# THE
# NEW YORK STATE
# GEOLOGICAL ASSOCIATION

## 42nd ANNUAL MEETING

## MAY 1, 2, 3, 1970

## CORTLAND, NEW YORK

# NEW YORK STATE GEOLOGICAL ASSOCIATION

42nd Annual Meeting May 1, 2, 3, 1970

# FIELD TRIP GUIDEBOOK

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Cortland, New York

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# PREFACE

Once again the annual meeting of the New York State Geological Association takes place in the region of Central New York after an absence of six years. This 42nd Annual Meeting devolves to an institution which has never before played host to the organization and whose Department of Geology had not yet come into official existence when Syracuse hosted its outstanding meeting in 1964.

It is, perhaps, because of our departmental youth here at Cortland that we have had to depend so heavily on the cooperation of geologists outside our college for articles and field trips. Gone are the days when the host department could assemble its Geology 1 and 2 trips for presentation to the Association and, if they were lucky, could muster one or two research-oriented trips if a graduate student or faculty member had reached that stage of his endeavor. Fortunately, we have become a little too professional for that, and field trips must demonstrate principles and meaningful relationships, rather than simply the local stratigraphic sequence or a series of "gee-whiz" features. The articles written by field trip leaders and others are splendid summaries of research, to date, in their areas and because of this, these guidebooks published each year by the Association are extremely valuable resources.

However, despite the growing professionalism, this organization has remained true to its original purpose: bringing together in the field geology graduate students, undergraduates, their instructors and other professionals to discuss matters of geologic interest for mutual enlightenment. The technical session initiated by John Prucha at Syracuse six years ago has become especially significant as a forum for student research papers dealing with the geology of New York State. Hopefully, the NYSGA will continue along the lines of increasing professionalism accompanied by increasing student participation.

The editorial contribution to the guidebook this year has been minimal. The copy for the guidebook was offset from original finished copy submitted by the individual authors; and I must acknowledge here my deepest gratitude for their splendid contributions and cooperation in meeting deadlines. I must also express great thanks to the members of the Department of Geology at Cortland for their help in the organization and operation of the meeting, and especially to John Fauth for taking charge of the technical session. Students in the department have, likewise, rendered great service in assembling the guidebook and performing ancillary tasks in running the meeting. Mrs. Alice Huntley, besides handling the secretarial work for two departments, typed announcements, abstracts and other portions of the guidebook.

David Price and the members of the Office of Continuing Education took complete charge of finances and arrangements for dinner and transportation as well as the binding of guidebooks and their contribution is hereby acknowledged. Lastly, I could think of no one more appropriate than John Wells to speak at the annual dinner and gratitude is expressed here.

William Graham Heaslip
Editor and President, 1970

## THE GEOLOGIST'S TWENTY-THIRD

Geology is my major, I shall not want another.
It maketh me to go down in dark places;
   It leadeth me into the running waters.
It ruineth my soles.
   It leadeth me on the paths of the outcrops
   for its name's sake.
Yea, though I search through the valleys,
   I find the rocks on the hills,
   I fear great evil when on the cliffs;
   The hammers and chisels discomfort me.
It preparest a bedding plane for me in the
   Presence of my brunton, it anointest my
   Body with mud, my collecting sack runneth over.
Surely to goodness if I follow this vocation all the
   Days of my life, I shall be buried in a landslide
   forever.

Robert C. Rasely

# BETHNIC COMMUNITIES OF THE GENESEE GROUP (UPPER DEVONIAN)

by

Jonathan W. Harrington
The University of Calgary

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

---Hugh Miller

## Introduction

The New York Devonian is unique in its completeness, fossil content, numerous outcrops, and relatively undisturbed nature. It is the standard reference section for North America and displays a classic example of facies transition. Stratigraphic and paleontologic investigation over the past century has resulted in a wealth of information. "Despite this, perhaps another century of rigorous study will be required before a thorough understanding of its paleontology, lithology, stratigraphy and paleoecology can be attained." (Rickard, 1964).

It is doubly apropos that we examine the Genesee Group in the Cortland area. The rocks of this region and their organic remains are of considerable historical interest, having received attention since the earliest days of geological investigation in New York State. In fact, the presence of fossil shells in the Devonian rocks of New York was first noted in 1751 at a hillside outcrop in Cortland County by John Bartram, a member of Lewis Evans' Onondaga expedition (Wells, 1963).

## Previous Work

The early stratigraphic work on the Upper Devonian of New York was done mainly by James Hall, J.M. Clarke, and H.S. Williams, between 1840 and 1915. These workers subdivided the succession, described the faunas and attempted to correlate along the strike. Due to complex interfingering of the argillaceous western sequence with the thicker arenaceous eastern sequence, correlations proved difficult. Only in the 1930's with the work of Chadwick (1935) did it become apparent that the major facies had migrated across the basin of deposition as the Catskill Delta prograded.

Since 1942 investigation of the Upper Devonian has emphasized physical stratigraphy. The works of Sutton, J.F. Pepper, W. deWitt, Jr., and G.W. Colton have outlined the stratigraphy of the Senecan Series. The cyclic repetition of widespread black shales in western New York has been used to subdivide the succession. Paleontologic studies have, until recently, consisted of clarification and classification of forms originally described by Hall and Clarke between 1847 and 1915. The rarity of new discoveries signifies the accuracy of their monumental works.

## Stratigraphy

The Genesee Group of New York represents the lower half of the Finger Lakes Stage. It includes the ammonoid zones of *Ponticeras perlatum* and *Manticoceras simulator* correlative with the upper part of the $I\alpha$ and the lowermost portion of the $I(\beta)\gamma$ zones in Europe.

The sequence consists of a series of complexly interfingering units representing several major depositional phases. Throughout most of the area, the group is underlain by the Tully Limestone, which contains the zone of *Pharciceras amplexum* and marks the base of the Upper Devonian. It is overlain by the Middlesex dark shale and its eastern extension - the Montour shale (base of the "Enfield"), containing the zone of *Probeloceras lutheri*.

The Genesee group is basicly a regressive sequence marked at the top by a minor transgression (see Fig. 1). The units rapidly thicken and become coarser to the east; from 450 feet of fine-grained offshore marine sediments in the Naples area to over 1500 feet of coarse marine and continental sands and silts in the Oneonta meridian.

Over the past 50 years (largely based on the works of Williams, 1913) a nearshore zonation of the New York Upper Devonian has evolved utilizing the appearance or extinction of brachiopod species. Any extensive zonation of benthonic organisms must be critically evaluated. However, these zones seem to be quite reliable within certain limits and may be easily recognized in the field. They are clearly time transgressive, their limits changing across the basin of deposition (Williams, 1913).

The zones, in fact, are closely tied to sedimentary types and consist of discrete fossil communities, whose areal extent is compatable with the biotic attributes. These communities may be considered in terms of (1) feeding types and vagility, (2) species diversity and population density, (3) animal-sediment relationships, and (4) morphologic adaptations of specific forms.

## Feeding Types

The feeding types of benthic animals are of considerable significance as they reflect conditions determined by the physical environment. Recognition of feeding types in fossil invertebrates is often tenuous. At best, only generalizations may be made. In fact, many animals display multiple feeding types. However, by analogy with recent forms, by shell morphology,

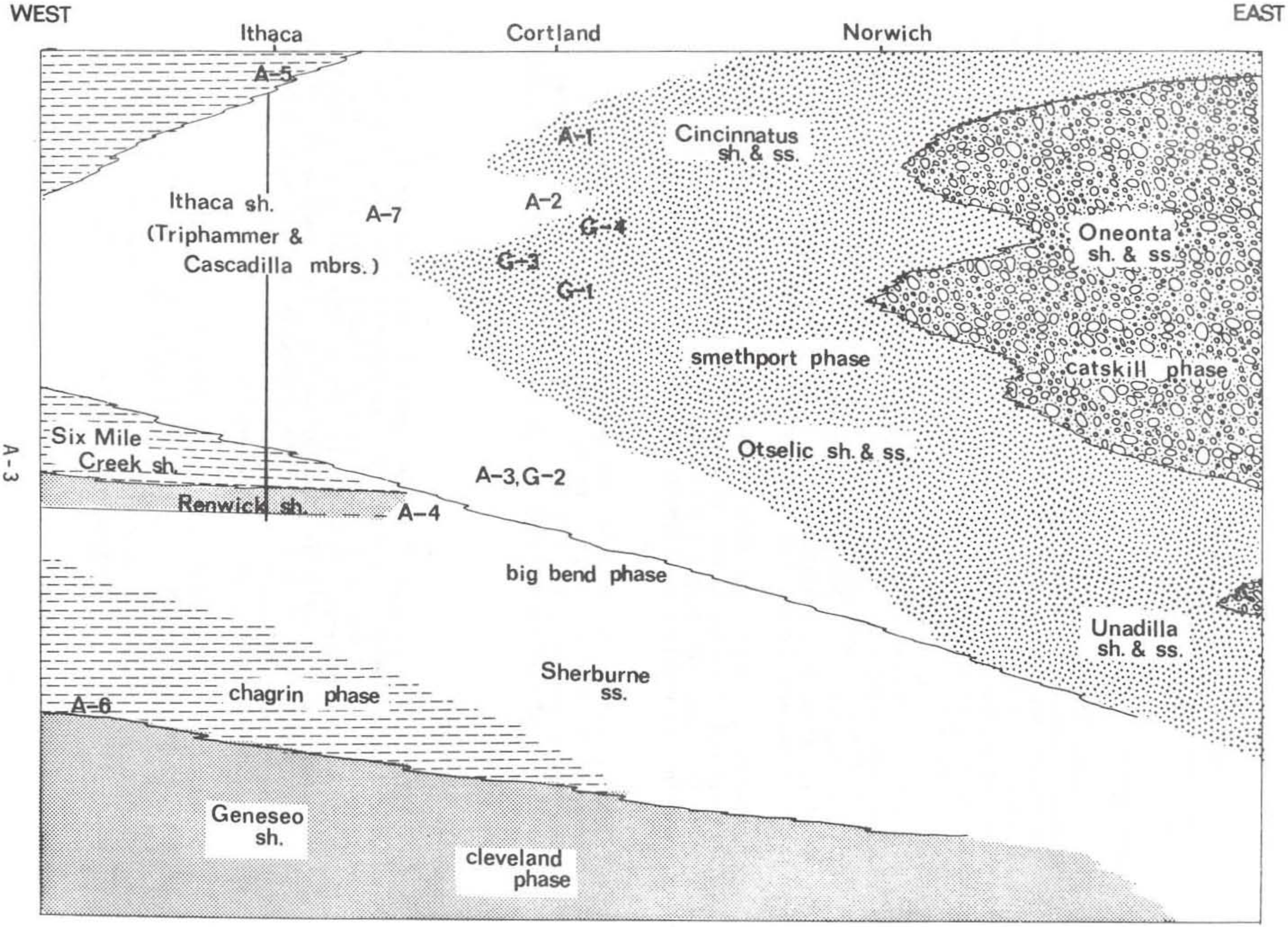


Fig. 1 Stratigraphic Relationships of the Genesee Group

and by determination of infaunal or epifaunal habit reasonably accurate inferences may be drawn.

## Filter-feeders

Included here are epifaunal and infaunal animals which derive nourishment from suspended micro-organisms and particulate organic matter. Infaunal filter-feeders are most abundant in well-sorted sands and silts. They derive their nourishment from food carried by currents. Therefore, the greater the current the greater is the available food supply, resulting in an increased abundance of forms up to the point where currents tend to move sediment into their burrows (Driscoll, 1969).

This type is represented by many polychaetes and other vermes that may leave recognizable burrows, and by some pelecypods, such as Grammysia, Schizodus, Edmondia, and Cypricardella. Bivalves are characterized by relatively massive, equivalved shells, absence of byssal notch or gape, and by a pallial sinus in siphonate genera. Stanley (1968) has shown that siphonate forms are virtually absent from the Paleozoic.

Filter-feeders which live above the sediment-water interface are much more widespread, thriving on mud, silt and fine sand bottoms. They benefit from the increased food supply provided by higher velocity currents without encountering the problems of sedimentation that restrict infaunal filter-feeders.

Bryozoa, brachiopods, crinoids and sponges are all quite definitely epifaunal filter-feeders. Certain pelecypods also belong in this group. They are characterized by the presence of a byssal notch and inequivalved shells, as illustrated by Actinopteria, Leptodesma, Goniophora, Cornellites, and Modiomorpha.

## Deposit feeders

This feeing type includes forms that directly ingest particulate food matter. Deposit feeders are particularly abundant in fine-grained deposits indicative of low-current velocities. Fine particulate organic material is deposited by such currents. In higher current velocity regimes, it remains in suspension and is unavailable as a food source. The reduction of current velocities eventually introduces detrimental effects. Interstitial circulation becomes restricted, causing the buildup of toxic by-products which are reflected in a decrease in deposit feeding forms.

Included in this type are many of the worm phyla, some pelecypods, and possibly certain ophiuroids. Although it is difficult to generalize, deposit feeding bivalves are usually small, thin and relatively unornamented. The feeding type is particularly well developed in the protobranchs; the nuculoids, Palaeoneilo and Pterochaenia are representative.

### Carnivore-Scavengers

There is no clear-cut distinction between these feeding types. Their distribution depends on the abundance of a food supply, rather than on any sediment type. Forms are locally abundant, especially in quiet water environments characterized by the accumulation of organic debris. Virtually all carnivores and scavengers are vagrant epifauna or are nekton. In the strictest sense, coelenterates are carnivores, feeding on suspended planktonic micro-organisms. These microphragous carnivores are largely restricted to well-circulated waters for the same reasons that sessile filter-feeders are.

Representatives of this group are determined largely by analogy to modern forms. Asteroids are typically macrophragous carnivores. Many gastropods may belong here, but others may be herbivores or deposit feeders. Modern forms display highly diverse feeding habits, which are not reflected in shell morphology.

## Diversity and Density

### Population Density

In general terms the relative density of fossil communities seems to vary from low densities on offshore mud bottoms to relatively high densities onshore silt and fine sand substrate. This appears to be related to available nutrient levels, the ultimate food sources being terrigenous. Theoretically, the very nearshore areas characterized by rapidly shifting sediments have a low population density and few species. The high current activity results in high substrate mobility. The characteristic fauna being dominated by vagrant filter-feeders. By their very nature, these shallowest water environments are probably not normally preserved even under stable geographic conditions (Ager, 1965).

### Species Diversity

The gradient in terms of diversity is more complex. Both shallow and deep water environments display low species diversity. The greatest numbers of species seem to have occupied silt and mud bottoms at intermediate depths. The nearshore diversity low may be due to salinity, temperature, and desiccation stress conditions (Bretsky, 1969), as well as the high degree of substrate mobility (Purdy, 1964). The offshore, low-diversity environment appears to reflect an area of low primary benthonic productivity and poor circulation with low levels of oxidation. This is expressed, not only in the low diversity, but also in the color and texture of the sediments, and to some extent in morphological modifications of indigenous species.

Diversity reaches a high point in fine silt and mud bottoms of intermediate depths. This environment is characterized by a luxuriant encrusting epifauna, as well as by maximum-size development of a number of species. Ager (1965) considers maximum size attainment as a guide to optimum conditions.

## Animal-Sediment Relationships

As has already been stated the distribution of many organisms bears a relation to sediment type and current velocity. Infaunal burrowing forms and their characteristic trace fossils, are common at all depths. Infaunal filter-feeders are particularly abundant in shallow-water sands where they are characteristically adapted for deep vertical burrowing (Rhoads, 1966; 1967). This dominance appears to relate to the protection from environmental stress, such as temperature and salinity fluctuation, and desiccation (McAlester and Rhoads, 1967). Deposit-feeding forms are abundant in fine-grained, organic-rich sediments characteristic of deeper, quieter waters. In this environment near-surface horizontal burrows and tracks and trails predominate.

In addition to the orientation of trace fossils, the amount of sediment reworking is significant. Deposit-feeders are increasingly abundant in quieter waters. As Moore and Scruton (1957) have shown in the case of the Mississippi delta, the relative amount of bioturbation trends from insignificant in laminated sediments, through an intermediate phase of mottled structures, to total reworking in fine-grained homogenous sediments.

## Morphologic Adaptation

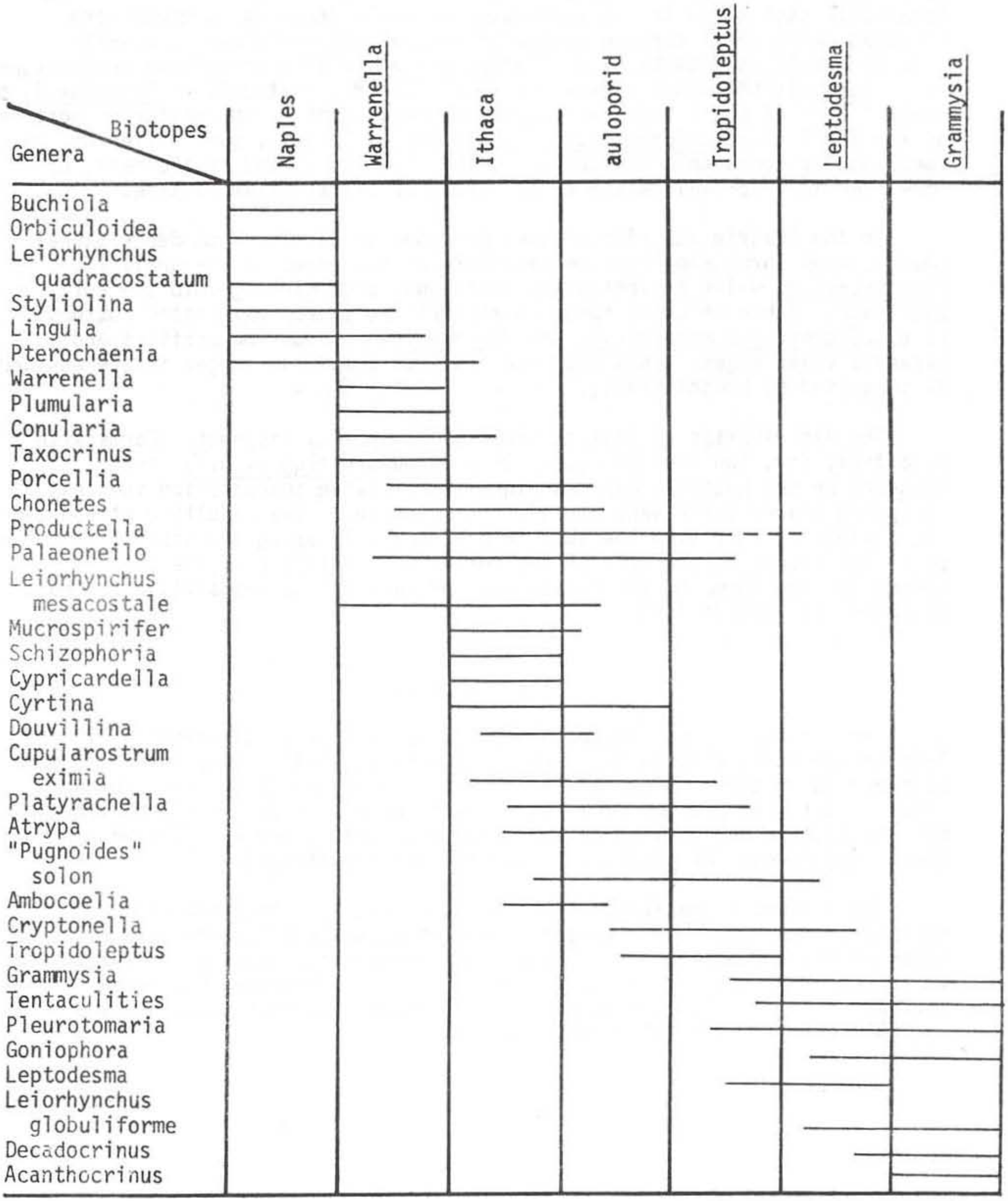
In the interpretation of fossil communities of particular importance is consideration of morphologic adaptation, especially of the abundant epifaunal brachiopods. Copper (1966) has shown that their distribution may often be closely correlated with depositional phases. Morphologic adaptations are largely in response to problems of support, separation of inhalant and exhalant currents, and sedimentation.

Brachiopods anchor, stabilize or affix themselves to the substrate or to host objects. They successfully invaded mud bottoms, living and dead shells forming a common base for attachment. In some forms, the distal end of the pedicle may have split into rootlets anchoring it directly in the sediment, as in the modern genera, Terebratulina and Chlidonophora.

Many of these forms (as well as other filter-feeders such as crinoids) were somewhat elevated above the low velocity currents near the sediment-water interface into areas where more rapid currents transported suitable food supplies. This undoubtedly allowed them to colonize a wider range of environments.

In the neanic stages probably all brachiopods possessed a functional pedicle attaching the individual to, and supporting it above, the substrate. Some forms tend to show an almost complete closure or covering of the pedicle opening in later life stages. Typical pedunculate forms occur on

Fig. 2. Inferred Distribution of Abundant Genera in the Genesee Group



## (1) Grammysia Biotope

Communities characterized by large numbers of the infaunal filter-feeder, Grammysia, and the byssiliferous epifaunal genus, Goniophora, inhabited coarse, unstable sand bottoms in the nearshore Smethport depositional phase. The environment is highly variable in lithology and faunal composition. Strongly developed species dominance and low diversity are characteristic. Brachiopods are typically sharply costate and possess well-developed fold and sulcus. Locally developed in more sheltered areas are dense colonies of crinoids (Decadocrinus and Acanthocrinus) or hexactinellid sponges (Actinodictya placenta). In these areas where there is an accumulation of organic debris, gastropods, asteroids, and ophiuroids are abundant.

## (2) Leptodesma Biotope

On silt and shale substrates in areas of moderate current activity are developed communities of large numbers of filter-feeding epifaunal species, with smaller numbers of deposit feeding genera. In general, species diversity and population density are moderate. Common fossils are: Atrypa, "Pugnoides", Cryptonella, Pleurotomaria, Leiorhynchus globuliforme, Goniophora and Leptodesma.

## (3) Tropidoleptus Biotope

This community represents an adaptation to stable, organic-rich, silt and mud bottoms. It is characterized by an abundant brachiopod epifauna, especially of large numbers of the spiriferid, Platyrachella. Other abundant genera are: Productella, Cupularostrum, Atrypa, "Pugnoides", Ambocoelia and Tropidoleptus.

## (4) Auloporid Biotope

This sporadically developed biotope is characterized by an abundant filter-feeding epifauna in association with the deposit-feeding genus, Palaeoneilo. Many brachiopods display morphological adaptations to a soft mud substrate (e.g. frilled atrypoids). In association with these forms is a rich encrusting epifauna of bryozoans and auloporid corals. The presence of these forms precludes rapid burial, and indicates rather low and discontinuous sedimentation. The genera present represent an admixture of forms from the Ithaca and Tropidoleptus biotopes. This is not the Cladochonus subfauna of Williams (1913).

## (5) Ithaca Biotope

This community is well developed on mud bottoms in areas of moderate currents. It is characterized by a highly diverse epifauna of brachiopods (Mucrospirifer, Chonetes, Productella) and the infaunal filter-feeding bivalve, Cypricardella. Moderate species diversity and low population density are typical of the biotope.

### (6) Warrenella biotope

A mixed association of benthic and pelagic forms characterized by poorly oxygenated, offshore mud bottoms. Brachiopods typically develop low, expanded outlines (i.e. Warrenella and Leiorhynchus mesacostale). Deposit feeding pelecypods, such as Palaeoneilo and Pterochaenia are abundant. Linguloid brachiopods and small crinoids (i.e. Taxocrinus) are locally developed, as are the microphagous carnivores (?) Plumularia and Conularia. Species diversity and population density are low.

### (7) Naples biotope

Pelagic species comprise the majority of this fauna. The reduced mud bottoms supported rare deposit-feeders (i.e. Pterochaenia) and occasional linguloids. More typical filter-feeders (Orbiculoidea and Leiorhynchus quadracostatum) are interpreted as having been epiplanktonic, living attached to floating plant material in the well-oxygenated surface waters.

## Controlling Factors

The benthic communities of the Genesee Group bear similarities to other paleoecologic analyses of the New York Upper Devonian. However, differences in the distribution and association of genera are apparent.

Physical controls may have differed significantly throughout the Upper Devonian. McAlester (1960) considered bottom stability and current velocities to control distribution of pelecypod associations in the Chemung stage. Whereas, Sutton and others (1966) stressed variations in rate of sedimentation and in salinity in their study of the Sonyea Group. On the other hand, the communities may have evolved through this time interval in the manner suggested by Bretsky (1968). Such changes in environmental preference need not be reflected by any morphologic modifications.

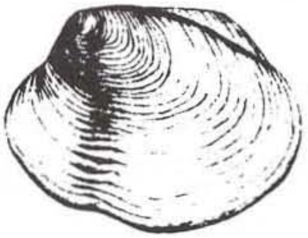
The environmental conditions in the Genesee Group appear to represent a complex interaction of factors of substrate, rate of sedimentation, current velocity, salinity and oxygenation. The strongest controls on distribution are probably bottom conditions and trophic levels. The control is certainly not primarily bathymetric as has been suggested for certain communities of Silurian brachiopods (Ziegler, 1965; Cocks, 1967). Nor is there any evidence that the brachiopods can be separated into euryhaline (tolerant) and stenohaline (restricted) groups as suggested by Ivanova (1962).

## Plate 1. Common Genesee Fossils

**Palaeoneilo**

**Leptodesma**

**Goniophora x 1/2**



**Grammysia x 1/2**

**Cypricardella**

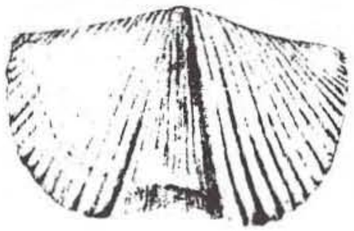
**Loxonema**

**Pleurotomaria**

**Pterochaenia**

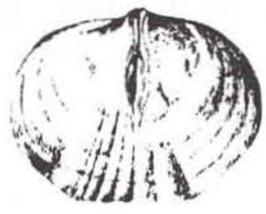
**Mucrospirifer**

**Cupularostrum**



**Platyrachella**

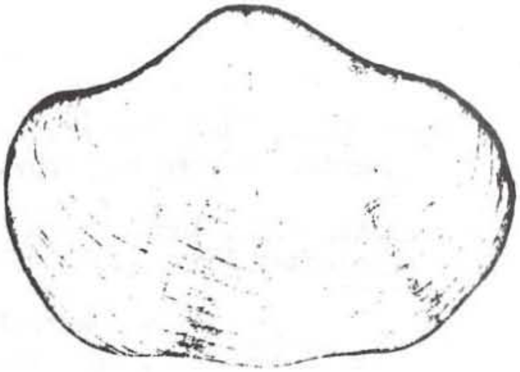
**Pugnoides**



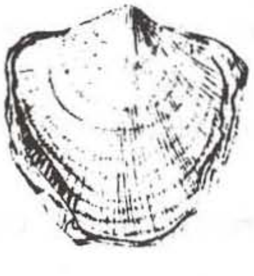
**Leiorhynchus mesacostale**

# Plate 2. Common Genesee Fossils

**Leiorhynchus quadracostatum**



**Warrenella**



**Atrypa**

**Productella**

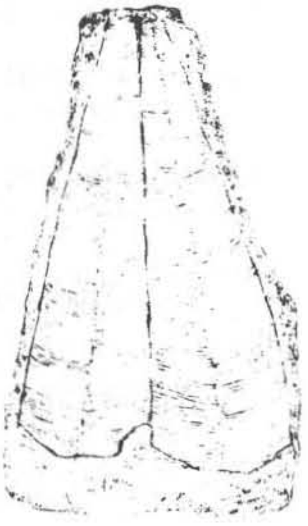
**Ambocoelia**

**Tropidoleptus**

**Chonetes**

**Orbiculoidea**

**Tentaculites x2**



**Conularia**

**Plumulina**

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Trip A - Benthic Communites of the Genesee Group (Upper Devonian)

Selected Exposures

1. Small quarry on West River Road, just south of Bloggett Mills, Cortland Co.

This exposure in the Upper Ithaca formation (correlative with the Triphammer member in the Cayuga Lake meridian) consists of fine shales and siltstones of the Smethport depositional phase. The Leptodesma biotope is represented by an abundant fauna, consisting of the spiriferid, Platyrachella, and Leptodesma, with numerous large pectinoid and mytiloid pelecypods. Most brachiopods, especially the rhynchonellids, are conspicuously absent.

2. Hillside quarry, 1 mile south of Cortland on Rte 90.

At this outcrop in the upper Ithaca the Big Bend phase is represented by a sequence of gray shales and siltstones, with some lenses of leached coquinite. An extremely varied benthic fauna is present. Especially abundant are Leiorhynchus mesacostale and "Pugnoides" solon.

3. Outcrop in Homer Gulf on Rte 41A, 4 miles north of Cortland.

Ponticeras perlatum has been identified from exposures in Homer Gulf. This places the section in the lower portion of the Ithaca formation, probably correlative with the Renwick shale member. The lithology is extremely variable; consisting mainly of gray and reddish shales and siltstones. The fauna contains elements of both the Warrenella and Ithaca biotopes. Particularly common are: Conularia, Plumularia, Mucrospirifer, "Pugnoides", Cupularostrum eximia, Taxocrinus and linguloid brachiopods.

4. Fitzpatrick quarry ("Frozen Ocean"), north of Omro, Cayuga Co.

This is the northernmost exposure of the Ithaca formation in this area. Here, a series of reddish brown and dark gray shales represents the lowermost Renwick member, and possibly part of the Cornell member of the Sherburne (Smith, 1935). The sparse fauna contains elements of the Naples and Warrenella biotopes. Especially abundant are well preserved specimens of Leiorhynchus mesacostale.

Lunch Stop - Stewart Park, Ithaca.

5. Fall Creek, Ithaca

This exposure, and that of adjacent gorges, constitutes the type section of the Ithaca formation. The sequence displays a complex interfingering of at least four of the biotopes that have been discussed.

The top of the Sherburne formation is marked by the presence of the *Warrenella* biotope (at the base of the falls). The commonest fossils are: *Warrenella laevis*, *Palaeoneila filosa*, *Pterochaenia fragilis*, *Chonetes lepida*, *Taxocrinus ithacensis*, *Porcellia nias* and *Styliolina fissurella*.

Above, in the lower vertical wall of the gorge is the Renwick member of the Ithaca, a reddish black fissile shale containing a sparce Naples fauna. *Lingula complanata*, *Leiorhynchus mesacostale*, *Orbiculoidea lodensis* and *Styliolina fissurella* are the commonest fossils.

In the upper portion of the vertical cliffs are gray shales and siltstones representing the Six Mile Creek member, containing a *Tropidoleptus* fauna with *Platyrachella mesastrialis*, *Rhipidomella vanuxemi*, *Cyrtina hamiltonensis*, *Pleurotomaria capillaria* and *Cryptonella endora*.

Above the falls the upper 300' of the Ithaca formation is represented by the Cascadilla and Triphammer members. At the base of the Cascadilla member the Ithaca biotope contains an abundant fauna, primarily of brachiopods. Especially common are: *Leptostrophia*, *Cyrtina*, *Productella*, *Atrypa*, *Schizophoria*, *Leiorhynchus mesacostale*, *Cypricardella* and *Palaeoneilo*.

The top of the Ithaca is marked by the recurrence of the *Warrenella* biotope, which is exposed at Forest Home, above the Cornell campus. Between these two zones are a sequence of virtually barren shales with a sparse Naples fauna, and at least one minor incursion of the Ithaca biotope.

6. Hubbard quarry, on Rte 89 at Lively Run, 1.5 miles northeast of Interlaken, Seneca County.

This is one of the few places where the contact of the Geneseo black shale and the Sherburne formation can be seen.

The uppermost 6' of the Geneseo carry typical fossils of the Naples biotope: *Barriosella spatulata*, *Orbiculoidea lodensis*, *Schizobolus truncatus*, *Leiorhynchus quadracostatum*, *Pterochaenia fragilis*, *Ponticeras perlatum*, and fish and plant fragments.

In the lower Sherburne the following fossils occur: *Chadochonus* sp., *Leiorhynchus quadracostatum*, *Loxonema noe*, *Palaeotrochus praecursor*, *Panenka* sp., brevicone nautiloids and *Ponticeras perlatum*.

This fauna of mixed benthonic and pelagic types is similar to the "Naples fauna" of the West River shales further to the west. It seems to represent the environments of the *Warrenella* biotope.

7. Roadcut on Rte 13, just east of Dryden, Tompkins Co.

This exposure in the lower Triphammer member is one of the most richly fossiliferous outcrops of the Ithaca formation. It contains abundant encrusting epifauna representing the auloporid biotope, with minor incursions of the Ithaca biotope from the west and the _Tropidoleptus_ from the east. Diversity is at a maximum, with maximum size development of _Leiorhynchus mesacostale_, _Atrypa reticularis_ and _Platyrachella mesastralis_. Other common fossils are: _"Pugnoides" solon_, _Porcellia nias_, _Mucrospirifer posterus_ and _Cyrtina hamiltonensis_.

# UPPER DEVONIAN DELTAIC ENVIRONMENTS

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## INTRODUCTION

The Upper Devonian of New York is composed of a lithologically and paleontologically diverse sequence of clastics that have played an historic role in the development of geological thought. Study of these strata resulted in the classical "facies" papers by Chadwick, Caster, Cooper and others in the 1920's and 1930's. In the years since 1940, most work has been concerned with detailed geologic mapping and more precise stratigraphic correlation. These studies have been summarized on the geologic map and Devonian correlation chart of New York State (Broughton and others, 1962; Rickard, 1964).

In New York State, the Upper Devonian marine strata cropout in a generally east-west belt over 200 miles long and extend from Lake Erie on the west to the Catskill Mountains in the east. These strata have been subdivided into seven groups, some of which are marked by thin, persistent black shales that enclose eastward-thickening rock wedges. Within each wedge diverse lithologies and faunas can be recognized and delineated. Moreover, similar lithologic and faunal associations can be recognized in each wedge forming the basis for the facies concept mentioned above. That portion of Rickard's Devonian Correlation Chart (formational and members names omitted) with which this field trip is concerned is shown in figure 1.

In 1965, the writers began an analysis of the Smethport or Chemung facies using both paleontological and sedimentological evidence to reconstruct its paleoenvironments. The initial studies were confined to the Sonyea Group in order to define a set of essentially contemporaneous environments that could be compared with those in modern deltas (Sutton, Bowen, and McAlester, in production). The second or current phase of research has dealt with the post-Sonyea Chemung facies in central and western New York.

