale horizon in the base of the Onondaga has often been mistaken for the Oriskany in the areas where the latter actually is lacking. For the distribution of the Oriskany in the Cayuga Lake Region see the map on the opposite page.)

This is one of the oldest-known and most famous of American Devonian fossil localities. It was visited as early as 1810 by De Witt Clinton, later governor of the state:

> "The higher stratum is composed of limestone [Onondaga], and the next adjoining one of sandstone [Oriskany] embedded with marine substances. There is but one stratum of sandstone, of the thickness of two or three feet, and below and beneath as well as above it there is limestone [lower ls. = Manlius]. The sandstone contains several marine shells, which appear to be strange, and I should therefore pronounce them marine. There are littoral ones also, such as scallops [probably Costispirifer arenosus] and in one instance a periwinkle [Platyceras?] was found and sent to Peale's Museum in Philadelphia. One strange substance is larger than a scallop, and one is like a horse shoe in miniature [Hipparionyx proximus].... This collection of sandstone demonstrates the existence of the ocean here."

A few years later (1815), Clinton remarked of these fossils: "These petrifactions are worthy of a more minute examination. I have no doubt but that a very interesting set of shells might be made from this immense stratum of sandstone."

In 1819 David Thomas of Aurora noted that the fossils in the sandstone were mostly in the bottom of the bed, due to the "shells sinking more speedily than the sand" in the Flood, i.e., diatactic settling of the sedimentologists!

Benjamin Silliman sent some fossils from Yawgers Woods to Alexandre Brongniart in Paris in 1820. Brongniart was unable to name them: "... the sandstones of Cayuga, containing terebratulids which I shall perhaps be able, at some future time, to give you the exact name." By 1829, however, Brongniart was able to correlate, more or less correctly, "le grès blanc de Cayuga" with sandstones of Devonian age in Europe, but it was many years before Conrad, Hall, and Vanuxem figured and described the fossils of the Oriskany.

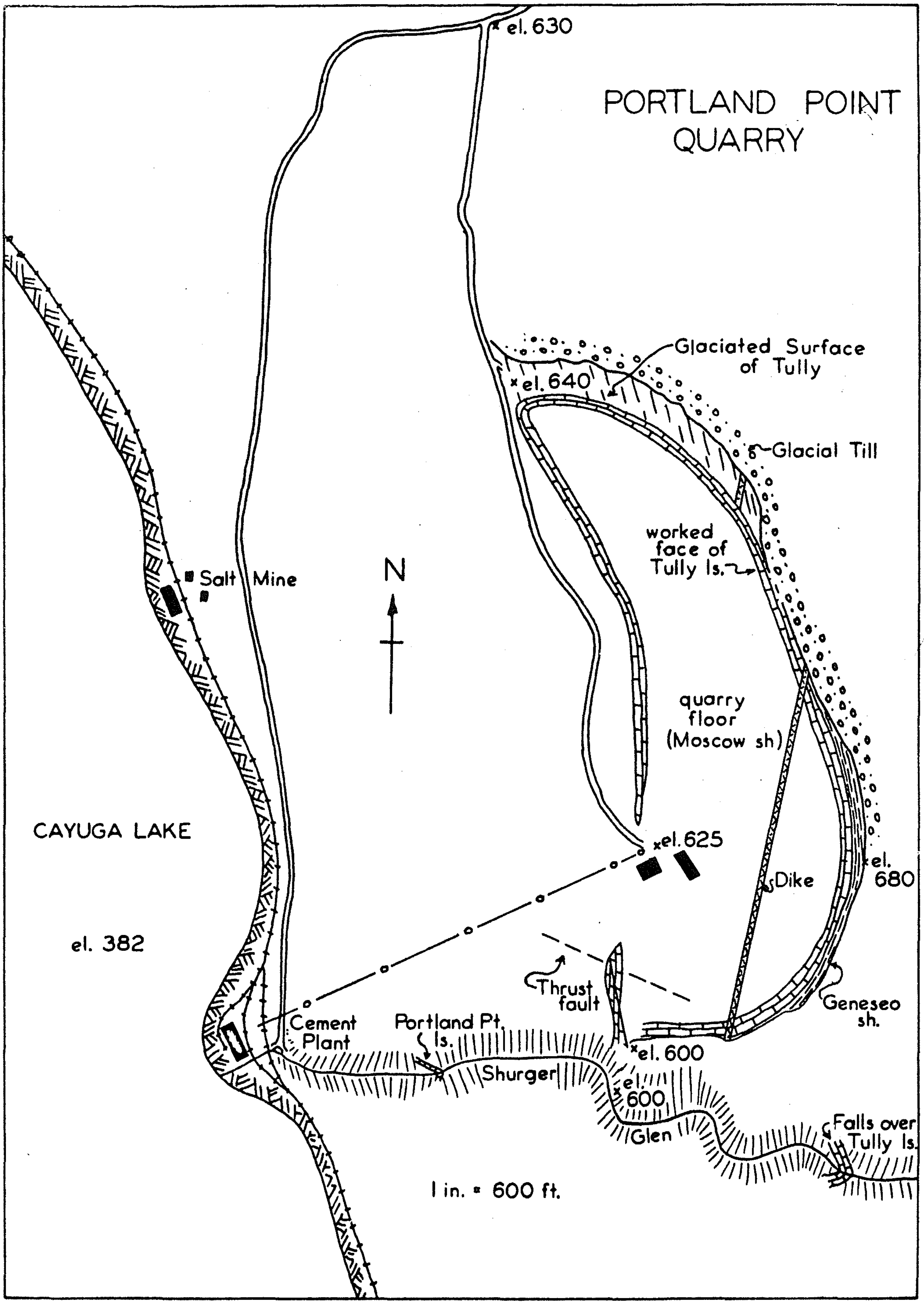
Fossils are scarce in the Manlius at this locality. The fauna is small, consisting of benthonic forms indicative of hypersaline conditions:

