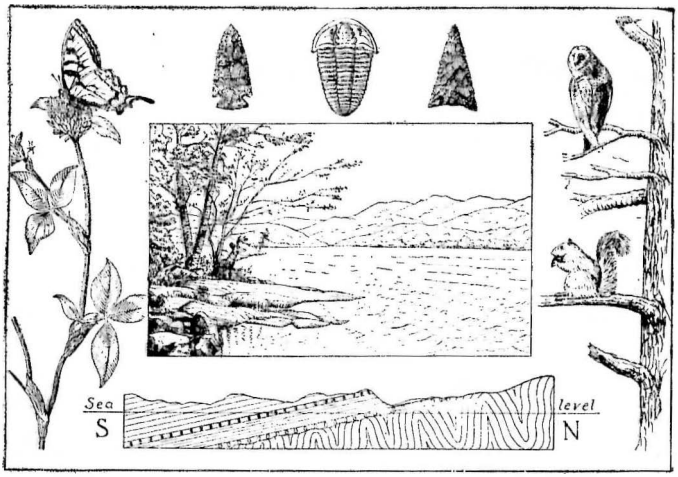
New York State Museum Handbook 14

NEW YORK STATE MUSEUM
CHARLES C. ADAMS, *Director*

GUIDE TO THE GEOLOGY OF JOHN BOYD THACHER PARK (INDIAN LADDER REGION) AND VICINITY

BY WINIFRED GOLDRING M.A.
Assistant State Paleontologist, New York State Museum



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THE UNIVERSITY OF THE STATE OF NEW YORK
1933

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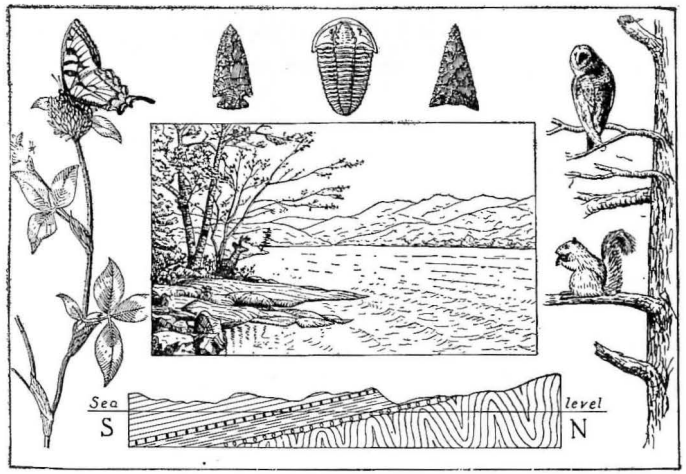

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GUIDE TO THE GEOLOGY OF JOHN BOYD THACHER PARK (INDIAN LADDER REGION) AND VICINITY

By Winifred Goldring
Assistant State Paleontologist, New York State Museum

PREFACE

The area covered by this guide is part of the territory that has from the earliest days been the stamping ground for geologists and paleontologists, and now that the good roads and automobiles have made the Helderbergs accessible it has become a favored tourist area. A picnic at the Indian Ladder in the earlier days meant a day's trip by horse and carriage or a long tramp from the railroad station at Voorheesville or Meadowdale, and one very often had the place entirely to himself. The automobile has shortened the distance from Albany, and with the establishment of the John Boyd Thacher Park and the construction of a new road into the park, the number of persons visiting the Indian Ladder area has increased year by year. From early summer through the lovely fall days one can no longer expect to be alone there. There are picnickers and excursionists through the day, and as they depart in the late afternoon they pass the cars bringing in those coming to cook their suppers and to find, in this beauty spot, relaxation and a brief change from the heat and noise of the city. Besides these there are the students of geology and paleontology who are brought to

this region to study the classic section; and meetings of societies, scientific and otherwise, are sometimes held there.

All this has created a popular demand for some publication from which a knowledge of the region can be obtained. The older reports are out of print and much of the information is presented in a form beyond the grasp of the individual who has no or little previous training. The Indian Ladder area will of course be discussed in the bulletin on the Berne Quadrangle already mapped, but this too, will demand a more or less technical treatment. Therefore it was decided to have a guide to the Indian Ladder area and vicinity written in language nontechnical enough to satisfy the needs of the layman and yet not so simple that it will fail to be of use to the student of geology. The area covered by the guide, as shown by accompanying maps, includes a bit of the Albany plain to the east of the Altamont–New Salem line, the Helderberg escarpment from Wolf hill above New Salem to High Point above Altamont and the country in back of the escarpment as far west as the village of East Township and the Warner lake area. It was deemed advisable to include Thompson's and Warner lakes because this section is so well known to the summer campers and tourists, and also includes some geological features not elsewhere shown. It is planned to follow the discussion of the geology of the region by brief descriptions of possible excursions on foot or by automobile.

The author wishes here to express appreciation to Dr Charles C. Adams, Director of the New York State Museum, for the interest he has shown in this guide. To Dr Rudolf Ruedemann, State Paleontologist, the author

is indebted for reading and criticizing the manuscript and for the use of his geologic map of the Albany quadrangle in making the map for this guide. The manuscript has also been read by Clinton Kilfoyle, technical assistant in paleontology, and some of the drawings of fossils were made by him. The majority of the drawings of fossils were made by the Museum draftsman and photographer, Edwin J. Stein, to whose skill also are due the excellent photographs. To Professor H. F. Cleland of Williams College the author wishes to make acknowledgment for permission to use the block diagram of the Indian Ladder area.

INTRODUCTION

GENERAL SETTING

The Helderberg cliff or eastern escarpment of the Helderberg plateau, popularly known as the Helderberg mountains, forms one of the most striking topographic features of Albany county, indeed of central eastern New York (figure 30). More than one explanation has been given for the name of these mountains. One explanation is that they were named after an old fortification in Holland, since they stand up like a rampart against the sky; another, and the more likely explanation, is that they received their name from the light colored limestones forming the cliff (from the Dutch *helder,* bright or light; *berg,* mountain). The Helderberg mountains, while famous for their natural scenery, are likewise noted for the steep cliff of massive limestones (Manlius, Coeymans limestones), measuring up to 100 feet in height, which marks the northern and eastern margin of the plateau and is visible for many miles on the east and north. The greatest development of the Helderberg escarpment is found between Altamont and New Salem in the area covered by this guide. Above Altamont the top of the limestone cliff has an elevation of approximately 1300 feet (High Point) but the cliff itself is not so prominent because of the long slopes beneath. Thence the cliff turns westward with decreasing elevations and variable steepness, in places again showing increasing prominence.

To the south of Altamont, as shown on the accompanying map (figure 31), the slopes become shorter and the cliffs increase in height, making the escarpment, which here turns abruptly southward, more prominent, although

the top of the cliff (top of Coeymans limestone) gradually decreases in elevation until above New Salem it has an elevation of approximately 800 feet. The Indian Ladder region, now included in the John Boyd Thacher Park, lies about halfway between these two points, and in this area the Helderberg escarpment has its best development (figure 1). The top of the cliff here, just where the old Indian Ladder road comes up over the face of the escarpment, is marked by two large reentrants or gulfs—Cave gulf, about half a mile north of the Indian Ladder road, and Indian Ladder gulf, immediately south—both of which were eroded in preglacial times (Cleland, '30) and are at present occupied by tributaries of Black creek.

TOPOGRAPHY

To the north and east from the foot of the Helderberg escarpment stretches a great plain or inner lowland toward the Mohawk and Hudson rivers. This lowland lies between the plateau of sedimentary rocks and the older folded mountains on the north and east, from which the plateau is backing away through weathering. The deep valleys of the Hudson and Mohawk rivers are sunk into this plain, which has an elevation at Albany of about 200 feet above sea level. The plain rises slowly westward to an elevation of 300 to 400 feet. The bedrock underlying the lowland consists of shales and sandstones of unknown depth belonging to the early Paleozoic age, but the bedrock is exposed only in scattered places since this area has been more or less deeply covered with boulder clay, sands, gravels, etc., deposited by the ice sheet and the stratified or layered clay deposits laid down at lower levels in the body of water, known as Lake Albany, which

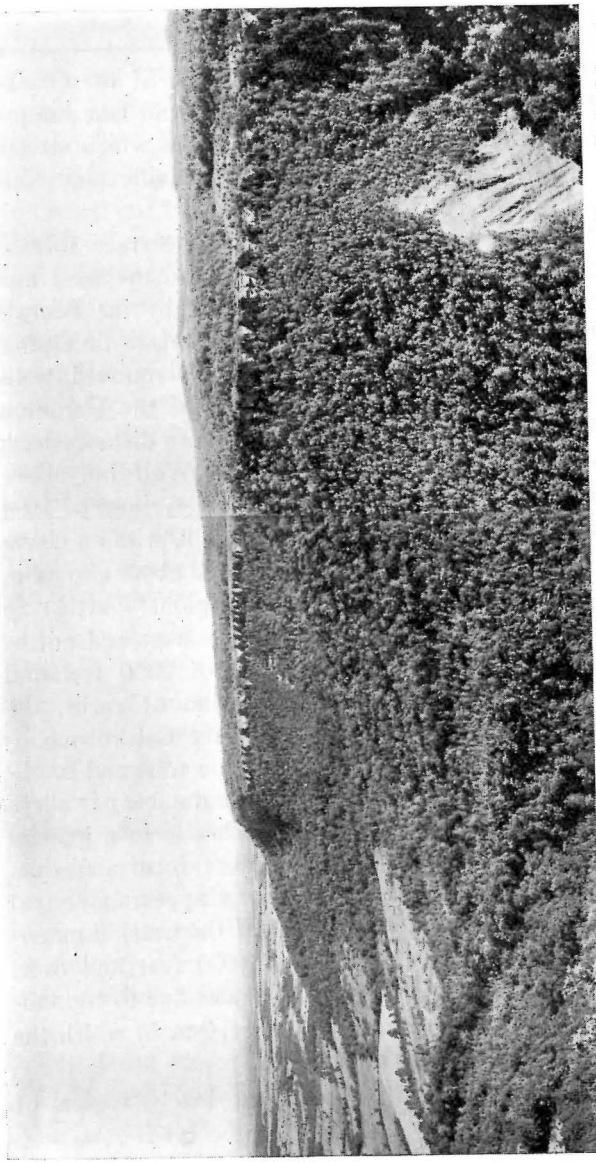

Figure 1 Helderberg escarpment in the Indian Ladder region, showing a section from Upper Ordovician to Middle Devonian: Indian Ladder beds (lower right) of Ordovician age; the Brayman shale, Rondout waterlime and Manlius limestone of Silurian age (in cliff) and the Devonian rocks from the Coeymans limestone (in cliff) to the Hamilton beds (hills in background). (Photograph by E. J. Stein)

flooded much of the lowland at the close of the Glacial Period. The clay and loam beds of this old lake bottom have made the very rich, level farm lands which stretch from Albany westward to the Voorheesville and New Scotland areas.

Back of the Helderberg cliff and the terrace formed on the Coeymans limestone at its top, to the west and southwest, are the terraces formed first by the Becraft and Oriskany formations, then the Onondaga limestone. Behind these terraces rise the long, fairly rounded, well-wooded hills formed by the dissection of the Hamilton shales and flags. Such hills, only a short distance back of the cliff, are Countryman hill and Wolf hill above (west and southwest) New Salem, with elevations of 1694 and 1684 feet respectively, and Sunset hill, with an elevation of 1823 feet, near Camp Pinnacle and about two miles directly south of the Indian Ladder region. Farther to the west back of Rensselaerville, to the west and northwest, these hills rise to an elevation of 2000 feet and higher and embrace a higher formation of rocks, the "Oneonta" beds, which continues into the Catskill mountains to the southwest. The whole region west and southwest of the escarpment is broken up by a number of valleys into a series of hills and ridges which rise to a general level so that their tops from a distance form a distinct sky line, above which farther southwest appears a second distinct sky line formed by the tops of the Catskill mountains, which rise to heights up to 4000 feet and over. These skylines represent base level planes due to continuous wearing down or weathering of regions in which the rocks have a uniform hardness.

The Helderberg area is the most lovely region of

the capital district and, indeed, one of the loveliest regions anywhere; but one only knows it well by departing from the main highways into the less inhabited, even deserted areas. One can, also, only appreciate it to the full when one has seen it in all its moods: under its white blanket of snow in winter, in the soft coloring of spring, in the summer sunshine and haze and decked out in flaming fall attire which at its best gives a breath-taking beauty to the whole region. There are no lakes of great size in the Helderberg mountains but there are a number of small ones like beautifully clear jewels nestling among the hills. The two best known, and those included in the area treated here, are Thompson's lake and Warner lake, which have become popular for camp sites in the past few years since the good roads and automobiles have made them so accessible. To the west of Rensselaerville are three smaller lakes, Myosotis, Crystal and Triangle, less well-known—even unknown to some—but as roads are improved their shores, too, are being used for sites for camps and summer homes.

Bare rock or rock thinly covered with soil is found over broad areas in the Helderbergs; but, especially, toward the west and southwest the slopes of the hills have been thickly covered with glacial till. Even when the hilltops are covered the rock is but little below the surface. The region as a whole, therefore, is not fertile. The fertile areas are found in the broader stream valleys and on the till-covered slopes of the hills. Dutch settlers were brought into this region by the Patroons, to whom they and their descendants for generations paid heavy rents until freed from this burden through the so-called "Helderberg War" or "Rent War" (1839). Descendants

of these earlier settlers are in some cases still found occupying the more fertile valley farms, but conditions have changed greatly. Children have been lured to the seemingly more attractive life of the city and the parents, unable to run the farms, have allowed them to pass into other hands or have abandoned the farms and allowed the buildings to fall to ruin. Whole sections are practically deserted, and the woods are reclaiming these areas. Some of these deserted areas are the loveliest spots in the region. A number of the farms have been bought and put into shape as country homes for dwellers in the cities, and there will be much more of this in the future; other places have been restored and large stock farms established.

VEGETATION

The magnificent woods that once covered the Helderberg plateau region are gradually coming back into their own, and the variety of trees covering the slopes (oaks, elms, red maples, birches, lindens, white pines, hemlocks etc.) is well revealed in the gorgeous fall coloring. The formations composing the plateau vary from the Helderberg limestones to quartzose rocks (Oriskany) and sandstones and shales (Esopus and Hamilton), and with the variation in soils goes a variation in the character of the forest growth and the small plants as well.

The writer is indebted to the State Botanist of the Museum staff, Dr H. D. House, for some facts of general interest relative to the vegetation of the region. The belt of country, about five miles wide, back of the cliff is noted for dry conditions, because the moisture seeps down through the rocks, and here one finds plants requiring a humus soil. At the front ledges of the Indian Ladder

region and upon the Helderberg ledges in the Clarksville and New Salem area, where the soil is acid, due to the leaching away of the basic elements beneath, a peculiar vegetation is found consisting of such plants as the Oak (*Quercus*), the Flowering Dogwood (*Cornus florida*), Foxglove, Bush Clovers etc. On the limestone ledges are also, characteristically, found the Cork or Rock Elm (*Ulmus thomasi*), a special form of Linden or Basswood (*Tilia neglecta*) and, especially along the top of the Indian Ladder cliff, large stands of Snowberry (*Symphoricarpos albus*), as also the June Berry (*Amelanchier amabilis*), the Hairy Honeysuckle (*Lonicera hirsuta*) and the Purple Virgin's-Bower (*Clematis verticillaris*). The Aromatic or Prickly Ash (*Zanthoxylum americanum*) grows in woods and thickets and is characteristic of limestone ledges, although it grows to some extent elsewhere. A number of characteristic ferns, some of them rare, are found below the limestone cliff. Among them is, notably, the Walking Fern (*Camptosorus rhizophyllus*) which grows on shaded rocks and cliffs, usually limestone, often covering the fallen limestone blocks with a rich green blanket. This fern is rather abundant on exposed limestone formations from the Catskill region northward. Other ferns growing on rocks and cliffs and preferring limestone are the Purple-stemmed Cliff Brake (*Pellaea atropurpurea*), the Slender Cliff Brake (*Cryptogamma stelleri*), the Maidenhair Spleenwort (*Asplenium trichomanes*) and the Wall-Rue Spleenwort (*Asplenium Ruta-muraria*).

The Yew (*Taxus canadensis*) and the Hemlock (*Tsuga canadensis*) seek shady places where the atmospheric temperature is more constant. Both these species occur

in the stream gorges, and, although found in the Hamilton gorges, are particularly characteristic of those in the Esopus shales, where the sides are often heavily covered with rich, dark green mats of Yew. The Hemlock grows where the soil is poor, as also does the White Pine (*Pinus strobus*) and that is why they are so often seen in areas underlain by the Esopus shales. Stands of White Pine are frequently seen now in the Hamilton shale areas where it is reestablishing itself. The Red Cedar (*Juniperus virginiana*) is a dry soil plant. The areas of Oriskany sandstone and Esopus grit, that is, belts of sandstone and gritty shales, may be recognized by the prevailing cedar trees and junipers. The low bushy form of juniper, the Erect Juniper (*Juniperus communis* var. *depressa*), is common along the edge of the Helderberg cliff in the dry belt.

In mapping one soon learns the general relation between the vegetation and the rock beneath. Hardwood forests are found quite generally in the limestone belts. They also occur in the Hamilton shale belt, although here there is considerable white pine and the pines are reclaiming the deserted areas. Cedars and junipers mark the sandstone and gritty shale areas. The Esopus grit may show stands of hemlock and pine but frequently in the Helderberg area it is marked by open fields with poor vegetation, even the grass being very sparse. The New Scotland shaly limestone belt is usually the area under cultivation. The broader stream valleys and the slopes heavily covered with till are under cultivation regardless of formation. In this way as soon as one has learned the formations and their general relations to one another, one can with a fair degree of accuracy pick them out in the landscape.

ORIGIN AND STRUCTURE OF HELDERBERG PLATEAU

The Helderberg plateau is composed of a series of limestones, sandstones and shales which are still nearly horizontal and in much the same position in which they were deposited in the ancient seas of late Silurian and Devonian times. These beds constitute, in large part, the earlier Devonian rocks, while the Catskills stretching to the southwest and resting upon the Helderberg formations are composed of the later Devonian rocks. All these formations, millions and millions of years ago, stretched northward across the plains of the capital district and lapped upon the ancient massif or "oldlands" of the Adirondacks. During Devonian times the continental land lay off to the east of the present area of New York State and a shallow interior sea occupied all of the State as far north as the southern Adirondacks, receiving drainage from the land to the north and the east. In this sea, just as along the coast today, were laid down seaward dipping deposits which now constitute the formations composing the Helderberg and Catskill mountains of today. The deposits were in time consolidated and uplifted, increasing the original southerly inclination of the sediments, and the sea gradually receded from the entire area of the State. When sea bottoms along the coast are uplifted to form land a smooth, gently sloping plain, known as a coastal plain is formed, bordering the harder ancient rocks (figure 2). Such a coastal plain was formed by the recession of the sea at the close of Devonian times. In the eons of time that have elapsed since then, through stream and atmospheric erosion, the formations constituting this ancient coastal plain have been gradually worn

away, forming an escarpment, known now as the Helderberg escarpment, which has slowly wandered toward the southwest away from the Adirondacks, growing higher at the same time with increased distance from the old shore line. The lowland formed is now occupied by the

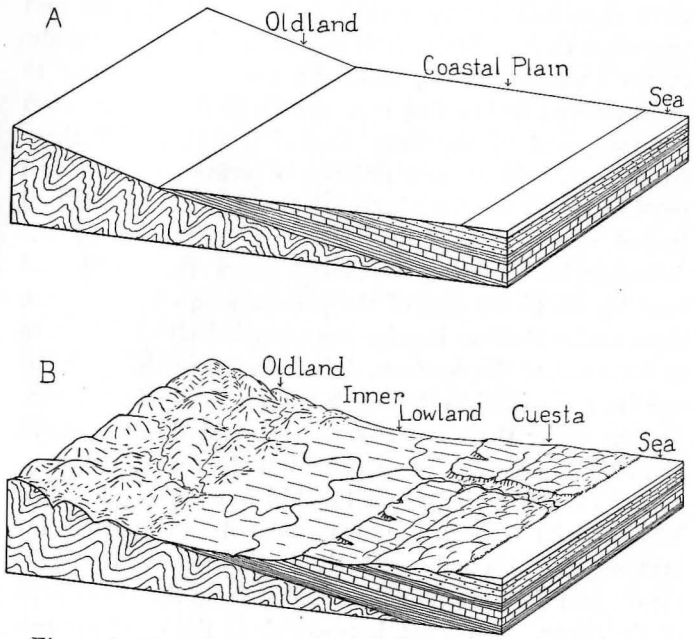

Figure 2 Block diagrams illustrating the dissection of a coastal plain. *A* The coastal plain as first uplifted, with the rock strata dipping gently toward the sea. *B* The same after dissection, with a ridge or cuesta formed on the harder rocks and an inner lowland developed in the softer beds

Mohawk and Hudson river valleys. As seen from the Indian Ladder region, the lowland extends from the Helderberg plateau on the south and west to the Taconic

mountains on the east and the Adirondacks on the north (figure 3). Such a lowland formed between an area of sedimentary rocks and older folded mountains, from which the sedimentary rocks are receding through erosion, has received the special name of *inner lowland*; and the upland, preserved through the occurrence of harder beds (as the Helderberg limestones), is known as a *cuesta* (from the Spanish), meaning an upland plain or ridge with a steep face or cliff on the side toward the inner lowland and a gentle slope in the opposite direction.

