New York State Museum Bulletin

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CHARLES C. ADAMS, *Director*

GEOLOGY OF THE BERNE QUADRANGLE

By WINIFRED GOLDRING

Assistant State Paleontologist, New York State Museum

WITH A CHAPTER ON GLACIAL GEOLOGY

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LIST OF ILLUSTRATIONS

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PREFACE

The area covered by the Berne quadrangle lies in the northern Helderberg region part of which (Albany quadrangle) was mapped by Doctor Ruedemann for his Capital District bulletin. The mapping of the Berne area has occupied parts of several summer seasons, and some of the results have already been made available in a popular guide (Handbook 14) to the geology of the John Boyd Thacher Park (Indian Ladder region) and vicinity. The writer has attempted so to present the subject matter that this bulletin will be of value to the layman as well as to the trained scientist. The illustrations, particularly as regards the plates of fossils, have been planned with the layman in mind.

It has not been deemed advisable to use an overprint on the geological map. In the eastern part of the area outcrops are so frequent that this is unnecessary; in the western part of the area, although the till covering is heavier, outcrops are frequent enough in ravines and road cuts and, also, the best outcrop areas are noted in the text. Quarries, including the larger road metal quarries, are indicated on the map. New ones are constantly being made and old ones abandoned as more extensive road-building is carried on.

The writer wishes here to express appreciation to Dr Charles C. Adams, Director of the New York State Museum, for the interest he has shown throughout this work. To Dr Rudolf Ruedemann, State Paleontologist, the author is indebted for assistance in the field, particularly in the Ordovician area and for reading and criticizing the manuscript. Chris A. Hartnagel, Assistant State Geologist, likewise, visited with the writer outcrops of Silurian formations. All the drawings of fossils (taken from various museum publications) were made by the Museum draftsman and photographer, Edwin J. Stein,

to whose skill also are due the majority of the photographs, many of which are his personal property. The writer also makes acknowledgment here to the late Professor H. F. Cleland of Williams College for permission to use the block diagram of the Indian Ladder area; to Professor G. H. Chadwick of Catskill and Dr G. Arthur Cooper of the United States National Museum for helpful suggestions in the field and through correspondence. Professor John H. Cook kindly consented to write the glacial geology for the region, and to him, also, the writer is indebted for the restoration of the Indian Ladder to its appearance before the road was put through.

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 not only of Albany county but also of central eastern New York. Of the several explanations for the origin of the name the most likely is that it was derived from the light-colored limestones forming the cliff (from the Dutch *helder*, bright or light; *berg*, mountain). It has been stated (Verplanck Colvin, '69, p. 653) that "this name was given by the first settlers of Schoharie county, who had the bold and distinct *berg* constantly in view during their first day's journey westward into the then wilderness" and that " 'Helderberg' is a Dutch corruption of the old German *Heller-berg*, meaning 'Clear Mountain.' "

The Helderberg mountains, famous for their natural scenery, are likewise noted for the vertical cliff of massive limestones (Manlius, Coeymans), with a height of about 100 feet, which marks the northern and eastern margin of the plateau and is visible for miles on the east and north. The greatest development of the Helderberg escarpment is found between Altamont and New Salem, and in the Indian Ladder region (John Boyd Thacher Park), which lies about halfway between these two points, the cliff is most conspicuous (figure 1). Here the cliff 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 (figure 2). 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. From this point, the cliff turns westward with decreasing elevations and variable steepness, in places again showing increasing prominence. To the south of Altamont 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.

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 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, once stretched northward across the plains of the Capital District and lapped up on the ancient massif or "oldlands" of the Adirondacks. In the eons of time (between 200 and 300 millions of years) that have elapsed since then, through stream and atmospheric erosion the formations, constituting an ancient (Devonian) 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, getting higher at the same time with increased distance from the old shore line. The lowland formed by this recession of the escarpment is now occupied by the Mohawk and Hudson valleys. Such a lowland formed in a coastal plain between an area of sedimentary rocks and older folded mountains from which the sedimentary rocks are receding through erosion has been termed an "inner lowland," and the upland preserved through the occurrence of harder beds (as the Helderberg limestones) is known as a "cuesta" (from the Spanish), that is, 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 inner lowland, as seen from the Indian Ladder region, extends from the Helderberg plateau or cuesta on the south and west to the Taconic mountains on the east and the Adirondacks on the north (figure 1).

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°, and for the Berne quadrangle has been computed to be in general about 100 feet to a mile. The southwest dip of the rocks carries the outcropping edge of the Coeymans limestone, which forms the top of the conspicuous vertical 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 to the general level of the country and show folding and faulting (belonging to Appalachian

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Revolution) which becomes more pronounced southward, particularly in the Middle Hudson region.

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, since 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 plateau are of this type until one approaches the western area (as around Rensselaerville). 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. Three peneplanes have been traced out in the Capital District (Ruedemann, '30, p. 19–21). 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 characters of an erosion plane or peneplane, for it cuts across the formations, folded and unfolded beds alike regardless of rock structure. This is regarded as an incipient peneplane, the lowest or Albany (Somerville) peneplane which was developed in late Tertiary times 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" which 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 difference in structure and hardness of the rocks, and subsequent uplift initiated the Mohawk and Hudson river valleys cut deeply below the general 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.

The tops of the Helderberg hills and ridges, as seen looking west or southwest from certain points in the vicinity of Albany, 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, with an average elevation of 1600 to 1800 feet, are seen in the Grafton and Stephentown hills (Rensselaer grit plateau). The Rensselaer and Helderberg plateaus are considered (Ruedemann '30) to be parts of the same peneplane which 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 (figures 66, 67). This peneplane was once a low plain extending widely over eastern United States, and was elevated in early Cretaceous time. It is known as the Cretaceous or Kittatinny peneplane, and remnants of it are also seen in the tops of the Adirondacks and the Taconic and Green mountains.

TOPOGRAPHY AND DRAINAGE

The inner or Albany lowland, as discussed above, stretches to the north and east from the foot of the Helderberg escarpment and into it are sunk the deep valleys of the Hudson and Mohawk rivers. The bed rock underlying the lowland consists of shales and sandstones of unknown depth belonging to the early Paleozoic age, but it 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 clay deposits laid down at lower levels in the body of water, known as Lake Albany, which 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 Onon-

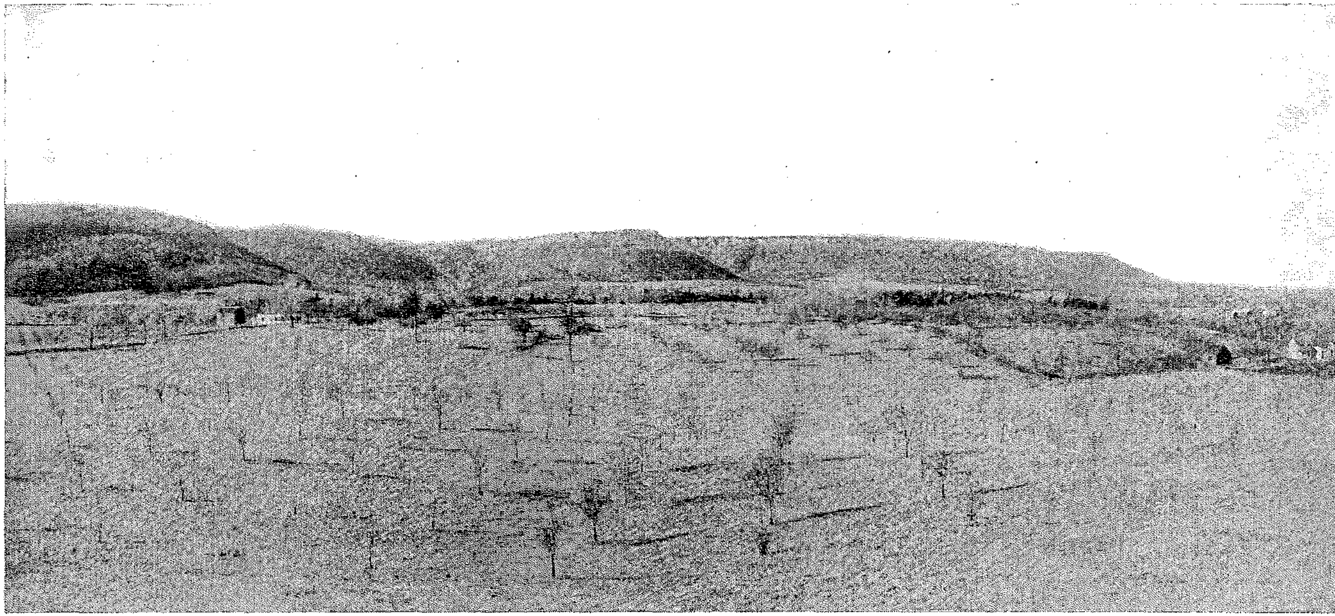

Figure 2 View of the Helderberg escarpment from the Ten Eyck farm along the Voorheesville-Altamont road. High Point above Altamont is shown at the extreme right of the escarpment, "Fallen Rocks" marking the fault area at the left; at the center, to the right is Cave gulf, to the left Indian Ladder gulf. (Photograph by E. J. Stein)

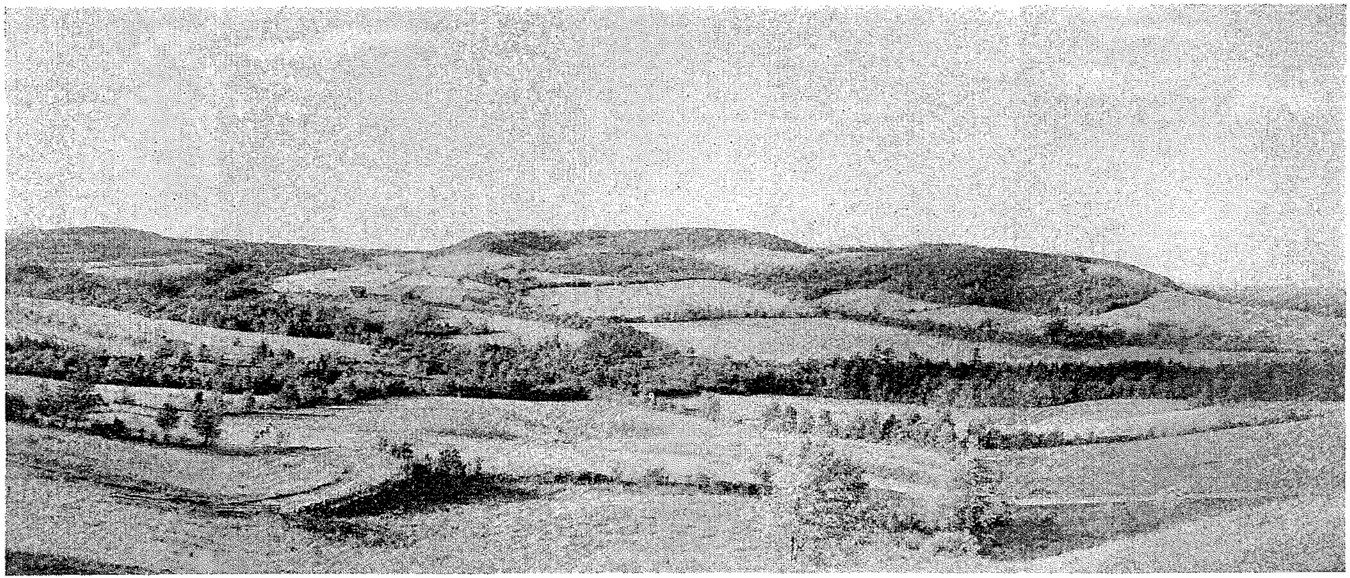

Figure 3 View from Wolf hill across the Onesquethaw creek toward the back slope of Countryman hill. This is characteristic Helderberg topography. (Photograph by E. J. Stein)

daga limestone. Behind these terraces rise the long, fairly rounded, well-wooded hills formed by the dissection of the Hamilton shales and flags, such as Countryman hill (figure 3) and Wolf hill above (west and southwest of) New Salem and the hills (Sunset hill etc.) near Camp Pinnacle, about two miles directly south of the Indian Ladder region. Back of Rensselaerville, to the west and northwest, the higher hills embrace a higher (later) formation of rocks, the "Oneonta" beds (figure 66), 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. These sky lines represent the base level planes or peneplanes (Early Tertiary and Cretaceous), discussed above, which are due to continuous wearing down or weathering of regions in which the rocks have a uniform hardness.

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.

The Helderberg area is the most lovely region of the Capital District and, indeed, one of the loveliest regions anywhere; but it can be known well only by departing from the main highways into the less inhabited, even deserted areas. It can also only be appreciated to the full when seen 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 are Thompsons lake and Warners lake (figures 4, 51) which have become very popular for camp sites of late years since the good roads and automobiles have made them so accessible. 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.

The main stream of the Capital District is the Hudson river and its largest tributary is the Mohawk. 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 the city 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 (Feuri Spruyt). 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 (Feuri Spruyt) and their tributaries. Back in the Helderberg hills, the Rensselaerville area is drained by tributaries of the Catskill (Tenmile 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 (figure 67) 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 body of water, 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.

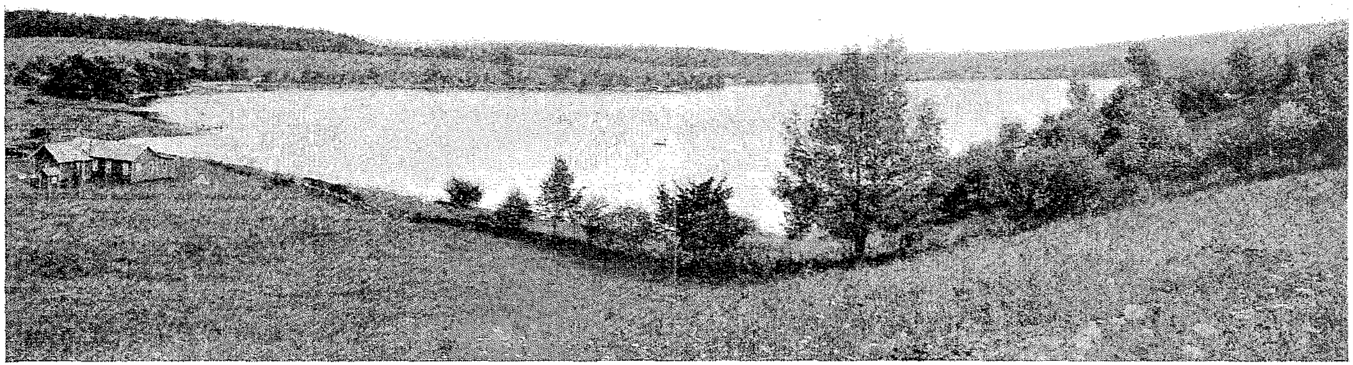

Figure 4 Warners lake. View looking toward the east shore, taken before the camps became numerous. (Photograph by E. J. Stein)

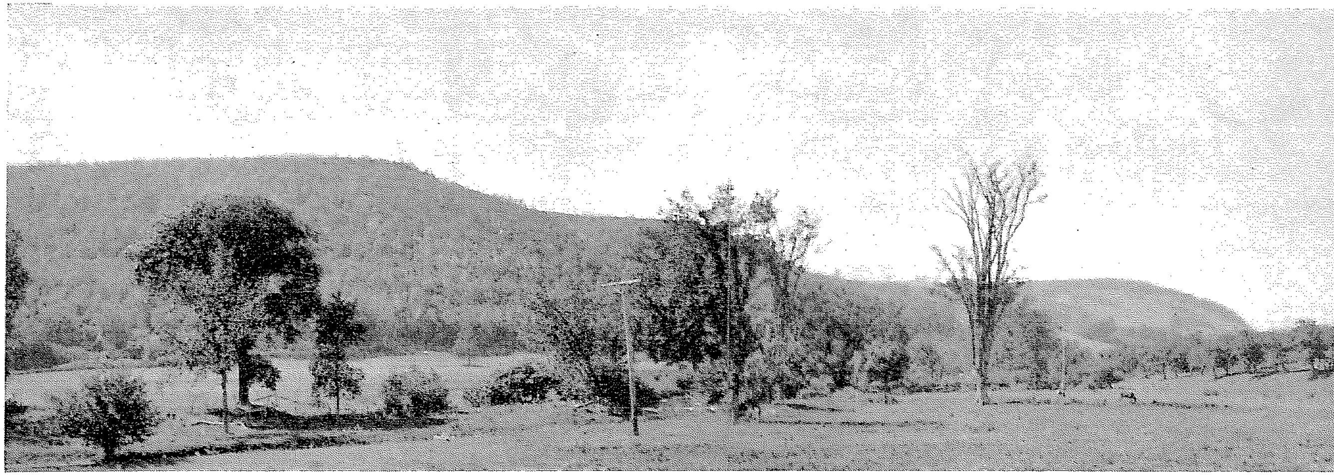

Figure 5 Looking south across the Fox Kill valley toward the Hamilton hills between East Berne and Berne. (Photograph by W. Goldring)

Fox creek and the Switz kill have the largest valleys in the Helderberg area (figures 5, 6). They, with their tributaries drain the whole area from Thompsons 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. The 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 Warners and Thompsons lakes area. At Berne (once Beaverdam) 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 the 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 by a series of falls showing beautiful rock sections. This is strikingly shown by the streams joining from both sides the broadly open section of the Switz Kill valley. The writer has interpreted this condition as indicating that the Fox kill and Switz kill have again adjusted themselves in preglacial valleys and have cut down much faster than the tributaries, which have been carving new valleys in the bed rock, thus producing hanging valleys. Very fine examples of hanging valleys are seen in the tributaries of the Bozen kill, especially those from the southwest (figure 17). Tenmile creek also apparently occupies a preglacial valley, and a splendid example of a hanging valley, also very accessible, may be seen in the outlet of Myosotis lake (Rensselaerville falls). In general, the drainage of the Berne quadrangle has no relation to the dip of the rocks but seems rather to have followed the slopes of the till-covered surfaces.

The drainage of the Indian Ladder-Thompsons lake area deserves special mention (figure 7). It has been very carefully worked out by the late 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, over a million years ago (Tertiary times). Glacial erosion played an 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 the Helderbergs, underground solution causes cave-ins of the surface and depressions of varying sizes, called *sink holes,* are formed, known as *karst phenomena* from their occurrence in the Karst region of the Dalmatian Alps. Thompsons lake is such a sink hole in the Onondaga limestone and there are a number of smaller ones in the neighborhood. These 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 Thompsons lake drainage basin flowed northeast through the reentrant occupied by Hailes' 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 Thompsons 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 Hailes' cavern beneath the Coeymans-Manlius cliff in Cave gulf, and very nearly all the year 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.

Thompsons 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 Thompsons lake depression formed a 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. Thompsons 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

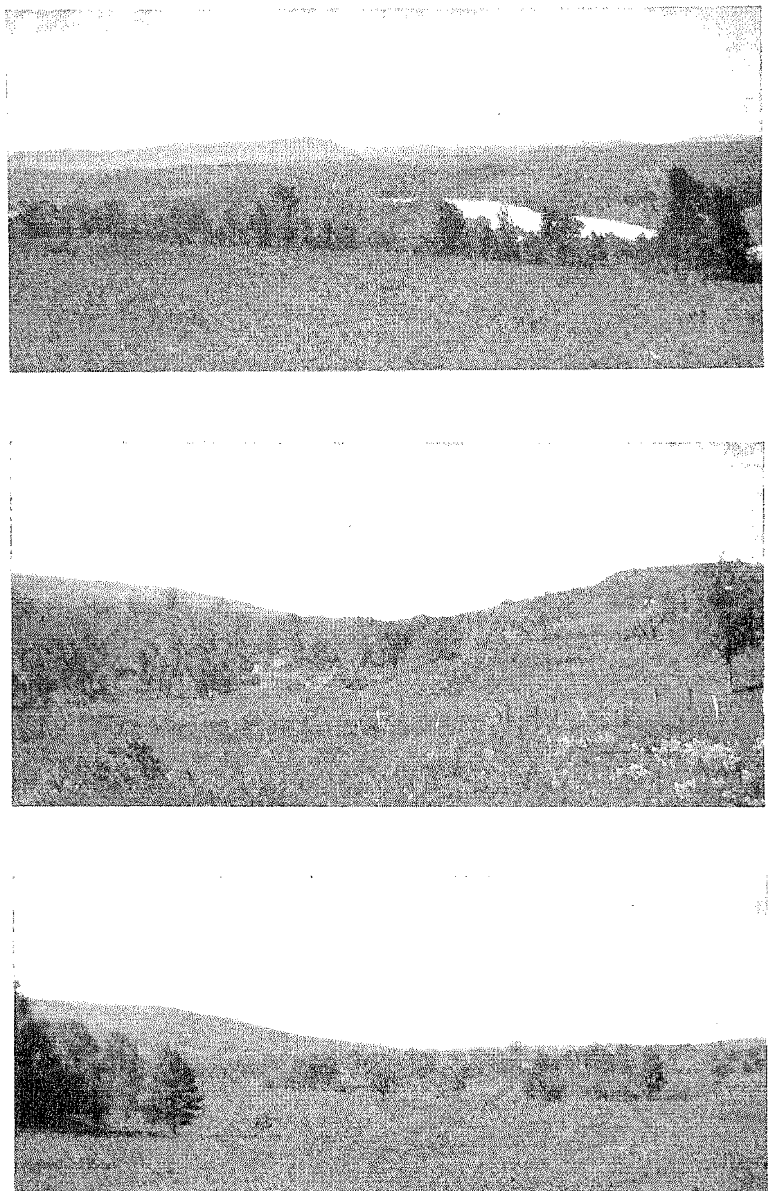

Figure 6 Three views in the Switz Kill valley. View across Lake Onderdonk (Mud Hollow pond), at the headwaters, and the dissected Tertiary peneplane to the Catskills; two views in the more broadly open valley between the Hamilton hills. (Photographs by W. Goldring)

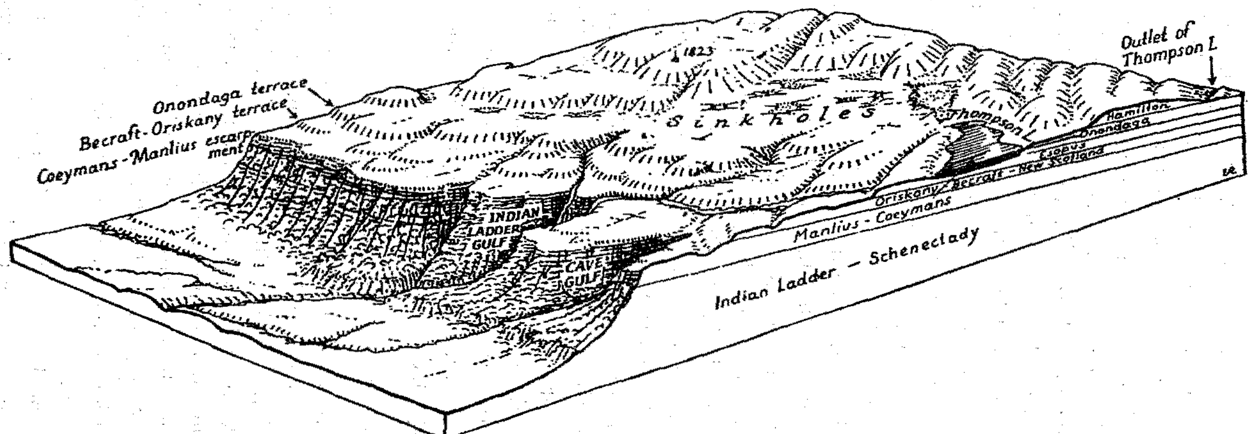

Figure 7 A generalized northwest-southeast block diagram of the Indian Ladder-Thompsons lake area, showing why the streams that formerly flowed over the Helderberg escarpment were captured. The southward dipping beds and the sinkhole topography developed on the Onondaga limestone are seen to have been 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)

relative to it; later Professor Cleland who had made the same discovery published his findings ('30). Except in the 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 Thompsons 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).

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 brought out 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, 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 shale, 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. 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 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.

SETTLEMENT

The story of the settlement of the Helderbergs may be found in a number of writings. Two works in particular are recommended: Landmarks of Albany County, by General Amasa Parker (1897), and the History of Albany and Schenectady Counties, by Howell and Tenney (1886), and it is largely from these that the material for this chapter is drawn. Some of the history of Helderberg settlement is also to be found in histories of Schoharie county by Sias ('04), Simms ('45) Roscoe ('82) and others.