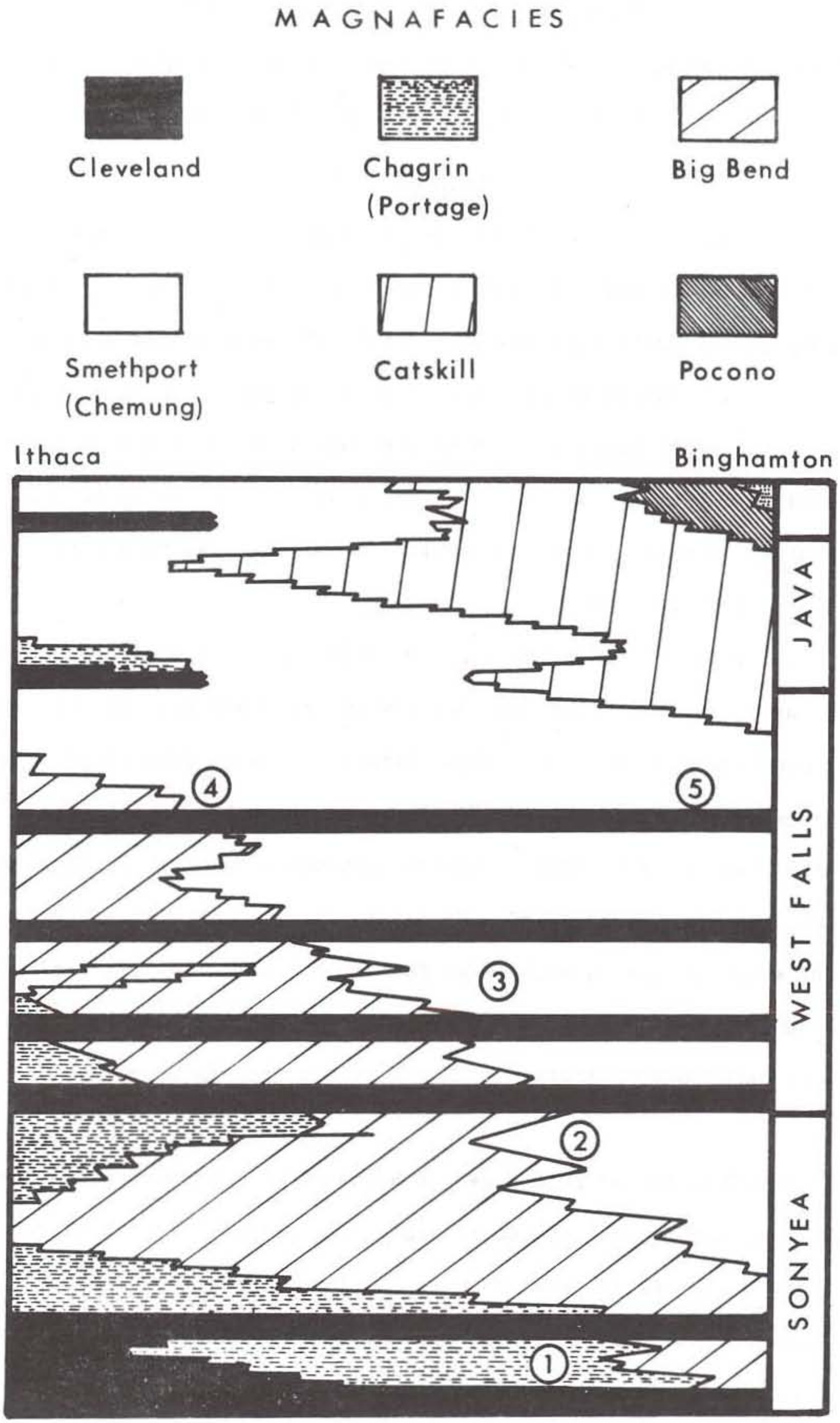

Figure 1. Simplified Correlation Chart of Upper Devonian Showing Major Facies Relationships.

In all, 334 outcrops have been analyzed as to lithology, sedimentary structures and faunal populations. From this analysis the following environments can be recognized: open shelf, prodelta, delta platform, delta front sands, channels, distributary mouth bars, and estuaries. Five outcrops have been chosen for this trip to display some of these environments. The locations of the stops are shown in Fig. 2 and in the diagramatic cross-section of the inferred environments in Fig. 3. A brief description of each environment and its modern analogue is given below. The major features seen at each stop are shown in Table 1.

## ENVIRONMENTS

### Open Shelf

In modern deltaic settings, the open shelf environment extends from the outer edge of the shelf to the base of the prodelta (Fig. 3). It is a smooth area with a water depth of about 130 feet near the prodelta, sloping gradually to between 240 and 650 feet and 650 feet at the shelf edge. It is slowly supplied with grayish-green silts and clays which are intensely bioturbated and devoid of lamination (Allen, 1964, p. 31).

Upper Devonian rocks interpreted as open shelf deposits consist of interbedded shales and siltstones, the latter marked on their lower surfaces by casts of grooves, tracks, trails and flutes. Internally, the siltstones are cross-laminated, and their tops are marked by current ripples. Shelly benthonic fossils are relatively rare, but burrows, tracks, and trails are abundant. These structures, coupled with the fine grain size of the rocks, suggest slow deposition in relatively deep water. Only clays and silts ordinarily reached this environment where weak currents periodically reworked and sorted the sediments to produce most of the thin beds of silt. More rarely, turbidity currents moving down the prodelta slope deposited coarser-grained silts on the open shelf.

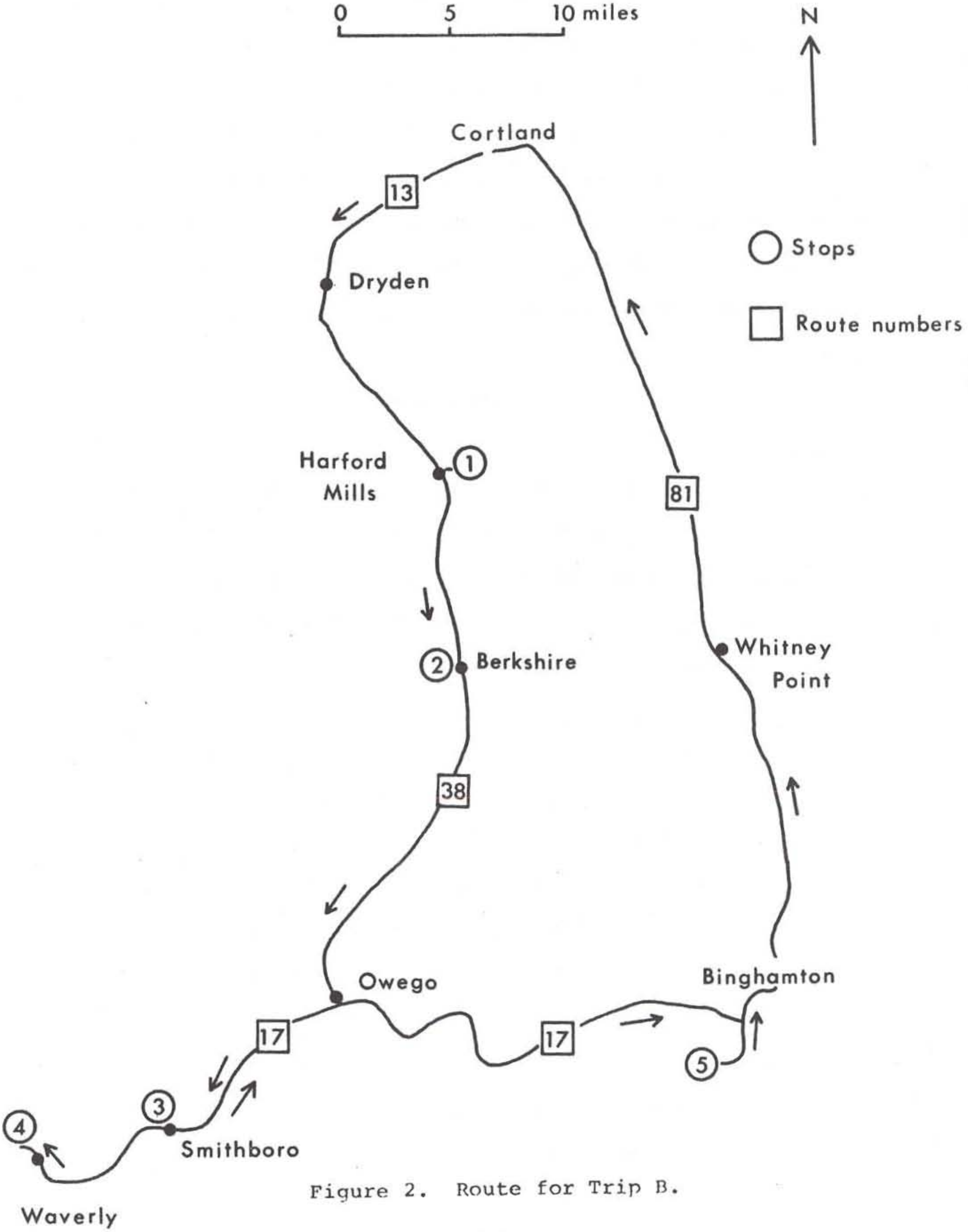

Figure 2. Route for Trip B.

## TABLE 1 MAJOR FEATURES SEEN AT EACH STOP

| ENVIRONMENT | LITHOLOGY AND STRUCTURES | PALEONTOLOGY* |
|---|---|---|
| 1 OPEN SHELF<br>(Harford Mills) | Interbedded gray and dark gray shales, siltstones and mudstones. Small flute casts, groove casts, cross-laminae concretions, tracks and trails | Shelly fossils *relatively rare*<br>Tracks, trails, burrows<br>(7 taxa found, all rare) |
| 2 PRODELTA<br>(Berkshire) | Mudstone interbedded with siltstone and minor amounts of shale and sandstone. Groove casts, cross-laminations and cuspate ripples | Shelly fossils *common*<br>*Leiorhynchus* *Chonetes*<br>*Productella* *Leptodesma*<br>*Ambocoelia*<br>Tracks, trails and burrows<br>plus 9 other less common taxa |
| 3 PLATFORM<br>(Smithboro) | Mudstone interbedded with sandstone, shale, siltstone, and coquinite. Cross-bedding, laminations, ball and pillow, cuspate ripples, load casts | Shelly fossil *abundant*<br>*Atrypa* *Cyrtospirifer*<br>*Productella* Crinoids<br>*Douvillina* Auloporid corals<br>*Ambocoelia* *Cornellites*<br>*Schuchertella* Rugose corals<br>*Tylothyris* Plant fragments<br>plus 13 other less common taxa |
| 4 DELTA FRONT SANDS<br>(Glory Hill) | Mostly sandstone with small amounts of shale, mudstone, and coquinite. Cross-bedding, cross-laminations, current ripples, parting lineation, mud chips | Large shelly fossils *abundant*<br>Tracks, trails, and burrows<br>*Productella* *Thiemella*<br>*Atrypa* *Nervostrophia*(?)<br>*Cyrtosperifer* *Chonetes*<br>*Tylothyris* Crinoids<br>*Douvillina* Auloporid corals<br>*Ambocoelia* Plant fragments<br>Rhynchonellids *Cornellites*<br>plus 8 other less common taxa |
| 5 NEAR SHORE FACIES<br>Channels, Lagoons, and Levees<br>(Ingraham Hill Quarry) | Sandstone and shales with small amounts of shale-pebble conglomerate. Cross-bedding, linguoid ripples, groove casts | Shelly fossils *uncommon*<br>Plant fragments and tracks, trails, and burrows abundant.<br>plus 18 other less common taxa |

*Only most abundant forms listed.

## Prodelta

In modern deltas, the prodelta environment extends from the delta front, at the edge of the delta platform, outward to the open shelf, over which the delta progrades (Fig. 3). It is entirely below sea level and is usually covered by 30 to 120 feet of water. Much of the prodelta environment is below the reach of active wave erosion. Sediment supplied to the prodelta comes in plumes of turbid water that spread over the sea above it. The prodelta region typically has a very gentle slope (only 1/4 degree on the Orinoco Delta), a high rate of sediment accumulation, and extensive animal burrowing (Straaten, 1960). In modern Niger Delta the prodelta slopes are covered by thin layers of clayey silt and silty clay with a maximum grain size of very fine sand. The layers are laminated and cross-laminated, with plentiful biogenic stfuctures and shell accumulations (Allen, 1964, p. 31).

Upper Devonian sediments apparently deposited in a prodelta environment are similar to, and intergrade with, those of the open shelf. Like the open shelf sediments, they contain numerous grooves, tracks, trails, cross-laminae, and current ripples. They differ, however, from the open shelf deposits in several respects: the maximum grain size is larger (fine sand instead of silt), many beds are laminated, coquinite shell accumulations are common, and mudstones make up a larger proportion of the lutites. These features indicate the presence of currents sufficiently strong to move fine sand, concentrate shells and form unreworked laminae. Significantly, however, such structures as wave ripples, pillow structures, flute casts, and cross-bedding are extremely rare.

## Delta Platform

In modern deltas, the delta platform is a gently inclined, terrace-like structure 5 to 15 miles wide extending from the shore line to the break in slope on the delta front, which normally occurs at water depths between 30 and 60 feet (Fig. 3). It is persistently, but erratically, supplied with suspended silt and clay by flows of turbid water emanating from distributaries. Currents generated by waves and tides are strong enough to move fine sand and coarse silt in the shallower parts of the platform. Near shore, laminated or cross-laminated sands and silts are common. Farther out, the platform may be covered by coarse silt and dark gray clayey silt with finely divided plant debris. Biogenic structures and concentrations of shells are common, particularly on the outer platform. With delta progradation, river sands may build over the platform, where they may ultimately be converted into bars or beaches as a result of wave attack.

Strata deposited on Upper Devonian delta platforms consisted primarily of mudstones and sandstones. Most of the muds, now represented by mudstones, were deposited directly from turbid water and show little or no internal particle orientation. The sands were concentrated through active reworking of the sediments by storm, tidal or wave-produced currents. Cross-bedding, wave and current ripples, groove casts, pillow structures and parallel laminae are common, especially in the coarser sediments. Fossils are abundant and diverse, and coquinite shell accumulations are common, particularly in the outer platform deposits where they occur at the base of reworked sand and silt beds.

### Delta Front Sands

Delta front sand deposits in modern deltas are produced by extensive reworking of sediments on the outer parts of the platform by currents and waves. The finer-grained fraction is winnowed out, and the sand accumulates as submerged or partially exposed bars that may be extensive enough to restrict the circulation over the inner platform area behind the bars (Moore, 1966).

Such sand bar deposits are common in the Upper Devonian. They generally show a westward progression up the stratigraphic sequence corresponding to a rapid westward progradation of the Catskill delta. Fossils are abundant and diverse and shell accumulations, now exposed as thin coquinites, lie parallel to the inclined bar surfaces in many of these sands.

### Channels

Near-shore channels of modern deltas are filled with coarse detritus interbedded with clay layers. The deposits show several varieties of scour features, trough and planar cross-bedding, load casts, erosional truncation, and clay chip inclusions. Distorted bedding is common due to slumping of the channel walls, or flow in the channel bottom. The sediments are usually poorly sorted, with parallel and cross-laminations undisturbed by organic influences. They may contain remains of marine, brackish and fresh-water faunas (Coleman and others, 1964; Moore, 1966; Straaten, 1960).

Upper Devonian rocks interpreted as channel deposits contain all of the features described above, and are distinguished from the bar sands at the mouths of distributaries by large-scale slump structures, particularly where the channel sands overlie marsh or estuarine deposits. They are coarse-grained poorly sorted and contain mud chips. Shell accumulations are abundant in some of these sands, but the fauna is low in diversity.

### Estuaries

Estuaries are partially restricted arms of the sea in which dilution by fresh water lowers the salinity from that of normal sea water. Modern estuarine deposits are commonly dark gray, clayey silts, interbedded with plant debris, clean silts, and thin beds of very fine-to-coarse sands. Thicker sands are restricted to submarine channels. Parallel and cross-laminations, and biogenic structures may be present. Faunal remains include autochthonous brackish-water species, and allochthonous marine species that have been brought in by storms (Allen, 1964; Straaten, 1960).

Upper Devonian estuarine deposits consist of laminated, dark gray, silvery, arenaceous shales interbedded with widely spaced, thin, cross-laminated, and rippled siltstones. Some of the siltstones contain appreciable quantities of poorly preserved fossil debris and current structures showing an easterly current trend, suggesting that the material was swept in from the platform to the west. Thick beds of sandstone with pillow structures and load casts, representing sites of channel development are often associated with the estuarine deposits. Shelly fossils are uncommon but diverse including marine and non-marine forms. Tracks, trails, and burrows are abundant.

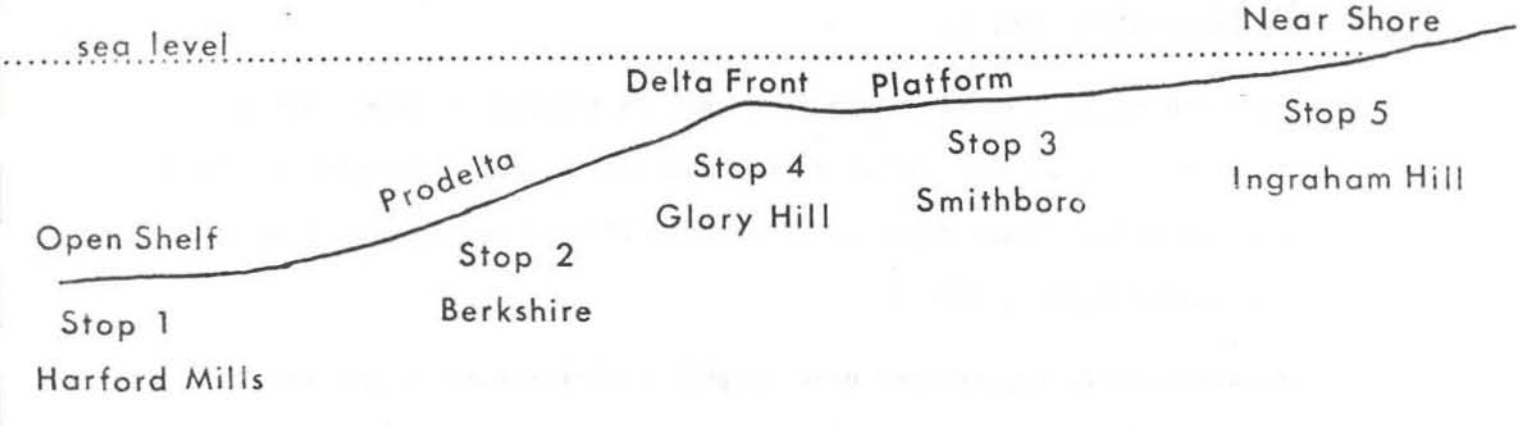

Figure 3. Cross Section of Inferred Sedimentary Environments.

## FIELD TRIP ROUTE DESCRIPTION

Start - Holiday Inn, Cortland.

Travel south on New York Route 13 to Dryden (11.8 miles). From Dryden, proceed south on N.Y. 38 to Harford Mills (7.8 miles). Turn left (east) on N.Y. 200 and continue to Griggs Gulf Road (0.6 mile). Turn right. Proceed (0.6 mile) to STOP 1.

Return to N.Y. 38 and continue south to Berkshire (8.4 miles). Turn right (west) on Glen Road and proceed less than 0.5 mile to outcrops of STOP 2.

Return to N.Y. 38 and continue south to Owego (about 16 miles). Follow N.Y. 17 west from Owego to the west side of Smithboro (10.9 miles) for STOP 3.

Continue west on N.Y. 17 past Waverly to O'Brien's Restaurant (11.5 miles) on Glory Hill, STOP 4.

Turn around on N.Y. 17 and proceed east to Binghamton (approximately 41 miles). Leave N.Y. 17 at Pennsylvania Avenue exit and proceed south for 2.5 miles. Turn right on Ingraham Hill Road and proceed 1 mile to Corbisello Quarry, STOP 5.

Return to N.Y. 17, proceed east (right) to Interstate 81 and return to Cortland (approximately 40 miles).

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## FIGURE CAPTIONS

Fig. 1 Field trip stops shown on Upper Devonian correlation chart. Chart and magnafacies boundaries modified after Rickard (1964).

Fig. 2 Route map showing stops.

Fig. 3 Cross-section of inferred sedimentary environments.

TRIP C

# TRANSITIONAL SEDIMENTARY FACIES OF THE CATSKILL DELTAIC SYSTEM IN EASTERN NEW YORK STATE

by

Kenneth G. Johnson
Skidmore College

## INTRODUCTION

One of the greatest thicknesses of Devonian rocks on the North American continent is at the northeastern end of the Allegheny Synclinorium in east-central Pennsylvania and southeastern New York. The sequence crops out along a north-facing escarpment extending from Lake Erie to the Catskill Mountains, a distance of some 300 miles. The escarpment continues south along the west side of the Hudson Valley into the Valley and Ridge physiographic province of the Appalachian highlands. The New York sequence is accepted as the standard for the Devonian System of North America. In the Catskills, although the top has been eroded, the Devonian is some 10,000 feet thick. It thins to about 2500 feet at the western edge of New York State and also thins toward the southwest. In northeastern New York Devonian rocks have been removed by erosion. In New York State the Devonian sequence was only slightly affected by the Appalachian Revolution; it was deformed into gently undulant folds. More intense tectonic forces to the southwest in Pennsylvania folded the same strata into elongate, plunging anticlines and synclines.

The upper Middle Devonian and Upper Devonian of eastern New York and Pennsylvania consist of a thick wedge of continental rocks that have a progradational relationship to marine formations farther west. These rocks have a deltaic character.

The deltaic wedge is composed of detritus derived from a source area east of the present-day Catskill Mountains which was being elevated by the first pulses of the Acadian Orogeny. At the base of the clastics is an interval of some 2500 feet of fossiliferous sandstones and shales (Hamilton Group) which thins toward the west and southwest. Penetrating eastward from the marine basin into the upper Hamilton clastics are two thin fossiliferous limestone beds (Centerfield and Portland Point) which were deposited during the time that the source terrain was in the beginning stages of uplift. The Tully Limestone, a transgressive carbonate tongue at the base of the Upper Devonian, represents the last significant limestone deposition in the New York Devonian prior to the overwhelming of the marine basin by clastic influx.

After deposition of the Tully, uplift apparently accelerated and continued on a large scale into the Mississippian. A thick wedge of clastic continental sediment (Catskill lithofacies) was deposited at the margin of the basin. The red and green-gray sandstones, shales, and conglomerates of this wedge interfinger westward with littoral and shallow marine (Chemung lithofacies) sandstones and shales. These grade into dark-colored shales and siltstones

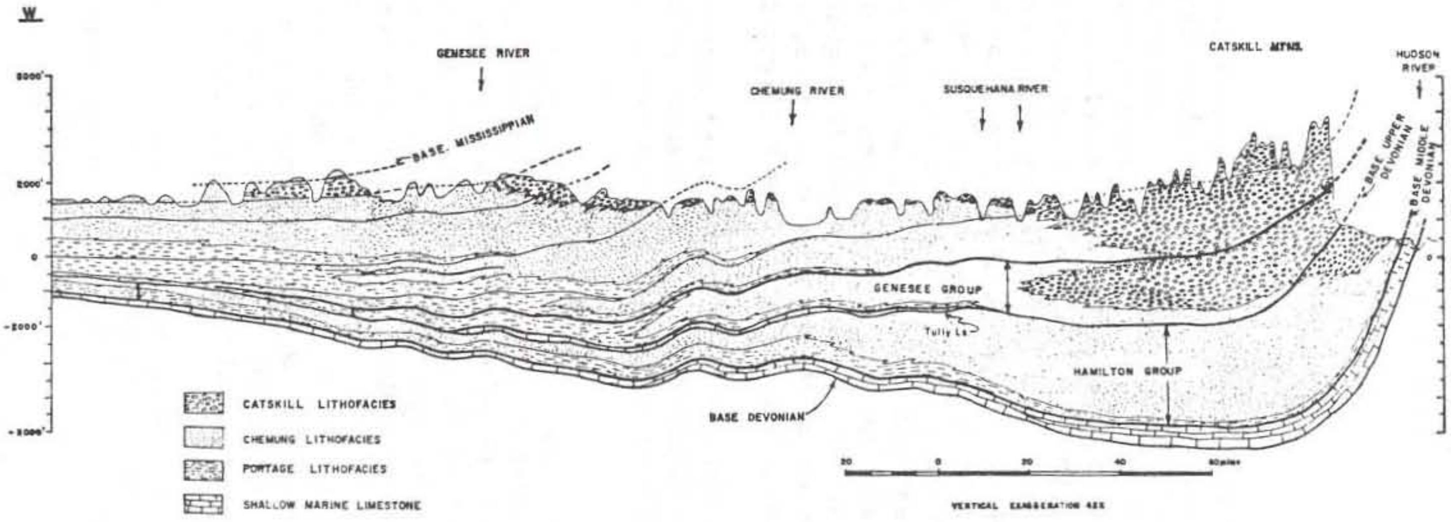

Fig. C-1. Cross-section of Devonian System Along New York - Pennsylvania Border (After Broughton, et al, 1966)

(Portage lithofacies) farther west that are of deeper marine origin. The irregular, interfingering contact between the continental beds and the marine formations rises stratigraphically towards the west and the continental beds consequently have the appearance of over-riding the marine strata. This prograding relationship, the result of displacement of the late Devonian sea by the expanding clastic wedge, is shown in the cross-section along the N. Y. - Pa. border (Fig. C-1). Dunbar and Rodgers (1957, p. 137-140) give a concise description of the New York Middle and Upper Devonian from the point of view of the facies concept. A correlation chart by Rickard (1964) shows the relationship of the depositional phases of the Devonian rocks in New York State.

Within the Tully Limestone and its eastern clastic correlatives are rocks that are representative of the spectrum of sedimentary environments that comprised the Catskill deltaic system during early Late Devonian Time. These were studied (Fig. C-2) in order to develop associations of criteria that will permit recognition of sedimentary environment elsewhere in the Catskill complex.

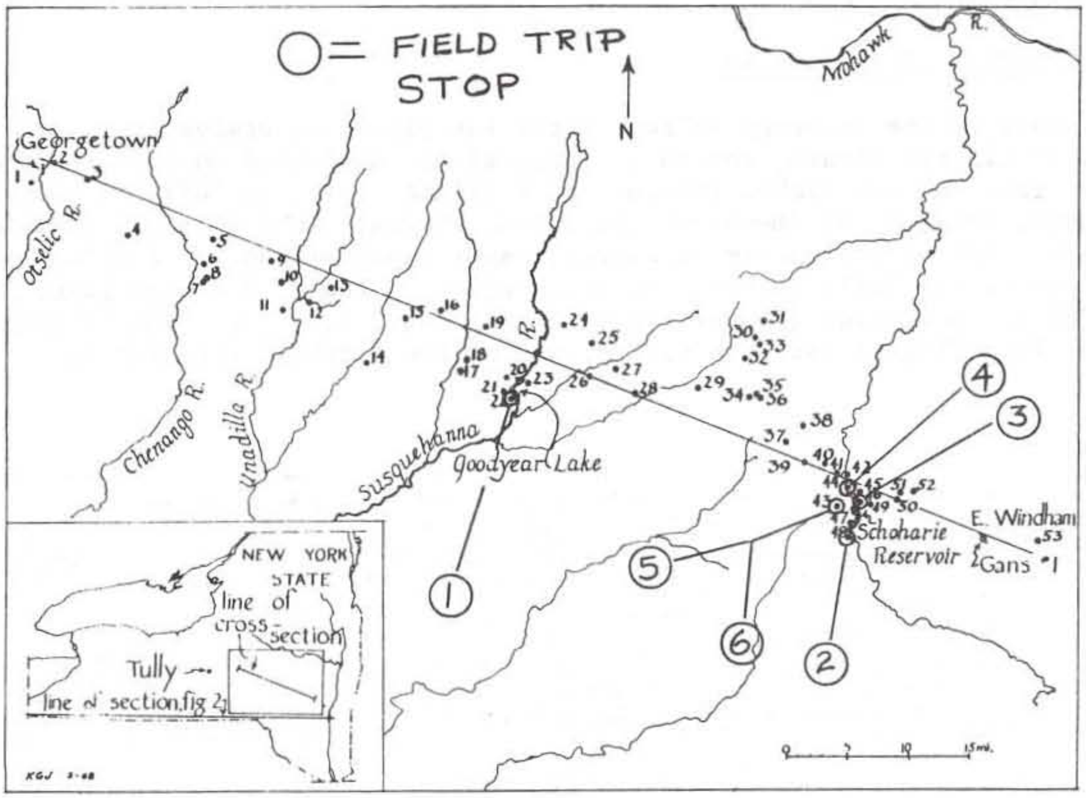

Fig. C-2. Measured Section Locations and Line of Cross-section for Figs. C-4, C-5, C-6.

## GENERAL STRATIGRAPHY
## TULLY LIMESTONE AND EASTERN CLASTIC CORRELATIVES

### Tully Limestone

The name Tully Limestone was applied by Vanuxem (1838) to a series of beds which are well exposed in central New York in the vicinity of the village of Tully. The Tully, composed mostly of gray calcilutite with subordinate biocalcarenite, constitutes an excellent stratigraphic marker which varies in thickness from 3 to 48 feet in central New York.

The Tully is subdivided, from the oldest to youngest, into the Tinkers Falls, Apulia, and West Brook members (Cooper and Williams, 1935). The guide fossil Hypothyridina venustula characterizes the Apulia Member and the fimbriata biozone is included in the West Brook Member. Both of these zones, which extend into the western part of the Tully clastic correlatives, provide stratigraphic control which was essential for study of the pattern of depositional facies. As defined by Trainer (1932, p. 8), the Tully includes all beds between the Geneseo Shale and the uppermost shale in the Moscow Formation. The Tully interval thickens eastward but the limestone beds become thinner, and east of the Chenango Valley are replaced by terrigenous rocks (New Lisbon and Laurens) (Fig. C-3).

### Tully Eastern Correlatives

East of the Chenango Valley, where the limestone grades into very fine-grained clastic strata, the Tully interval is subdivided on a biostratigraphic basis into the New Lisbon (Cooper and Williams, 1935, p. 809) and Laurens (Cooper, 1934, p. 5) "Members" (Fig. C-3). Farther east in the clastic wedge, suitable biologic elements for stratigraphic subdivision are lacking, and that portion of the Tully interval in this region is included in the lower part of the Gilboa Formation (Cooper and Williams, 1935, p. 818). The Gilboa Formation interfingers eastward with strata of the Catskill lithofacies.

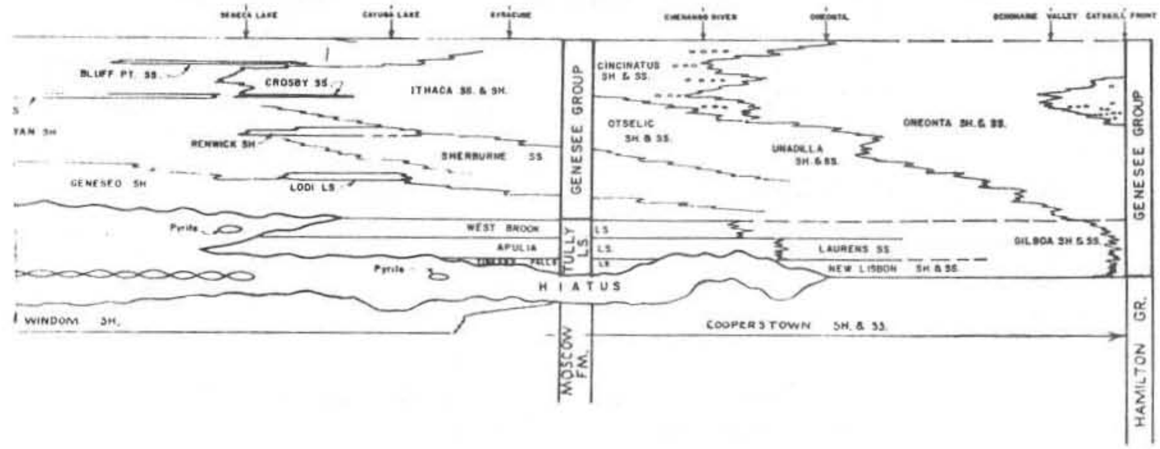

Fig. C-3. Correlation within Genesee Group, basal Upper Devonian, New York State (after Rickard, 1964).

# LITHOSOMES
## TULLY AND ASSOCIATED STRATA

The Tully Limestone and associated starta are subdivided into four lithosomes (Fig. C-4). Lithosome A is the thinned eastward extension into the study area of the Tully Limestone. The unit consists of argillaceous calcilutite and sandy biocalcarenite. Lithosome B, which lies directly above Lithosome A and is co-extensive with the tongue shaped eastern extension of the Geneseo Shale, consists of very dark fissile shale grading eastward into shaly siltstone. Lithosome C forms a massive clastic wedge which in cross-sectional view envelops Lithosomes A and B. It is comprised of interlensing gray siltstone and slightly lighter gray, very fine-grained sandstone which contains flow-rolls, trace fossils, coquinite lenses and, at the eastern margin of the lithosome, fossil seed-ferns. Lithosome D consists of red and green siltstone and mudstone with interbeds of gray, fine to medium-grained, texturally very immature sandstone.

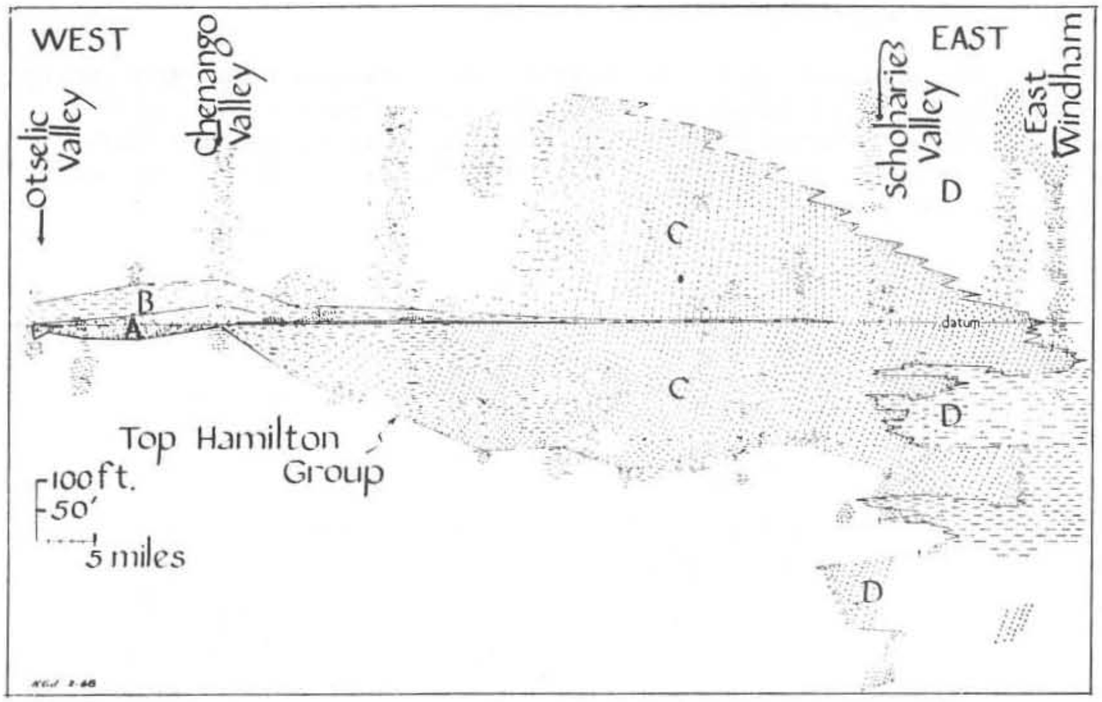

Fig. C-4. Cross-section, Lithosomes in Tully Clastic Correlatives

## SEDIMENTARY FACIES OF TULLY INTERVAL

The environmental spectrum of the Tully interval includes alluvial plain, tidal and sub-tidal facies each of which can be further subdivided on the basis of multiple recognition criteria such as sedimentary structures, lithology, geometric relationships of rock units and character of biologic content. Rocks of alluvial derivation are well exposed in the eastern part of the study area. Sandstone bodies of alluvial channel origin truncate underlying beds, contain basal shale-pebble lag-concentrates, are well cross-bedded, are texturally very immature and invariably display a "fining-upwards". The alluvial strata of overbank origin are horizontally laminated, red and green siltstones which locally include large very highly organic lenses and beds representing a marsh environment. At the distal margin of the alluvial plain, just below the Tully interval, a swamp environment is represented at the three levels of the Gilboa seedferns.

Sedimentation that resulted in strata of tidal origin within the Tully interval was of the Wadden-type. The tidal flat facies consists of gray, very finely cross-laminated muddy siltstone and very fine-grained sandstone, which contain allochthonous brachiopods and locally well-developed mud-cracks. Sedimentary structures of the tidal channel facies are essentially identical to those of the alluvial channel facies, but can be distinguished by the unique character of the basal lag-concentrate, which contains very abundant allochthonous brachiopod shells.

Within the strata of sub-tidal derivation a nearshore, predominantly sandstone, facies and an offshore, predominantly siltstone, facies are recognized. Well developed trends of change in texture, general biologic character and type and scale of sedimentary and biologic structures are present in the sub-tidal strata.