The strata composing the Helderberg plateau dip to the south, west of Albany, giving an east-west direction to the escarpment. In Albany county the dip changes gradually to a southwest direction, so that the escarpment extends in a southeast direction east of Altamont. The dip to the southwest is very gentle, between 1° and 2°. The dip in the Helderbergs on the Berne sheet has been computed to be not more than 100 feet to a mile. In the High Point area the rocks have been forced upward, giving a locally greater dip and change in direction, and in the region of Thompson's lake and the Indian Ladder it is much less (not over 35 feet to a mile). The dip is somewhat variable in this region due to slight faults. The southwest dip of the rocks carries the outcropping edge of the Coeymans limestone, which forms the top of the cliff along the face of the plateau, from an elevation of 1200 to 1300 feet above tide south of Altamont to 1100 feet at the Indian Ladder road, approximately 800 feet above New Salem and 660 feet one mile south of New Salem. Farther south the dip of the beds gradually decreases, the direction changes to almost due west and formations are brought down to the general level of the country and show

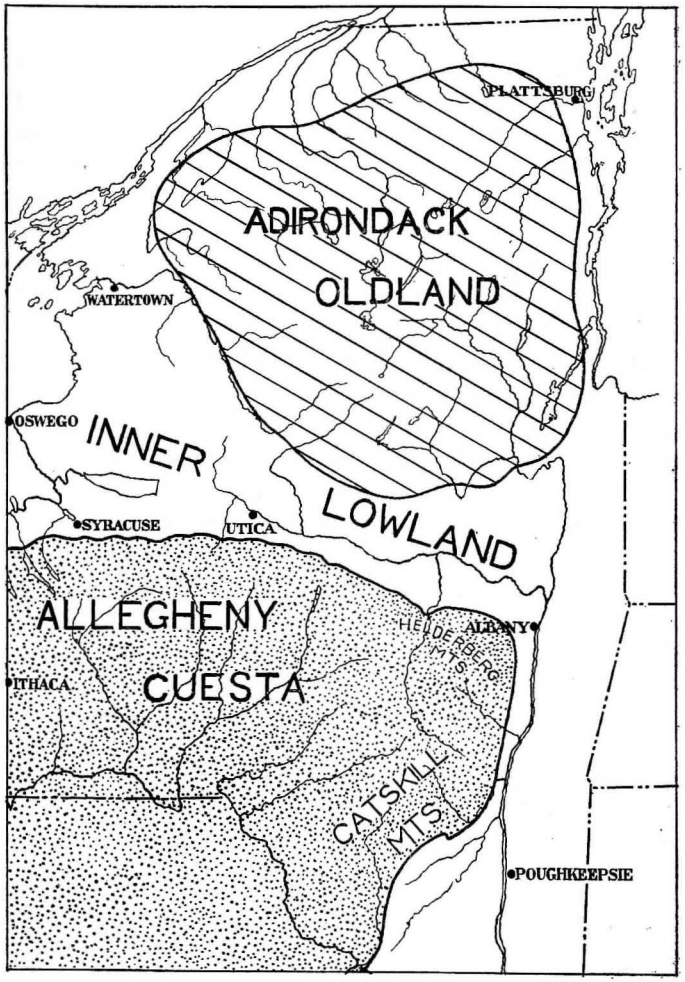

Figure 3 Outline map of eastern New York showing the location of the oldland, inner lowland and cuesta of the ancient dissected coastal plain

folding and faulting, which becomes more pronounced southward. This folding belongs to the Appalachian Revolution, a period of great mountain building, which brought to a close that era of time known as the Paleozoic nearly 200,000,000 years ago. In the eastern Helderberg plateau the folds, if they occur at all, are only gentle, but farther south and particularly in the Middle Hudson region between Catskill and Rondout occur conspicuous folding and faulting, with overthrusting of the Helderberg rocks.

From the front the Helderberg mountains give the appearance of a solid plateau breached only by a few creeks, but from the interior, back of the Helderberg cliff, the general southwest slope of the country is discernible. As the rocks dip in a southwesterly direction, weathering, which follows the harder rocks, has finally exposed the surface of the sloping harder beds. This is particularly well shown in the hills composed of the Hamilton shales and flags that have resisted erosion. These hills have a steep slope on the northeast and a gradual slope toward the southwest, following the dip and known as the dip slope. All the interior hills of the Helderberg mountains are of this type until one approaches the Rensselaerville area. Such hills, for example, are Sunset hill and its neighbors near Camp Pinnacle, Countryman hill and Wolf hill, respectively west and southwest of New Salem, Bennett hill, south of Clarksville, and Copeland and Blodgett hills farther east and south of the Clarksville-Callanans Corners-South Bethlehem road.

THE PENEPLANES

An area which has been worn down through the action of streams and atmospheric erosion to a general level, or base level, has been termed a *peneplane*. Any hills rising above the general base level and owing their preservation to the harder rock of which they are composed are termed *monadnocks,* from Mount Monadnock in the Berkshires, which is of such a nature. When such a base-leveled region is later uplifted and dissected by erosion evidence of the former base-leveled condition is to be looked for in the sky line presented by the higher hills. Three peneplanes (figure 4) have been traced out in the capital district (Ruedemann '30). The inner lowland, which has an elevation of 200 feet above sea level at Albany and rises slowly westward to 300 to 400 feet and eastward to about 600 feet at the base of the Rensselaer plateau, shows distinctly the characteristics of an erosion-plane or peneplane, for it cuts across the formations, folded and unfolded beds alike, regardless of rock structure. This may be regarded as an incipient peneplane and is the lowest or Albany (Somerville) peneplane which was developed in late Tertiary times, 500,000 to 1,000,000 years ago, before the advance of the ice sheet over the country in the Glacial Period. Above this incipient peneplane rise numerous hillocks of the nature of "monadnocks" because they owe their existence to harder rocks such as grits or chert beds. The mantle of drift left by the ice sheet, and the deposits of Lake Albany clays as well, have smoothed out many of the irregularities in the lowland due to dissection and the differences in structure and hardness of the rocks; and subsequent uplift initiated the Mohawk and Hudson river valleys cut deeply below the general

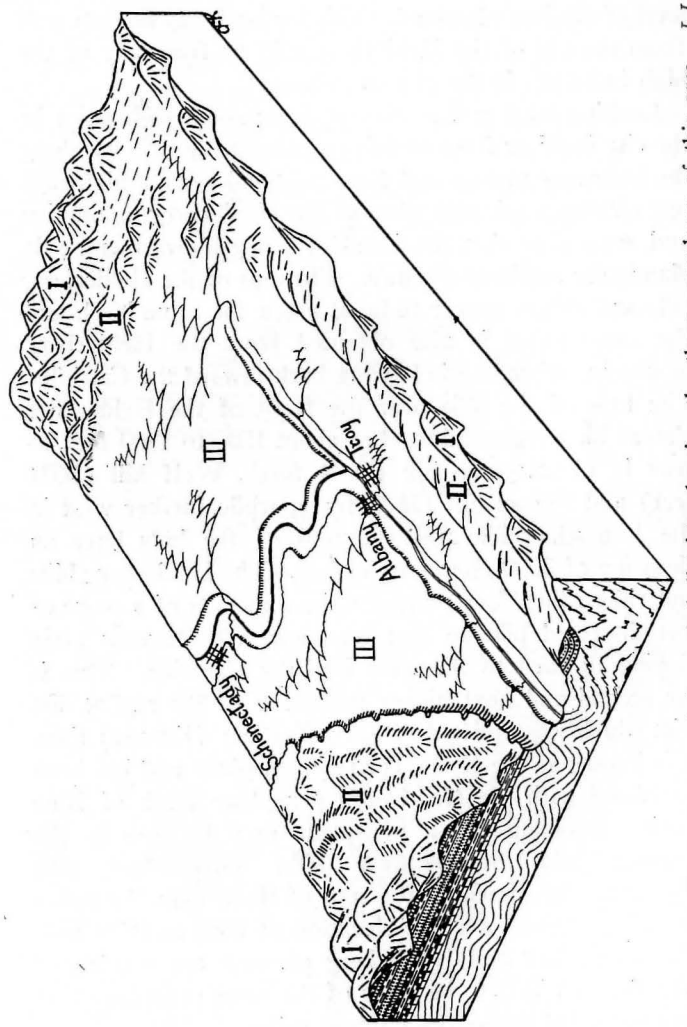

Figure 4 Block diagram of the capital district, showing the three peneplanes of this area. *I-I* Cretaceous peneplane. *II-II* Tertiary peneplane. *III-III* Incipient recent or Albany peneplane (inner lowland). (From R. Ruedemann, 1930)

level of the inner lowland. This lowland may be seen well from the top of the Helderberg cliff or from any of the high buildings in the city of Albany.

Looking west and southwest from some high point in the city itself or from certain points outside the city along the Delaware avenue and New Scotland avenue highways one obtains a splendid view of the Helderberg mountains and, on a clear day, the Catskills rising above them, pale blue in the southern distance. The tops of the Helderberg hills and ridges appear to be at about the same level, and the same effect is also obtained from the Helderberg mountains when one is looking back toward the Catskills. The tops of the hills near the front of the Helderberg plateau have a general level of about 1700 to 1800 feet, as seen in Countryman hill (1694 feet), Wolf hill (1684 feet) and Sunset hill (1823 feet), while farther west in the Rensselaerville area the tops of the hills have an elevation of 2000 feet, more or less. The Helderberg hills and ridges therefore represent the remnants of a more or less dissected plateau that was once a continuous plain sloping upward to the west into the Catskills. This is the second and next higher peneplane of the capital district which was uplifted in Early Tertiary (Eocene) time. It is known as the Early Tertiary peneplane and has been correlated with the Harrisburg peneplane south of New York. Remnants of a peneplane may be seen in the Grafton and Stephentown hills (Rensselaer grit plateau). As shown by the tops of these hills, the peneplane here has an average elevation of 1600 to 1800 feet. The Rensselaer and Helderberg plateaus are considered (Ruedemann '30) to be parts of the same peneplane that once extended across the Hudson valley.

The third and highest peneplane in the capital district is seen in the even tops of the Catskill mountains, now at an elevation of about 4000 feet. This peneplane was once a low plain extending widely over the East and was elevated in early Cretaceous times. It is known as the Cretaceous or Kittatinny peneplane, and remnants of it are seen in the tops of the Adirondacks and the Taconic and Green mountains.

THE DRAINAGE

The main stream of the capital district is the Hudson river, and its largest tributary is the Mohawk river. Several tributaries of the Hudson river on the west side drain the inner lowland in the vicinity of Albany and westward to the Helderbergs. Patroons creek empties into the Hudson just north of Albany; the Normanskill joins the Hudson just south of Albany and has for its tributaries the Black creek and Bozen kill, the Hunger kill, Krum kill and Vly creek; the Vlauman kill enters the Hudson river at Cedar Hill; and Coeymans creek joins the river at Coeymans and has for its tributaries the Onesquethaw creek and Sprayt kill. The Hudson river has returned in general to its old preglacial valley; but the tributaries have a postglacial course in the glacial moraine and the postglacial clays and sands of Lake Albany, and with the numerous small brooks tributary to them have eroded deep ravines in the soft clays and sands, only occasionally striking the irregularities of the old rock bottom.

The Helderberg escarpment in the region of the Indian Ladder area is breached by tributaries of the Black creek forming the reentrants known as Cave gulf and Indian

Ladder gulf. The New Salem area is drained by the Vly creek, and the Helderberg formations in the vicinity of Clarksville and southward are dissected by the Onesquethaw and Hannacrois creeks, Sprayt kill and their tributaries. Back in the Helderberg hills, the area about Rensselaerville is drained by tributaries of the Catskill (Ten Mile creek) and the Schoharie creek (Little Schoharie). These valleys are cut deeply into glacial drift, and only occasionally is rock exposed in the main valley, although splendid exposures are found in the deep tributary ravines. This region boasts three lovely lakes, mentioned above: Myosotis lake, just back of Rensselaerville and Triangle and Crystal lakes four miles west of there along the road to the Little Schoharie valley and Huntersland. The Westerlo-Reidsville area is drained by the Basic and Hannacrois creeks, the present source of the Albany water supply; and while this area, too, is fairly well covered with drift, the Hannacrois and its tributaries have in places cut deep ravines in the Hamilton flags and shales, occasionally developing high falls. Basic creek drains a small lake, Troutner's pond, just about a mile north of the village of Westerlo. Another small lake, now popular for camp sites is situated a mile southeast of South Berne. This is Mud Hollow pond, now known as Lake Onderdonk, which is drained by the Switz kill, tributary of Fox creek. Fox creek and the Switz kill have the largest and broadest valleys in the Helderberg area. They, with their tributaries, drain the whole area from Thompson's lake on the east to Mud Hollow pond and Rensselaerville on the south and as far north as East Township, West Township and almost to Quaker Street. Fox creek heads just about two miles west of Wolf hill and near the village of

East Berne is joined by a branch from the north bringing in the drainage from the Warner and Thompson's lakes area. At Berne the Beaverdam creek, which drains the Knox area, comes in from the north, joining the Fox creek in the broad open valley below the village. Halfway between Berne and West Berne the broad valley of the Switz kill enters from the south, and beyond Gallupville Fox creek joins the Schoharie, which finally flows into the Mohawk river. Both these streams have broad open valleys, particularly the Switz kill, and they both flow through till-covered areas. Only in occasional places are rock outcrops found in the main valleys, but the tributaries in many cases enter the main valleys through steep ravines showing beautiful rock sections. This is strikingly shown by the streams joining, from both sides, the broadly open section of the Switz kill valley. In general, the drainage has no relation to the dip of the rocks but is rather accidental, following the slopes of the till-covered surface.

The drainage of the Indian Ladder-Thompson's lake area deserves special mention (figure 5). It has been very carefully worked out by Professor H. F. Cleland of Williams College ('30), and the results of his studies are given here. It is believed that the Helderberg escarpment existed essentially in its present position and form before the Pleistocene or Glacial Period, more than a million years ago (Tertiary times). Glacial erosion played a very unimportant part in the erosion of the cliff. On the contrary, the ice is believed to have protected the cliffs from weathering and erosion because the lower part of the ice, not being able to move up the vertical cliff, became stagnant and only the part above the top of the escarpment was in motion. In a limestone region, such as

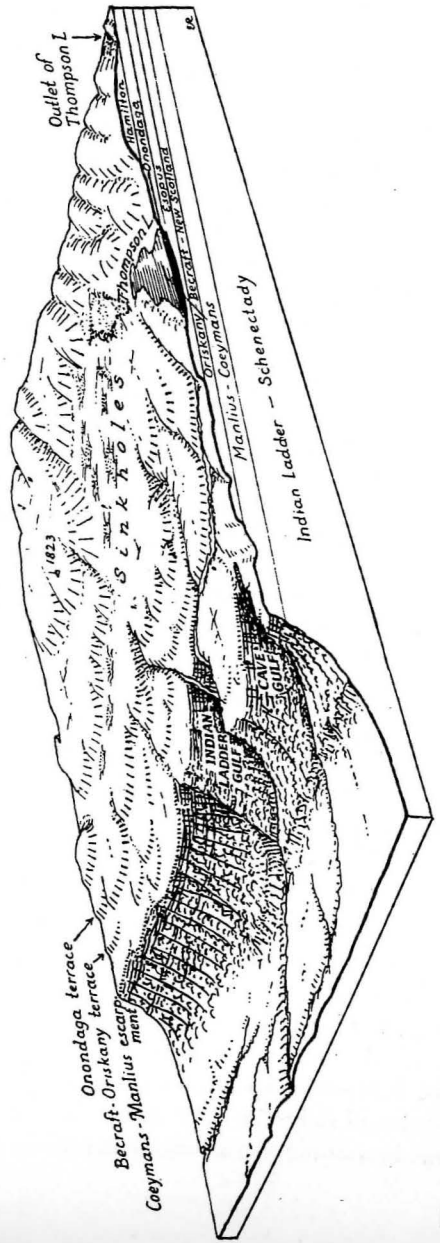

Figure 5 A generalized northwest-southeast block diagram of the Indian Ladder-Thompson's lake area, showing why the streams that formerly flowed over the Helderberg escarpment were captured. The southward dipping beds and the sinkhole topography developed on the Onondaga limestone are seen to have been important factors in this capture, and in the resulting preservation of the Tertiary outline of the escarpment. Geology by W. Goldring. (After H. F. Cleland, 1930)

the Helderbergs, underground solution causes cave-ins of the surface; and depressions of varying sizes, called *sink holes,* are formed. Such sink holes are also known as *karst phenomena* from their occurrence in the Karst region of the Dalmatian Alps. Thompson's lake is such a sink hole in the Onondaga limestone, and there are a number of smaller ones in the neighborhood. Sink holes which were already developed during the Tertiary Period absorbed most of the surface water, and the underground water for the most part followed the dip of the rock to the southwest. This left little water to flow over or under the cliff. Before this underground drainage was established, a stream from the Thompson's lake drainage basin flowed northeast through the reentrant occupied by Haile's cavern and designated as Cave gulf. This stream later was robbed of some of its water by the Indian Ladder stream. The reentrant immediately south, known as the Indian Ladder gulf, is now occupied by two small brooks, popularly known as Outlet and Minelot brooks, which join at the base of the escarpment to form a tributary of Black creek. Through the diversion of the drainage underground through the Thompson's lake sink, the stream flowing through Cave gulf has been effaced and the volume of the Indian Ladder streams greatly reduced. In the spring or after a period of heavy rains water pours from the mouth of Haile's cavern beneath the Coeymans-Manlius cliff in Cave gulf, and very nearly all the year round more or less water issues from the springs at the base of the cliff beneath Outlet and Minelot falls. In very dry weather not the least trickle of water comes over either of these falls.

Thompson's lake has a maximum depth of about 30

feet. Its origin is explained in one of two ways. As stated above, the lake lies in a sink hole. Either the outlet in the bottom of the sink was plugged by glacial drift or the drift was deposited across a long sink hole of which the Thompson's lake depression formed the northern extension, leaving the southern extension to drain a small area. The latter is believed the more probable explanation. The drift barrier would prevent the drainage flowing into the northern extension from escaping through the underground outlet at the south and a lake would result which must overflow unless there were some outlet underground through joints in the Onondaga limestone. Thompson's lake has no surface outlet and for years the underground outlet was unknown. This outlet was discovered first by Professor John H. Cook, former superintendent of the John Boyd Thacher Park, who made the discovery public in 1915 but never published anything relative to it; later Professor Cleland who had made the same discovery published his findings ('30). Except in spring or after a season of heavy rains the evaporation from the surface of the lake about equals the inflow. The outlet of the lake is in a small cave at the southern end through wide solution joint fissures. When the lake level is high the water pours through this cave in large volume, coming to the surface again in a large and deep spring on the Pitcher farm, one and a half miles to the southwest. The water flows out here in about the same volume that it is seen to pour through the cave from the lake. It has been stated that sawdust placed in the lake has come out in the pool and that a pickerel from the lake was once found floating in the spring, but there seems to be some doubt about this. The dip of the rocks in the

Thompson's lake-Indian Ladder area, although somewhat variable, is about 35 feet to a mile (southwest), enough to divert the drainage from the escarpment. Thus through the dip and the underground drainage rain falling near the escarpment, instead of journeying the direct route by way of the Black creek to the Normanskill and thence into the Hudson river, drains to the southwest, through the Fox and Schoharie creeks to the Mohawk river and thence into the Hudson, a route involving many times the distance. The dip of the rocks to the southwest, therefore, has indirectly preserved the position of the Helderberg escarpment as it was in Tertiary times. According to Professor Cleland, "the scenery of the Indian Ladder and of the Helderberg escarpment in general was as beautiful in Tertiary times as now and, with the exception of minor details, would probably impress the casual observer as being the same as that which excites his imagination now" (p. 296).

