THE ONONDAGA LIMESTONE AND THE SCHOHARIE FORMATION IN SOUTHEASTERN NEW YORK

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TRIP A

Correlation and facies changes in the Schoharie and Onondaga Formations; relationship to the Esopus Formation; relationship of the outlier at Highlands Mills to the main belt along the Catskill Front.

Editor's Note: This trip was organized by John Johnsen in Poughkeepsie, William Oliver in Washington and John Southard in Cambridge. The presentation consists of a paper on the Onondaga in the Front area by William Oliver, a paper by John Johnsen and John Southard as co-authors on the Schoharie in the Front area and the Schoharie and Esopus in the outlier, and combined notes and discussion of the situation at each scheduled stop.

THE ONONDAGA LIMESTONE IN SOUTHEASTERN NEW YORK[1]

by William A. Oliver, Jr.[2]

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Introduction

The Onondaga Limestone in New York is a complex of lithic and faunal facies that has been subdivided into four members of more or less constant age across the state. In central New York, these members are further subdivided into a succession of 12 local faunal zones which persist laterally for several tens of miles. Lateral changes permit the recognition of several facies within each member. One purpose of the present trip is to observe the facies changes along the outcrop belt between Catskill, Kingston, Wawarsing, and Port Jervis, a total distance of about 50 miles. In the following paragraphs, the formation is first discussed in its type area near Syracuse, then in the Helderberg escarpment just north of the trip area, then in the trip area itself, and finally in the vicinity of Stroudsburg, Pennsylvania, just south of the trip area.

The Type Area

In the type area near Syracuse, New York, the Onondaga Limestone has been subdivided into four members (Oliver, 1954). From the bottom these are:

Edgecliff Member: Light-gray, coarse-grained limestone in beds ranging from half a foot to 3 feet in thickness. Light-gray chert is common in the upper part, but in places, especially toward the east, it is found throughout the member. The Edgecliff Member is characterized by solitary rugose and tabulate corals which in places are so abundant as to form coral biostromes. The matrix consists of crinoidal debris; certain large columnals, three-fourths inch in diameter, are characteristic. Brachiopods are found at most exposures but are not common. The member is 8 feet thick at Syracuse and thickens toward the east.

Nedrow Member: Shaly limestone grading upward into more massive fine-grained limestone. The lower part of the member is characterized by an abundance of platyceratid gastropods and two species of solitary coral, but both are less common upward. Brachiopods are very common, but the same species range into the overlying Moorehouse Member. The thickness ranges from 10 to 15 feet.

Moorehouse Member: Medium-gray, fine-grained limestone with black chert throughout but especially abundant in the upper half. A variety of brachiopods, gastropods, small corals, nautiloid cephalopods, and trilobites form the largest and most varied fauna of any of the members. The thickness ranges from 20 to 25 feet.

Seneca Member: A succession of distinctive beds of fine-grained limestone similar to the upper part of the Moorehouse in the lower part, but becoming darker and less cherty upward. The basal unit of the member is the Tioga Bentonite (of Fettre, 1952); successive beds are characterized by the brachiopod Chonetes lineatus and a few additional brachiopod and coral species. This member grades upward into the Union Springs Black Shale (of Cooper, 1930).

The Helderberg Area

Facies changes east and southeast of Syracuse have been described by Oliver (1954, 1956a). Changes in the Helderberg area, just north of the field trip, are summarized in the following paragraphs.

The Edgecliff Member maintains the same lithology and fauna as in the type area, but is represented by a bioherm (reef) facies at many localities from Richfield Springs east to the Helderbergs and south to Coxsackie (Oliver, 1956b). The southeasternmost reef is just 10 miles north of Leeds (stop 2). The normal thickness of the member in this area is 30 feet.

The Nedrow Member passes eastward into a lithology like that of the Edgecliff Member. Although not shaly, the Nedrow is thin bedded in its lower part and is characterized by the same species of platyceratid gastropods and corals as in the type area. Associated with these are a variety of brachiopod and coral species not limited to the member. The thickness in the Helderbergs is the same as in the type area.

The Moorehouse Member thickens to the east and is about 70 feet thick in the Helderbergs where it is divisable into three distinct units: a lower noncherty unit, a middle unit with dark-gray chert, and an upper noncherty unit. All three units are lighter colored and coarser grained than in the type area, but the middle cherty unit is darker and finer than the other two. In the Helderberg area the lower and upper units are lithologically similar to the Edgecliff Member. The typical Moorehouse fauna persists to the east, but a larger variety of Edgecliff-type corals is present.

East of the type area the Seneca Member grades laterally as well as upward into the Union Springs Black Shale of the Marcellus Formation (Oliver, 1956a, p. 1466) and the Onondaga-Marcellus contact is time-transgressive. The Seneca Member is not present east of Cobleskill and the Moorehouse Member grades upward into the black shale in the Helderberg area.

Southeastern New York

(Field Trip Area)

From the Helderbergs, the Onondaga outcrop belt extends south to Catskill and Kingston, then southwest along the Rondout Valley to Wawarsing and Port Jervis. Lithologic and faunal changes are described in detail in connection with the individual stops but are summarized here. Onondaga stratigraphy in this area was described by Oliver (1956a).

Edgecliff Member: At Leeds near Catskill, and at Kingston (stops 2 and 4), the Edgecliff Member is somewhat thicker (36 feet) and much more cherty than in the other area described. Corals are less common but the characteristic large crinoid columnals are present throughout the member. Farther southwest at Wawarsing (stop 5), the Edgecliff is a thinner, darker, and finer-grained limestone with little chert. Fossils include the characteristic crinoid columnals, small corals and scarce brachiopods, bryozoans, etc. At Wawarsing and farther south, the Edgecliff is recognized mainly by its large columnals.

Nedrow Member: The eastern facies of this member as described for the Helderbergs persists as far south as Kingston. At Leeds (stop 2) and Kingston (stop 4) the member is lithologically similar to the Edgecliff. At Leeds some 43 feet of platyceratid-bearing beds are referred to the Nedrow. The thickness at Kingston is unknown, but at Saugerties (midway between Leeds and Kingston) the Nedrow is approximately 34 feet thick. South of Kingston the platyceratids disappear and the member cannot be distinguished from the Moorehouse Member.

Moorehouse Member: No complete section of this member is known in the field trip area. In the Leeds-Kingston area the lithology and subdivisions are as described for the Helderberg area and the member is predominantly a medium-light-gray, medium-coarse-grained limestone. Southwest of Kingston at Wawarsing (stop 5) the lower 50 feet of the member is darker and has a less varied fauna. Exposures in small quarries near Ellenville, just southwest of Wawarsing, indicate that the lighter and coarser limestone persists in the higher part of the member at least that far south. At Port Jervis, only small exposures are known, all lithologically similar to the Wawarsing outcrop. The Moorehouse thickness increases from 70 feet in the Helderbergs to more than 100 feet at Saugerties. The thickness at Port Jervis is estimated at 190 feet.