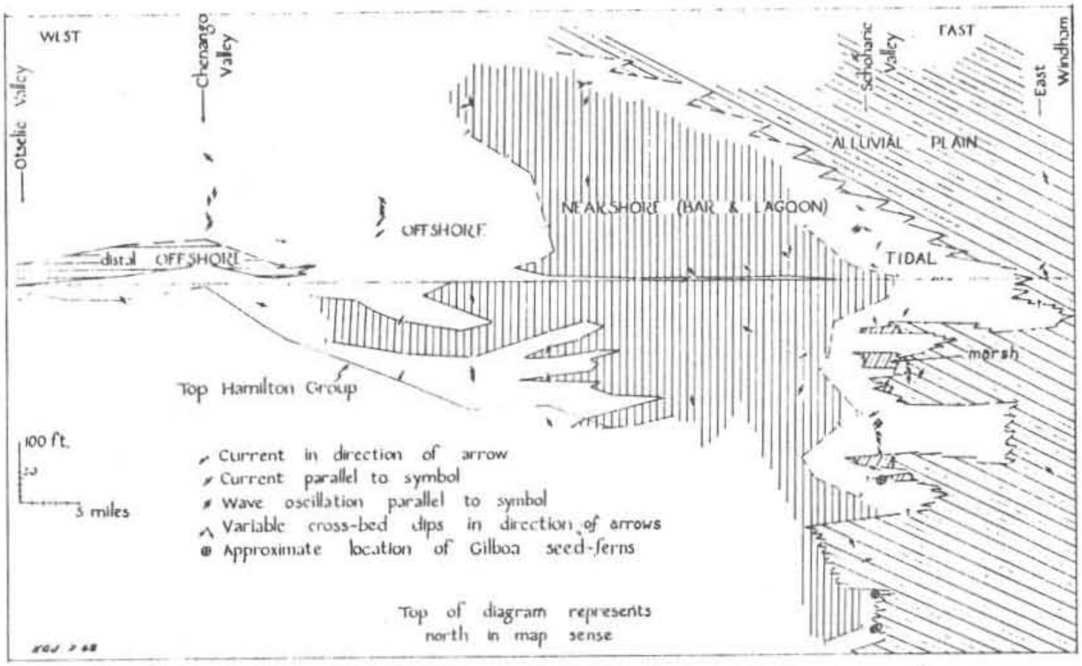

Fig. C-5. Cross-section, Sedimentary Facies in Tully Clastic Correlatives

The purpose of this trip is to study the characteristics of rocks within the Tully clastic correlatives that appear to have evolved in shallow nearshore, tidal and distal alluvial plain sedimentary environments. Those interested in the Tully Limestone are referred to a recent comprehensive report by Heckel (1966) dealing with the stratigraphy and sedimentology of the limestone facies in Central New York.

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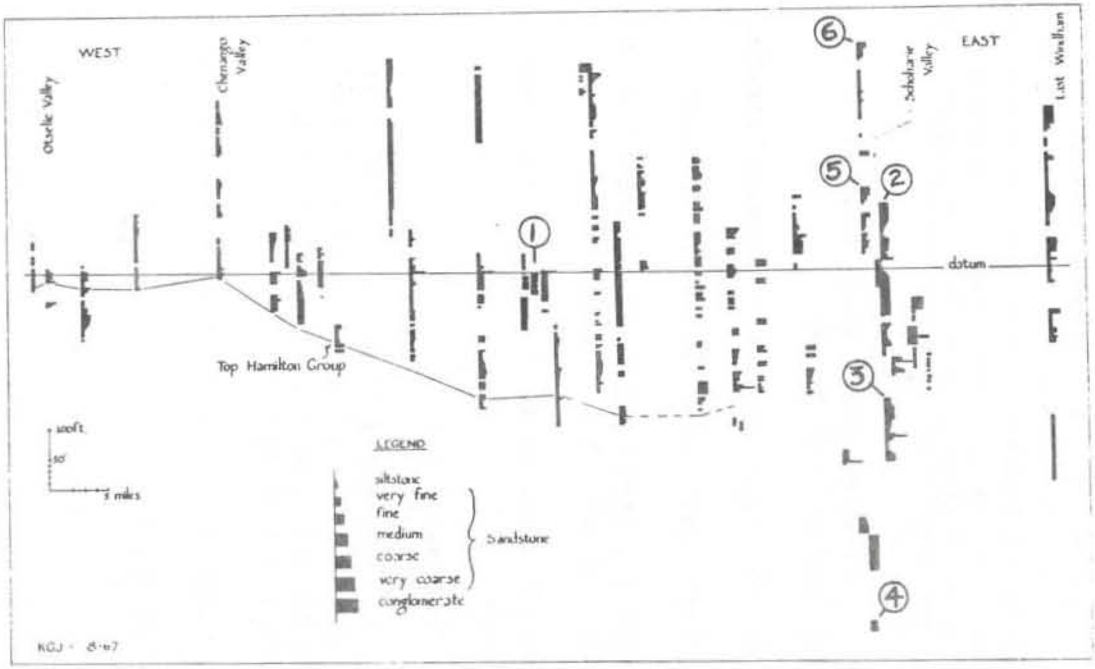

Fig. C-6. Cross-section, Tully Limestone and associated rocks, east-central New York State showing mean grain-size. Note increasing grain-size of sandstones eastward between Chenango Valley and Schoharie Valley. <u>CIRCLED NUMBERS INDICATE FIELD TRIP STOPS</u>.

## TRIP C: TRANSITIONAL SEDIMENTARY FACIES OF THE CATSKILL DELTAIC SYSTEM IN EASTERN NEW YORK STATE

Kenneth G. Johnson

| Total Miles | Miles from last point | Route description |
|---|---|---|
| | | Assembly point: Parking lot, Holiday Inn, Cortland |
| | | Departure: 8:15 A.M. Sharp! |
| | → | Proceed south via Interstate 81 to Route 41. Take Route 41 east through McGraw, to Route 26 in the Otselic River Valley. Turn north on Route 26 and proceed to Route 23. Turn east on Route 23. Junction of Routes 26 and 23 is considered zero point for this road log. |
| 2.8 | 2.8 | On right (S) swamp which forms headwaters of south flowing Genegantslet Creek. |
| 6.5 | 3.7 | On left (N) large outcrop of Chemung Lithofacies. |
| 14.6 | 8.1 | Cross Canasawacta Creek in South Plymouth |
| 16.9 | 2.3 | On right (S) large gravel pit in glacio-fluvial sedimentary deposit. |
| 18.6 | 1.7 | In Norwich cross Route 12 and continue east on Route 23. |
| 19.2 | 0.6 | Cross Chenango River |
| 23.0 | 3.8 | Road cut in Catskill Lithofacies. On left (N) excellent example of alluvial channel facies (cross-bedded, gray, graywacke) resting on over-bank facies (red shale). |
| 27.1 | 4.1 | Cross Route 8 and continue east on Route 23. |
| 27.2 | 0.1 | Cross Unadilla River |
| 34.6 | 7.4 | Descend river terraces. |
| 35.2 | 0.6 | Center of Morris. Note stone buildings constructed of Chemung lithofacies flagstone. |
| 36.3 | 1.1 | On left large gravel pit in glacio-fluvial deposit. |
| 40.1 | 3.8 | West Laurens. |
| 45.2 | 5.1 | West Oneonta. |
| 46.1 | 0.9 | Ahead on left large gravel pit in Kame deposit. |

| Total Miles | Miles from last point | Route description |
|---|---|---|
| 47.6 | 1.5 | Junction of Routes 23 and 205. Continue east on Route 23. |
| 48.6 | 1.0 | Oneonta. Junction Routes 23 and 7. |
| 49.6 | 1.0 | On left in used car lot adjacent to Nick's Diner horizontal, very thin bedded Chemung lithofacies containing abundant spiriferid brachiopods.<br>Proceed through Oneonta on Route 7. |
| 52.6 | 3.0 | On right view of glacial deposits in mouth of Charlotte Valley. |
| 54.5 | 1.9 | On right across valley very large gravel pit in Kame terrace. |
| 55.9 | 1.4 | Junction Routes 7 and 28. Turn left (N) onto Route 28. |
| 56.3 | 0.4 | On right power station at Goodyear Lake Dam. On left extensive outcrop.<br><u>STOP 1</u><br>(Indicated as Section 22 on Fig. C-2 and as ① on Fig. C-6.)<br>This outcrop contains as example of the flow-rolls which are locally common in Lithosome C. The flow-rolls occur as beds of internally distrubed structure underlain and overlain by horizontal, well-bedded strata. Within the flow-roll beds are nodule-shaped, concentrically laminated masses of medium gray, very fine-grained sandstone enclosed in slightly darker colored siltstone. The laminar structure is due to concentric, extremely thin, dark laminae composed largely of very fine plant fragments. The enclosing siltstone commonly has a diapiric relationship to adjacent pillows. This outcrop is at the distal edge of the nearshore (bar and lagoon) facies.<br>Return to Route 7. |
| 57.4 | 0.7 | Junction Routes 28 and 7. Turn right (W) on Route 7. |
| 60.0 | 2.6 | At drive-in theatre turn left onto County Route 47. |

| Total Miles | Miles from last point | Route description |
|---|---|---|
| 60.5 | 0.5 | Cross creek. |
| 61.7 | 1.2 | Kame and Kettle topography. |
| | | Road designation changes to Delaware County Route 11. |
| 63.6 | 1.9 | Junction Routes 11 and 23. Turn left (E) on Route 23. |
| 63.8 | 0.2 | Passing through Kame and Kettle topography. |
| 65.7 | 1.9 | Davenport Center. |
| 67.8 | 2.1 | On left well defined river terrace. |
| 68.5 | 0.7 | On right outcrop of dark Gilboa Formation shale. |
| 70.0 | 1.5 | Davenport. |
| 73.6 | 3.6 | Traffic light in center of Stamford. |
| 81.1 | 7.5 | Grand Gorge. |
| 81.6 | 0.5 | Junction of Routes 23 and 30. Continue east on Route 23. |
| 84.6 | 3.0 | On right power sub-station. Park and walk down unsurfaced road across from power station. |
| | | STOP 2 - Hardenburgh Falls<br>(Indicated as Section 48 on Fig. C-2 and as ② on Fig. C-6.)<br>The beds here are medium gray and olive gray, trough cross-bedded, fine to medium-grained, graywacke and medium gray, shaly siltstone of Lithosome C. Pebble and coquinoid conglomerate lenses, rich in plant fragments, are common. The strata are interpreted as being of tidal channel and tidal flat origin. |
| | | Continue east on Route 23. |
| 85.0 | 0.4 | Kame (?) topography. |
| 85.5 | 0.5 | Prattsville. |
| 86.2 | 0.7 | Cross Schoharie Creek. Take sharp left (N) onto County Route 11. |
| 88.3 | 2.1 | On right sandstone ledges of Catskill lithofacies (Lithosome D). |
| 89.9 | 1.6 | On right more sandstone ledges of Catskill lithofacies. |

| Total Miles | Miles from last point | Route description |
|---|---|---|
| 90.9 | 1.0 | Park on left side of road just before crossing bridge over Manor Kill.<br>STOP 3<br>(Indicated as Section 46 on Fig. C-2 and as ③ on Fig. C-6.)<br>The beds exposed in the Manor Kill Gorge are within the upper part of the Hamilton Group. Those in the lower part of the section, adjacent to the Schoharie Reservoir, are trough cross-bedded, burrowed, medium-grained sandstone of Lithosome C assigned to the tidal channel facies. Some of these sandstones are rich in plant material and in a few places during low water stages of the reservoir fossil seed-fern stumps may be seen. The remainder of the section upstream consists of interbedded red and green shales, dark gray shales and medium gray, shallowly cross-bedded, fine-grained sandstone; interpreted, respectively, as distal alluvial plain, tidal flat and tidal channel facies. Walk down path on left (W) side of road to east bank of reservoir at mouth of Manor Kill to observe cross-bedded, burrowed sandstone. |
| | | Continue across Manor Kill bridge and bear left. |
| 91.9 | 1.0 | On right Gilboa-Conesville Central School. |
| 92.2 | 0.3 | On left Gilboa Dam constructed mainly of tidal channel (and bar?) sandstone of Lithosome C. |
| | | Continue down hill bearing left (on surfaced road). Cross bridge over Schoharie Creek about 0.5 mile north of Gilboa Dam. |
| 92.9 | 0.7 | On left, at west end of bridge.<br>STOP 4<br>Display of Gilboa seed-ferns taken from quarry (abandoned) a short distance back in woods.<br>(Lower few feet of quarry is designated as Section 44 on Fig. C-2 and as ④ on Fig. C-6.) Over 200 such seed-fern stumps were taken from this quarry. They apparently represent a distal alluvial plain or tidal swamp which was buried by shifting tidal channel sands. |
| | | Continue west to Route 30. |
| 94.0 | 1.1 | Turn left (S) on Route 30. |

| Total Miles | Miles from last point | Route description |
|---|---|---|
| 95.0 | 1.0 | Park on right side of road opposite outcrops near base of steep hill. |
| | | STOP 5 |
| | | (Basal part of section which is designated Section 43 on Fig. C-2. Designated ⑤ on Fig. C-6.) Outcrop consists of medium gray and olive gray, tabular and trough cross-bedded, fine to medium-grained, immature graywacke. The sandstone contains well-developed lag accumulations of large spiriferid brachiopods and a few large burrow structures. The sandstone is interpreted to represent a tidal channel deposit. |
| | | Continue up the hill (S) on Route 30. |
| 95.3 | 0.3 | Park on right opposite red beds. |
| | | STOP 6 |
| | | (Upper part of section which is designated 43 on Fig. C-2. Designated ⑥ on Fig. C-6.) Outcrop consists of grayish red, highly micaceous siltstone and silty, very fine-grained sandstone of the overbank alluvial facies (Lithosome D). Dark greenish gray mottles are common in these beds. |
| | | Resting in channel contact on the red beds is well cross-bedded, apparently unfossiliferous, medium gray, very fine-grained sandstone and olive-gray, fine-grained sandstone. Within this 30 foot sandstone interval is a well-developed compound channel that migrates to the right (SW) upward in the section. |
| | | Proceed south towards Grand Gorge on Route 30. |
| 96.0 | 0.7 | In distance ahead note accordant summits which are typical of this part of the Catskill Mountains. |
| 96.9 | 0.9 | Junction of Routes 30 and 23 in Grand Gorge. Turn right (W) on Route 23. |
| | | Return to Cortland via Routes 23, 26, 41 and 81. |

TRIP D & H

# Paleontology, Stratigraphy, and Paleoecology of the Ludlowville and Moscow Formations (Upper Hamilton Group), in Central New York

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## Introduction

The Middle Devonian Hamilton Group of New York State is structurally simple and highly fossiliferous, thereby lending itself to detailed stratigraphic and paleontologic studies.

The writer (1966) examined the Hamilton sequence in the Tully Valley to determine the sequence of lithologies and faunas. The zones thus determined were compared with those defined by Cleland (1903), who made a similar study of the Hamilton Group along the Cayuga Lake meridian, 30 miles west of the Tully Valley (Fig. D-1). A paleoecological interpretation of the Hamilton rocks of the Cayuga Lake region was made by Fernow (1961).

## Structure

The Hamilton Group in central New York consists of approximately 1,000 feet of shales, silty shales and siltstones lying above the Onondaga Limestone and below the Tully Limestone. Three thin carbonate beds serve to define the formational boundaries. The stratigraphic relations of the Hamilton Group of New York as now understood were first clarified by Cooper's classic papers (1930, 1933).

The Hamilton rocks in the Tully Valley dip to the south 25° west at approximately 48 feet per mile, based upon the Centerfield Member as a datum (Grasso, 1966).

The value obtained for the dip agrees with Cooper's (1930) estimate of 45 to 50 feet per mile to the southwest. Wedel (1932) suggests a gentle southward dip of 50 feet per mile for the Cayuga Lake Hamilton section.

Superimposed on the regional dip are local low anticlines and synclines and faults. A thrust fault with associated folding occurs just south of Marcellus along N. Y. Route 173 (Smith, 1935). Oliver (1951) shows conclusively that several normal faults, downthrown to the north, occur on the southwest side of the Tully Valley near Lords Hill. A thrust fault in the Onondaga Limestone and overlying Union Springs Member can be seen 1 mile south of Nedrow (Prucha, 1964, p. 99).

At Cayuga Lake, there are at least three low anticlines in the Hamilton Group (Fernow, 1961). The Portland Point anticline, the most conspicuous of the Cayuga Lake folds, is best viewed looking east from Taughannock Point on the west side of the lake. A thrust fault in the Tully Limestone exposed in one wall of the Portland Point Quarry has drag folded the uppermost portion of the underlying Moscow Formation.

## Hamilton Section in the Tully Valley and Cayuga Trough

The Devonian System of central New York State varies from carbonates at the bottom (Helderbergian and Ulsterian Series) to coarse continental clastics at the top (Chautauquan Series) and represents a westward regressive sequence of which the Hamilton is a small part (Rickard, 1964).

In the Tully Valley, the Hamilton is composed mainly of two facies that transgress time westward. The lower is a black and dark shale facies referred to as the "Cleveland" facies (Caster, 1934) (Rickard, 1964), the "Marcellus" facies (Cooper, 1932) or the "Leiorhynchus" facies (Cleland, 1903, Cooper, 1930).

Lying above the "Cleveland" facies in the Tully Valley but partly contemporaneous with it farther to the east is the "Big Bend" facies (Caster, 1934), a silty shale and siltstone carrying an entirely different fauna. The fauna of the "Big Bend" facies is sometimes called the Hamilton fauna or the Tropidoleptus fauna (Williams, 1903, Cooper, 1930) and represents better oxygenated bottom conditions than the "Cleveland" facies. A third facies of calcareous shale and thin limestones, the "Moscow" facies, recurs at intervals in the group. It comprises only 35 feet of the Hamilton strata in the Tully Valley, however, it is important stratigraphically as this facies occurs as three thin bands that are major datum planes dividing the Hamilton Group into four formations which are from oldest to youngest the Marcellus, Skaneateles, Ludlowville, and Moscow Formations. The "Moscow" facies is also referred to as the calcareous part of the Hamilton and possesses a Tropidoleptus fauna, although somewhat modified from the standard Tropidoleptus fauna farther east by possessing more of a brachiopod - coral - bryozoan assemblage.

The gradual replacement of the "Marcellus" facies by the "Big Bend" facies migrating in from the east is the history of the Hamilton Group in the Tully Valley. This began in late Marcellus time and was followed by a period of oscillation between the two facies during early and middle Skaneateles time. The "Big Bend" facies completely replaced the "Marcellus" by late Skaneateles time.

The "Big Bend" facies did not reach the Cayuga Lake meridian until late Devonian time. The "Marcellus" facies persisted until Late Ludlowville time when it was replaced by the "Moscow" facies.

These environmental differences are reflected in the distribution of the faunal zones. In the Tully Valley, 26 assemblage zones were distinguished by the writer (1966) and 25 by Cleland (1903) at Cayuga Lake. However, in the Cayuga Lake section, 20 of Cleland's zones are found between the upper part of the Ludlowville Formation (King Ferry Member) and the base of the Tully Limestone, whereas in the same approximate time interval 9 or 10 zones can be discriminated in the Tully Valley (Fig. D-1).

## Ludlowville Formation

The Ludlowville Formation is the most fossiliferous formation in the Tully Valley. It consists of about 260 feet of intertonguing silty shales and siltstones and on the basis of these Smith (1935) divided the Ludlowville above the Centerfield into four members, the Otisco, Ivy Point, Spafford, and Owasco (Fig. D-1).

The Ludlowville thickens westward, an anomalous condition for most of the Hamilton formations, to 360 feet on Cayuga Lake where it consists of a lower dark or black shale, the Ledyard Member, and an upper fossiliferous, gray, calcareous, gritty shale, the King Ferry Member (Fig. D-1).

### Centerfield Member

In the Tully Valley area, the Centerfield Member is lithologically gradational with the underlying Butternut Member of the Skaneateles Formations. It is a coarse siltstone about 25 feet thick. The lower and upper 10 feet are flaggy but the middle portion is calcareous and fossiliferous. The siltstone beds in the flaggy portions are about one inch thick and at some localities crossbedded. The contact with the overlying Otisco is sharp.

The Tully Valley Centerfield fauna is characterized by a great number of large epifaunal pelecypods. *Cornellites flabellum* and *Actinopteria decussata* occur most frequently along with *Glyptodesma erectum* and *Limoptera* *macroptera*. Corals are not abundant but a few species are found mainly in the calcareous portion of the Centerfield: *Favosites turbinata*, *F. hamiltoniae*, *Cystiphylloides americanum*, and *Heterophrentis simplex*. The brachiopods are mostly robust forms such as: *Fimbrispirifer venustus* and *Spinocyrtia granulosa*. Two other common brachiopods are: "*Spirifer*" *sculptilis* and "*Camarotoechia*" *dotis*. The occurrence of "*Spirifer*" *sculptilis* and *Fimbrispiriter venustus* in this assemblage is nowhere repeated in the Hamilton section of the Tully Valley.

According to Fernow (1961) the Centerfield Member at Cayuga Lake is a very calcareous relatively even bedded shale, medium to dark gray when fresh, abundantly fossiliferous, weathering to a medium brown color. The uppermost few centimeters are iron stained, very fossiliferous, and characterized in places by phosphate nodules up to one-half inch in diameter.

The fauna of the Cayuga Lake Centerfield, in addition to being more plentiful, contrasts markedly with that of the Tully Valley. Brachiopods dominate the fauna with *Longispina vicinus*, *Douvillina inaequistriata*, *Spinocyrtia granulosa*, "*Spirifer*" *sculptilis*, *Nucleospira concinna* being some of the more common species. Fernow (1961, pp. 52-55) lists the complete Centerfield fauna from Cayuga Lake along with relative abundances of the constituent species. The near absence of *Fimbrispirifer venustus* is conspicuous. Among the bivalves found in the Tully Valley Centerfield a questionable *Cornellites flabellum* is reported, *Actinopteria decussata* is less abundant, *Limoptera macroptera* is very rare, and *Glyptodesma erectum* does not occur at Cayuga Lake. The bivalve assemblage instead is headed up by various species of *Goniophora*, *Modiomorpha* and *Paleoneilo*. In short, there is a distinct lack of epifaunal suspension feeders and a preponderance of infaunal deposit feeders.

Some of the infaunal forms may have been asiphonate filter feeders living at or near the sediment water interface. For a detailed analysis of bivalve habitats and feeding mechanisms, see Stanley (1968), and Fernow (1961).

Many more bryozoa and corals occur in the Centerfield on Cayuga Lake than in the Tully Valley.

Fernow (1961, p. 175) concludes that the presence of corals and bryozoa indicates that the Centerfield waters in the Cayuga region were well oxygenated, gently circulating, and carried abundant nutrients in suspension.

The crossbedded coarse siltstones of the Centerfield in the Tully Valley indicate a higher energy shallow water environment of strong currents carrying both organic and inorganic particles in suspension. This may account for the abundance of large eipfaunal filter feeding bivalves and brachiopods. Sedimentation was probably too rapid to permit the firm establishment of a coral-bryozoan community.

### Otisco Member

This unit is a soft, thinly bedded, slightly calcareous, silty, medium-gray to medium-dark gray shale, interbedded toward the top with thin siltstone beds. The contact with the Ivy Point Member, about 165 feet above the Centerfield, is sharp.

The Otisco Member is especially interesting for two coral biostromes which have been given submember status by Oliver (1951). The lower, designated the Staghorn Point by Smith (1935) is about seven feet thick in the Tully Valley. Oliver (1951) traced this unit over an area of 150 square miles. It occurs about 50 feet above the top of the Centerfield and rests on a massive calcareous, siltstone platform about three feet thick. The upper biostrome was named the Joshua Submember by Oliver (1951). It varies from 0 to 55 feet in thickness in the Tully Valley and is less extensive than the Staghorn Point Submember covering some 40 square miles.

The fauna of the coral beds is composed almost exclusively of solitary rugose corals. Aside from a few Favositidae, other organisms are extremely rare (Oliver 1951).

Oliver (1951, Table 1, p. 712) lists the most abundant species present in the Staghorn Point Submember as: Siphonophrentis halli, Cystiphylloides americanum, Cystiphylloides conifollis, Heliophyllum halli, Bethanyphyllum robustum, and Heterophrentis ampla.

The siltstone platform provided a firm bottom upon which the corals were able to become established. Succeeding generations used the skeleton of their predecessors as substrates (Oliver, 1951).

Faunally, the Joshua Submember is much the same as the Staghorn Point, however, the Joshua rests on a thin bed composed entirely of the colonial rugose coral Eridophyllum subcaespitosum. Oliver (1951) suggests "...these colonial rugose corals colonized the area during an interval of favorable conditions and formed a crude platform for the solitary corals."

The remaining portion of the Otisco Member is also very fossiliferous, especially the first 20 and the uppermost 70 feet.

The lowest 20 feet of the Otisco Member is characterized by the abundance of 3 species of brachiopods: Chonetes vicinus, Chonetes scitulus, and Tropidoleptus carinatus.

The upper 70 feet of the Otisco are marked by the great abundance of Mucrospirifer mucronatus. Associated with this species are large numbers of mostly epifaunal brachiopods and pelecypods such as: Spinocyrtia granulosa, Megastrophia concava, Stropheodonta demissa, Athyris spiriferoides, Cornellites flabellum, and Pseudaviculopecten princeps. Less abundant though still conspicuous in this assemblage are a wide variety of other typical Hamilton forms, many of which are considered to be infaunal, such as Modiomorpha mytiloides.

Early and late Otisco time in the Tully Valley represents times of diverse ecological conditions. The varied and abundant epifauna and infauna of the lower and upper portions of this unit suggest opulent conditions of a near shore, shallow water, well oxygenated environment. Clastic sedimentation must have been fairly rapid and there was enough organic material in suspension and the substrate to support the faunal association. The absence of corals and to some extent bryozoans in these lower and upper zones is evidence of rapid deposition and excess turbidity.

The two coral biostromes reflect times of different environmental conditions. The circumstances necessary for coral growth and development such as relatively shallow, clear, warm, water implies very little clastic sedimentation during these two intervals. This probably explains the thinning of the Ludlowville east of Cayuga Lake while the other formations of the Hamilton Group thicken in this direction. Currents sufficiently strong to carry abundant food in suspension must have moved across the coral "flats" which were perhaps very near wave base. The corals thrived and were able to compete with other invertebrates to the extent of excluding them completely from these areas.

The Otisco Member changes very rapidly westward where much of it is equivalent to the dark shales of the Ledyard Member (Fig. D-1).

## Ledyard Member

Along the Cayuga Lake meridian, the Ledyard consists of 190 feet of dark gray to black, brittle, fissile, slightly calcareous, sporadically fossiliferous shale. The upper 30 feet contain three zones of concretions, some of which are fossiliferous (Fernow, 1961). The Ledyard is equivalent to Cleland's (1903) Third Leiorhynchus Zone.

The fauna of the Ledyard consists primarily of infaunal pelecypods, small epifaunal and epiplanktonic brachiopods, and cephalopods. Nucula corbuliformis, Pterochaenia fragilis, Nuculites triqueter represent some of the bivalves, Ambocoelia umbonata, Chonetes setigerus, and Leiorhynchus multicosta the brachiopods, and Tornoceras n. sp. and "Orthoceras" sp. the cephalopods identified by Fernow (1961).

The Ledyard lithology and fauna indicate a paleoenvironment dramatically different from that represented by the Otisco in the Tully Valley. The water was probably deeper and poorly oxygenated west of the Skaneateles Meridian. This in combination with the lack of turbulence and material in suspension as evidenced by the fine grained nature of the rocks was inimical to a well developed epifaunal community (Fernow, 1961). The presence of some epifaunal brachiopods and infaunal pelecypods indicates that there was some oxygen in the water with zero Eh surface at or just below the sediment-water interface.

### Ivy Point Member

This unit is about 37 feet thick in the Tully Valley and is dominantly a flaggy, slightly calcareous, gray siltstone that weathers to a distinct yellowish-brown color. Most of the siltstone beds are approximately one inch thick. A fossiliferous silty shale unit from 4 to 7 feet thick occurs about 27 feet up from the base of this member. Spheroidal, calcareous, non-septarian, unfossiliferous concretions 3 to 18 inches in diameter are present in the lower 20 feet.

Although the author did not find many fossils in the massive siltstone beds of the lower Ivy Point, they are reported to be moderately fossiliferous containing large epifaunal pelecypods, and brachiopods along with the large trilobite Dipleura dekayi (Clarke and Luther 1904).

The upper 10 feet are more fossiliferous than the lower beds and contain abundant diverse epifaunal and infaunal elements. Epifaunal brachiopods include Mucrospirifer mucronatus, Athyris spiriferoides, Protoleptostrophia perplana and Atrypa reticularis. Eipfaunal pelecypods are represented by Cornellites flabellum, Pterinopecten vertumnus, and Actinopteria decussata. The dominant infaunal bivalves include Modiomorpha concentrica, M. subalata, Macrodon hamiltonae, Pholadella radiata, and Nuculites oblongatus.

The lower Ivy Point probably represents a recurrence of the Tully Valley Centerfield conditions discussed above, page 4. The upper Ivy Point is very similar lithologically and faunally to the upper part of the Otisco Member above the Joshua Submember and probably represents a recurrence of those ecological conditions.

The upper part of the Otisco along with the Ivy Point, Spafford, and Owasco Members are equivalent to the King Ferry Member on Cayuga Lake (Fig. D-1).

### Spafford Member

The Spafford Member consists of 27 feet of thin bedded gray, silty shale sharply overlying the coarse Ivy Point Member.

Faunally the Spafford is exactly the same as the upper 10 feet of the Ivy Point and represents a continuation of the same environmental conditions.

### Owasco Member

This member is a massive, calcareous, well cemented siltstone bed 2 feet thick.

Smith (1935) defined the Owasco on the basis of "...the thin but important Spirifer tullius (Allanella tullius) Zone which follows the Spafford and is limited above by the Portland Point..."

Fossils are difficult to extract and found in discontinuous highly fossiliferous zones consisting mostly of Mucrospirifer mucronatus, Allanella tullius and Tropidoleptus carinatus.

The lithologic character of this unit suggests another recurrence of a shallow water high energy environment near wave base. The occurrence of the fossils in discontinuous zones and the lack of numerous large epifaunal forms contrasts markedly with the underlying Ivy Point, Otisco, and Centerfield. The Owasco fossils may represent current deposits and hence would not be indicative of the Owasco live assemblage. The Owasco probably represents an environment of higher energy than any of the ones discussed thus far.

### King Ferry Member

The silty shale and siltstones of the upper Ludlowville Formation in the Tully Valley pass westward into a mass of blue-gray, nonfissile, calcareous gritty shales, the King Ferry Member.

Fernow (1961, p. 64) states "...the fauna of the King Ferry Member is rich and varied but dominated by pelecypods (52 species) and brachiopods (26 species) ..." The infaunal forms predominate over the epifaunal. Cleland (1903) subdivided the King Ferry into 6 zones, none of which can be recognized in the Tully Valley. However, his Michelinia Zone, which is characterized by the tabulate coral Pleurodictyum americanum, has been traced by Cooper (1930, p. 225) westward to Lake Erie.

The King Ferry Member was deposited in deeper, less agitated water than correlative units in the Tully Valley. The relative abundance of infaunal to epifaunal forms probably reflects a decrease of current in deeper water, with its attendant decrease in organic material available for epifaunal filter feeders.

## Moscow Formation

Exposures of the lower 70 feet of the 175 foot thick Moscow Formation are difficult to find in the Tully Valley. Therefore, this interval could not be examined thoroughly and many of the remarks pertaining to the Portland Point and lower and middle Windom Members were derived from the examination of a single selection; Bucktail Falls Ravine on the west side of the neighboring Otisco Valley. Along the Cayuga Lake meridian, the Moscow Formation is completely exposed.

Although lithic and faunal distinctions can be made in the Moscow Formation between Cayuga Lake and the Tully Valley, there are many more similarities, a consequence of uniform paleoecological conditions that prevailed over central New York in late Hamilton time.

### Portland Point Member

The upper and lower contacts of the Portland Point Member are sharp in the Tully Valley. A basal crinoidal, shelly limestone about 1 foot thick is succeeded by 11 feet of gray silty shale interbedded with thin crinoidal, shelly limestone bands 2 inches thick or less and about 8 inches apart. The silty shales are sparsely fossiliferous.

On Cayuga Lake, the Portland Point consists of a 5 to 7 foot sequence beginning with a massive crinoidal limestone, followed by a middle zone of less resistant shale and capped by an upper resistant sandy or limey fossiliferous shale. The basal cronoidal limestones varies from 2-5 feet thick.

The Portland Point is not very fossiliferous nor does it carry a distinctive assemblage in the Tully Valley. On Cayuga Lake, however, it is a highly fossiliferous unit of brachiopods, pelecypods, ostracods (from crinoidal basal layer), crinoids, corals, and massive bryozoa.

The crinoidal layer, according to Fernow (1961), was deposited above effective wave base as indicated by its coquina-like character which appears to be a residual lag deposit.

The shales above the basal layer at Cayuga Lake indicate a change to quieter, slightly deeper water which supported a rich benthonic community just below wave base (Fernow, 1961).

In the Tully Valley, the Portland Point Member probably represents an oscillation of the bottom from just below to just above wave base. The paucity of fossils in the shales may be due to the lack of good exposures of this unit in the Tully Valley.

Windom Member

The Windom Member in the Tully Valley is a thin bedded gray to medium gray shale grading upward to medium-gray silty shale to a point 20 feet below the Tully, where a sharp lithologic change takes place to a dark gray or grayish black, non-calcareous, pyritiferous shale and this is in turn sharply overlain by the Tully Limestone. This dark shale appears as a reddish-orange zone beneath the Tully due to the weathering of the pyrite. Zones of calcareous unfossiliferous, non-septarian concretions are recurrnet throughout the Windom. The upper two zones are particularly noticeable and occur 30 feet and 8 feet below the Tully. The lower concretion zone, about 10 feet thick, consists of flattened elliptical concretions under 8 inches in diameter and 2-3 inches thick. The upper concretion zone is 4 feet thick and composed of round cannon ball type concretions 6 to 10 inches in diameter.

The Windom consists of fossiliferous zones which are separated by intervals of sparsely fossiliferous rocks. The fossiliferous zones contain numerous epifaunal brachiopods, infaunal pelecypods, small corals, bryozoans, crinoid stems and trilobites. Epifaunal pelecypods are conspicuously low in number.

The dark shales at the top of the Windom contain epiplanktonic brachiopods, small epifaunal brachiopods, and small infaunal bivalves. Some of the species represented are: Leiorhynchus multicosta, Pustulatia pustulosa, Allanella tullius, Tropidoleptus carinatus, Camarotoechia dotis, Nucula varicosa and Paleoneilo constricta. The brachiopods Pustulatia pustulosa and Allanella tullius occur in the uppermost 10 feet of the Windom.

At Cayuga Lake, the Windom is predominately a gray, gritty moderately calcareous, non-fissible shale. Fernow (1961) was able to subdivide it into 6 local units. His uppermost unit (Windom Zeta) which immediately underlies the Tully is a "...dark, fissil, non-calcareous, very pyritiferous shale..." He further states it does not occur on the east shore of Cayuga Lake. Most certainly, the Windom Zeta unit is the same as the 20 feet of shales lying below the Tully Limestone in the Tully Valley. Its absence on the east side of Cayuga Lake could be the result of erosion, since the Tully Limestone is known to overlie unconformably the Windom in west central New York.

The Windom fauna at Cayuga Lake is very similar to that found in the Tully Valley area. This is reflected by several of Cleland's (1903) zones being recognized by the author in the Windom in Bucktail Falls Ravine and Tinkers Falls Ravine.

The lithology and fauna of most of the Windom in the Tully Valley and

Cayuga Lake sections indicate a modified King Ferry environment (Fernow, 1961). The marked decrease in epifaunal pelecypods reflects even quieter water conditions.