DESCRIPTION OF FORMATIONS

Accompanying this guide is a topographic map of the area involved (figure 31). Numbers have been placed on this map marking localities, especially referred to in the text, which can not be so easily located by description alone. Roman numbers have been used since they show more distinctly on the map, and each number corresponds to the number used for the formation in the table that follows. When a section shows more than one formation, to avoid confusion, only one number has been used, and this number is referred to under the description of each formation. There is also a geologic map (figure 32) enlarged one and one-half times from the topographic map, showing the distribution of the formations. A greater enlargement of the John Boyd Thacher Park area, showing the distribution of the formations is shown in figure 6. These maps were planned to be used in connection with the descriptions that follow. It was found necessary to use patterns to distinguish the various formations on the maps, but anyone interested can color the formations lightly with either water colors or, preferably, crayons so that they will stand out more distinctly. The formations covered by this guide are included in three periods of geologic time, the Ordovician, the Silurian, and the Devonian, as shown in the table below (see also figure 7). In this table the oldest formations are at the bottom, as is customary in geologic tables, the youngest at the top, and they will be described in order. It is not considered advisable in this guide to describe the fossils that are mentioned under the discussion of the formations though some will be figured. Those interested in identi-

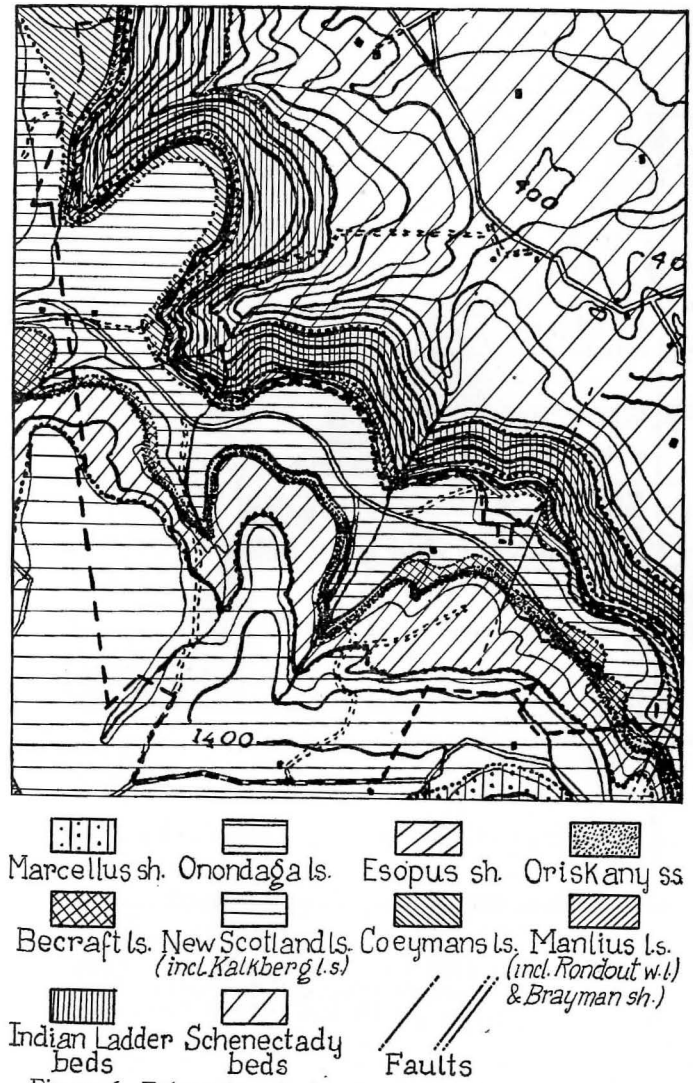

Figure 6 Enlarged geologic map of the John Boyd Thacher Park area. Only the 40 and 100-foot contour lines are shown. Scale: approx. 2 inches = 1 mile

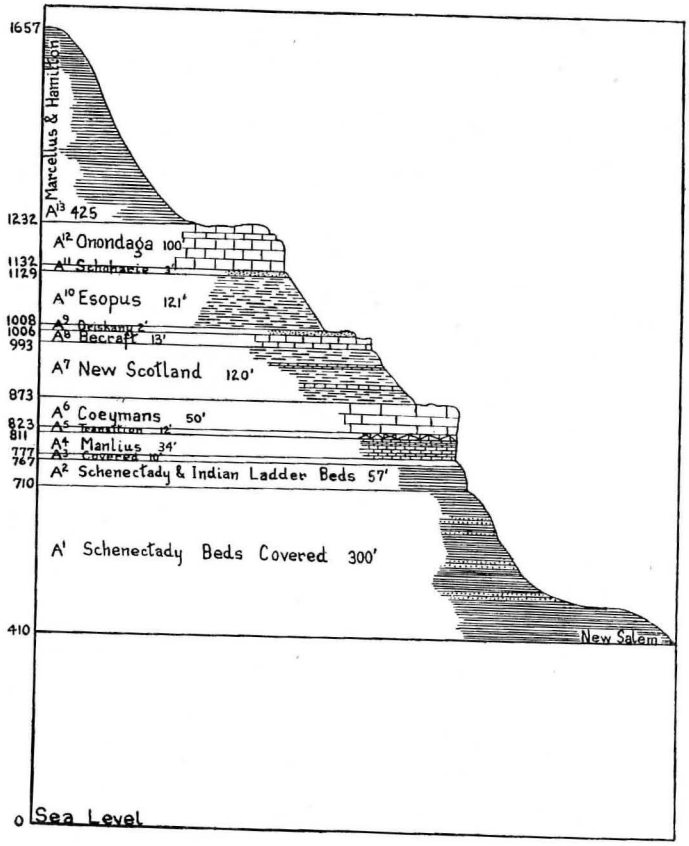

Figure 7 Section of Countryman hill, near New Salem. Shows the two prominent cliffs formed by the Coeymans-Manlius and Onondaga limestones and the minor cliff developed on the Becraft limestone. Scale: 1 inch = 400 feet. (From Prosser & Rowe 1899)

fying specimens are referred to State Museum Handbooks, 9, 10: Handbook of Paleontology for Beginners and Amateurs, specimens in the museum cases, and the paleontologic staff of the Museum.

Table of Formations

Devonian	Middle	15 Hamilton shales and flags 14 Marcellus black shale 13 Onondaga limestone 12 Schoharie grit
	Lower	11 Esopus grit 10 Oriskany sandstone 9 Becraft limestone 8 New Scotland shaly limestone 7 Kalkberg limestone 6 Coeymans limestone
Silurian	Upper	5 Manlius limestone 4 Rondout waterlime 3 Brayman shale [1]
Ordovician	Upper	2 Indian Ladder beds
	Middle	1 Schenectady beds

[1] Brayman shale considered by some a residual soil at top of Ordovician.

The names of the various formations have been taken from the towns or localities where they were first described. The period names are the same as those used in Europe for rocks of the same age. The period names used here, Ordovician, Silurian and Devonian, are those given by English geologists, since the rocks of these ages were first studied in Great Britain. The Ordovician rocks were studied in Wales and the name was taken from the Ordovices, an ancient Celtic tribe which at the

time of the Roman conquest occupied the territory now included in northeastern Wales and the adjoining parts of England. The Silurian rocks were studied on the borderland between England and southern Wales and received their name from the Silures, a warlike tribe that occupied this territory in the days of the Romans. The Devonian rocks were first found to represent a distinct system through studies in Devon and Cornwall, hence the name.

1 SCHENECTADY BEDS

Description. The Schenectady beds received their name from typical exposures of these rocks in the vicinity of the city of Schenectady. They were formerly included with other formations in the old "Hudson River" group, which comprised all the Ordovician shales of the Hudson valley. The Schenectady formation has a thickness of more than 2000 feet and consists of grits and sandstones interbedded with black and gray shales. The thickness of the formation has not been measured, but was computed from the width of the belt and the dip. In a well drilled at Altamont the drill went through 2880 feet of sandstone and shales (including some Canajoharie shale) before it reached the limestone formation below.

The Schenectady beds owe their great thickness to the fact that they were deposited in a rapidly sinking basin or trough extending in a northeast to southwest direction in front of the rising folds of the Green mountains to the east, and the basin was rapidly filled with sediments. The sandstones and shales form an uniformly alternating series throughout the whole formation. The heavy sandstone beds are abruptly followed by shales of a clayey nature (argillaceous), in which higher up thin

layers of sandstone appear. These become more frequent and are followed in turn by a heavy sandstone bed, and the succession is then repeated. This constant alternation of sandstones with shales indicates frequent shifting of currents in deposition, and a shallow water origin is indicated by a number of features, such as shrinkage cracks, like sun or mud cracks, in the thinner sandstone layers, rapid change in the thickness of beds, frequent layers of mud pebbles, and cross bedding (thin layers or laminae inclined at various angles to the main bed).

The Schenectady formation occurs in the southwest corner of the Saratoga quadrangle and from there extends as a broad belt (six to eight miles wide in the capital district) between Schenectady and the Helderberg escarpment, reaching into the Schoharie valley (at Schoharie village). In driving toward the Helderbergs from Albany over the inner lowland one passes first over another belt of Ordovician shales (the Snake Hill beds) with a good exposure at Normansville below the bridge; but from about a mile beyond Slingerlands to the Helderberg escarpment the lowland is underlain by the Schenectady sandstone and shales. In Albany county the Schenectady beds are overlain by the Indian Ladder beds.

Outcrops. The portion of the lowland covered by this guide is fairly well overspread with glacial drift and there are only occasional rock outcrops. There is a good outcrop, very accessible, just outside our area. This is the cut along the state road, three-quarters of a mile east of New Salem, at the Mount Pleasant cemetery. The Schenectady beds are also well exposed in the ravine above New Salem (Ia), which is best reached from the state road above. Along the old Indian Ladder road, just where the steep part of the hill begins (Ib), the contact between the Schenectady beds and the overlying

Indian Ladder beds may be seen. There is no extensive exposure of the Schenectady beds here; but there are good exposures in the bank of the ravine at the left (Indian Ladder gulf) and in the lower section (Ic) of Cave gulf just north. Cave gulf may be reached from the old Indian Ladder road around the spur of the hill or from the state road to Altamont up the stream valley or across the open fields. The contact between the Schenectady and Indian Ladder beds is also exposed in this ravine. Along the state road climbing the Altamont hill, along the old road and in the ravine at the left are many rock exposures. The new state road at the top of the hill passes through a very fine cut in the Schenectady beds, but there are exposures (Id) along this road all the way from the old Helderberg Inn (now a Catholic Seminary) to the top of the hill. About a quarter of a mile beyond here a road branches off to the left past a cemetery (Ie) and continues up over the Helderberg cliff. There are a number of outcrops of the Schenectady formation along this road, and a short distance from the foot of the cliff a few feet of Indian Ladder beds are exposed, very near to their contact with the Schenectady beds.

Fossils. On the whole the Schenectady beds are very barren. The leaflike seaweed *Sphenophycus latifolius* is quite characteristic; and, as it is well distributed through the whole thick formation, it is the most reliable index fossil of these beds (figure 8). This fossil can be found in the rocks outcropping along the road at the New Salem cemetery and in the sandstone exposed at the top of the Altamont hill. Graptolites, looking like thin pencil markings, are found in the black shales which were deposited when the waters were at their quietest. Two forms that

the average collector may find are *Climacograptus spinifer* and *Lasiograptus* (*Thysanograptus*) *eucharis.* The brachiopod *Dalmanella rogata,* the cephalopod *Trocholites ammonius* and the trilobite *Triarthrus becki* may also be collected in the Indian Ladder region. Eurypterids, the most striking element of the fauna, have been found in shale layers between sandstone beds in quarries on the

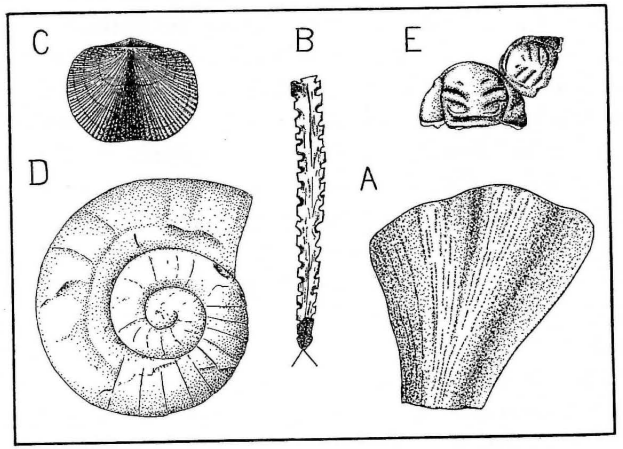

Figure 8 Schenectady beds fossils. *A* Seaweed, *Sphenophycus latifolius,* x¾. *B* Graptolite, *Climacograptus spinifer,* x2½. *C* Brachiopod, *Dalmanella rogata,* x¾. *D* Cephalopod, *Trocholites ammonius,* x½. *E* Trilobite head, *Triarthrus becki*

outskirts of Schenectady, which have since been filled in, and also in the bluestone quarries about Duanesburg and Delanson. These form an extinct order of marine arachnids or scorpionlike spiders. They probably, like the seaweed *Sphenophycus* and some of the graptolites, are well distributed through the whole thick formation, but

the chances of finding them are rather slim. Several other groups of fossils are represented in these beds, some only by one specimen. A single specimen of a starfish, the Brittle Star *Taeniaster schohariae,* was found below Schoharie village.

2 INDIAN LADDER BEDS

Description. The Indian Ladder beds have received their name from the typical exposures in the Black creek ravine, Indian Ladder gulf. These beds have a very local distribution. The type section is along the upper left branch of Black creek and may easily be seen from the top of the Helderberg escarpment. The ravine is best reached from the Indian Ladder road. In this section more than 400 feet are exposed. The lowest hundred feet consists of dark gray to black argillaceous (clayey) shales with two sandstone beds each about four feet thick. Above this are about 100 feet of alternating gray shales and thin yellow, rusty-looking calcareous sandstone bands (one-half to one inch or more thick) which are very characteristic and quite different from the Schenectady beds. About 100 feet are covered, and the next 120 feet (at the top) consist of prevailingly heavy sandstone beds with intercalations of dark sandy and argillaceous shales. At the very top, just below the base of the cliff, this formation ends in a heavy bed of white sandstone with large rounded grains, three and one-half feet thick, separated from an underlying heavy gray sandstone bed by a few feet of shale.

There is a restricted horizontal east and west distribution of the Indian Ladder beds. About a mile and one-half west of Altamont, just below the escarpment (IId), a few feet of the calcareous Indian Ladder beds

are found in the road ditch, and within two and one-half miles to the west no indications of the beds are found. In the same way these beds thin rapidly from the maximum thickness in the Indian Ladder area to a few feet about a mile southeast of New Salem. The fossils in these beds are not represented anywhere else in eastern New York, and this together with the restricted horizontal distribution suggests that the shales and sandstones of this formation were deposited in a narrow arm of the sea extending from the south northward in one of the long troughs of the Appalachian region.

Outcrops. The section in the Indian Ladder gulf (IIa) is the most accessible. In Cave gulf (IIb) is another excellent section which can be followed up from the Schenectady beds to the base of the cliff at Haile's cavern. This section is much less accessible than the other and the climbing in the ravine is rather difficult. About one mile southeast of the Indian Ladder gulf, in a ravine (IIc) near the first fault line, there is another very good section, also not so accessible as the one in Indian Ladder gulf. Here the top bed of sandstone below the Brayman shale is seven feet thick with 20 feet of dark shale and thin sandstone beds between it and the ten-foot solid sandstone bed below. The three sections mentioned supplement one another. The few feet shown about a mile and one-half west of Altamont (IId), along the first road to the left beyond the top of the hill, are of no consequence as an outcrop, except to those interested in tracing out the formation. The Indian Ladder beds are exposed in the ravine above the village of New Salem (above Ia and state road). Fifteen feet of the yellowish-weathering calcareous beds are

exposed 30 feet below the base of the Manlius cliff, where are located the springs which are the source of the suburban water supply. Farther up little disturbed blocks of the heavy top sandstones are seen. About a mile southeast of New Salem small outcrops of dark blue to olive-tinted shales occur just under the cliff, which apparently represent the Indian Ladder beds, but no fossils have been found.

Fossils. This formation has an extremely barren aspect on the whole (see figure 9). Graptolites have

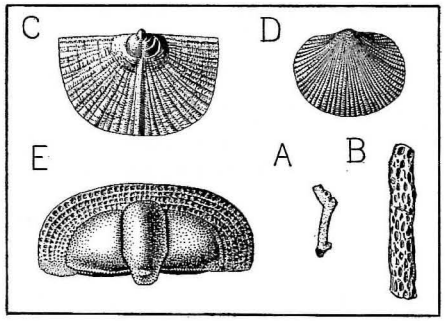

Figure 9 Indian Ladder beds fossils. *A* Bryozoan, *Hallopora onealli,* x2. *B* Enlargement of same, x4½. *C* Brachiopod, *Rafinesquina ulrichi,* x5. *D* Brachiopod, *Dalmanella multisecta.* *E* Trilobite head, *Cryptolithus bellulus,* x2

been found in the dark shales, among them the characteristic *Dictyonema arbusculum, Dicranograptus nicholsoni* and *Climacograptus typicalis.* The greater number of species have been found in the thin calcareous sandstone intercalations. Joints of crinoid stems, which resemble small disks with a hole at the center, are quite likely to be

found, also the characteristic bryozoan *Hallopora onealli,* the brachiopods *Rafinesquina ulrichi* and *Dalmanella multisecta* and the trilobite *Cryptolithus bellulus.* The fauna of the Indian Ladder beds (the same as that of the Eden beds of Cincinnati) is not represented anywhere else in eastern New York and it is for this reason that these beds were separated from the Schenectady beds.

3 BRAYMAN SHALE

Description. The Brayman shale was named from its occurrence at Braymansville in Schoharie county. It is a green or gray sandy shale or sandstone, more or less thickly charged with iron pyrites, and is so soft that it rots away easily. By some students this formation is correlated with those of Upper Silurian age. Others regard it as a residual bed or soil of the Ordovician representing an erosion interval between the Indian Ladder beds (Upper Ordovician) and the Cobleskill limestone or Rondout waterlime (Upper Silurian) above; that is, during this interval the area under consideration was land and erosion was going on while the formations between the Upper Ordovician and Upper Silurian were deposited elsewhere. The greatest thickness of the Brayman shale occurs in the Schoharie area, where there are 40 feet between the Schenectady beds below and the Cobleskill limestone above. In the Indian Ladder area the Cobleskill is missing and the Rondout waterlime overlies the Brayman shale, which here has a maximum thickness of two feet four inches.

Outcrops. The Brayman shale, although more or less covered by talus, is exposed at the two waterfalls, Outlet falls and Minelot falls, in Indian Ladder gulf, reached

by taking the path beneath the cliff to the south of the Indian Ladder road. The exposure at the second falls is the better and here the iron pyrites is fairly abundant. The upper heavy sandstones of the Indian Ladder beds are exposed in both these places. The best exposure of the Brayman shale, as well as of the uppermost Indian Ladder beds, is rather more difficult to reach as it occurs in the ravine (IIc) near the fault, about a mile southeast of the Indian Ladder road. This exposure is best reached from the highway along the top of the cliff, by climbing down the ravine one-half mile southeast of the Indian Ladder gulf or by climbing down through a break in the Coeymans-Manlius cliff in the neighborhood of the Antemann cottage, about a quarter of a mile beyond this ravine, and following along the base of the cliff. The Brayman shale has dwindled to ten inches in a glen (III) one-half mile south of New Salem. Farther south of our area in the Feura Bush (South Albany) and Bethlehem stone quarries (Callanan Road Improvement Company) is a thickness of nine feet of shale carrying an abundance of iron pyrites and giving the same analysis as the Brayman shale in the Schoharie area. This is considered by some as Brayman shale and by others as Rondout waterlime.

Fossils. This peculiar formation has furnished no fossils, wherefore its age has remained uncertain.

4 RONDOUT WATERLIME

Description. The Rondout waterlime received its name from its fine development in the extensive quarries and cement mines in the vicinity of Rondout. It is a uniformly and finely bedded lime mudrock which has but small thickness in our area, the greatest measurement being

three and three-quarters to four and three-quarters feet. The average maximum thickness of the Rondout is 40 feet, but in the Cobleskill region it thickens to 60 feet, the lower six feet of which formerly was mined at Howe's Cave by the Helderberg Cement Company for the manufacture of natural or Rosendale cement. At Rondout, also, the upper beds included in the formation are not used for cement, but the lower beds are quarried to a thickness of 12 to 15 feet. At Rondout and, to a certain extent, at Schoharie (West Hill) the upper beds show a remarkable series of mud-crack structures, mostly pentagonal in form, which indicate very clearly that this rock was formed from a fine lime mud that was probably exposed at low tide to the drying influence of the sun. The uppermost surface in the South Bethlehem quarry southeast of our area also shows mud-cracks. In the Indian Ladder region there is no exposure showing the surface of the rock, and the waterlime does not have its typical appearance here. The lower six feet at Howe's Cave is a banded lime mudrock which is rather massively bedded, bluish gray in color when fresh but weathering brownish. Above the cement bed the formation consists mostly of lime mudrocks with frequent layers of a more sandy texture. Many of the beds are very shaly with a considerable amount of argillaceous (clayey) material which upon weathering leaves much clay behind. These upper beds are considered of no value in the manufacture of cement. In the John Boyd Thacher Park area the Rondout waterlime may be recognized by its brownish color, thin banding and fine texture. It is sharply separated from the underlying Brayman shale, and because of its soft nature weathers back under the cliff

formed by the Manlius limestone, forming what has long been known as the Lower Bear path. For long stretches till and talus are banked up against the cliff covering the Rondout waterlime and the lower part of the Manlius cliff, and the name Bear path now includes, as well, the path following over the till and talus along the cliff. The Bear path may be reached from either side of the old Indian Ladder road, but for most persons frequenting the John Boyd Thacher Park the name has come to be restricted to that portion of the path included between the road and the ladder scaling the cliff beyond (south of) the second (Minelot) falls.

Outcrops. As stated above, there is no good exposure of Rondout waterlime in the region covered by this guide. It may be seen along the Bear path under the cliff in Indian Ladder gulf at both waterfalls, although the exposure at the second falls is the better, and at Haile's cavern in Cave gulf. The best exposure in the Indian Ladder region, showing the complete thickness not only of the Rondout waterlime but of the Brayman shale as well, occurs in the ravine (IIc) near the fault, less than a mile to the southeast. In the small glen (III) about one-half mile south of New Salem the waterlime is again well exposed, and here there is a thickness of six and one-half feet. If the nine feet of shale carrying pyrite found in the Feura Bush (South Albany) stone quarry is Rondout waterlime (rather than Brayman shale, as considered by some), there are exposed here 12 feet of this formation; and 14 feet occur in the large quarry at South Bethlehem. Both these quarries (belonging to the Callanan Road Improvement Company) lie a few miles to the southeast of our area but are very easily reached with a car.