A charter or grant of land, known as Rensselaerwyck was given in the year 1630 to the first Patroon, Kilian Van Rensselaer. This grant embraced, with other lands, the county of Albany. The town of Watervliet (now Colonie) is the "mother of towns." The manor of Rensselaerwyck was divided by the Hudson river into an east district and a west district (1779). The town of Watervliet, erected in 1788, included the west district and certain government lands in the northeastern part. From this town of Watervliet were cut off Rensselaerville in 1790 (including what is now Berne and part of Westerlo); Coeymans in 1791 (including a part of the present Westerlo); Bethlehem in 1793 (including what is now New Scotland); Niskayuna in 1809. Today Albany county is divided into nine towns: Bethlehem, New Scotland, Coeymans, Berne, Knox, Rensselaerville, Westerlo, Guilderland, Colonie (formerly Watervliet). Of these, Berne and Knox comprise the heart and larger part of the Berne quadrangle, with small parts of Guilderland in the northeast, New Scotland at the east, Rensselaerville and Westerlo at the south, Schoharie county at the west and Schenectady county at the north.

Town of Berne. The town of Berne, situated on the western border of Albany county, is the central one of the three western towns, with the town of Knox forming the major part of the area covered by the Berne quadrangle. It was set off from the town of Rensselaerville in 1795 and originally included the territory of the town of Knox. Of this town General Parker writes: "Along the northern part is a ridge that rises abruptly from the Foxenkill in three spurs which bear the local names of Grippy, Irish Hill and Uhai; the first of these names has an unknown origin; the second is from the number of Scotch-Irish settlers in that vicinity, and the third signifies high garden, from the Indian language" ('97, p. 499). The chief streams of the area are the Fox kill (named after William Fox an early settler in the town) and the Switz kill, along which were built extensively the saw and grist mills necessary to the community. The valleys of these streams were found to be very fertile and the hillsides excellent for grain land; in the mountains in many places was found lighter soil suitable only for meager pasturage. Warners lake north of East Berne took its name from Johannes and Christopher Warner who early settled its banks; Thompsons lake was named for John and William Thompson.

Settlement was begun in this town by eight families (Weidman, Zeh, Ball, Dietz, Knieskern, Shultes, Bassler and Hochstrasser), at the time (1750) when Indians led settlers to Schoharie along the trail by way of Knox. Furniture, provisions, tools etc. were carried upon their backs. Camping here and there, footsore and weary they finally reached the site of the present village of Knox. Here a dispute arose as to the leadership, and it is believed that the name "Fechtberg" or "fighting hill," applied to that locality, came from this incident. The party apparently divided, some going on to Schoharie and the others settling in Berne. This does not conflict with the belief that the town was settled from Schoharie, for it is known that some of the families that located in Schoharie county returned to the town of Berne. This trail to Schoharie by way of the Fox Kill valley, followed by these early settlers, was the second of five Indian trails or footpaths (see page 36). Over this route went the first Schoharie road to Albany.

It is not possible here to go into the details of settlement, but a few of the pioneers should be mentioned. Jacob Weidman, one of the pioneers came from Berne, Switzerland (hence the town name), with his wife and four sons and settled in the town as early as 1750.

He seems to have been a very energetic man. His land was on the bank of the Fox kill on the site of Berne village and he soon established saw and grist mills there. Weidman's mills were known as early as 1787. Frederick Bassler, pioneer from Basle, Switzerland, was one of the Palatinates who left his country to escape religious intolerance. Jacob Hochstrasser owned a tract of land where the White Sulphur Springs House stands. Other springs of a similar character occur in the valley of the Switz kill. The water is strongly sulphurous in these occurrences, but springs impregnated with carbonate of iron and sulphureted hydrogen were found at Reidsville. The Dietz family settled for the most part in the valley of the Switz kill. This valley was the scene of an Indian massacre in 1781. General Parker describes this massacre at length (*ref. cit.*, p. 500, 501):

In the strife between the Tories and Indians and the patriotic colonists, at least two stockades were built within the limits of what is now Berne; one of these was near the Petrus Weidman house in Berne village, and another on the Adams I. Dietz farm in the Switzkill valley. This town was the scene of a bloody deed during the Revolutionary War that distinguishes it in that respect from all the other towns of Albany county. Johannes Dietz, the pioneer, was an ardent patriot in the cause of independence; his family were his wife, his son and his son's wife, with four young children, and with them was a man servant and a boy named John Brice. This family was massacred by the Indians and Tories in 1780 (1781).

There were 15 Indians and Tories in the party, and Johannes Dietz and seven members of his family (including a servant girl) were killed. The son, Captain William Dietz, and the boy, John Brice, were tied to a near-by apple tree while the plundering was going on and then were taken away as prisoners, together with a younger brother of Brice who had stopped over there on the way from Rensselaerville to the Jacob Weidman grist mill. General Parker continues his description:

Finishing their terrible work, the Indians set fire to the building and then started with their prisoners and horses along the path towards Rensselaerville. The first night they camped within a mile of the Brice residence, and on the morning of the second day continued on to Potter's Hollow, Oak Hill, Middleburg, Breakabean, Harpersfield, through the Susquehanna valley, and eventually reached Canada. When news of the massacre reached the Schoharie garrison, scouting parties were at once sent out and in the pursuit, when near Middleburg, the Indians were so closely pressed that several were wounded by the scouts and their horses and plunder were abandoned.

Captain Dietz died in confinement at Niagara; the Brice boys returned after an absence of three years. The bodies of the massacred family were buried in one grave on the eastern side of the line wall of the Pine Grove cemetery. In recent years (1926) the Tawasentha Chapter of the Daughters of the American Revolution have set up a monument (figures 8, 9) at the site of the Dietz home in the Switz Kill valley with the following inscription: "Near this spot in September, 1781, Johannes Dietz and seven members of his family were massacred by Tories and Indians."

Following these early pioneers, in 1790 there came into this town from the town of New Scotland three Scotch-Irish families (Hay, Young, Curran) that settled on a large tract of land on Irish Hill. Soon after came the Filkins and Congers; the former locating on what is known as Filkins hill, the latter around Reidsville. After the close of the Revolution a New England element came into the town (Gallup, Whipple, Crary, Brown, Williams). The first carding machine was established in 1797 by Miner Walden, who came from Vermont. Here wool and cloth was carded and dressed. As the community needs grew saw mills and grist mills developed, other carding and fulling mills, asheries and tanneries, blacksmith shops etc. Malachi Whipple, who came from Stonington, Conn., in 1793 and settled in the present town of Knox, moved to Berne village in 1825, ran a grist mill and with others a carding and fulling mill. His farm (town of Knox) was long considered the model farm of Albany county. The first store is believed to have been one conducted by a Johannes Fischer. A store was established in the town as early as 1800 by Stephen Willis, one of the Connecticut pioneers, a mile from the village of East Berne, and nearby was an ashery and tannery. On the north side of the creek was established a whisky distillery, which General Parker refers to as "a very necessary institution in those times," and a saddle and harness and shoe shop. In 1790 a mill was established near the site of the village of West Berne (Jacob Post) and at the same time a cloth mill (Asa Culver or Culvard) was opened at what is now South Berne. It was around these various early industries that hamlets and villages sprang up, centers of such trade as was required by the people. The Simmons Axe factory (erected 1825) is worthy of notice here. Simmons was a blacksmith who settled in Berne. He hammered out axes by hand on his anvil and produced a product so superior that it had a wide reputation. From this small beginning grew up a business requiring 21 forges and employing 200 men. The axes were shipped even as far away as Asia and Africa. Transportation became a serious problem, the firm became heavily involved and in 1833 the factory was removed to Cohoes. Many of the best men of the village were left almost penniless by the failure. Mixed farming was the rule in this town and an effort was made to establish dairying and cheese-making on a more extensive base. A cheese factory was built near Berne village in 1878 and was successful; but a second one built at East Berne in 1884 was abandoned. An early resident of Berne, who should be mentioned here is Jacob Settle, native born, who was in every way a public-spirited and valuable citizen. He was engaged in mercantile business in Berne from 1812 to 1864, and it was largely through his influence that the plank road was constructed through this town from Schoharie.

Schoolhouses were being built probably as early as 1765. The records of early schools, as with the other towns of the county, are most meager. The early schools were of a primitive character and were located in various parts of the town, generally for a number of years in log buildings, which were later replaced by frame. In 1812 a resolution was adopted in this town which was very liberal and progressive for that early period, namely that "there shall be five hundred dollars raised in the town of Berne for the use of common schools in said town to be appropriated to regular men's schools that will bear the inspection of a school committee" (Parker, *ref. cit.* p. 510). The establishment of the Simmons Axe factory seemed to indicate a bright future for the town and an academy was founded in 1833, but with the failure of the factory the plan was abandoned. A select school was organized in 1882.

The first religious organization was the Reformed Church of Beaverdam (1763), and a log church was built in 1765 on the site of Pine Grove cemetery. This was superseded by a frame structure which, midway between Berne and Peoria, or West Berne, served for both villages until 1835, when the society was divided and each had its own church. Other religious organizations came in later (Lutheran, 1790; Methodist Episcopal, 1812; Christian Church, 1821).

The village of Berne, which is situated on the old Weidman mill property, was known as Beaverdam for some years after the first settlement. Beavers were numerous along the Fox kill as well as in Schoharie county and they had several dams. The old Beaverdam road from Albany to Schoharie by way of New Salem and Countryman hill (see page 116) passed through Beaverdam (Berne). The upper waters of the Fox kill between East Berne and West Berne were apparently then called the Beaverdam. The dam itself was on

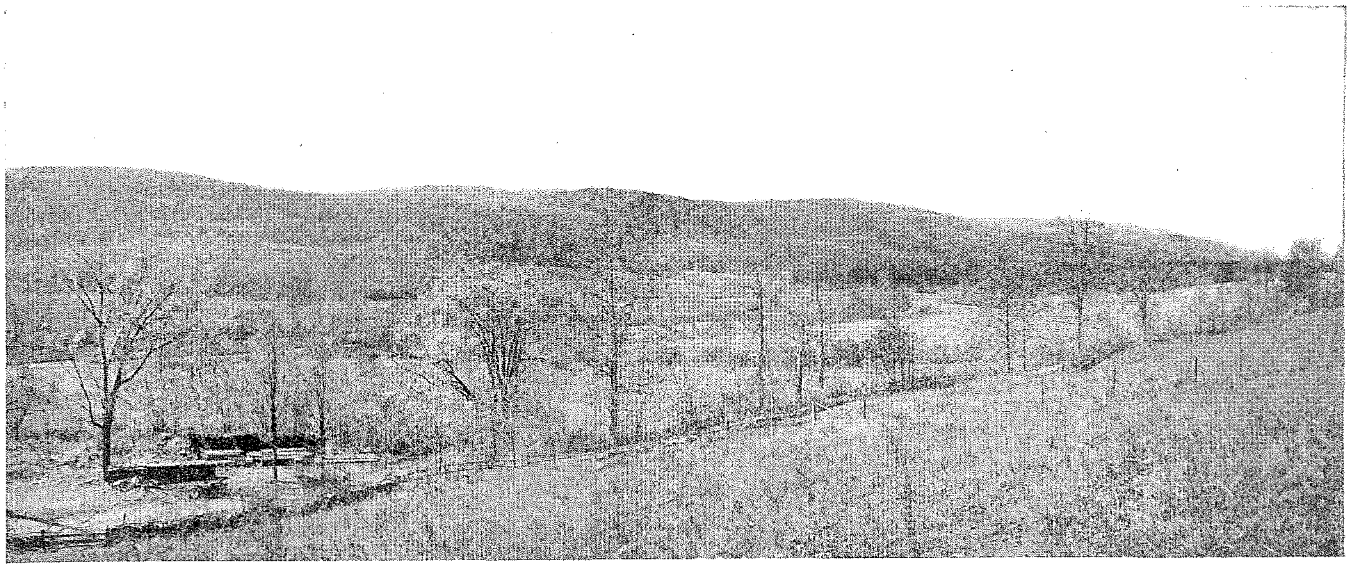

Figure 8 View of Switz Kill valley from above the Dietz massacre monument. The monument is seen in front of the lumber pile at the left. (Photograph by E. J. Stein)

Figure 9 The Dietz massacre monument in the Switz Kill valley. Placed in 1926 by the Tawasentha chapter D. A. R. (Photograph by E. J. Stein)

the Fox kill and early gave its name to the villages along the valley. A tavern was opened in the village of Berne in 1817, called Corporation House, and the village was also for a long time known as Corporation. Its present name was given with the establishment of the post office in 1825.

West Berne was located on the lower Beaverdam (Fox kill) near the site of Post's Mills. About 1830–35 it was called Mechanicsville, because of the numerous mechanics residing there. Then the name Peoria was given by the miller, Paul Settle, who owned property in Peoria, Ill. The name West Berne was given when the post office was established (1825). In the days of the early settlers this place, too, apparently was known as Beaverdam.

East Berne on the Fox kill was first known as Warner's Mills. Locally it was called Philley because Elnathan Stafford who kept the tavern in 1820 sent to Philadelphia for his liquors. The present name was given in 1825 when the post office was established.

South Berne grew up on the site of the old mill property of Asa Culver, and previous to 1825 was known as Centerville. The local name was Mud Hollow from the swampy nature of the soil in that vicinity. A carding mill established in 1830 manufactured satinet cloth; and there was a wheelwright shop in 1866 (Joseph Dietz).

Reidsville was named after Alexander Reid, who settled there in 1828 and opened the first tavern.

Town of Knox. The history of settlement in the town of Knox is much the same as that of Berne, from which it was erected in 1822, receiving its name from the celebrated Colonel Knox, of Revolutionary fame. The Bozen kill (derived from "boos," angry, because of its rapids and falls) forming its boundary in the northeast and the Beaverdam in the southern part are the two principal streams.

The names seen in various lists indicate a Dutch element in the population, through descendants of some of the earliest families. The details of the Dutch settlement before the Revolutionary war, however, are almost entirely wanting. General Parker writes: "It is known that many of the pioneers espoused the royal cause during the Revolution and removed to Canada after the success of the American colonists, but Captain Jacob Van Aernden's name has come down as one of the loyal Whigs of that time" (*ref. cit.* p. 538). The improvements made in this section before the Revolution seem to have consisted almost wholly in clearing part of the land for farming and establishing a few mills, churches and schools. The Lutheran Church was organized in 1750 and settlement appears to have progressed considerably by that time, although the names of most of the Dutch pioneers are lost in the past. After the War settlers came in from New England with Samuel Abbott and Andrew Brown of Connecticut among the first. Twenty or thirty others from the same state soon followed them. Before the town organization in 1822 the names recorded are such as Brown, Todd, Williams, Denison, Crary, Chesebrough, Gallup, Taber, Gage, Wentzel, Frink, Bassler, Schoonmaker, Zimmer, Pinckney, Williamson, Sand, Swart, Keenholtz etc. Between 1825 and 1850 were added to the above families the Whipples, Van Aukens, Skinners, Van Derkers, Chapmans, Danes, Seaburys, Russells, Withers etc. These names appear through the early history of the town and are found represented by descendants down to recent times. The New England settlers brought with them their habits of industry and the religious tenets of their forefathers, and a Presbyterian Church was early established.

Before 1825 saw mills were operating. A small grist mill was in operation early in the northern part of the town, but it disappeared along with most of the saw mills and grain was taken to Berne and Altamont. In 1831 a tannery (Alexander Crounse) was erected along the main road, which did a large business in manufacturing harness and leather until the centralization of the trade elsewhere. One interesting pioneer was a man by the name of Gideon Taber, who was one of the first shoemakers in town, a native of London, Conn., and son of Quaker parents. During the Revolution he went to Canada, because of noncombatant beliefs, and for a time had command of a vessel on Lake Champlain. He came back to Knox after the War and went about as an itinerant shoemaker in accordance with the custom of the times. Subsequently he established a tannery, making leather for his own trade and harness. Early in the nineteenth century, a Walter Crary began the manufacture of wooden pill boxes and supplied some of the largest pill makers in the country.

According to tradition there were two primitive schools, taught in log schoolhouses in Knox, one probably on the present site of the village of Knox, the other near West Township. There may have been others, but trace of them has been lost. The town was divided into school districts long before the separation from Berne. A Knoxville Academy was organized under state laws about 1830. It had a large patronage for many years, but has not been in operation since 1880. It is believed that the success of this old institution was to the disadvantage of the district schools, retarding their advancement.

West Township and East Township had no business of any account. The village of Knoxville or Knox in past years has had a small mercantile business. There was no hotel in the place or town. The first church was Lutheran (1750). The Reformed Church of Knox had its origin in the Presbyterian Church (1825). There was a Baptist Church known as the Church of Berne previous to 1825, but it began to decline and became extinct so far as holding services was concerned. The Methodist Episcopal Church at Knox village was connected with those of Berne, Reidsville, Middleburg (Schoharie county) and Schoharie to form the Berne circuit. The first Methodist Church in Knox village was erected in 1851 and there was one about the same time in West Township. A third was in the eastern part of the town (1841).

Gallupville and Quaker Street. At the west a portion of Schoharie county, mainly the town of Wright, is included in the Berne quadrangle area. The town of Wright, formed from the town of Schoharie in 1846, was named in honor of Governor Silas Wright. The first settlement in the town was made by Jacob Zimmer about 1735 on the outskirts of the German settlements in the Schoharie valley. Gallupville, the principal village of the town, was named after the Gallups, who migrated from New England in 1817 and purchased the land upon which the village now stands. They built a thriving and progressive village through their enterprise and industry. July 26, 1782, the notorious Tory, Captain Adam Crysler, with a party of about 25, mostly Indians, made a raid into the Fox Kill valley, beginning their murderous work at the house of David Zimmer, near the present village of Gallupville. They passed down the Fox kill to near Shutter Corners and crossed over the hill to Cobleskill. After the surrender of Burgoyne at Saratoga, a number of the German troops, instead of returning home, settled in this town south of the Fox kill and became thrifty farmers.

Quaker Street at the north is in the southern part of Schenectady county, in the town of Duanesburg. Quaker Street, Quaker Street Depot or New Quaker Street, as it was variously known, was early settled by the Briggses, Moshers, Hoags and others. Numerous residences of members of the Society of Friends were scattered along the road running through what is now the center of the village, hence the name. The first Quaker meeting was held there early in the nineteenth century. A Quaker meeting house was one of the first buildings erected after a few dwelling houses, and for many years there was only one store there. Shoes were made there for retail trade in 1845, a business which by 1886 employed 30 to 40 men, putting out 1200 cases annually. Stores and a hotel grew up; carriages were manufactured in 1870. It was the Albany and Susquehanna railroad (now Delaware and Hudson) which brought about the development of this village.

Town of Rensselaerville. The southern part of the area of the Berne quadrangle comprises the northern portions of the towns of Rensselaerville and Westerlo. Rensselaerville was the first town erected (1790) from the "mother" town of Watervliet, and its name was derived from the patroon, Stephen Van Rensselaer. A map of the Manor of Rensselaerwyck, made for the proprietor in 1767 (by J. R. Bleecker), showed no inhabitants, dwellings or roads within the limits of the present town. In 1770 a piece of land upon the flats just above the village of Preston Hollow was settled by Derrick Vandyke, who was the first settler in the southwestern part of the town. According to tradition he was a Tory during the Revolution. General Parker writes:

> At this time there were five footpaths or trails used by the Schoharie Indians, the main path beginning at Catskill and following the creek of that name up to its source at the vlaie, and running thence to Middleburg, passing through the site of Preston Hollow. Over this route now runs the Schoharie turnpike. This path was traversed by the Indians of the Stockbridge and Schoharie tribes, the former tribe being in the habit of camping for weeks on what is now Coon's meadow in Preston Hollow, during their fishing season in the Catskill Creek. (*ref. cit.*, p. 462).

A Tory camp, built of logs in wigwam style, was found on Tenmile creek by the first settlers. Another is reported as found "on the ground now covered by Rensselaerville pond." The settlers apparently built their homes on the highest part of their land. Paths were traced from cabin to cabin by blazed trees and these blazed trails were the beginning of the present roads from hilltop to hilltop. According to a map made in the years 1786-87, 67 settlers had begun improvements and 59 homes, probably log cabins, were built, and these were chiefly located along the so-called Old and New roads from Freehold to Schoharie. It was over these roads, apparently, that settlers came in from the south and spread mainly to the north and west. Among the early settlers here, too, was some dread of the Indians. At the time of the massacre of the Dietz family in the Switz Kill valley, two boys, sons of Mr Prie, were captured while on their way to Berne, and kept prisoner by the Indians for many years. "These Indians under Brant at this time came down past the site of Preston Hollow and camped on the site of Cooksburg, and thence passed on over the hills to Blenheim and thence to Schoharie. They were followed by armed men, who, however, were unable to overtake them" (Parker, '97, p. 467).

The first settler in Rensselaerville was a certain Apollos Moore, a veteran of the Revolutionary War, who came from Pittsfield. His piece of land was about two miles east of the present village. He came on foot and his wife rode a horse (cost five dollars) which carried all their goods. In 1783 John Coons came from Columbia county, and Silas Sweet from West Stockbridge, Mass., settling about one mile from Rensselaerville village. In 1787 Joseph Lincoln, John Rensier and several brothers named Hatch settled in the northern part of the town, and south of the village Peckham and Griggs erected a store-dwelling house and tannery. The first settler on ground that grew to be the village of Rensselaerville was Samuel Jenkins, who came February 22, 1788, which is therefore considered as the date of the founding of the village. He erected at that time the first frame dwelling house and the first grist mill. Daniel and Josiah Conkling were also early settlers; Daniel carried on tanning and a boot and shoe factory. Among the early settlers appear names such as Culver, Watson, Huyck, Fuller, Mulford etc. Rensselaerville's ambitions were brought to a halt when the proposed (1831) Catskill and Canajoharie railroad, the only one to thread that vicinity, stopped at Cooksburg (1839), eight miles south.

It was the tanning and felt mills at Rensselaerville, vestiges of which can be seen today, that gave promise of making this a metropolis of the forest. Here was the original Huyck mill where Waterbury and Huyck developed the felting process. The felting industry moved to Kenwood in 1880 and to Rensselaer in 1894. Members of the Huyck family have been identified with Rensselaerville for many years. Other prominent and wealthy men have come from this village.

Preston Hollow in the southwestern part of the town was founded in 1798 by Dr Samuel Preston, who erected the first frame building in the village. The first settlers in this area were Andries Huyck and Sebastian Smith. Another pioneer was Captain Daniel Shay, the leader of the famous "Shay's Rebellion" in Massachusetts. He settled near the village of Preston Hollow in 1790. Potter Hollow, also in the southwestern part of the town, was settled in 1806. In 1803, Gerardus Drake, a prominent member of the Society of Friends, settled near there. Potter Palmer, the well-known Chicagoan, was born and grew up here. Medusa, in the southeastern part of the town was settled in 1783 (Uriah Hall and son Joshua) and bore for many years the name of Hall's Mills.

The first town organization dates back to 1791. Berne was taken from this town in 1795 and part of Westerlo in 1815. The first town meeting was held in 1795. Among the roads of the town was the military road from Athens (then Lunenberg), Greene county, which passed through the southern part of the town and was crossed by a road from Beaverdam (Berne). There was another road that crossed the town farther north, known as the "Basic Path." It was originally an Indian trail and then was used to transport military stores. In the early days these roads were so covered with underbrush as to be passable only for ox teams. In 1802 the Schoharie Turnpike Company incorporated (road through Preston Hollow in the southern part of the town); in 1805 the Albany and Delaware Turnpike Company was incorporated to build a road from Albany to Brink's Mills, running through Rensselaerville village.

The first religious organization was that of the Baptists in Preston Hollow, 1790. Most of the early settlers around the village of Rensselaerville were Baptists. There was no meeting house in the village until 1830. The first one was built in what is now the town of Berne. The first Presbyterian Church was organized in 1793 and had a log house as a place of worship on what is known as Mount Pisgah. The first Dutch Reformed meeting house was built in 1795 in the southern part of the town on a ridge of land known as Oak hill. The Methodist Church was established later (Rensselaerville, 1839). The Quakers were very numerous in early times, but by the end of the century had nearly disappeared from the town.

Town of Westerlo. The town of Westerlo was the seventh town erected in the county (1815) and was formed from parts of Rensselaerville and Coeymans. The name was given in honor of the Rev. Eilardus Westerlo, who came from Holland in 1760 and was pastor of the Reformed Dutch Church at Albany. The principal streams are the Hannacrois, Basic and Eightmile creeks, with their tributaries.