The upper dark shales of the Windom were deposited in quiet, low oxygenated waters. Its fauna is peculiar in that it contains some genera found in "normal" sediments, although they are smaller in size (dwarfed?). The paleoecologic conditions probably resembled those in operation during the deposition of the Ledyard Member as discussed on pages D-8 and D-9, but even more restrictive.

## Acknowledgment

The author thanks Dr. John W. Wells of Cornell University for critically reviewing the manuscript.

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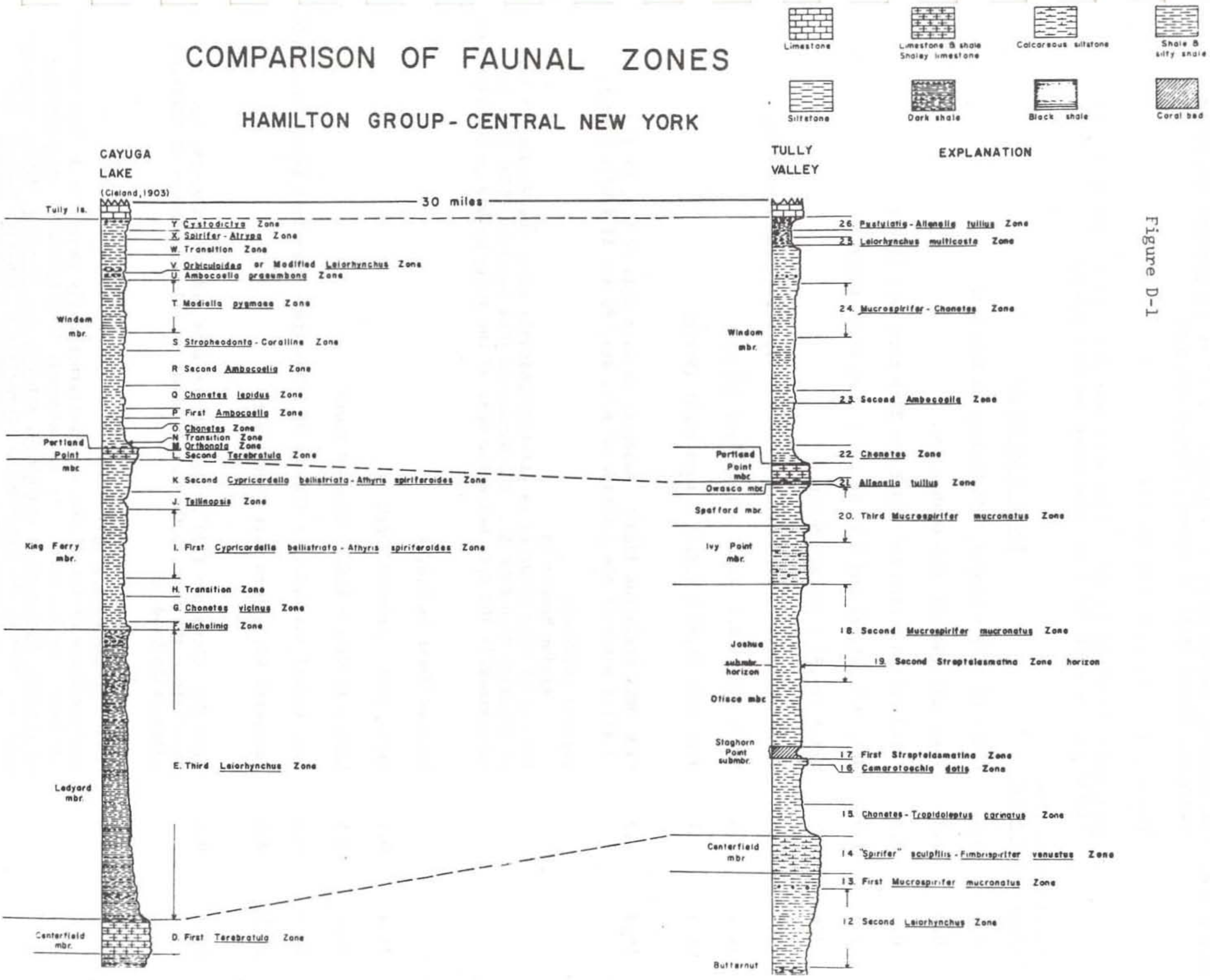
Figure D-1



COMPARISON OF FAUNAL ZONES

HAMILTON GROUP - CENTRAL NEW YORK

# TRIP D & H: STRATIGRAPHY, PALEONTOLOGY AND PALEOECOLOGY OF THE LUDLOWVILLE AND MOSCOW FORMATIONS (UPPER HAMILTON GROUP), CENTRAL NEW YORK

Thomas X. Grasso, W. Graham Heaslip

Quadrangles referred to are 7½ minute quadrangles. Elevations after the "STOPS" are those of the first continuous bedrock exposure.

| Total miles | Miles from last point | Route Description |
|---|---|---|
| 0.0 | 0.0 | Start of trip - Campus SUNY College at Cortland |
| 0.0 | 0.0 | Turn left (North) onto Graham Ave. |
| 0.2 | 0.2 | Intersection Groton Ave. (N.Y. Rt.222) turn left (West) |
| 1.2 | 1.0 | Jct. N.Y. Rt.222 and N.Y. Rt.281 - turn right (North) |
| 2.4 | 1.2 | Enter Int.81 - proceed North |
| 3.4 | 1.0 | Roadcut on east side of I-81 is in the Upper Devonian Ithaca Fm. |
| 16.4 | 13.0 | Tully Exit - N.Y. Rt.80 - turn left (West) |
| 16.5 | .1 | Jct. N.Y. Rt.80 & U.S.11 - turn right (North) |
| 16.8 | .3 | STOP ONE Elevation 1280': Roadcut, on east side of U.S. Rt.11, .3 miles north of the junction of N.Y. Rts. 80 and 11 (Tully Quad.).<br>Exposed thickness:<br>Windom Member 35'<br>The top of this exposure is stratigraphically below the Windom outcrop on Kingsley Road (STOP 5). The Windom at this locality (STOP ONE) is approximately 100 feet below the base of the Tully Ls and is fossiliferous.<br>Proceed North on U.S.11 |
| 16.9 | 0.1 | Enter I-81 - proceed North |
| 24.4 | 7.5 | LaFayette Exit - U.S.11 proceed South |
| 24.5 | 0.1 | Jct. U.S.11 and U.S.20 - Village of LaFayette - turn left (West) on U.S.20 |
| 24.7 | 0.2 | LaFayette Rd. - turn left (Northeast) |
| 25.1 | 0.4 | STOP TWO Elevation 1330': Roadcut, on west side of LaFayette Rd. just before the bend in this road, about .4 miles northwest of LaFayette (Jamesville Quad.).<br>Exposed thickness:<br>Otisco Member 30'<br>This exposure of the Otisco is stratigraphically above the Joshua Submember and below the Ivy Point. It is extremely fossiliferous. *Mucrospirifer mucronatus*, *Spinocyrtic granulosa*, *Athyris spiriferodes*, *Megastrophia concava* are some of the brachiopods, *Cornellites flabella*, *Modiomorpha mytiloides*, *Pseudaviculopecten princeps*, *Paleoneilo constricta*, *Cypricardella bellistriata* are some of the pelecypods found here. |

|  |  |  |
|---|---|---|
|  |  | Proceed North on LaFayette Road |
| 27.6 | 1.5 | Reidy Hill Road on right - proceed North |
| 29.9 | 2.3 | Bull Hill Road - turn left (West) |
| 31.0 | 1.1 | Intersection Bull Hill Rd. and Sentinel Heights Rd. - turn left (South) onto Sentinel Heights Rd. |
| 31.2 | 0.2 | Road leading to WSYR TV Tower - turn right (West) |
| 31.3 | 0.1 | STOP THREE Elevation 1400': Base of WSYR TV Tower on Miller Hill, .3 miles southwest of the intersection of Sentinel Heights Road and Bull Hill Roads (Jamesville Quad.).<br>Exposed thickness:<br>Joshua Submember 15.5'<br>Numerous solitary rugose corals occur here such as *Cystiphylloides*, *Siphonophrentis*, and *Heterophrentis*. The colonial rugose coral *Eridophyllum sabcaespitosum* is also abundant. |
| 31.4 | 0.1 | Return to Sentinel Heights Rd. - turn right (South) |
| 33.8 | 2.4 | Intersection of Sentinel Heights Rd. and Commane Rd. - turn right (West) |
| 34.0 | 0.2 | Intersection of Commane Rd. and U.S.11 - turn left (South) |
| 37.0 | 3.0 | Jct. U.S.11 and U.S.20 - LaFayette - turn right (West) |
| 44.0 | 7.0 | Jct. U.S.20 and N.Y.80 - turn left (South) proceed several hundred feet |
| 44.2 | .2 | STOP FOUR Elevation 1380': Lords Hill, on N.Y.80, south of the junction with U.S.20 (South Onondaga Quad.).<br>Exposed thickness:<br>Portland Point Member 10'<br>Owasco Member 2' Elev. 1380'<br>Spafford Member 2'<br>Ivy Point Member - not measured - small exposures on both sides of road<br>Joshua Submember - 70' (projected) Elev. of top 1280' (Oliver, 1951)<br>Joshua corals are found in the regolith on both sides of the road. The Owasco contains an abundance of *Allanella tullius* and *Mucrospirifer mucronatus*. The basal crinoidal layer of the Portland Point nests directly on top of the Owasco Member. This is succeeded by 9 feet of interbedded shales and thin limestones. |
|  |  | Proceed South on N.Y.80 |
| 45.2 | 1.0 | Kingsley Rd. - turn left (East) |

| | | |
|---|---|---|
| 46.7 | 1.5 | STOP FIVE Elevation 1500': Roadcut, on both sides of Kingsley Road just west of the intersection of Hitchings Rd. (South Onondaga Quad.). |
| | | Exposed thickness:<br>Windom Member 28'<br>The top of this exposure is about 20 feet below the base of the Tully Limestone. The Windom here is unfossiliferous. |
| | | Turn left (North) onto Hitchings Rd. |
| 48.7 | 2.0 | Intersection - Hitchings Road and U.S.20 - turn left (West) |
| 51.7 | 3.0 | Intersection - U.S.20 and Hogsback Rd. - turn right (North) and proceed several hundred feet. |
| 51.8 | 0.1 | STOP SIX Elevation 1050': Peppermill Gulf, parallel to and just east of Hogsback Rd., 1.3 miles west of the junction of U.S.20 and N.Y.80 (South Onondaga Quad.). |
| | | Exposed Thickness:<br>Centerfield Member 30'<br>Butternut Member --<br>A waterfall just north of U.S.20 exposes approximately 30 feet of Centerfield. The Butternut - Centerfield contact is gradational - is therefore difficult to establish. The Centerfield is a coarse siltstone at this locality. Fossils are difficult to extract because of the lack of good bedding plane exposures. |
| | | Return to U.S.20 - turn left (West) |
| 64.8 | 13.0 | Village of Skaneateles |
| 68.8 | 4.0 | Entering City of Auburn - LUNCH STOP |
| 70.3 | 1.5 | Jct. U.S.20 and N.Y.34 and 38 - turn left (South) |
| 71.3 | 1.0 | N.Y.38 on left - proceed straight (South) on N.Y.34 |
| 75.8 | 4.5 | Settlement of Fleming Jct. N.Y.34 and N.Y.34B - turn right onto N.Y.34B |
| 86.8 | 11.0 | Settlement of Poplar Ridge - intersection of N.Y.34B and Poplar Ridge - Aurora Rd. - turn right (West) |
| 90.3 | 3.5 | Intersection of Poplar Ridge - Aurora Rd. and unnamed gravel road (Prospect Corners) - turn left (South) |
| 90.9 | 0.6 | Unnamed gravel road on right leading downhill to a bridge over Paines Creek - Walk down road to Paines Creek and then downstream to Moonshine Falls. |
| | | STOP SEVEN Elevation 475': Moonshine Falls on Paines Creek, 1 mile south of Aurora (Sheldrake Quad.). |

Exposed thickness:

Ledyard Member --
Centerfield Member 25'

Centerfield at this locality is abundantly fossiliferous with numerous species of brachiopods, pelecypods, corals, and bryozoaus. The Ledyard Member sharply overlies the Centerfield and carries a fauna of small, thin shelled pelecypods and brachiopods. The contact between these 2 units occurs just upstream from the waterfall.

Return to buses - proceed Southeast and east on unnamed road.

92.4 1.5 Intersection of unnamed road and Black Rock Road - turn right onto Black Rock Rd.

93.8 1.4 Settlement of Black Rock - turn right (West)

STOP EIGHT Elevation 720': Black Rock on Paines Creek (Sheldrake Quad.).

Exposed thickness:

| | | |
|---|---|---|
| Portland Point Member | Dense fossiliferous shale | 28" |
| | Blue-gray fossiliferous shale | 8" |
| | Basal crinoidal layer | 16-20" |

King Ferry Member 8'

The lip of the falls is 8 feet lower than the base of the crinoidal limestone, therefore the uppermost King Ferry is accessible here. The Portland Point is very fossiliferous containing numerous brachiopods, pelecypods, ostracodes, crinoids and trilobites.

Return to buses - proceed West

94.8 1.0 Intersection N.Y.90 - turn left (South)

98.8 4.0 Junction N.Y.90 and N.Y.34B - Settlement of King Ferry - turn right onto N.Y.34B

111.8 13.0 Portland Point Road - turn right

112.4 .6 Entrance to Portland Point Quarry on left

113.1 .7 STOP NINE Elevation 620': Portland Point Quarry on east lip of Cayuga Trough (Ludlowville Quad.).

Exposed thickness:

Geneseo Black Shale 15'
Tully Limestone 16'
Windom Member 5'

This locality is one of the most fossiliferous exposures along the Cayuga Lake meridian. Numerous corals, bryozoa, crinoids, brachiopods, pelecypods, trilobites, and gastropods are found in the upper 5 feet of the Windom. (see Guidebook - 31st Annual Meeting N.Y.S.GA) Ithaca, N.Y.)

At the south end of the quarry a thrust fault overthrust to the northwest occurs in the Tully Limestone and has drag folded the upper Windom at this locality.
On the east side of the quarry an alnoite dike about 1 foot thick occurs in one of the N-S joints.

| | | |
|---|---|---|
| 113.8 | .7 | Return to Portland Point Road - turn left |
| 114.6 | .8 | STOP TEN Elevation 460': Roadside quarry on Portland Point Road (Ludlowville Quad.).<br>Exposed thickness:<br>King Ferry Member --<br>The King Ferry Member exposed here is about 20 feet below the Portland Point Member. |
| 116.0 | 1.4 | Return to N.Y.34B - turn right (East) |
| 116.6 | .6 | Jct. N.Y.34 and 34B - proceed straight (East) on N.Y.34 |
| 117.4 | 0.8 | N.Y.34 turns left (North) - continues straight on Old State Road |
| 124.4 | 7.0 | Intersection Old State Rd. and N.Y.38 - continue east on Old State Rd. |
| 127.6 | 3.2 | Intersection - Dryden Rd. - turn left - enter McLean |
| 127.8 | 0.2 | Intersection - Dryden Rd. and Gulf Hill Rd. - continue straight (Northeast) on Cortland Rd. |
| 130.6 | 2.8 | Lime Hollow Road off to the right - turn left - continuing on Cortland Rd. |
| 133.0 | 2.4 | Intersection - Cortland Rd. and N.Y.281 - continue straight (East) on Cortland Rd. |
| 133.4 | 0.4 | Intersection - Cortland Rd. and N.Y.13 - turn left onto N.Y.13 |
| 134.2 | 0.8 | Cortland City limits |

# MINERAL INDUSTRIES IN PARTS OF ONONDAGA, CORTLAND AND TOMPKINS COUNTIES

By Newton E. Chute
Syracuse University

Central New York has had important production of industrial minerals and rocks for many years. In 1967 (Minerals Yearbook) the order of value of these products in Onondaga County was as follows:

1st Salt
2nd Lime
3rd Stone (also 3rd county in state)
4th Cement
5th Sand and gravel
6th Clays

Industrial minerals and rocks now being produced in the field trip area are described briefly. Those formerly produced are discussed in the following section.

## Salt

The first commercial salt production was in 1788 from springs and wells near the south end of Lake Onondaga. Production continued for over 135 years, but amounted to very little after 1923 because of reduction in the salt content of the brine (Newland, 1921, p. 222). No bedded salt is known in the area, and the brine is thought to have come from leaching of salt beds to the south.

At the present time salt is mined by the Cayuga Rock Salt Company at Myers on the east side of Cayuga Lake and is obtained from brine wells in Onondaga Creek valley near Tully by the Solvay Process Division of the Allied Chemical Corporation. The International Salt Company operated brine wells until 1962 about a mile north of the Cayuga Rock Salt Company's shaft. Danger of water entering the mine from the brining operations may have been a factor in the termination of production.

The Cayuga Rock Salt Company's mine is on the crest of the Firtree Point anticline (also called the Portland Point anticline). A folded and deformed bed of salt has been mined at a depth of about 1800 feet. Geological work by Dr. J. J. Prucha (1968) has demonstrated the presence of a decollement below which the salt beds are not appreciably deformed and mining conditions much better.

The Solvay Process Division of the Allied Chemical Corporation has produced salt brine from wells in Onondaga Creek Valley near Tully, about 17 miles south of Syracuse, since 1888. The brine is obtained from salt beds at depths of 1100 to 1400 feet below the surface and is piped to the company's plant at Solvay for use in the manufacture of soda ash products and chemicals.

According to Gordon French, Solvay Process Div. geologist, the Syracuse Formation is about 345 feet thick in the Tully area about half of which is salt in three or four beds. Gypsum, anhydrite, and shale are the chief impurities in the salt. No salt has been found in the Vernon shale below the Syracuse Formation.

The top contact of the Syracuse Formation is placed at a vuggy bed of dolomite not far above the highest salt bed. The Camillus Formation above the Syracuse Formation contains beds of gypsum but no salt beds, and gypsum beds are lacking in the Syracuse Formation.

How far the salt beds originally extended northward is not known. No bedded salt is known north of Route 20, but this may be largely a consequence of solution. Gordon French is of the opinion that the northern limit may have been near the present limits.

Formerly water was added to the wells to dissolve the salt. In recent years, however, enough ground water has been available to make addition of water unnecessary. As wells are depleted, new ones are drilled in the area, usually about four new wells are drilled each year.

The salt beds of the Syracuse Formation are of Upper Silurian age and occur in the Salina Basin throughout much of central and western New York. The large available reserves has made New York one of the leading salt producing states. In 1967 (Minerals Yearbook) the state ranked 4th in tonnage and 3rd in value of salt production in the United States.

## Limestone

Limestone is used in central New York for crushed stone, lime and cement manufacture, and building stone.

### Crushed Stone

Crushed stone quarries are located along the plateau front in Onondaga and adjacent counties in the Manlius and Onondaga Formations.

Stratigraphic Section to show the
formations quarried in the Syracuse area
(listed in order of age with the oldest at the bottom)

| Formation | Member |
|---|---|
| Onondaga Limestone (75-80') | Seneca Limestone |
| | Tioga bentonite (8") |
| | Moorehouse Limestone |
| | Nedrow argillaceous limestone |
| | Edgecliff Limestone (may be several feet of sandstone at base) |

| Formation | Member |
|---|---|
| Oriskany Sandstone (generally absent but usually in some sandstone in base of Onondaga Limestone) | |
| Manlius Limestone (60') | Pools Brook Limestone<br>Jamesville Limestone<br>Clark Reservation Limestone<br>Elmwood limestone and argillaceous dolomite<br>Olney Limestone<br>Thacher Limestone |
| Rondout argillaceous dolomite | |
| Cobleskill Dolomite | |

The Tioga bentonite, the sandstone if thick, the Elmwood argillaceous dolomite, and the Rondout dolomite are not satisfactory for concrete aggregate and are not quarried. Also an argillaceous dolomite bed in the lower part of the Thacher Limestone is not satisfactory and limits quarrying downward for good quality stone. These problems will be discussed further at the quarry stops.

The old quarry of the Pennsylvania-Dixie Cement Company in the Tully Limestone near Myers in Tompkins County has been worked by the Cayuga Crushed Stone Company since 1961 (Minerals Yearbook). This quarry illustrates the value of a good location for marketing stone. It is the farthest south of the limestone quarries in the central and western parts of the state and is able to reach the market in the southern tier counties and northern Pennsylvania to best advantage. As a result of this, the quarry operation is unusual in the thickness of glacial overburden and shale that it is economic to strip to quarry the limestone.

See the descriptions of the quarry stops for additional information concerning the quarries visited.

## Building Stone

Both the Manlius and Onondaga Limestone formations have been quarried for building stone in the Syracuse area. The Onondaga Limestone was used for the exteriors of a number of the older buildings, much of which was obtained from the large quarry just south of Syracuse on the Onondaga Indian Reservation. This quarry has been idle for many years. The Manlius Limestone has been used for foundations and walls and production still continues from this formation near Manlius. Present production is mainly for retaining walls, flagstone, and fireplaces, including some for house exteriors.

## Lime

Old lime kilns are all that remain of the former widespread lime production in the Syracuse area. Luther (1895, p. 271-273) described lime production in Onondaga County in the late 1800's. The Manlius and Onondaga Limestones were quarried in many places along the outcrop in the Syracuse area for lime manufacture, but by 1914 the output had nearly ceased (Hopkins 1914, p. 28-29). At the present time only the Solvay Process Division of Allied Chemical Corporation produces quick lime and mostly for its own use.

## Portland Cement

Both marl and limestone have been used for the manufacture of portland cement in Onondaga County. The plants that used marl are described separately below under the section on former mineral industries.

The Pennsylvania-Dixie Cement Company operated a cement plant near Myers in Tompkins County until 1948 using Tully limestone and Geneseo Shale for raw material. This plant is said to have been closed because of obsolescence. Some efforts have been made in recent years to revive production at this plant but without results.

The Alpha Portland Cement Company has operated a cement plant for many years at Jamesville just south of Syracuse. This plant was rebuilt and enlarged in 1952 to have a capacity of 900,000 bbls. per year. Limestone is obtained from the Solvay Process Division of the Allied Chemical Corporation, and shale is quarried at the company's own quarry 1 and 1/4 miles east of Jamesville. Most of the shale used is from the Cardiff Member of the Marcellus Formation, some has been obtained from the underlying Chittenango Member. Use of the Chittenango Shale is limited because the presence of considerable pyrite makes the shale too high in sulphur for some of the types of cement manufactured.

## Lightweight Aggregate

The Onondaga Lightweight Aggregate Corporation, formerly the Onondaga Brick Corporation, began operations in September 1954 at the Warners plant. According to W. D. Rogers, sales manager for the company, this is the oldest lightweight aggregate company in the State. Over a million tons of lightweight aggregate have been manufactured and sold during the past 15 years. The product has been used in concrete for many buildings in central New York and as far away as New York City and Buffalo.

Vernon Shale, obtained at the old quarry on the northwest side of Brickyard Road about 0.6 of a mile northeast of Warners, is used for the raw material. This is the same quarry previously worked by the Onondaga Brick Corporation for shale for brick manufacture. (See the quarry stop for description of the shale)

At the plant, which is located on the railroad about half a mile east of Warners, the shale is crushed, screened, and mixed with coal. It is then sintered on a 66-foot sintering machine at 2400 degrees F. for about 15 minutes. The coal burns out leaving the shale aggregate porous and partly vitrified. After sintering the chunks of material are crushed and screened to four sizes for marketing. Each size has particular uses such as for lightweight blocks, structural material, roof fill, concrete aggregate, bridge abutments, etc.

### Pottery

Flower pots and urns, some of which are enameled or glazed, have been manufactured by the Syracuse Pottery Company since about 1875. The first plant was on Division Street in Syracuse. In 1920 it was moved to the present site about 2 miles east of Warners to be near the clay pit. The present plant was built after a fire destroyed the previous plant in 1947.

The clay used is dug from the bottom of the valley just west of the plant. Some is obtained from a swamp area and some from higher ground adjacent. Although the clay of these two sources differs somewhat in physical and burning properties, they are parts of the same deposit and probably were the same originally. To obtain the best results the two types of clay are blended. The clay from the higher ground burns redder and has higher shrinkage than the clay from the swamp area. Leaching of some calcium carbonate from the clay under the higher ground probably is the main reason for the different firing behavior. That leaching has occurred is indicated by the presence of small irregular calcium carbonate nodules in the clay in places 2 or more feet below the surface.

The clay deposit is lens-shaped and occupies a depression in the bottom of the valley. Although the clay is not varved, it probably is of glacial origin.

Each year in June, after the water level has receded, the clay pit is pumped out and enough clay is dug in the course of a few days to meet the needs of the plant for a year. The clay is stockpiled and used as needed. About 8 feet of the clay is dug after stripping 6 to 10 inches of overburden. Although some clay occurs deeper, it is said to be too high in calcium carbonate to be satisfactory.

The clay is prepared for use by blending and mixing with pug mills and rolls. After the pots are shaped from soft clay on presses, they are fired in a tunnel kiln at about 1800 degrees Fahrenheit. A second firing is required for glazed pots.

## Sandstone

The Finger Lakes Stone Company operates dimension sandstone quarries in the Enfield Formation, on the south side of Cascadilla Creek Valley, about 2 and 1/2 miles east of Ithaca. The old quarry was first operated early in the 20th Century to obtain stone for construction of Cornell University buildings and is still owned by the University. The Finger Lakes Stone Company began operating the old quarry about 1955. The stone is marketed widely in the state and has been used in buildings and walls at Syracuse University, Cortland State College, and many other places.

The stone is quarried in large slabs without blasting. Wedges are used to separate the slabs along joints and bedding. Usually the slabs consist of one bed of sandstone 6 to 12 inches thick bounded above and below by layers of shale.

A considerable amount of the material quarried is waste. In places it is necessary to strip as much as 60 feet of overburden to obtain good stone. The company has acquired new property west of the old quarry where the amount of stripping is less.

The blocks of sandstone quarried are cut into the desired sizes and shapes in the mill using diamond and wire saws. Seam faced stone is bounded on at least one side by joint surfaces which give the stone a pleasing color and surface texture. Seam face production is obtained especially from parts of the quarry where vertical joints are numerous. Advantage also is taken of the interesting patterns produced on bedding surfaces by sole markings. Blocks with good markings are placed in structures so as to expose them to view.

## Sand and Gravel

Sand and gravel deposits of glacial origin are widespread and extensively worked in central New York. The quality of the sand and gravel is determined by the degree of weathering and the amounts of such unsound and deleterious materials as:

1) shale
2) clay in lumps or coatings on stones
3) other soft rock or rock such as siltstone that splits readily
4) calcium carbonate cement

The types of rock that compose the stones of gravel are dependent in a considerable measure upon the kind of bedrock in the area. Where shale is prevalent, it usually is common in the gravel. This is illustrated by the large glacial lake deltas in Onondaga Creek Valley southwest of Syracuse. The glacial meltwaters that deposited the gravel of these deltas flowed eastward along the edge of the plateau through shale areas and, as a result, the gravel is shaly.

The valley trains that occupy the bottoms of large north-south valleys south of the Valley Heads moraine constitute another large reserve of sand and gravel. The route of the field trip is over the valley train between Tully and Cortland where interesting features of these deposits are illustrated.

One of the surprising aspects of most of these valley train deposits is the high percentage of far-travelled stones such as crystalline rocks, limestone, and red Medina Sandstone. Although the valley trains are in valleys that have bedrock walls composed of shale, siltstone, and sandstone primarily, the amount of shale and poor stone in the gravel is surprisingly low. The meltwater from the melting ice transported the sand and gravel southward down the valleys frequently without a large admixing of local shale. As the gravel was transported by the streams, it was milled by the grinding action of the stones, and soft stones were progressively eliminated. Only the hard resistant stones have survived long transportation. This is well illustrated by the gravel along the Susquehanna River in the Binghamton area where sandstone, limestone, and gneiss from the northern part of the state are common.

In several of the large valleys, such as the Chemung River Valley, the terrace and kame gravels often are of poorer quality than the gravel in or near the bottoms of the valleys. If, however, the gravel deposit is so low that it is flooded periodically, the gravel may contain too much clay and silt to be usable.

Post-glacial alluvial fans formed by temporary streams in ravines on the sides of the large valleys also may interfere with working of gravel in the bottoms of the valleys. The larger fans can be recognized on topographic maps by their shapes. Usually they are composed of blocks of siltstone, shale, and dirt unsuitable for anything but fill. The larger fans may cover considerable good gravel on the valley bottom and also may contaminate good gravel nearby.

## Sand and Gravel of the Tioughnioga River Valley between Tully and Cortland

A large tonnage of sand and gravel underlies the Tioughnioga River Valley between Tully and Cortland. Zoning laws of the towns partly restrict commercial development of the gravel, and, therefore, information concerning the geology of the deposits is particularly important for locating the best available gravel.

Numerous gravel pits have been worked between Tully and Cortland, but most are small and were operated only temporarily. A number were worked during the period of construction of Route 81. At the present time two pits are operated about a mile north of Homer. A third active pit is located half a mile southeast of the city limits of Cortland. A fourth pit just south of Green Lake, near the moraine, is worked intermittently for bank-run gravel.

The limited subsurface information available indicates that the valley is underlain by about 200 to 250 feet of drift. Durham (1954, p. 31-32) mentioned a well at Little York Lake that reached bedrock at 220 feet, and a seismic survey at the south end of Tully Lake that located bedrock at a depth of about 225 feet. In the Cortland area bedrock may be somewhat deeper (Asselstine, 1946, p. 15).

Workable gravel is limited to the upper 30 to 50 feet of the valley fill. At the operating pits north of Homer, sand and gravel are dug to a depth of about 40 feet to the top of a thick deposit of silt and clay. About half a mile south of these pits, where Route 81 crosses Route 11, test holes drilled by the Bureau of Soil of Mechanics of the State Department of Public Works showed sand and gravel to a depth of 39 to 45 feet with chiefly sand in the bottom 8 to 18 feet. The sand and gravel deposit is underlain by silt with some clay to the bottom of the deepest hole at 91 and 1/2 feet. Logs of wells in the Cortland area show the presence of two gravel beds each about 50 feet thick separated by about 100 feet of sandy silt (Asselstine, 1946, p. 17). The thick deposit of silt appears to be widespread below the upper gravel and limits the depth to which the gravel can be worked. This deposit of silt probably is a lake deposit formed after the deposition of morainic material in the valley of Fall Creek and Otter Creek southwest of Cortland blocked the previous course of the Tioughnioga River (von Engeln, 1961, p. 43-44). The overflow from this lake very likely escaped to the southeast over a divide between two tributary valleys. (Fairchild, 1925, p. 85: Muller, 1966, p. 2-3). In time a combination of filling of the lake basin and erosion of the divide drained the lake and the sand and gravel outwash was deposited.

The Valley Heads moraine swings southward to the west of the Tioughnioga Valley and during its formation outwash was brought to the Tioughnioga Valley through several tributary valleys, particularly Otisco Valley, Skaneateles Lake Valley, and Fall Creek-Otter Creek Valley. Some probably was also contributed by the tributaries that enter from the east. Each successive tributary southward tended to contribute coarser gravel because of proximity to the ice margin, and, the grade size of the gravel in the main valley does not decrease uniformly southward from the moraine at Tully as might be expected. For example, gravel worked southeast of Cortland is coarser than the gravel worked north of Homer. This coarser gravel evidently came from the margin of the ice when it stood a short distance west of Cortland. Von Engeln (1921, p. 60) noted that the alluvial fans built into the Tioughnioga Valley by outwash from the tributary valleys appear to indicate that outwash continued to come through these valleys longer than from the Onondaga Valley near Tully. He also pointed out that the outwash fans built up at the mouths of the tributary valleys on the west side of the Tioughnioga Valley have forced the river over to the east side.

The water table is close to the surface under much of the Tioughnioga Valley between Tully and Cortland. At the gravel pits just north of Homer, the water level is only 2 to 3 feet below the surface. Nearly all of the gravel there is dug from below water, and it is of better quality because of little or no weathering. In places, especially in the northern part of the valley, the water table is 10 to 25 feet below the surface. Much of this gravel above water does not pass state tests for concrete aggregate.

A few kames along the sides of the valleys predate the valley train gravels. They contain a high percentage of local shale and siltstone and are the Olean type of gravel (Moss & Ritter, 1962, p. 90-105) of poor quality. A good example of this type of gravel can be seen in a gravel pit worked for fill in a kame on the northwest side of Route 13 about 1.3 miles northeast of Cortland. In locating a gravel pit in the area between Tully and Cortland, it is especially important to take into consideration the various geological factors that might have influenced the quality and grade size of the gravel.

## Industrial Minerals and Mineral Products Formerly Produced

Gypsum, bricks, natural cement, and marl for portalnd cement have been produced in important amounts in central New York. They are described briefly although only a few examples of these operations will be seen on the field trip because of insufficient time.

Some discontinued operations of mineral materials still produced are referred to above under the descriptions of the present-day operations.

### Gypsum

The first discovery of gypsum in New York was in the town of Camillus in 1792. (Newland, 1929, p. 7). Although thin beds of impure gypsum occur in the Syracuse and Camillus formations of the Salina Group, the production of gypsum in the Syracuse area was limited to a layer 25 to 65 feet thick constituting most of the Forge Hollow Formation of the Bertie Group. According to Newland, (1929, p. 81) the quarries near Jamesville, Lyndon, Fayetteville, and Manlius were the leading quarries in the state for the production of "landplaster." The largest production came from a group of quarries in the hills north of Woodchuck Hill Road southwest of Fayetteville. Most of the gypsum was used as a soil conditioner. As this use was discontinued and purer gypsum was required for wall board and other uses, the quarries ceased to be operated about 1914 (Newland, 1929, p. 82). The bedded gypsum still can be seen exposed in the larger quarries near Lyndon.

### Bricks

Although several brick plants have been operated in Onondaga County in the past, none remain in operation. The two largest producers were the Syracuse Brick Corporation and the Onondaga Brick Corporation. Both companies used Vernon shale for raw material.

The quarry of the Syracuse Brick Corporation was near Cicero, north of Syracuse, and the plant was in the north part of Syracuse. Production started in the 1850's and continued to 1959. The Onondaga Brick Corporation operated a plant and quarry at Warners a few miles northwest of Syracuse for many years. According to Luther (1895, p. 251), the company manufactured 10,000,000 building bricks annually in the late 1800's. Brick manufacture was terminated sometime prior to 1954 and in that year the plant was converted to the manufacture of lightweight aggregate. It is now operated by the Onondaga Lightweight Aggregate Corporation.

<u>Natural Cement</u>

Rock suitable for the manufacture of natural cement was first discovered in central New York in Madison County east of Syracuse about 1818 (Newland, 1921, p. 43). The cement rock was obtained from the Elmwood A and C beds of the Manlius formation (Hopkins, 1914, p. 28-29) which crops out in an east-west belt along the plateau front. The stratigraphic position of the Elmwood beds is as follows: (rock units listed in order of age from bottom up)

| | |
|---|---|
| Manlius Limestone Formation | Pools Brook Limestone Member |
| | Jamesville Limestone Member |
| | Clark Reservation Limestone Member |
| | Elmwood Member |
| | Elmwood C - argillaceous dolomite<br>3 to 4 feet thick |
| | Elmwood B - dolomitic limestone<br>4 feet thick |
| | Elmwood A - argillaceous dolomite<br>5 to 6 feet thick |
| | Olney Limestone Member |
| | Thacher Limestone Member |

The construction of the Erie Canal stimulated production and numerous small quarries were worked for the raw stone. Manufacture of natural cement was an important industry in central New York until about 1907 when curtailed by the growth of the Portland Cement industry. The natural cement industry in Onondaga County near the close of the last century is described by Luther (1895, p. 267-271).

### Portland Cement from Marl

According to Eckel (1901, p. 863-866), T. Millen and Sons commenced producing portland cement from marl at Warners in 1886. The plant was purchased in 1890 by the Empire Portland Cement Company and almost completely rebuilt to obtain larger production. It was rebuilt again in 1901 and rotary kilns installed.