Fossils. No fossils have been found in our area. The coral *Favosites helderbergiae* var. *precedens* has been found, as fragments and small heads, at Howe's Cave in the lower portion of the formation. This species has passed up from the underlying Cobleskill limestone, which is not present in the Indian Ladder and capital district region but is there represented by an erosion interval. Since the coral is of Silurian age, there is no question of the Silurian age of the Rondout waterlime whatever may be the age of the Brayman shale.

5 MANLIUS LIMESTONE

Description. The Manlius limestone was named from the exposure at Manlius, N. Y. (near Syracuse), and in Onondaga county includes near the top two thin beds of waterlime which are used for cement. This formation has been known as the "Waterlime group of Manlius" and also as the "Tentaculite limestone" from the abundant occurrence of the fossil *Tentaculites gyracanthus,* which often covers the surfaces of slabs of this rock.

In our area the Manlius is very characteristic and easily recognized as forming, because of its hardness, the lower portion of the 100-foot Helderberg cliff (figure 10). Typically it is a thin-bedded, dark blue limestone similar to the underlying beds but of a purer composition. The layers, which are one to three inches or more thick, are especially thin in the lower part with alternating light and dark beds ("ribbon limestone"). A few heavy bedded, somewhat more sandy layers occur. Most of the beds are very firm, and slabs of this limestone break with a ringing sound when struck with a hammer. The rock when weathered has a characteristic light color. At

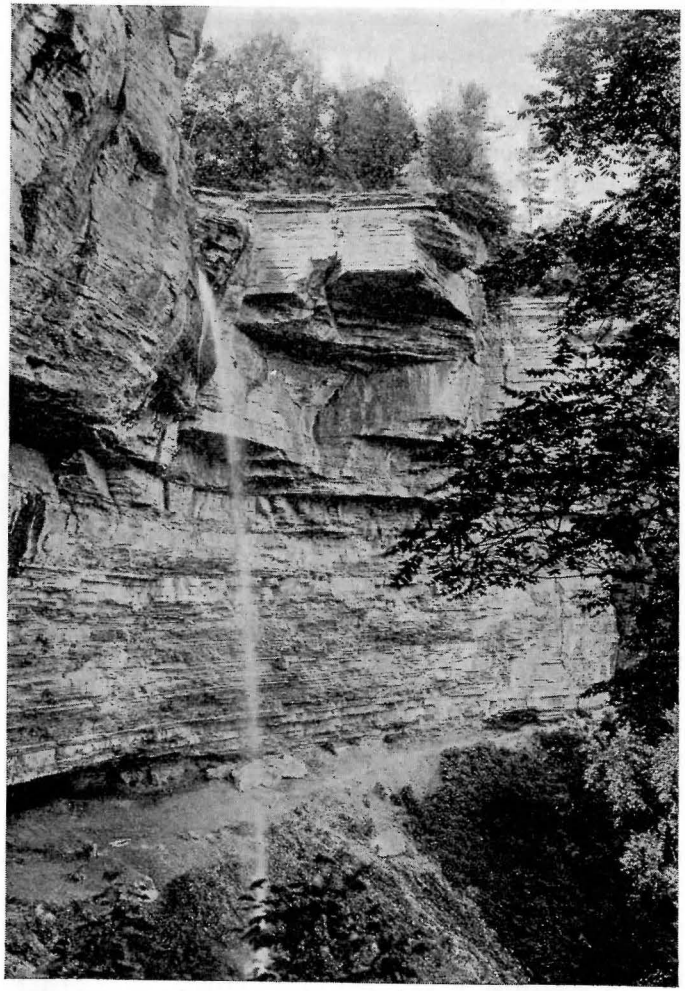

Figure 10 Helderberg cliff at Minelot falls showing complete Coeymans-Manlius section with the Coeymans limestone projecting over the Manlius limestone. The Rondout waterlime is represented by the few feet of rock weathered back beneath the Manlius; below this are the Brayman shale and Indian Ladder beds. (Photograph by E. J. Stein)

Becraft mountain near Hudson and at Howe's Cave the Manlius is quarried for Portland cement, and there are a number of road metal quarries in this formation. The maximum thickness of the Manlius is found in the western part of the State (150 feet, more or less) but in the Helderberg and Schoharie region there is a thickness of about 45 to 50 feet. In the Indian Ladder area there are about 14½ feet of so-called transitional beds below the Coeymans limestone that are included in this measurement, and below these transitional beds at the top of the typical Manlius occurs a varying thickness (less than four feet here; two feet ten inches in New Salem quarry) of waterlime, which because of its softer nature has weathered out to form the Upper Bear path.

Besides the thin bedding, this limestone shows features such as mud-cracks and faint ripple marks, thin shaly films separating the limestones, broken up shells, parallel arrangement of *Tentaculites* shells, mud pebbles in bottom beds etc., all of which clearly indicate tide flat conditions. The Manlius is characterized by several *Stromatopora beds,* one eight to nine feet thick considered as marking the top of the Manlius formation. The *Stromatoporas* are coral-like forms (hydrocorallines) now extinct which appear as large subglobular masses, of concentric structure, which are connected horizontally. Recent representatives, such as the Elk-Horn Coral, are among some of the most important reef-builders today. The heavy *Stromatopora beds,* seen in the Manlius formation for long distances, represent ancient coral reefs. These reefs, taken into consideration with the thin bedding of the limestone, the mud-cracks, ripple marks and mud pebbles, and the fossils, suggest that the Manlius limestone was chiefly

deposited on tide flats in a lagoon behind coral reefs. The transitional beds contain layers with Manlius fossils alternating with beds carrying fossils characteristic of the following Coeymans limestone, and thus indicate oscillating conditions of the sea.

Outcrops. One of the best places for studying the Manlius limestone is in the road metal quarry (Va) above New Salem along the State road just before the road to John Boyd Thacher Park branches off to the right. There are 45 feet of Manlius in the New Salem area and the upper 25 feet are exposed in this quarry. Here are exhibited such features as mud-cracks and ripple marks on the exposed surfaces and mud-pebbles in the bottom beds, and the three commonest fossils may be collected here. Three *Stromatopora beds* are shown. In the glen (III), one-half mile south of New Salem there is a full exposure of Manlius. In an abandoned road quarry (Vd) along the Altamont-Knox road, just one-half mile from the junction with the Thompson's lake road, one may see the upper heavy *Stromatopora bed* with the floor of the quarry on the Manlius. The lower beds of the Coeymans are also exposed here.

Perhaps some will prefer to study the exposures in the vicinity of the Indian Ladder. The full exposure of the Manlius and Coeymans limestones with the Rondout below is beautifully shown at Haile's cavern (Vb), and here the heavy *Stromatopora bed* marking the top of the Manlius stands out distinctly. In walking back along the cliff path to the entrance at the top of the cliff one can easily study all parts of the formation as one mounts higher and higher, and particularly one should study the *Stromatopora beds* at close range. *Tentaculites* and the small *Leperditia* may be found on the surfaces of the thin

beds and perhaps the small *Spirifer*. From the top of the cliff near the cave, looking south toward the Indian Ladder gulf, there is a beautiful view of the Coeymans-Manlius cliff with the Upper Bear path showing well for long stretches. Descending the Indian Ladder road (VIa) one sees, at the left, the "Battlements" formed by the Coeymans limestone and the upper Manlius beds. Here again may be seen the heavy *Stromatopora bed* marking the top of the Manlius, the transitional beds and the waterlime belt that forms the Upper Bear path. Some of the exposed surfaces show an abundance of *Tentaculites,* and loose pieces may be found with little searching. It is near this spot in the Indian Ladder road that one enters (at the right) the Bear path in Indian Ladder gulf, following along the Manlius all the way until beyond the two waterfalls the path climbs up to the Coeymans limestone and the ladder scaling the upper 30 feet or so of the cliff. Along this path may be seen again the thin bedding of the Manlius and sometimes thin slabs showing fossils are picked up. At the waterfalls, just as at Haile's cavern, the entire Coeymans-Manlius cliff is shown. The ravine about half a mile to the southeast (VIb) shows a beautiful section starting at the top of the Coeymans and running well down into the Manlius. Along this part of the cliff fine slabs covered with *Tentaculites* have been found. The climbing in the lower part of this ravine is somewhat rough.

Perhaps the most instructive section for the student, and also the most difficult to reach, is the one exposed in the ravine (IIc) near the fault. This place is much more difficult than any other to reach, whether one walks around from the ravine above mentioned or climbs down through the break in the cliff near the Antemann cottage.

Here is a full exposure of the 100-foot Coeymans-Manlius cliff, below which are two feet eight inches of Rondout, two feet four inches of Brayman shale and a considerable thickness of Indian Ladder beds (seven-foot heavy sandstone bed, 20 feet of alternating fine shale and thick sandstone beds with shales increasing toward the base, ten-foot heavy sandstone bed with a considerable thickness of shale below). It is not advisable for anyone to visit this ravine alone. One may continue beyond (south) of the ravine until the section of the cliff where the fault occurs is reached. Within recent years a huge block fell from the cliff at this place leaving a scar that is plainly visible from the Voorheesville-Altamont state road (figure 14). It is unwise to climb along the cliff in the fault area, since there are loose blocks that may fall at any time. This fault will be discussed in connection with the Coeymans and New Scotland outcrops (pages 57, 68).

Fossils. Three species of fossils (figure 11) will surely be found by any person searching slabs of Manlius limestone, and one in particular, the pteropod *Tentaculites gyracanthus,* is so abundant in certain layers that it has given the name "Tentaculite limestone" to this rock. This species is so abundant that its shells literally cover whole surfaces. The shells are about a quarter of an inch to half an inch in length, conical, tapering and marked by strong transverse rings, closer together near the apex. Because of their characteristic appearance children have termed these fossils "carrots." The parallel arrangement of these *Tentaculites* tubes is one of the indications of the tide-flat conditions under which the Manlius limestone was deposited, and another is the

piled-together masses of shells of *Leperditia alta,* a small crustacean (ostracod) having a bivalve shell. Other surfaces are covered with a small brachiopod, *Spirifer vanuxemi.* These three fossils are rather rare in the heavier strata and common in the thin-bedded layers, although usually only one species is abundant on a given slab of rock.

The fauna of the transitional beds represents oscillating conditions between the Manlius and Coeymans. There

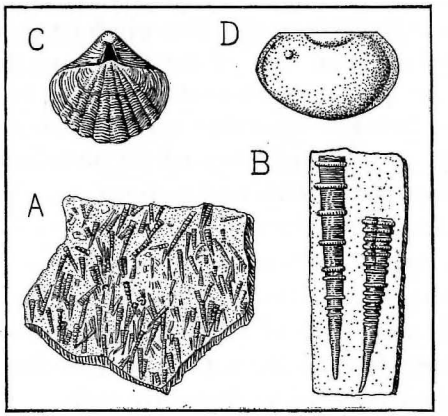

Figure 11 Manlius limestone fossils. *A* Pteropod, *Tentaculites gyracanthus,* x½. *B* The same, x2. *C* Brachiopod, *Spirifer vanuxemi,* x1½. *D* Ostracod, *Leperditia alta,* x2

are beds with the Coeymans brachiopods *Stropheodonta varistriata* and a variety of *Camarotoechia semiplicata* with, at intervals, beds with the typical Manlius fossils. These fossils are rare in the Indian Ladder area.

6 COEYMANS LIMESTONE

Description. The Devonian system of rocks in the Helderberg region begins with the Coeymans limestone, which received its name from the town of Coeymans in Albany county. In older reports it was known as the "Lower Pentamerus" limestone from the most common brachiopod *Pentamerus galeatus* (now *Sieberella coeymanensis*). This limestone not only in the Indian Ladder area, but from Schoharie through the entire Helderberg area southeast to Rondout, has a thickness of about 50 feet (figure 12). It is of massive character and is the principal cause of the Helderberg cliff, into which enters the underlying Manlius. The base of the Coeymans limestone is generally accepted to be above the transition beds and, because these beds are softer the Coeymans limestone usually projects as a massive cliff beyond the underlying Manlius and Rondout beds, which tend to form caves and shelters as in the Indian Ladder region. The Coeymans is a hard rock with vertical joints along which wide cracks open up, breaking the rock up into huge blocks, which from time to time fall from the face of the cliff, especially in the spring of the year after alternate thawing and freezing have widened the cracks and weakened the rock.

The Coeymans is readily distinguished from the Manlius by its massiveness, its bluish gray color, weathering light gray, and its rather coarse semicrystalline character. The most massive beds are in the lower part, several feet thick, while toward the top the formation becomes more thin-bedded. There are also occasional shale partings, nodules and thin lenses of chert.

Outcrops. The Coeymans limestone may be studied in the cliff above (west of) New Salem, where there is

practically a full exposure of this formation, in the quarry along the state road (Va) and in a similar unused quarry (Vd) along the Altamont-Knox road near the junction with the Thompson's lake road. The full exposure is shown in the upper part of the cliff at Haile's cavern, and loose fossils may be picked up at the top of the cliff near the entrance. The entrance to the path leading to the cave is through a crevice along one of the joint planes in the Coeymans, through the entire thickness of which one descends to the Bear path, but it is not very convenient to study the formation here. At the right, climbing down, one may see in the rock a section through a compound coral which, because of its shape, has been regarded by some laymen as a fossil fish. At the top of the old Indian Ladder road the Coeymans may easily be studied and here again are seen sections through large and small head corals (Favosites). The Coeymans forms the upper 50 feet of the impressive "Battlements" at the left looking down the road (figure 12). Following along the Bear path in Indian Ladder gulf one may see the massive Coeymans limestone in the cliff, often projecting beyond the Manlius (figure 10). The waterfalls of both Outlet and Minelot creeks start their tumble at the top of the Coeymans and strike the upper Indian Ladder beds below, giving a height of more than 100 feet to the falls. The Coeymans may be very well studied in the next ravine to the southeast (Vb).

An exposure of Coeymans, very interesting and instructive to the student, occurs in the region of the fault (VIb), about one and one-half miles southeast of the Indian Ladder road. This fault or break runs in a NE-SW direction, along a small ravine and is distinctly

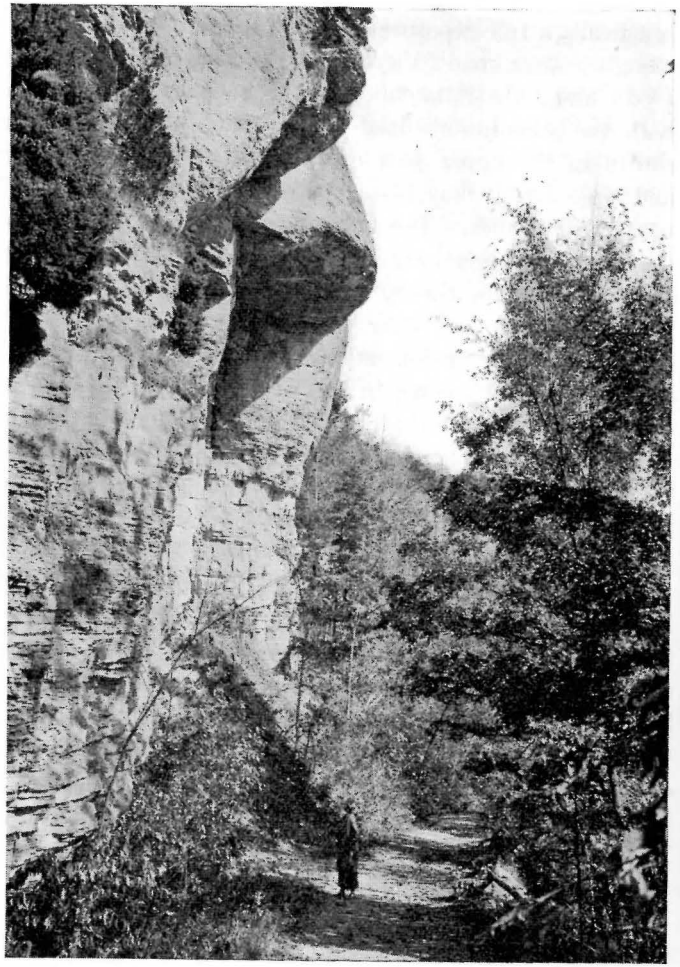

Figure 12 The "Battlements" at the top of the old Indian Ladder road. The upper 50 feet are formed by the Coeymans limestone. (Photograph by E. J. Stein)

shown near the edge of the cliff. The Coeymans on the east side of the fault has been shoved up so that its top is 55 to 60 feet above the top of the same formation on the west side, that is, above the top of the cliff on the west side. On the uplifted side (east) there has been developed in the Coeymans, due to pressure, a parting of the rocks into thin vertical plates, called fracture cleavage (figure 13). This vertical cleavage is very strong, and it is unusual to find it so well developed in a pure limestone. It is very well shown in small cliffs in the woods to the east of the ravine a little way back from the edge. The New Scotland shaly limestone in the open fields above the cliffs shows the same vertical fracture cleavage, finer if anything. The cliff, in the region of the fault, has been weakened, and something more than a decade ago a long section of the cliff broke away along a joint plane, leaving a bare exposure, like a great scar, with a long talus slope or rock slide beneath. This scar in the cliff is very plainly visible from the Voorheesville-Altamont road on the plain below (figure 14). The fault region and the cliffs showing fracture cleavage may be reached from the main highway by walking through the open fields, keeping the small ravine on the left. Entering in this way one arrives at a group of summer camps on the left near the cliff, and the Coeymans cliffs with cleavage are found in the woods at the right 50 to 60 feet above the normal cliff edge. At the ravine marked Vb on the map a dirt road leads off from the main highway and passes near the cliff edge in front of the Antemann cottage to the fault area. This is in part a private road, and must anyway be traveled on foot from the Antemann cottage on because the bridge across the small stream near the fault is unsafe for cars. Just across

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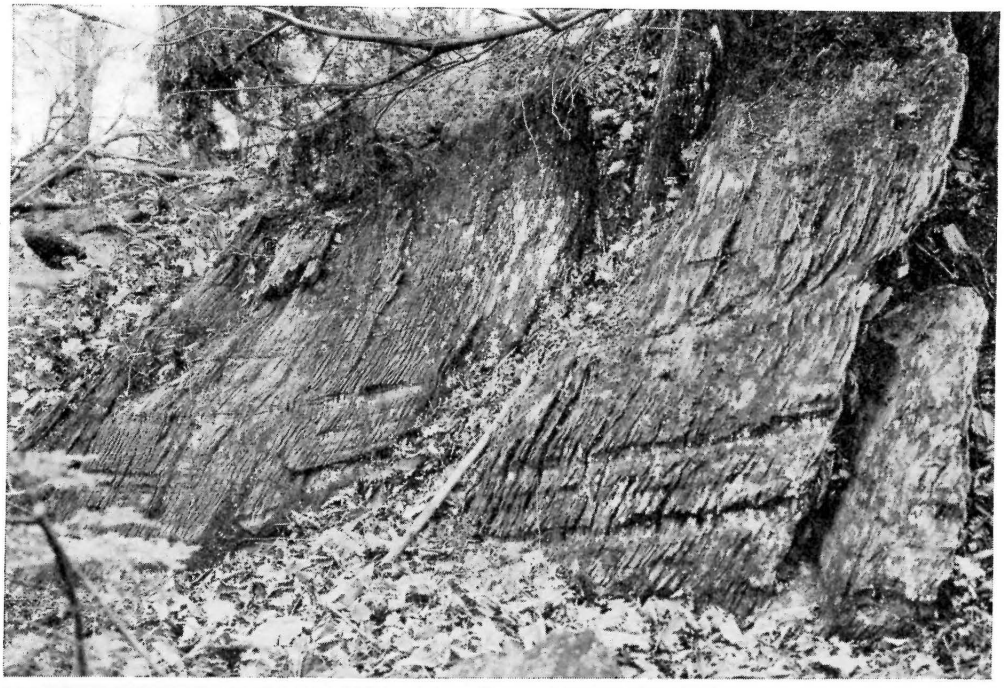

Figure 13 Vertical fracture cleavage developed in the Coeymans limestone in the fault area. (Photograph by E. J. Stein)

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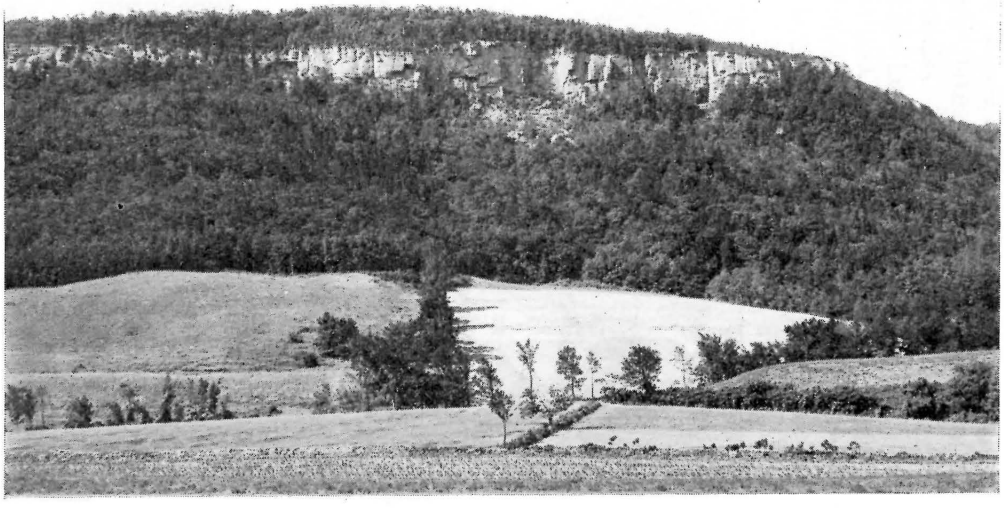

Figure 14 Scar in the Helderberg cliff where a huge block of rock has dropped out, due to the weakened condition of the cliff in the vicinity of the fault. Seen from the Voorheesville-Altamont road. (Photograph by E. J. Stein)

the small stream bed, usually dry, are the summer cottages and in the woods to the right of them (facing the cliff), the Coeymans cliffs showing vertical fracture cleavage.