Howellella vanuxemi — *Schuchertella interstriata*
Brachyprion varistriata — *Tentaculites*
Leperditia alta

The fauna of the Oriskany is characterized especially by large brachiopods in anormous numbers, with occasional pelecypods and gastropods but few other forms:

Costispirifer arenosus — *Rensselaeria ovoides*
Acrospirifer murchisoni — *Hipparionyx proximus*
Costellirostra peculiaris

Only the lowest one or two feet of the Onondaga limestone cap the Oriskany at Yawgers Woods, representing the basal Springvale sand horizon (Zone A of Oliver, 1954), and the lowest beds of the Edgecliff member (Zone C of Oliver). Collecting is poor, but some loose blocks of the Springvale in the field at the east edge of the woods contain corals and the black, phosphatic sandy nodules characteristic of the Springvale. Purple fluorite is sometimes found in intradissepimental cavities in the corals. The Springvale represents weathered Oriskany reworked by the westwardly-transgressing Onondaga sea.



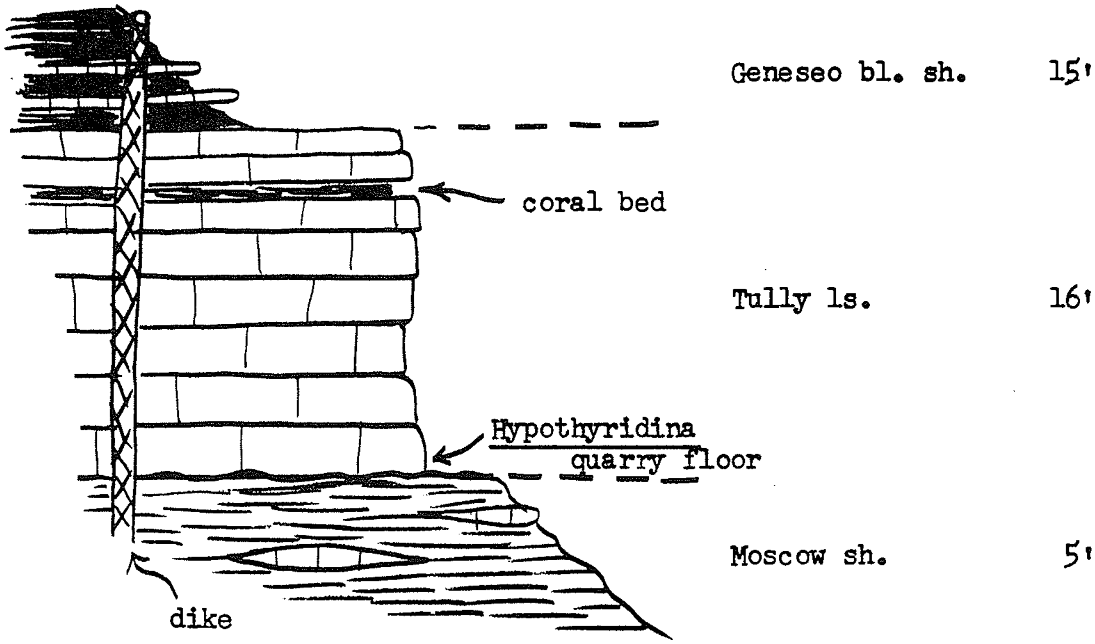
PORTLAND POINT
QUARRY
el. 630
Glaciated Surface
of Tully
el. 640
Glacial Till
worked
face of
Tully ls.
Salt Mine
N
quarry
floor
(Moscow sh)
CAYUGA LAKE
el. 625
Dike
el.
680
el. 382
Thrust
fault
Geneseo
sh.
Cement
Plant
Portland Pt.
ls.
el. 600
Shurger
el.
600
Glen
Falls over
Tully ls.
1 in. = 600 ft.