Seneca Member: The uppermost member of the type Onondaga is replaced in the Helderbergs by the lower part of the Marcellus Shale. No exposures of the uppermost part of the Onondaga are known in the trip area, but it is unlikely that the member reappears in southeastern New York.

Southwest of Port Jervis

Thirty-five miles southwest of Port Jervis, just northeast of Stroudsburg, Pennsylvania, the Buttermilk Falls Limestone of Willard (1939, p. 144) is the approximate equivalent of the Port Jervis Onondaga. The

basal 20 to 30 feet of the Buttermilk Falls contains the characteristic large crinoid columnals of the Edgecliff Member, but it is otherwise similar to the overlying beds.

According to D. C. Alvord of the U. S. Geological Survey, Willard's Buttermilk Falls Limestone includes an upper unit with interbedded shale, approximately 50 feet thick, and a lower, more massive, cherty unit, 150 feet thick (oral communication, 1961). Both units are finer and darker than the Helderberg Onondaga and the lower one is similar in all respects to the Onondaga exposed in the Wawarsing-Port Jervis area.

Between Kingston and Stroudsburg, the typically lighter colored and coarser Onondaga passes into the darker and finer Buttermilk Falls type of lithology. The northeastward extent of the shaly upper unit of the Buttermilk Falls is unknown. However, it may extend into New York, and lack of upper Onondaga outcrops in the Wawarsing-Port Jervis area may indicate that this part of the formation is less resistant to erosion.

Formation Thickness

The eastward thickening of the Onondaga Limestone is indicated by the following approximate figures:

Syracuse	65 to 70 feet thick
Morrisville	90
Cherry Valley	118
Helderberg area	115

South of the Helderbergs in the trip area the formation has a minimum thickness of 165 feet at Saugerties, midway between Leeds and Kingston. At Port Jervis the thickness is probably no more than 200 feet, the known thickness at Stroudsburg, Pennsylvania, 35 miles to the south.

Age of the Onondaga

Oliver (1960) has recently summarized the faunal evidence for a Middle Devonian (Eifelian) age for the Onondaga Limestone. Two coral faunas are recognized in this part of the Devonian in western New York, the lower one being limited to the sub-Edgecliff *Amphicoenia* zone (zone B, 2 feet thick, of Oliver, 1954). In the Helderberg region some elements of this lower coral fauna are found in the typical Schoharie Formation (of Vanuxem, 1840, p. 378). The lower corals themselves are largely endemic and do not bear on the age question. Associated brachiopods are of Early Devonian (Emsian) age, according to A. J. Boucot (oral communication, 1961).

The upper coral fauna is abundantly represented in the Edgecliff Member and in the eastern facies of the Nedrow and Moorehouse Members. These corals indicate a Middle Devonian (Eifelian) age for the Onondaga Limestone in central and eastern New York. Nautiloid cephalopods in the Nedrow and Moorehouse Members and rare goniatites in the Nedrow Member support this age assignment (Flower and House in Oliver, 1960, p. 174).

In the Wawarsing-Port Jervis area corals are not common and the more diagnostic forms do not appear. Correlation is based on tracing the large crinoid columnal beds from the type area and the Helderbergs, south to Port Jervis and Stroudsburg. Such a thin and persistent zone is not likely to vary significantly in age in this short distance. It is concluded that the Onondaga Limestone, in the Wawarsing-Port Jervis area, and the Buttermilk Falls Limestone, in the Stroudsburg area, are of Middle Devonian age.

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THE SCHOHARIE FORMATION IN SOUTHEASTERN NEW YORK

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Introduction

This article was prepared from three sources: (1) a paper by Johnsen (1957) which presented a major revision of the Schoharie Formation; (2) an unpublished paper by Southard (1960) dealing in part with rocks of Esopus and Schoharie age in the northern part of a narrow outlier southeast of the main belt of Esopus and Schoharie outcrop; and (3) notes from one summer's field work by Southard in 1961 to work out in more detail the stratigraphy of the Esopus and Schoharie Formations along the main belt of outcrop from Leeds to Port Jervis, New York. Since this article is based on independent work of both writers, neither assumes the status of senior author. The general statement about the Schoharie was written by Johnsen and is based entirely on his work. The description of the Schoharie in the field trip area, exclusive of the outlier, was written by Southard using Johnsen's work as a basis and incorporating his own views (involving a few major changes)[3]. The section on the outlier is entirely Southard's.

The Schoharie Formation Redefined

- A General Statement -

Detailed stratigraphic and petrographic studies permit redefinition of the Schoharie Formation. It is a complex of lithologic facies extending along the Devonian (Onesquethaw) outcrop from Herkimer County, New York, at least to Monroe County, Pennsylvania, a distance of more than 200 miles (Fig. 1). The formation thickens south to Port Jervis, New York, and thins again in New Jersey and Pennsylvania (Fig. 3). The general character of the Schoharie succession is that of a moderately thick transition zone of mixed clastic carbonate rocks lying above the dominantly clastic rocks of the Esopus Formation and below the carbonate rocks of the Onondaga Formation.

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3. These changes concern the recognition of the black bed in the Carlisle Center Member (p. 11), the nature of the contact between the Carlisle Center and Aquetuck Members (p. 13), and the tracing of the Aquetuck Member south from Leeds (p. 13).

Several subdivisions are recognized. The lowest subunit is designated the Carlisle Center Member. It consists primarily of calcareous mudstone and calcareous siltstone and is characterized by a sparse fauna made up of small forms. Taonurus cauda-galli is common in east-central New York (Herkimer to Albany counties), less common in the Mid-Hudson Valley and rare in southeastern New York. A more detailed description of the Carlisle Center follows in the section on the field trip area.

The Carlisle Center Member, for the most part, corresponds to the "Carlisle Center Formation"[4] of Goldring and Flower (1942). These authors applied the name "Carlisle Center Formation" to 20 feet of shale which were formerly included in the upper part of the Esopus Formation and which underlie the "Schoharie Formation" of Vanuxem (1840) in Schoharie and Otsego Counties, New York. They pointed out (op.cit., p. 690) that these beds are present along the belt of outcrop to Port Jervis, New York, where they measure 200 to 225 feet. At Leeds in the Mid-Hudson Valley and at Port Jervis, beds assigned by Goldring and Flower to the "Carlisle Center Formation" are correlated with the Esopus Formation. In these localities, the Carlisle Center Member is higher in the section.

Except in portions of east-central New York, the contact with the Esopus Formation is placed at the bottom of the lowest beds of siltstones or mudstone sufficiently calcareous to effervesce in cold dilute hydrochloric acid. North of Kingston, New York, the base is locally marked by glauconite; south of Kingston, a persistent zone of Leptocoelia acutiplicata aids in defining the base.