Fossils. The most common and characteristic fossil is the brachiopod *Sieberella coeymanensis* (formerly *Pentamerus galeatus,* then *Gypidula galeata*) with the characteristic helmetlike shape of the shells (figure 15).

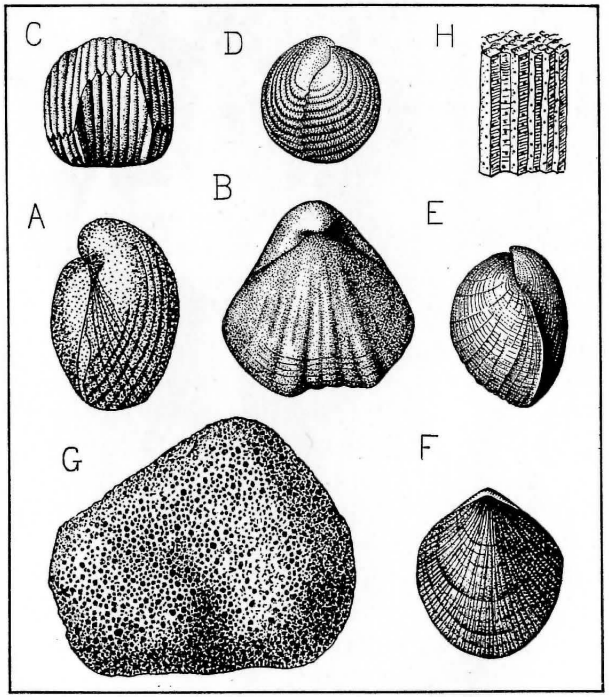

Figure 15 Coeymans limestone fossils. (Brachiopods, *A-F;* coral, *G, H*). *A, B Sieberella coeymanensis* (=*Gypidula galeata*), x¾. *C, D Uncinulus mutabilis,* x¾. *E, F Atrypa reticularis,* x¾. *G, H Favosites helderbergiae,* x½, with enlargement of corallites

This species may be picked up loose at the top of the cliff, especially near the entrance to Haile's cavern and also along the Bear path, particularly in the early part of the summer season. The next common forms are two other brachiopods, *Uncinulus mutabilis,* a subglobular form with many ribs, and *Atrypa reticularis,* a long range form with many fine ribs and prominent concentric lines on the shell. These last two named forms have often been picked up loose in the Bear path. Other brachiopods that may be looked for are the *Stropheodonta varistriata* and *Camarotoechia semiplicata,* found in the transition beds of the Manlius, and the *Meristella laevis* fairly common in the later New Scotland beds.

The head coral *Favosites helderbergiae* occurs in this formation and may be recognized as large or small heads resembling a honeycomb, because it is made up of numerous small prismatic tubes, from which it receives the name "honeycomb coral." In section or in a broken head the separate tubes may be distinctly seen. Some very beautiful specimens of this form have been collected in the Onondaga quarries in this area. Trilobites may be found and a species of pelecypod (mussel or bivalve), but they are rare.

7 KALKBERG LIMESTONE

Description. The typical exposure of the Kalkberg is found along the Catskill, near the village of Catskill, and the name was derived from the local name (Kalkberg) for the Helderberg ridge, meaning limestone mountain. Originally these beds were regarded as transition beds between the Coeymans and New Scotland shaly limestone as they carry a mixed Coeymans-New Scotland

fauna. This limestone is characterized by parallel seams of chert which form heavy beds in the type section. The Kalkberg is of darker color, more impure, less granular and more fossiliferous than the Coeymans, and typically more silicious and less shaly than the New Scotland, weathering a buff color. In the type area this formation has a thickness of about 40 feet, but in the Helderberg area only about 20 feet are represented. Where the chert beds are heavy and the limestone impure, as in the type area, the Kalkberg forms a cliff in continuation with the Coeymans limestone, but in the Helderberg area it forms a low terrace above the Coeymans cliff, a little way back from the edge, that is often quite a conspicuous feature in the topography. The upper beds here are more impure and grade into the shaly limestone above.

Outcrops. The terrace formed by the Kalkberg limestone is well shown in the region of Haile's cavern, and fossils may be collected in the terrace face and in the field stretching from it toward the cliff. The best place for studying the formation and collecting is in the portion of the terrace between the old Indian Ladder road and Outlet creek. Here the top of the terrace is marked by the bungalow. Following up the Indian Ladder road from the Coeymans one can make almost a bed to bed collection of fossils up to the top of the terrace because the road is unused and heavy rains keep the rock fairly well washed off. There is loose material here which makes collecting simple. These beds also outcrop in Outlet creek and loose specimens may be found in the banks. The Kalkberg terrace is well shown to the north and west of the Cave gulf area, but this region is not very accessible except where (two and one-half miles to the northwest)

the old Thompson's lake road climbs up over the Helderberg cliff to the Kalkberg terrace (VII) and thence onto the New Scotland.

Fossils. The lower beds are marked by the characteristic small *Bilobites varicus* with its deeply lobed, heart-shaped shell (figure 16). Bryozoans are found throughout the formation but are particularly character-

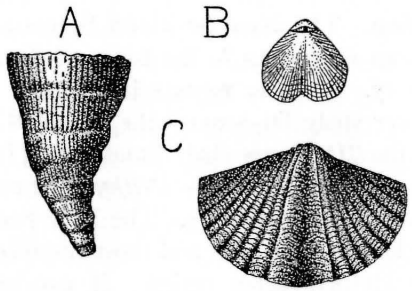

Figure 16 Kalkberg limestone fossils. *A* Coral, *Streptelasma* (*Enterolasma*) *strictum*. *B* Brachiopod, *Bilobites varicus*, x1½. *C* Brachiopod, *Spirifer cyclopterus*

istic of the upper beds where they cover whole surfaces. They appear as lacelike patches, twiglike forms etc. Large crinoid stems (*Mariacrinus stoloniferus*) are also characteristic.

Certain brachiopods found in the Coeymans are also found in the Kalkberg, especially the *Sieberella coeymanensis* and *Atrypa reticularis*. Two Spirifers quite characteristic of the New Scotland limestone, *Spirifer macropleura, S.* (*Delthyris*) *perlamellosus,* are fairly common in these beds as well as a smaller form, *Spirifer cyclopterus*. *Leptaena rhomboidalis* is also present, and

a number of other characteristic New Scotland species have already appeared in the Kalkberg, such as *Eatonia medialis, Uncinulus abruptus, Meristella laevis* etc.

Trilobites occur but are not common. The honeycomb coral *Favosites helderbergiae* and the small cup coral *Streptelasma* (*Enterolasma*) *strictum* are present.

8 NEW SCOTLAND LIMESTONE

Description. The New Scotland limestone received its name from exposures in the town of New Scotland, Albany county. In older reports it has been referred to as the "Lower shaly limestone," the "Catskill shaly limestone" and the "Delthyris shaly limestone" [from two of the most common brachiopods *Delthyris* (now *Spirifer*) *perlamellosa* and *macropleura*]. The New Scotland limestone is the least conspicuous and most fossiliferous member of the Helderbergian series. It consists of thin-bedded, very impure shaly limestone and calcareous shales. The middle beds on the whole are the most fossiliferous. In places, as at the Indian Ladder, the lowest 20 feet or so show heavier bedding and are quite unfossiliferous; and, locally, seams of black chert appear in the uppermost 20 feet or so. In fresh exposures the rock has a dark, bluish gray color and massive appearance and looks like a true limestone. When weathered the beds have a gray or gray-brown color. The New Scotland beds are not conspicuous but form gentle slopes in back of the Coeymans cliff. Good outcrops are usually rare because the rock weathers readily and forms soil-covered slopes which are used for grazing and farming. The best outcrops are found where cuts have been made by streams or in the building of roads etc.

The thickness of the New Scotland beds in this section averages about 100 feet. The greater thicknesses of the New Scotland given by various authors includes the Kalkberg, as for instance the 120-foot measurement given in the Countryman hill section.

Outcrops. A complete section of the New Scotland beds may be studied along the road (VIIIa) into John Boyd Thacher Park, and specimens may be collected from the loose material. For years past the ground around the old Voorheesville waterworks, above this road and below the "Kenny" Parrish house (IXb) on the old road around Countryman hill, has been visited by college classes in geology for collecting fossils. The New Scotland outcrops also along the Berne road (VIIIb) and in the woods to the east. There is good collecting in these shaly beds. The best section of all, and the most convenient to study, is the one in the John Boyd Thacher Park region along the continuation (VIIIe) of the old Indian Ladder road (known as Rock road). This section starts just above the terrace on which the bungalow stands, about where the brook crosses the road, and continues for about half a mile almost to the four corners. In the field at the top of the hill at the left both the Becraft and the Oriskany may be found. Just where the road turns to the left near the four corners the contact between the New Scotland and Becraft may be seen, the nine feet of Becraft above and on top of this 30 inches of Oriskany. The contact between the New Scotland and Becraft is not sharp because there are calcareous layers in the upper New Scotland beds and shaly seams in the lower part of the Becraft limestone. This New Scotland section affords excellent collecting in the loose material on both sides of the road.

An excellent section of the formation, but not affording such good collecting, may be studied by following up the left branch of Outlet creek (left of VIIIe). This section leads one up over the entire New Scotland formation into the Becraft and Oriskany and even to the Esopus and Onondaga if one wishes to continue that far. The New Scotland outcrops to a certain extent in the other stream beds, but it is wise to study the better and more complete sections.

A very interesting structure may be studied along the main highway about a mile southeast of the Indian Ladder road (VIIId). Here in a small road cut, a fault or break in the rocks (the same one referred to under the discussion of the Coeymans) causes a repetition of the New Scotland beds. The small brook crossing the road runs over New Scotland and just above may be seen the cliff of the Becraft limestone, and then New Scotland follows again because the rock on the southeast side of the break was shoved up, bringing the New Scotland beds higher. Continuing along the road toward New Salem one passes from the New Scotland to the Becraft, Oriskany and Esopus in the normal succession. In the field to the east of the fault just above the cliff of Coeymans occur outcrops of New Scotland showing fracture cleavage, due to pressure in the fault area (see discussion under Coeymans outcrops). About a mile beyond this fault, toward New Salem, is another small disturbance (represented by two parallel lines on the geologic map). Here (VIIIc) there are two small breaks or faults which have caused a block of Becraft limestone about 90 feet wide to drop down into the New Scotland. This feature is plainly visible along the road, and is located at the base

of a steep rise in the road and about under the home of Daniel O'Connell, situated on the Onondaga cliff above.

Fossils. The New Scotland formation is the most fossiliferous member of the Helderberg group, and collecting in these beds is the easiest. In fact, the term "dry-dredging" is applied to this sort of collecting, since the rock weathers so readily that specimens in numbers may be picked up loose in a short time (figures 17, 18). The more shaly beds in the middle of the formation are the most fossiliferous. In general, fossils occur in the New Scotland only as impressions or natural molds, but in certain areas the limestone is more silicious and the fossils have become silicified. Numbers of such silicified specimens may be gathered in the Indian Ladder area. It would be out of the question even to list the abundant New Scotland fauna, but there are certain fossils that the collector is sure to find, among them the two very characteristic Spirifers, *Spirifer (Delthyris) macropleura* and *Spirifer (Delthyris) perlamellosus*. Other brachiopods are the long range form, *Leptaena rhomboidalis,* the large form *Leptostrophia (Stropheodonta) becki,* also *Rhipidomella oblata, Meristella laevis* and *Eatonia medialis*. The lower 20 feet or so of the New Scotland in the Indian Ladder area are more heavily bedded and fossils are rare. Two brachiopods have been found in small numbers, both forms with black horny shells: *Orbiculoidea* sp., with shell almost circular in outline, and *Lingula* sp., with shell oval to wedge-shaped. Pelecypods or mussel shells, such as *Actinopteria textilis,* are found in the upper beds, but they are not common. The gastropods or snails are represented by *Platyceras spirale, P. ventricosum.* The trilobite *Dalmanites (Odontochile)*

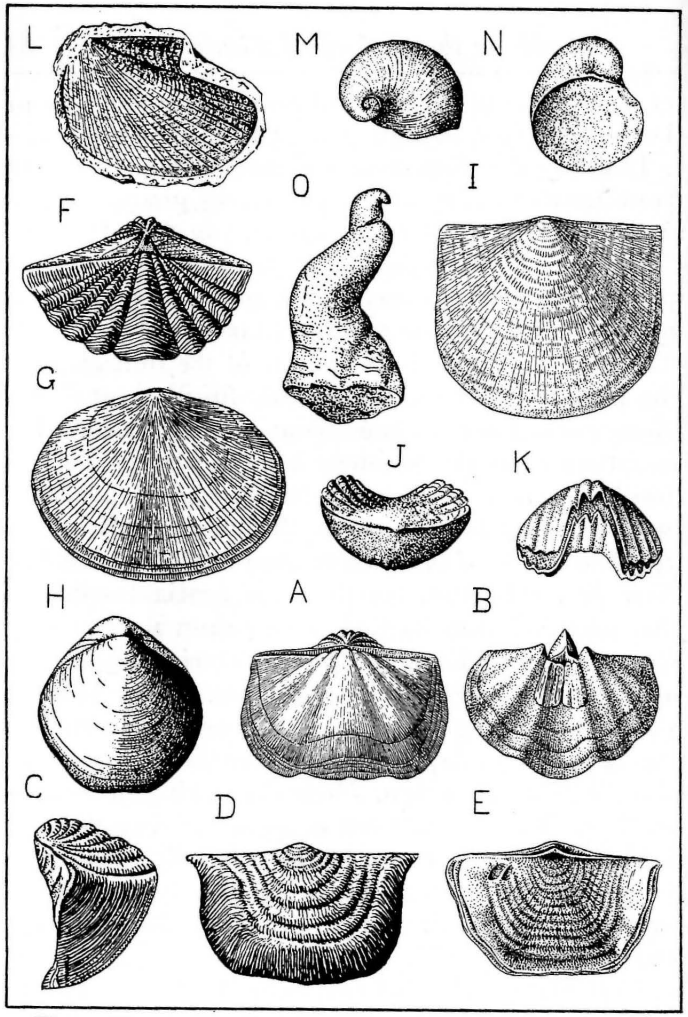

Figure 17 New Scotland limestone fossils. (Brachiopods, *A-K;* pelecypod, *L;* gastropods, *M-O*). *A Spirifer macropleura,* x½. *B* Internal mold of same, x½. *C, D, E Leptaena rhomboidalis,* x½; two valves and lateral view. *F Spirifer perlamellosus,* x¾. *G. Rhipidomella oblata,* x¾. *H Meristella laevis,* x¾. *I Leptostrophia (Stropheodonta) becki,* x¾. *J, K Eatonia medialis,* x¾. *L Actinopteria textilis,* x¾. *M, N Platyceras ventricosum. O. P. spirale,* x½

pleuroptyx is quite frequently collected; other forms may be found (*Phacops logani*). Among the other fossils a small cup coral *Streptelasma* (*Enterolasma*) *strictum* is quite common and the straight cephalopod *Orthoceras rude* fairly so, also the pteropod *Tentaculites elongatus.* The sponge *Hindia inornata* is found all through the New Scotland beds; it resembles a small round concretion.

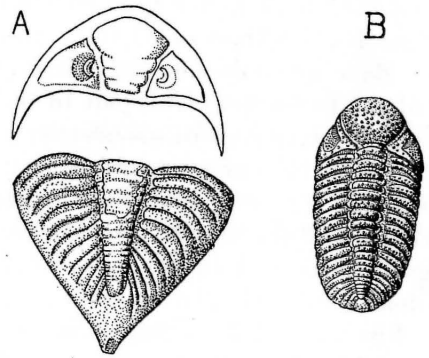

Figure 18 New Scotland limestone fossils. Trilobites: *A Dalmanites pleuroptyx,* x½. *B Phacops logani,* x¾

9 BECRAFT LIMESTONE

Description. The Becraft limestone received its name from the exposure in Becraft mountain, near Hudson, Columbia county. It was formerly known as the "Scutella" or "Encrinal" limestone because of the presence of numerous crinoid bases or Scutellas (*Aspidocrinus scutelliformis*); and also as the "Upper Pentamerus" limestone because of the characteristic brachiopod *Sieberella* (*Pentamerus*) *pseudogaleata.* The Becraft is

typically a very coarse-grained rock and not infrequently has the character of a shell-rock or coquina. The typical rock is light colored with pinkish and light gray, with sometimes yellowish, tints and it darkens somewhat on weathering. This is a very pure limestone on the whole, massive, forming conspicuous ledges. In the Schoharie area the formation has a thickness of 15 feet and in the Helderberg and capital district area nine to 27 feet. It thickens southward until in the type section at Becraft mountain there is a thickness of 45 feet. In the Indian Ladder area there are only nine feet, representing the lower part of the formation. This part of the limestone is thinner-bedded with seams of abundantly fossiliferous silicious shale, sometimes of a greenish color and one to several inches thick. There is no sharp contact between the New Scotland and the Becraft, since the lower Becraft has partings of shale and in the upper New Scotland occur limestone bands with an abundance of crinoidal fragments. Southeast of New Salem the Becraft takes on the more typical "Scutella" limestone aspect. A good place to see this is along the Albany-Clarksville road, a mile and a quarter out of Clarksville just before the cross-road connecting with the Feura Bush road. Like the Coeymans limestone the Becraft is also broken up into blocks by widely opened joint fissures.

Outcrops. The Becraft outcrops pretty well over the whole area, forming conspicuous cliffs in places because of its massive nature, sometimes broadening out into flats. This rock outcrops along the New Salem-Wolf Hill state road, just beyond VIIIb in the woods. Another exposure, with a thickness of 13 feet, is found along the old road (IXa) branching off to the left from the

Park road and the old road leading around Countryman hill (north) past the Parrish house. There is a good outcrop just below the old Parrish house (IXb). Back of the house the joint system of the formation is well exposed, and here is still to be recognized the first road that led from Schoharie to Albany, the old "Beaverdam road." The Becraft may be seen outcropping above the New Scotland at the left above the new Indian Ladder road until finally it appears along the road (VIIIc) where a block, due to two faults, is dropped down into the New Scotland (see discussion under New Scotland outcrop). At IXc along this road the joint system is well exposed in the woods at the right (east). In this neighborhood may be seen not only the Becraft, but above it 18 inches of Oriskany and the Esopus, seen in a gravel pit along the road at the left (west). The Becraft is seen as a cliff near the larger fault (VIIId) and there is a good exposure near the four corners (IXd) where the Indian Ladder road (Rock road) turns to the left toward Thompson's lake. As stated under the description of the New Scotland formation, here may be seen three formations in contact, the New Scotland, Becraft and Oriskany. The Becraft crosses the road which goes directly north from the four corners and is also found along the edge of the woods to the right, where it forms a cliff; then it turns back to the road again and may be followed for some distance. This road is passable all the way through only on foot. Along the Altamont-Knox road about three-quarters of a mile beyond the junction with the Thompson's lake road, on the right and a short distance back from the road, is an abandoned quarry (IXe) giving a full section of a greater thickness of the

Becraft limestone (15½ feet here), capped by 20 inches of Oriskany sandstone. One walks over a flat surface formed by the Oriskany to reach this quarry.