The asheries here in the early days constituted a prominent industry and they also served as an incentive for clearing much of the dense wilderness. The trees were cut down, burned and the ashes sold to the ashery or exchanged for supplies for the family. The inhabitants for the most part have always been engaged in agriculture. Dairy farming and sheep-raising have been profitably followed. The first mill was erected (Lobdell and Baker) in 1795, a short distance south of Chesterville (Westerlo) on Basic creek (meaning low, flat). A carding mill was established below Chesterville on the Basic creek in 1812, later converted into a turning shop and finally into a grist mill. Bee culture has been an important industry of the village, and there was also a fruit evaporator here. At South Westerlo were formerly a tannery and asheries belonging to Smiths, who afterwards erected grist mills. Later mills for the manufacture of flannels, cassimeres, satinets and yarns were located here on Basic creek, as were also a fruit evaporator and butter factory. Grist and saw mills were located on the Hannacrois near Dormansville. In fact, saw mills were numerous throughout this region. It has been impossible to determine who were the first settlers within the present limits, but certainly they came before the Revolution. A Jacob Ford is recorded as having come from Hillsdale in Columbia county in 1795. Also in 1790 came Adam St John, of Scotch origin, who migrated from Old Paltz and settled at Lamb's Corners. Originally he came with the Huguenots from Holland. There were settlements at Dormansville in 1795 (John Gibbons) and Germans (Lodowick and Jacob Hanes) settled at an early day on Basic creek near Dormansville. Among other early settlers in the town were the Havelands, Birds, Arnolds, Beckers, Stantons, Reynolds, Lockwoods etc.

Chesterville was named after the Rev. John. Chester, formerly pastor of the Second Presbyterian Church of Albany. The post office was established in 1827, at which time the name was changed to Westerlo. Previous to this letters and papers were delivered once a week by postriders (Brown and Peck). South Westerlo was first called Smith's Mills (after David Smith) and this name, too, was changed in 1827. Dormansville was named for Daniel Dorman, the first postmaster (1832). Van Leuvans Corners was named after Isaac Van Leuvan, one of the early settlers. This hamlet in the northern part of the town was located on the Delaware turnpike, and it formerly had a tavern, mills, tannery etc. It was first called Sackett's Corners after James Sackett, a colonel in the War of 1812. later Preston's Corners.

Schools were established in the town at an early date. A select school for the education of the Quaker sect was taught by the Quaker John Mott, but other sects were not excluded. At that time the sect was numerous. The early settlers who came from New England and the adjoining counties on the river were fired with religious zeal and soon organized religious societies. The first was organized in 1793 in the township of Rensselaerville and the first church was built in 1796. A Reformed Church was organized at Westerlo in

1793. Later other churches were organized, the first Baptist in Dormansville (1800), the first Methodist Episcopal in Dormansville (1826), the first Christian Church in South Westerlo (1820). An Episcopal Church, something of the nature of a Union Church, was organized in 1875 in the northern part of the town.

Town of New Scotland. At the east the Berne quadrangle comprises parts of the towns of New Scotland and Guilderland, and something of their history, at least of the area bordering upon our quadrangle, should be of interest here. New Scotland was separated from Bethlehem in 1832. The territory now embraced in this town is part of the Van Rensselaer Manor and part of it was included in the Jan Hendrickse Van Baal purchase from the Mohawk Indians in 1660. The first settlers in the latter section were on the Normanskill about 1700 (La Granges and Koenradt Koens) and several families in the vicinity of New Scotland took their leases from these families as early as 1716. The patroons took action to invalidate their title, won out July 6, 1776, and 66 families were deprived of their estates after a peaceable possession of 90 years.

The first settler on the Onesquethaw flats in this town was Teunis Slingerlands, who arrived about 1660. He established the first grist mill soon after his arrival. Between the years 1700 and 1750 a number of settlers came into what is now the town of New Scotland, bringing with them the customs of the Old World and the industrious hardihood of the race. Among them were such names as Seger, Moak, Hellenbeck, Houck, Delong, Hoogtaling, Mead, Thompsons, Bradt, Slingerland etc. Until 1775 most of the settlers on the lands of the patroons were squatters, occupying their lands without leases, and slow progress was made in improvements. About this time the Slingerlands, who had made more extensive improvements, started mills at Clarksville. From 1750 to 1775 there was a large influx of settlers from Scotland, Ireland and England. Immigration practically ceased during the Revolutionary period, but it began again after the close of the war. "Property rights being settled, industry protected, a market provided for crops, together with the attendant blessing of peace, gave encouragement to settlers already located and stirred the enthusiasm and ambition of the adventurous" (Parker, '97, p. 548). Among those coming in between 1775 and 1800 were families whose names are well known through their descendants in the county today.

The village of New Scotland (post office 1765) derives its name from the many early Scotch settlers. Before the establishment of the post office, the mail, as in other hamlets was carried on horseback or by stage. As the merchandise and produce were carried to market in the same slow manner, numerous public houses grew up. Clarksville was originally known as Bethlehem, and takes its present name from Adam A. Clark, who settled there about 1822. Travel from Rensselaerville was greatly increased after the Albany and Delaware Turnpike Company took out its charter in 1805 and roads were improved, and as Clarksville was about halfway it became a convenient and popular stopping place and taverns were built. Saw and grist mills were early established here. The hamlet of Feura Bush was formerly known as Jerusalem. Onesquethaw, about one and a half miles south of Clarksville, was locally known as Tarrytown. Taverns and public houses had grown up here. One tavern was kept in a large building known as "the Castle" and became a resort for idle and dissolute persons who would "tarry" there until unseemly hours; hence the local name. When the Erie canal was constructed large quantities of stone were quarried in this neighborhood and many workmen were employed. The church of Onesquethaw was built in 1825 from bluestone (Onondaga limestone) left from that quarried for the canal, and the reverent farmers drew the stone many miles. Voorheesville is a railroad junction (West Shore and Delaware and Hudson). The village was named after Alonzo B. Voorhees, who built one of the first dwellings before the completion of the Delaware and Hudson Railroad. New Salem was located at the foot of the Helderbergs on the old Beaverdam road, which later became the Albany and New Scotland plank road. Locally the hamlet was known as Punkintown. The post office was opened soon after the establishment of the town and the present name was given. The first settlement on this site was in 1770 (Seth Price, Christian Bradt, Van Valkenburgs and a few others) and other settlers soon followed. Taverns and public houses grew up. Tanneries, saw mills and grist mills were established. A grist mill established by the La Granges (1831) on the Vly creek just to the north of New Salem was in operation down to recent times. A carding mill was also early established. Wolf hill (Berne quadrangle) was a post office west of New Salem, and up to 1896 another post office existed on the Beaverdam road under the name of Helderberg.

Early schools were like those in other localities. First they were taught in private houses, often the home of the teacher; later there were log schoolhouses. One of the original log schoolhouses was located at Clarksville, another in the village of New Scotland. The Scotch and Irish settlers were of the Presbyterian faith. The earliest religious organization of which there is authentic record is the one that later became the New Scotland Presbyterian Church. Open air services were held about 1776. A church was built in 1791. There were Dutch settlers in the town as early as 1650 but there are no records of an organized church until 1780. It is thought probable that the people went to Albany or Schenectady to worship. The first Methodist preacher held a service in this town in 1820, but the earliest record of a church seems to be 1850 (New Salem).

Town of Guilderland. The town of Guilderland, extending into the northeast corner of our area, was separated from Watervliet (now Colonie) in 1803. The settlement in this town was considerably advanced previous to the Revolutionary war and most of the settlers were Dutch, as were a great majority of the pioneers of the county. Besides farming, there was the operation of the saw and grist mills and factories. Cloth works were established at French's Mills in 1795. There was an inn here in 1800 and early in the century Peter French built a factory. The Spafford Gazeteer of 1813 states that 100 looms were working in the town, producing 25,000 yards of cloth annually. One of the oldest industries of the county was established in this town in 1792. A factory for the manufacture of window glass was built at the site of the village of Guilderland. This was termed the "Glass House," around which gathered the oldest settlement also known by that name until in 1796 the name of Hamilton was substituted in honor of Alexander Hamilton. Spafford's Gazeteer of 1813 states that 500,000 feet of window glass were made here annually. Later this settlement was known as Sloan's from a family of that name and now as Guilderland. The highway passing through here (eight miles from Albany) was known as the "Great Western Turnpike." As roads were laid out and improved and post routes and stage lines established, taverns were opened at frequent intervals along the roadsides.

The village of Guilderland Center near the center of the town was formerly known as "Bang-all." The name is said to have been given because of the somewhat rude character of part of the inhabitants. This village practically includes the site of old French's Mills. Dunnsville in the northern part of the town was named for Christopher Dunn, who was the original owner of lands here.

Altamont is the largest village of the town and also in the area covered by the Berne quadrangle. It lies westward of the center of the town at the foot of the Helderbergs and was formerly known as Knowersville after the Knower family who were early settlers there. For a long time after the change in name the section of the town where the Knower homestead was located, somewhat remote from the present business center, was known as Old Knowersville. There was a tavern here in Revolutionary time and a woolen factory was in operation in 1800. The place was of little importance until the building of the railroad. In September 1863 the first passenger train from Albany to Central Bridge (Schoharie county) passed through here; and at that time there were only two farm dwellings on the lands that constitute by far the larger part of the present site of Altamont. Residences, stores and hotels were soon built; saw and planing mills were established. In 1874 a carriage factory was built. Altamont developed into an extensive haymarket and shipping point for other products from a wide territory. In 1884 the Knowersville Enterprise was established, later known as the Enterprise, now as the Altamont Enterprise. The Altamont Driving Park and Fair Association was organized in 1893 and held its first fair that year. The name Altamont was given in 1887, from the high mountain near by (High Point). Many Albany residents have summer homes here, particularly on Altamont hill.

Antirent War. No discussion of the settlement of the Helderbergs is complete without an account of the antirent war which continued even into the closing quarter of the last century. The trouble was largely centered in the township of Berne. The antirent war is fully discussed by both Howell and Tenney and General Parker, whose description ('97, p. 114–19) is largely quoted here:

Anti-rentism came into existence very soon after the death of Stephen Van Rensselaer, the last holder of the Manor of Rensselaerwyck under the British crown. He died January 26, 1839. He had inherited the great manor under the law of primogeniture, as the eldest son, which had existed here through the colonial period. The American laws following the Revolution worked a radical change in this respect, and in order to keep his vast landed interests in possession of his sons and their descendants, Stephen Van Rensselaer on arriving at his majority, adopted the plan of selling his land in fee, reserving to himself and his assigns all minerals, streams of water for mills, and some of the old feudal rents in wheat, fowls, service with horses, etc., and finally, the reservation of one-quarter of the purchase price on every vendition of land. It is said that Alexander Hamilton drew this form of conveyance and advised his client that he could adopt it. But there was at that time an English statute in opposition to such a method of sale, such right belonging to the crown alone. It is believed that Mr Hamilton assumed that the English statute had not been in force in this colony, and that therefore it had no real force here. In any event the patroon sold his lands, warranting the title, his deeds containing the feudal reservations above mentioned.

While this system of sale worked satisfactorily during his life and generally during the lives of the first purchasers, trouble began soon afterward. The patroon devised all his interest in the lands thus sold in fee to his two eldest sons, William P. and Stephen. To the latter, who was the older of the two, were given the rents in Albany county, and to the other those in Rensselaer county. The old patroon was a kindly man and doubtless his many favors to those who had purchased from him served to pacify them under the onerous burdens. But when the sons came into their estate, either their different treatment of the landholders, or changes in the business and agricultural relations of the time, led to complaints and later to more serious trouble. Litigation began and continued many years. . . .

Early in the spring of 1839 the anti-renters held a meeting for the purpose of deciding upon some equitable basis of settlement of the dispute. A committee was appointed to call upon Stephen Van Rensselaer, the elder son, and learn upon what terms they could purchase the soil outright. The committee was composed of the foremost men of the district involved; they called at the manor office in Watervliet on May 22, 1839, and met Mr Van Rensselaer, who refused to recognize them in any manner. They then passed into the inner office, occupied by the agent, Douw B. Lansing, while the latter held a lengthy conversation with Mr Van Rensselaer, after which the committee were informed that they would be communicated with in writing. The committee felt that this was an insult and went away. Subsequently Mr Van Rensselaer sent a letter to Lawrence Vandusen, of Berne, who was chairman of the committee, in which he declined to sell on any terms; this letter was read throughout the manor during that year. The landholders now began active opposition to the collection of rents; agents were insulted and their personal safety endangered; bodies of masked men resisted and attacked sheriffs in discharge of their duties and other demonstrations of force were made in various localities. In December 1839, Sheriff Michael Artcher called to his aid the posse comitatus; with a body of about 600 men he started from Albany on the 3d day of December, 1839, for Reidsville, in the Helderbergs. Arriving near the place, the sheriff selected about seventy-five of the most courageous of his men and continued towards Reidsville, where it was known many of the anti-renters had gathered. Just before reaching the place they encountered a force of 1,500 mounted men, who barred the road and ordered the sheriff and his party back. There was no alternative but to obey, and the whole party hastened back to Albany. When, on the following day, the sheriff acquainted Governor Seward with the outcome of his brief campaign, the governor called out the military in numbers sufficient to have captured every person in the western part of the county. The military force comprised the Albany Burgesses Corps, Albany Union Guards, Albany Republican Artillery, First Company and Second Company Van Rensselaer Guards, Troy Artillery, Troy Citizens Corps, and the Troy City Guards. The command of this force was given to Major William Bloodgood, and, headed by Sheriff Artcher, the march was taken up towards Reidsville on December 9. No resistance was met with before Reidsville was reached, and even then no enemy was found. It was a ridiculous sight—a great body of armed troops upon a long and weary march, to meet not even a single landholder upon whom to expend their ardor. The return was made amid a pitiless rain storm. Resistance to rent collections continued against various methods of compulsion, without much advantage to either side. The landholders hoped by petty and threatened acts of resistance to force the proprietors into an acknowledgment of their position, while the latter seemed to think that by military and legal action they could compel the landholders to pay whatever was demanded. At last the controversy was made a political issue, and a paper, the Freeholder, was started in Albany in support of the cause of the landholders. Both the Whig and the Democratic parties strove to obtain the advantage of alliance with the anti-renters, but the former party had the largest number of them in its ranks. Their power was soon manifested in the political field. Eleven counties promptly elected representatives with anti-rent proclivities to the Legislature, and Albany county elected Ira Harris to the Assembly in 1845 by more than 2,000 majority. Silas Wright, who had been considered invincible, was defeated by John Young for governor in 1846 through the influence of the anti-renters, and the strife went on. As far as its political features were concerned, little was accomplished and in that respect the cause soon lost its influence.

Among the conditions of the manorial grants in fee was a provision that the grantee, or his heirs, was to pay to the proprietor on every sale of the land, ad infinitum, one-quarter of the purchase price; so that if a farm worth say $2000, on which all the improvements had been made by the purchaser, was sold four times at that price, the proprietor would get the whole value of the farm, including the improvements, in four payments of $500 each. Litigation began in the courts on this quarter-sale provision in 1848 and in 1852 went to the Court of Appeals. Without here attempting to follow the details of the decision, let it suffice to say that it was in favor of the oppressed landholders. . . .

After this decision was rendered the manor proprietors were advised by counsel to sell, and this was done in some cases prior to 1852. With the changed conditions under the decision of the court, and the low prices at which lands were now offered by the proprietors, speculators and adventurers came into the field and made many purchases. The principal buyer was Walter S. Church, then of Allegany county, who during the succeeding thirty or forty years, was responsible for endless trouble for himself and the landholders. Litigation continued and in many instances families were dispossessed of their farms amid distressing conditions.

After the decision on the quarter sale described above, one of the first cases that went to the Court of Appeals was Van Rensselaer vs. Ball in 1858. Decision in that case was based upon a statute passed by the Legislature in 1805, maintaining the right of ejectment on the part of manor proprietors or purchasers of their interest. This decision so shocked the public mind that the statute of 1805 was repealed by the Legislature of 1860. The feudal rent litigation was then renewed and other cases passed from the lower courts to the Court of Appeals, where they were decided in 1863, in favor of the proprietors, with two of the most distinguished of the eight judges refusing to share in the decision. General Parker continues:

Upon that remarkable decision hung all the later merciless exactions of the proprietors, or purchasers of this interest, against the landholders and the many instances of dispossession and suffering with which citizens of Albany county are familiar. . . . The working of this injustice has thus been pictured by Andrew J. Colvin, who has given much study to the matter: "Ejectment suits are brought to recover one year's rent claimed to be due—generally the last year—and recovery of possession of the farm for non-payment. The landholder, on prosecution, goes to the office in Albany to pay the year's rent sued for, and the costs of the action. Payment will not be accepted unless he will also pay all rents claimed to be in arrear; it may be for fifteen or twenty, perhaps thirty years. The landholder remonstrates on the ground, as often happens, that he had only owned the farm a few years, and should not be asked to pay longer than he has owned. He is told that that makes no difference; the farm is liable, no matter who may have been the owner, and he must pay all rents claimed or lose the farm. On inquiry as to the amount claimed, he is startled to learn that it exceeds the value of the farm, perhaps, with all the buildings and other improvements. That result is brought about by charging the fullest prices for the wheat, the fat fowls, and the days' service with carriage and horses, with annual accumulations of interest on each. It is the old story; the successors of the old patroon chastised the landholders with whips; the adventurers chastise them with scorpions."

Claims made upon the board of supervisors for services in the antirent difficulties were rendered as late as 1866, as exemplified in the following (*ref. cit.*, p. 118, 119):

	Claimed	*Allowed*
Lennard & Bradt	$1 295.72	$1 268.59
Edward Scannell	1 053.00	576.00
Tenth Regiment, N. G. S. N. Y.	992.25	992.25
Company F, 25th Regiment, N. Y.	762.24	762.24
Company C, 25th Regiment, N. Y.	626.40	626.40
Company G, 25th Regiment, N. Y.	256.92	256.92
Lord & Thornton	500.92	498.02
Albany & Susquehanna R. R. Co.	228.80	228.80
John Cutler	157.00	150.00
Augustus Brewster	122.00	80.00
Walter S. Church	115.00	Disallowed

That the conditions continued to a much later date is indicated by the following quotation from the writings of Howell and Tenney in 1886 (p. 816, 817):

Where the blame lies it is not the province of this paper to say. That it was detrimental to the growth and development of this town (Berne) every candid mind will concede. For years valuable time was spent amid excitement and revelry; money was wasted, and a habit of indolence and a lack of thrift were engendered. Churches, schools and business enterprises have felt the blighting curse of feudal tenure, and are rejoicing that the reign of terror is well-nigh over.

JOHN BOYD THACHER PARK

The Indian Ladder region, as the rest of the Helderberg area, has been from the earliest days the stamping ground for geologists and paleontologists (*see* Kunz, '14, p. 349 for names) and has also been much visited by the layman. Now that good roads and automobiles have made the Helderbergs more accessible, this has become a favored tourist area. With the establishment of the John Boyd Thacher Park and construction of a new road into the park the number of people visiting the Indian Ladder area has increased year by year, because of the short distance from Albany. 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 supper and to find in this beauty spot relaxation and a brief change from the heat and noise of the city. Then there is the camper, for whom some provision has been made by the park authorities. Besides these 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 here.

In 1914, through the generous gift of Mrs Emma Treadwell Thacher, of Albany, N. Y., 350 acres of land in the Helderbergs were given to the State of New York to be a public park, in memory of her husband, the late Honorable John Boyd Thacher, a distinguished citizen of Albany, for four years its mayor (Kunz, '14, p. 343–77; Wiswall, '30, p. 47–51). The property, included in the towns of New Scotland and Guilderland, centered at the Indian Ladder. The John Boyd Thacher Park was at this time placed in the custody of the American Scenic and Historic Preservation Society, in whose reports are recorded all data concerning it. In 1920 Mrs Thacher added to her original gift 50 acres of land, in the town of Knox, on the west shore of Thompsons lake, two miles west of the original area. In 1924, an additional 5.8 acres were purchased and the State obtained an option on 140 acres more. The purchase comprised a strip of land along the face of the cliff varying from 50 to 300 feet wide and extending for half a mile south of the Indian Ladder road. This gave the State control of the Bear path, which runs along the face of the cliff midway between the rim and the talus. Since then the society has acquired by purchase, with state funds, other parcels of land to round out the property into a solid block, so that the park now comprises 920 acres, conserving six miles of the cliffs and much attractive woodland on the slopes above the escarpment. The John Boyd Thacher Park is the only state park in Albany county and it is the second largest state property in the custody of the society.

John Boyd Thacher Park is a wild life preserve as well as a public park. It is of interest to note here, in this connection, the establishment in the fall of 1921 of a sanctuary for wild life adjacent to the park by the owners of the neighboring property. In September 1921 three deer—a buck, a doe and a fawn—were seen in or near the state park, and it was hoped the family would become permanent residents. This was one of the reasons for the establishment of the sanctuary, which is a private park, known as Ferncliff Park. The tract so set aside includes "all lands lying and situate on or near the Helderberg Cliff and extending back therefrom to a distance of upwards of one and one-half miles, and extending along said cliff the entire distance from that point on or near the said cliff on the easterly boundary of the property owned by Kenny Parrish, near the old reservoir of the Village of New Salem, to the Thacher State Park, at a point adjoining the property owned by James Feeney; . . . ." (27th Ann. Rep't Amer. Scenic and Hist. Pres. Soc., 1922, p. 45).

The geology and vegetation of John Boyd Thacher Park has been discussed elsewhere in the introduction and to a certain extent in the detailed description of the formations. In the first description of the park (Kunz, '14) was included a short discussion (p. 357–59) by Dr H. D. House, State Botanist, of the vegetation of the escarpment near Indian Ladder; and the writer has prepared a guide to the geology of John Boyd Thacher Park and vicinity ('32). There are a few points of interest about the Indian Ladder region, however, that may be touched upon here.

Many questions have been asked about the Indian Ladder and the age of the road. The history of the Indian Ladder is discussed by Verplanck Colvin in his article on The Helderbergs ('69) and also by Doctor Kunz in his article on the park ('14, p. 344). Mr Colvin writes (p. 664, 665):

> What is this Indian Ladder so often mentioned? In 1710 this Helderberg region was a wilderness; nay, all westward of the Hudson River settlement was unknown. Albany was a frontier town, a trading post, a place where annuities were paid, and blankets exchanged with Indians for beaver pelts. From Albany over the sand plains—Schen-ec-ta-da (pine-barrens) of the Indians—led an Indian trail westward. Straight as the wild bee or the crow the wild Indian made his course from the white man's settlement to his own home in the beauteous Schoharie Valley. The stern cliffs of these hills opposed his progress; his hatchet fells a tree against them, the stumps of the branches which he trimmed away formed the rounds of the Indian Ladder. (See figures 10, 19).
>
> That Indian trail, then, led up this valley, up yonder mountain slope, to a cave now known as the "Tory House." The cave gained that name during the Revolution: of that more anon. The trail ended in a corner of the cliffs where the precipice did not exceed 20 feet in height. Here stood the tree—the old Ladder. In 1820 this ancient ladder was yet in daily use. There are one or two yet living who have climbed it. Greater convenience became necessary and the road was constructed during the next summer. It followed the old trail up the mountain. The ladder was torn away, and a passage through the cliffs blasted for the roadway. The rock-walled pass at the head of the road is where the Indian Ladder stood.

The "Tory House" referred to above was reached from the trail that wound up the valley and "is a large circular or semicircular cavity in the cliff, just above the road, a good view of which it commands" (*ref. cit.*, p. 660). This cave or grotto has a diameter of perhaps 25 or 30 feet. The path leading to the cave starts along the high cliffs, now known as the "Battlements" (figure 30) and is found by climbing the débris beneath the mantlepiece-like projection, the Dome. "This place became known in Revolutionary days as the 'Tory House', because it had the repute of being at once a place of meeting and an asylum for the defenders of England's cause in the war. Local tradition tells that John Salisbury, a British spy, was tracked here and captured about the time of Burgoyne's campaign, which ended so disastrously at Saratoga in 1777" (Kunz, '14, p. 345).

Caves are numerous in the Helderbergs and most of them are of small size. They are dark and dungeonlike, damp and muddy. The one that attracts attention in the Indian Ladder region is Hailes' cavern, formerly known as Sutphen's cave, which is about 2800 feet long, the last 1600 feet having an average height of two feet and a width of 12 inches. In times of heavy rains water pours from the mouth of this cavern. Bats have been found clinging to the walls some distance from the entrance. The arch at Hailes' cavern has been called the Proscenium arch (figures 11, 26). In July 1905 "a mass of rock 35 feet long, three feet thick and from 9 to 12 feet wide fell from the Proscenium Arch. This is the second considerable rock fall within the memory of residents of the neighborhood" (21st Ann. Rep't. Amer. Scenic and Hist. Pres. Soc., 1916, p. 101).

The first and smaller falls (Outlet creek) to the south of Indian Ladder road is referred to by Verplanck Colvin as "Dry Falls," although he adds: "The latter name you will hardly appreciate should you visit it when swollen by recent rains. Here you may enjoy an unequalled shower-bath; but the stream carries pebbles, and the dashing water itself stings like a shower of shot" (p. 656). Eastward the path leads to the falls (figures 24, 25) variously known as "Big," "Mine Lot" or "Indian Ladder Falls." Doctor Kunz in discussing this falls remark that "in 1850 or thereabouts a sawmill was built some distance up the creek which supplies this fall, and the fall at the cliff edge is frequently called by the resident population the Saw Mill Falls" (*ref. cit.*, p. 348). Behind Minelot falls at the base of the cliff "is a low, horizontal cavity in the rock, from four to six feet in height, fifty or sixty feet in length, by fifteen in depth. . . . . Mine strictly there is none; but the marks of mining implements and the excavation show that operations of some kind have been carried on" (Verplanck Colvin, '69, p. 677). Mr Colvin refers to a bed or vein of iron pyrites. The miners, if any, must have been attracted by the pyrites which impregnates the Brayman shale, but the so-called mine appears to be only another example of the shelters found at the base of the Manlius cliff (see figure 23).