The Rickard Hill Member lies above the Carlisle Center Member in east-central New York and corresponds to the "Schoharie Formation" of Vanuxem (1840). It consists principally of sandy limestone and calcareous sandstone containing may brachiopods and conspicuous cephalopods. Some of the rock is argillaceous sandy limestone and calcareous argillaceous sandstone. The member ranges in thickness from a thin film, where it wedges out one mile southwest of East Springfield, New York, to six feet in Schoharie and western Albany Counties. Variations in thickness are not regular but general eastward thickening is apparent. At places glauconite is abundant in the lower part of the member.

The Rickard Hill Member passes laterally into finer calcareous strata in southern Albany County which are readily divisible into two subunits in the Mid_Hudson Valley. The lower subunit, designated the Aquetuck Member, is composed of calcareous siltstone with minor argillaceous limestone and calcareous sandy mudstone. Chert is present within the member in the upper Mid-Hudson Valley, but the chert diminishes rapidly to the south as the subunit becomes vaguely banded and limier. Glauconite is present in association with sand-size grains of detrital quartz in some sections. The member carries meager fauna in all sections.

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4. Originally Sharon Springs Formation, a name subsequently found preoccupied. Winifred Goldring and R. H. Flower, Discussion: Am. Jour. Sci., vol. 242, 1944, p. 340.

The upper subunit, or Saugerties member, is distinguished by conspicuous layers of limestone alternating with layers of calcareous mudstone, calcareous argillaceous sandstone or argillaceous limestone which often contain varying amounts of quartz sand in Albany, Greene and Ulster Counties. Southward pure limestone is absent and the Aquetuck and Saugerties Members gradually become increasingly difficult to separate in the field.

Except for the Richard Hill Member, the Saugerties is the most fossiliferous subdivision of the Schoharie formation. The fauna is not restricted to any one rock type. Brachiopods exceed all other faunal groups in numbers of individuals and species. A few fragmentary orthoceracones and cyrtoceracones, typical of the Rickard Hill Member, are present in highest Saugerties beds in the upper Mid-Hudson Valley, suggesting contemporaniety with the Rickard Hill Member.

In the Port Jervis region, all members of the Schoharie Formation are nearly alike in composition, texture and appearance. At Trilobite Mountain, the Carlisle Center beds are limier upward and, by imperceptible changes, the rock gradually takes on the lithology of the upper members. The selection of the exact position of the boundary between the lower and upper divisions is a matter of opinion.

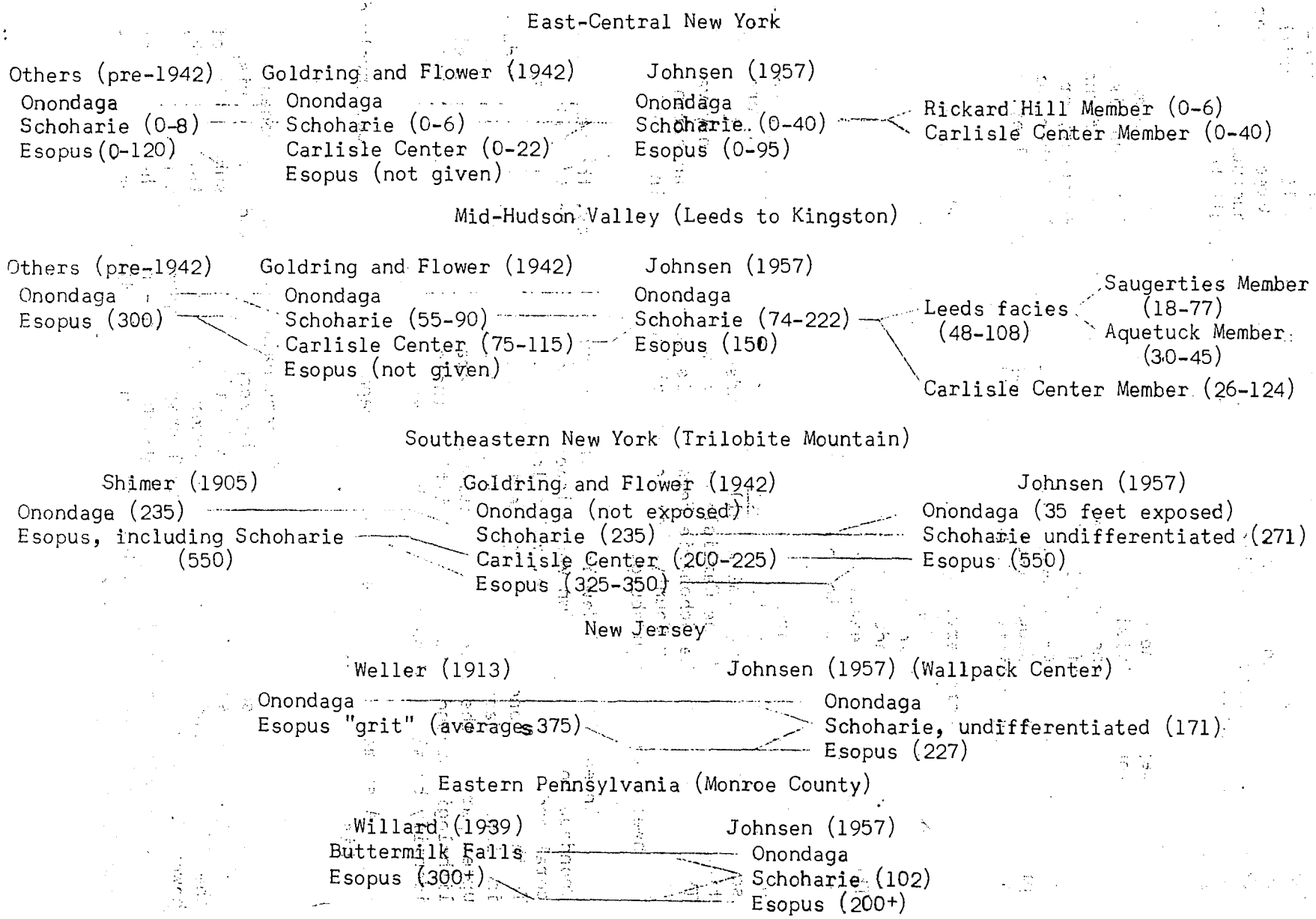
Sections are rare and incomplete in New Jersey and eastern Pennsylvania. Persistance of the Leptocoelia zone to Experiment Mills, one mile south-southwest of Buttermilk Falls (Stroudsburg region) serves to distinguish the base of the Carlisle Center in Monroe County, Pennsylvania. The upper part of the Schoharie Formation is marked by the appearance of quartz sand in Sussex County, New Jersey, which increases in quantity southwestward to Stroudsburg.