Operation of the plant continued until about 1908. Remains of the plant can still be seen on the north side of the old canal a few hundred feet west of Newport Road at Warners.

The marl was dug with a clam-shell bucket on a revolving derrick and was transported to the plant on a small railroad owned by the company. Plate 87 in Eckel's report is a picture of the pit operations. The process of cement manufacture also was described by Eckel (1901, p. 865-866) and illustrated by a picture of the plant (plate 88).

The marl bed covered several hundred acres about one hundred of which had been excavated by 1900. A section of the deposit where the clay and marl were dug, as given by Eckel (1901, p. 864), is as follows:

| | |
|---|---|
| Muck | 1'2" |
| Upper bed white marl | 4'7" |
| Lower bed gray to brown marl | 4'7" |
| Sand | 0'1" |
| Bluish clay | 2'5" |

The average charge to the kiln was 25 per cent clay and 75 per cent marl. The marl ran 91 to 95 per cent $CaCO_3$.

Another cement plant using marl was built in 1892 by the American Cement Company on the north side of the old Erie Canal about 5 and 1/2 miles west of Warners. This plant operated until 1900 when it was closed (Eckel, 1901, p. 861). The bed of marl worked is reported to be from 8 to 15 feet thick and to be underlain by blue clay which was dug for mixing with the marl.

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# TRIPS E AND I: MINERAL INDUSTRIES IN PARTS OF ONONDAGA, CORTLAND AND TOMPKINS COUNTIES

Newton E. Chute

STOP 1. - Finger Lakes Stone Company's sandstone quarry located on Quarry Road a short distance south of its intersection with Ellis Hollow Road, about 2 and 1/2 miles east of Ithaca.

The quarry is in the upper part of the Enfield Formation which is about 650 feet thick in the Ithaca area. Layers of sandstone alternate with layers of shale in the quarry. Slabs of sandstone are obtained without blasting by drilling holes on seams and separating them with wedges. The slabs are cut to the required sizes in the mill by diamond and wire saws. Pieces with good joint surfaces are used for seam face stone. Those with sole markings on bedding surfaces are used for special surface effects. The stone is laid in various patterns with different finishes, as illustrated by the exterior of the company's office at the quarry.

STOP 2. - Quarry of the Cayuga Crushed Stone Company on the east side of Cayuga Lake near South Lansing, about 5 miles north of Ithaca.

This is the old quarry in the Tully Limestone and the Geneseo Shale that was worked by the Penn.-Dixie Cement Company until 1948. The quarry is on the crest of the Portland Point anticline above the Cayuga Rock Salt Company's mine. The Cayuga Crushed Stone Company reopened the quarry and has worked it for a number of years.

The Tully Limestone, which is 16 to 18 feet thick at the quarry, is underlain by fossiliferous Moscow Shale of Middle Devonian age and is overlain by unfossiliferous Geneseo Shale of Upper Devonian age.

Two peridotite dikes have been known in this quarry for many years. They are marked on a map in the guidebook for the 31st annual meeting of the N.Y.S.G.A. sponsored by Cornell University in 1959. One is shown to extend for about 1700 feet across the southeastern part of the quarry.

A dike, 1'5" thick, is presently exposed in the southern part of the quarry face and for about 100 feet on the quarry floor. It diminishes in thickness to about 6 inches near the south end of the exposure. The dike is vertical and strikes N 5 to 10 degrees W parallel to a prominent set of joints about at right angles to the axis of the Portland Point anticline.

The first description of a periodite dike in this quarry was by Sheldon in 1921. Other descriptions are by Martens (1924) and Broughton (1950).

A cluster of six or seven dikes each 6" to 8" thick was observed recently in the middle part of the quarry face by J. J. Prucha. He also knows of at least eight peridotite dikes in the salt mine below the quarry (personal communication, April 1970). Martens (1924) described this dike rock as kimberlite or alnoite depending upon the presence of melilite, an essential constituent of alnoite. Broughton (1950) did not observe any melilite in the thin sections he examined and called the rock kimberlite.

Of particular interest at this quarry is the unusual thickness of glacial overburden and shale that it is economical to strip to quarry the limestone. At the south end of the quarry in particular, the depth of the stripping is several times greater than the thickness of the limestone quarried. The favorable location of the quarry for marketing stone in the southern part of the state is an important factor in making the unusual depth of stripping possible. Small quarries have been worked in the Tully Limestone in various places in central New York in the past, but this is the only one worked in recent years.

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STOP 3. - The Cayuga Rock Salt Company's mine shaft and the former plant of the Penn.-Dixie Portland Cement Company.

A brief stop will be made to observe the headframe of the Cayuga Rock Salt Company's mine and the remains of the old cement plant on the lake shore.

Return to Cortland and take Route 81 north to Tully. Turn off onto Route 80 and proceed to the brine well field in the bottom of the Onondaga Valley near Tully.

STOP 4. - Brine well field of the Solvay Process Division of the Allied Chemical Corporation.

Brine is obtained from wells about 1100 to 1200 feet deep that penetrate salt beds in the Syracuse Formation of the Saline Group. The brine is piped to the company's plant at Solvay for the manufacture of soda ash and chemicals.

A tour of the brine field will be conducted by Mr. Michael Slexak who is a geological engineer with the Solvay Process Division.

STOP 5. - Lunch stop at Clark Reservation State Park south of Syracuse.

The remarkable abandoned waterfall and plunge basin in this park were formed by a temporary river that drained a glacial lake in Onondaga Creek Valley when glacial ice blocked the drainage to the north.

The lip of the falls is on the Edgecliff Member of the Onondaga Limestone. The Nedrow and Moorehouse Members are exposed nearby at higher elevations on the north and south sides of the plunge basin.

This is the type locality for the Clark Reservation and Jamesville Members of the Manlius Formation. These and other members of the Manlius, except the Thacher which is covered, are exposed along the stairway on the south side of the plunge basin. The section here is as follows:

Onondaga Limestone

| | |
|---|---|
| 17 to 18' | Edgecliff Member, 2' of sandy limestone and calcareous sandstone at base. |

--------------Disconformity--------------

Manlius Limestone

| | |
|---|---|
| 5'9" | Pools Brook Member, dolomitic limestone |
| 19' | Jamesville Limestone, numerous stromatoporoids in upper 8 feet. |
| 3'3" | Clark Reservation oolitic limestone |
| 9'10" | Elmwood dolomite and dolomitic limestone member |
| | 2'7" Elmwood C argillaceous dolomite submember |
| | 2'9" Elmwood B dolomitic limestone submember |
| | 4'6" Elmwood A argillaceous dolomite submember |
| 22' | Olney Limestone to bottom of exposure. |

STOP 6. - Limestone quarry of the Solvay Process Division of the Allied Chemical Corporation, located on the north side of the Seneca Turnpike just east of Jamesville.

This is one of the largest limestone quarries in the state and provides a good illustration of selective quarrying. The rock units quarried are as follows:

Onondaga Limestone Formation

- Moorehouse Member
- Nedrow Member
- Edgecliff Member with several feet of sandstone at the bottom

Manlius Limestone Formation

- Pools Brook Member
- Jamesville Member
- Clark Reservation Member

the quarry floor is at the top of the Elmwood Member below the Clark Reservation Member

The Clark Reservation, Jamesville, Pools Brook, and the noncherty part of the Edgecliff member have the highest purity, and they are quarried for use by the Solvay Process Division for kiln stone and for cement manufacture by the Alpha Portland Cement Co. The Onondaga Limestone above the Edgecliff Member is quarried for crushed stone. The sandstone at the base of the Edgecliff Member and the cherty part of the Edgecliff are stripped separately and wasted.

The Tioga Metabentonite, which is about 8" thick, overlies the Moorehouse Member and separates it from the Seneca Member above. The metabentonite is unsatisfactory in crushed stone and is stripped along with some of the Seneca Member where they occur at the south edge of the quarry.

Two reverse faults that strike about N 70 degrees W and dip southward offset the beds in the quarry a few tens of feet. Fluorite and calcite crystals have been found in fractures along the fault zones.

Additional points of interest to be seen on this quarry property are an old lime kiln, an old quarry worked for Elmwood argillaceous dolomite used for natural cement manufacture, and part of an old gypsum quarry in the Forge Hollow Formation of the Bertie Group.

STOP 7. - Split Rock quarry located at the west end of Split Rock Gulf Road about 0.7 mile southwest of the junction of Route 173 and Onondaga Blvd.

This quarry illustrates the influence of the unconformity at the base of the Onondaga Limestone on the amount of limestone available for quarrying. Here the Edgecliff Member of the Onondaga overlies Elmwood A unit of the Elmwood Member. The Clark Reservation, Jamesville and Pools Brook limestones, seen at the Solvay Process Division's quarry, were eroded prior to the deposition of the Onondaga Limestone.

Most of the floor of the bottom part of the quarry is on the top of the Rondout dolomite, about 33 feet of Olney and Thacher Limestone overlie the Rondout. Two or three stromatolite zones and a dolomite bed are present in the lower part of the Thacher. The upper part of the Thacher and the Olney are mainly the "drab and blue" type of alternating thin beds of dolomitic brownish weathering and purer gray weathering limestone. The Edgecliff Limestone at the top of the south side of the quarry contains some small coral reefs a few feet to a few tens of feet in diameter.

STOP 8. - Syracuse Pottery Company plant and clay pit. The plant is on the west side of Pottery Road about 0.9 mile north of its junction with Route 173 and 2.2 miles east of Warners.

This company, which manufactures mainly flower pots and urns from glacial clay dug a short distance west of the plant, has been operating nearly continuously since about 1875. The clay is dug to a depth of 8 feet after stripping 6 to 10 inches of topsoil. The part of the clay bed under a swamp has different firing characteristics from the part on higher ground. The part under the higher ground has been partly leached of calcium carbonate and this apparently causes the clay to burn redder and to shrink more than the clay from below the swampy area. These two types of clay are blended to obtain the desired firing characteristics.

After the flower pots are molded by presses, they are fired in a tunnel kiln at a temperature of 1800 degrees F. Some of the pots are glazed and some are coated with colored enamel.

STOP 9. - The old portland cement plant of the Empire Cement Company and the marl pits. Ruins of the old cement plant can be seen on the north side of the old Erie canal a few hundred feet west of Newport Road at Warners. The water-filled marl pits are west of the plant between the canal and Canal Road.

This cement plant is historically significant because it was one of the early portland cement plants and because marl was used as a source of calcium carbonate. The plant was first built in 1886, and operated until about 1908. Depletion of the supply of marl suitable for cement manufacture may have been a factor in the plant closing. Two other cement plants that used marl were operated for a short time in this region. One was the American Cement Company's plant about 5 and 1/2 miles west of Warners and the other was at Montezuma north of Cayuga Lake.

STOP 10. - Plant of the Onondaga Lightweight Aggregate Corporation located about 0.6 mile east of Warners on the north side of the railroad.

Lightweight aggregate has been produced here since 1954. Some years previously the plant was used by the Onondaga Brick Corporation for the manufacture of building brick. The raw material is Vernon Shale obtained from an old quarry about half a mile north of the plant (Stop 11). After crushing the shale is sized, mixed with coal, and sintered on a sintering machine at 2400 degrees F. The sintered chunks are crushed and screened to four sizes for marketing. This plant is said to be one of the first lightweight aggregate plants in New York State. The product is marketed widely, especially in the central part of the state.

STOP 11. - Vernon Shale quarry of the Onondaga Lightweight Aggregate Corporation located in the hillside on the north side of Brickyard Road about half a mile northeast of Canton Street in Warners.

The quarry, which probably is in the upper part of the Vernon, exposes 25 to 30 feet of red and greenish gray shale. Gypsum nodules are present in the shale in places and also some small shiny black crystals of specular hematite. Usually the hematite crystals are associated with cavities that probably contained gypsum or salt. Some of the cavities are molds of salt hopper crystals. In places the red shale contains very irregular patches of the green shale suggesting partial decolorization of the red shale.

This quarry is one of the few places in central New York where more than a few feet of the Vernon are well exposed for examination.

STOP 12. - Gravel pit on the south side of Lake Road, opposite the south end of Green Lake, about a mile west of Tully.

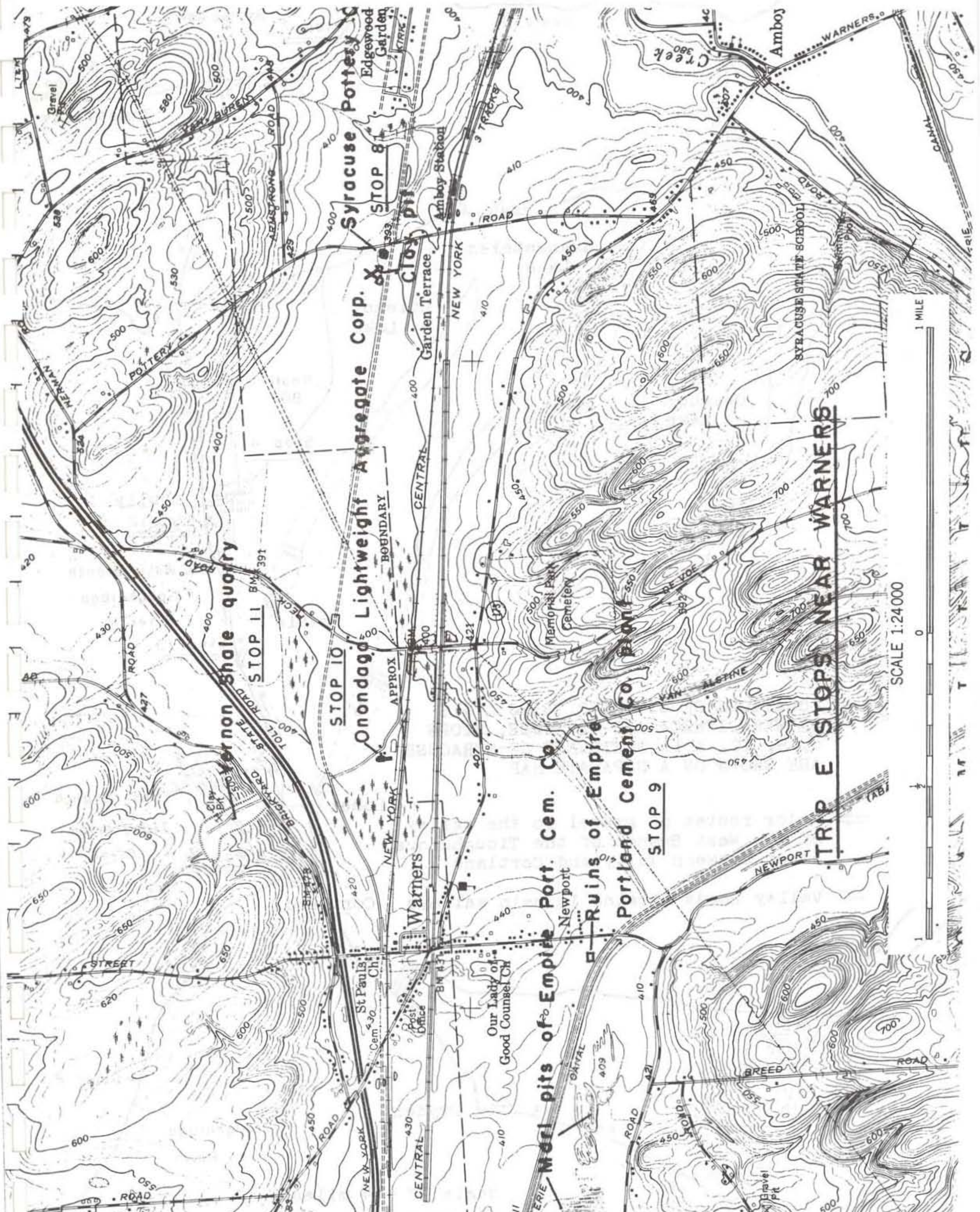
The pit is close to the Valley Heads moraine near Tully and has some interesting features. The gravel in the pit appears to have come from two different sources, probably because of diversion around the ice block that stood in the position of Green Lake. The gravel in the western half of the pit came from the northwest and is much lower in shale than the gravel in the eastern half which cross bedding and imbriccate structure show came from the northeast. Shale is abundant in a layer 2 to 4 feet thick near the middle of the face on the east side.

STOP 13. - Stop on Route 281 at Preble to view the alluvial fan built in the main valley at the mouth of Otisco Valley.

STOP 14. - Gravel pit operated by the Cortland Ready Mix Company. This pit is on the west side of Route 11 about a mile north of the Homer city line. Entrance to the pit is opposite the end of Health Camp Road.

This pit, and the pit of the Concrete Materials Corporation nearby on the east side of Route 11, illustrate the kind of gravel available in this part of the valley of the West Branch of the Tioughnioga River. Gravel and sand are dug to a depth of about 40 feet below which is a thick deposit of silt and clay. Most of the gravel is dug from below water and is not weathered.

STOP 15. - Gravel pit in a kame on the northwest side of the valley of the east branch of the Tioughnioga River, about a mile northeast of Route 81. This pit provides a good illustration of the Olean type of gravel which is characterized by much local shale and siltstone. This type of gravel is of very poor quality and is usable mainly for fill. Varved clay exposed on the side of the kame may indicate the presence of a lake in the valley after the kames formed.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STOP 10
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STOP 11
Marl pits of Empire Port Cem. Co.
Ruins of Empire Portland Cement Co. Plant
STOP 9
Warners
Amboy
Amboy Station
Garden Terrace
Edgewood Garden
Newport
St Pauls Ch.
Post Office
Our Lady of Good Counsel Ch
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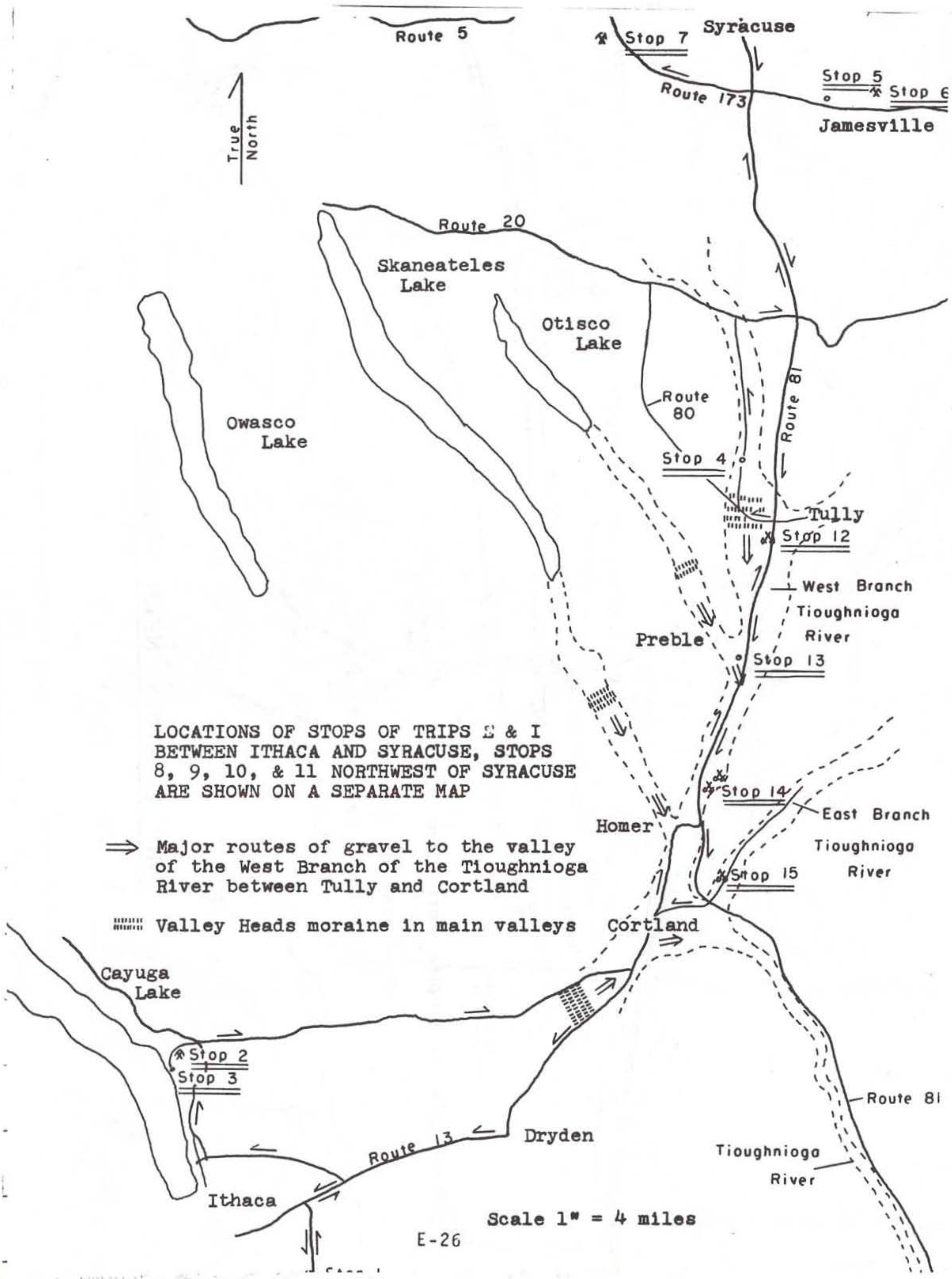
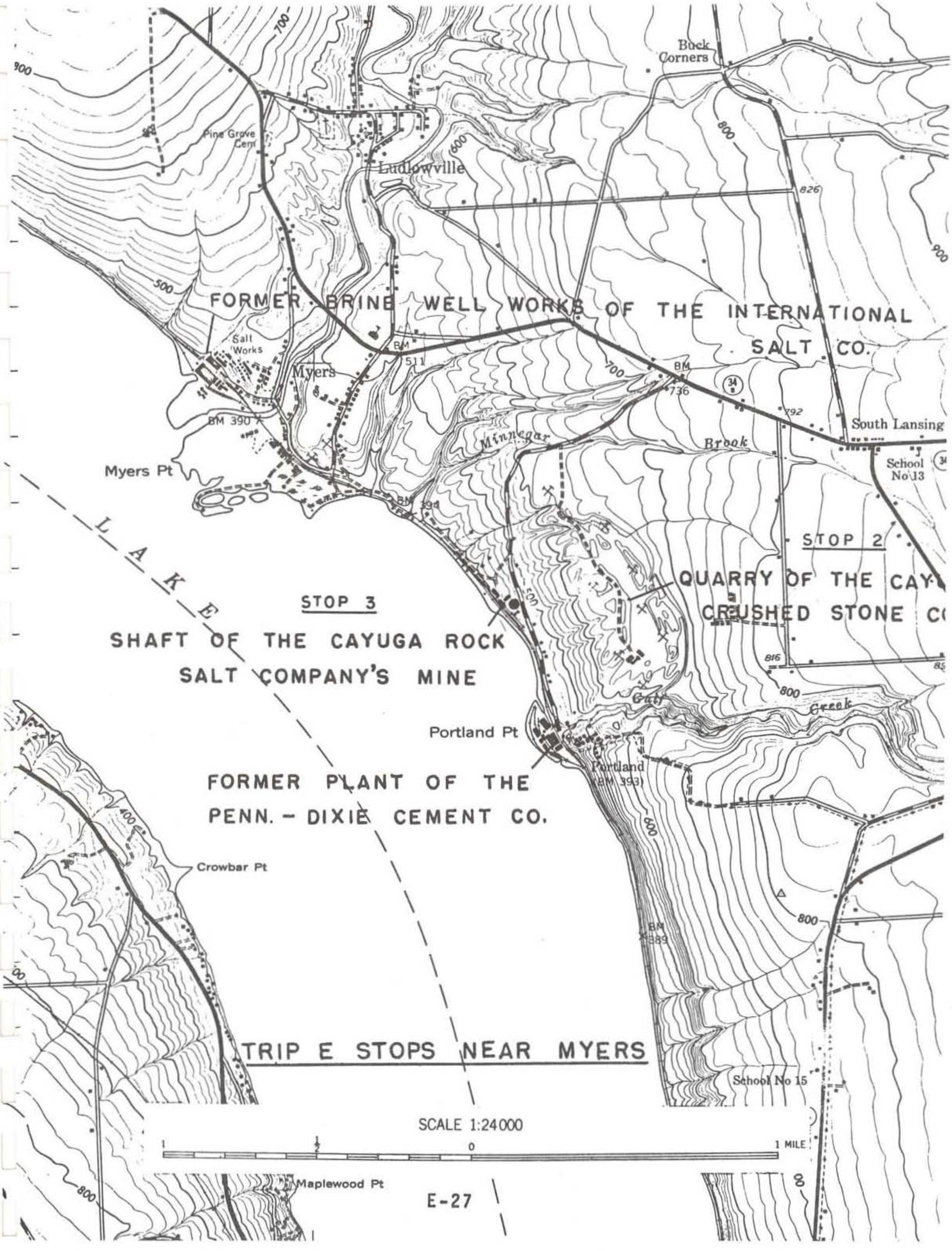


LOCATIONS OF STOPS OF TRIPS E & I BETWEEN ITHACA AND SYRACUSE, STOPS 8, 9, 10, & 11 NORTHWEST OF SYRACUSE ARE SHOWN ON A SEPARATE MAP

⇒ Major routes of gravel to the valley of the West Branch of the Tioughnioga River between Tully and Cortland

▥ Valley Heads moraine in main valleys



TRIP E STOPS NEAR MYERS

# DEGLACIATION OF THE EASTERN FINGER LAKES REGION

by James Kirkland
State University of New York at Binghamton

## Acknowledgments

The writer is indebted to Dr. James Bugh at the State University of New York College at Cortland and Dr. Donald Coates at the State University of New York at Binghamton for their encouragement and criticism.

## Regional Setting

The field trip area is located in central New York State and comprises parts of the Tully, Otisco Valley, Truxton, Homer, Sempronius, and Cortland 7½ minute U.S.G.S. topographic quadrangles. This region consists predominately of gently southward dipping Devonian shales with an east-west system of broad anticlines and synclines (Tarr, 1909).

There is wide disagreement in the literature concerning residuals from preglacial erosion.

Durham (1954) described three erosion surfaces in the surrounding region, the highest or Schooley Peneplain at 1600 to 1999 feet, the next between 1500 and 1700 feet, and the lowest between 1100 and 1300 feet. He further considers only the Schooley Peneplain to be a true peneplain and the others to be the result of structural control by resistant strata.

Denny (1956) concluded that remnants of former peneplanation have been reduced.

Muller (1965) stated that summit accordance is valid only if summit reduction by glaciation is light and that "... summit contours generalized to a six mile grid give an impression of imperfect summit accordance." (1966)

Clayton (1965) stated: "... the whole of the relief near the Finger Lakes is the work of ice, and is quite independent of the form of the preglacial landscape. The destruction of that earlier landscape is almost complete, ..."

The present form of the topography is probably the result of multiple cycles of glaciations and interglacials (Coates, 1966) with erosion by late Wisconsinan glaciation contributing little to the present bedrock form of the topography.

## Through Valleys

The first reference to through valleys was by William Morris Davis as reported by Tarr (1905): "One of the most striking features in the topography of the divide region between the Saint Lawrence and Susquehanna drainage is the marked absence of well defined divides between the larger streams which head in this region. Along a number of valleys it is possible to pass from one drainage system to the other through open valley in which the present divides are determined not by rock but by drift deposits. A similar condition is found between the headwaters of the larger tributaries on each side of the main divide; and even in the case of the smaller tributaries there is frequently a condition of lowered divides. ... Professor Davis applied the very descriptive name of "through valleys" to this condition of valleys connected across lowered divides."

The through valleys, such as the Tully Valley, were probably formed along north-south lines of preglacial drainage. Coates (1966) suggests a multicyclic theory for the origin of the through valleys: These "... drainage anomalies represent the combination of a long period of preglacial erosion followed by a series of unusual glacial, interglacial, and proglacial stream diversion channels that were repeatedly exploited by later ice movements." It was this exploitation of channels by the ice that scoured out the through valleys and created their characteristic U-shaped channels.

The Tully Valley extends south from Onondaga Reservation and is joined by Otisco Valley just south of Preble. The valley ends south of Cortland in an outwash plain. Von Engeln (1921) attributed 600 feet of erosion in the Tully Valley to glaciation and suggests an additional 100 feet now filled by drift.

A profile (Fig. 2) from seismic data of Durham (1954) and Faltyn (1957) indicates approximately 200 feet of fill south of the Tully Moraine, 800 feet at the moraine and about 600 feet to the north.

## Wisconsinan Glaciation
### Olean-Binghamton

The substages of Wisconsinan glaciation in the central New York region have been the subject of much controversy. MacClintock and Apfel (1944) subdivided till sheets south of the Finger Lakes region into Olean and Binghamton Substages on the basis of lithology. They concluded that the earlier Olean ice moved southwest whereas the Binghamton ice moved south.

Moss and Ritter (1962) divided the drift of central New York into the Olean Substage and the Valley Heads Substage on the basis of constructional topography, heavy minerals, pebble lithology, texture, and till pebble orientation. They recognized in the Olean till areas, drift resembling the exotic rich Binghamton drift of MacClintock and Apfel (1944) and termed it as "Binghamton type drift". They found no evidence to support the claim of a separate advance during "Binghamton time" in central New York.

Muller (1965) accounts the difference between the lime-deficient upland or Olean till and the exotic-rich lowland or Binghamton-type till in the following manner: "... regional dip is gently southward, outcrop belts swing abruptly toward the plateau where they cross major through valleys. The result is significantly shorter transport for exotic constituents derived from through-valley exposures than for those from exposures at the north margin of adjacent upland. Channeling of basal ice-flow by underlying topography presumably served to intensify southward transport in through valleys, whereas ice overriding the uplands was both relieved of exotic load by shearing over stagnant basal ice and given fresh debris derived from scour of exposed upland surfaces."

## Valley Heads

The term Valley Heads was first used by Fairchild (1932) to describe thick plugs of drift in the southern end of the Finger Lake valleys. The moraine occurs in all major valleys but is sporadic and in many areas untraceable on the uplands.

According to Holmes (1952) the Valley Heads (Ontarian) glacier formed in the deepest part of the Ontario Basin whereas Connally (1960) places the source of the ice in the Grenville meta-sediments northeast of Lake Ontario. The glacier spread outward from the northwest (Fig. 5). Radiocarbon dates (Muller, 1965) indicate that Valley Heads recession occurred more than 12,000 years B.P.

The terminus of Valley Heads glaciation in the Tully Valley is located just south of Song Lake (Fig. 1) in what Muller (1966) referred to as an advance Valley Heads position. Subsequent heavy mineral studies by Kirkland (1968) confirm this location. This advancal position represents a minor oscillation of Valley Heads ice with the major location of the active ice front at the Tully Moraine. Equivalents of the Tully Valley advancal position, although not as pronounced, are present in other through valleys.

The occurrence of stagnant ice features such as the Tully kettle lakes indicates a short length of time for outwash deposition south of the Tully Moraine, because during a longer period the ice would have melted and the subsequent kettles would have been filled by the outwash.

Valley Heads ice did not cover the hills northwest of the Tully Moraine as indicated by north-south striae on Vesper Hill (Kirkland, 1968) and north-south till fabric (Holmes, 1939) on the north side of Rattlesnake Gulf.

The Valley Heads advancal phase represents a shift in the center of the outflow, with a short-lived stand at the location of the Tully Moraine during late Wisconsinan time rather than a separate retreat and advance of Wisconsinan ice.

The following sequence is proposed for the late Wisconsinan glacial history for Central New York:

1. End of outflow from Hudson Valley which fanned outward across New York State (Fig. 3). Generalized directions on the map are from 399 striae locations.* It is this phase that was responsible for deposition of the "Olean type" drift.

2. Shift of outflow to a southward direction (Fig. 4) with most activity in the valleys thus bringing the exotic rich Binghamton-type drift into the valleys. This stand was of short duration and resulted in stagnant ice in the Tully Valley at Little York Lake and to a lesser degree farther south towards Cortland. The final activity of this Binghamton phase occurred at the Tully Moraine with outwash being deposited over the stagnant ice in the valley creating the Little York Lakes and numerous smaller kettles to the south towards Cortland.

3. Final shift of ice flow to the southeast (Fig. 5) with the major stand at the Tully Moraine but with a minor readvance to the advancal position just south of Song Lake. Subsequent outwash deposition over ice left at the advancal position created the Tully Kettle Lakes and further covered remnant stagnant ice to the south.

4. Recession from the Tully Region and discontinuation of melt-water drainage from the region.

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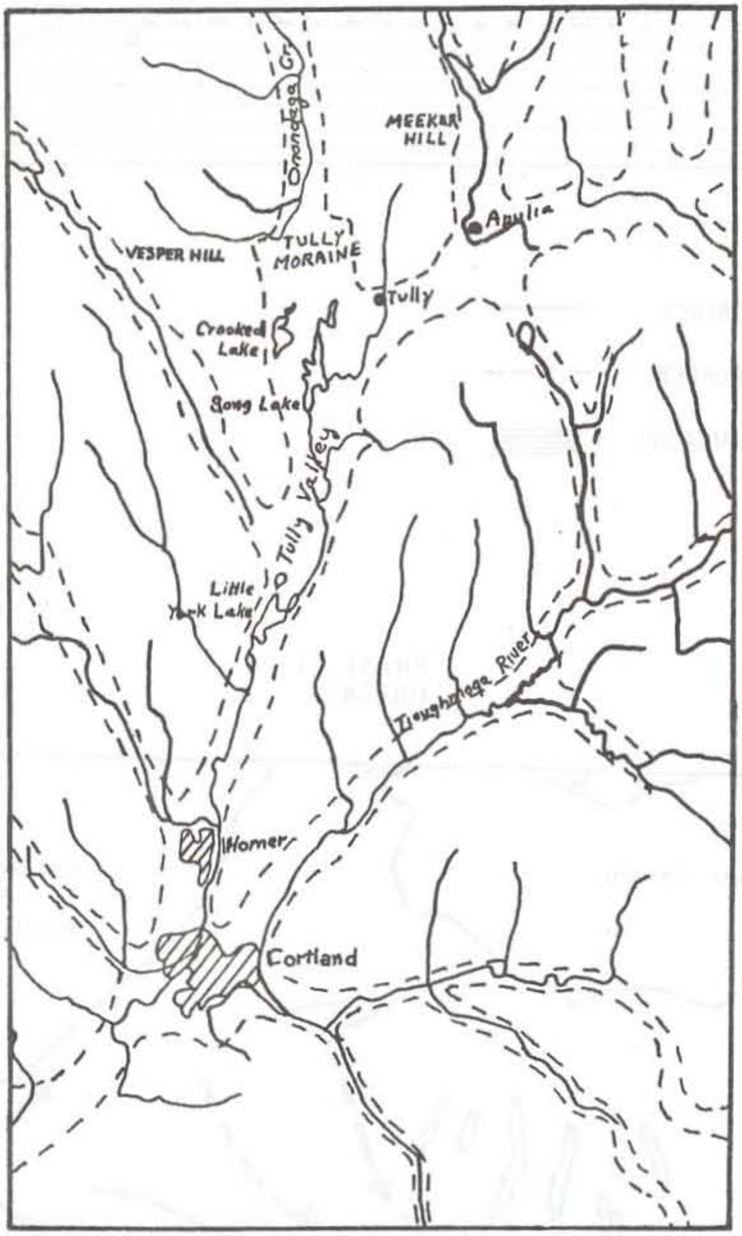
*The computergraphic routine of the Harvard Laboratory of Computer Graphics was used for analysis of the striation data.