The reader is referred to the reports of the society for the details of the history and administration of the park, particularly the articles by Dr George Kunz, president of the society ('14), and the Honorable Frank L. Wiswall, chairman, John Boyd Thacher Park Committee ('30). The first superintendent of the park was Professor John H. Cook, paleontologist and geologist, and he was succeeded in 1929 by Scott Knowles, the present superintendent. Senator Wiswall points out that "the Society has been fortunate in having the services of chairmen, who gave it keen interest, especially one of the more recent, Judge Ellis J. Staley, of Albany, who lived on a farm within the present park area when a boy, and who was instrumental in having the new state road built to it. The preserve has been maintained largely in the natural state desired by Mrs Thacher in carrying out

Figure 10 Restoration of the escarpment at the "Battlements" to its appearance when there was only an Indian trail through here. At the center leaning against the cliff is a felled tree representing the one used as a ladder by the Indians. (Restoration by J. H. Cook)

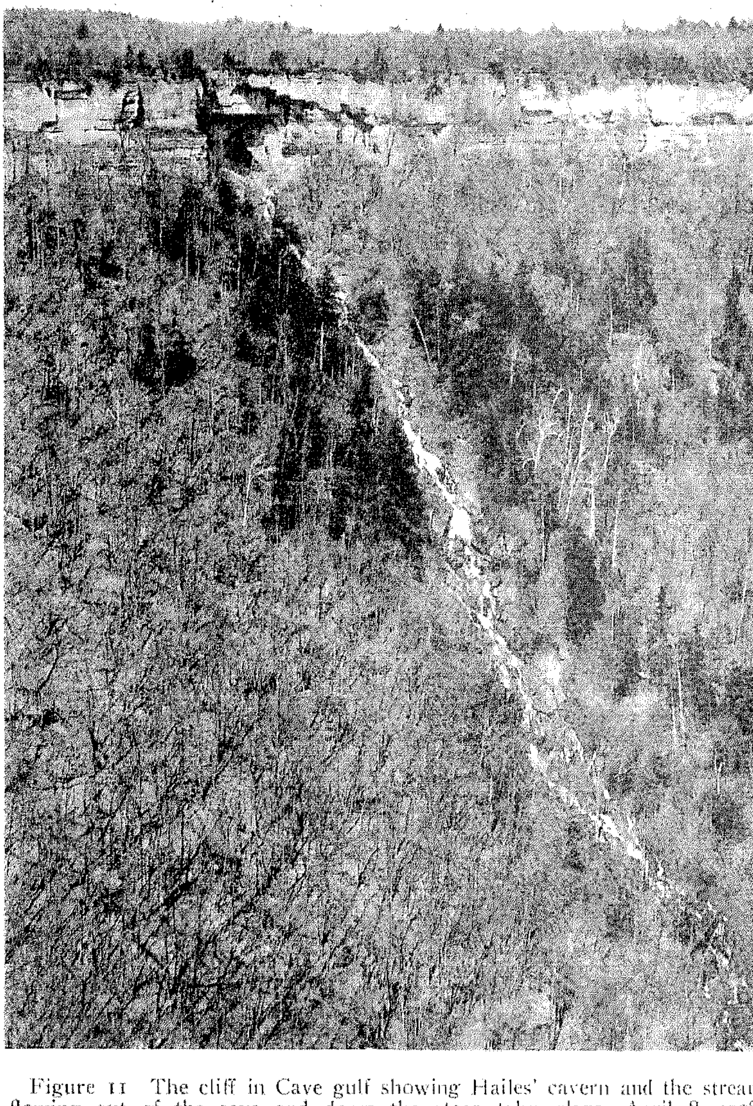

Figure 11 The cliff in Cave gulf showing Hailes' cavern and the stream flowing out of the cave and down the steep talus slope, April 8, 1928. The Indian Ladder beds are exposed in this ravine. (Photograph by E. J. Stein)

her husband's wishes, with due consideration for the convenience and comfort of visitors" ('30, p. 51). The park has been made much more accessible by the new state road that climbs by easy grades from New Salem, running along the top of the cliff to the headquarters at Indian Ladder. For the comfort and safety of the public the society has made many improvements "including shelters, sanitary facilities, water supply reservoir and distribution pipes, parking places and fences at the brink of the cliffs. Thousands of young trees have been planted and are now well grown . . . ." (*ref. cit.* p. 48). Two women's clubs of Albany have become interested in the park and are sponsoring the placing of markers at spots of particular geological interest (Dana Natural History Society) and a proposed small geological museum and botanical garden (Fort Orange Garden Club)[1]

DESCRIPTIVE GEOLOGY

There are 18 or 19 recognizable formations (or members) on the Berne quadrangle, extending from the Middle Ordovician to the Upper Devonian. They are as follows in ascending order:

Devonian system

19 "Oneonta" beds (nonmarine Hamilton "red" beds; see page 181)
18 Hamilton shales and flags (largely Marcellus: Cardiff)
17 "Marcellus black shale" (see Hamilton: Berne member; page 189)
16 Onondaga limestone
15 Schoharie grit
14 Esopus grit
13 Oriskany sandstone
12 Port Ewen limestone
11 Alsen limestone (?)
10 Becraft limestone
9 New Scotland limestone
8 Kalkberg limestone
7 Coeymans limestone

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[1] On November 5, 1933, a bronze tablet was dedicated by the Tawasentha Chapter, Daughters of the American Revolution, and the State of New York, in memory of those pioneer geologists whose researches in the Helderbergs from 1819 to 1850 made this region classic ground. The tablet is placed on the cliff face at the north side of the upper Indian Ladder road near the entrance to the Bear path.

Silurian system
- 6 Manlius limestone
- 5 Rondout waterlime
- 4 Cobleskill limestone
- 3 Brayman shale[1]

Ordovician system
- 2 Indian Ladder beds
- 1 Schenectady beds

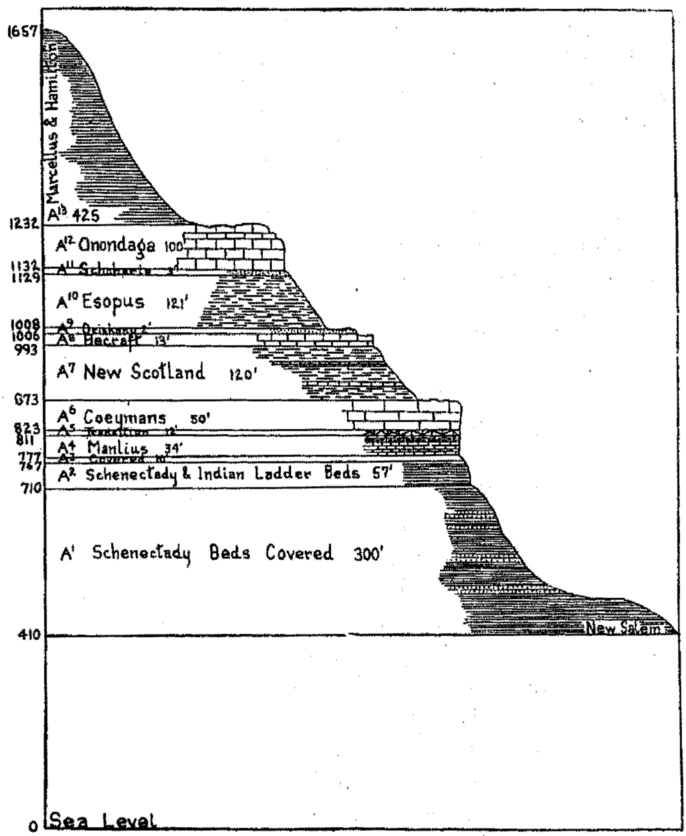


Figure 12 Section of Countryman hill, near New Salem. Shows the two prominent cliffs formed by the Coeymans-Manlius and Onondaga limestones and the minor cliff developed on the Becraft limestone. Scale: 1 inch=400 feet. (From Prosser & Rowe, 1899)

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

This series of formations belongs to the western trough of the Capital District. The geological structure of the Capital District is fully discussed in previous papers (Cushing and Ruedemann, '14; Ruedemann, '30) and briefly is set forth by Ruedemann as follows ('30, p. 130, 132): The first period of folding occurred in Precambrian time producing several long barriers which extended in north-northeast to south-southwest direction across the district forming two or more troughs. Two of the troughs have been positively recognized and designated as the eastern and western troughs, each characterized by their entirely different geologic series of formations (figure 69). The formations of the two troughs are now in close contact, due principally to the fact that folding and faulting along numerous fault planes has carried the rocks of the eastern trough westward. The eastern trough has been termed the Levis trough (Ulrich and Schuchert, '02) from Port Levis in Canada, and in this trough occur the Lower Cambrian beds and the long series of graptolite shales, the Schaghticoke, Deep Kill and Normanskill shales and the Snake Hill beds of Canadian and Ordovician age. The western or Chazy trough, to the southern extension of which has been given the name Lower Mohawk trough (Ruedemann, '14), contains the "normal series" of beds, those listed above and below them in descending order the Canajoharie shale, Glens Falls limestone and Amsterdam limestone of Middle Ordovician age and the Little Falls dolomite, Theresa formation and Potsdam sandstone of Ozarkian age. It is thus seen that no formation up to the Silurian is common to the two series or troughs, which, according to the records left in sediments and fossils, persisted through Ordovician time. In the Cambrian, Ozarkian, Canadian and Ordovician periods this was due to oscillating movements which alternately drained and submerged the two troughs, the one being drained while the other was submerged; in the Silurian and Devonian periods this was brought about partly through an hiatus of nondeposition and partly through extensive erosion of the formations outside of the Helderbergs. The formations of the two troughs are given below (adapted from Ruedemann, '30, p. 27).

Systems	*Western Trough*	*Eastern Trough*
Upper Devonian	....	Rensselaer grit
Middle Devonian	"Oneonta" beds Hamilton shale and flags "Marcellus black shale" Onondaga limestone Schoharie grit	
Lower Devonian	Esopus grit Oriskany sandstone Port Ewen limestone Alsen limestone Becraft limestone New Scotland limestone Kalkberg limestone Coeymans limestone	
Upper Silurian	Manlius limestone Rondout waterlime Cobleskill limestone	
Ordovician — Silurian interval Upper Ordovician	 Brayman shale Indian Ladder beds	
Middle Ordovician	Schenectady beds Canajoharie shale Glens Falls limestone Amsterdam limestone	 Snake Hill shale Tackawasick limestone and shale Rysedorph conglomerate Magog shale
Lower Ordovician	....	Normanskill shale (Bald Mountain limestone)
Canadian	....	Deep Kill shale Schaghticoke shale
Lower Ozarkian	Little Falls dolomite Theresa formation Potsdam sandstone	
Lower Cambrian	....	Schodack shale and limestone Troy shales and limestones Diamond rock quartzite Bomoseen grit Nassau beds
Precambrian	Precambrian rocks	Precambrian rocks

On the Berne quadrangle the formations of the western trough begin with the Schenectady beds.

1 SCHENECTADY BEDS

The Schenectady beds received their name from typical exposures in the vicinity of Schenectady (Ruedemann, '12). They overlie the Canajoharie shale in the Capital District and are now known to be of upper Trenton age (Ruedemann, '12, '14, '30), though previously they were included in the "Hudson River" group and considered of Lorraine or Frankfort age, because of the identification at the time of the underlying black Canajoharie shales with the Utica shale and the fact that lithologically these beds are like the Lorraine beds. Ruedemann ('30, p. 33, 34) states as follows regarding the age of the Schenectady formation:

The Schenectady beds are overlain by the Indian Ladder beds. The latter are of younger than Utica (of Eden) age. Provided there is no hiatus between the Schenectady and the Indian Ladder beds corresponding to the Utica shale, it is to be inferred that the upper part at least of the Schenectady is of Utica age, although the fauna does not give any support to this view. Indeed, Doctor Raymond ('16) has suggested that the Schenectady beds are of Utica and probably also of Frankfort age. The fossil evidence, however, is in favor of the Trenton age of the formation and the Utica aspect of a portion of the fauna is undoubtedly due to the shaly facies. This evidence will be given later when the fauna is discussed. To this may be added that the Schenectady formation rapidly dwindles westward and that the Utica, as well as the Frankfort shales, do the same eastward in the upper Mohawk valley.

The Schenectady beds occur in the southwest corner of the Saratoga quadrangle and from there extend in a broad belt (six to eight miles wide in the Capital District along the western margin), between Schenectady and the Helderberg escarpment, reaching into the Schoharie valley (at Schoharie village). This formation has a thickness of at least 2000 feet and consists of grits and sandstones with interbedded black and gray argillaceous shales which form a monotonous, uniformly alternating series throughout the whole formation. The thickness of the formation, which has not been measured, is inferred from the width of the belt and the general dip (140 feet to the mile between Amsterdam and the Helderbergs, giving approximately 1700 feet thickness; Ruedemann, '12, p. 39). Ruedemann cites a well at Altamont in which the drill started 595 feet below the top of the Indian Ladder beds and passed through 2880 feet of sandstone and shales before reaching the Trenton limestone (*ref.*

cit., p. 38). Allowing 1200 feet at the base for the Canajoharie (Cumings, *ref. cit.* p. 466) and 300 feet for the Indian Ladder beds, which field work on the Berne sheet would indicate is more than generous, he thus has left a thickness of 1800 to 2000 feet for the Schenectady beds. The dips along the line Aqueduct (near Schenectady) to Schoharie, mostly southwest to west, amount to 1°–2° (frequently 5°, as at Aqueduct) indicating a thickness of more than 2000 feet (2681 feet with 1° dip). Continuous sections amounting to more than 1000 feet have been studied, as the one at Waterstreet Hill near Rotterdam west of the Capital District (Cumings, '00, p. 451–52).

The astonishing cause of the thickness of the Schenectady beds has been explained (Ruedemann, '12, p. 39; '30, p. 34) as due to deposition in a sinking basin in front of the rising Green Mountain folds to the east and the basin being rapidly filled with sediments. Sun-cracks or shrinkage cracks found in the thinner sandstones (as shown in the Bozen kill area), frequent layers of mud pebbles which occur mostly on top of the sandstone beds when the latter are followed by argillaceous shales, cross-bedding with plunge structure and also, among other features, a very rapid change in the thickness of the beds, all indicate shallow water origin for most of the shales and sandstones of the Schenectady beds. Ruedemann ('12, p. 41) expresses the following views regarding the causes of the structure of these beds:

The constant alternation of more or less coarse sandstone with shales is indicative of a frequent shifting of the conditions, presumably through currents, either reversal (tidal) or continuous currents. There is sometimes clear evidence of absolutely regular or rhythmic shifting. Such a place for instance was observed in an abandoned quarry on the Bozenkill between Altamont and Delanson. The base is here formed by a compact bed of sandstone some 15 feet thick. This sandstone is abruptly followed by dark argillaceous shale in which higher up thin sandstone layers appear, that become more frequent until another thick sandstone bed is formed, like the basal one. This in turn is cut off by a shale that gradually yields to sand. The whole cycle is in this place repeated three times, shales and sandstones being each of equal thickness, the whole indicating a most remarkable regularity of change of deposition which on account of the very shallow water character of the rocks of that locality may well have been a condition due to reversal or tide currents.

Conditions exactly duplicating those found in the Schenectady beds have been described by Sheldon ('28) in a paper on sedimentations in the Middle Portage rocks and are discussed by Ruedemann ('30, p. 35):

She finds that these Portage sandstones begin abruptly above the shale as a massive sandstone with scattered mud pebbles, that above this flat sedimentation prevails in the middle and minute cross-bedding and ripple marks at the top. This succession is the result of a regularly diminishing current, which in the first stage kept the sediments thoroughly churned, then in the middle produced distinguishable channels and finally diminished enough to produce ripples at the bottom. Sheldon sees the cause in fluctuations in the strength of the transporting waters. If fluctuations in the power of moving water alone is the cause, the alternations in the Schenectady beds would indicate gradually increasing currents from the shale to the sandstone.

The alternating shales and sandstones (called bluestones) of the Schenectady formation have been quarried for many years in various places, as about Schenectady and Aqueduct, about Duanesburg and near Delanson, largely for crushed stone. Two such quarries, now abandoned, are accessible along the Delaware and Hudson railroad tracks, about three miles northwest of Altamont (figure 13). Formerly considerable quarrying was carried on in the Schenectady beds for dimension stone. The sandstone used for building purposes is fine-grained and of a light gray or greenish gray or bluish color and weathers to a mellow yellowish tint. Some of these quarries are still active about Schenectady. The quarrying is made relatively easy by the even-bedded and well-marked jointed structure of the formation. This Schenectady bluestone has been used in the construction of many of the older buildings in the Capital District (*ref. cit.* p. 199–200; Smock, '90, p. 329), among them in Albany, St Peter's Protestant Episcopal Church, on State street; the Protestant Episcopal Church of the Holy Innocents, corner of North Pearl and Colonie streets; the Second Presbyterian Church on Chapel street; St Joseph's Roman Catholic Church, Ten Broeck street. In Schenectady the bluestone has been used in the East Avenue Presbyterian Church, in the new Armory and the Memorial Hall of Union University; in the church at Menand's station and at Watervliet in St Patrick's Roman Catholic Church.

Although the area of the Schenectady beds on the Berne quadrangle is fairly well covered with till, there are plenty of outcrops to be studied along roads, in railroad cuts and in stream beds. The soil covering is so thin in many places that new work on the roads exposes the rock in cuts along the road or at least in the ditches. Outcrops are fairly abundant along the roads north of West Township and south of Quaker Street. The best outcrops for the study of the Schenectady beds and the ones most accessible are those along the branches of the Black creek north (Cave gulf) and south (Indian Ladder gulf) of the old Indian Ladder road; along the road between Altamont and East Township, especially where it mounts the hill, and in the stream immediately southeast; along the Delaware and Hudson railroad tracks for about three miles northwest of Altamont and in the Bozen kill and its side branches (from west), also northwest of Altamont (figures 14, 17).

In the exposures in Indian Ladder and Cave gulfs the dark shales of the Upper Schenectady formation are seen and graptolites may be found here. Very heavy gray, coarse sandstone beds, 15 feet and more thick, are found in the upper part of the formation west of Altamont and are well exposed along the state road near the top of Altamont hill. *Sphenophycus latifolius* occurs abundantly in these beds, which are very even-grained. Shore markings such as big mud pebbles and mud flows are common. Beneath the heavy beds are thin-bedded gray shales and sandstones.

The remarkable alternation of sandstones and shales of the Bozen kill has already been described. In the upper (western) branches of this creek continuous outcrops are found extending through 200 to 300 feet of rock which consists prevailingly of bluish and greenish shales with several intercalations of sandstone beds sometimes reaching a thickness of 15 feet. These beds are nearly barren. A few fragments of eurypterids were found in the lowest part (Ruedemann, '12, p. 48) and a specimen of *Trocholites ammonius* loose in the stream bed.

About one mile northwest of Altamont where the road approaches the creek (near the junction with a branch road directly north) is an excellent section in which to study the succession of beds and the transition from shale to sandstone. There are about ten feet of shale. First the shales are thin; then sandstone bands appear, quarter and half-inch bands between the shales; then one, two and three-inch sandstone beds. This succession is repeated hundreds of times throughout the whole formation.

The cuts along the Delaware and Hudson railroad are particularly well worth study. The first cut (about two miles from Altamont) shows a section of 20 to 25 feet of rock displaying well the alternation of shales and sandstones. Even the thin beds thicken or thin in either direction and not any of them is continuous if traced out. The beds dip to the southwest, with an amount of 1° as in the Helderbergs. A mile north of this cut are another cut and two abandoned quarries. At the top in the cut is a ten-foot sandstone

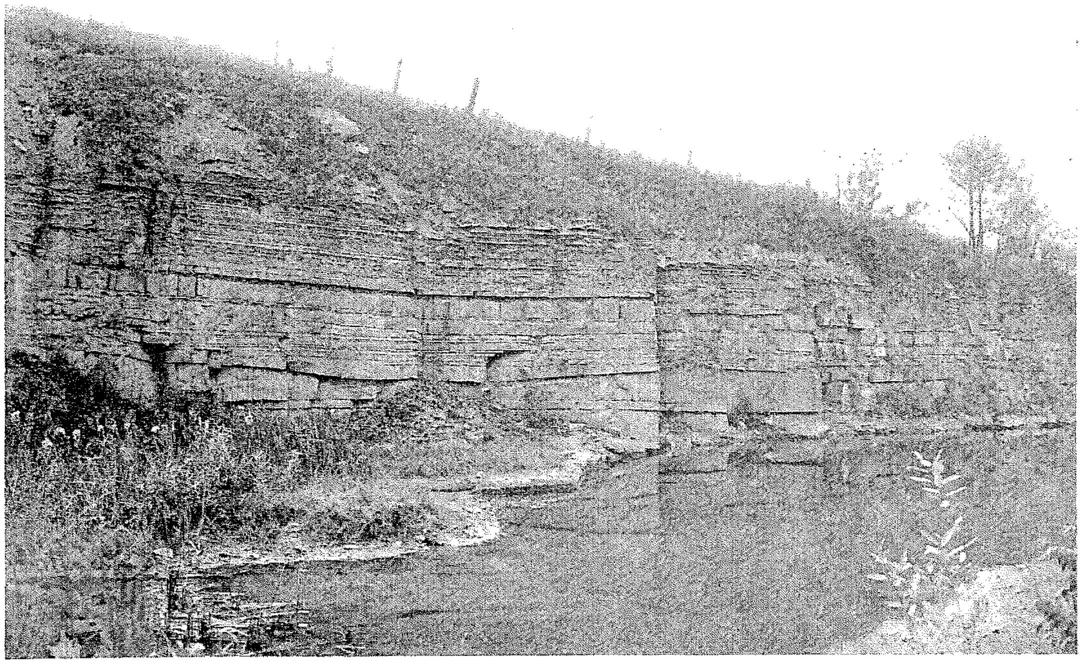


Figure 13 Quarry in Schenectady beds along the Delaware and Hudson railroad in the Bozen Kill valley. The pinching out of the heavy sandstone beds is very clearly shown here. (Photograph by E. J. Stein)

Figure 14 Schenectady beds along the Bozen kill, one and a quarter miles northwest of Altamont. The change from the shale into the heavy sandstone bed is clearly shown. (Photograph by E. J. Stein)

bed; below this three feet of shale and thin sandstone layers; then an 18-inch bed of sandstone with three or four-inch shale seam interbedded; below, shale and thin sandstone layers. Clay balls, formed during deposition by the sand coming in and overwhelming the mud, are seen in the bottom of the heavy sandstone beds. The old quarry at the right (east) shows only the upper heavy bed (10 to 15 feet). The 15-foot heavy sandstone layer below the level of the quarry forms a fall in the near-by stream. Two sandstone beds of less thickness form falls farther down. All the side streams of the Bozen kill are typical hanging valleys, because the Bozen kill has eroded its valley more rapidly. The quarry at the left (west) is now filled with water but a good section remains. Here the action of shifting currents, resulting in the pinching out of beds in either direction is beautifully shown.

About an eighth of a mile beyond this quarry another hanging valley joins the main stream. A splendid section is found here, especially well shown at the junction with the main creek. At the top of the section is a ten-foot sandstone bed, then in descending order, 30 feet of shale with one to two-foot sandstone beds; five feet of sandstone; eight feet of sandstone with thin shale partings; four feet of sandstone; 15 feet of shale with half foot beds of sandstone; ten feet of solid shale; 30 feet of sandstone with thin shale partings which thicken in lower ten feet; below this in stream bed (below junction of small side stream) four feet of shale and then heavy sandstone in the creek bottom.

Other sections in these tributary hanging valleys may be obtained by following the road beyond (northwest of) the first railroad cut. These tributary streams reach the level of the main stream by one fall or a series of falls and it is possible to climb down from the road to the foot of the falls and study the sections.