In east-central New York and the Mid-Hudson Valley, the Schoharie-Onondaga boundary is drawn where lowest Onondaga limestone is typically a coral and crinoid biostrome, which locally may pass into a bioherm facies. To the south, conditions of sedimentation were more nearly uniform producing lower Onondaga sediments very similar in appearance to those of the upper part of the Schoharie Formation. Separation is difficult on purely lithologic grounds, but characteristic crinoid columnals (Oliver, 1956) identify basal Onondaga to Stroudsburg, Pennsylvania.

A summary of the usage of stratigraphic names for the rocks involved in this study is given in Figure 2.

NOTE: Within the last year, Southard (personal communication) began a restudy of the Esopus-Schoharie rocks between Catskill and Port Jervis, New York. He essentially shares the writer's views on the subdivision of the Schoharie and the placing of the lower and upper contacts. His work, however, has resulted in some internal changes regarding the position of the Schoharie subdivisions in the Kingston region - namely the placing of the Carlisle Center-Aquetuck boundary. Southard's discussion in the section that follows is based on his point of view.

FIGURE 2. THICKNESS OF SCHOHARIE FORMATION (IN FEET) AND USAGE OF STRATIGRAPHIC NAMES



The Schoharie Formation in the Field Trip Area

Carlisle Center Member

The Carlisle Center Member consists of calcareous mudstone with interbedded muddy limestone layers of varying degrees of distinctness. There exists a complete range of beds of rock type intermediate between muddy limestone and slightly calcareous mudstone. The most calcareous beds are thin (4-12 inches), distinct, and widely spaced (2-10 feet). They weather light and are less affected by cleavage than the calcareous mudstone. The less calcareous beds, which comprise most of the member, are thicker and less distinct than the muddy limestone beds. The member shows a gradual increase in lime content upward, so that most of the calcareous beds occur in the upper part; moreover, as the member thickens southward, these highest calcareous beds become more distinct.

The rocks of the member display prominently the results of activity of burrowing organisms. The tubular burrows, 1-5 mm thick, tend to be flattened in the plane of the bedding. They appear both as spots and streaks on weathered surfaces. They show sharp contacts with the surrounding sediment. The organisms have blurred the contacts between layers (such contacts are either abrupt or gradational) by carrying sediment from one layer down into another, resulting in light weathering burrows in dark weathering sediment, or vice versa. Taonurus cauda-galli markings are present in the lowest part of the member as far south as Kingston.

A distinctive two- to three-foot black bed consisting of very hard fine-grained siliceous slightly calcareous rock (not true chert) is present in all sections in the main belt of outcrop from Leeds to Wawarsing, except at Catskill. It is black where fresh and black to reddish purple where weathered. Its extent north of Leeds and south of Wawarsing is uncertain. At Trilobite Mountain (1 mile NE of Tristates, N.Y.) the part of the section in which the bed should occur is not exposed. Its character and great lateral extent suggest that it represents some sort of relatively brief episode of chemical deposition superposed on the normal Carlisle Center deposition.

In all sections from Leeds to Trilobite Mountain the Carlisle Center Member is underlain by the Esopus Formation. The contact is well exposed in most sections from Leeds to Kingston, but at Wawarsing and Trilobite Mountain it is covered. Although the calcareous mudstones of the Schoharie rest with abrupt contact on the non-calcareous mudstones of the Esopus wherever the contact is exposed, there is physical evidence of disconformity only at the railroad cut in Kingston. There the lowest bed of the Carlisle Center truncates the strata of the Esopus at a small angle. This truncation seems to be merely a local feature, however, because where the contact is exposed along the railroad tracks a few hundred yards east of the main section (p. 17) there is no evidence of truncation, the contact having the same character as in sections elsewhere. Glauconite and quartz sand grains are present in the lowest beds of the member wherever the contact can be observed. A break in deposition between the Esopus

and Schoharie is likely, even though a disconformable relationship can be proved in only one locality, because of the abruptness of the upward change from non-calcareous to calcareous strata and the presence of glauconite and quartz grains in the basal beds of the Carlisle Center.

Glauconite grains and quartz sand and fine pebbles also occur in the upper part of the Carlisle Center Member. This is discussed in connection with the lower contact of the Aquetuck Member (see below).

Aquetuck Member

At Leeds the Aquetuck Member consists of interbedded calcareous mudstone and muddy limestone with abundant thin layers of dark-weathering cherty rock not sharply distinct from the calcareous mudstone, and layers of small chert nodules. The muddy limestone layers are similar to those in the upper part of the Carlisle Center Member to the south, as is the nature of the interbedding. To the south (Kingston) the chert nodules disappear and the thin dark-weathering layers in the calcareous mudstone become inconspicuous (but do not disappear). Layers of 3- to 10-inch nodules of light-gray-weathering slightly muddly limestone that show abrupt contacts with the surrounding calcareous mudstone are present instead of continuous layers of muddy limestone. The nodules contain less mud than the limestone beds in the Aquetuck at Leeds or in the underlying Carlisle Center. South of Kingston, exposures of the upper part of the member are poor; the lower part is the same as at Kingston except that the layers of limestone nodules are more widely spaced and the nodules are larger. The member as a whole becomes more calcareous upward, so that in the upper part the calcareous mudstone verges on very muddy limestone. Burrow markings are present throughout the member but are not as conspicuous as in the Carlisle Center.

Although the contact between the Carlisle Center Member and the Aquetuck Member is nowhere sharp, the gradation between them takes place over a progressively greater thickness from Leeds (about 6 inches) to Kingston (4-6 feet). The glauconite and quartz sand in the upper part of the Carlisle Center, occurring as irregular wisps, lenses, and scattered grains, in greatest abundance at the top of the member and decreasing in quantity downward, seem to be closely associated with the change from the Carlisle Center to the Aquetuck. Both their quantity and the proportion of the Carlisle Center in which they occur decrease to the south, along with the increase in thickness of the transition strata between the members. They disappear entirely before reaching the Kingston railroad cut. This evidence suggests, but does not prove, that there was an interval of nondeposition between the members in the north but not in the south. That there was a change in deposition is shown by their differing lithology; that this change was accompanied by (or preceded by) some unusual depositional event is shown by the sand and glauconite. The cause of the increase of sand and glauconite upward to the top of the Carlisle Center and its irregular (non-bedded) distribution is not known; its explanation would help clarify the significance of the contact. South of Kingston the change between the Carlisle Center and the Aquetuck is so gradual that the location of the contact is arbitrary.

Saugerties Member

In the Mid-Hudson Valley the Saugerties Member consists of interbedded medium-gray slightly muddy limestone in even beds 3 to 12 inches thick and medium-gray very calcareous mudstone (or very muddy limestone) in even beds 3 inches to 2 feet thick. The more calcareous beds weather light gray, and the less calcareous beds weather yellowish brown, producing a prominent banding on weathered surfaces. Roughly two-thirds of the member consists of the less calcareous beds, but the proportion of more calcareous beds increases upward. Contacts between the two sorts of bed, although not sharp, are well defined. Burrow markings are present in the less calcareous beds, but they are not conspicuous. At Wawarsing and Trilobite Mountain the member does not show its typical lithology; it is more like the Aquetuck Member. Distinction between the two members there is uncertain.