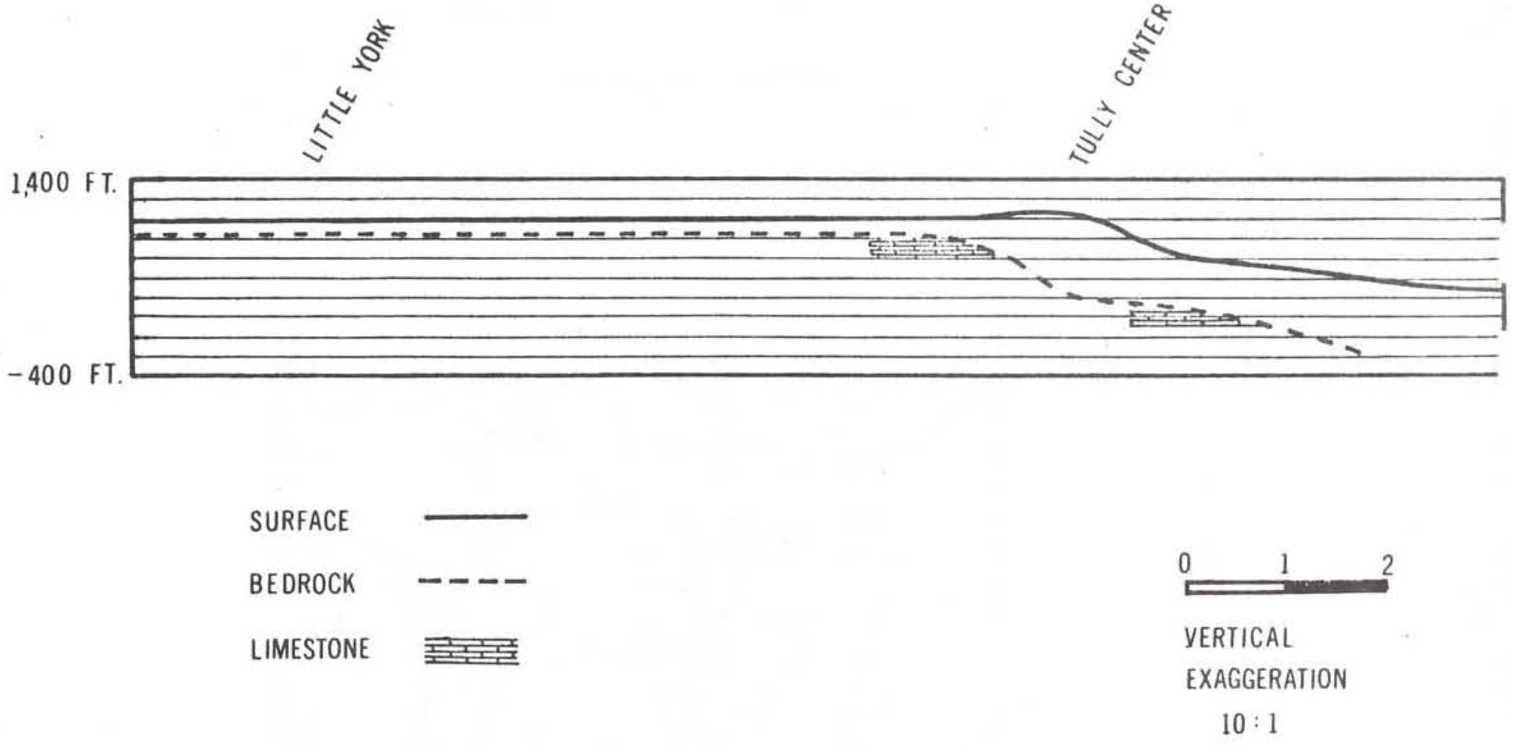
FIG. 1

MAP OF THE FIELD TRIP REGION

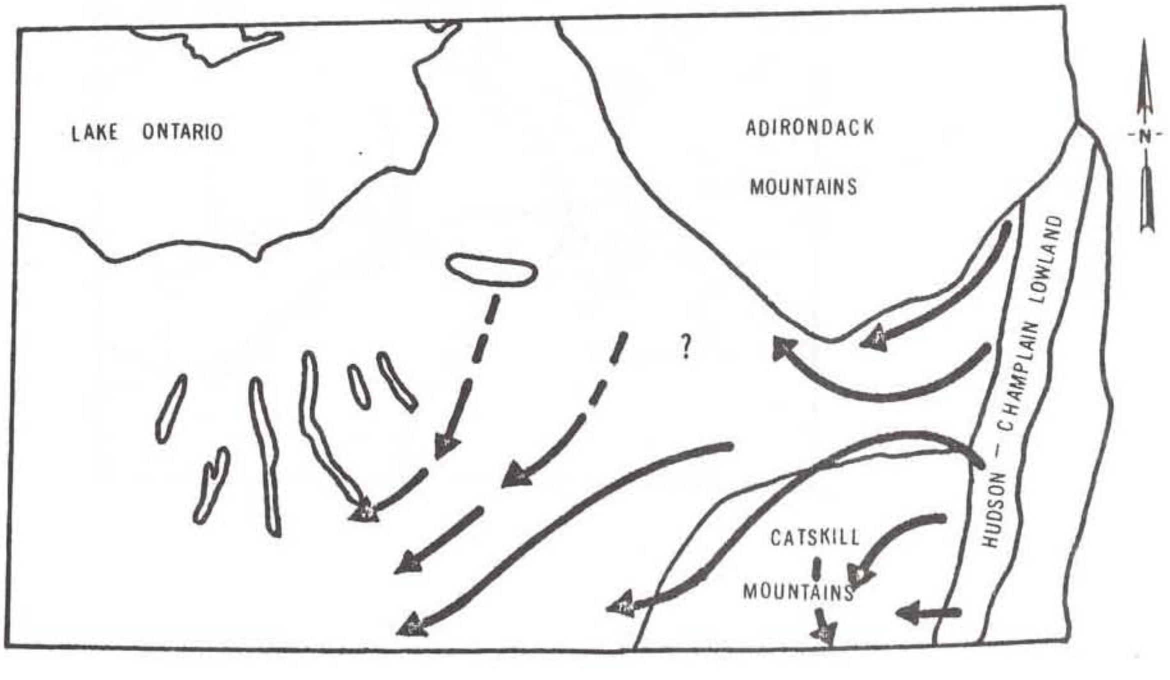
SHOWING THROUGH VALLEYS



PROFILE OF THE TULLY VALLEY (FIG. 2)

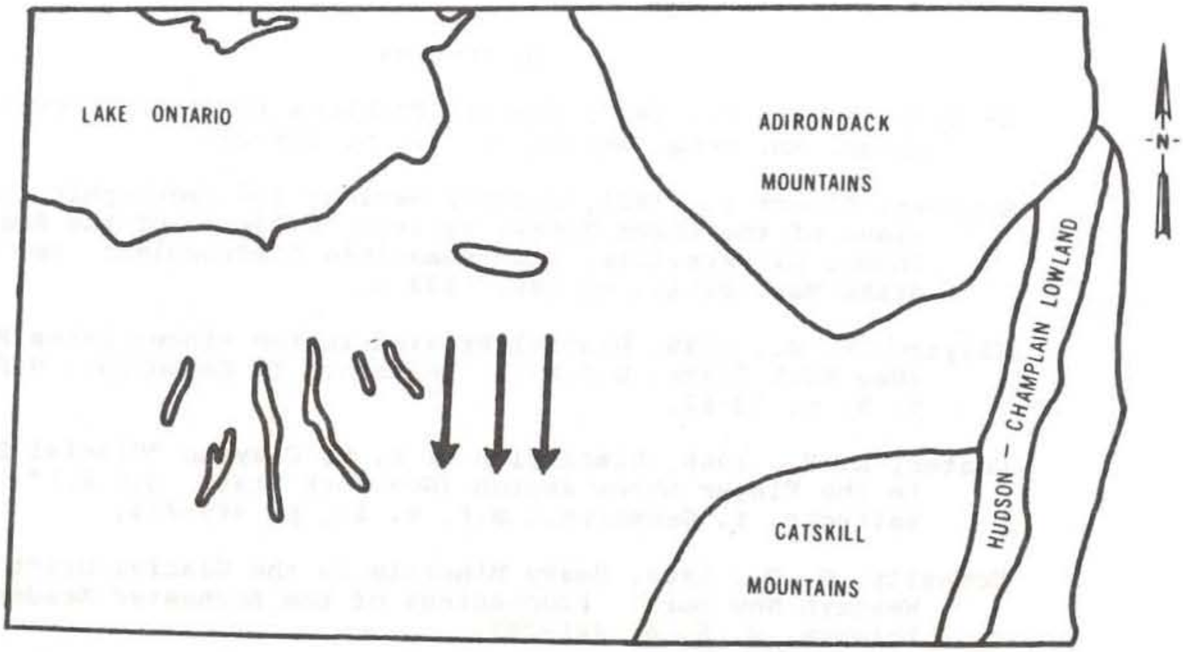


PHASE 1 (OLEAN) (FIG. 3)



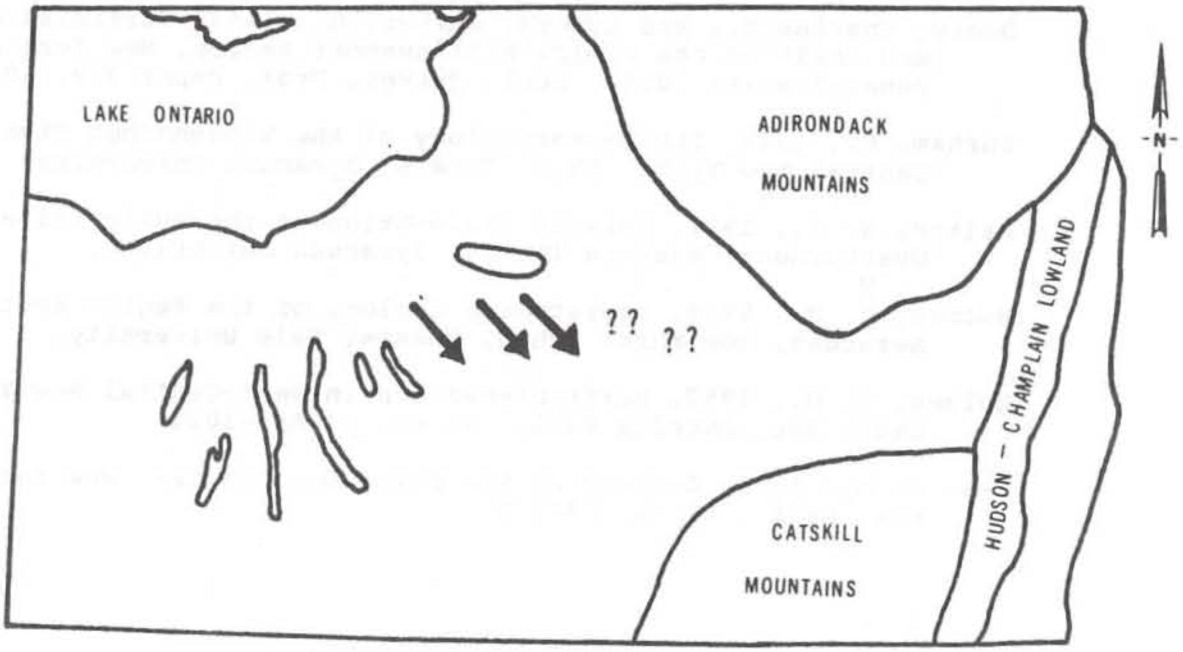
### PHASE 2
### (BINGHAMTON)

(FIG. 4)



### PHASE 3
### (VALLEY HEADS)

(FIG. 5)



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## TRIP F: DEGLACIATION OF THE EASTERN FINGER LAKES REGION

James Bugh, James Kirkland and George Kelley

| Total Miles | Miles from last point | Route description |
|---|---|---|
| 0.0 | 0.0 | Leave the Holiday Inn and proceed west on Route 13 through Cortland. |
| 1.6 | 1.6 | The campus of the State University College at Cortland is situated on a bedrock hill or umlaufberg which rises 110 feet above the surrounding outwash plain. The knob represents an extension of the ridge extending northeast from Cortland. Muller (1966) attributes the formation of the knob to ..."Concentrated glacial scour at the south end of the Tully-Cortland trough effected the reducing and isolating of the knob. Aggrading valley fill completed separation of knob from upland."<br>Query: How many cycles does the formation of the knob represent and what effect have fluvial processes had in its formation?<br>The valley fill underlying Route 13 is composed of two gravel units, each approximately 50 feet thick, separated by 100 feet of sand and silt. The intermediate unit presumably represents conditions of low gradient and restricted drainage south across the Tioughnioga col. The upper gravel relates to deposition of coarse outwash aggrading east-north eastward from the Valley Heads moraine just west of South Cortland. |
| 3.1 | 1.5 | Proceed past Munsons Corners crossing South Cortland outwash plain, rising southwest at about 20 feet/mile. Several streamlets from the till slope to south disappear into this permeable coarse gravel plain. |
| 4.7 | 1.6 | STOP ONE. SOUTH CORTLAND KAMES.<br>Active borrow pits in kame complex on south flank of valley expose structure of ice disintegration deposits comprising a linear ridge which is relatively smooth on the distal slope but with massive kame-like aspect to the northwest. Lateral variability of sorting and coarseness is characteristic. The gravels are characterized by crystalline-carbonate-clastic relationship of about 5:15:80 which is representative |

TRIP F (Continued)

| Total miles | Miles from last point | Route description |
|---|---|---|
| | | of through valley drift in this area. The kame complex contains sections of highly cemented gravels. What does this indicate about carbonate leaching and ground water conditions? |
| 5.2 | 0.5 | Turn right (N) on Webb Road toward Fish Hatchery. Descend sharply on ice contact face of kame terrace, into complex of ice disintegration deposits marking stagnant toe of north-eastward trending Valley Heads ice tongue. |
| | | Continue north through Gracie across ice disintegration complex. |
| 6.2 | 1.0 | Turn right (E) on Lime Hollow Road. In 0.6 mile cross abandoned meltwater channel cut by stream flowing from melting ice blocks responsible for the Fish Hatchery kettles. Return to kame terrace. |
| 8.2 | 1.6 | Turn left (N) onto Route 13. At "Y-intersection", in 0.2 mile, bear left on Route 281. Cross Otter Creek. Note lake of post glacial modification of outwash plain. |
| 10.1 | 1.9 | Turn left (W) onto Kinney Gulf Road built largely across alluvial fan of Dry Creek. In 1.3 miles Dry Creek and road pass through narrow rock-walled gorge which shortly opens out to form Kinney Gulf. Leave Cortland 7½' quadrangle. |
| | | Cross southwest corner of Homer quadrangle and enter Sempronius 7½' quadrangle. |
| 13.8 | 3.7 | Rise across outwash to well-defined Valley Heads valley-stopper moraine which forms divide between Dry Creek (Susquehanna drainage) and headwaters of Fall Creek (St. Lawrence drainage). |
| 14.7 | 0.9 | At "T-intersection", turn left onto Route 90. Carney (1909) reported glacial striae to be oriented S45W on summit of West Hill to north of intersection. |

TRIP F (Continued)

| Total miles | Miles from last point | Route description |
|---|---|---|
| 16.0 | 1.3 | Turn right (N) on Lake Como Road. On summit of southeast end of Summer Hill west of route, Carney (1909) reported glacial striae to be oriented S71E, indicating opposing directions of ice flow during late Wisconsin Stage. |
| 16.9 | 0.9 | Turn right (E) onto West Hill Road. Cross small tributary of Fall Creek which drains Lake Como. |
| 17.2 | 0.3 | Turn left (N) toward Como. To northwest (left ahead) the valley floor opens out as an intermorainal basin, part of which is occupied by Lake Como. Lower slopes enclosing the basin on north and east are marked by strong kame and kettle development. |
| 18.6 | 1.4 | Turn right (E) at Como onto Homer Gulf Road (Route 41A) and proceed across nose of stagnant ice deposits at drainage divide, before entering Homer Gulf, a canyon incised 300 to 500 feet deep. |
| | | Re-enter Homer 7½' quadrangle. |
| 21.7 | 3.1 | STOP TWO. HOMER GULF.<br>Post-glacial modification of the upper part of the Gulf is minor, and latest gorge-cutting relates to Valley Heads glaciation. |
| | | Note the fan deposited by water from Homer Gulf in the Skaneateles trough. |
| | | Query: Is this gulf a product of a single episode of gorge-cutting? Is the moraine position on the divide co-incidental? |
| 21.9 | 0.2 | Turn left (N) onto Route 41 proceeding north over outwash and postglacial alluvial fan deposits of Skaneateles trough. In about 2.3 miles cross Valley Heads terminal moraine. Road follows an open, irregular channel cut by meltwater during wasting of stagnant toe of the Skaneateles ice tongue. |
| 26.0 | 4.2 | Proceed north on Route 41 through Scott, thence following valley of Grout Brook. Enter Otisco Valley 7½' quadrangle. |

TRIP F (Continued)

| Total miles | Miles from last point | Route description |
|---|---|---|
| 27.7 | 1.6 | Stay right at fork, climbing to summit on Ripley Hill Road. |
| 30.3 | 2.6 | STOP THREE. RIPLEY HILL SUMMIT<br>At elevation of 1986 feet above sea level Ripley Hill is one of the highest points in Onondaga County and representative of the heavily scoured but relatively unreduced remnants of an essentially accordant pre-glacial summit surface. If pre-glacial summit accordance is accepted, the present departure from summit accordance affords a measure of summit reduction by glacial scour. Elongation of ridges commonly relates to ice-flow. Through valleys, long interpreted as showing a pattern inherited from pre-glacial stream systems, have recently been referred to as "intrusive troughs" implying only minor dependence on inherited pre-glacial controls. |
| | | Proceed north on Ripley Hill Road. |
| 31.5 | 1.2 | Turn right (E) onto Cold Brook Road. |
| | | Proceed southeastward on Cold Brook Road, enter Otisco Valley 7½' quadrangle, through South Spafford; enter Homer 7½' quadrangle, through East Scott, to Pratt Corners. The road parallels Cold Brook, a southward draining stream tributary to the Tioughnioga River. |
| 41.1 | 9.6 | Turn left (N) on Route 281 at Pratt Corners. |
| 42.7 | 1.6 | STOP FOUR. DWYER PARK GRAVEL PIT.<br>The upper 3 feet of stratified outwash has been interpreted on the basis of heavy mineral studies to represent the last or Valley Heads phase of Wisconsinan Glaciation while the lower approximately 8 feet of gravel represents the earlier Binghamton phase. |
| | | Return to Route 281 and turn right (N). On the west side of the valley is Mount Toppin, which Von Engeln (1921) refers to as a truncated spur, the result of glacial scour. Holmes (1939) accounts for the over steepened appearance of the east facing valley wall by differential |

| Total miles | Miles from last point | Route description |
|---|---|---|
| | | insolation and therefore greater deposition on the east side of the valley. |
| 44.2 | 1.5 | STOP FIVE. OTISCO VALLEY FAN.<br>South of Preble is evidence that the ice tongue in Otisco Valley was active for a longer time than the ice in the Tully-Cortland trough. A fan was deposited by waters from Otisco Valley over the outwash from the Tully Moraine. Note that the southern part of the fan is a collapsed surface. Buried ice must have extended into the valley with melting and collapse in progress as glacial water was distributing the fan material. |
| | | Continue north on Route 281 on the outwash materials of the Tully-Cortland trough. The road trends to the east side of the valley to skirt the Tully Lakes kame and kettle complex on the west side of the valley. Cross the southeast corner of the Otisco Valley 7½' quadrangle and enter the Tully 7½' quadrangle. |
| 49.4 | 5.2 | Turn left (W) on Route 80 at Tully Center and proceed west onto the Tully Moraine, parallel to steep slope marking the proximal border of the moraine. Kettles are to be seen on both sides of the road. |
| 50.6 | 1.2 | STOP SIX. SOLVAY GRAVEL PIT.<br>Steep-walled gravel pit exposes materials composing major part of Tully moraine, showing it to be largely a product of outwash deposition from a stationary to narrowly oscillating ice margin. Exotic component in this through valley gravel is high with crystalline-carbonate-clastic ratios on the order of 10:40:50. The "bright" character of the gravels results from proximity to carbonate sources, attrition of diluting shale fraction from the lake plain, and effectiveness of glacial transport in a major through valley. |
| | | Query: How can we account for this ratio in view of the 5:15:80 ratio found at the Cortland kames? |

TRIP F (Continued)

| Total miles | Miles from last point | Route description |
|---|---|---|
| 52.3 | 1.7 | Turn around and proceed (E) on Route 80 toward Apulia. About 0.5 mile east of Tully cross low, smoothed valley choker moraine, convex eastward. This moraine may correlate with the "advance Valley Heads" position defined in Tully Valley by the outer border of the Tully Lakes area. If so, the smoothed nature of this ridge is puzzling, but may relate to imponding at the ice margin. |
| 54.0 | 1.7 | Continuing eastward on Route 80, near Markham Hollow Road enter Valley Heads moraine complex of Butternut trough. Proximal margin of moraine is less sharply defined than in Tully Valley. "Main Valley Heads" position is south of Apulia Station. |
| 55.8 | 1.8 | Turn right (S) onto Route 91 in Apulia. The Apulia-Fabius trough extends eastward for several miles. Although segmented by drift deposits that define the heads of several drainage basins, this valley has the continuity suggestive of origin as part of a southwestward draining pre-glacial stream system. |
| 56.4 | 0.6 | Cross moraine ridge. Toward axis of north-south through valley this ridge separates into three small but well-defined ridges marking recession of "advance Valley Heads" ice. The road follows a marginal meltwater channel between moraine ridge and valley wall. |
| 57.7 | 1.3 | Meltwater channel widens, opening onto outwash plain upon which shallow Labrador Pond is located. Valley floor is less than 0.5 mile wide between 750 foot walls which converge southward as though toward a bedrock col. Labrador Pond, however drains southward by Labrador Creek on gradient developed by outwash deposition.<br>Query: How does the transverse relationship of the Apulia-Fabius trough and the Butternut-Labrador trough clarify the relative importance of inherited valley system as opposed to glacier scour in determining the through valley pattern of this part of the plateau? |

TRIP F (Continued)

| Total miles | Miles from last point | Route description |
|---|---|---|
| 60.0 | 2.7 | Cross Shackham Brook. State reforestation area and experimental drainage basin to east of route. Kame complex developed in valley wall re-entrant where Shackham Brook debouches into Labrador trough. Leave Tully, enter Truxton 7½' quadrangle. |
| 61.8 | 1.8 | Pass Labrador Mountain Ski resort. |
| 63.0 | 1.2 | STOP SEVEN. TRUXTON TOWN HIGHWAY DEPARTMENT BORROW PIT.<br>Stratified sand and silt, with foreset beds and collapse structure. Dominance of shale in gravel, with small percent of crystallines and carbonates indicates dilution by uptake of local rock material. Rapid attrition of such material with fluvio-glacial sorting might within a few miles of through valley transportation "brighten" even this drab gravel, giving it a Binghamton-type lithology. |
| 64.0 | 1.0 | Turn right onto Route 13 in Truxton, birthplace of J. J. McGraw, for 30 years manager of the New York Giants. |
| 69.4 | 5.4 | Continue southwest through East Homer settled by Revolutionary War veteran John Albright in 1827. Route 13 lies along valley of East Branch Tioughnioga Creek, apparently a major tributary of the pre-glacial drainage line inferred to have extended west from Cortland toward Cayuga trough. |
| 71.1 | 1.7 | Continue southwest past East River, on Route 13 toward Cortland. Leave Truxton, enter Homer 7½' quadrangle. Coarse kame terrace gravels exposed in several pits in next three miles. Esker parallels Route 13 south of Light House Road where John Miller built first cabin in 1792. |
|  |  | Note that the East Branch Tioughnioga Creek is diverted to the south side of the valley by the alluvial deposits of the south flowing tributaries. Since the recent floodplain deposits are generally less than eleven feet thick, the fan-shaped deposits are now being |

TRIP F (Continued)

| Total miles | Miles from last point | Route description |
|---|---|---|
| | | eroded and there is a general lack of new fan deposition, the East Branch Tioughnioga Creek must have been diverted by these fans shortly after the ice melted from the valley, |
| 72.5 | 1.4 | STOP EIGHT. GRAVEL PIT IN COARSE TILL. The till was part water-laid and there is outwash material at the south end of the cut. |
| | | Continue southwestward on Route 13 passing gravel pit with well stratified sediments on the right (N) in 0.9 miles. Enter the Cortland 7½' quadrangle. |
| 75.0 | 2.5 | Pass under Interstate Route 81 and cross West Branch of Tioughnioga Creek. Draining the Tully-Homer-Cortland trough, this creek joins the East Branch of Tioughnioga Creek 0.5 miles east. The combined discharge drains south in a through valley with converging walls indicative of a pre-glacial divide a few miles south of Cortland. |

# TRIP G: PALEONTOLOGY OF THE CORTLAND AREA

Jonathan W. Harrington

All of the exposures visited on this trip are in the Ithaca formation. The participant is referred to the discussion on benthic communities of the Geneseo Group (Trip A).

## Selected Exposures

### 1. Roadcut on Rte 81, 3 miles south of Cortland

This exposure represents the Grammysia biotope in the Smethport depositional phase. Lithology is highly variable with shales, and ripple-marked and cross-laminated siltstones and fine sandstones. Coquinite lenses, especially with Cupularostrum, are frequent and usually show distinct size-sorting and differential accumulation of valves. Areas of high currents are dominated by the infaunal filter-feeder, Grammysia, and the byssally attached bivalve, Goniophora. Occasional vertical burrows may be seen.

Sheltered areas support an abundant epifauna of crinoids (Decadocrinus and Acanthocrinus) and occasional brachiopods. This environment is characterized by the accumulation of plant fragments and orthoconic cephalopods, and by the high incidence of carnivores and scavengers - the gastropods, Pleurotomaria and Loxonema, several asteroids (Urasterella, Lepidasterella) and ophiuroids.

The orientation of many of the smaller crinoid calices (inverted with free arms outspread) indicates very slight water agitation. However the preservation of fragile specimens such as asteroids and the scyphomedusa, Plectodiscus cortlandensis, requires periodic rapid sedimentation. Fecal material is occasionally found at this outcrop. It has tentatively been identified as Tomaculum problematicum, a form not previously reported in North America.

### 2. Outcrop in Homer Gulf on Rte 41A, 4 miles north of Cortland.

Ponticeras perlatum has been identified from exposures in Homer Gulf. This places the section in the lower portion of the Ithaca formation, probably correlative with the Renwick shale member in the Cayuga Lake meridian.

Lithology is extremely variable; consisting mainly of gray and reddish shales and siltstones. The fauna contains elements of both the Warrenella and Ithaca biotopes. Particularly common are: Conularia, Plumularia, Mucrospirifer, "Pugnoides", Cupularostrum eximia, Taxocrinus and linguloid brachiopods.

### 3. Small outcrop on the west side of Cosmos Hill, 1 1/2 miles northwest of Cortland.

At this outcrop shales and fine siltstones of the Smethport phase are exposed. The fauna is that of the *Leptodesma* biotope, with abundant epifaunal filter-feeding faunas.

4. Roadcut on Rte 81 at Homer, Cortland Co.

The sequence here consists of alternating dark shales and fine siltstones, occasionally ripple-marked. The sparce fauna, representing the *Leptodesma* or *Grammysia* biotope, consists of rare brachiopods and occasional crinoids (*Acanthocrinus*). At several horizons are colonies of the hexactinellid sponge, *Actinodictya placenta*. These fragile forms were almost certainly preserved *in situ*.

Small hillside quarries immediately north of this exposure have yielded *Ponticeras perlatum*. Thus, indicating a correlation with the lower portion of the Ithaca (Renwick or Six Mile Creek Members) in the Ithaca meridian.

TRIP J

# PROGLACIAL LAKE SEQUENCE IN THE TULLY VALLEY, ONONDAGA COUNTY

by

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## Introduction

Few locations in the New York State display as varied an array of geological features as does the Tully Valley.

The Tully Valley is a glacially scoured trough carved into the northern margin of the Appalachian (Allegheny) Plateau (von Engeln, 1921). The glacial erosional and depositional features found here have been the subject of a number of theses and publications (Fairchild, 1909, 1932; von Engeln, 1921, 1959; Brainerd, 1922; Faltyn, 1957; Durham, 1958; Muller, 1964).

Most of the valley lies within the outcrop belt of the Middle Devonian Hamilton Group. Unlike similar steep-sided troughs to the west, the Tully Valley does not now contain a finger lake. Because of the relatively low temporary base level, due to the absence of a lake, tributary streams have opened excellent exposures even in the lower formations of the Hamilton Group. East-west tributaries, in hanging valleys have carved deep, post-glacial, bedrock gorges, wherein the extremely fossiliferous Hamilton rocks are easily accessible. Therefore, the Tully Valley is also a highly stimulating region for the paleontologist and stratigrapher.

The purpose of this narrative is to outline the proglacial lake sequence of the Tully Valley as indicated by correlating the elevations of the delta masses deposited in these lakes with those of the abandoned outlet channels southeast of Syracuse.

This report is a compilation based mostly on the work of previous investigators and the examination of topographic maps. It should not be misconstrued as the final authoritative explanation of the apparently simple, but actually complex late Pleistocene history of the Tully Valley.

The Tully Valley lake sequence occurred during the Lake Dana stage (Fairchild, 1909, 1932) after the second Lake Warren (elevation 690 ft.), outlet through the Mississippi system and before the Lake Iroquois stage (elevation 435 ft.), outlet through the Mohawk River. Calkin (1966) has correlated high level lake stages in the Huron, Erie and Ontario basins with years B.P. and indicates an age of about 12,000 - 12,500 B.P. for Lake Dana.

The reader should consult Calkin's report, Fairchild's numerous publications, and also those by Rich (1908), von Engeln (1921, 1959), Hough (1958), Muller (1964, 1965), and Krall (1966) for more details concerning this extremely fascinating topic.

## Description of Deltas

The great delta remnants of the Tully Valley extend from the village of Cedarvale on the west, eastward through South Onondaga and north-eastward to the city of Syracuse. They occur as a series of terraces that the author has grouped into five stages, whereas Fairchild (1909) distinguishes six. The South Onondaga 7 1/2 minute quadrangle covers this area.

The highest delta remnant declines in terraces from an elevation of 860 to 780 feet. The major portion of this delta is located at the Western end of Pumpkin Hollow and south-southeast of Cedarvale. Two other remnants of this delta occur as mesas farther to the east; one just southeast of Nichols Corners with a summit elevation of 800 feet and the other northwest of South Onondaga with a summit elevation of 780 feet. These would correlate with Fairchild's (1909) Upper Terrace and Mesa Terrace.

The next series of deltas begins at an elevation of 720 feet and extends down to 660 feet. This delta is found in two distinct masses. The first, just east of the main mass of the first delta and northwest of Nichols Corners. It is bounded by Amber Road on the west, Holmes Road on the north, and Tanner Road on the south. The remainder of this delta is located northwest of the village of South Onondaga. This delta corresponds to Fairchild's (1909) middle Terrace.

The third delta mass (640 feet - 600 feet) is perhaps the most extensive and best developed of the Tully Valley deltas. The village of South Onondaga rests directly on its summit, that extends up the northwest side of the valley ending north of Indian Village. On the south and southwest side, this delta forms a large triangular mass from just west of the settlement of Ironsides to the east branch of Onondaga Creek. Hitchings Road north of its intersection with U. S. Route 20 and south of its intersection with Nichols Road traverses this large delta. Fairchild (1909) has named this delta the South Onondaga Terrace.

At an elevation of 560 feet, the fourth delta terrace can be recognized. It is composed of small deltaic remnants occurring on both sides of the Tully Valley north of Indian Village and south of Nedrow. These may in part be kame terraces (Muller, personal communication). Fairchild (1909) refers to this deltaic remnant as the Lower Terrace.

The lowest easily recognizable delta, Fairchild's (1909) Lowest Terrace occurs at an elevation of 500 feet. It is located north of the 560 foot delta, on both sides of the valley, underlying Nedrow and the southern extremities of the city of Syracuse.

## Description of Meltwater Channels

Southeast of Syracuse, lies a group of meltwater channels that carried the waters of the proglacial lakes in the Tully Valley eastward across the intervalley divide into the adjacent trough, the valley of Butternut Creek. These are, from south to north, the Smoky Hollow, Clark Reservation, Rock Cut, Meadowbrook and Erie Canal Channels.

Muller (1964) and Sissons (1960) have described the numerous channels found in east central New York. Sissons (1960) further suggests that many of these glacial meltwater channels are subglacial and not marginal in their origin.

Smoky Hollow is the highest of the meltwater channels with a threshold of approximately 790 feet. It is about 2.25 miles long and over 100 feet deep. This channel is distinctive because of the large horseshoe-shaped meander loop located east of Barker Hill Road.

Perhaps the most impressive meltwater features to be found in the area are those of the Clark Reservation Channel at Clark Reservation State Park. Here, glacial meltwaters once plunged over a horseshoe waterfall more than 100 feet high. The abandonment of this channel has left behind a large ampitheater at the base of which is a plunge pool basin containing Green Lake.

East of the precipice a well developed channel leads into the Butternut trough. Just west of the brink of the ampitheater, there is a smaller plunge pool feature, the basin of Dry Lake. Muller (1964, p. 31) in discussing this feature states:

> "...Although considerably smaller and shallower than the basin of Green Lake, this too has characteristics of a plunge pool occupied for a short interval and cut perhaps by a stream with smaller discharge. The rock threshold at 720 feet, between the two basins, rules out any suggestion of uninterrupted progressive headward migration of the falls. Rather, it raises a question as to the initial declivity responsible for originating the upper plunge-pool."

There is no well developed channel upstream from Dry Lake. The source of the water responsible for the meltwater scour presents a problem. The water could have been carried over or through the ice from the Tully Valley lake then emerging as a subglacial or submarginal stream at Clark Reservation. Another possibility is that the waters are derived entirely from the ice mass as englacial streams.

The best developed channel is the Rock Cut Channel. It has a threshold of 555 feet, is 100-200 feet deep, and 2-3 miles long. Due to the magnitude of this channel plus certain features on the south wall (Muller, 1964), it seems reasonable to hypothesize more than one episode of glacial meltwater scour.

Just north of the Rock Cut Channel is the Meadowbrook Channel. This channel is smaller in size than the others and has a threshold at about the same elevation as the Rock Cut Channel.

The Erie Canal Channel, the lowest of the scourways, lies at about 410 feet. This channel was utilized by the old Erie Canal (now Erie Boulevard) through the city of Syracuse. The floor of this channel is depositional rather than erosional (Muller, 1964).

## Tully Valley Lake Sequence

The classical approach to analyzing the proglacial drainage in New York

State has been that of H. L. Fairchild or some modification thereof. Fairchild (1909, p. 7) succinctly states this premise as follows:

> "... The glacier acting as a barrier to northward drainage is the fundamental fact to be apprehended by the reader. The ice sheet was a melting dam during both its advance and its retreat, and waters were flowing copiously from it, not into it. Valleys or land depressions sloping toward the ice front were by the ice barrier made into lake basins ...."

This notion has been recently challenged by Sissons (1960), who suggests that the ice was permeable substance and that subglacial and/or englacial drainage was a common occurrence. In the Tully Valley, the proglacial lake sequence can best be explained by the ice dam hypothesis, or a combination of the two. The cross-channels may well have been initiated subglacially, (Muller, personal communication).

When the ice front melted back from the Valley Heads Moraine at Tully New York, Lake Cardiff was formed south of the ice front and north of the moraine (Fig. J-1 & J-2). It drained south over the moraine into the Susquehanna system and had an elevation of about 1200 feet. Another lake at a slightly lower elevation in the vicinity of Cedarvale drained southwest into the Otisco Valley (Krall, 1966). This lake is not shown in Fig. J-2.

The ice front continued to retreat northward until it permitted initial eastward drainage, (Fig. J-3) through Smoky, Hollow, of the imponded Tully waters. The northward drainage of waters in the neighboring Otisco Valley to the west, blocked by the ice located near Marcellus, overflowed to the east through Pumpkin Hollow. As this meltway debouched into the "Smoky Hollow" lake, the first delta (860-780 feet) was constructed (Fig. J-3).