Stop 7. Portland Point Quarry, 1 mile southwest of South Lansing, Tompkins County.

This quarry, from which the Tully limestone was formerly taken for cement manufacture, and now worked for riprap and road stone, is one of the most fossiliferous localities in the Cayuga Lake Basin. Over 100 species of corals, bryozoa, crinoids, brachiopods, pelecypods, gastropods, cephalopods, and trilobites, have been collected from the top few feet of the Moscow shale exposed in the floor of the quarry.

The quarry is situated on the crest of a low anticlinal axis. At the south end is a low-angle thrust fault overthrust to the northwest. On the east side of the quarry is a serpentinized alnoite dike about a foot thick following one of the N-S joints. Glacial striae are exposed on the surface of the Tully limestone at the north end.

Section in the Portland Point Quarry:



The black, bituminous Geneseo shale is sparsely fossiliferous, but contains a mixture of pelagic marine fossils (Orbiculoidea, Styliolina fissurella, linguloids, Paracardium, Leiopteria, Tornoceras uniangulare), freshwater fish (Dinichthys, crossopterygian scales), and land plants (Aneurophyton).

The Tully limestone is fossiliferous, but fossils are hard to extract. The guide fossil Hypothyridina venustula is found in clusters in the lower part of the basal bed. The thin dark shaly bed, packed with corals, in the upper part of the Tully, is a widespread datum plane from Skaneateles Lake across the Cayuga Lake Basin nearly to the western limits of the Tully east of Canandaigua Lake. The corals of this zone—Heliophyllum, Heterophrentis, Siphonophrentis, Cystiphylloides, Favosites, and Alveolites, are not found in the Tully outside of this bed, and represent a recurrence of Hamilton forms.

The upper 5 feet or so of the Moscow formation (Windom member) exposed in the quarry floor, is very fossiliferous. The fauna is the typical normal shale *Tropidoleptus* fauna. Especially abundant or characteristic are:

Corals:

Amplexiphyllum hamiltoniae
Bethanyphyllum robustum
Cystiphylloides americanum
Eridophyllum archiaci
Favosites hamiltoniae
" *turbinata*
" *arbuscula*
Heliophyllum halli
Heterophrentis spp.
Stereolasma recta
Stewartophyllum intermittens
Trachypora vermiculosa
(= *T. romingeri*, *T. limbata*)

Bryozoa:

Fenestrellina spp.
Fistulipora fruticosa
" *furcata*
Ptilopora striata
Polypora multiplex
Sulcoretepora incisurata
Taeniopora exigua

Brachiopods:

Athyris spiriferoides
Atrypa "reticularis"
Brachyspirifer audaculus
Camarotoechia sappho
Chonetes coronatus
Cryptonella planirostra
Cyrtina hamiltonensis
Douvillina inaequistriata
Elytha fimbriata
Megastrophia concava
Mucrospirifer mucronatus
Pholidostrophia nacrea
Protoleptostrophia perplana
Rhipidomella vanuxemi
Spinocyrtia granulosa
" *marcyi*
Stropheodonta demissa
Tropidoleptus carinatus

Gastropods:

Naticonema lineata
Platyceras erectum

Pelecypods:

Actinopteria boydii
" *decussata*
Aviculopecten princeps
Cypricardella bellistriata
Grammysia arcuata
Leiopteria greeni
Lyriopecten interradiata
Modiomorpha mytiloides
Goniophora hamiltoniae
Palaeoneilo muta
Plethomytilus oviforme

Cephalopods:

Michelinoceras sp.
Nephriticerina juvenis
Spyroceras sp.

Trilobites:

Dechenella rowi
Dipleura dekayi
Greenops boothi
Phacops rana