The contact between the Aquetuck Member and the Saugerties Member is everywhere gradational. In sections around Leeds the gradation takes place over only a foot or two and is accompanied by small quantities of glauconite and quartz grains irregularly distributed throughout the transition beds. The difference in lithology between the two members, together with the relatively rapid gradation between them, makes the contact easy to draw. Between Leeds and Kingston the glauconite and quartz disappears. At Kingston the distinction between the two members (while real) is not as great as to the north. Moreover, the gradation between them is almost imperceptible, so that the contact between them is difficult to place. The contact relations between the Aquetuck and Saugerties are similar to those between the Carlisle Center and Aquetuck in the field trip area, but the evidence suggesting a break in deposition is not as strong.

The contact between the Saugerties Member and the overlying Onondaga limestone is gradational over a thickness of a foot or two everywhere it is exposed from Leeds to Port Jervis. The less calcareous beds in the Saugerties gradually become thinner and less muddy, and disappear upward.

Outlier

About 30 miles southeast of the main Schoharie outcrop belt there is a narrow outlier of Silurian and Devonian rocks extending from Cornwall southward into New Jersey (fig. 1). Rocks of Esopus and Schoharie age are best exposed at Highland Mills, near the northern end.

Boucot (1959) assigned previously unstudied strata everlying the Connelly conglomerate (Oriskany age) and underlying the Kanouse sandstone (pre-Edgecliff Onondaga age) at Highland Mills to the Esopus Formation, and subdivided them into the Highland Mills Member, the middle member, and the Woodbury Creek Member (in ascending order). The Woodbury Creek and Kanouse are described briefly below, and their relation to the Schoharie Formation and Onondaga limestone in the main belt is discussed.

The Woodbury Creek Member consists of indistinctly bedded tan and light gray weathering siltstone which is so deeply weathered that except in the lowest part of the member no fresh surfaces can be found. Strata in the lowest part are slightly finer grained and not as deeply weathered. They are dark gray and slightly calcareous where fresh, and light gray and non-calcareous where weathered. It is suspected (but not known) that the upper part is calcareous where fresh. In an exposure in the northernmost part of the outlier (Cornwall) the entire member is slightly finer grained than at Highland Mills, and the lower calcareous part is thicker. At Highland Mills the member is about 120 feet thick.

Tubular contorted bodies of dark sediment lying in the plane of the bedding and flattened normal to it are a prominent feature of the member, particularly in the lower part. When viewed on surfaces normal to the bedding they appear as strips and lenses. Although they are not so clearly the result of annelid activity as the burrows in the Carlisle Center (p. 11), they seem to be the same sort of feature.

The contact between the Woodbury Creek Member and the underlying middle member is gradational over 2-3 feet. It is marked by an upward change from the abundant Taonurus markings in the middle member to the abundant burrow-like sediment bodies in the Woodbury Creek Member, and an upward change from non-calcareous to calcareous strata.

The Kanouse sandstone consists mostly of indistinctly bedded hard gray medium sandstone composed mostly of quartz; 3- to 12-inch layers of hard gray conglomerate composed of very fine to fine well-rounded quartz pebbles are interbedded with the sandstone in the lower part of the formation. The conglomerate beds have sharp and slightly undulating lower contacts, and they grade upward into sandstone. The Kanouse is less than 5 feet thick at Highland Mills.

The lower contact of the Kanouse is gradational by interbedding. Sandstone beds, showing the same contact relations with the adjacent strata (siltstone) as the conglomerate beds in the Kanouse, appear in the uppermost Woodbury Creek, and upward the grain size of both the coarser beds and the intervening strata increases.

There is an unexposed interval of at least 140 feet between the highest exposed Kanouse and the overlying Cornwall shale (black shale which grades upward into the Bellvale sandstone of Hamilton age).

The unit-by-unit correspondence between the Esopus Formation in the main belt and the strata overlying the Connelly conglomerate and underlying the Woodbury Creek Member in the outlier (a correspondence which exists but is not discussed here) and the similarity of the lower contacts of the Carlisle Center and Woodbury Creek, indicate that the lower part of the Woodbury Creek has the same stratigraphic position as the lower part of the Carlisle Center. This and the lithologic similarity between the lower parts of the two units show that these lower parts are facies equivalents.

Boucot (oral communication, 1961) considers that the Kanouse sandstone and the upper part of the Woodbury Creek Member in the outlier and the sub-Edgecliff strata (zone B of Oliver, 1954) of the Onondaga limestone in western New York are part of the Amphigenia zone. It is not known whether this zone is present in the outcrop belt from Leeds to Port Jervis; if it is, it would comprise the upper part of the Schoharie Formation, as Oliver (this guidebook) considers that the lowest Onondaga in the field trip area is younger than the Amphigenia zone. If there is a hidden break at or near the Schoharie-Onondaga contact, rocks of upper Woodbury Creek and Kanouse age in the main belt might be missing in part or entirely. Apparently quartz silt, sand, and fine gravel were deposited in the outlier region while the main belt region was either receiving predominantly calcareous sediments or was undergoing erosion. The steady upward increase of lime in the Schoharie in the field trip area makes unlikely the possibility that terrigenous sediments similar to the Kanouse were deposited in the main belt region and later eroded. It is not known whether strata similar to the Onondaga overlie the Kanouse in the outlier.

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ROUTE STOPS

Stop #1, Erie Railroad Cuts near Highland Mills

Railroad cuts just north of Pine Hill road, NW ninth of Popolopen Lake 7½' quadrangle, Schunemunk 15' quadrangle.

Although there is a complete section of the Esopus Formation (p. 13) and the Kanouse sandstone exposed on the east side of the New York Thruway one-half mile east of Highland Mills, the stop will be made at the cut on the Erie Railroad a few hundred yards west of the Thruway, because of traffic danger on the Thruway. Here the Highland Mills Member, the middle member, and the lowest 60 feet of the Woodbury Creek Member (p. 14) are exposed. One-half mile north, the upper non-conglomeratic part of the Kanouse sandstone (p. 14) is exposed on a steep slope just east of the railroad.

Stop #2, Leeds Gorge

Gorge of Catskill Creek, just west of Mill Pond in Leeds, SE corner, Leeds 7½' quadrangle, Coxsackie 15' quadrangle.

Onondaga Formation

This is one of the most complete sections of the Onondaga in the trip area. With a steep easterly dip, the lower 115 feet, conformably overlying the Schoharie Formation, are exposed in a fairly short distance in the bed of the creek. Although the formation is well exposed, only a short time will be devoted to the Onondaga at this stop. Facies changes between here and Kingston (stop #4) are minor and the nature of the rocks and the fossils can be observed to better advantage at that place.