The combined faunal list (see figure 15) of the Schenectady formation (Ruedemann, '12, p. 48; '30, p. 35) consists of:

Plants

Sphenophycus latifolius (*Hall*)

Graptolites

Corynoides *sp. Rued.* MSS.
Dictyonema multiramosum *Rued.*
Azygograptus *sp. nov.*
Mastigograptus *sp. nov. cf.* simplex *Walcott*
M. *sp. nov.*
Diplograptus vespertinus *Rued.*
Climacograptus spinifer *Rued.*
C. typicalis *Hall*
Lasiograptus (Thysanograptus) eucharis (*Hall*)

Pelecypods

Saffordia ulrichi *Rued.*

Gastropods

Cyrtolites *cf.* ornatus *Conrad*

Conularids

Conularia trentonensis *Hall var.* multicosta *Rued.*

Cephalopods

Cyrtoceras *sp. nov.*
Spyroceras bilineatum (*Hall*)
Trocholites ammonius *Conrad*

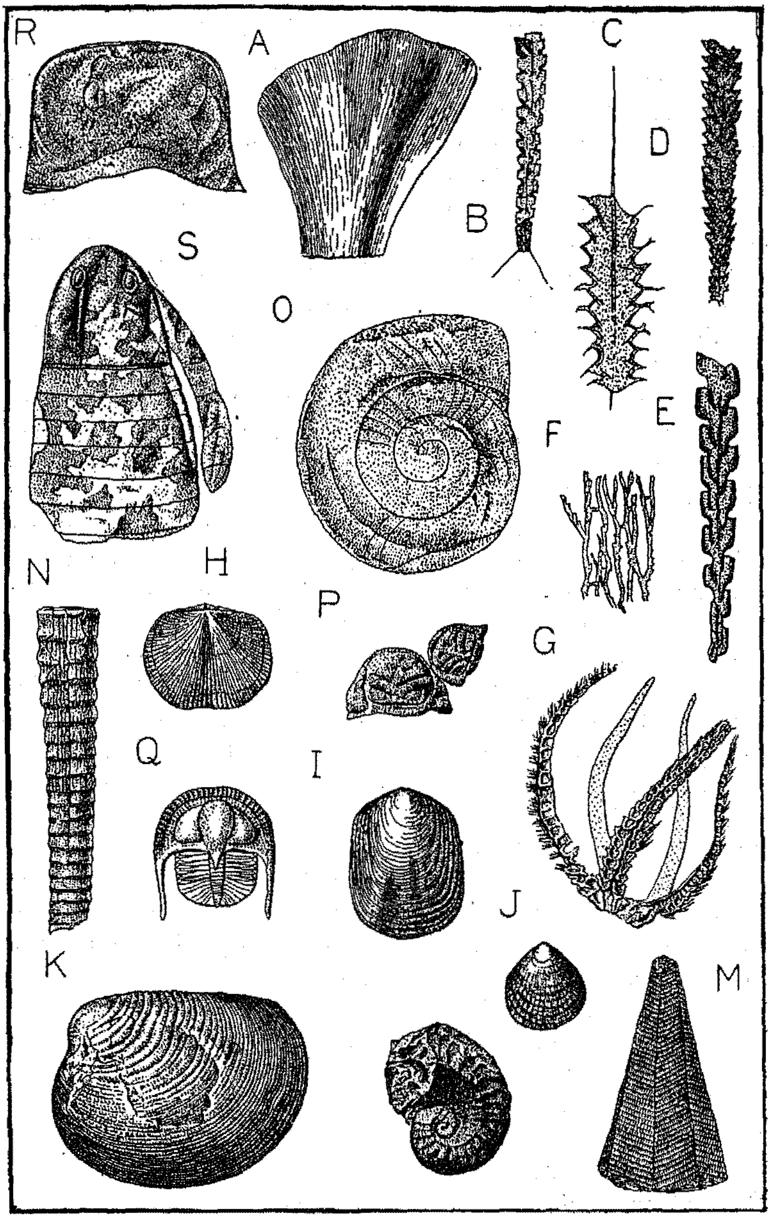


Figure 15 Schenectady beds fossils. (Seaweed, *A;* graptolites, *B-F;* brittle star, *G;* brachiopods, *H-J;* pelecypod, *K;* gastropod, *L;* conularid, *M;* cephalopods, *N, O;* trilobites, *P, Q;* eurypterids, *R, S*). *A Sphenophycus latifolius,* x ¾. *B Climacograptus spinifer,* x 2½. *C Lasiograptus (Thysanograptus) eucharis,* x 5. *D Diplograptus vespertinus,* x 2½. *E Climacograptus typicalis,* x 7. *F Dictyonema multiramosum,* x 2½. *G Taeniaster schohariae,* x 2½. *H Dalmanella rogata,* x ¾. *I Lingula rectilateralis,* x ¾. *J Leptobolus insignis. K Saffordia ulrichi,* x 2½. *L Cyrtolites ornatus,* x ¾. *M Conularia trentonensis,* x ¾. *N Spyroceras trilineatum,* x ½. *O Trocholites ammonius,* x ½. *P Triarthrus becki. Q Cryptolithus tessellatus. R Eurypterus pristinus,* x 1½. *S Hughmilleria magna,* x ¾.

Crinoids
Stem joints

Starfish (Brittle stars)
Taeniaster schohariae *Rued.*

Worms
Serpulites *sp.*

Brachiopods
Lingula (Pseudolingula) rectilateralis *Emmons mut.* major *Rued.*
Lingulasma elongatum *Rued.* ('16, p. 70)
Leptobolus insignis *Hall*
Dalmanella rogata *Sardeson*
Rafinesquina ulrichi *James*
Plectorthis plicatella *Hall*
Orbiculoidea *sp.*

Trilobites
Triarthrus becki (*Green*)
Isotelus gigas *Dekay*
Cryptolithus tessellatus *Green*

Ostracods
Primitia *sp.*
Eurychilina *cf.* subrotunda *Ulrich*

Eurypterids
Eurypterus pristinus *Clarke* and *Rued.*
E. megalops *C.* & *R.*
E.? (Dolichopterus?) stellatus *C.* & *R.*
E.? longiceps *C.* & *R.*
Dolichopterus frankfortensis *C.* & *R.*
D. latifrons *C.* & *R.*
Hughmilleria magna *C.* & *R.*
Pterygotus nasutus *C.* & *R.*
Stylonurus? limbatus *C.* & *R.*

Ruedemann ('30, p. 36) comments upon the fauna thus:

> This fauna contains, on one hand, elements of the Utica fauna, on the other, Trenton biota, and finally a large element of its own. The Utica elements are for the most part forms connected with the shaly facies and therefore already appearing in the Canajoharie shale. Such are *Climacograptus typicalis, Lasiograptus eucharis, Leptobolus insignis.* The forms pointing to the Trenton age are *Conularia trentonensis, Spyroceras bilineatum, Triarthrus becki* (the Utica form being *T. eatoni*), *Cryptolithus tessellatus.* The species apparently restricted to the Schenectady beds are: *Sphenophycus latifolius, Dictyonema multiramosum, Taeniaster schohariae, Saffordia ulrichi* and especially the eurypterids.

The fact that the Schenectady shales and sandstones are often densely filled with remains of the peculiar seaweed *Sphenophycus latifolius* agrees well with the evidence of shallow water or shore origin for these beds. This seaweed is considered the most reliable index fossil of the formation. It is found in the highest of the Schenectady beds above Altamont.

Only a single specimen of the brittle star (*ref. cit.* p. 37) was found below the village of Schoharie.

The eurypterids, regarded as the most striking element of the Schenectady fauna, constitute the largest Ordovician eurypterid fauna yet known (*ref. cit.*), and until Ruedemann's discovery of this fauna a few fragments from the Cincinnati region, formerly described as graptolites, and Walcott's *Echinognathus* (Utica fragment) were the only eurypterids known. The quarry (Deltbarn quarry) in which the eurypterids were found, and which was the principal eurypterid locality (situated on the outskirts of Schenectady between Van Vranken avenue and the river), has been filled in and the district built over. Ruedemann states that he found the eurypterids in the shales between the sandstone (bluestone) banks and with them a fauna of graptolites, trilobites and other fossils. Other localities listed by him, where were found smaller collections of eurypterids less favorably preserved, are the bluestone quarries about Duanesburg and near Delanson and on Waterstreet hill near Rotterdam junction. He considers it probable that the seaweed *Sphenophycus,* the eurypterids and the graptolites also are well distributed throughout the whole formation (*ref. cit.*)

In concluding his discussion (*ref. cit.*) of the Schenectady beds Ruedemann sums up as follows:

It is quite apparent that the hundred-fold repetition of sandstone or grit beds and shale together with the eurypterids, seaweeds and scattered graptolites and other marine fossils indicate conditions of deposition different from those usually found. We have already seen that the beds were laid down in a basin or trough extending north-south or more correctly north-northeast to south-southwest in the direction of the later Green mountain folding, and that this basin was rapidly sinking. The writer sees in the lithic and faunal conditions evidence of currents that brought in the material probably from the northeast; in times when they were very strong the sandstones were deposited; when they were weak the shales were formed, the black shales with the graptolites indicating the times of least motion of the water. Others would consider these beds as the result of rapidly changing depth of water and the moving up or down of the shore line, and still others see in them delta deposits.

2 INDIAN LADDER BEDS

This formation is typically exposed in the Black Creek ravine, Indian Ladder gulf, hence the name (Ruedemann, '12). These beds extend from there, rapidly thinning below the Helderberg escarpment, to the north and to the south. They disappear a short distance south of the village of New Salem on the south, but they can still be recognized in the ravine above the village. To the north only a few feet are found after crossing the Altamont-Knox state road, and within two and a half miles to the west no indications of the beds are found (figures 12, 16). They are well exposed below Hailes' cavern in Cave gulf to the north of the old Indian Ladder road. This locality, the type section (figures 1, 18) and a third exposure near the fault about a mile southeast of the Indian Ladder together give a fairly complete section of the Indian Ladder beds.

With the discovery of a fauna in the Black Creek ravine this formation was separated from the Schenectady beds. The fauna was found to be younger than Utica age, corresponding to that of

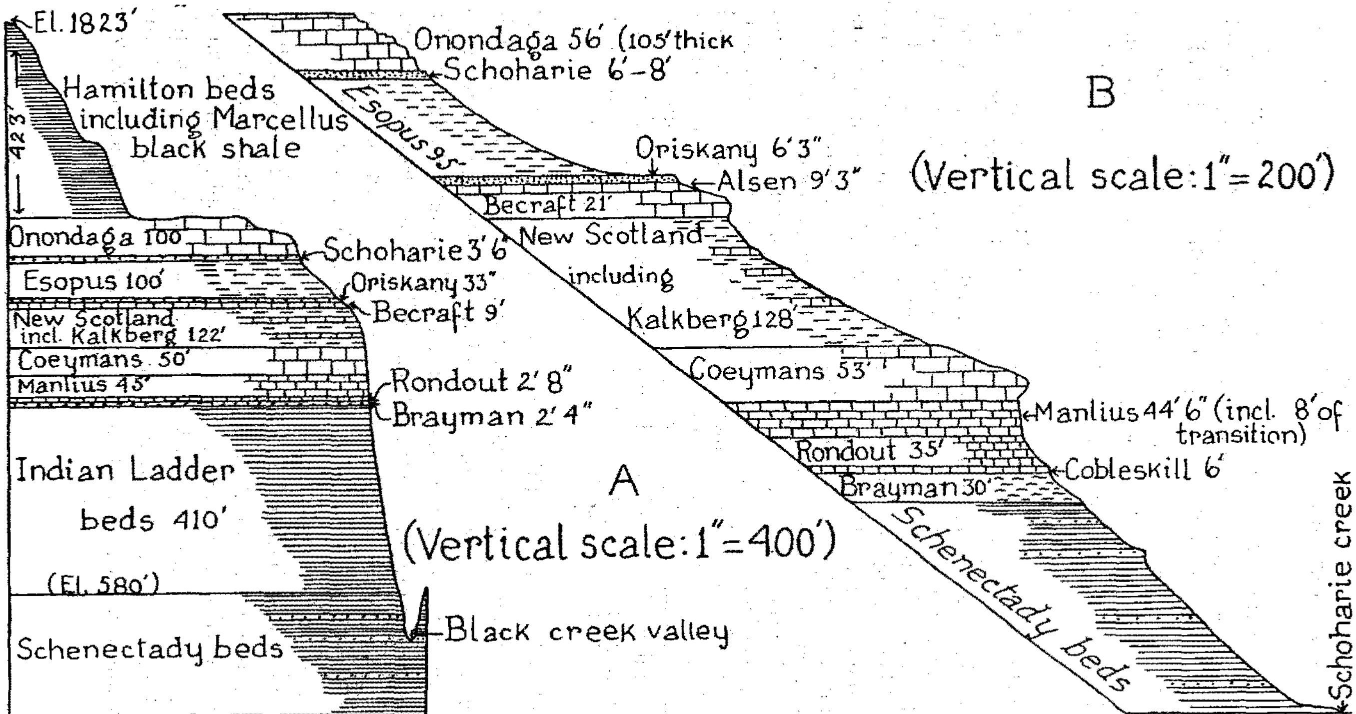


Figure 16 *A* Section from Indian Ladder gulf directly south to sunset hill (near Camp Pinnacle). Horizontal scale: 1 inch to 1 mile. *B* Section of West hill in the Schoharie valley (modified after Grabau, 1906). See figure 2.

the Southgate member of the Eden shale about Cincinnati and in age to the Frankfort shale of central New York (Ruedemann, '12, '30).

The type section and also the best section of the Indian Ladder beds is along the upper left branch of Black creek, forming the fall and deep ravine in Indian Ladder gulf, south of the old Indian Ladder road (figure 19). This section may be reached from the John Boyd Thacher Park or from the Voorheesville-Altamont state road. The section is described as follows (*ref. cit.* '12, p. 50; '30, p. 38):

The section comprises about 410 feet (aneroid measurement), of which the lowest 100 feet are dark gray to black argillaceous shales with two thick sandstone bands (each about four feet), while the next 100 feet are of a character not met with in the Schenectady beds. They consist of rapidly alternating gray shales and thin yellow rusty-looking, somewhat calcareous sandstone layers, one-half to one inch or more thick. The uppermost part of this portion becomes quite sandy. Nearly 100 feet are there covered, while some 120 feet at the top consist of prevailingly heavy sandstone beds with intercalated dark arenaceous and argillaceous shales, and an occasional thin limestone band. The top is formed by a white hard sandstone bank three and one-half feet thick and consisting largely of rounded sand grains. This is separated by shale, one layer of which consists of pyrite, from an underlying gray sandstone bed, also composed of rounded grains. The sandstone beds of this upper part of the formation are extremely irregular courses; in one case a bed was seen to run out within ten feet from four feet to one-half a foot.

The dip of the beds in this section is rapid to the southwest and is about the same as the beds above and below. All the heavy sandstone beds show plunge structure, which with the mud flows seen on the sandstone slabs and the characteristic mud pebbles in the sandstone indicate rapid current action. Where fine black fissile mud shales alternate with sandstone layers a change in the character of the current is indicated or a difference in elevation, since the shales are deposited in deeper water.

The uppermost Indian Ladder beds are exposed in an excellent section in a ravine about a mile southeast of the Indian Ladder near the fault (marked by a scar in the cliff due to dropping out of large block of the limestone). Here is a complete exposure of upper Indian Ladder beds, Brayman shale, Rondout waterlime and the Manlius and Coeymans limestones. At the top of the Indian Ladder

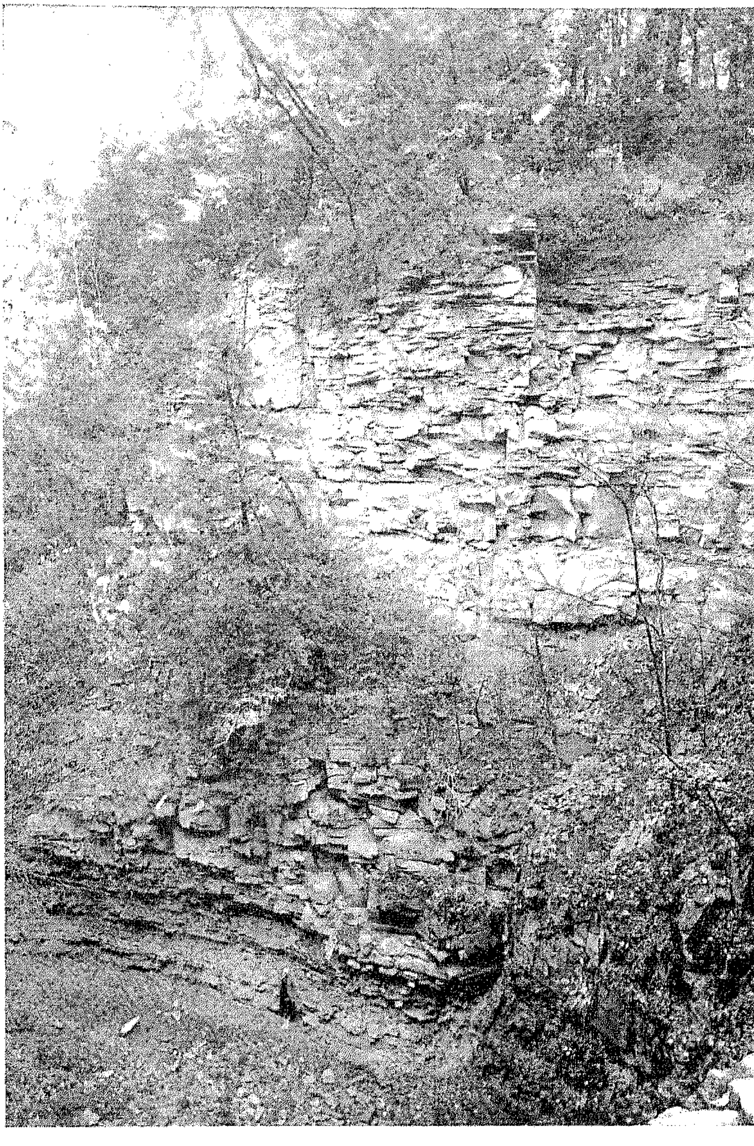


Figure 17 Schenectady beds near one of the hanging valleys joining the Bozen kill from the west, showing the gradation from shales through thin-bedded sandstones to heavy sandstone beds. (Photograph by E. J. Stein)

Figure 18 Near view of the Indian Ladder beds showing the heavy sandstone beds at the base of the section and the interbedded thin calcareous sandstone bands in the shales above. (Photograph by E. J. Stein)

beds just beneath the Brayman shale is a seven-foot sandstone bed; below this are 20 feet of alternating dark, fine shales and thin beds of sandstone with the shales increasing downward; then a ten-foot bed of solid sandstone, beneath which is a considerable thickness of dark gray shale. This section, which is just over the southern boundary of the Berne quadrangle, is well worth study.

In the ravine at Hailes' cavern (Cave gulf) the Indian Ladder beds are covered down to 70 feet below the base of the Manlius, that is, at least 65 feet below the top of the formation, which means that this section probably follows very closely beneath the one described above. In descending order are exposed five-foot, two-foot and three-foot heavy sandstone beds; five feet of alternating sandstones and shales; 30 feet of black shales with yellowish sandy layers; ten-foot heavy sandstone bed; three and one-half feet of dark shale; one-foot and five-foot sandstone beds; 11 inches of thin shale and sandstone beds; ten inches of thin-bedded sandstone; one-foot heavy sandstone bed; two feet four inches of thin sandstone beds and shales; three feet of black shales. Below this are about 200 feet of talus. Exposures of the upper Schenectady and lower Indian Ladder beds are also found in the lower part of this ravine, best reached from the Altamont state road. In this section the lower 100 feet of black shales are exposed and above this 45 feet of the rapidly alternating gray shales and calcareous sandstone layers followed by heavy talus (figure 20). Aneroid measurements give 40 to 50 more feet of this formation in the Cave gulf than in Indian Ladder gulf.

The Indian Ladder beds are on the whole extremely barren. The majority of the fossils have been found in the exposures at the foot of the old Indian Ladder road (Walcott, '90, p. 345) and, particularly, in the section in the Black creek ravine, Indian Ladder gulf (Ruedemann, '12, p. 51; '30, p. 39). Very careful searching discovered in the lower 100 feet of shales a small graptolite faunule, and the thin calcareous sandstone beds of the second hundred feet have yielded a second faunule (figure 21).

The fossils furnished by the shale (*ref. cit.*) are:

Graptolites

Dictyonema arbusculum *Ulrich.*
Diplograptus *cf.* nexus *Rued.*
Dicranograptus nicholsoni *Hopkinson.*

The fauna of the calcareous shale, determined by E. O. Ulrich, (*ref. cit.*) comprises:

Cystoids
Calyx plates and columnals of cystoid allied to Cheirocrinus

Crinoids
Crinoid columnals (Heterocrinus)

Machaeridians
Lepidocoleus jamesi *H. & W.*

Bryozoans
Hallopora onealli (James) *Ulrich*
Arthrostylus tenuis *Ulrich*

Bryozoans (continued)
Helopora *sp. nov.*
Rhinidictya *cf.* parallela (*James*)

Brachiopods
Rafinesquina ulrichi (*James*)
Plectambonites centricarinatus *Rued.*
P. plicatellus (*Ulrich*)
Dalmanella multisecta (*Meek*)

Trilobites
Cryptolithus bellulus (*Ulrich*)
Acidaspis crossota *Locke*
Calymene *sp.*

Ruedemann also lists in his earlier paper ('12, p. 51) the pteropod *Tentaculites* cf. *flexuosus* Hall; the ostracod *Ceratopsis chambersi* (Miller), typical; and the trilobites *Ceraurus pleurexanthemus* Hall (fragments) and *Dalmanites* (*Pterygometopus*) sp. (small cranidia).

Southeast of the Indian Ladder area the Indian Ladder beds have been described from only two places, the Countryman Hill section and another locality south of New Salem (Prosser & Rowe, '97, p. 334, 338; Ruedemann, '30, p. 39). In the New Salem section 80 feet of gray and black, partly sandy beds (which may be Schenectady or Indian Ladder beds) have been observed in the ravines leading from the village to the state road above, and 15 feet of the characteristic, yellowish- weathering, calcareous sandstone intercalations are exposed 30 feet below the base of the Manlius, with blocks of the heavy top sandstones in little disturbed position farther up. Ruedeman years ago found in the shales of this locality two species of graptolites, *Dicranograptus nicholsoni* and *Climacograptus typicalis* var. In the outcrop about half a mile to the east the contact between the Ordovician shales and the overlying beds is shown. These dark blue to olive-tinted argillaceous shales just under the cliff have furnished no fossils and Ruedemann (*ref. cit.*) regards them as lithologically noncommittal.