Fossils. Fossils are very hard to collect in the Becraft limestone, and are mostly crinoids and brachiopods (figure 19). The very fossiliferous shaly layers

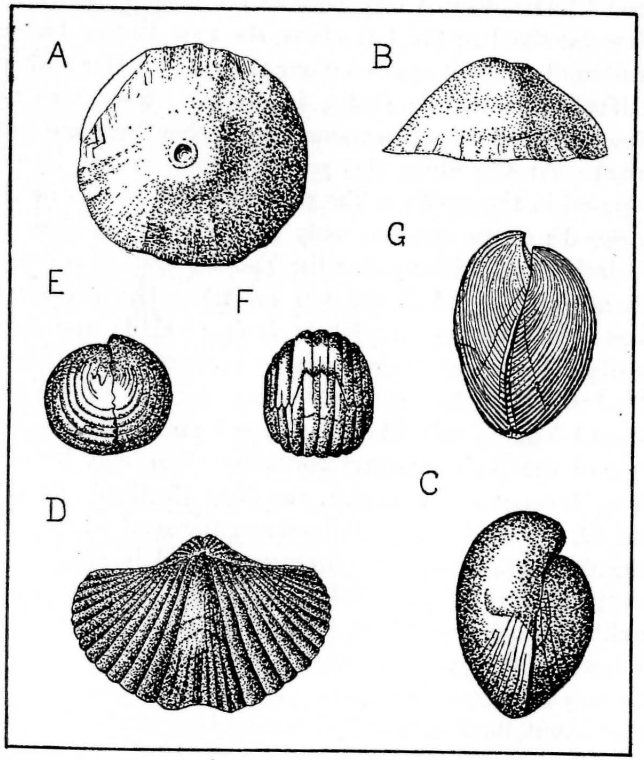

Figure 19 Becraft limestone fossils. (Crinoid base, *A, B;* brachiopods, *C-G*) *A, B Aspidocrinus scutelliformis. C Sieberella pseudogaleata. D Spirifer concinnus. E. F. Wilsonia ventricosa. G Schizophoria multistriata*

in the lower portion furnish the best collecting, especially when weathered. The Scutellas, found everywhere in the Becraft limestone, constitute its best index fossil, although they also appear in the upper part of the New Scotland limestone. Another characteristic fossil is the brachiopod *Sieberella* (*Pentamerus*) *pseudogaleata.* Other brachiopods to be looked for are *Spirifer concinnus, Schizophoria multistriata, Uncinulus nobilis* and *Wilsonia ventricosa.* A number of brachiopods found in the New Scotland beds and previous formations occur also in this limestone as the long range *Leptaena rhomboidalis* and *Atrypa reticularis,* the large form, *Stropheodonta becki,* and such forms as *Rhipidomella oblata.* The *Atrypas, Sieberellas* and *Rhipidomellas* are quite abundant in the shaly partings in the lower part of the formation, and also the little cup coral *Streptelasma* (*Enterolasma*) *strictum.* The specimens in these shaly layers have become silicified. Probably the two best localities for collecting will be found to be the ledges around the Parrish house (IXb) and in the Indian Ladder area at the four corners (IXd).

10 ORISKANY SANDSTONE

Description. The Oriskany sandstone was named from the type locality at Oriskany falls, Oneida county, where it consists of a nearly pure, white fossiliferous quartz-sand rock 20 feet in thickness. It represents shore deposits laid down while the land was subsiding and the sea was gradually creeping over it. Farther to the southeast two other formations intervene between the Becraft and the Oriskany, in the Schoharie area one.

In the northern Helderberg area the rock is a very dark, bluish gray, hard quartzitic sandstone with a strong admixture of lime grains which increases southward. When the

rock is exposed the lime is commonly dissolved out leaving a brown, porous sand rock in which the fossils are beautifully preserved as both internal and external molds. The fossils in the fresh rock are both hard to distinguish and to extract. In the Helderberg area the Oriskany has an average thickness of only one to two feet, with a maximum of four feet. In the areas where it outcrops it has been used extensively in fences, and these old stone fences both around Schoharie and in the Helderberg area have been the source of a large part of the wonderful collections of Oriskany fossils that have been made. Because of the flinty nature of the Oriskany sandstone the rock is very resistant; and wherever the beds are more or less horizontal, even though of little thickness, it forms a level platform or terrace, the softer Esopus beds above having been eroded. The surface is covered with the characteristic worm burrows *Taonurus cauda-galli,* which also mark the Esopus shales and which because of their appearance were termed "Cocktails." The Oriskany is broken up into blocks by a system of intersecting joint fissures; and it is this which has helped to make the Oriskany sandstone so satisfactory for use in the old stone fences.

Outcrops. The Oriskany outcrops in many places over the area covered by the guide. A good outcrop may be seen along the old road going south around Countryman hill, forming the flat at the left of the road above IXa. Another good outcrop is found back of the barn of the Parrish house on the old Countryman hill (north) road, and north of this along the road for a considerable distance. The formation is 20 inches thick in this area. The Oriskany is also well shown along the new Indian Ladder road (near IXc) at the bottom of a road metal quarry in the Esopus shale, about a mile and a quarter

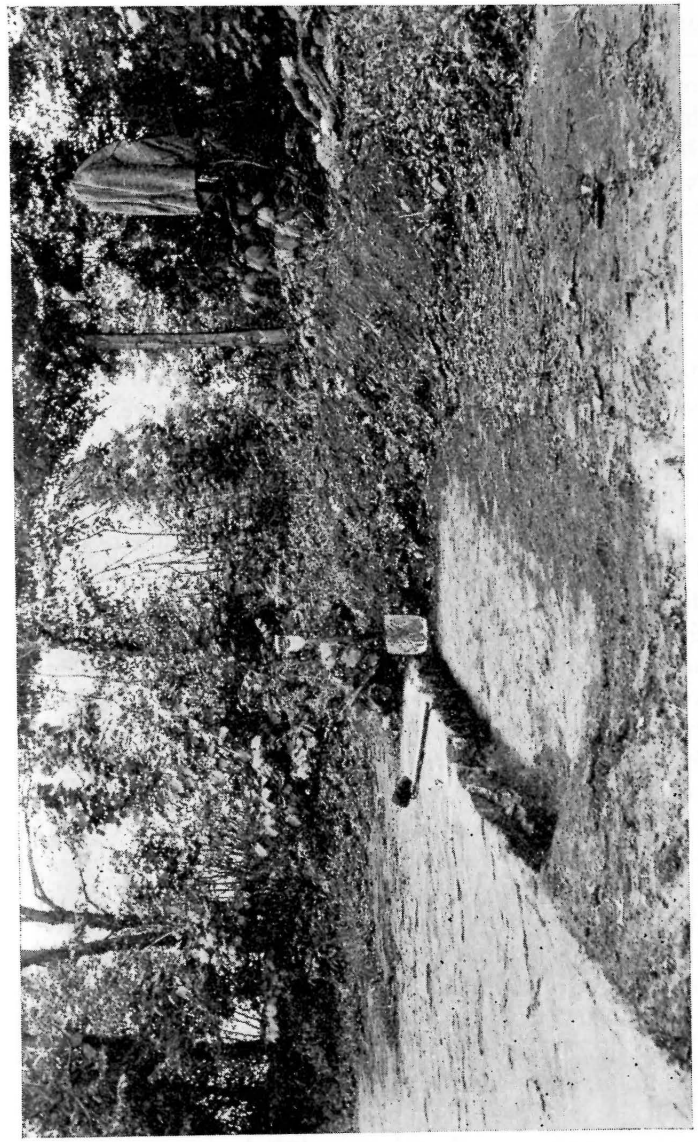

Figure 20 One of the "step faults" in the Oriskany sandstone. North of the four corners on the old Indian Ladder-Thompson's lake road (Rock road). (Photograph by J. H. Cook)

southeast of the Indian Ladder, and here it is 18 inches thick. On the opposite (east) side of the road the Oriskany is found overlying the Becraft with a sharp, "welded" contact; that is, the two formations adhere so tightly that they are broken out as one piece of rock. The Oriskany may be seen in several places in the Indian Ladder area, but the best place for collecting a few fossils is near the four corners (IXd) where the Indian Ladder road (Rock road) turns left toward Thompson's lake. Here there is a thickness of 30 inches. Several of the most characteristic forms have been collected here. The Oriskany outcrops over a considerable area along the road turning north from the four corners (Xb). A succession of small faults or breaks, varying from a few inches to about a foot in displacement, forms a series of steps in this area, and they are known as "step faults" (figure 20). They are shown in the road and along the edge of the road where it passes through the woods, and the fault showing the greatest movement or displacement occurs just before the woods ends at the right. The break or fault line has a general northeast-southwest direction and the uplift (or upthrow) side is toward the north. The sum total of the movement of all these small faults gives about two feet of displacement. On a fresh surface the faults may be seen breaking across glacial scratches, showing that the faults are postglacial. Along the Altamont-Knox road beyond the junction with the Thompson's lake road (Xc and west) the Oriskany, for a long distance, may be found on both sides of the road; in fact, it forms the terrace upon which the road is built, and here in the fences along the road there is good collecting. The Oriskany, with a thickness of 20 inches, may be seen capping the Becraft limestone in the abandoned quarry in this area (IXe).

Fossils. The fossils of the Oriskany are notable for their large size and thick shells. They indicate rather turbulent conditions along an advancing shoreline in the sea of the region. Among the most common and characteristic fossils (figure 21) to be found in the Helder-

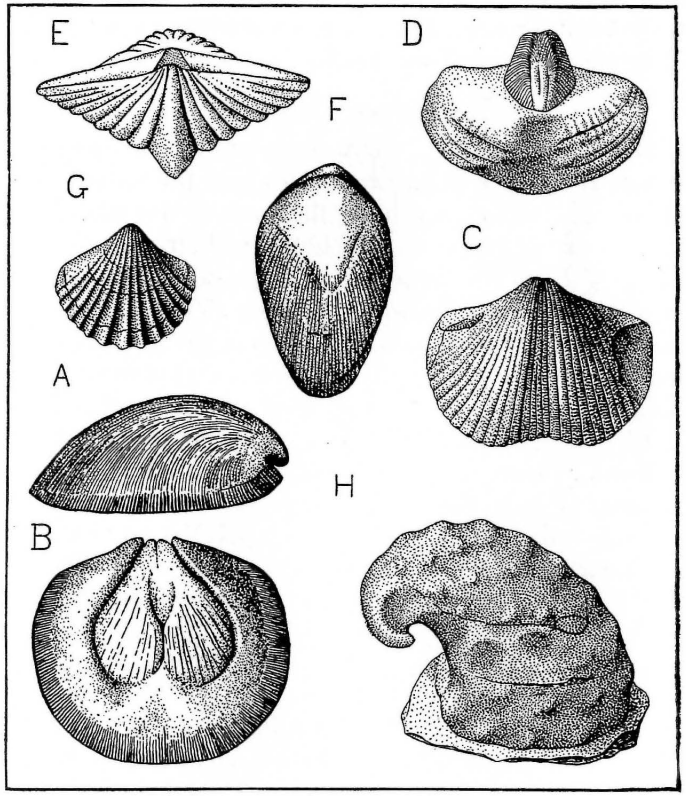

Figure 21 Oriskany sandstone fossils. (Brachiopods, *A-G;* gastropod, H) *A, B. Hipparionyx proximus,* x½. *C Spirifer arenosus,* x½. *D* Internal mold of same, x½. *E S. murchisoni,* x¾. *F Rensselaeria ovoides,* x½. *G Leptocoelia flabellites. H Platyceras nodosum,* x½

berg region are the brachiopods *Spirifer arenosus* and *S. murchisoni, Hipparionyx proximus, Rensselaeria ovoides, Leptocoelia flabellites,* and the gastropod *Platyceras nodosum.* The worm burrows, *Taonurus caudagalli,* or "Cocktails" are also characteristic on exposed surfaces. As mentioned above, the best collections can be made from the stone fences and these are quite accessible along the Altamont-Knox road.

11 ESOPUS SHALE

Description. The Esopus shale or Esopus grit was named from the excellent exposures near the Esopus settlement (Kingston) and along the creek of that name. It was previously known as the "Cauda-galli grit" or "Cocktail grit" from the abundant markings, which resemble a rooster's tail, made by worm burrows (*Taonurus caudagalli*) on the bedding planes. They are the same type of markings as those found on Oriskany surfaces. The Esopus is a blackish or dark gray grit or sandy shale which throughout the Helderberg region maintains a very uniform character. It commonly splits up into small rectangular fragments which cover the slopes of the hillsides underlain by it. The aspect of the rock varies according to the way in which the cuts are made (figure 22). In certain cuts the surface is covered with small cubical blocks, resembling a pile of stone, but other cuts are made in such a way that the rock appears very solid and resistant. In the northeastern Helderberg area the lower eight or ten feet of the grit in places was found to be highly silicious or flinty, indicating a close relation with the Oriskany sandstone below. The middle beds are more argillaceous (with clay) and the upper part becomes strongly silicious again with a heavy (five to six-foot)

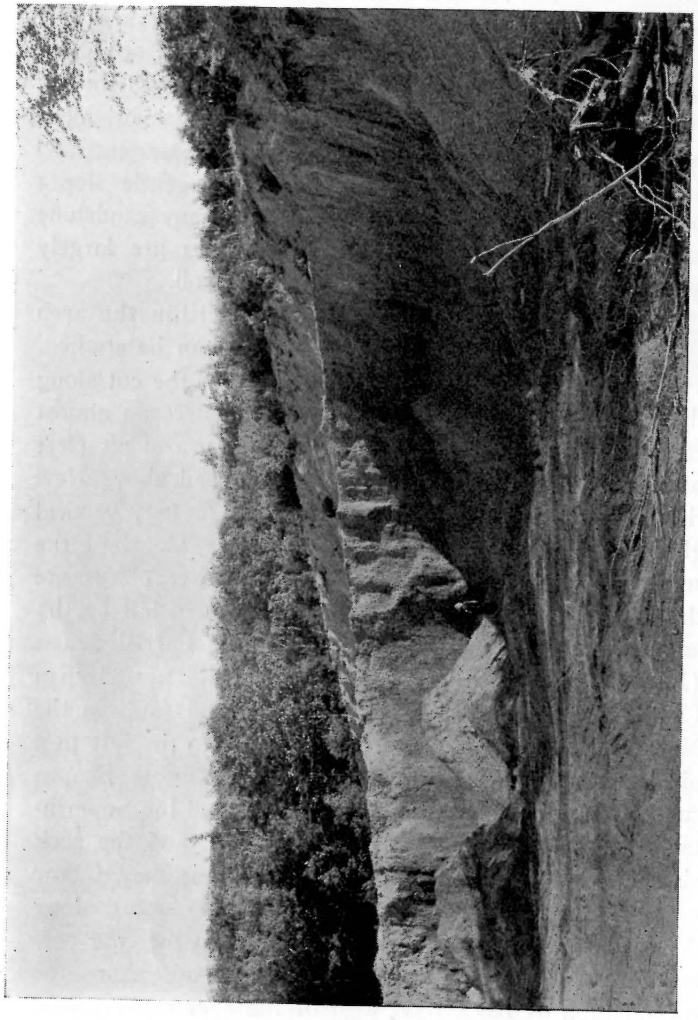

Figure 22 Esopus grit gravel pit along the new Indian Ladder road. Taken when the road was under construction. (Photograph by E. J. Stein)

sandstone bed at the top. In the Helderberg area the Esopus has a thickness of 100 to 120 feet. Southward this formation thickens (700 feet at Port Jervis), but in the other direction, toward Schoharie, it loses in thickness and not far west of Otsego county disappears entirely. In the landscape the Esopus grit forms gentle slopes between the terraces formed by the Oriskany sandstone and Onondaga limestone; and these slopes are largely given up to grazing because of the poor soil.

Outcrops. There are many places within the area covered by this guide where the Esopus can be studied. Perhaps the two most convenient places are the cut along the New Salem-Wolf hill road (XIa), where an almost complete section is now exposed, and the gravel pit (left of IXd) along the new Indian Ladder road above New Salem. In the first-mentioned locality (XIa), vertical glaciated surfaces may be seen in the upper part of the section, at the right along the road. Other places are the old road going south around Countryman hill (XIb) and north along this same road above the Parrish house (XIc). Beyond the gravel pit along the new Indian Ladder road, just before the road cut and fault in the New Scotland at VIIId, a road leads off to the left to a picnic spot along the brook and here is another Esopus cut (XId). The stream to the west, beyond the Superintendent's house (XIe), shows a good cut and the rock also outcrops along the old road which one may follow up onto the Onondaga. Other exposures occur along the road (XIf) leading directly south from the four corners west of the old Indian Ladder road, along the continuation of Rock road west of the four corners past Thompson's lake (road cut, XIg), and in road gravel pits

along the Altamont-Knox road west of the junction with the Thompson's lake road (XIh and on).

Fossils. Except for the worm burrows (*Taonurus cauda-galli*) the Esopus grit is remarkably barren of organic remains (figure 23). Fossils have been reported

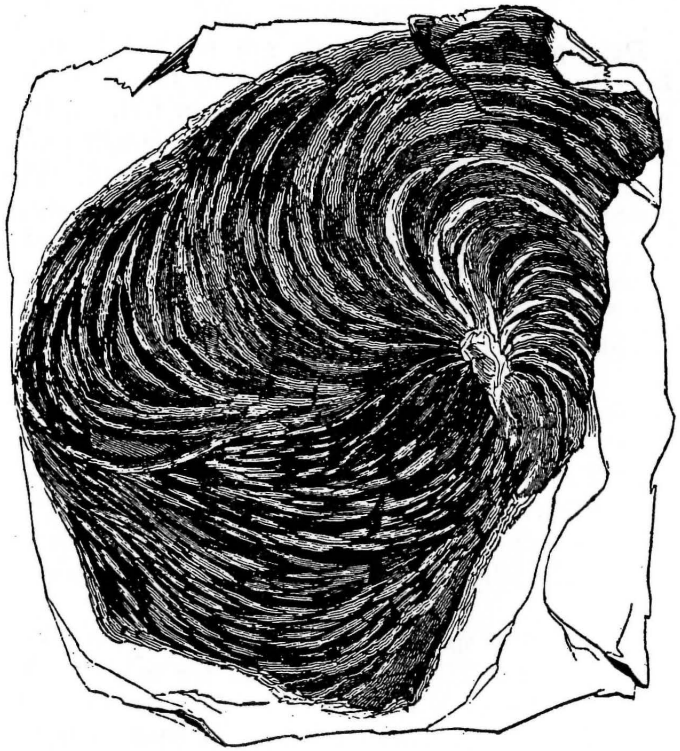

Figure 23 Esopus grit fossil. The worm burrow or "Cocktail", *Taonurus cauda-galli*

from the Esopus creek area and a few fossils, mostly brachiopods have been found in the lower silicious beds of the Catskill area. The chances of finding fossils in this formation in the Helderbergs are very slim. A small brachiopod has been found in this region.

12 SCHOHARIE GRIT

Description. The Schoharie grit received its name from the type locality in Schoharie county (at Schoharie), where it has a thickness of six to seven feet. It is a formation of somewhat local development, extending west to Otsego county but not everywhere continuous. The greatest thickness in the Helderberg area is not more than three feet and in places it is missing entirely, the Onondaga resting directly upon the Esopus. Six to eight feet have been found on the Albany quadrangle (vicinity of Callanans Corners), and to the south, in Becraft mountain, some 150 to 200 feet have been referred to the Schoharie grit on the basis of the fossils, although in rock aspect the beds are more similar to the Esopus. In the Catskill area the formation is more of a fine-grained, impure limestone and has a thickness of 100 feet. The Schoharie grit is an impure silicious limestone, dark bluish-gray in color when fresh and weathering to a dark buff or brown porous sandstone. Some parts of the rock are shaly and rather sparingly fossiliferous. In the northern Helderberg and capital district area not only has the Schoharie grit been found merging into the overlying Onondaga, with the lower Onondaga somewhat sandy, but interfingering of the grit and limestone have been observed and fossils have been found passing freely across the welded contacts. In some places the Esopus grit passes

gradually up into the Schoharie grit; in other places breaks have been found between the Schoharie grit and the formations above and below. Some consider the Schoharie grit as a continuation of the Esopus sedimentation; others regard it as an initial sandy phase of the Onondaga limestone.

Outcrops. There are few places in our area where the Schoharie grit outcrops. It may be studied in the ditch and in the woods at the right (north) along the New Salem-Wolf hill state road just where the road comes up over the hill onto the Onondaga terrace (above XIa). The thickness here has been estimated to be about three feet. A better exposure occurs along the old road from New Salem over the southern slope of Countryman hill (near XIb). Here 22 inches are fully exposed beneath the Onondaga at the right (north) side of the road and fossils may be collected. Two feet ten inches have been found at the base of the Onondaga in the cliff to the south and west of the old Parrish house on the old Countryman hill road (SW of IXb). There is one exposure, quite accessible, in the John Boyd Thacher Park area, along the upper course of Minelot brook (XII) which forms the second (east) falls in the Indian Ladder gulf. An old road follows this stream. The Esopus grit is well exposed in and along the road. A spring flows out beneath the Onondaga along the road at the right, and at the spring and along the road in that vicinity there is a fair exposure of Schoharie grit and good specimens of both cup and compound or head corals have been found here.

Anyone who is interested in studying the Schoharie grit and cares to go outside the area covered by the guide will find two very good exposures on the Albany quadrangle.

One exposure is in the gorge of the Onesquethaw, just outside (east) of the village of Clarksville on the south side of the gorge below the falls. Here near the top of the gorge were found two feet seven inches of typical Schoharie and below this a foot of gritty shaly layers weathering like the Schoharie grit and transitional to the Esopus below. There is a sharp contact with the Onondaga limestone above. The upper two feet of the Schoharie grit are very fossiliferous with corals very abundant in the upper eight inches. The second locality is along the road turning south (to Coeymans) from Callanans Corners, about three-quarters of a mile from the corners on the slope in the woods to the right. Six to eight feet of the grit are exposed here, and here also is shown, in places, interfingering of the Schoharie and Onondaga, with the lower Onondaga somewhat sandy.