The Leeds Gorge section is as follows:

Moorehouse Member (upper part not exposed):

25' + Middle unit; medium-dark-gray, fine-grained limestone with abundant dark-gray chert; corals and bryozoans common, brachiopods and other fossils present.

12' Lower unit; light-medium-gray, medium-grained limestone with no chert; corals common; other fossils present.

Nedrow Member:

4' Light-medium-gray, medium-grained limestone with few chert nodules; platyceratids, corals and brachiopods. This unit is lithologically and faunally transitional to the Moorehouse.

39' Light-medium-gray, medium-coarse and fine-grained limestone with abundant light-medium-gray chert; platyceratids, corals and brachiopods.

Edgecliff Member:

32' Light-medium and light-gray, medium-coarse and coarse limestone with abundant light-medium-gray chert; large crinoid columnals common, corals, and brachiopods.

3' Medium-gray, fine-grained limestone with no chert; fragmental fossils.

Transition to Schoharie Formation:

1½' Alternating limestone and gritty limestone.

Schoharie Formation

The entire Schoharie Formation is excellently exposed at the falls in the gorge of Catskill Creek. The strata are nearly vertical to overturned.

Saugerties Member:

16' Interbedded light-gray weathering limestone and yellowish-brown weathering muddy limestone; proportion of less pure limestone beds decreases upward; purer limestone beds are continuous layers except for a few layers of limestone nodules in lower part; grades up into Onondaga Limestone.

Aquetuck Member:

40' Yellowish-brown weathering dark gray calcareous mudstone, becoming sandy and glauconitic in uppermost 3 feet; interbedded light weathering muddy limestone beds not sharply set off from the mudstone; abundant indistinct layers of dark weathering rock and layers of small chert nodules.

Carlisle Center Member:

13' Yellowish-brown and yellowish-gray weathering dark gray calcareous mudstone with interbedded lighter weathering slightly limier layers; glauconite and quartz sand both in upper part and lower part, but not in middle; "black bed" (p. 11), 3 feet thick, 5 feet from base. Abrupt contact with underlying Esopus Formation.

Stop #3, New York Central Railroad Cut, Kingston

Cut on the N.Y.C. (West Shore) Railroad, just north of West O'Reilly Street, Kingston West 7½' quadrangle, Rosendale 15' quadrangle.

The entire Schoharie Formation is excellently exposed in a small syncline beneath the Edgecliff Member of the Onondaga Limestone.

The section is as follows:

Saugerties Member:

30' Interbedded light-gray weathering limestone and yellowish-brown weathering muddy limestone; prominent banding shown on surfaces of cut; possible to recognize several subunits.

Aquetuck Member:

44' Yellowish-brown and yellowish-gray weathering very calcareous mudstone or very muddy limestone; interbedded layers of light-gray weathering limestone nodules; a few continuous limestone layers; thin inconspicuous dark-weathering layers in the calcareous mudstone.

Carlisle Center Member:

143' Yellowish-brown and yellowish-gray weathering calcareous mudstone; interbedded limier layers, becoming more distinct and more calcareous upward; prominent burrows in upper two-thirds (p.); Taonurus in lower part; "black bed" (p.) 55 feet above base; basal bed of sandy glauconitic calcareous mudstone less cleaved than above, truncates dark gray non-calcareous mudstone of Esopus Formation.

Stop #4, Ulster County Highway Department, Quarry, Kingston

Quarry southwest of Route 209 on west side of Kingston, 0.2 mile WSW of Route 209-28 intersection, Kingston West 7½' quadrangle, Rosendale 15' quadrangle.

This is an excellent exposure of the Nedrow and Moorehouse Members with good (and typical) fossil collecting in both units. The beds are flat lying and fossils are best observed on the extensive flat surfaces in, and at the top of, the quarry.

The section is as follows:

Moorehouse Member (upper part not exposed):

24' Middle unit; lithology as at Leeds; brachiopods, gyroconic cephalopods and small horn corals are common; trilobites and sponges ("Hindia" sp.) are also present.

7' Lower unit; lithology as at Leeds; fossils are common but hard to collect in quarry face.

Nedrow Member (lower part not exposed):

8' Moderately coarse and light-colored limestone with medium-light-gray chert; platyceratid gastropods, brachiopods, bryozoans, corals, "Hindia" sp.

Stop #5, Abandoned Quarry in Wawarsing

Small quarry north of Route 209, 0.5 mile northeast of Vernooy Kill Road, Kerhonkson 7½' quadrangle, Slide Mountain 15' quadrangle.

Between Kingston and Wawarsing the lower part of the Onondaga becomes darker and finer grained. The characteristic Nedrow platyceratids are not present and the member cannot be recognized. The Edgecliff is marked by characteristic large crinoid columnals but is otherwise hard to distinguish from the superjacent Moorehouse Member.

The section is as follows:

Moorehouse Member (upper part not exposed):

29' Medium-dark-gray limestone in beds 2 to 10 inches thick, some shaly beds in upper part; trilobite fragments; 2-inch chert bed at base.

20½' Limestone similar to above; Levenia lenticularis, brachiopod fragments and apparent juveniles are common; trilobite fragments, gyroconic cephalopod, small horn corals.

Edgecliff Member:

13' Medium-gray, medium-fine-grained limestone with scattered chert nodules in the lower-middle part; large crinoid columnals and small horn corals are common; brachiopods and bryozoans are also present.

Transition to Schoharie Formation:

2-3' Brown-weathering silicous limestone forms the lowest beds in the quarry.

Stop #6, Trilobite Mountain

On northwest facing hill between two roads and the Erie R.R. near Port Jervis Golf Club, 1.1 miles northeast of Tristates, Port Jervis South 7½' quadrangle, Port Jervis 15' quadrangle.

Only the lower few feet of the Edgecliff Member are exposed here on the northwest side of the hill, facing the Country Club. The beds are lithologically and faunally similar to the Wawarsing exposures and to the Stroudsburg outcrops farther south. Corals, brachiopods, and the large crinoid columnals are fairly common and make up most of the fauna.

The Schoharie Formation is exposed between the Edgecliff face and the Erie railroad tracks. There are a few large unexposed intervals. Thicknesses, based on dip and slope measurements, are approximate.

8' Unexposed up to the Onondaga Limestone.

Saugerties or Aquetuck Member:

25' Yellowish-gray and yellowish-brown weathering muddy limestone containing vague layers of nodules of purer limestone.

21' Unexposed (concealed by road).

Carlisle Center Member:

12' exposed

25' unexposed

24' exposed

70' unexposed

41' exposed

Olive-gray weathering dark gray calcareous mudstone; interbedded lighter weathering limier layers; a few distinct limestone beds in upper part; traces of burrows (p. 11).

30' Concealed by railroad tracks down to dark gray mudstone of Esopus Formation.