Westward, between Altamont and Schoharie the uppermost part of the Ordovician is nearly everywhere buried under drift. The occurrence of orange-colored limestone has been recorded in a road ditch halfway between East and West Township, ten feet below a ledge of Manlius limestone (*auth. cit.*, '12, p. 53). The writer has been unable to locate any outcrop of Indian Ladder beds on the Berne quadrangle more than about two and a half miles west of Altamont. In a small ravine on the north side of the state road to Knox, one

Figure 19 The old Indian Ladder road that leads up over the Indian Ladder beds where the Indian trail once passed. (Photograph by E. J. Stein)

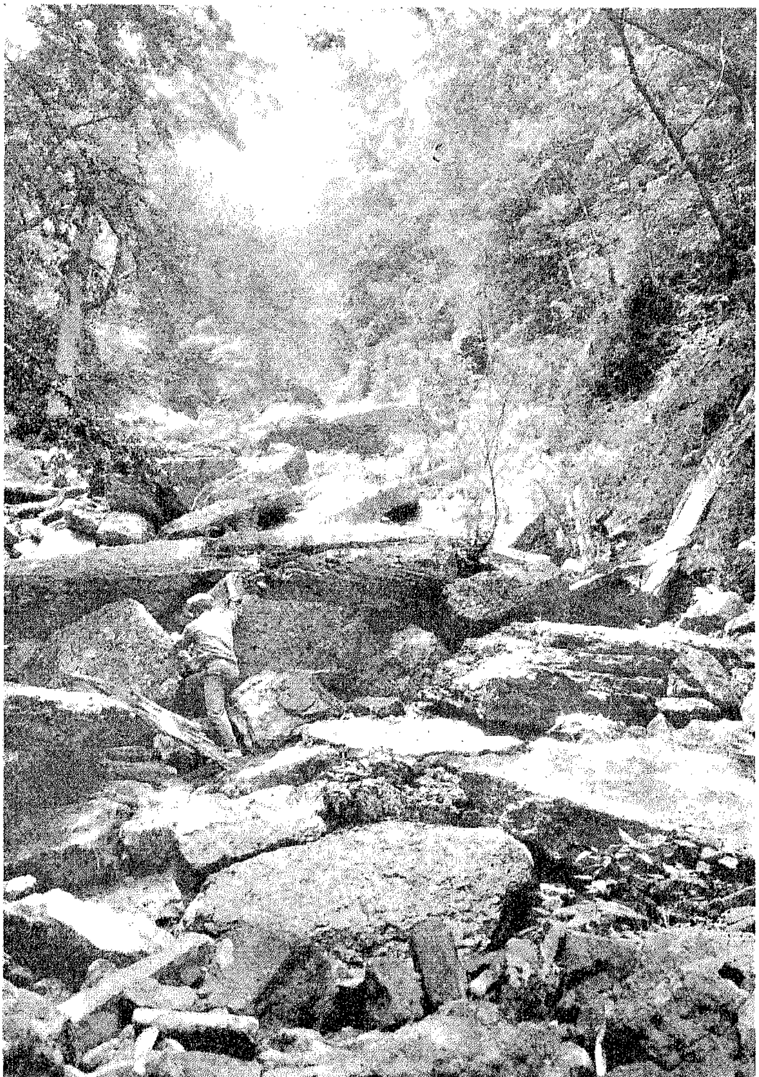


Figure 20 The lower part of the ravine below Hailes' cavern, Cave gulf. A talus of numerous huge blocks of rock, largely Coeymans from the cliff above, is found here, making climbing difficult and in places completely hiding the Indian Ladder beds. (Photograph by E. J. Stein)

quarter of a mile from the junction with the Thompsons Lake road, a few feet of calcareous sandstone were observed which may represent the Indian Ladder beds. A short distance beyond the top of the Altamont hill a road turns south past the High Point Cemetery. Along this road Schenectady sandstone with *Sphenophycus latifolius*

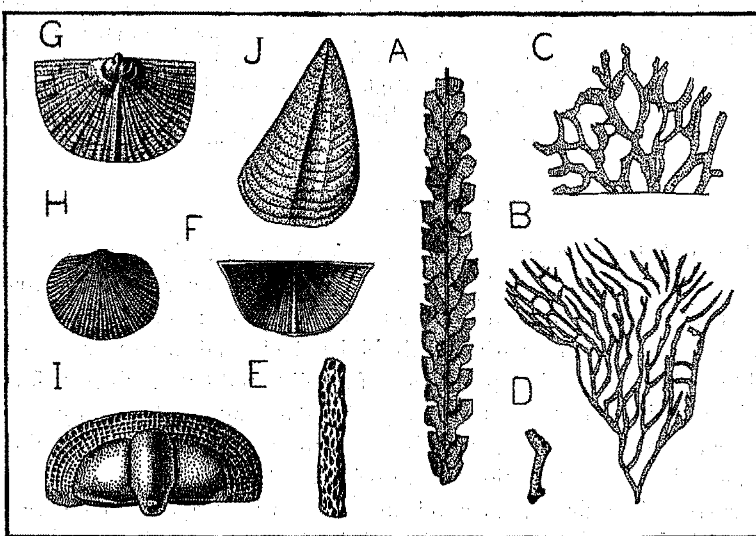


Figure 21 Indian Ladder beds fossils. (Graptolites, *A-C;* bryozoan, *D, E;* brachiopods, *F-H;* trilobite, *I;* echinoderm, *J*). *A Dicranograptus nicholsoni*, x 5. *B, C Dictyonema arbusculum*, x 2½, with enlargement, x 5. *D, E Hallopora onealli*, x 2, with enlargement, x 4½. *F Plectambonites centricarinatus*, x 4. *G Rafinesquina ulrichi*, x 5. *H Dalmanella multisecta*. *I Cryptolithus bellulus*, x 2. *J Lepidocoleus jamesi*, plate x 7½.

was found 160 to 165 feet (aneroid measurement) below the base of the Manlius limestone. Near the cliff and about 35 feet below the base of the Manlius, sandstone, apparently Schenectady, occurs in the ditch. Twenty-two inches of yellowish calcareous sandstone are exposed in the ditch five feet above, and may belong to the Indian Ladder beds. The thickness of the Indian Ladder beds here, therefore, allowing for some Rondout waterlime and Brayman shale, can not be greater than 160 feet, and the possibility is that there are no more than 30 or 35 feet of this formation.

Ruedemann (*ref. cit.* p. 40) concludes his treatment of the Indian Ladder beds with the following discussion of their origin and age:

The Indian Ladder beds with their restricted horizontal distribution, east and west, in spite of the great thickness that they attain at the Indian Ladder, represent a puzzling formation, especially since their fauna is nowhere else represented in eastern New York. It is, however, of the same age as that of the Moose Creek member of the Whetstone Gulf formation of central New York, corresponding to the Southgate member of the Eden formation (Upper Ordovician) of Ohio. It is to be inferred from the distribution of the rocks and the character of the fauna that the Indian Ladder beds represent an independent advance of the Eden sea from the south northward in one of the long troughs developing in the Appalachian region. In Pennsylvania the Martinsburg shale represents in part the Eden formation and it is probable that this isolated occurrence of a formation, younger than Utica, has there its derivation.

3 BRAYMAN SHALE

These shales were named (Grabau, '06) from their occurrence at Braymansville in Schoharie county. At the type locality this formation reaches a thickness of 40 feet and consists of olive or grayish clay shales often alternating with bluish beds and weathering to a lighter color, having the appearance of a solid mud bank. Concretions of iron pyrites of all sizes are very abundant, although usually they are not larger than a man's fist. Oxidation of the iron pyrites changes the exposed portions to an ochery color and commonly stains the surrounding shales. A good outcrop of the Brayman shale, very accessible for study, occurs on the left bank of the Schoharie creek, a short distance above the Fair street (Gebhard) bridge on the old Gebhard farm (now owned by R. Veenfliet). Here the Brayman shale is seen in several excavations made in search of ore, overlying the Schenectady beds and overlain by the Cobleskill limestone.

The Brayman shale as observed on the Berne sheet is not typical and it is exposed in only a few places. In the Indian Ladder region at the foot of the waterfalls of Outlet and Minelot creeks (Indian Ladder gulf) the seven-foot bed of sandstone at the top of the Indian Ladder beds is overlain by two feet four inches of greenish rock, sandstone to coarse arenaceous shale, in which iron pyrites is very abundant (figures 12, 16). The rock is soft and rots away easily, hence the scarcity of outcrops. The best exposure in this area is found at the base of the cliff just over the edge of the Berne quadrangle in the small ravine near the fault line, about one mile southeast of the Indian Ladder. Here the two feet four inches of pyritiferous Brayman shale is seen to be separated from the underlying heavy sandstone of the Indian Ladder beds, by a disconformity plane full of pyrite. The disconformity between the Brayman shale and the overlying Rondout waterlime is well shown here and also at Minelot falls. Farther to the southeast on the Albany quadrangle this shale, exposed in a glen one-half mile south of New Salem, has dwindled to ten inches. Still farther to the south in the Feura Bush (South Albany) stone quarry (Callanan Road Improvement Company) occurs a thickness of nine feet of shale charged with an abundance of iron pyrites and giving the same analysis (R. Jones, 1930) as the Brayman shale in the Schoharie area. Some consider it possible that this shale represents the Brayman shale; others continue to regard it as Rondout waterlime as formerly.

In the northern portion of the Berne quadrangle the Brayman shale has been found exposed only near Gallupville, five miles east of Schoharie. Farther to the east this formation is very likely slightly overlapped by the Cobleskill limestone. The exposure at Gallupville was found on the west side of the first road to the right west of Gallupville, about a third of a mile from the main road, at the second bridge. C. A. Hartnagel has told the writer that there should be about 17 feet of Brayman shale here and at the most no more than 22 feet, (27 feet in Schoharie area). The exposure was studied by Hartnagel and H. L. Alling some years ago when the exposure was fresh. A landslide has since covered these shales leaving a gap of 25 feet between the exposed base of the Cobleskill limestone and the Schenectady beds below. By digging into the débris just below the Cobleskill some Brayman shale was exposed.

No fossils have yet been found in the Brayman shale, and its age therefore has remained uncertain. When first described (Prosser and Rowe, '99) from the New Salem and Indian Ladder region it was thought that these shales possibly represented the attenuated Clinton formation. It has been considered of Salina age (Upper Silurian) by Hartnagel, Clarke, Alling ('28, p. 97–102) and others. Grabau ('06, p. 104) regarded it as "probably the partial equivalent of the lower cement bed of Rosendale" (Salina beds of western New York). Moreover he argues that the Brayman shale by its lithic character and the nature of the contact is more sharply set off from the overlying beds than the sandstones below, and he would draw the boundary between the Ordovician and Silurian somewhere below in the sandstone beds, considering "the sandstone beds immediately in contact with the Brayman shales as the equivalent of the Binnewater sandstones (*ref. cit.*, p. 127)". Ulrich and Ruedemann independently arrived at the conclusion that these shales probably represented a residual bed or soil of the Ordovician formed during an erosion interval and representing the hiatus between the Indian Ladder or Schenectady beds (Upper or Middle Ordovician) and the Cobleskill limestone or Rondout waterlime (Upper Silurian) above. "This conclusion is based in part on the character of the shale and in part on its overlapping of various Ordovician formations (Frankfort shales in west, Schenectady beds in the Schoharie region, Indian Ladder beds farther east). The Brayman shale is therefore not directly attachable to any of the Ordovician formations, but independent of them (Ruedemann, '30, p. 41)."

4 COBLESKILL LIMESTONE

This limestone, resting immediately upon the Brayman shale in the Schoharie valley, was named (Clarke, '02; Hartnagel, '03) from its exposure on the Cobleskill, Schoharie county. Before this it was known as the "Coralline limestone" from its great abundance of corals, a name given by John Gebhard, who began to study the formations of the Schoharie region early in the nineteenth century. The Cobleskill limestone has been thoroughly studied by C. A. Hartnagel (*ref. cit.*). It is a typical coral facies and, while it does not show the reef character, it has the reef species. It is a heavy bedded, semicrystalline, fossiliferous limestone. Some parts of it consist largely of fragments of shells, crinoids and corals; other parts are more muddy and consist largely of impalpable waterlimes. The formation on the whole is thin, having its greatest thickness of 7 to 30 feet in east-central New York and a thickness of five to eight feet in western New York (figures 12, 16). To the dolomitic phase, "Bullhead limestone," in Erie county, which Hartnagel regards as a little later faunal development than the Cobleskill, the name "Akron dolomite" (Scherzer and Grabau, '09) has been given.

On the Berne quadrangle the easternmost outcrop of the Cobleskill has been found by the writer about one mile east of West Township, forming a ledge in the field on the south side of the highway. The outcrop here is between four and five feet thick and shows the characteristic Stromatoporas. Just north of Gallupville, in the section along the stream, discussed in connection with the Brayman shale, seven feet three inches of typical Cobleskill are exposed. The jointing of this limestone which causes the rock to split into long narrow blocks, often of less width than thickness, is shown here. At the base of the Cobleskill are here seen 15 to 18 inches of waterlime, which Hartnagel suggests (in conversation, 1930) may represent the Bertie waterlime. A graptolite regarded by Ruedemann as a form of *Palaeodictyota*, near *Palaeodictyota clintonensis* Ruedemann, has been found in these beds at Saltspringville, five miles from Cherry Valley in Otsego county (Alling, '28, p. 35, 36). Another outcrop of the Cobleskill on the Berne sheet is found about three and a half miles to the northwest of the above occurrence. This outcrop of between four and five feet is quite accessible, occurring in the road and on the hill slope to the east, about three-quarters of a mile south of the state road through Quaker Street (to west) and half a mile from the western boundary of the quadrangle.

For good fossil collecting in this formation it will be necessary to go somewhat farther to the west. At Shutter Corners, about a mile and a half west of Gallupville, just outside the area of the Berne quadrangle, the Cobleskill with a thickness of perhaps 15 to 20 feet (Hartnagel) forms a ledge low in the hills at the south. Its coral reef character is shown here in the uneven, hummocky surface and it is very fossiliferous. Hartnagel collected more than 30 species here. Another exposure, not too far from the Berne area, accessible and affording fossil collecting, is found a short distance south of the Gebhard (Fair street) bridge at the old pyrite mine. Here the Cobleskill is well shown, capping the Brayman shale and displaying a marked jointing.

Twenty-five species of fossils were described by Hall (1852, p. 321–38) and considered as a Niagaran fauna. The post-Salina age of the Cobleskill has long been established (Hartnagel, '03) and the list of fossils considerably increased (60 species for Schoharie county). The Cobleskill is characterized by a peculiar gastropod and cephalopod fauna (*ref. cit.* p. 1109). Among the characteristic fossils (figure 22) of the Cobleskill are the corals *Halysites catenulatus, Favosites helderbergiae* var. *precedens, Diplophyllum coralliferum* and the cup coral *Enterolasma caliculum,* and species of *Stromatopora* (hydrocorallines). The coral *Cyathophyllum hydraulicum* and the brachiopod *Spirifer eriensis* are the distinctive fossils of the Akron phase. In the Schoharie area and westward the pelecypod *Ilionia sinuata* is characteristic and the presence of the trilobite *Lichas* (*Corydocephalus*) *ptyonurus* always identifies the Cobleskill.

Hartnagel states that on the Stevens farm south of Shutter Corners and three miles east of Schoharie, where the formation is partly exposed for some distance, he has found the best collecting ground

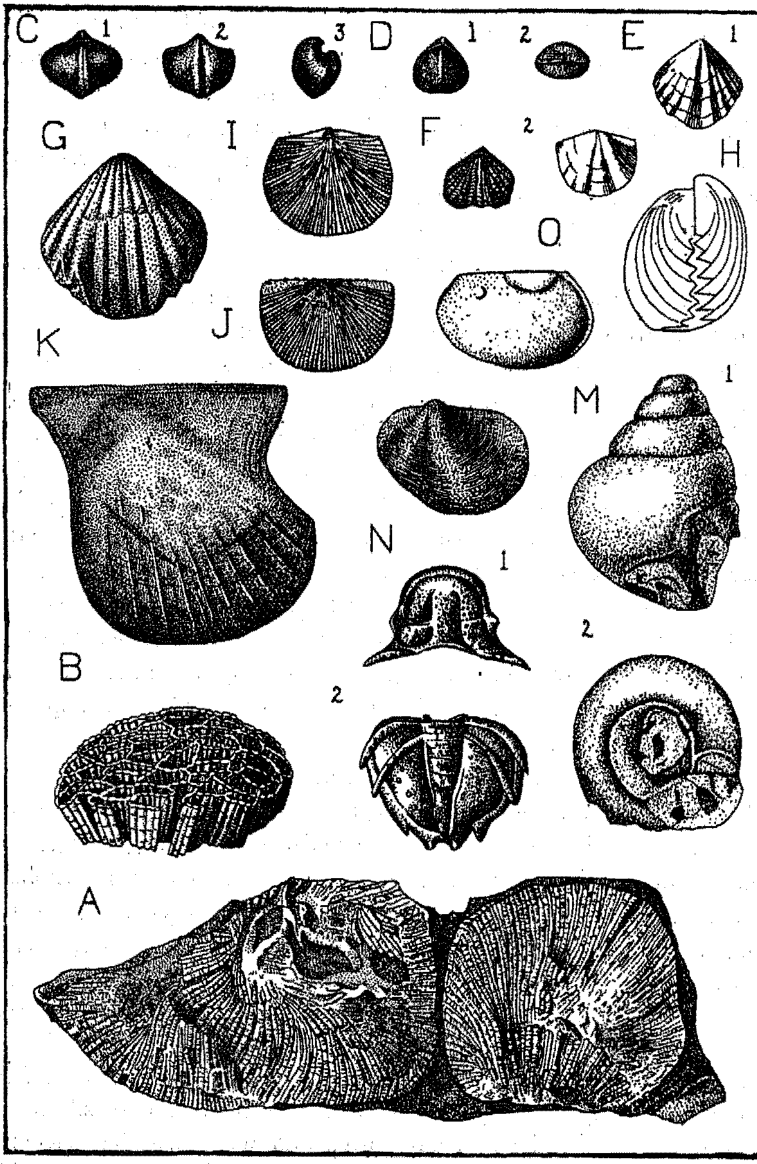


Figure 22 Cobleskill limestone fossils. (Corals, *A*, *B*; brachiopods, *C-J*; pelecypods, *K*, *L*; cephalopod, *M*; trilobite, *N*; ostracod, *O*). *A Favosites helderbergiae* var. *precedens*, x ½. *B Halysites catenulatus*, x ½. *C 1, 2, 3 Spirifer corallinensis*. *D 1, 2 Whitfieldella nucleolata*. *E 1, 2 Spirifer eriensis*. *F Camarotoechia lamellata*. *G, H C. litchfieldensis*. *I Schuchertella interstriata*, x ¾. *J Chonetes jerseyensis*. *K Pterinea securiformis*, x ¾. *L Ilionia sinuata*, x ¾. *M 1, 2 Trochoceras (Mitroceras) gebhardi*, x ⅜. *N 1, 2 Lichas (Dicranogmus) ptyonurus*, x 2. *O Leperditia scalaris*, x 2.

for Cobleskill fossils yet observed. The following species are listed (*ref. cit.* p. 1117, 1118):

Corals

Acervularia (?) inaequalis *Hall*
Favosites helderbergiae *var.* precedens *Schuchert*
Enterolasma caliculum *Hall*
Stromatopora concentrica *Hall*
S. constellata *Hall*

Brachiopods

Atrypa reticularis *Linné*
Camarotoechia neglecta *Hall*
Chonetes jerseyensis *Weller*
Orthothetes (Schuchertella) interstriatus *Hall*
Rhynchonella (?) lamellata *Hall*
R. pisum *Hall & Whit.*
Spirifer crispus *var.* corallinensis *Grabau*
S. eriensis *Grabau*
Stropheodonta bipartita *Hall*
S. textilis *Hall*
Whitfieldella nucleolata *Hall*
Ilionia *cf.* canadensis *Billings*
I. galtensis *Whiteaves*
I. sinuata *Hall*
Mytilarca *sp.*
Pterinea securiformis *Hall*
P. subplana *Hall*
P. *cf.* subrecta *Hall*
Tellinomya equilatera *Hall*

Gastropods

Bellerophon (*large sp.*)
Bucania *sp.*
Murchisonia (?) terebralis *Hall*
M. *sp.*
Pleurotomaria *sp.*
Poleumita *cf.* crenulata *Clarke & Rued.*

Cephalopods

Trochoceras gebhardi *Hall*
T. turbinatum *Hall*
Kionoceras darwini *Billings*
Orthoceras trusitum C. & R.
O. (*large*)
Cyrtoceras *sp. undet.*

Worms

Cornulites arcuatus *Con.*

Ostracods

Beyrichia (*2 species*)
Leperditia jonesi *Hall*

Trilobites

Calymene camerata *Con.*
C. niagarensis *Hall*
Dalmanites *sp. undet.*
Homalonotus *sp.*
Lichas (Corydocephalus) ptyonurus *Hall*
Proetus *sp. undet.*

5 RONDOUT WATERLIME

The Rondout waterlime (Clarke and Schuchert '99) received its name from the fine development in the extensive quarries and cement mines in the vicinity of Rondout. This drab-colored waterlime, formerly known as the "Salina waterlime," extends as far west as Seneca county, where it is overlapped by the Onondaga. In the intervening area it lies between the Cobleskill and the Manlius limestones as far east as the neighborhood of West Township on the Berne quadrangle. Southeast of this locality on the Berne and Albany quadrangles it rests first upon the Brayman shale and then upon the Schenectady beds (Feura Bush quarry) and the Normanskill sandstone and shale (South Bethlehem). The Rondout waterlime is exposed in few places on the Berne quadrangle (also southeast of this area on the Albany quadrangle) and is of varying but small thickness, except around Gallupville in the western part of this area (figures 12, 16). It is exposed in the Indian Ladder region along the Bear path at the base of the cliff, at Hailes' cavern (two feet four inches), at the two waterfalls and about a mile to the southeast in a ravine near the fault line where the best section is found. Prosser ('00, p. 54) gives the thickness as varying from three and three-quarters to four and three-quarters feet with the best exposure at the waterfall (second); but the writer has measured no more than three feet there and believes Brayman shale may be included in Prosser's measurements. Near the fault line two feet eight inches are exposed in the cliff and here is well shown the disconformity with the Brayman shales below and one with the Manlius limestone above, the latter also well shown at Minelot (second) falls. In the John Boyd Thacher Park (Indian Ladder) area the Rondout is not typical and may be recognized by its brownish color, thin banding and fine texture. Because of its soft nature it weathers back under the Manlius limestone cliff, forming what has long been known as the Lower Bear path; and it is through this formation that springs at the base of the Manlius cliff issue.

The greatest thickness of the Rondout on the Berne quadrangle is found in sections in the Gallupville area, along the first and second roads to the right on the north (left) side of the ravines. The section in the first ravine has been discussed in connection with the Brayman shale and Cobleskill limestone. Here 20 feet of the waterlime are exposed with the Manlius limestone outcropping five feet above. In the second ravine a ten-foot exposure of Rondout has been found, but not a complete section. Small streams, evidently having their source in springs, have formed large deposits of calcareous tufa, sometimes reaching down almost to the road level.

On the Albany quadrangle, to the southeast of our area, the Rondout is seen in the glen one-half mile south of New Salem (Prosser & Rowe, '99, p. 338), where six and one-half feet are exposed above the Brayman shale. 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. There is no cement rock in this waterlime in the Capital District. The formation here consists of drab-colored, impure magnesian limestones with shaly intercalations.

While the average maximum thickness of the Rondout is 40 feet (Howes Cave), in the Cobleskill region it thickens to 60 feet, the lower six feet of which formerly was mined at Howes 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; 35 feet) the upper beds show a remarkable series of mud-crack structures (Grabau, '06, p. 111), 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. The lower six feet at Howes Cave is a banded lime mudrock which is rather massively bedded, bluish gray in color when fresh but weathering brownish. Above this 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 (*ref. cit.*). The Rondout shows a transition from the Cobleskill limestone below and into the Manlius limestone above. "The transition from Cobleskill to Rondout is marked by a change from the limestone of the Cobleskill to the cement of the Rondout. The weathered surface of the upper portion of the Cobleskill varies slightly from the weathered Rondout, but fresh fracture clearly shows the distinctive character of the cement rock" (Hartnagel, '03, p. 1115).

No fossils have been found in the Rondout limestone in our area, nor have any been observed in the Capital District localities mentioned. The Silurian coral *Halysites catenulatus* was found by Hall in the Rondout of Herkimer county. In the lower portion at Howes Cave have been observed by Grabau and others fragments and small heads of *Favosites helderbergiae* var. *precedens* which have passed up from the Cobleskill below. Since the Cobleskill limestone is of Silurian age, there is no question of the Silurian age of the Rondout waterlime whatever may prove to be the age of the Brayman shale.

6 MANLIUS LIMESTONE

The Manlius was named from the exposure at Manlius, near Syracuse, N. Y. (Clarke and Schuchert '99) and includes near the top in Onondaga county two thin beds of waterlime which are used for cement. This formation has been known as the "Waterlime group of Manlius" (Vanuxem '39) and also as the "Tentaculite limestone" (Gebhard, Mather and others) from the abundance of the little straight shells of the pteropod *Tentaculites gyracanthus.*

It extends under the Coeymans limestone (Lower Devonian) as far west as Onondaga county, and west of this is overlain by the Oriskany or Onondaga to the limit of its extent in Seneca county (Harris, '04). The only occurrence (55 feet) of Manlius east of the Hudson river is in the Becraft mountain outlier, near Hudson (Grabau, '03, p. 1034)[1]

On the Berne quadrangle and in the Capital District in general the Manlius limestone is best exposed in the lower part of the vertical Helderberg cliff. Typically, it is a thin-bedded, dark blue limestone of fairly pure composition. The layers are one to three inches or more thick, and are especially thin in the lower part with alternating light and dark beds ("ribbon-limestone"). Due to its remarkable hardness and resistance slabs of this limestone break with a ringing sound, and the rock when weathered has a characteristic light color. Also, on account of the hardness of the rock, it tends to form a distinct vertical cliff by itself or together with the Coeymans limestone above. The Manlius limestone and the Rondout beneath are inclined to form caves and shelters as in the Indian Ladder region (Hailes' cavern and others). Certain surfaces of the rock show immense numbers of the Tentaculites, while others are covered with the little brachiopod *Spirifer vanuxemi* and still others with numerous specimens of the fairly large ostracod *Leperditia alta*. These three fossils together with the other characteristics make this a most easily recognized formation.

The finest exposure in our area and, indeed in the whole Albany area, is at the Indian Ladder where the entire thickness of this formation and the overlying Coeymans is shown in the cliff in a number of places (figures 23–26, 30) as at Hailes' cavern in Cave gulf, the two waterfalls in Indian Ladder gulf and the section at the small ravine near the fault about one mile southeast. The thickness given by Prosser ('00, p. 54) at the Indian Ladder is 31½ feet of typical Manlius and 14½ feet of so-called transition beds. In a later paper ('07) the same author records a thickness of 54⅔ feet at the Indian Ladder with two feet of transition beds above it. This second measurement seems excessive. The writer has measured 45 feet (aneroid measurement) at Hailes' cavern. Below the transition 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 (figures 28, 29). The Manlius can be traced fairly persistently along the foot of the Helderberg cliff

[1] Also found in Mount Ida, slightly northeast of Hudson.