Fossils. The Schoharie grit is remarkable for its great wealth of fossils (figure 24). The Schoharie-Helderberg area has furnished 123 species of fossils and the great majority are large and striking forms confined to this horizon. Of these the mollusks are the most striking, particularly the cephalopods, among which the straight forms (Orthoceras) prevail. The student is referred to the Geology and Paleontology of the Schoharie valley for a full list of the fossils. A few will be mentioned here. Among the fossils that have been found in the Helderberg area are species of the cup corals *Zaphrentis* and *Streptelasma* and the compound coral *Favosites;* the brachiopods *Atrypa reticularis, Rhipidomella alsa, Strophеodonta (Leptostrophia) perplana, Meristella nasuta, Pentamerella arata,* and *Spirifer raricostatus;* the pelecypod *Conocardium cuneus;* the cephalopods *Orthoceras*

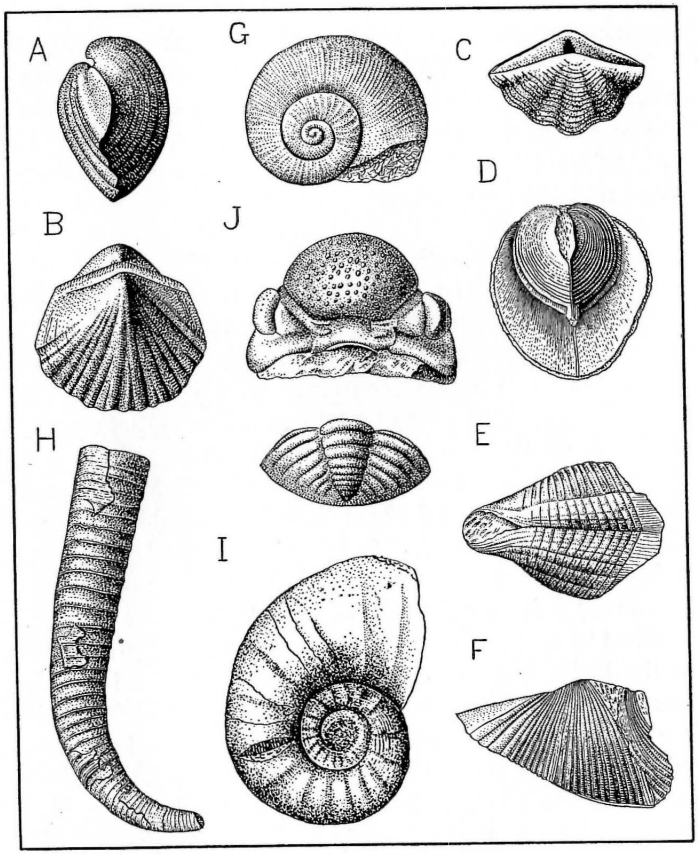

Figure 24 Schoharie grit fossils. (Brachiopods, *A-C;* pelecypod, *D-F; gastropod, G;* cephalopods, *H, I;* trilobite *J*). *A, B Pentamerella arata. C Spirifer raricostatus. D-F* Three views of *Conocardium cuneus,* x¾. *G Pleurotomaria arata,* x½. *H Cyrtoceras (Ryticeras) eugenium,* x⅓. *I Trochoceras discoideum. J Phacops cristata;* head, x¾; pygidium

zeus, O. thoas, Cyrtoceras (Ryticeras) eugenium, etc.; and the trilobites *Phacops cristata* and *Dalmanites anchiops.*

The best collecting, of course, is in the Schoharie valley, where the formation is so characteristically developed, and the best opportunity for studying the rock, according to Grabau (1906), is found on the northern end of both West and East hills.

13 ONONDAGA LIMESTONE

Description. The Onondaga limestone derived its name from its occurrence in Onondaga county. It has a wide distribution and extends with very uniform character of rock and fauna from New Jersey in the southeast, across the State into Ontario, Canada. The greatest thickness of the Onondaga in the western part of the State is between 150 and 200 feet. In the Schoharie area there is a thickness of about 100 feet; in the northern Helderberg area 85 to 100 feet; and southward from here it thins somewhat until in southeastern New York (Kingston area) it has a thickness of about 50 feet.

The Onondaga limestone forms the second great cliff of the Helderbergs seen from the Albany plain, but it is more interrupted than the Manlius-Coeymans cliff. This is a moderately pure limestone of light bluish color, often thinly bedded in the lower portion but in general massive. Lenses of chert in parallel layers (four to six inches and more thick) occur, particularly in the lower part of the formation, but the distribution is very irregular, since the chert has been found to be abundant in some places, sparse in others (figure 25). A black calcite has been found to be quite abundant in certain places in the northern Helderberg area. The Onondaga limestone fauna is characterized by corals, because much of the limestone was undoubtedly formed by coral reefs.

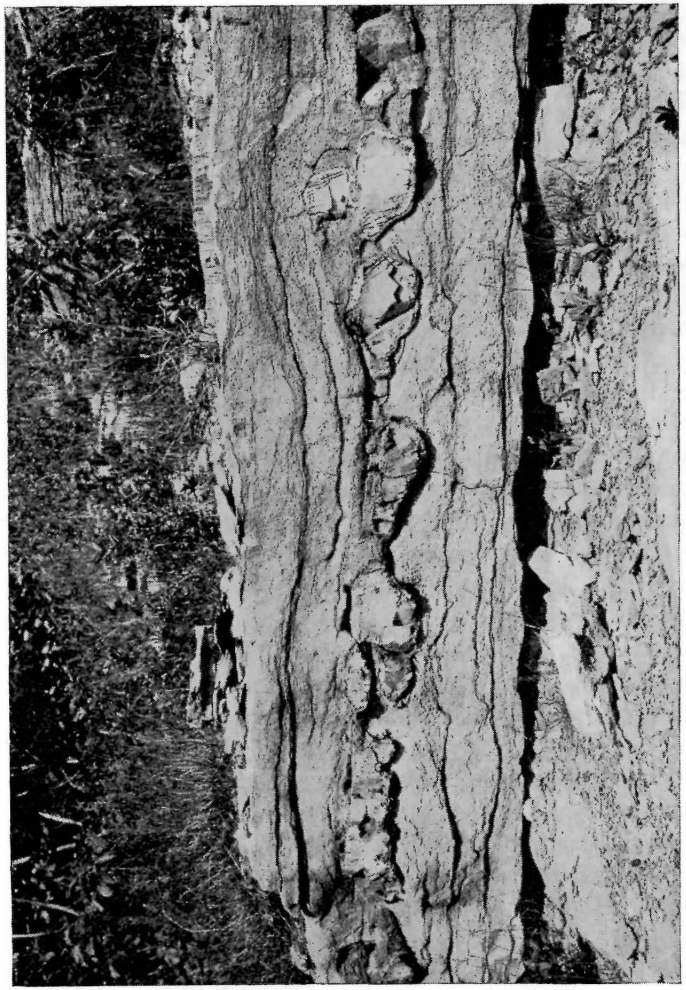

Figure 25 Chert layer in Onondaga limestone. New Scotland town quarry along New Salem-Wolf hill state road. (Photograph by E. J. Stein)

Because of the comparative softness of the overlying Marcellus black shale these beds are widely eroded away leaving the Onondaga limestone as a continuous terrace along the Helderbergs above the cliff, not very wide in some places, but in other places, such as the area east and west of Thompson's lake and the area southeast of Wolf hill, it has a width of more than a mile and forms a broad stretch of good farming land, as in the vicinity of the village of Clarksville. The roads often follow this Onondaga terrace for miles. Like the other limestone formations in the Helderbergs, the Onondaga is traversed by a system of intersecting joint fissures which are weathered out by solution into broad, deep crevices. The joint fissures help to produce the cliff by the breaking away of the rock along the vertical joints. It is these widely opened joint fissures that have produced the underground drainage, referred to in the introductory chapter, and the "sinks" large and small, such as the Thompson's lake sink, which are characteristic of a limestone region.

Outcrops. The Onondaga limestone stretches over such broad areas that it may be found outcropping in numerous places. The cliff extending from the Countryman hill area to the Indian Ladder region affords many outcrops for study. There are three very excellent quarry exposures, two in our area (XIIIa, XIIIi). One is the New Scotland town quarry along the New Salem-Wolf hill road a short distance from the junction with the Clarksville road. The joint fissures and the seams of chert are well shown. The rare gastropod *Platyceras dumosum* has been found here, cephalopods and corals particularly. A small anticline or upward fold in the limestone is also shown. The top or crest of the fold

is located about in the state highway. The arching of the fold is very well shown in the floor of the quarry on the south side of the road. Only minor disturbances have occurred in the northern Helderberg area. Another small disturbance occurs in the upper Onesquethaw creek north of Wolf hill (XIIIb). Here there is a thrust fault in the Marcellus shale. The fault is almost horizontal and the upper part of the formation was shoved over the lower part with consequent crumpling of the shales. This is well shown a short distance above the bridge on the right. The Onondaga limestone is involved in this disturbance, and farther upstream small folds or swells in the limestone are seen.

A new quarry has been opened up recently, in connection with road building just outside the park area (XIIIi), about three-quarters of a mile along the road turning directly south from the four corners on the old Indian Ladder-Thompson's lake road (Rock road). This quarry is in an area that has yielded fine specimens of corals.

The third excellent exposure of Onondaga is not in our area, but only four miles beyond its western edge. This is another road quarry just about a half mile beyond (west of) Berne on the left side of the road. Very fine coral specimens have been found here and some good specimens of black calcite.

Several other outcrops that are all fairly accessible may be mentioned. The old road from New Salem skirting the southern flank of Countryman hill cuts across the Onondaga cliff (XIIIc) which outcrops on both sides of the road in the woods. Good exposures of the cliff have been studied above the old Parrish house. The road continues north around Countryman hill and crosses the cliff mounting up onto the terrace formed by the limestone.

At the right (XIIId) in the vicinity of the home of Daniel O'Connell the cliff may be studied to good advantage. In the park area the Onondaga outcrops well in the vicinity of the spring where the Schoharie grit exposure (XII) occurs. Another good exposure where corals may be collected is on the south side (XIIIe) of the old Thompson's lake-Indian Ladder road (Rock road), not far from the junction with the state highway. In the rock exposed along the shore of Thompson's lake near the hotel boat landing (XIIIf) a variety of corals may be seen, and also in the outcrops at the southern end of the lake a short distance from the state road. The cave which serves as the outlet of Thompson's lake is situated in this rock back (east) of the hotel at the southeast corner of the lake (XIIIg), and the spring in which the waters come to the surface again is located about a mile and a half to the southwest (XIIIh), the spot being best reached from the Pitcher farm at the left of the side road.

Fossils. The fauna of the Onondaga limestone is characterized by corals, because it was undoubtedly of coral reef origin. The abundance of the corals and the purity of the limestone indicate congenial living conditions for corals and marine life in general (figure 26). The corals include cup corals as *Zaphrentis gigantea, Z. prolifica* and *Cyathophyllum robustum* and compound forms as *Favosites, Syringopora* and *Eridophyllum.* Among the brachiopods are *Atrypa reticularis, A. spinosa, Leptaena rhomboidalis, Spirifer duodenarius* and *acuminatus, Stropheodonta inaequiradiata* and the very large forms, *Spirifer divaricatus, Stropheodonta hemispherica* and the index fossil of the Onondaga, *Amphigenia elongata.* Pelecypods, which are characteristic of muddy bottoms, are rare. Gastropods are represented by the large and

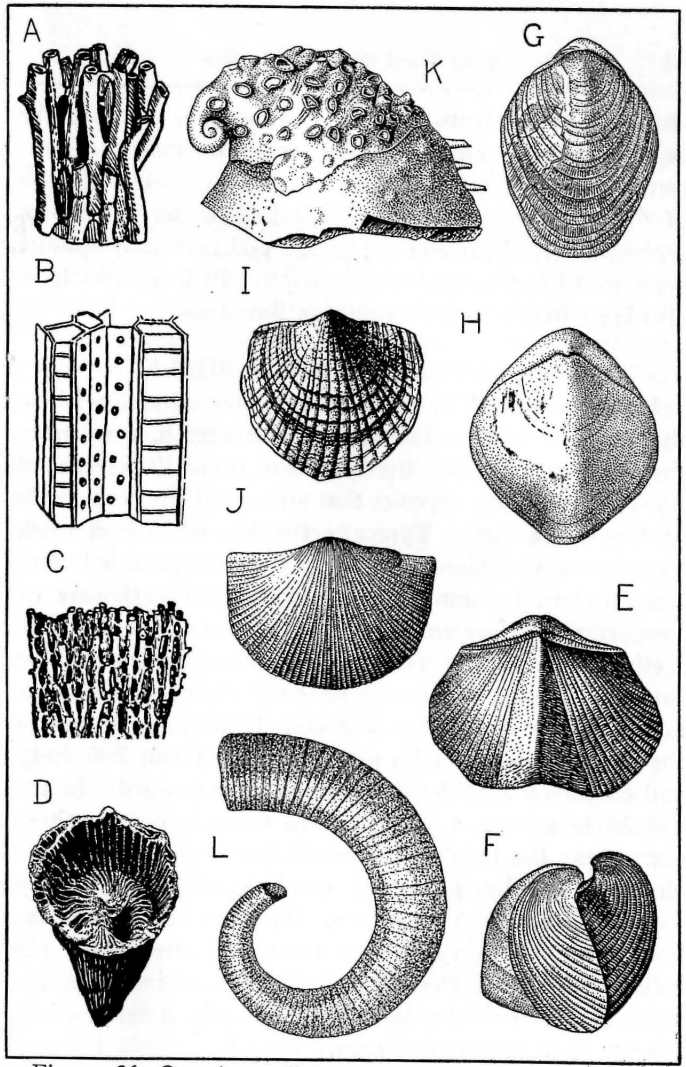

Figure 26 Onondaga limestone fossils. (Corals, *A-D;* brachiopods, *E-J;* gastropod, *K;* cephalopod, *L*). *A Syringopora maclurei. B* Enlarged corallites of *Favosites basalticus. C Syringopora hisingeri. D Zaphrentis prolifica,* x½. *E. F. Spirifer acuminatus,* x¾. *G Amphigenia elongata,* x½. *H Meristella nasuta,* x¾. *I Atrypa spinosa,* x¾. *J Stropheodonta inaequiradiata,* x¾. *K Platyceras dumosum,* x¾. *L Ryticeras (Gyroceras) trivolve,* x⅓

striking spinose form *Platyceras dumosum.* Among the cephalopods the curved (Cyrtoceras) or coiled (Gyroceras) forms prevail. Among trilobites one finds species of *Phacops* and *Dalmanites* (including the largest known representative, *D. myrmecophorus*) and peculiarly spinose types as *Lichas* (*Conolichas*) *eriopis.* Fish remains have also been found in the Onondaga limestone.

14 MARCELLUS BLACK SHALE

Description. The Marcellus black shale, with a thickness of 170 to 180 feet in our region, constitutes the lowest member of the Hamilton beds. These shales represent the mud deposits that succeeded the coral reefs of Onondaga time. Typically the Marcellus is a black bituminous, pyritiferous, very fissile shale, which is also characterized by numerous concretions of carbonate of lime scattered through certain portions of it. These concretions vary in size from a few inches to several feet in diameter and appear to be most abundant near the middle of the bed. The Marcellus black shale occurs in the Hudson valley (with a thickness of about 200 feet) and extends across the State, thinning westward. In the Schoharie area and westward to Ontario county there occur near the base of the black shale calcareous layers characterized by goniatites (cephalopods), the *Cherry Valley* (*Agoniatite*) *limestone.* This limestone band has not been located in our area but the occurrence of the coiled cephalopod *Parodiceras discoideum* indicates the continuation of the fauna of the Agoniatite limestone into the northern Helderberg area.

The Marcellus black shales are not extensively exposed, for on all the hillsides they are so much weathered that the outcrops are covered with soil. They form the gentle slopes above the Onondaga terrace. Outcrops are to be looked for in stream valleys, road cuts and road gravel quarries. To a certain extent the boundary between the Marcellus black shale and the succeeding Hamilton shales is shown in the Hamilton hills. The marked stiffening of the Hamilton beds above the Marcellus black shale by the prevalence of sandy flags has brought about the development of a more or less distinct shoulder. Looking south from the Indian Ladder area this shoulder may be picked out in the Hamilton hills, particularly Sunset hill. This feature, shown to a certain extent in Countryman hill, is extremely well shown outside our area in the Clarksville area and southward, in Bennett, Copeland and Blodgett hills.

Outcrops. There are four excellent exposures of the Marcellus black shale in the area covered by the guide. The best one for study occurs along the upper Onesquethaw creek, north of Wolf hill. One starts on the Onondaga and finally walks over the full section of the Marcellus (XIVa) to the falls formed by one of the heavier sandstone beds of the Hamilton shales. It is along this stream that the thrust fault described under "Onondaga outcrops" occurs. The concretions of carbonate of lime mentioned in the description above are well shown in the bed of the stream in this section. A similar section in the Marcellus is shown in the branch of the Onesquethaw coming in from the north (XIVb). A section that is very accessible is found in the cut made by the road leading to Camp Pinnacle (XIVc) from the old New Salem (Parrish hill) road running north of Countryman hill. Here an almost complete section is exposed in a short distance. This section may be reached from the Indian Ladder area on foot or by car; by way of the Parrish hill road which, although rough, is accessible by car;

and from the Wolf hill—East Berne State highway by a good road leading to the right to Camp Pinnacle, and so labeled. Another section showing the upper portion of the Marcellus black shale and the gradation into the dark Hamilton shales is found in a road metal quarry a mile and a half east of East Berne (XIVd). The road along which this section occurs is always passable and usually in good condition.

Fossils. The Marcellus black shale in this area has a very poor fauna and in certain beds is quite barren. Fossils (figure 27) have been found in the first three sections mentioned. The lowest somewhat sandy beds are quite fossiliferous, carrying the characteristic small brachiopods *Leiorhynchus limitaris* and *L. mysia.* Another

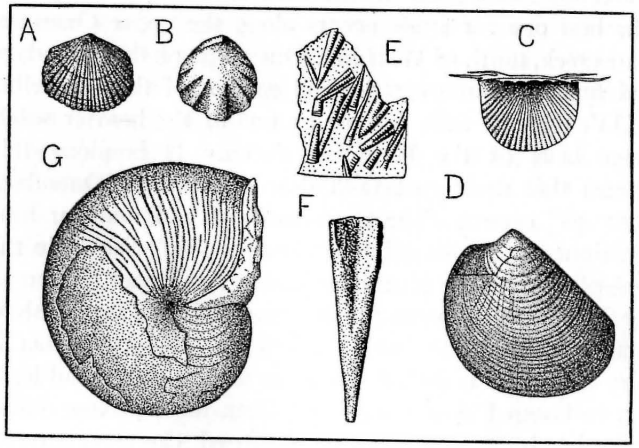

Figure 27 Marcellus black shale fossils. (Brachiopods, *A-C;* pelecypod, *D;* pteropod, *E, F;* cephalopod, *G*). *A Leiorhynchus limitaris. B L. mysia. C Chonetes mucronatus,* x¾. *D Lunulicardium marcellense,* x¾. *E Styliolina fissurella,* x3. *F* The same, x6. *G Parodiceras discoideum,* x¾

brachiopod that will be found is the small *Chonetes mucronatus.* Also to be looked for are the small pelecypod, *Lunulicardium marcellenese* and the minute needle-like pteropod shells, *Styliolina fissurella,* which are abundant in some layers. The cephalopod *Parodiceras discoideum* has been collected in the northern Helderberg area, and that and other species of cephalopods may be looked for.

15 HAMILTON SHALES AND FLAGS

Description. The Marcellus black shale is succeeded by a series consisting of sandstones and sandy shales. These are the highest beds of the Helderberg area covered by our guide. In the vicinity of Rensselaerville and westward higher Hamilton beds come in and the "Oneonta" shales. These formations with the Catskill beds, found in the Catskill mountains, with a thickness of thousands of feet, once spread over the whole Helderberg region and beyond, but they have been carried away as waste by the rivers.

In our area probably no more than 700 to 800 feet of this formation are present, which does not take us into the higher heavy sandstone beds or flagstones. The thickness of the Hamilton formation in the western part of the Berne quadrangle, southwest of West Berne, has been estimated as 1415 to 1720 feet including the Marcellus black shale; in the Schoharie valley the thickness has been found to be about 1500 feet, exclusive of the Marcellus black shale, which gives approximately the same thickness in both places for the Hamilton shales and flags. The lower few hundred feet consist of dark to black argillaceous (clayey) shales, with

intercalations of dark, slightly calcareous sandstone, and are not very fossiliferous. The shales contain enough sand to cause them to break blocky, a quite characteristic feature of the lower beds that is more distinct higher in the section where the beds become more sandy, weathering to a brownish color. The sandy intercalations increase steadily in number and thickness going upward in the series, and fossils become more abundant. The sandstone beds are not evenly distributed and vary greatly in thickness from an inch or less to ten to fifteen feet and more. The heaviest beds occur in the upper portion of the formation. The sandstone and shale intercalations in the upper part of the formation are in about equal proportions, and the heavy sandstone beds give rise to conspicuous outcrops, and in the hill slopes tend to form a series of small terraces. Much of the sandstone is dark gray but the upper beds tend to be lighter in color (weathering light brownish) and certain beds have a slight greenish gray tinge. The sandstone is moderately fine grained, splitting readily along the bedding planes into slabs of varying thickness (one-half inch to three inches or more). Such heavy beds, termed "flags" or "flagstones," gave rise to the flagstone industry that flourished for so many years in the northern Helderberg area and still persists in some places, as at Reidsville.