Stop #7, Tristates Point

Delaware River shore near Tristates Point in Laurel Grove Cemetery just west of Tristates, Port Jervis South $7\frac{1}{2}$' quadrangle, Port Jervis 15' quadrangle.

An estimated 25 feet of dark-gray limestone is exposed on the west side of the cemetery. The rock is part of the Moorehouse Member but its exact stratigraphic position is unknown. Corals, small gastropods, and trilobite fragments are fairly common.

ROAD LOG

0.0 Start at Minisink Hotel, Port Jervis. Go north on U.S. Rte. 6 and U.S. Rte 209.

0.1 Turn right, following US 6 and US 209.

0.5 Go straight on US 6 where US 209 goes left.

2.0 Bear left on US 6 at junction with Rte. 23.

16.4 Bear right at fork, off US 6 and onto unmarked short cut.

18.3 Bear right onto old US 6.

18.8 Turn right, back onto US 6 east.

22.1 Onto US 6 and NY 17 east (dual highway).

35.6 Leave dual highway at exit marked "US 6, NY 32" (last exit before Thruway; don't miss it). Turn left (N) at end of ramp, onto US 6 east and NY 32 north.

37.0 Keep straight on NY 32 north (US 6 goes right).

38.2 Turn right onto Park Street, Village of Highland Mills.

38.6 Turn left into parking lot for abandoned Erie RR station.

Stop No. 1 (p. 16): The contacts between the Highland Mills Member, the middle member, and the Woodbury Creek Member are marked with white paint on the railroad cut.
Watch out for trains.

Turn right onto Park Street from RR station parking lot.

39.0 Turn left onto NY 32 south.

41.5 Turn left onto Thruway entrance ramp after crossing bridge over dual highway.

41.7 Thruway toll booth. Take Thruway north "Albany and Buffalo." There will be a short rest stop along the Thruway.

88.9 Leave Thruway at Kingston exit.

89.2 Thruway toll booth.

89.6 Traffic Circle - take Interstate 587 and NY 28 to Kingston.

90.8 Complicated intersection, with traffic lights; take Broadway, roughly straight ahead.

91.5 Turn right on W. O'Reilly Street.

92.0 New York Central RR underpass on W. O'Reilly Street -

Stop No. 3 (p. 17, Stop No. 2, at Leeds, cancelled): cuts on both sides of the track a few hundred feet north along the track. Contacts between members of the Schoharie are marked with white X's on both sides of the track. The top and bottom of the black bed in the Carlisle Center Member are shown by paint marks along the bedding.
LISTEN FOR TRAINS - they come by often.

Continue along W. O'Reilly Street.

92.1 Turn right on Wilbur Avenue (NY 213).

93.0 Straight across at intersection with Greenkill Avenue.

94.5 Turn right on Henry Street (NY 32 and NY 213).

95.0 Turn left (W) onto Broadway.

95.3 Complicated intersection, with traffic lights; follow US 209 south (Albany Avenue).

95.6 Traffic light; bear right on Clinton Avenue (US 209 south).

95.8 Bear left on N. Front Street (US 209 south).

96.1 Turn left onto Washington Avenue (leave US 209).

96.3 Turn right onto Lucas Avenue.

96.5 Turn right into Forsyth Park and Zoo.

Lunch stop. The Ulster County quarry (Stop No. 4) borders Forsyth Park on the north. The Schoharie-Onondaga contact is located along Lucas Ave. near the Park entrance and the outcrops within the Park give a section through the Edgecliff and Nedrow Members.

Leave park, turn left (N) onto Lucas Avenue.

96.7 Turn left onto Washington Avenue.

96.9 Straight through at stop sign (onto US 209 south).

97.0 Turn left on Hurley Avenue (US 209 south).

97.1 Turn left at entrance to Ulster County quarry.

Stop No. 4 (p. 18): The contact between the Nedrow and Moorehouse Members of the Onondaga Limestone is marked with white paint on the quarry wall.

Continue south on US 209.

113 Pass through Village of Accord on US 209.

118 Pass through Village of Kerhonkson on US 209. Main intersection is Times Square, Broadway and 42nd Street.

120.8 Turn right into quarry of Ulster Limestone Corporation (just before reaching Wawarsing on US 209).

Stop No. 5 (p. 19).

Continue south on US 209.

125 Pass through Ellenville on US 209.

151.2 Pass Huguenot Hotel on US 209.

155.2 Enter Port Jervis on US 209.

155.9 Turn left onto US 6 (US 209 goes right).

157.1 Bridge over Neversink River on US 6; turn left onto N. Maple Avenue just past bridge.

157.3 Erie RR underpass.

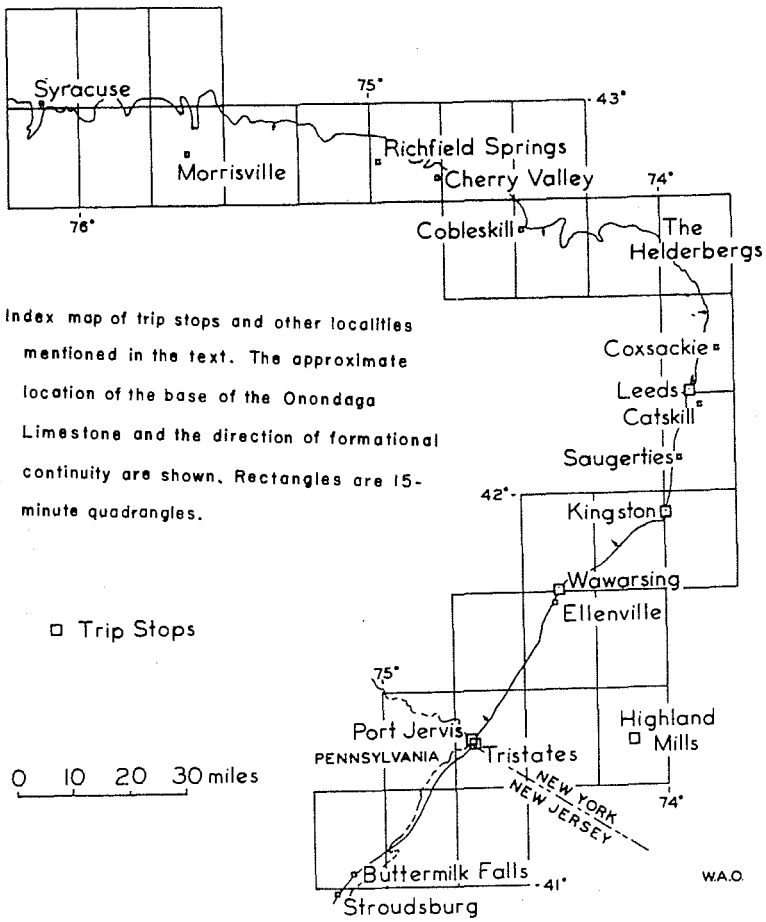
158.3 Stop No. 6 (p. 19): Cuts along both sides of road.