With continued northward withdrawal of the ice front, a new lower outlet was uncovered, the Clark Reservation Channel (Fig. J-4). The lake level dropped to a lower elevation of about 720 feet. The Smoky Hollow Channel was abandoned and the first delta became a terrace above lake level. Reworking of the first delta partially contributed to formation of the lower delta at about 720 feet (Fig. J-4).

The Clark Reservation Channel may have been formed at the same time or before the Smoky Hollow Channel as discussed on page J-5. However, the geographic location of this channel, north of the Smoky Hollow and south of the Rock Cut Channels, best fits the lake drainage sequence hypothesized here, i.e., that it is the second oldest channel.

The downcutting of the Rock Cut Channel began when the ice front retreated north of the Clark Reservation Channel. This scourway controlled lake level from 720 feet down to 560 feet (Fig. J-5). As the elevation of the lake was gradually lowered in response to the outlet, deltas number two (720-660), three (640-600 feet), and four (560 feet) were formed in succession (Fig. J-5). Each succeeding delta received a portion of its material from the reworking of the previous higher delta.

The Meadowbrook Channel, because of its size and orientation toward the ice front (Muller, 1964), may have operated briefly and perhaps simultaneously with the Rock Cut Channel. If this happened, it occurred just prior to the opening of the Erie Canal Channel.

Finally, the Erie Canal Channel was uncovered and began to drain water from the Tully Valley trough. The lake level gradually dropped from about 550 feet to 410 feet. The fifth delta terrace at 500 feet (Fig. J-6) is one of the deltaic deposits that record this final episode in the Lake Dana history of the Tully Valley. (Figs. J-6, J-7)

In conclusion, it should be pointed out that the delta terraces may not have been deposited from highest to lowest as outlined above. Muller (1964) and Krall (1966) offer evidence for multiple episodes of glaciation involving at least one major readvance and perhaps numerous oscillations of the ice front. Furthermore, Krall (1966) suggests that delta remnants in the vicinity of Nichols Corners were built one on top of the other. Certainly the lake sequence is more complex than that proposed here. However, in the absence of fully detailed analysis the sequence of events and deltaic terraces is still most economically explained in terms of a gradual lowering of lake levels within a single deglacial episode.

## Acknowledgements

The author thanks Mr. Robert A. Sanders of Monroe Community College and Dr. Ernest H. Muller of Syracuse University for critically reviewing the manuscript and offering many helpful suggestions.

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Fig. J-1

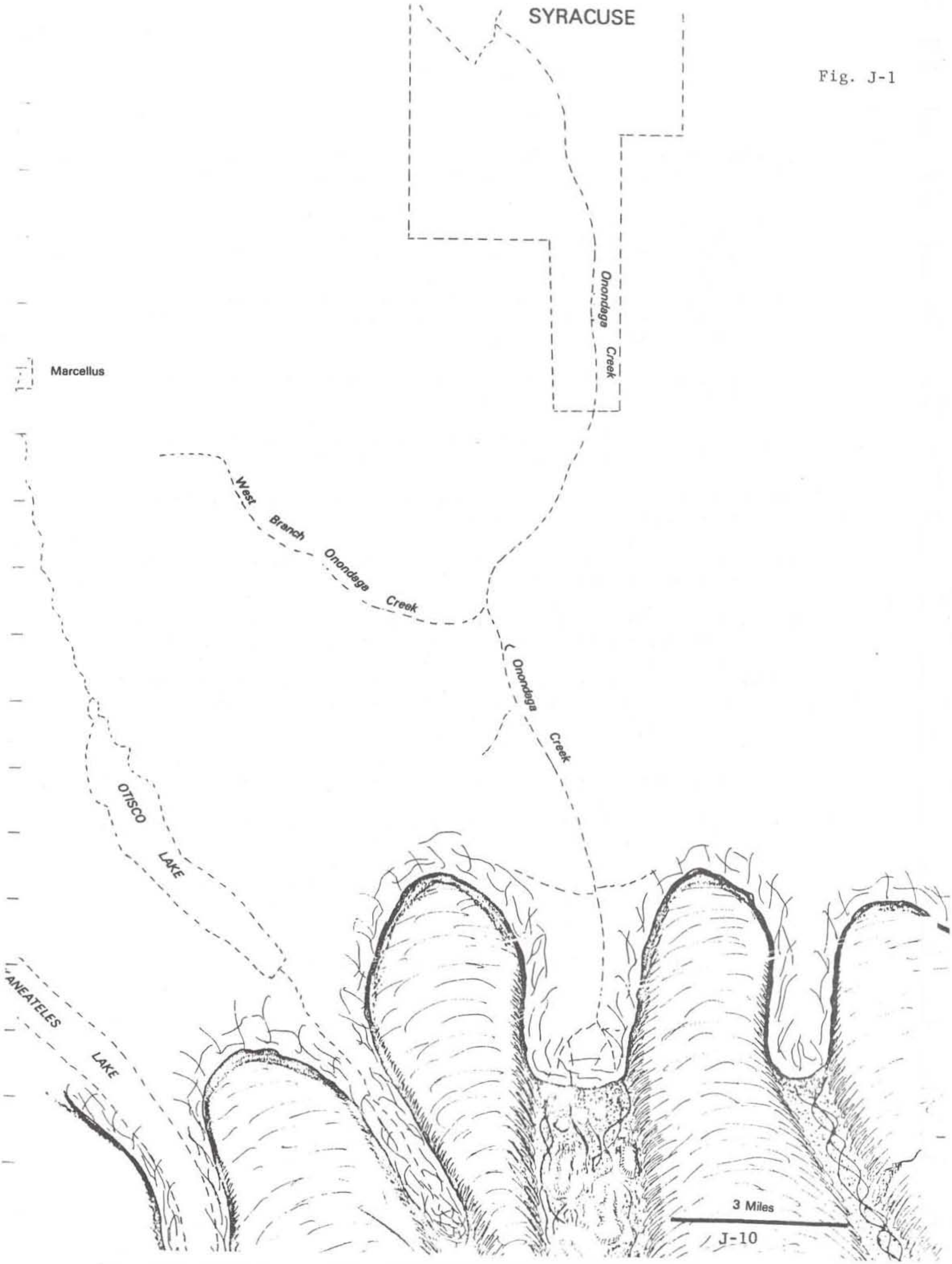

SYRACUSE
Marcellus
Onondaga Creek
West Branch Onondaga Creek
Onondaga Creek
OTISCO LAKE
ANEATELES LAKE
3 Miles

Fig. J-2

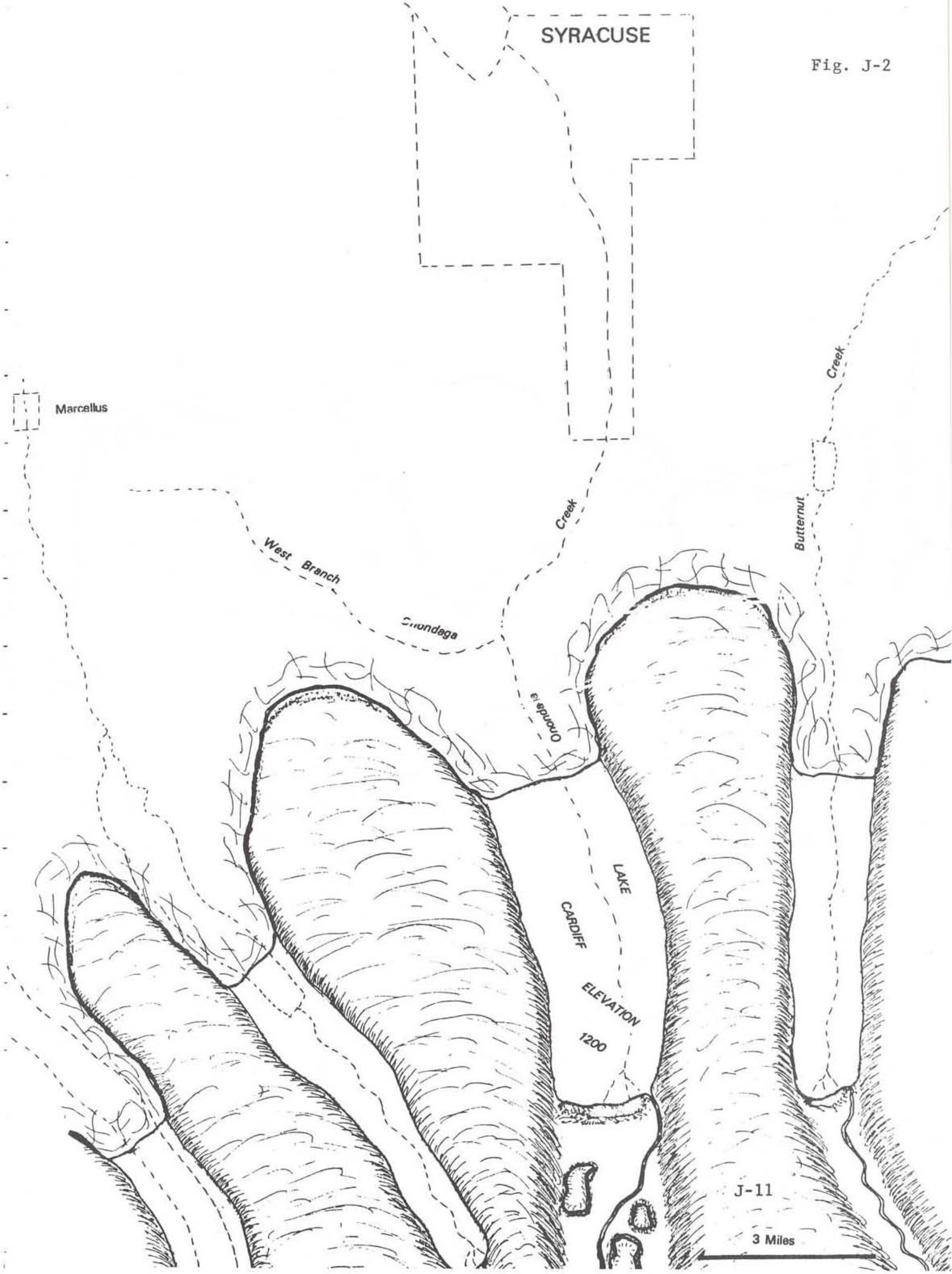

SYRACUSE
Marcellus
West Branch
Onondaga
Creek
Butternut
Creek
Onondaga
LAKE
CARDIFF
ELEVATION
1200
3 Miles

Fig. J-3

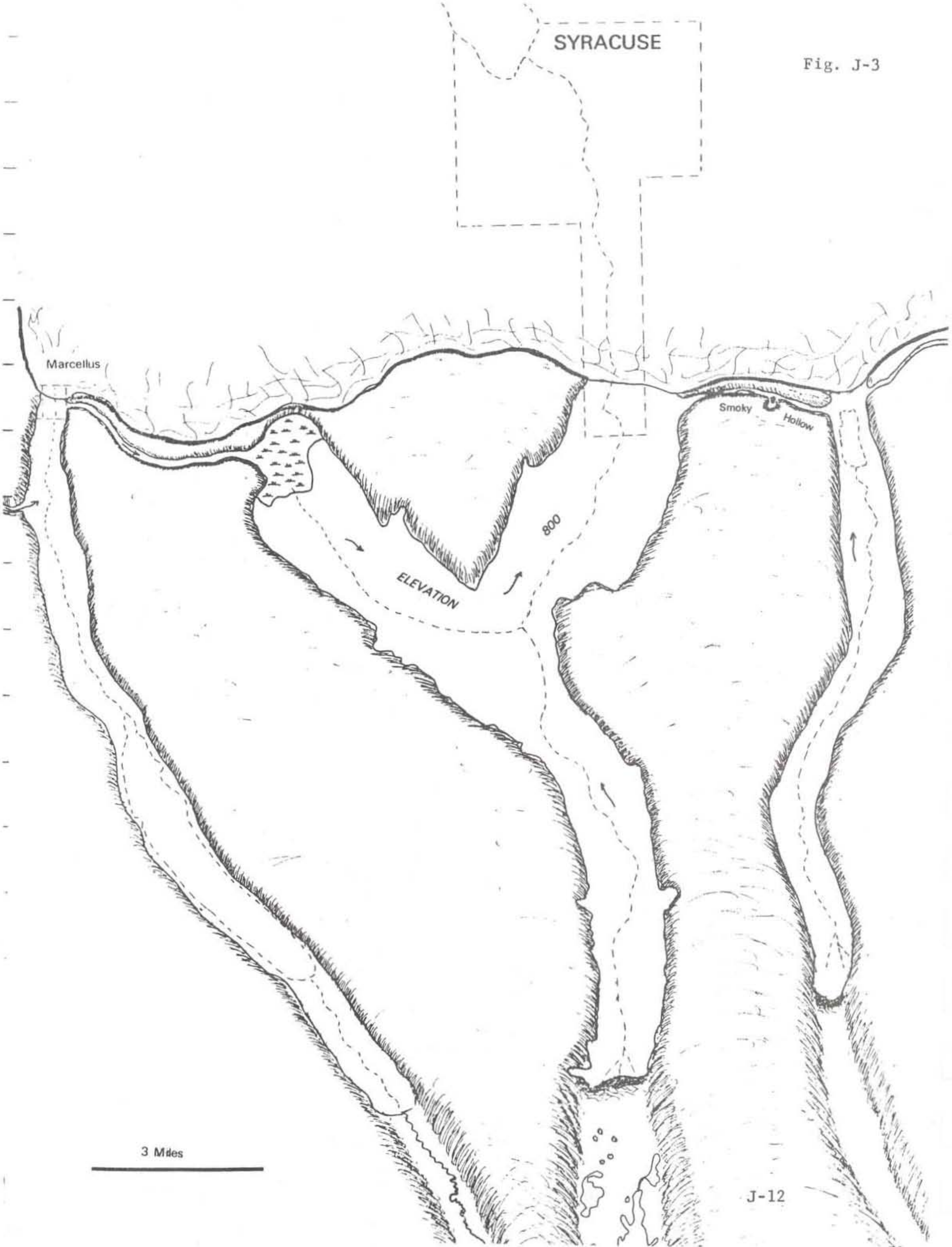


Fig. J-4

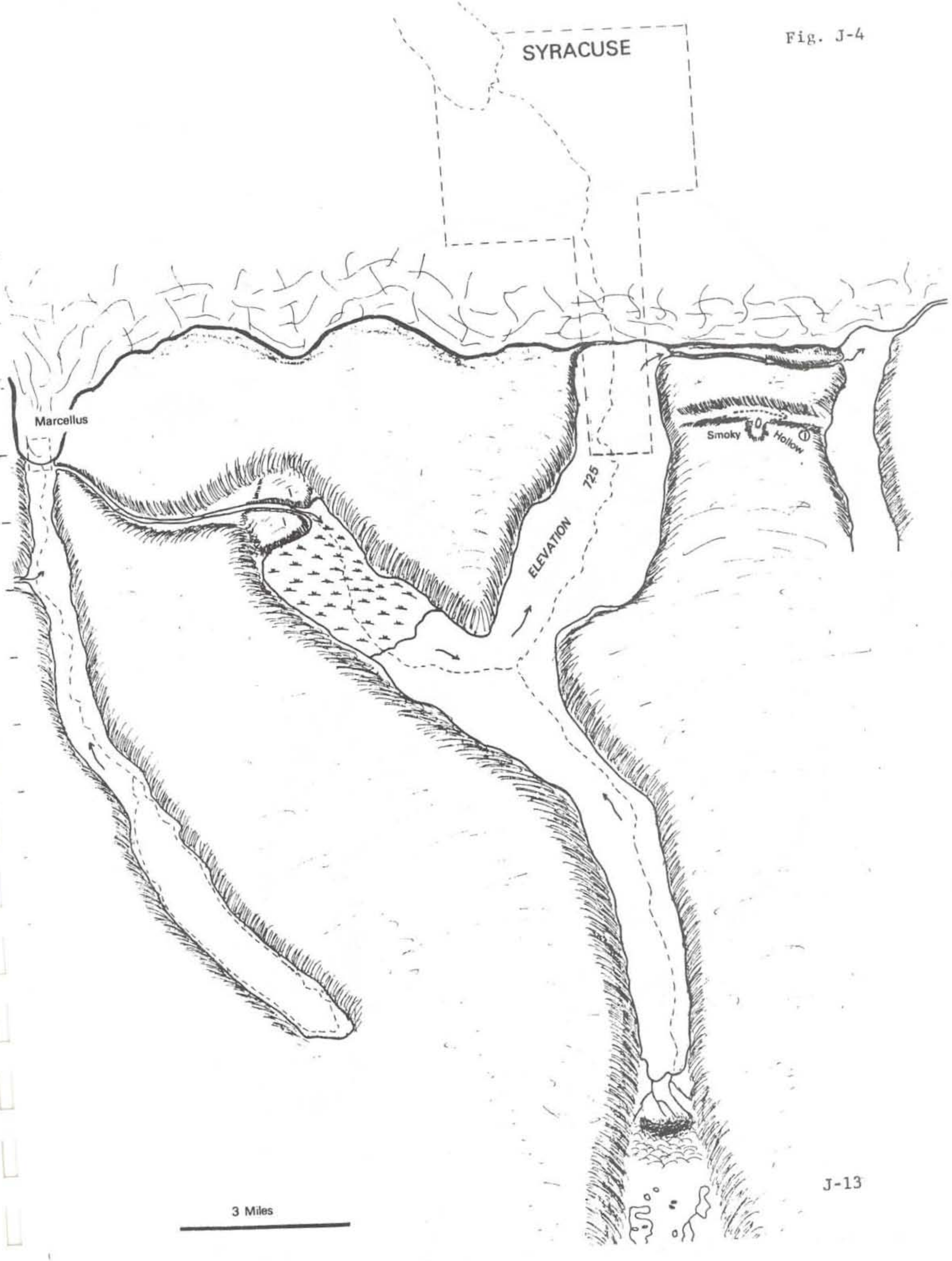


Fig. J-5

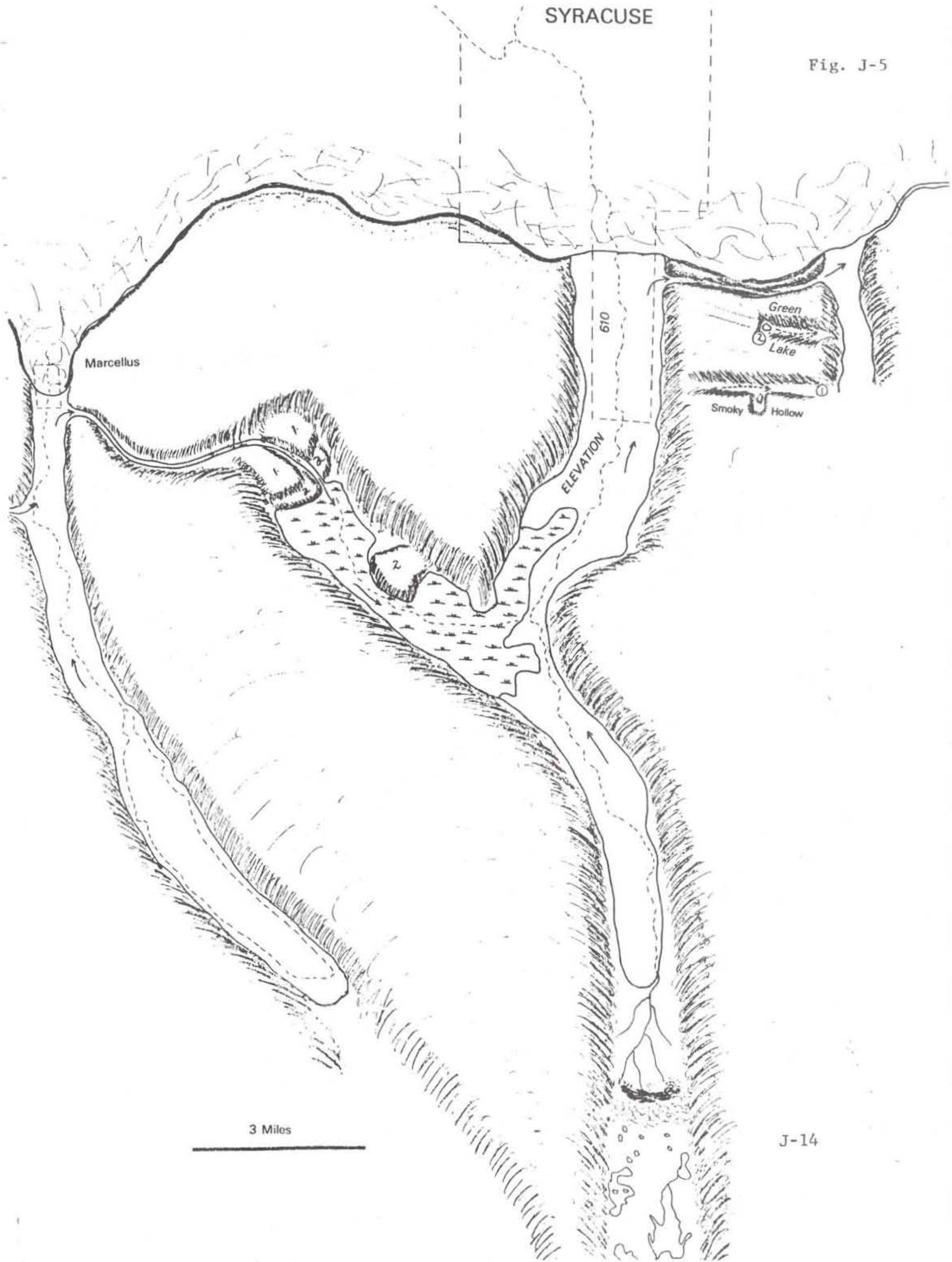
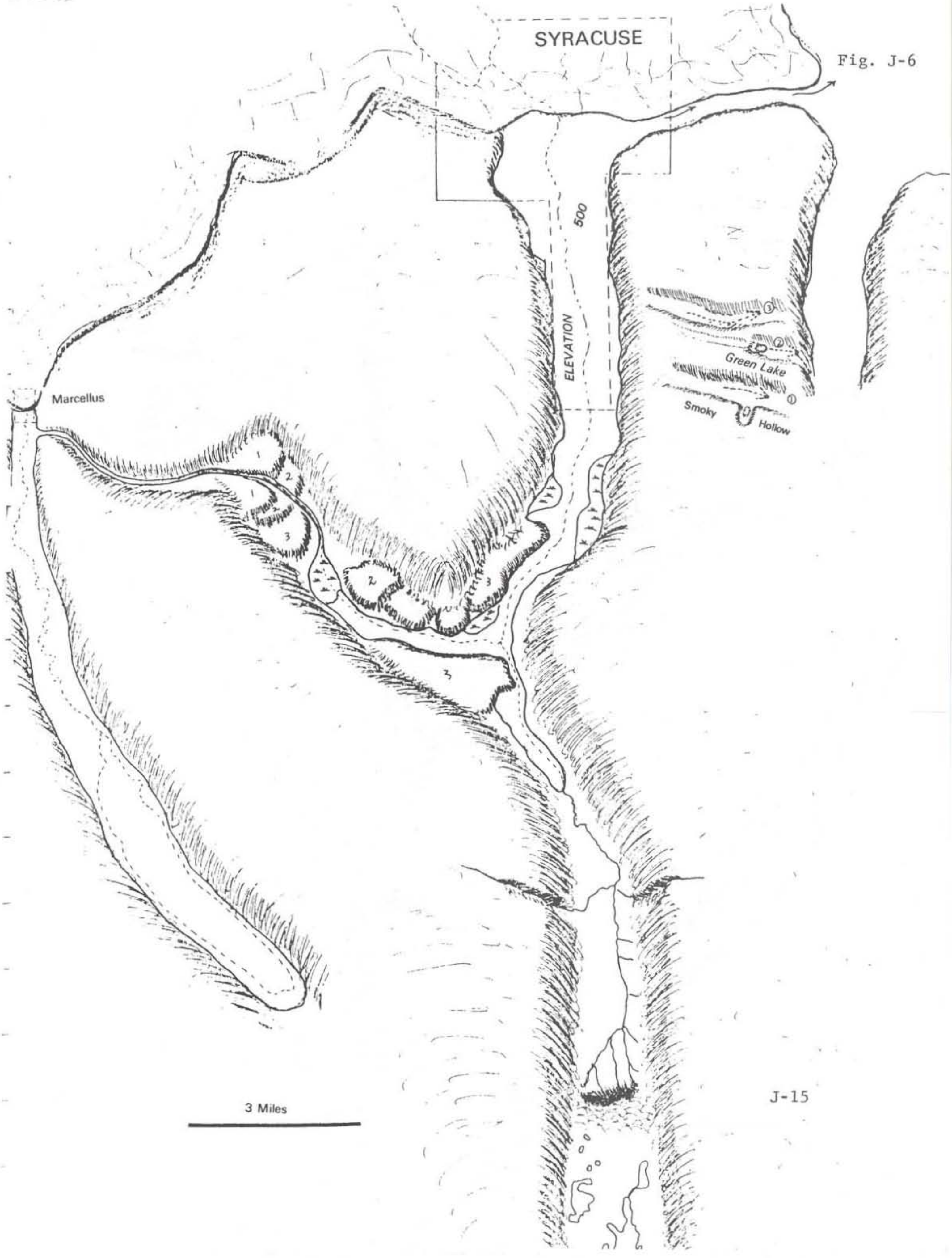

SYRACUSE
Marcellus
610
ELEVATION
Green
Lake
Smoky
Hollow
①
②
1
1
2
2
2
3 Miles

Fig. J-6



SYRACUSE
500
ELEVATION
Green Lake
Smoky
Hollow
① ② ③
Marcellus
1
2
1
2
3
2
3
3
3 Miles

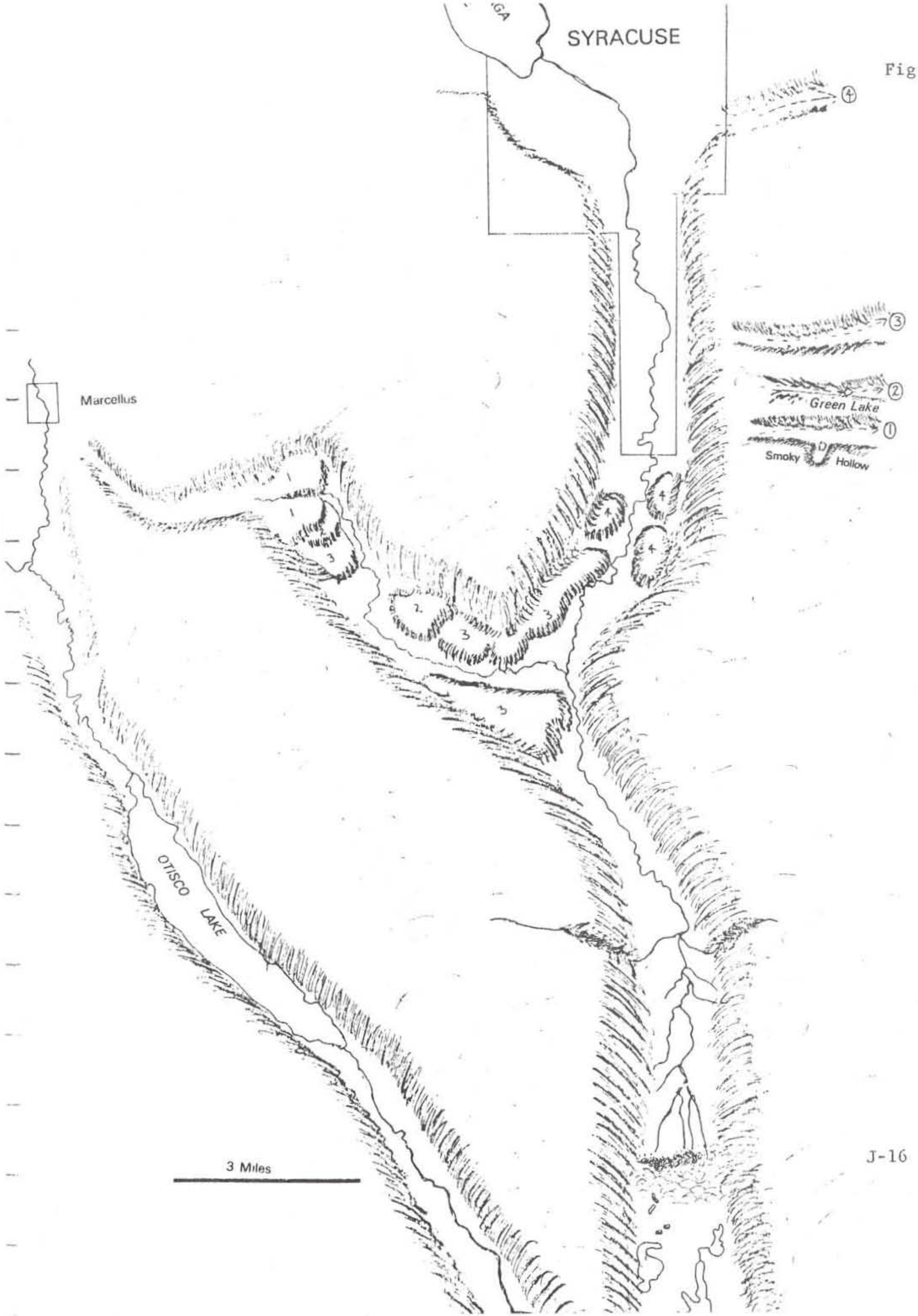

GA
SYRACUSE
④
③
②
Green Lake
①
Smoky Hollow
Marcellus
1
1
2
3
2
3
3
3
4
4
4
OTISCO
LAKE
3 Miles

Fig. J-7

## TRIP J: PROGLACIAL LAKE SEQUENCE IN THE TULLY VALLEY, ONONDAGA COUNTY

Leader: Thomas X. Grasso, Monroe Community College, Rochester, N.Y.

| Total miles | Miles from last point | Route description |
|---|---|---|
| 0.0 | | Right (E) on Route 13 from Holiday Inn to Interstate 81. |
| 0.1 | 0.1 | North on Interstate 81. Notice along the route that kettles are more numerous on the west side of the valley where a narrow bench can also be seen. Greater insulation and melting occurred along the east sides of valleys at the time of final deglaciation. The ice remained longer along the west valley wall where it was protected from the afternoon sun. Here the relatively thicker ice masses were finally buried to form Little York Lake, Crooked Lake and Song Lake. |
| 10.0 | 9.9 | In the Preble region, Interstate 81 crosses a fan deposited by a stream from Otisco Valley. Deposition of the fan crowded the West Branch Tioughnioga River against the east wall of the valley. These factors suggest that ice was active longer in Otisco Valley than in Onondaga Valley. Buried ice still existed in the valley so that melting and collapse were occurring while deposition continued from the northwest source. |
| 14.0 | 4.0 | Proceed north on Interstate 81 to Tully Exit (#14), New York Rte. 80. |
| 14.2 | 0.2 | Turn left (west) on New York Rte. 80. |
| 15.5 | 1.3 | Turn right (north) onto Tully Farms Road. |
| 15.7 | 0.2 | STOP 1. Gravel Pit in Tully Moraine |

GATEHOUSE POND AND SOLVAY GRAVEL PIT

Steep-walled gravel pit exposes materials composing major part of Tully moraine, showing it to be largely a product of outwash deposition from a stationary to narrowly oscillating ice margin. Exotic component in this through valley gravel is high with crystalline-carbonate-clastic ratios on the order of 10:40:50. The "bright" character of the gravels results from proximity to carbonate sources, attrition of diluting

| Total miles | Miles from last point | Route description |
|---|---|---|
| | | shale fraction from the lake plain, and effectiveness of glacial transport in a major through valley. |
| | | Continue north on Tully Farms Road. |
| 19.4 | 3.7 | Intersection, Otisco Road, continue north on Tully Farms Road. |
| 21.0 | 1.6 | Cross Onondaga Creek which drops at Fellows Falls with hanging and barbed juncture into Onondaga trough, in this area called Tully Valley. Ahead (NE), local relief exceeds 1250 ft. from upland to trough floor on proximal (northern) flank of massive Tully (Valley Heads) Moraine. The abrupt proximal border and gently graded distal slope of this moraine is characteristic of valley blocking moraine loops of this system on divides and northward opening valleys of central New York. |
| | | Seismic refraction profiles suggest that the unconsolidated valley fill in mid-trough opposite Fellows Falls may be 400 to 500 ft. thick, with the bedrock floor at 300 to 400 ft. msl. Northward, in the vicinity of Syracuse the bedrock floor of the trough lies below sea level. Southward the rock floor rises to 975 ft. above sea level in the col at Tully Lake. |
| 22.1 | 1.1 | Junction U.S. Rte. 20 - turn left (west). |
| 23.8 | 1.7 | Now riding over the surface of the third delta (el. 610') built into a lake whose outlet was the Rock Cut Channel. |
| 24.4 | 0.6 | Intersection of Hitchings Road - continue west. |
| 25.7 | 1.3 | Junction N.Y. Rte. 80 - continue west. |
| 26.7 | 1.0 | Southwest of Joshua Corners note level swampy area at head of minor meltwater channel which deposited a delta complex into a predecessor of Otisco Lake, 3 miles to the southwest. |
| 28.1 | 1.4 | Intersection of Amber Road (Navarino) - continue west. |

| Total miles | Miles from last point | Route description |
|---|---|---|
| 28.6 | 0.5 | Cross Smith Hollow (Navarino Channel). With threshold at 1005 ft. about one mile north of Rte. 20, the Navarino Channel developed as an outflow or overflow channel, bearing meltwater from Pumpkin Hollow (Lake Cedarvale) into Lake Marietta in Otisco trough. |
| 30.3 | 1.7 | Intersection Slate Hill Road - turn right (north) onto Slate Hill Road. |
| | | Four small marginal meltwater channels notch the nose of Slate Hill to the west. |
| 31.8 | 1.5 | Intersection Seal Road - continue north on Slate Hill Road. |
| | | Observe Pumpkin Hollow to the east (right). Cut sharply through Hamilton Shale section and floored on Onondaga Limestone. This is one of the largest of the cross channels which carried drainage eastward along the plateau margin. Pumpkin Hollow is about 0.25 miles wide and as much as 400 feet deep. Three miles east of Marcellus it widens abruptly to nearly a mile. |
| 33.4 | 1.6 | Intersection Rockwell Road - bear right on Slate Hill Road. |
| 33.7 | 0.3 | Junction N.Y. Rte. 175 - turn right (north) on N.Y. Rte. 175. |
| 34.1 | 0.4 | Intersection Pleasant Valley Road - turn right (east). |
| | | This is the head of the channel that carried the meltwaters from the Otisco Valley eastward into the Tully Valley. It becomes progressively wider eastward (downstream). |
| 37.4 | 3.3 | Sharp hairpin turn in Pleasant Valley Road. Proceed for several hundred feet. |
| | | STOP 2. The sudden widening of the valley at this point, plus the absence of bedrock exposures in this area has led Krall (1966) to suspect that this is a buried pre-glacial or interglacial valley. |

| Total miles | Miles from last point | Route description |
|---|---|---|
| | | Continue on Pleasant Valley Road |
| 39.1 | 1.7 | Intersection Amber Road - turn right. |
| 39.3 | 0.2 | Intersection Cedarvale Road - turn left. |
| 41.2 | 1.9 | Intersection Tanner Road - turn left. |
| 41.7 | 0.5 | STOP 3. Gravel Pit Entrance - turn right. |
| | | This pit is being excavated in the second series of deltas (elev. approx. 700'). Shale pebbles occur frequently in the gravel and crossbedding is conspicuous. |
| | | Return to Tanner Road - turn right. |
| 42.3 | 0.6 | Intersection South Onondaga Hill Road (Makyes Road) - turn right. |
| 42.8 | 0.5 | Break in slope on S. Onondaga Hill Road. |
| 43.1 | 0.3 | Entering Village of South Onondaga. |
| 43.3 | 0.2 | Junction - N.Y. Rte. 80, Cedarvale Road and S. Onondaga Hill Road (Makyes Road) - Turn right onto Cedarvale Road. |
| 43.4 | 0.2 | STOP 4. Gravel Pit Entrance. |
| | | Gravel pit is in the second delta terrace. (Fairchild's Middle Terrace) |
| 43.7 | 0.2 | Return to Cedarvale Road - turn left. Junction - N.Y. Rte. 80, Cedarvale Road, S. Onondaga Hill Road (Makyes Road) continue straight through the intersection on N.Y. Rte. 80 (Cedarvale Road). |
| 44.6 | 0.9 | Bear right on N.Y. Rte. 80. |
| 44.7 | 0.1 | Griffin Road on left. |
| 45.1 | 0.4 | Hitchings road on right. |
| 45.7 | 0.6 | Unnamed road at bend in N.Y. Rte. 80 - turn right. |

| Total miles | Miles from last point | Route description |
|---|---|---|
| 46.5 | 0.8 | Junction - Unnamed road and N.Y. Rte. 11A-turn left (north). |
| 47.0 | 0.5 | Settlement of Indian Village |
| 47.6 | 0.6 | Leaving Indian Village |
| 50.9 | 3.3 | Junction U.S. Rte. 11 - turn right. |
| 51.8 | 0.9 | Overpass (bridge) carrying I-81. |
| 51.9 | 0.1 | Intersection - Kennedy Road - turn left (east). |
| 51.95 | 0.05 | Bear sharp right onto Kennedy Road (south). |
| 52.9 | 0.95 | Intersection Bull Hill Road - turn left (east). |
| 53.9 | 1.0 | Intersection Sentinel Heights Road - turn right (south). |
| 54.2 | 0.3 | Road leading to base of WSYR TV tower - turn right (west). |
| 54.3 | 0.1 | STOP 5. Base of tower.<br>Looking west can view the Tully Valley deltas just traversed. Also Joshua Coral Bed (Ludlowville Fm.) is exposed here. |
| 54.4 | 0.1 | Return to Sentinel Heights Road - turn left. |
| 54.7 | 0.3 | Intersection Bull Hill Road - turn right (east). |
| 55.9 | 1.2 | Intersection Lafayette Road - turn left (north). |
| 56.6 | 0.7 | Coye Road on right - continue north on Lafayette Road. |
| 57.3 | 0.7 | Intersection Barker Hill Road - turn right. |
| 57.7 | 0.4 | Meltwater channel - Smoky Hollow with horseshoe-shaped loop |
| 58.5 | 0.8 | Floor of Smoky Hollow meltwater channel (elev. 790'). East Syracuse reservoir on left.<br>Smoky Hollow, with bedrock floor just below 800 feet, is sharply incised in Hamilton Shales. This outlet may have controlled drainage of |

| Total miles | Miles from last point | Route description |
|---|---|---|
| | | imponded waters in the Onondaga trough at the highest delta level in Cedarvale Channel (seen at STOP 3). Descend from drumlinized Hamilton upland onto channeled Onondaga bench. |
| 59.4 | 0.9 | Junction N.Y. Rte. 173 turn right (east). |
| 60.1 | 0.7 | Entrance Clarke Reservation - turn left.<br>Straight ahead to parking lot and "waterfalls". |
| 60.3 | 0.2 | <u>STOP 6</u>. Parking Area.<br>Clarke Reservation Channel observed here. |
| | | Erosion by glacial meltwater, solution by underground water and joint control responsible for the features. Green Lake occupies the plunge basin cut into the Onondaga Limestone and underlying beds by waterfalls fed by glacial meltwater. |
| 60.6 | 0.3 | Return to N.Y. Rte. 173 - turn left. |
| 61.3 | 0.7 | Jamesville City limits. |
| 61.9 | 0.6 | Crossing D.L.&W. Railroad tracks.<br>Make a sharp left onto Jamesville Road after crossing tracks. |
| 62.7 | 0.8 | Intersection Rockcut Road. |
| 62.8 | 0.1 | Bear left at fork in road. Proceed over one lane bridge. |
| 62.9 | 0.0 | Bear right. Entering Rock Cut Channel. |
| | | This steep-walled, flat-bottomed channel is floored by the Fiddlers Green Dolomite, with threshhold at 550 feet at the west end and average eastward gradient of less than 10 feet per mile. The size of this channel and the configuration of the south wall suggest glacial advance south of Rock Cut Channel after the channel had attained essentially its present dimensions. |
| 63.6 | 0.7 | Nottingham Road - continue straight. |
| | | Note features in south wall (left side) of channel. |

TRIP J (Continued)

| Total miles | Miles from last point | Route description |
|---|---|---|
| 65.4 | 1.8 | Syracuse City limits |
| 65.9 | 0.5 | Intersection E. Brighton Avenue - turn right on E. Brighton Avenue to I-81. |
| 66.8 | 0.9 | Bridge overpass I-81. |

END OF TRIP

# TRIP K: GLACIAL HISTORY OF THE FALL CREEK VALLEY AT ITHACA, NEW YORK

Arthur L. Bloom, Cornell University

Extracted from Marlin G. Cline and Arthur L. Bloom, Soil Survey of Cornell University Property and Adjacent Areas, New York State College of Agriculture, Cornell Miscellaneous Bulletin 68.