Sandstones and shales in these beds have been found to change into each other horizontally and cross-bedding has been observed. Such conditions, together with the character of the fossils (a prevailing brachiopod and pelecypod fauna), indicate that the deposits were laid down in shallow muddy waters with shifting currents. Westward the character of the Hamilton beds changes

and the sandy shales and sandstones of the east give place to equivalent calcareous shales and limestones.

Outcrops. There are not many places where the Hamilton shales are well exposed and quite accessible. In many areas the hill slopes are fairly well covered with glacial till. Here again we must depend upon road cuts, gravel pits and exposures along streams. Along the Camp Pinnacle road (XVa) south to Wolf hill several cuts in these beds occur to the west. Just north of Wolf hill (XVb) the lower beds are exposed along the road leading east across the Onesquethaw to join the road around Countryman hill. Here a fair collection of fossils may be made. A third exposure in the lower beds is found along the Wolf hill highway (XVc), just before the junction with the Rensselaerville road. Fossils have been found in the most eastern cut here and quite a fair collection of fossils may be made in the exposures extending over a couple of miles along the Rensselaerville road, particularly where changes in the road have made fresh cuts. In the stream immediately south of East Berne is a good Hamilton-Marcellus section. This section, the least accessible of those mentioned, is best reached from the road to the east, less than half a mile from the junction with the state highway. The finest section, giving an exposure of between 300 and 400 feet of Hamilton shales and sandstone above the Marcellus black shale, is found along a side road (southwest of East Berne) which turns south from the state road and climbs up onto the Hamilton hills (XVe). A fair collection of fossils may be made here in a short time.

Anyone who is particularly interested in making a collection of Hamilton fossils will find an excellent exposure for this purpose along the Westerlo-South Westerlo road, about one-half mile south of Westerlo. There

are certain layers in these beds that are literally packed with a great variety of pelecypods and brachiopods. The heavy flagstones of the upper Hamilton may be well studied in the Reidsville quarries, east of the Rensselaerville road and about three miles south of the Wolf hill road. These are rather barren beds on the whole, but they show macerated plant remains and very thin layers near the top of the quarry have a fair showing of brachiopods.

Fossils. The prevailing fauna of the Hamilton beds is one of pelecypods and brachiopods. It is an extremely rich fauna including, corals, worm-trails, brachiopods, pelecypods, gastropods, pteropods, cephalopods and trilobites (figures 28, 29). It would be out of the question to attempt to list the fossils that have been collected from these beds. For collecting fossils the locality southwest of East Berne (XVe), the cut north of Wolf hill (XVb) and the exposure one-half mile south of Westerlo are recommended. Among the brachiopods to be looked for are *Spirifer mucronatus, S. granulosus, Athyris cora, Chonetes coronatus, Tropidoleptus carinatus* and *Ambocoelia umbonata;* among the pelecypods, *Pterinea flabellum, Actinopteria boydi, Modiomorpha mytiloides, Grammysia bisulcata, Cypricardella bellistriata, Goniophora hamiltonensis, Nuculites oblongatus;* among the gastropods, *Loxonema hamiltoniae, Bembexia sulcomarginata, Diaphorostoma lineatum* and *Ptomatis patulus;* among the pteropods, *Tentaculites bellulus;* among the cephalopods, *Orthoceras crotalum;* among the trilobites, *Phacops rana* and *Homalonotus dekayi.* Corals occur but are not abundant. In the cut southwest of East Berne (XVe) certain sandstone layers in the lower part of the section show an abundance of cup corals, more frequently in the form of casts.

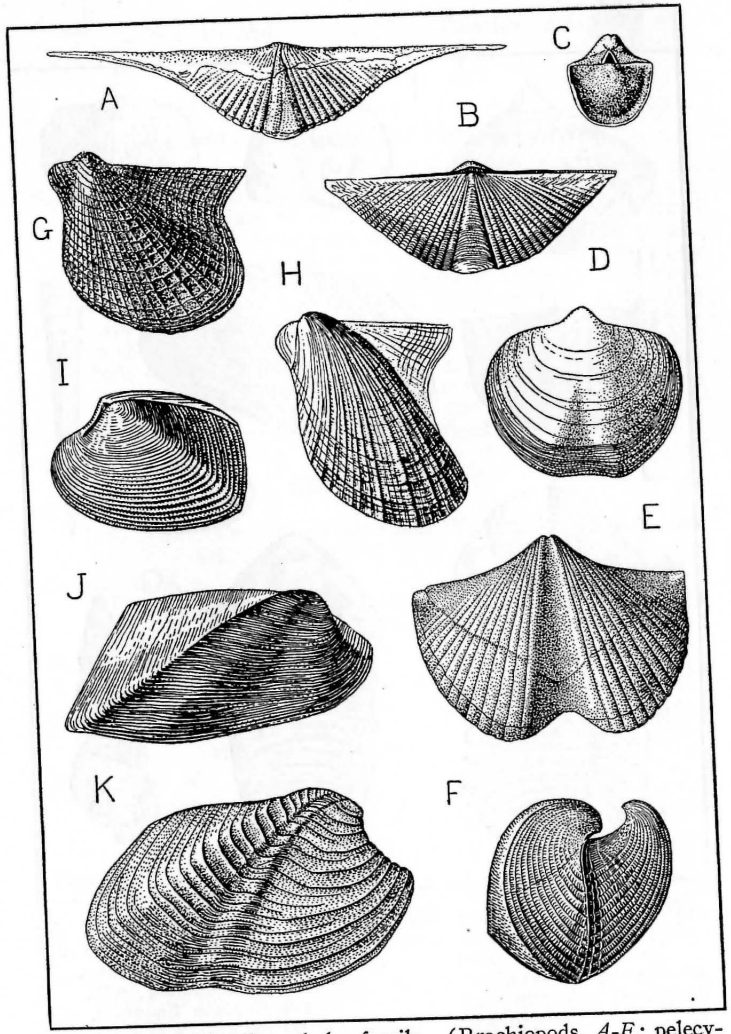

Figure 28 Hamilton shales fossils. (Brachiopods, *A-F;* pelecypods, *G-K*). *A, B Spirifer mucronatus,* x¾. *C Ambocoelia umbonata. D Athyris spiriferoides,* x¾. *E, F Spirifer granulosus,* x¾. *G Actinopteria boydi,* x¾. *H Pterinea flabellum,* x½. *I Cypricardella bellistriata,* x¾. *J Goniophora hamiltonensis,* x¾. *K Grammysia bisulcata,* x¾

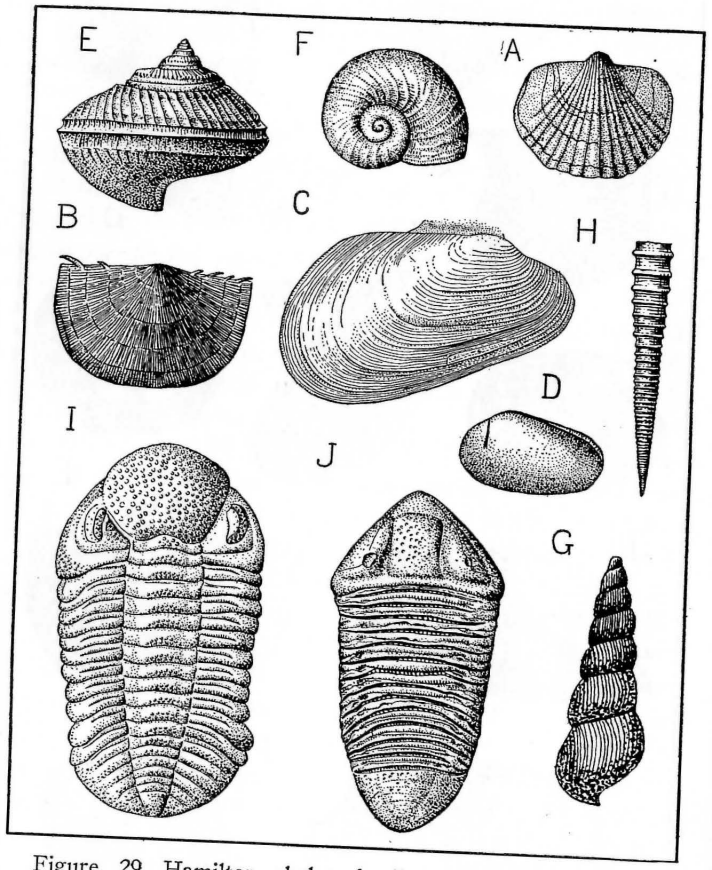

Figure 29 Hamilton shales fossils. (Brachiopods, *A, B;* pelecypods, *C, D;* gastropods, *E-G;* pteropod, *H;* trilobites, *I, J.*) *A Tropidoleptus carinatus,* x¾. *B Chonetes coronatus. C Modiomorpha mytiloides. D Nuculites oblongatus,* x¾. *E Bembexia sulcomarginata,* x¾. *F Diaphorostoma lineatum,* x¾. *G Loxonema hamiltoniae. H Tentaculites bellulus,* x2. *I Phacops rana,* x½. *J Homalonotus (Dipleura) dekayi,* x⅜

Supplementary Note On Hamilton Beds

While this paper was in press the writer was working in the Schoharie valley and eastward with Dr G. Arthur Cooper of the United States National Museum, who has been tracing the Hamilton beds across the State from west to east. The results of this work show that the thickness of the Hamilton beds (including the Marcellus black shale) in the Schoharie valley is somewhere in the neighborhood of 2500 feet, the Hamilton there comprising beds previously described as Sherburne and Ithaca. The thickness in the Helderberg area (Berne quadrangle) and southward (Durham quadrangle) is at least as much as this and a greater thickness is to be expected. The green and red beds of the Berne area, in the vicinity of Rensselaerville and westward, previously described as Sherburne and Oneonta, are of Hamilton age.

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POSSIBLE EXCURSIONS IN THE PARK REGION AND VICINITY

ON FOOT

Excursion 1

The Countryman Hill-Wolf Hill Area

This excursion can be made into a shorter trip by confining one's attention to the exposures along the eastern flank of Countryman hill, where a section from the Schenectady beds to the Onondaga limestone can be studied in a short distance.

For the trip as planned take an early morning bus from Albany to New Salem. Along the state highway above New Salem may be seen the Schenectady beds (Ia) and calcareous Indian Ladder beds (above highway) and the Manlius and Coeymans limestones (in road quarry). Turn off on the Indian Ladder road for a short distance and then take the old road to the left, leading over the southern flank of Countryman hill, which takes one over all the formations up onto the Onondaga terrace. Those who wish may end the excursion here and return to New Salem, otherwise the trip continues to the upper Onesquethaw, and turns south following the side road south along the creek, or down the creek bed itself over the Onondaga, to the Wolf Hill state road. At the place where the old road crosses the Onesquethaw one may turn up the creek for a short distance to study the Marcellus. It is possible to walk up the creek through the entire Marcellus black shale section to the falls on the Hamilton, but this side trip takes about two hours and may prove too much for the average person in addition to the rest of the trip. It could be planned as a separate trip.

From the point where one reaches the state road and turns northeast to New Salem the section is repeated in descending order. The New Scotland town road quarry in the Onondaga is situated along this road and there is also a good Esopus shale cut.

The trip, without the side trip up the Onesquethaw, is six to seven miles long returning to New Salem by way of the Wolf Hill state road. It is somewhat shorter returning by the old road.

Excursion 2

Circling Countryman Hill

This trip starts as the above from New Salem and is a full day's trip for a good hiker. Turn off the new Indian Ladder road onto the Parrish Hill road, following north along Countryman hill until the Onondaga terrace is reached, after passing over (from above New Salem) all the formations from the Schenectady beds to the Onondaga. After walking over the Onondaga terrace for a short distance, take the road to the left through the Marcellus black shale cut. The Camp Pinnacle road runs south over the Hamilton formation for about two and a half miles. At the place where the old road comes in from the east there is a choice of turning to the left (east) over the old road or to the right (west) toward the state road. The old road leads down into the Marcellus black shale, crosses the Onesquethaw, turns southeast and around the southern flank of Countryman hill, repeating in descending order the section from the Onondaga to the Schenectady beds above New Salem.

If the other route is chosen, the Wolf Hill-East Berne state road is reached about a mile and a quarter beyond

(west of) the junction with the Rensselaerville road. The state road is followed east along Wolf hill past exposures in the lower Hamilton beds until the Onondaga terrace is reached. Return to New Salem over the same route as in Excursion 1.

The trip is estimated to be about ten miles long returning by way of the old Countryman Hill road; 13 to 14 miles long if one returns by way of the state highway along Wolf hill.

Excursion 3

John Boyd Thacher Park-Indian Ladder Area

This excursion likewise starts from New Salem but follows the new road to the park, taking in on the way all the formations up to the Esopus shale. The Schoharie grit and Onondaga limestone may be seen along Minelot creek (XII) and the upper sandstones of the Indian Ladder beds, the Brayman shale and Rondout waterlime are exposed under the Manlius-Coeymans cliff at the two waterfalls. A day or several days can be profitably spent here looking up the exposures pointed out under the discussion of the various formations. One may return over the same route to New Salem or plan to go down the old Indian Ladder road to the Altamont-Voorheesville state road and thence to Voorheesville where there are better bus connections.

The trip from New Salem and return, without any additional walking in the park area, is about 11 miles. It is a little shorter returning by way of Voorheesville. The trip can be made from Voorheesville and return, which is about ten miles; but one misses the splendid cuts along the new road to the park. A morning train stops on signal at Meadowdale, which is three and one-half miles from the top of the old Indian Ladder road. The return, however, must be made by bus.

Excursion 4

Indian Ladder and Schenectady Beds, Indian Ladder Gulf

The Indian Ladder and Schenectady beds exposed along the branch of Black creek in Indian Ladder gulf can be reached from Meadowdale, Voorheesville and by walking down the old Indian Ladder road from the park. This is a section best planned to be studied by itself and half a day or even a day could be spent here collecting and studying the beds. Turn to the south into the stream valley just about where the steep part of the Indian Ladder road begins. The first exposures found along the stream are in the Schenectady beds. The Indian Ladder beds begin about at the foot of the 200-foot cut on the left (south side) of the brook, going upstream, and are marked near the base by two thick (four foot) sandstone beds.

This trip, outside of the walk in the stream valley, involves less than two miles for the round trip from the top of the old Indian Ladder road and about eight miles for the round trip from Voorheesville.

BY AUTOMOBILE

Excursion 5

Altamont-Thompson's Lake-John Boyd Thacher Park-New Salem

This makes a day's trip, allowing for some time to be spent in the park; but it can be done in half a day. Fine cuts in the Schenectady beds may be studied along the road at the top of the Altamont hill. The trip includes the sink hole occupied by Thompson's lake and it is possible to visit the outlet (XIIIg) with the permission

of the owners. In the park one may look up as many as one wishes of the exposures discussed under the various formations, and the road from the park to New Salem passes formations in descending order, from the Esopus down to the Schenectady beds, which may again be studied in the road cut near Mount Pleasant cemetery about a mile beyond (east of) New Salem.

The distance covered by car on this trip is between 40 and 45 miles from Albany. The trip can be taken in reverse order.

Excursion 6

New Salem-Wolf Hill-Thompson's Lake-John Boyd Thacher Park-Altamont

This is another full day's trip, but can be taken in half a day by making shorter stops. The trip covers all the formations from the Schenectady beds to the Hamilton and includes the road quarry in the Manlius above New Salem (Va) and the road quarry in the Onondaga showing the small anticline (XIIa). In this excursion may be included the side trip up the Onesquethaw described in Excursion 1 or the Hamilton section southwest of East Berne (XVe). The stream crossed just east of Warner lake carries the drainage of Thompson's lake, the outlet (XIIIh) in a pool being located on the Pitcher farm, reached from the side road at the left (north of state road). The rest of the excursion covers the same ground as Excursion 5.

The distance covered by car on this trip is about 50 miles. As in Excursion 5, the trip can be taken in reverse order.

Excursion 7

Circling Countryman Hill

This trip repeats Excursion 2 (on foot) and can be made a half day or full day trip. The Parrish Hill road going north around Countryman hill will be found rather rough in places but is passable for cars, particularly smaller cars. With a car on this trip take the Camp Pinnacle road to the Wolf Hill-East Berne highway and return along Wolf hill over the Onondaga terrace to New Salem. The round trip from Albany covers about 35 miles.

Excursion 8

John Boyd Thacher Park-Indian Ladder Area

This is the same as Excursion 3 (on foot). By way of New Salem the round trip from Albany is about 30 miles. The trip can be taken as a half day or full day excursion or several days may be spent in the park area.

Excursion 9

Indian Ladder and Schenectady Beds, Indian Ladder Gulf

This trip duplicates Excursion 4. Drive to the top of the old Indian Ladder road in the park and reach the section on foot from there or drive to the foot of the Indian Ladder road by way of Voorheesville. The round trip from Albany is about 30 miles by the first route, 25 miles by the second.

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Fig. 30 Panorama from the Helderberg escarpment to the hills north of Albany

Fig. 31 Topographic map of Thacher Park area

Fig. 32 Geologic map of Thacher Park and vicinity

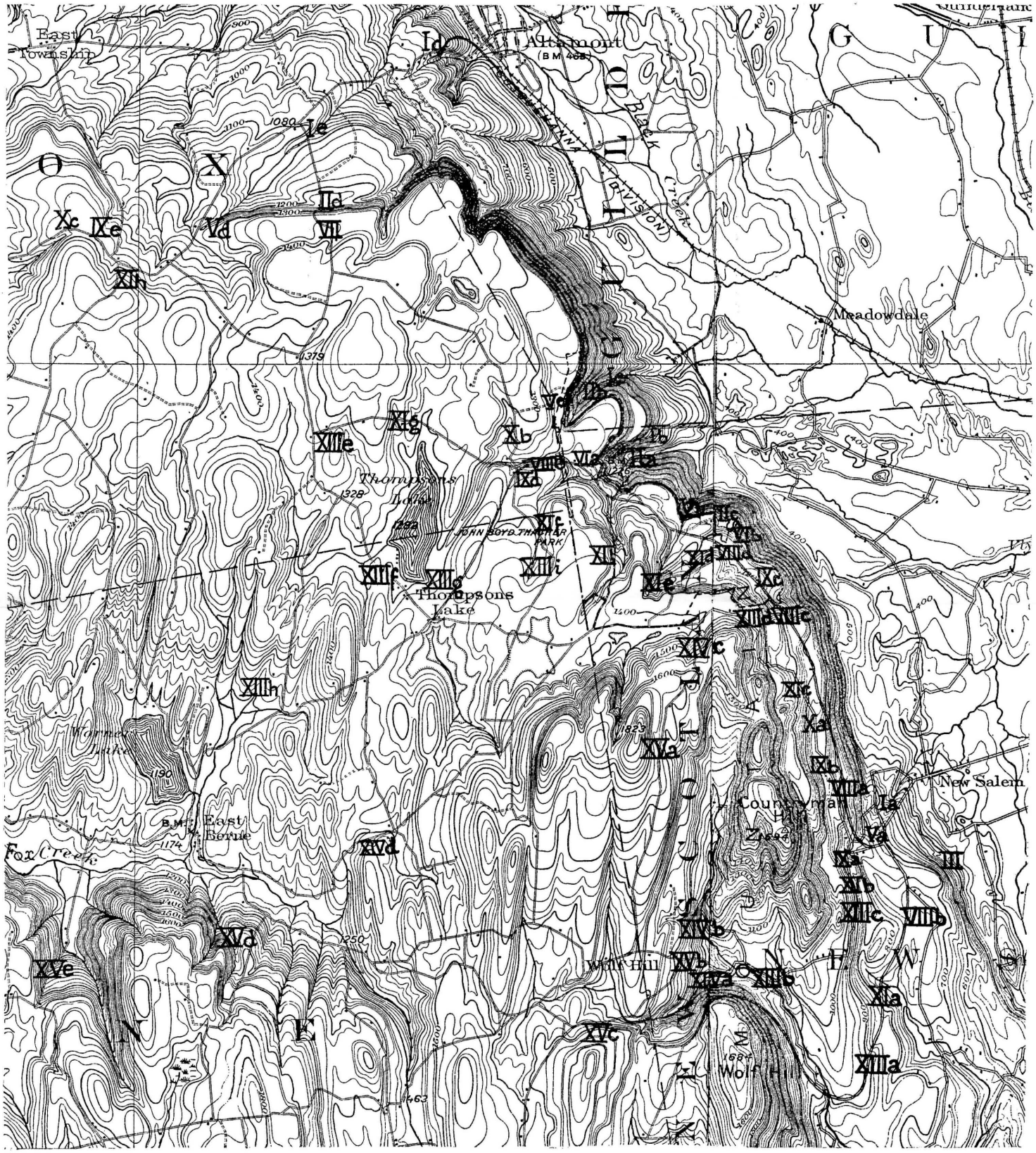

Figure 31 Topographic map of John Boyd Thacher Park and surrounding area covered by guide (parts of Albany and Berne quadrangles), with outcrop localities mentioned in the guide indicated

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