Turn around.

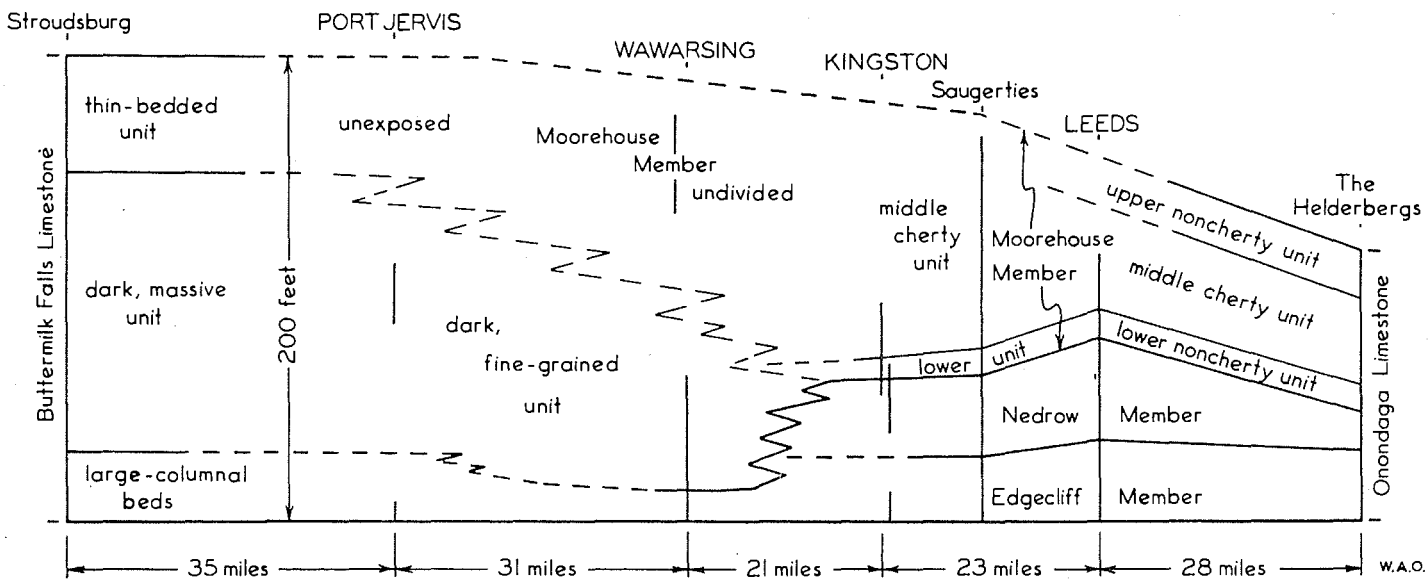
159.5 Turn right onto US 6.

161.1 Turn left, following US 6 and US 209.

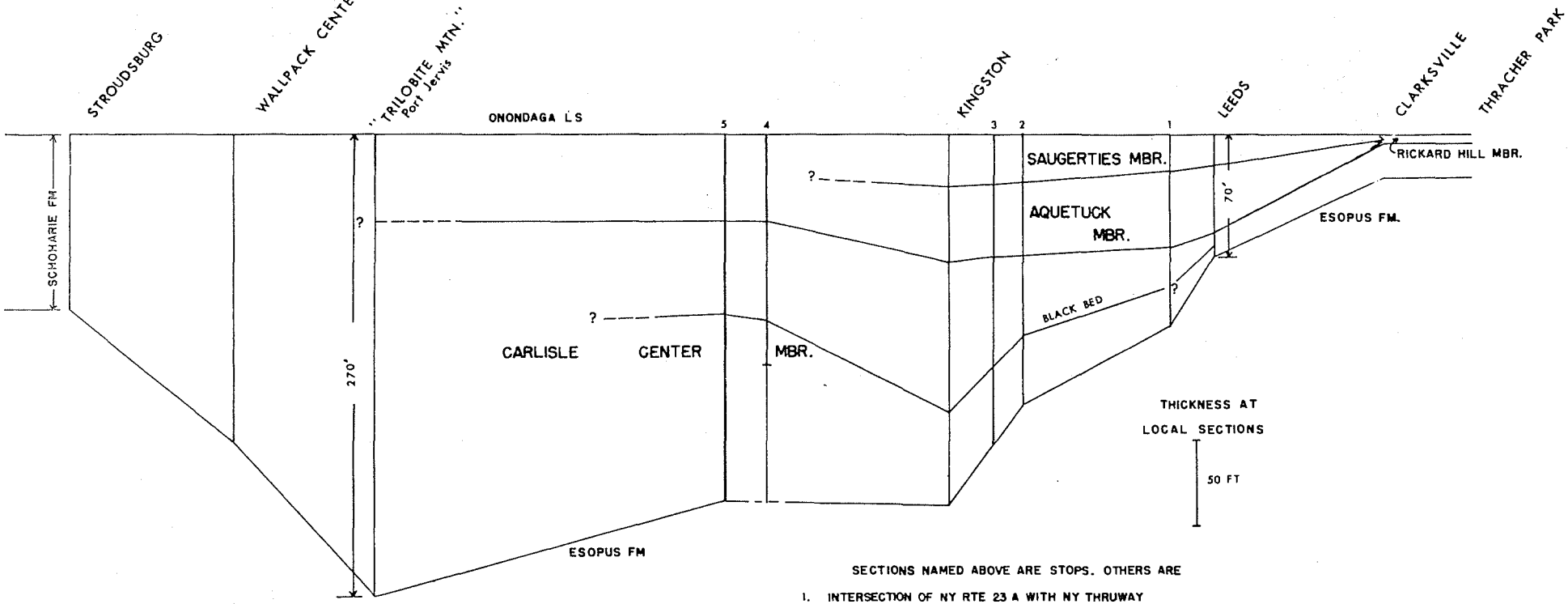
161.2 Minisink Hotel, end of trip.



Index map of trip stops and other localities mentioned in the text. The approximate location of the base of the Onondaga Limestone and the direction of formational continuity are shown. Rectangles are 15-minute quadrangles.



Diagramatic cross section of the Onondaga Limestone between the Helderbergs and Port Jervis, New York. Correlations with the Buttermilk Falls Limestone (Willard, 1939) near Stroudsburg, Pennsylvania are shown.



SECTIONS NAMED ABOVE ARE STOPS. OTHERS ARE

1. INTERSECTION OF NY RTE 23 A WITH NY THRUWAY
2. GLENERIE FALLS ON ESOPUS CREEK, GLENERIE NY
3. APPROACH TO KINGSTON—RHINECLIFF BRIDGE (NY 199), JUST EAST OF US 9W.
4. FALLS OF MILL BROOK, 1 MI. NE OF PATAUKUNK NY
5. WEST OF US RTE 209, 1 MI. NE OF WAWARSING NY