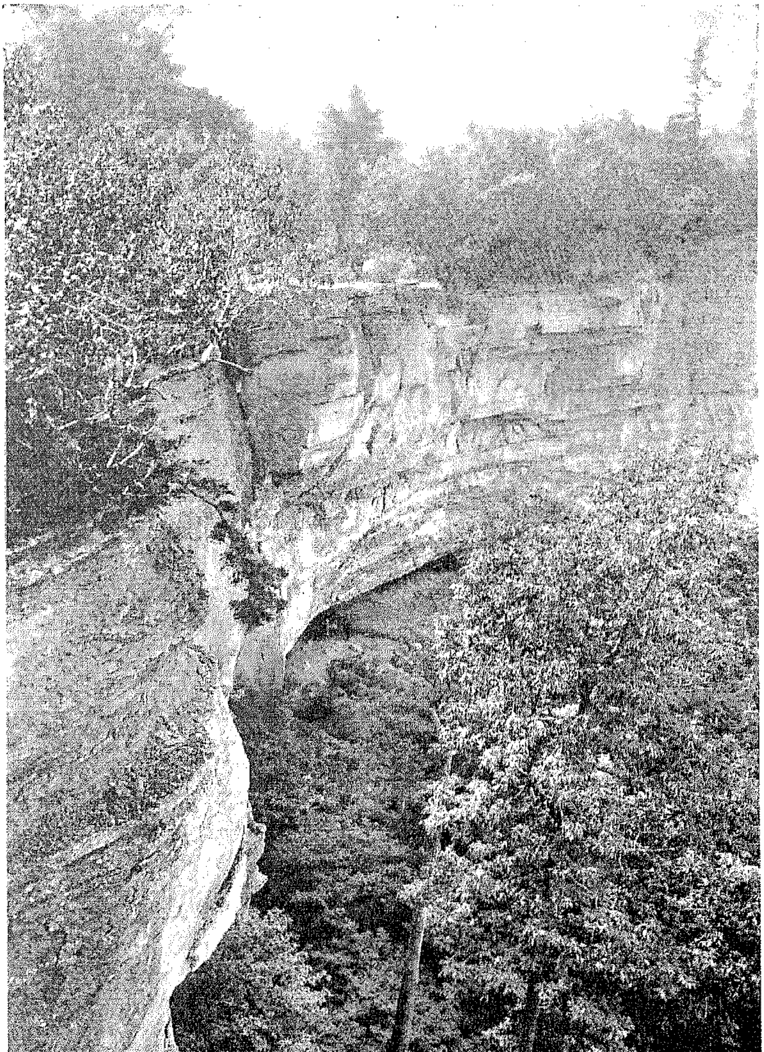


Figure 23 View from cliff edge nearest the ladder, Indian Ladder gulf, showing Minelot falls (dry) and so-called "Paint mine" cave. (Photograph by E. J. Stein)

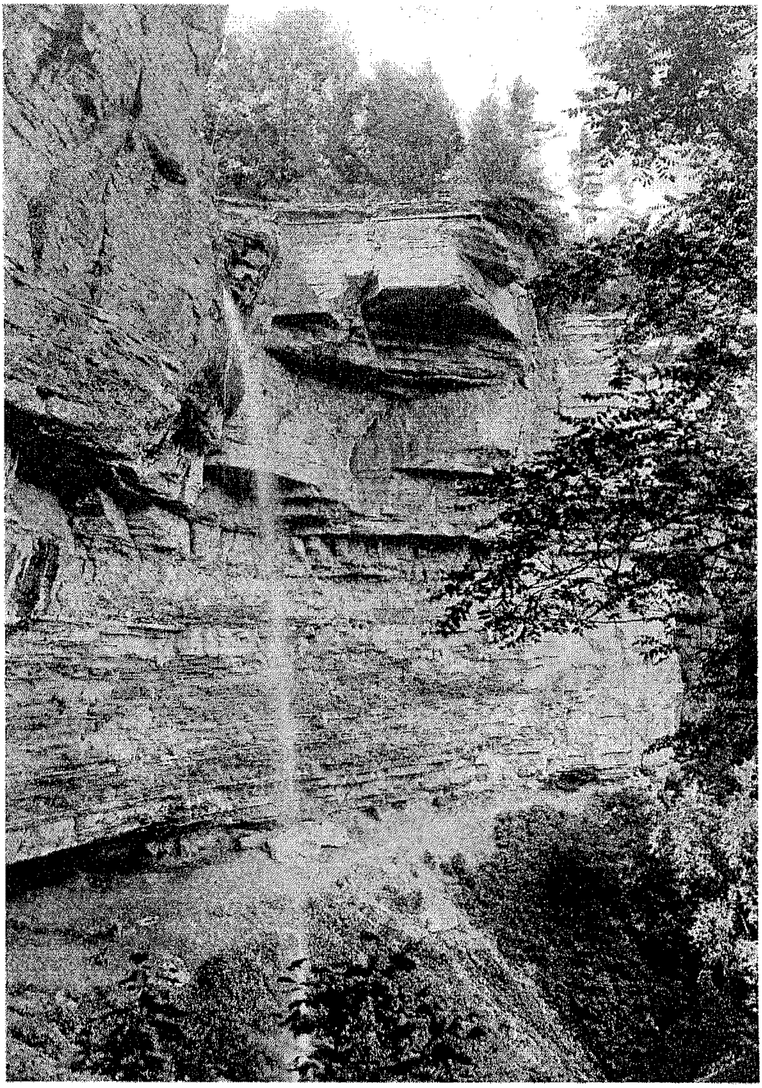


Figure 24 Helderberg cliff at Minelot falls showing complete Coeymans-Manlius section with the Coeymans limestone projecting beyond the Manlius limestone. The Rondout waterlime is represented by the few feet of rock weathered back beneath the Manlius; below this are the Brayman shale and Indian Ladder beds. (Photograph by E. J. Stein)

and in two places south of the Berne quadrangle (Indian Ladder area) comes to or nearly to the top of the vertical cliff owing to displacements along fault lines.

North of the Indian Ladder, above Altamont, the cliff swings to the west and crosses the Knox state road about a mile beyond the top of Altamont hill. Just before this point an old road metal quarry is located in the hill at the left and the Manlius is exposed in the bottom of the quarry. This cliff, with exposures of Manlius and Coeymans at intervals, stretches in a fairly east-west direction between East Township and West Township, then turns to the southwest toward Gallupville, forming part of the cliff on both sides of the ravine north of Gallupville and also being fairly well exposed in the next ravine to the west, particularly in an old road metal quarry high in the hill on the north side. In the area to the north of these two ravines the till is heavier and the outcrops fewer and of less extent. About one mile southeast of Gallupville, in a road metal quarry and cut along the state road, there is a good exposure of Manlius (almost complete section down to stream bed) with excellent fossil collecting. To the west of our sheet in the Schoharie area (West Hill) 44½ feet of Manlius have been measured, including eight feet of transition beds (Grabau, '06, p. 254).

Excellent exposures on the Albany quadrangle may be seen at the road metal quarries at South Albany, one and a half miles southeast of Feura Bush, and South Bethlehem (Callanan Road Improvement Company). At South Bethlehem Hartnagel has measured 36 feet of lower Manlius, four inches of waterlime with *Leperditia* and 15 feet of upper Manlius. The entire waterlime bed here is probably about four feet, as elsewhere, and is largely included in the measurement for the lower Manlius. In the small glen one-half mile south of New Salem Prosser ('99, p. 338) has measured 32½ feet of typical Manlius and 12½ feet of transition beds.

A very good place for the study of this formation is the small road metal quarry along the state road above New Salem, in which section 45 feet of Manlius have been measured. Here besides the thin bedding, the limestone shows features such as mud-cracks, and faint ripple marks, thin shaly films separating the limestones, mud pebbles in bottom beds, comminuted shells, parallel arrangement of Tentaculites shells and piled together masses of Leperditia shells (Ruedemann, '30, p. 45), all of which clearly indicate tide flat conditions. Here are seen three of the characteristic *Stromatopora beds*, one eight to nine feet thick, at the top of the formation. This Stromatopora bed forms the base of the quarry along the Altamont-

Knox state road and is very prominent in all exposures of the upper part of the Manlius. The Stromatopora beds are strikingly shown in the cliffs in the Indian Ladder area (John Boyd Thacher Park) and may be closely studied in two very accessible places, in the rock cut near the top of the old Indian Ladder road and along the path leading to Hailes' cavern, which descends through the combined thickness of the Coeymans-Manlius limestones.

The Stromatoporas belong to an extinct group of hydrocorallines represented today by forms, such as the elk-horn coral (*Millepora alcicornis*), which comprise some of the most important recent reef-builders. The Manlius form has been described as *Stromatopora (Syringostroma) barretti* Girty ('95). The Stromatopora beds represent coral reefs that can be seen in section stretching for long distances through the Helderberg cliff in the Manlius limestone. They consist of great subglobular masses, of concentric structure and horizontally connected. In interpreting these reefs Ruedemann says (*ref. cit.* p. 46):

When one sees these reefs stretching through the Helderberg cliff at various levels, one cannot help connecting the peculiar thin-bedded Manlius limestones with their tentaculites, ostracods and small spirifers and lamellibranchs, mud cracks and mud pebbles with these reefs and see in the Manlius limestone principally lagoon deposits on tide flats formed between and behind the coral reefs. The transition beds contain alternating layers with the fauna of the Manlius and with elements of the following Coeymans, thereby indicating oscillating conditions of the sea. The Coeymans elements found are especially the small brachiopods *Stropheodonta varistriata* and *Camarotoechia semiplicata.*

Ruedemann (*ref. cit.,* p. 45) in the New Salem section draws "the boundary line with the Coeymans along a distinct, somewhat wavy line with a thin seam of shale above where Manlius pebbles are seen in the Coeymans limestone." The attention of the writer was first called by G. H. Chadwick (in field, 1927) to a disconformity between the Manlius and Coeymans in the rock cut at the top of the old Indian Ladder road, marked by an irregular, wavy contact. In that same summer Chadwick called the writer's attention to the occurrence of Manlius pebbles in the base of the Coeymans in a quarry in the Catskill region, indicating the presence of at least a local disconformity between the Manlius and the Coeymans.

The fauna of the Manlius (figure 27) is very meager as might be expected from the nature of the formation. The three commonest fossils, and those most likely to be found, are *Tentaculites gyra-*

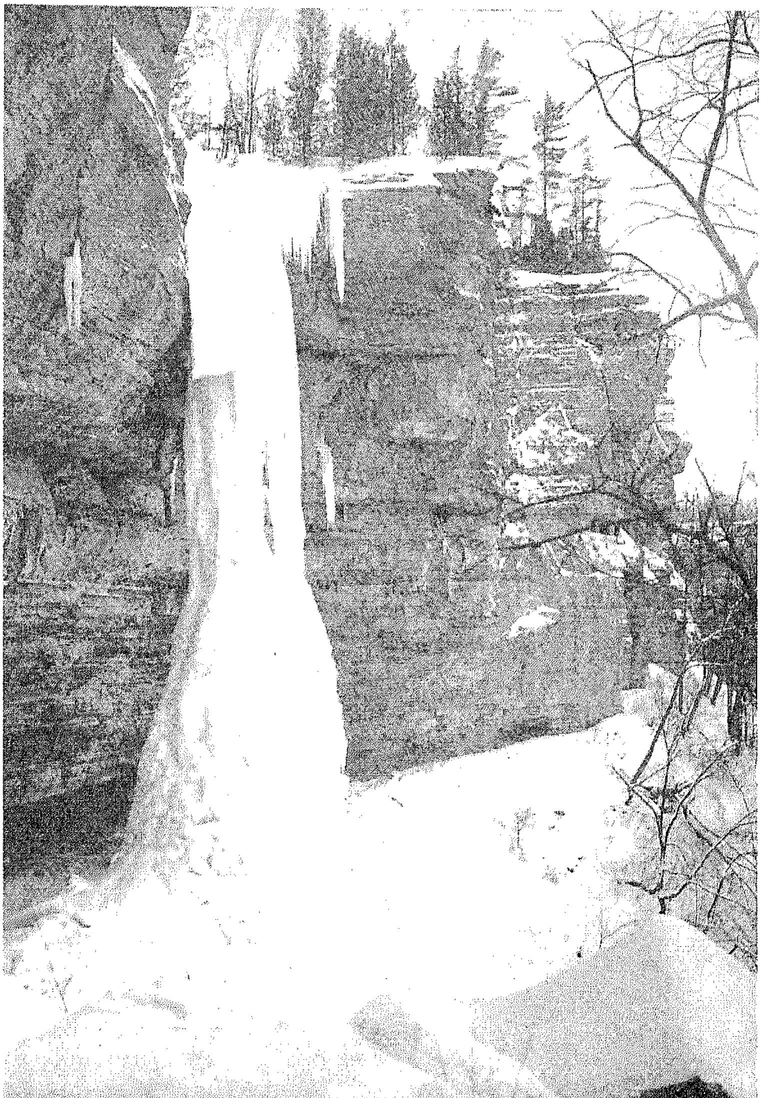


Figure 25 Giant ice column formed at Minelot falls in a typical winter. Total height about 100 feet. (Photograph by E. J. Stein)

Figure 26 "Proscenium Arch" at Hailes' cavern. A complete section of the Manlius and Coeymans limestones is seen here and the Stromatopora beds are well shown. (Photograph by E. J. Stein) *canthus, Spirifer vanuxemi* and *Leperditia alta.* The fauna for our area is as listed below:

Hydrocorallines

Stromatopora (Syringostroma) barretti *Girty*

Brachiopods

Spirifer vanuxemi (*Hall*)
Stropheodonta varistriata (*Con.*)
Camarotoechia semiplicata (*Con.*)

Pelecypods

Megambonia aviculoidea *Hall*
Modiolopsis? dubia *Hall*
Tellinomya nucleiformis *Hall*

Pteropods

Tentaculites gyracanthus (*Eaton*) *Hall*

Ostracods

Beyrichia (Kloedenia) notata *Hall*
Leperditia alta (*Conrad*) *Hall*

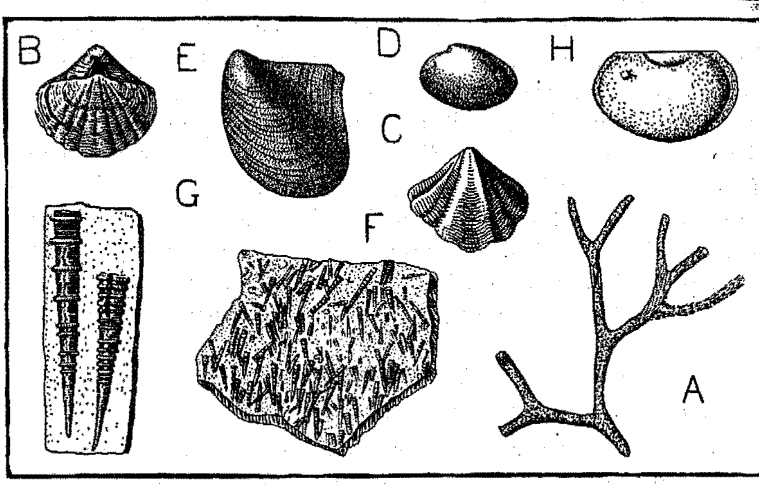


Figure 27 Manlius limestone fossils. (Bryozoan, *A;* brachiopod, *B, C;* pelecypods, *D. E;* pteropod, *F, G;* ostracod, H). *A, Monotrypella? arbusculum,* x ¾. *B, C Spirifer vanuxemi,* x 1½. *D Tellinomya nucleiformis. E Megambonia (?) aviculoidea. F Tentaculites gyracanthus,* x ½. *G* The same, x 2. *H Leperditia alta,* x 2.

In certain other regions, as at Jerusalem Hill near Litchfield, in southern Herkimer county, some very remarkable crinoids and cystoids have been found. For the Schoharie region from the typical Manlius limestone have been recorded 19 species consisting of one crinoid, one cystoid, one worm, two bryozoans, two brachiopods, five pelecypods, three gastropods, two pteropods and two ostracods. For the Manlius-Coeymans transition beds 16 species are listed (Grabau, '06, p. 319).

There has been considerable discussion over the demarcation of the Siluro-Devonian boundary. It is not pertinent to enter at length into that discussion here, but it might be advisable to summarize briefly the situation. The Lower Helderberg beds (below the Oriskany sandstone) in the early days of the Survey, under the leadership of James Hall, were classed with the Silurian. Later the Siluro-Devonian boundary was changed (J. M. Clarke) and the Lower Helderberg limestones with the exception of the Manlius were placed in the Lower Devonian and known as the Helderbergian group. The Manlius, because of the rather Silurian aspect of its meager fauna, was left in the Silurian and since then has been the subject of much discussion as to its age. Some, following Clarke, class the entire Manlius as Silurian, others would place it with the Devonian and a third group place the dividing line within the Manlius. According to the last view the lower portion of Manlius limestone exposed in the Helderberg-Schoharie area represents the lower beds and is the typical Manlius, Silurian in age. The upper two to 15 feet of limestone of the Schoharie-Helderberg area,[1] long distinguished as "transition beds", and the so-called Manlius beds exposed in the "Old Glory Hole" at Rondout are Upper Manlius and Devonian (Keyser of Maryland and Virginia) in age. In the Rondout and Rosendale areas the lower or typical Manlius is either entirely wanting or very thin. South of Rondout no Manlius (that is, the lower beds) occurs. The Upper Manlius beds of central New York are also considered as Keyser and Devonian (E. O. Ulrich, 1930; in writing).

7 COEYMANS LIMESTONE

The Coeymans receives its name from the town of Coeymans, Albany county (Clarke and Schuchert, '99). In the reports of the earlier geologists it was known as the "Lower Pentamerus" limestone from the most common brachiopod *Pentamerus (Gypidula) galeatus* (now *Sieberella coeymanensis*). This limestone extends farthest west of any of the members of the Helderberg group, reaching the town of Manlius in Onondaga county, where it is overlain by a thin representation of the Oriskany.

The Coeymans 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; eastward in Becraft mountain, near Hudson, the thickness decreases to about 45 feet (Grabau, '03, p. 1034). It is of massive character and because of its hardness and thickness is the most striking Helderberg formation and also the principal cause of the Helderberg cliff. The base of the Coey-

[1] Studies on the Manlius Group by R. M. Logie of Yale University have shown that nothing higher than the Olney horizon of the Manlius (Silurian) is present in the area and overlying horizons of the type region are wanting.

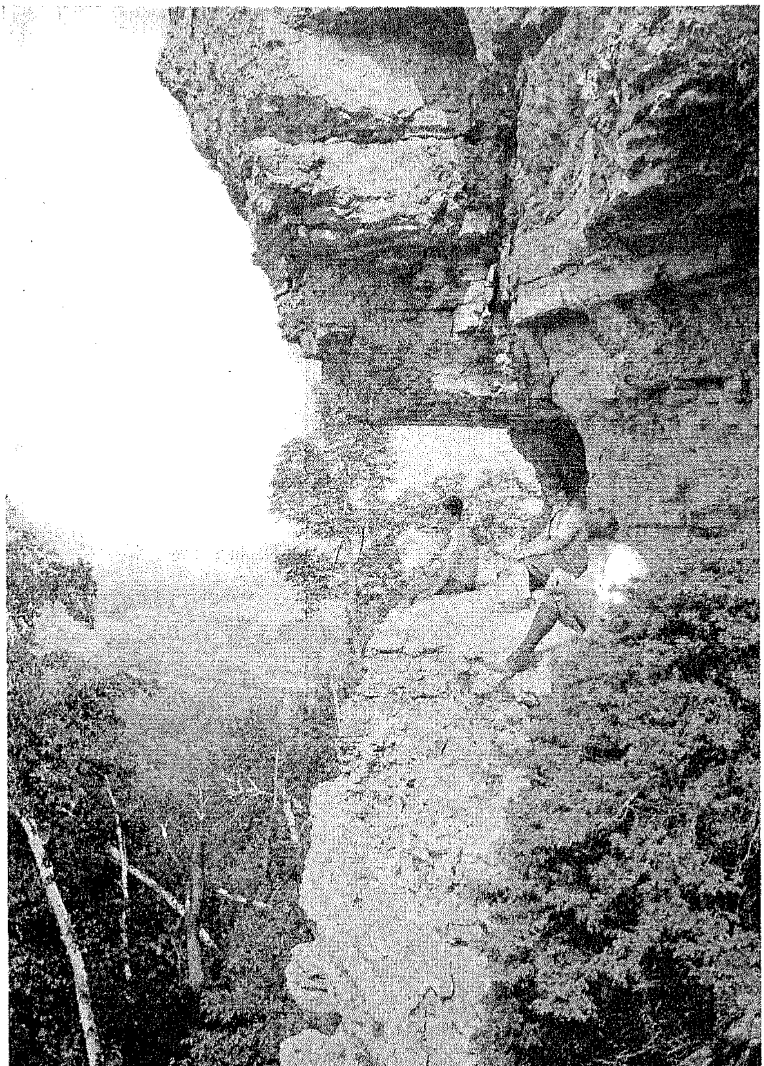


Figure 28 Section of the cliff beyond (east of) Minelot falls and the ladder showing well the Upper Bear path developed in the weaker waterlime bed of the upper Manlius. (Photograph by E. J. Stein)

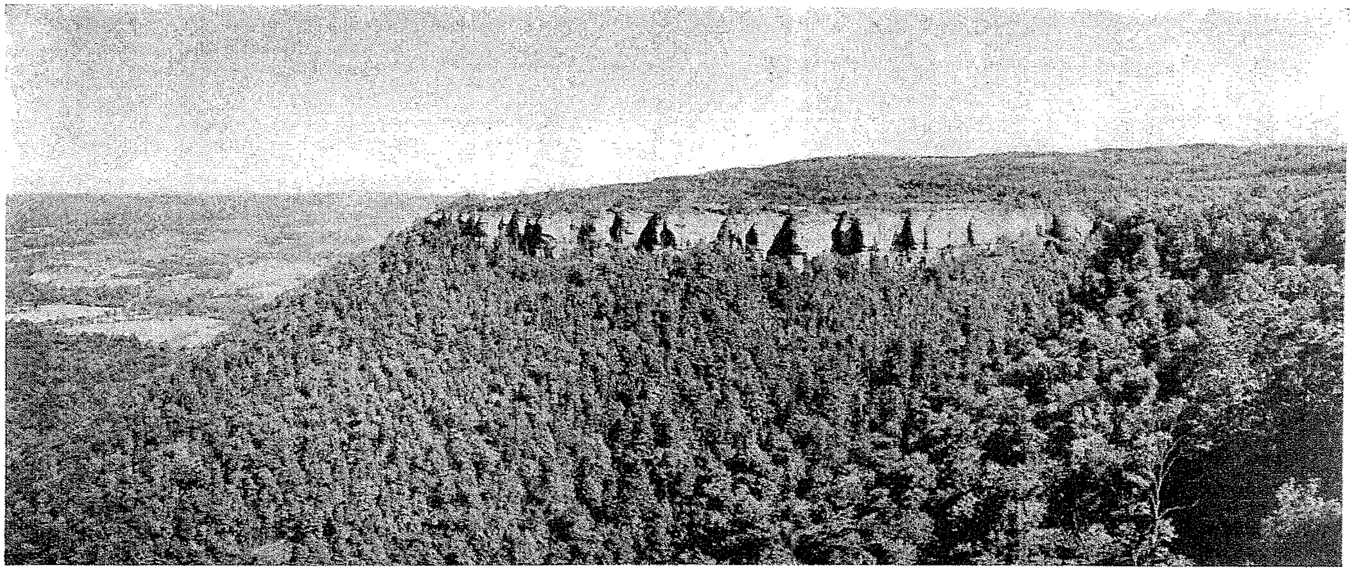


Figure 29 View from cliff in vicinity of Hailes' cavern, Cave gulf, looking southeast. The Upper Bear path in the Manlius is clearly marked in the Helderberg cliff and the long talus slope beneath the cliff is well shown. At the right rise the Hamilton hills. (Photograph by E. J. Stein)

Figure 30 The "Battlements" at the top of the old Indian Ladder road. The upper 50 feet are formed by the Coeymans limestone. Over the cliff at this place passed the old Indian trail. (Photograph by E. J. Stein)

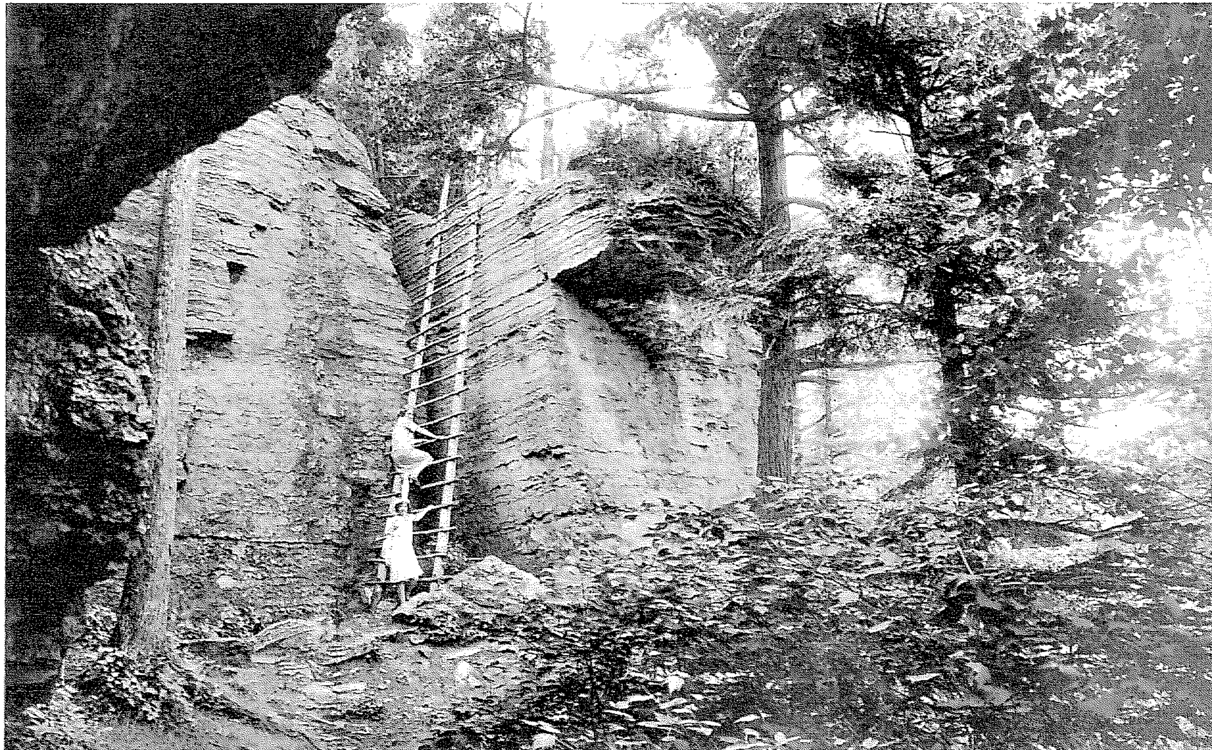


Figure 31 The ladder leading up the Coeymans limestone cliff just east of Minelot falls. (Photograph by E. J. Stein)

mans is generally accepted to be above the heavy Stromatopora bed where the first specimens of *Sieberella coeymanensis* come in. The characteristic vertical jointing of the Coeymans and the presence of the softer transition beds beneath cause this limestone to stand up as a vertical cliff usually projecting beyond the underlying Manlius and Rondout beds which tend to form caves and shelters (figures 23, 24, 26, 30, 31).