The area includes those parts of Cornell Plantations and experimental fields within three miles east of the Cornell University Campus. It extends on the north to Hanshaw Road, on the east to Monkey Run and Turkey Hill Roads, on the south to Ellis Hollow Road, and on the west to East Ithaca Station, the Cornell Campus, and the University Golf Course. The Savage farm on Triphammer Road has been included as an inset on Map A1. Areas of privately owned land intermingled with Cornell properties are included.

The soil maps are at a scale of about 6.7 inches to 1 mile, which is larger than the scale used for detailed mapping. The large scale was used to permit delineation of areas as small as ½ acre for accuracy of soil identification on experimental areas. A standard soil survey of Tompkins County at 4 inches to 1 mile has been published (United States Department of Agriculture, 1965) and has used a generalized version of the maps presented here. Because of the larger scale of the maps in this bulletin, it has been possible to present not only much more detailed maps, but also much greater categorical detail of the legend than is possible in the survey of Tompkins County.

## GEOLOGY AND SOILS

### Bedrock Geology

The entire area is underlain by the Enfield formation of Upper Devonian age. The formation consists of dark bluish-gray shale and thin-bedded sandstone, with sandstone beds becoming progressively more abundant in the upper part of the section. The rocks dip gently southward, so that the uppermost sandstones are exposed on the steep upper slopes of Turkey Hill east of Turkey Hill Road, and at lower altitudes immediately south of the mapped area, south of Ellis Hollow Road. Several quarries are opened in the sandstone beds of the formation along the north slope of Hungerford Hill, south of Ellis Hollow Road.

Bedrock is not the parent material of any soils in the area. Exposures of rock are limited to the bed of Fall Creek from the rose gardens downstream to Forest Home, the bed of Cascadilla Creek downstream from the fish hatchery, and minor outcrops in gullies and ditches. However, the Enfield and similar formations have contributed heavily to the glacial drift that blankets most of the area. Typically, 70 to 90 percent of the pebbles, cobbles, and boulders in the drift are derived from the Enfield formation and similar local rocks. The percentage is probably slightly lower in the sand-, silt-, and clay-size fractions, because the finer sediment generally was transported farther by ice or meltwater, and is thereby enriched in limestone and other rock types from source areas north of Ithaca. The Enfield formation is weakly calcareous to noncalcareous. It produces strongly acid soils in the upland regions south of Ithaca where the glacial drift is thin or discontinuous. On weathering, the formation produces thin sandstone slabs and channers in a gray or brown silty clay matrix.

### Glacial Geology

At the time when the retreating ice front of the Wisconsin glaciation stood at the Valley Heads moraines south and east of Ithaca, the entire Cornell University property was glaciated. An ice tongue extended southeastward up Sixmile Creek Valley to Slaterville Springs, and another extended northeastward up Fall Creek valley past McLean. Cascadilla Creek valley (Ellis Hollow) was presumably ice-filled, although Snyder Hill by then may have emerged through the ice. The ice tongues were actually little more than lateral protrusions from the thick ice that filled the Cayuga trough. This episode in the glacial history of the area is generally correlated with the late Cary substage of the Wisconsin glaciation in the midwestern glacial sequence. A minimum age of 12,000 years can be assigned from the radiocarbon age of wood overlying Valley Heads outwash in Erie Co., New York (Merritt and Muller, 1959, p. 476). Deglaciation must have been rapid, and by 11,400 years ago the ice front was north of King Ferry. Wood in a kettle north of King Ferry, associated with mastodon remains, dated 11,410 ± 410 years old and could not have been deposited until that locality was ice free (Merritt and Muller, 1959, p. 477).

The parent materials of the area were distributed during each of the following phases of the last glaciation, when (1) ice advanced up the Cayuga trough toward the area, (2) ice overrode the area at the maximum of glaciation, and (3) the ice front retreated and proglacial lakes developed in the valleys. The key regional landscape element is the deep trough now occupied by Cayuga Lake, which permitted ice to reach the latitude of Ithaca before the valleys of Fall Creek, Cascadilla Creek and Sixmile Creek were glaciated, and which maintained an active ice front over Ithaca until after the three lesser valleys were deglaciated.

The high banks along Fall Creek north of Varna (figure 1) show the glacial stratigraphy. The lower half of the undercut bank over 100 feet in height exposes poorly sorted, crudely stratified sand and gravel, contorted by ice push. About 90 percent of the pebbles in the gravel are sandstone and shale of local derivation, and about 10 percent are limestone and crystalline erratics from the north. The sand, silt and clay matrix of the gravel is strongly calcareous. This stratified sand and gravel records the damming of lower Fall Creek by ice spreading eastward out of the Cayuga trough, while the headwaters of the creek were still ice-free.

Overlying the sand and gravel is about 40 feet of compact, loam till that records the advance of ice up Fall Creek valley. Only about 70 percent of the till pebbles are of local origin, and most of the remaining 30 percent are limestone or dolomite. The tough, blue-gray loam matrix of the till is strongly calcareous. The upper 10 to 20 feet of the till is oxidized, as evidenced by brown colors. The topmost 4 to 6 feet of till is leached of carbonates, and there are gravel layers and silt lenses in the upper 5 to 10 feet that suggest water reworking.

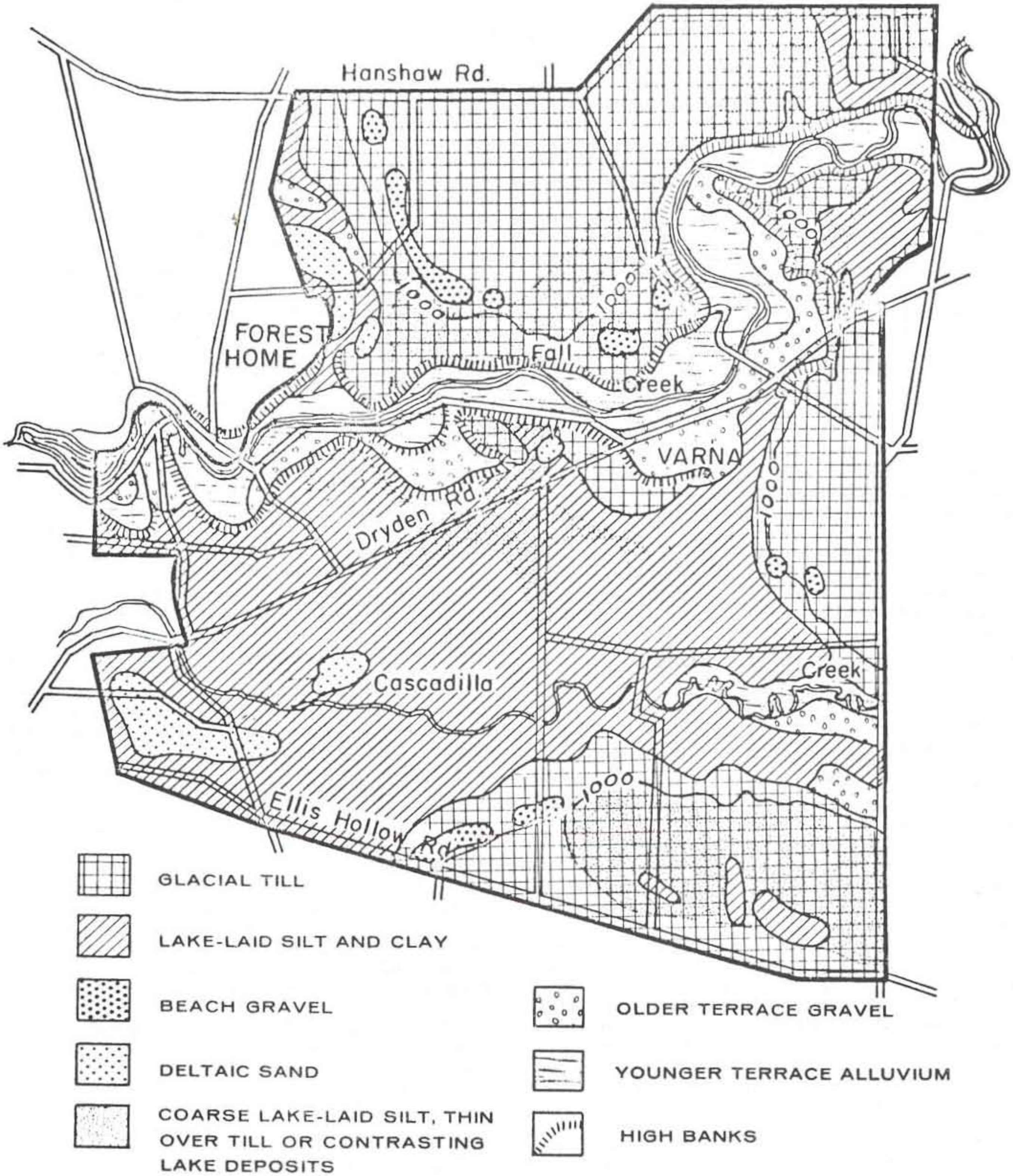


Figure 1. Parent materials of soils of the area.

The till in the high banks is capped by up to 10 feet of water-laid silt, fine sand, and minor amounts of clay. The excellent sorting and horizontal stratification of this layer indicate deposition in a shallow lake with currents sufficient to sweep away most of the clay in suspension. Figure 1 shows the silt to be widespread on the north side of Fall Creek on the Warren, Ketola and Fox farms, and also north of Ellis Hollow Road between Town Line Road and Turkey Hill Road. Over most of the area, the silt is much thinner than in the banks of Fall Creek, generally not exceeding 15 to 20 inches in thickness. The silt extends up to the 1060 foot contour line, and was deposited in a shallow proglacial lake that covered Fall Creek valley east of Forest Home and Ellis Hollow and overflowed south through the steep-walled valley at the head of Ellis Hollow. This lake persisted as long as the retreating ice front pressed against the west slope of Hungerford Hill above the sheep farm, for there was no lower outlet available into Willseyville Creek to the south. Fairchild (1934, p. 249–250) named this Cascadilla Lake, but the area submerged also includes the southern part of what he called Freeville-Dryden Lake.

When the ice front had melted back from the west slope of Hungerford Hill, the final stage of late-glacial deposition began. A large lake named Lake Ithaca (Fairchild, 1934, p. 252–257; Engeln, 1961, p. 93–96) formed from the merging of smaller proglacial lakes in each of the tributary valleys around the south end of the Cayuga trough. The overflow of Lake Ithaca was 2 miles south of Brooktondale at an altitude of slightly over 980 feet, into the head of Willseyville Creek. Lake Ithaca was larger, deeper, and less stirred by currents than the earlier, higher Cascadilla Lake, and clay and silt rather than coarse silt and sand are the dominant sediment types below the shoreline level. All of the lake-laid silt and clay below the 1000-foot contour on figure 1 was deposited in Lake Ithaca. Two patches of similar clayey material on the Fox farm and in the pine plantations northeast of Varna were deposited with the silt of Freeville-Dryden Lake, and two silt-filled basins in the southeastern corner of the mapped area form locally thicker patches of Cascadilla Lake silt.

Two deposits of Lake Ithaca deserve special mention for their soil-forming properties. First, beach gravel eroded from the till along the Lake Ithaca shoreline forms thin gravel veneers over till just below the 1000-foot contour south of Cascadilla Creek and just above the 1000-foot contour on the Warren farm (figure 1). Although these gravel beaches are 10 to 20 feet above the present altitude of the floor of the overflow channel, they may have formed before the channel was eroded to its final depth.

The second unusual deposit of Lake Ithaca is the thin sheet of coarse silt and fine sand that overlies contrasting clayey lake deposits from Caldwell Field eastward in an irregular arc through McGowan Woods (figure 1) and across the experimental plots north of the Game Farm. When the water surface lowered about 80 feet from the former Freeville-Dryden and Cascadilla Lakes to the level of Lake Ithaca, upper Fall Creek began dissecting the newly exposed silty plain of Freeville-Dryden Lake, and washed the coarse silt and sand into the shallow northeast arm of Lake Ithaca.

Lake Ithaca persisted long enough at the 980-foot level and later at the 940-foot level to deeply mantle all gentle slopes below these altitudes with silt and clay. Over most of the area of figure 1 the Lake Ithaca sediment is gray or gray-brown, reflecting a dominantly local source for the rock fragments. On the Savage farm on North Triphammer Road the Lake Ithaca sediments are slightly redder, reflecting a larger contribution of red-colored sediments carried from the north by the main lobe of ice in the Cayuga trough. The Lake Ithaca sediments are moderately to strongly calcareous.

The mapped area includes three small deltas, one at the western edge of the Warren farm, one a very small spot in the southern part of the Cornell Orchard, and the third extending from the New York Artificial Breeders Cooperative through the vegetable crops gardens at East Ithaca (figure 1). The deltaic sand and fine gravel overlie lake-laid silt and clay, and accumulated where streams discharged into Lake Ithaca.

## Postglacial Erosion and Soil Development

As the level of Lake Ithaca fell in postglacial time, progressively lower slopes emerged and the soil-forming processes began. The till on the higher ground north of Fall Creek, on the western slope of Turkey Hill and south of Cascadilla Creek already had been exposed for some time. The soils developed in this till have well expressed fragipans and typically are somewhat poorly drained. The catena of soils that includes the Langford, Erie, and Ellery series is mapped where till extends to the surface.

The thin deposits of coarse silt from Freeville-Dryden Lake and Cascadilla Lake above the Lake Ithaca shore were the next units to be exposed to soil formation. Recognizable remnants of these deposits range in thickness from as little as 12 inches to as much as 30 inches, but they are mainly of the order of 15 to 20 inches thick. The moderately well drained Canaseraga and the somewhat poorly drained Dalton series have been mapped where these mantles of silty or very fine sandy materials are thick enough over the till to be recognized as distinct deposits but not thick enough that the entire solum of the soil is in the mantle. In most places the thickness of the deposit is of the order of 15 inches, which is the minimum required for recognition of these two series. Consequently, these soils have been named 'thin mantle phases" of Canaseraga and Dalton soil types to indicate that they are intergrades to the Langford and Erie soils, which are in glacial till without the mantle. In the soil survey of Tompkins County (United States Department of Agriculture, 1965) the Canaseraga and Dalton series are not recognized and these areas are shown as Langford and Erie soils and are described as inclusions.

The high-level clayey deposits of Freeville-Dryden Lake on the Fox farm and in the pine plantations west of Monkey Run Road and south of Fall Creek have developed fine textured soils that have been included in the Hudson and Rhinebeck series. These are mentioned specifically because they lie at distinctly higher elevations than other areas of lake-laid silt and clay and are slightly older than the deposits of Lake Ithaca.

The beach gravel and deltas of Lake Ithaca were the next units to begin developing soils. The soil on the beach gravel is essentially a Chenango soil, but it overlies glacial till at shallower depth than is typical of the central concept of the series. These soils have been indicated as "Chenango gravelly loam over till." The adjacent lower areas are wet and have many seep spots. These areas have been mapped either as a complex of the poorly drained Ellery and somewhat poorly drained Erie soils or, where better drained, as a gravelly loam type of the Langford series. The Arkport series is mapped on the sandy deltas.

As Lake Ithaca continued to fall, the coarse silt and very fine sand veneer of the Caldwell Field-McGowan Woods area was exposed. This deposit is mainly 30 to 40 inches thick over more clayey sediments typical of the Collamer series. The deposit not only is distinctly coarser, but also is more acid than the materials associated with the Collamer soils.

The soils that have formed in it have been included in the Williamson series, which is characterized by a color B overlying a silty or very fine sandy fragipan. Though these soils are within the range of the Williamson series, they are influenced by more clayey material, like that of Collamer soils, in the lower part of the solum in most areas. Consequently, the fragipan is less strongly expressed than is typical of the central concept of Williamson soils. For this reason, these soils have been identified as "weak fragipan phases" of the Williamson soils. They are intergrades to the Collamer series and are inclusions in map units of the Collamer series in the Tompkins County Soil Survey (United States Department of Agriculture, 1965).

Where the coarse silt veneer thins southward and merges with the normal Lake Ithaca silt and clay across Caldwell Field, the Cornell Orchards, the Poultry Range, and the north edge of the Game Farm, the soils contain more clay but are still dominated by silt. The soils on these areas are identified as members of the catena whose well drained member is Dunkirk. Most of these areas are not so well drained as Dunkirk, however, and Collamer, the moderately well drained member of the catena, is the most extensive soil. Niagara, the somewhat poorly drained member, is a major associate. The poorly drained Canandaigua soils occupy the lowest-lying areas.

The soils of the western part of the Cornell Orchards, those south of Cascadilla Creek, and those on the Reed farm are higher in clay, mainly having silty clay or heavy silty clay loam B and C horizons. Most of these areas are somewhat poorly drained and are included in the Rhinebeck series. On the distinctly convex land forms of these areas, the Hudson series has been mapped, and in the poorly drained depressions and along drainageways, the soil is mainly Madalin. Small areas of soil in fine textured material at the western edge of the Warren farm are also included in these series.

The Savage farm, which is not shown on figure 1, lies well below the beach of Lake Ithaca and is almost entirely on silt and clay typical of those mapped in the Rhinebeck and Hudson soil series. The soils in this area are slightly redder than those in similar materials along Cascadilla Creek and reflect the contribution of red-colored sediments carried by the main lobe of ice in the Cayuga trough.

Fall Creek has had a complex postglacial history. As the succession of proglacial lakes in the Cayuga trough gradually fell to the level of present Cayuga Lake, Fall Creek has energetically re-excavated its interglacial valley. The thin cap of silt from Freeville-Dryden Lake was cut through while Lake Ithaca still drained through Willseyville Creek. Subsequently, Fall Creek established its postglacial course down the side of the Cayuga trough, soon to become superposed across buried rock spurs to give the succession of gorges and falls along the north edge of the campus. North of Varna, Fall Creek has not yet exposed its former rock floor, and flows over till capped by a thin gravel floodplain. The terraces and abandoned meanders of Fall Creek are cut into the stratified sand and gravel that form the bottom half of the valley fill. The gravel is non-calcareous, and when the calcareous fines were washed out by the stream, the gravel terraces developed acid soils.

Four levels of terraces and abandoned meanders apparently record temporary halts in the postglacial downcutting of Fall Creek valley. The highest level, typified by the eastern half of the plant breeding area north of Varna and the terrace that lies south of and at a higher elevation than the rose gardens, is clearly older than the other terraces and is mapped as "Older Terrace Gravel" in figure 1. On these highest terraces a well expressed 'Sol Brun Acide" profile has developed in gravelly material, and on these areas, the Chenango series has been mapped. Though these terraces are the highest in the valley, they lie well below the beaches of Lake Ithaca and must postdate the time at which the ice had receded far enough northward to permit the level of Lake Ithaca to fall at least as low as 900 feet above sea level.

The second series of terraces is only a few feet or a few tens of feet lower than the Chenango terraces described, but the soils on them are clearly much younger. The material is mainly gravelly or very gravelly and appears to be similar lithologically to that of the higher-lying Chenango terraces. The soils, however, have only faintly expressed color profiles and, on this basis, are judged to be distinctly younger than soils of the Chenango terrace. They flood occasionally, but they are distinctly higher than the current first bottomlands. Though higher and certainly somewhat older than the bottomland, these intermediate terraces have little evidence of greater expression of a genetic soil profile. Consequently, these soils have been included in the Tioga series as 'high bottom phases." These areas are typical of the rose gardens and the areas used by plant breeding both east and west of Freese Road (figure 1). The soils are strongly acid, and though pH may be higher deep in the substratum pH does not increase to values of 6 or above within the 3-foot section in most places.

The next lower terraces are subject to more frequent flooding, though they lie only a few feet lower than the "high bottoms." These soils are relatively free of gravel in the topmost two or three feet and are in recent alluvium. They are typically acid in the topmost several inches, but pH increases with depth and is commonly greater than 6 at a depth of 36 inches. The well drained soils have been included in the Tioga series; the moderately well drained soils, in the Middlebury series. Though these areas flood relatively frequently, the rate of deposition is apparently slow, and distinct A1 and very weak color B horizons have developed. The degree of genetic profile expression is comparable to that on the adjacent higher Tioga terraces.

Adjacent to the present course of the stream are areas where flood waters very frequently cut and recut new channels and deposit much very coarse material. These areas are mainly covered with vegetation. The soil on these areas has little genetic profile and is very heterogeneous. It is mapped as Alluvial land, a unit in which soils are unclassified.

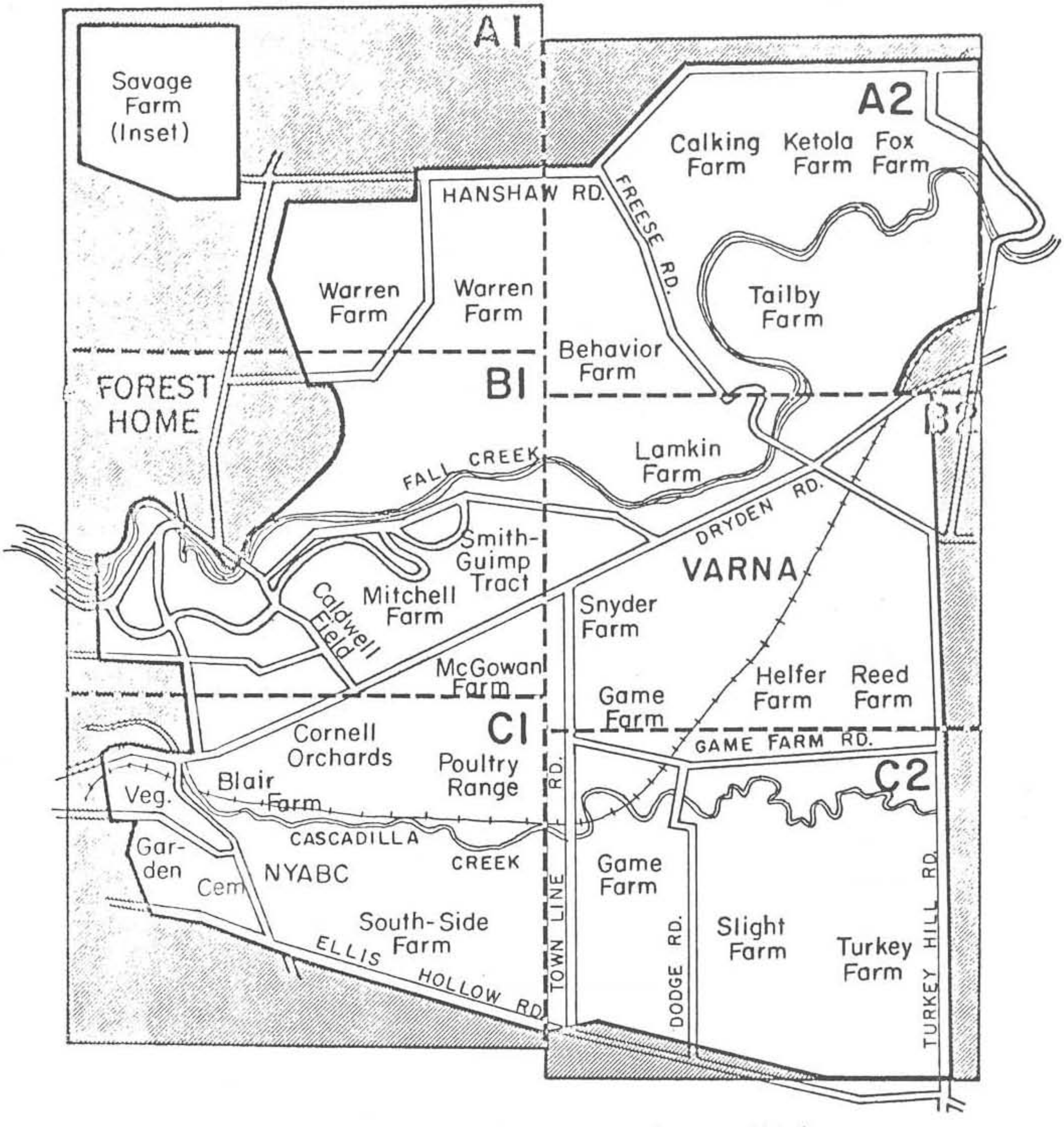


Figure 2. Index to principal Cornell properties and soil survey map sheets on which they occur.

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ABSTRACTS

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## GEOPHYSICAL INVESTIGATION IN THE NORTHERN ADIRONDACKS

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### ABSTRACT

In conjunction with a summer field study, gravity and seismic measurements were made in the Adirondacks along a traverse extending north from Paul Smiths to McColloms. The alluvium covering the bedrock was investigated and the effects of saturated versus unsaturated alluvium and granite are shown. The seismic and gravity data include the contact of the anorthosite body with a granite gneiss and a possible transition zone.

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## FOSSIL INVERTEBRATE GROWTH AS A GEOCHRONOLOGICAL TOOL

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### ABSTRACT

The growth patterns of recent and fossil Coelenterata and Brachiopoda reflect variations in food abundance, water temperature, and percentages of biogenic salts, in temperate oceans, caused by cyclic passages of time. These variations give rise to definite biological seasons, which remain constant from year to year due to their dependency on light intensity; the passage of these seasons is recorded on the exoskeletons of these organisms. The resulting growth features are grouped into annual increments, seasonal markings, monthly markings, and daily growth increments.

Lower Silurian Coelenterata and Brachiopoda indicate that the length of the year during this period was 421 days; the length of the synodic month was 32.4 days, with 13 synodic months per year. Upper Silurian Coelenterata and Brachiopoda indicate that the length of the year was 416 days; the length of the synodic month was 32.2 days, with 13 synodic months per year. Studies on similar Devonian invertebrates indicate that the length of the year during this period was 410 days, with 31.5 days per month, and 13 synodic months per year.

Paleontological data indicate that the length of the year throughout geologic time has decreased, though not at a uniform rate. These results are contrary to previous assumptions based upon geophysical computations. Also, evidence suggests that the moon originally was closer to the earth, resulting in a magnification of the earth's tidal forces. This might be a contributing cause for the scarcity of fossils representing the earlier geological periods and, as Lamar and Merifield (1967) suggest, a stimulating factor for the evolution of organisms with hard parts.

## PETROGENESIS AND EMPLACEMENT OF THE ALKALINE INTRUSION OF CUTTINGSVILLE, VERMONT: A REEVALUATION

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### ABSTRACT

Detailed mapping in the field, and petrographic and X-ray analyses of rocks in the laboratory were carried out to determine the origin and evolution of the igneous complex at Cuttingsville (Rutland County), Vermont.

The northwest trending intrusion (2.25 km. long; 1.65 km. wide) consists of alkaline plutonic and hypabyssal rocks typical of the White Mountain Magma Series, which intruded the Precambrian core of the Green Mountain Anticlinorium during the Middle to Upper Mesozoic time.

Two petrographic suites and eight phases of intrusion have been recognized and are listed below in order of emplacement:

A. Saturated magma suite

1. Monzogabbro
2. Hornblende syenite and biotite syenite (pulaskite)
3. Monzogabbro porphyry
4. Quartz syenite (perthitic)
5. Quartz syenite (non-perthitic)

B. Undersaturated magma suite

6. Essexite (feldspathoidal gabbro)
7. Sodalite syenite

Injection of numerous late dikes (eighth phase of intrusion), ranging in composition from lamprophyres to felsite porphyries, was facilitated by the prior development of steeply dipping sets of radial and tangential joints.

Spatially these units form a ring structure, having been emplaced as concentrically arranged lenticular bodies. The contact between the discordant intrusion and the Precambrian metamorphic country rock is sharp but irregular, and is characterized by a zone of abundant gneissic xenoliths and injections of syenite.

The evidence indicates that the intrusion was emplaced by ring-fracture stoping, as other stocks in Vermont of the same magma series. The intrusion of two distinct petrochemical suites, however, seems unique to Cuttingsville.

## UNUSUAL THRUST FAULTING AND OVERTURNING, FLY MOUNTAIN, ULSTER COUNTY, NEW YORK

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### ABSTRACT

The south end of Fly Mountain is located at the southwestern end of the Kingston arc complex, within the Appalachian fold belt.

Devonian, Silurian, and Ordovician, shales, carbonates, and sandstones are variously incorporated in the overturned limb of a recumbent fold overthrust by a syncline which forms the bulk of the mountain.

The thrust plane dips 9-12 degrees to the southeast and trends N50E. Middle Ordovician (Martinsberg? - Mohawkian?), Upper Silurian (High Falls, Binnewater, and Rondout - Cayugan), and Lower Devonian (Manlius and Coeymans - Helderbergian) formations are thrust upon overturned Lower Devonian (Port Ewen, Connelly, Glenerie, and Esopus - Helderbergian and Ulsterian) formations. A minimum lateral displacement of 1400 feet is estimated. It also appears that the southern end of the mountain has been rotated 20-25 degrees to the northwest, around a hinge near Kingston.

The structure of the southern end of Fly Mountain is noteworthy because of the magnitude of both the overturning and the thrust, each seemingly unparalleled in the Kingston-Rosendale area.

# COMPOSITION AND FABRIC OF OLIVINES FROM SELECTED ADIRONDACK METAGABBROS

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## ABSTRACT

X-ray determinations of the d (130) spacings in olivines from three layered metagabbros (Jay Mountain, Tahawus Club, and Texas Ridge) in the eastern Adirondacks show compositions in the range $Fo_{65}$ - $Fo_{79}$. In two of the bodies compositions are uniform but exhibit significant variation in the third, suggesting the possibility of crytic layering. Metamorphic reactions between plagioclase and olivine have produced 3-ply coronas and may have affected olivine compositions.

Petrofabric analysis of olivines from an olivine-rich layer revealed that concentrations of $\alpha$ poles are normal to the plane of the megascopic foliation, and $\beta\gamma$ girdles in this plane are complicated by $\gamma$ substitution for $\alpha$ poles. These patterns are attributed to laminar flow during intrusion.

# NEW EVIDENCE CONCERNING THE VALLEY HEADS PROBLEM

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## ABSTRACT

In studying the location of moraines in Central New York and their relation to recessional or terminal ice positions of Wisconsin time, it was resolved that there is no continuous belt of moraines constituting a time boundary. Noting that maps by previous authors locating the "Valley Heads Moraine" differed greatly when reduced to the same scale, led the author to investigate the distribution of glacial drift and the location of morainal belts in the Groton, Cortland, Dryden, and Harford topographic quadrangles. A map of the surficial geology was constructed using a catena diagram which relates soil series to parent material. Soil information was taken from the soil surveys of Cortland and Tompkins Counties. The vast majority of the drift is acid till covering the uplands and glacial outwash fills the valley. Both till and outwash decrease in lime content to the south. Lacustrine sediments and deltaic material suggest the presence of pro-glacial lakes especially in the valleys radiating from Dryden. Colluvial material and alluvium also can be located. Field work failed to locate drift of different ages. Conclusions based on the surficial map, constructional topography and field work are (1) the name Valley Heads should be dropped since there is no continuous moraine located in the area; (2) the several moraines occurring in the valleys of the region be renamed according to their geographical location, that is, the Tully Moraine, the Scott Moraine, etc. - such nomenclature indicates the independent status of the ice lobes in each valley; (3) deglaciation in the region of Central New York occurred as vertical ablation rather than lateral retreat.