The Coeymans is readily distinguished from the Manlius by its massiveness, its bluish gray color, weathering light gray, and its rather coarse semicrystalline structure (composed of fragments of shells, crinoids and corals). In places the limestone takes on something of the character of a shell limestone or coquina, with the brachiopod shells in large part in a very perfect state of preservation and weathering out on the surface or along exposed edges, where they may be collected. In general this rock is fairly regularly bedded, but weathering brings out "also an irregular subbedding into flat, interlocking lenses and corrugations" (Darton). 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. The Coeymans limestone is more silicious than the Manlius and the shells and crinoid stems which it carries tend to become silicified. Formerly this limestone was quarried and burned for lime in some sections.

While there is more of a tendency for caves to develop in the underlying Manlius and Rondout formations, they may also be found in the Coeymans, as, for example, the cave northeast of Shutter Corners, which though discovered about 40 years ago (Rev. L. Judson Westfall, Baltimore, Md.) was not recorded until the summer of 1928, when on August 13th it was explored by a party from the State Museum under the leadership of D. H. Newland and C. A. Hartnagel. The present opening of the cave (elevation about 1000 feet) is located about 2900 feet east of Shutter Corners on the north side of the road and at the north end of a dry ravine on the farm of Delos Treadlemire. The opening of the cave is in the lower New Scotland (Kalkberg) limestone but the cave appears to follow the Coeymans. In a description of the cave (manuscript, 1928), Newland states:

The cave is simply an underground stream channel varying from three to 10 or 12 feet in width, and averaging for much of its course 6 or 7 feet . . . . . Apparently the water courses which have caused the formation of the cave by solution of the limestone follow regular joint systems in the limestone. There are two main directions for these joints, one running a little west of north and the other N. 30° E. By alternately following one or another of these joints the stream has excavated the winding course which characterizes the openings throughout their extent. The Knox cave on the Truax farm, about 1.6 miles north of Knox on the Delanson road, was rediscovered in the winter of 1933 and opened to the public May 30th of that year. It also opens into the Coeymans limestone. Rumor has it that this cave was known to the adventuresome for about 200 years. Evidence of previous exploration was found when the cave was reopened.

The vertical jointing of the Coeymans limestone is very characteristic. There are usually two distinct groups of intersecting joint fissures, one northeast-southwest, the other northwest-southeast; but there are also minor joint fissures crossing the main groups. The writer has made measurements of the direction of the joint planes in various places. At the Indian Ladder the main joint fissures run N. 23° E. and N. 27° to 33° W. One of the minor joint planes has a more easterly direction (N. 67° E.). These joint planes help to produce the cliff by the breaking away of the rock along the vertical joints; and they weather out by solution into broad and deep fissures.

Fracture cleavage has been developed in the Coeymans (figure 32) in the region of the fault, just outside the area of the Berne quadrangle, about one and a half miles southeast of the Indian Ladder (Rock road). The fault line runs in a NE-SW direction along a small ravine and is distinctly shown near the edge of the cliff. The vertical cleavage developed is very strong, and it is unusual to find it so well developed in a pure limestone. This fracture cleavage will be further discussed in the chapter on Structural Geology.

Except in the northwestern section of the Berne quadrangle, the Coeymans limestone is fairly continuously exposed throughout our area, and even there the outcrops are rather frequent. By far the best outcrop occurs in the John Boyd Thacher Park (Indian Ladder) area, where there is a complete exposure, almost entirely in the vertical cliff, which is true of outcrops of this formation toward the southeast until a few miles beyond (southeast of) New Salem it spreads out to form flats of some breadth. To the west of Altamont, between East Township and West Township and a few miles north of Gallupville, the Coeymans again covers broad surfaces. With the Manlius it forms the cliffs bordering the ravines northwest of Gallupville and good exposures are found in the Fox Kill valley between West Berne and Gallupville, especially in the side ravines. In a very accessible road metal quarry along the state road, one mile southeast of Gallupville, both Coeymans and Manlius are exposed and fossils

Figure 32 Vertical fracture cleavage developed in the Coeymans limestone in the fault area above Rocks. (Photograph by E. J. Stein)

may be collected here with no great difficulty, particularly in the Manlius. The quarry along the Altamont-Knox state road and the one to the south of our area above New Salem are accessible and worth study. Also on the Albany quadrangle the quarries at Feura Bush (South Albany) and South Bethlehem, mentioned under the discussion of the Manlius, may also be cited here.

At the Indian Ladder, in the cut at the top of the old road (Rock road), the writer measured (aneroid measurement) exactly 50 feet of Coeymans limestone from the top of the heavy Stromatopora bed to the base of the Kalkberg limestone. Prosser ('00, p. 54) gives the measurements along the cliff here as varying from 49 to 52 feet for the thickness of the "Pentamerus," and for the Countryman Hill-New Salem sections, 50 feet. Grabau ('06, p. 254) has measured 53 feet in West Hill in the Schoharie area, and Darton ('94, p. 440) gives the average throughout Albany county as 65 feet, in which measurement he includes the Manlius-Coeymans transition beds.

The fauna of the Coeymans limestone is a small one, at least in the Albany county area, consisting largely of brachiopod shells (figure 33). Because of the hardness of the rock the fossils are difficult to collect. The three common brachiopods are sometimes picked up loose at the top of the cliff, as at Hailes' cavern in the Indian Ladder region, and also along the Bear path. The most common and characteristic fossil is the brachiopod *Sieberella coeymanensis* (formerly *Pentamerus galeatus,* then *Gypidula galeata*) with the helmetlike shape of the shell, from which it derived its name. 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. In the Indian Ladder region the writer has collected the following forms:

Corals

Favosites helderbergiae *Hall*

Brachiopods

Sieberella coeymanensis *Schuchert*
Uncinulus mutabilis (*Hall*)
Atrypa reticularis (*Linn.*) *Dalman*
Anastrophia verneuili (*Hall*)
Leptaena rhomboidalis (*Wilckens*)
Spirifer perlamellosus *Hall*
Meristella laevis (*Vanuxem*)

At Hailes' cavern at the top of the cliff were found the trilobite *Dalmanites pleuroptyx* (Green) and *Orthoceras rude* Hall; and at the top of the cliff at Outlet creek, a bryozoan. The cystoid *Lepadocrinus gebhardi* (Conrad) was found in a boulder loose in the stream bed in the first ravine north of Gallupville.

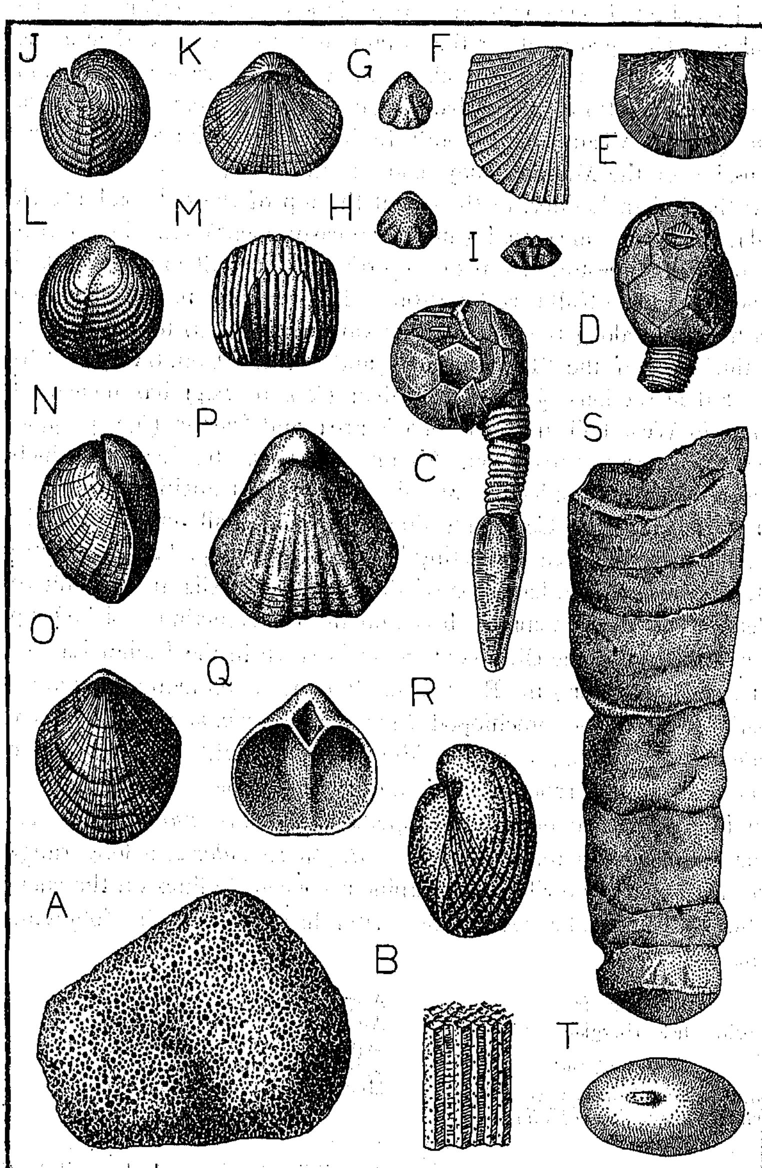


Figure 33 Coeymans limestone fossils. (Coral *A, B*; cystoid, *C, D*; brachiopods, *E-R*; cephalopod, *S, T*). *A, B Favosites helderbergiae*, x ½, with enlargement of corallites. *C, D Lepadocrinus gebhardi*. *E, F Stropheodonta varistriata*, x ¾, with enlargement. *G, H, I Camarotoechia semiplicata*. *J, K Anastrophia verneuili*, x ¾. *L, M Uncinulus mutabilis*, x ¾. *N, O Atrypa reticularis*, x ¾. *P, Q, R Sieberella coeymanensis* (=*Gypidula galeata*), x ¾. Interior of valve, x 1. *S, T Orthoceras rude*, x ½.

For the Albany quadrangle the list recorded is also small and the fauna of much the same composition as that from the Indian Ladder region (Prosser and Rowe, '99, p. 349):

Corals

Favosites helderbergiae *Hall*

Brachiopods

Sieberella coeymanensis *Schuchert*
Uncinulus mutabilis (*Hall*)
Atrypa reticularis (*Linn.*) *Dalman*
Anastrophia verneuili (*Hall*)?
Strophonella punctulifera (*Con.*)
Stropheodonta (Brachyprion) varistriata (*Con.*)
Spirifer perlamellosus *Hall*
S. vanuxemi *Hall*
Camarotoechia semiplicata (*Con.*)
Meristella laevis (*Vanuxem*)
Orthis (Orthostrophia) strophomenoides *Hall?*
O. *sp.*

For the Schoharie region Grabau ('06, p. 320) lists a fauna of 41 species, including two corals, one cystoid, three crinoids, one bryozoan, eleven brachiopods, six pelecypods, three gastropods, seven cephalopods, one pteropod, five trilobites and one ostracod. The Coeymans of the Schoharie region and Herkimer county have furnished a number of beautiful crinoids, *Lasiocrinus scoparius* (Hall), *Melocrinus pachydactylus* (Con.) and *M. paucidactylus* (Hall), and strange cystoids as the very characteristic *Lepadocrinus* (*Lepocrinites*) *gebhardi* (Con.). Clarke and Ruedemann found the small crinoid *Lasiocrinus scoparius* (Hall) occurring in great numbers at Jerusalem hill, near Litchfield, Herkimer county, in both the Manlius and Coeymans limestones, together with the peculiar starfish *Hallaster forbesi* (Hall). This would indicate that crinoid plantations grew in this region during these times in water apparently more quiet than prevailed farther east (Ruedemann, '30, p. 49).

8, 9 NEW SCOTLAND BEDS (including KALKBERG LIMESTONE)

The New Scotland limestone, known to the geologists of the first Survey as the "Catskill shaly," "Delthyris shaly" or "Lower shaly" limestone, received its name (Clarke and Schuchert, '99) from the town of New Scotland, Albany county (the village of New Scotland being located on Schenectady beds). It continues westward without interruption into Herkimer county where it disappears, due to uplift and erosion, and here the Onondaga rests upon the Coeymans. Farther west in Madison county, there is evidence that it reappears; but except for this occurrence the Oriskany is the only intervening formation and west of the central part of the State is the basal Devonian formation. The only occurrence of New Scotland east of the Hudson river is in the Becraft mountain outlier (near Hudson). The New Scotland limestone, with a thickness of 75 to 100 feet, is the least conspicuous and most fossiliferous member of the

Helderbergian series. It consists of thin-bedded, very impure, shaly limestones and calcareous shales which tend to be heavier and less fossiliferous in the lower portion, at least in certain areas as the Indian Ladder, where in the lowest 20 feet or so (of typical New Scotland) only the brachiopods *Lingula* and *Orbiculoidea* were found and these sparingly. Locally seams of black chert appear in the uppermost 20 feet or so. The middle beds are, on the whole, the most fossiliferous. In fresh exposures the rock has a dark bluish gray color and massive character and has the appearance of a true limestone (figure 34). Where weathered, these beds have a gray or gray-brown color. In general fossils occur in the New Scotland only as impressions or natural molds but in certain areas where the limestone is more silicious the fossils have become silicified. The New Scotland beds were known in the old days as the "Delthyris shaly limestone" because of the common and characteristic brachiopods *Delthyris perlamellosus* and *D. macropleura*, (now *Spirifer*).

The beds between the Coeymans and New Scotland formations, long known as transition beds, were separated by Chadwick ('08) as a distinct formation, the **Kalkberg limestone.** This limestone is typically exposed along the Catskill, near the village of Catskill, Greene county, and received its name from the local Dutch name for the Helderberg ridge (Kalkberg, meaning limestone mountain). The name was applied to these beds, variously included in Coeymans and New Scotland previously, because they have a wide distribution, carry a mixed fauna and are 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 and weathers a buff color. In certain areas, as the Helderbergs, there are thin, highly fossiliferous limestones interbedded with shales like those of the overlying New Scotland. In the type area the Kalkberg has a thickness varying from 25 to 40 feet, but in the Helderberg area only about 20 feet are represented. Where the chert beds are heavy and the limestone more pure, as in the type area, the Kalkberg forms a cliff in connection with or behind the Coeymans and in geological mapping is included with it; in the Helderberg area it forms a low terrace below the New Scotland that is often conspicuous in the topography, and on the geological map it is included with the New Scotland with which it belongs topographically (figure 35). The upper beds are more impure and grade into the shaly limestone above. Fossils here are even more abundant, especially the smaller ones and bryozoans which are very character-

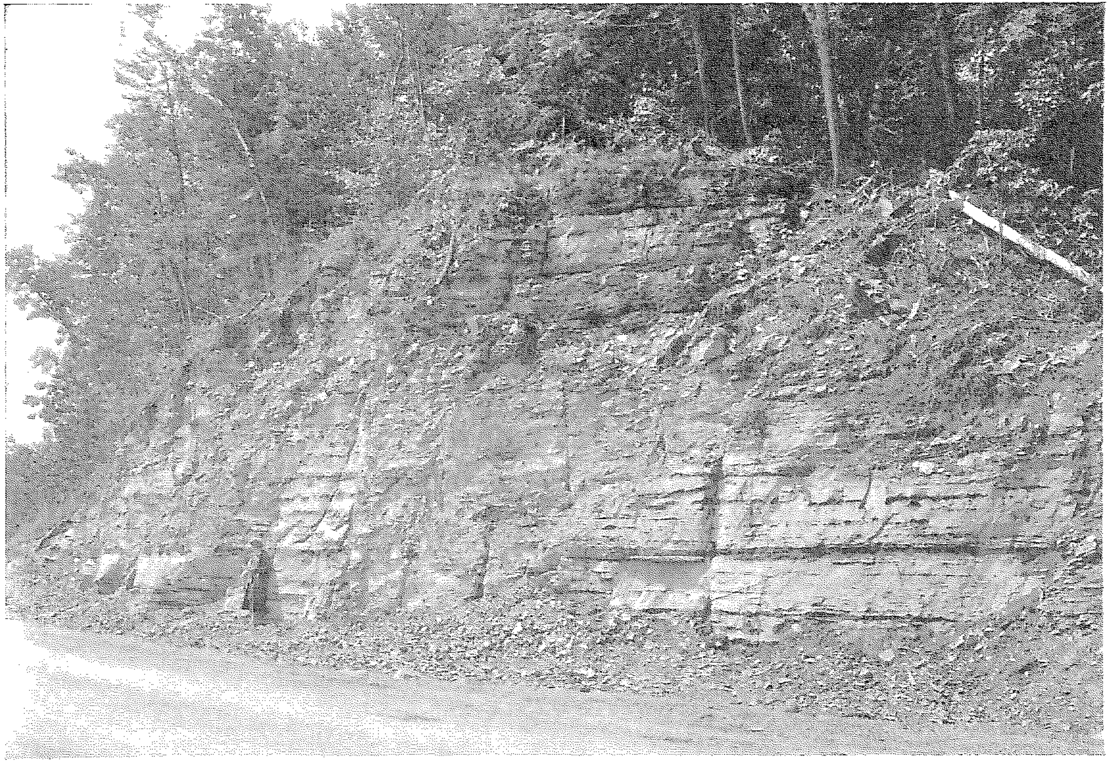


Figure 34 A cut in the New Scotland beds above New Salem, along the new road to John Boyd Thacher Park. This section shows well the character of this shaly limestone when fresh. (Photograph by E. J. Stein)

Figure 35 Cascade over Kalkberg limestone, Minelot brook. The harder, more silicious beds are well shown. (Photograph by E. J. Stein)

istic. Chadwick states (in conversation, 1927) that the Kalkberg and New Scotland limestones of the Helderberg area more nearly approach each other in character because the Kalkberg there is less silicious and the New Scotland more so than in the type area.

The terrace formed by the Kalkberg limestone is well shown in the region of Hailes' cavern and fossils may be collected here in the terrace face and in the field stretching from it toward the cliff. The best place for studying this formation and for collecting fossils is that portion of the terrace between the old Indian Ladder road (Rock road) and Outlet creek (first stream south). Here the top of the terrace is marked by the "Bungalow." Ascending Rock road from the top of the Coeymans it is possible to make almost a bed to bed collection of fossils up to the top of the terrace because this unused section of road is kept washed by heavy rains. 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 (Hailes' cavern) area, and sinkholes are found here; but this region is not very accessible except where (two and one-half miles to the northwest) the old Thompsons lake road leads up over the Helderberg cliff to the Kalkberg terrace and thence onto the New Scotland. Farther to the west a good road cut is seen along the road leading directly south from West Township, one-quarter of a mile from the crossroads. About a mile southeast of Gallupville near the junction of the state road with a side road a ravine from the northeast joins the Fox Kill valley. In the section in this ravine the Kalkberg is well exposed. It carries very large specimens of *Spirifer macropleura* and is very cherty, so much so that it forms a series of falls between the New Scotland and the Coeymans.

To the southeast of our area on the Albany quadrangle, the terrace of the Kalkberg is fairly well shown in the New Salem section in the field between the road quarry and the new road to the Indian Ladder and the abandoned lower portion of the Parrish hill road cuts across it. Near the edge of the Albany quadrangle, south of the Callanan quarry at South Bethlehem, Doctor Ruedemann and the writer found the Kalkberg formation distinctly recognizable and having firmer beds (with chert) than those in the Helderberg area, a condition very similar to that found in the ravine southeast of Gallupville. The uppermost Coeymans bed here was found to contain considerable chert.

The uppermost beds of the Kalkberg limestone, as pointed out above, are characterized by an abundance of bryozoans, represented by many genera (*Hallopora, Fistulipora, Monotrypa*, etc.). Fossils here are more abundant, especially the smaller ones. This formation is also characterized by thick stems of the crinoid *Mariacrinus stoloniferus,* and the lower beds are marked by the characteristic little brachiopod *Bilobites varicus,* which does not appear in the beds above. The fauna in general is a mixture of Coeymans and New Scotland types (figure 36) as is shown by the following list of species collected from the Indian Ladder area, mainly near the "Bungalow" in the Rock road cut.

Sponges

Hindia sphaeroidalis (inornata, fibrosa) *Duncan*

Hydrocorallines

Stromatoporoid

Corals

Mariacrinus stoloniferus *Hall*

Crinoids

Brachiocrinus nodosarius *Hall*

Bryozoans

Paleschara incrustans *Hall*
Fenestella *sp.*
Fistulipora *sp.*
Monotrypella *sp.*
Stictopora *sp.*
Thamniscus *sp.*
Callopora (Callotrypa) *sp.*
Ptilodictya *sp.*

Brachiopods

Bilobites varicus (*Conrad*)
Sieberella coeymanensis *Schuchert*
Spirifer perlamellosus (*Hall*)
S. macropleura (*Conrad*)
S. cyclopterus *Hall*
Leptaena rhomboidales (*Wilckens*)
Atrypa reticularis (*Linnaeus*)
Eatonia medialis (*Vanuxem*)
Meristella laevis (*Vanuxem*)
Rhipidomella oblata *Hall*
Dalmanella perelegans *Hall*
D. subcarinata *Hall*
Uncinulus nucleolatus *Hall*
U. *cf.* abruptus *Hall*
Strophonella leavenworthana *Hall*
Stropheodonta *cf.* varistriata (*Con.*)
Orthothetes woolworthanus (*Hall*) *H. & C.*

Trilobites

Phacops logani *Hall*

Because the New Scotland limestone consists of thin-bedded, very impure shaly limestones and calcareous shales, it weathers readily and forms the gentle slopes above the Coeymans limestone. The back slopes of the latter tend mostly to be wooded while the soil-covered gentle slopes of the New Scotland frequently constitute the farm lands and often are used for grazing. Good outcrops in the New Scotland, therefore, are not to be expected frequently. The best ones are to be found in road cuts and stream beds, and because they afford such fine collecting have always been much sought after by collectors. The Helderberg area was the source of much of the early collections of the New York State Survey but not so much the Indian Ladder region as the area to the southeast on the Albany quadrangle, in the Countryman Hill section and around the village of Clarksville. Ruedemann ('30, p. 49) draws attention to the fact that the Clarksville region was the "stamping ground" of Hall and his assistants (Beecher, Clarke, Schuchert, Simpson, the Van Deloos, father and son, Walcott and Whitfield) and many fine collec-

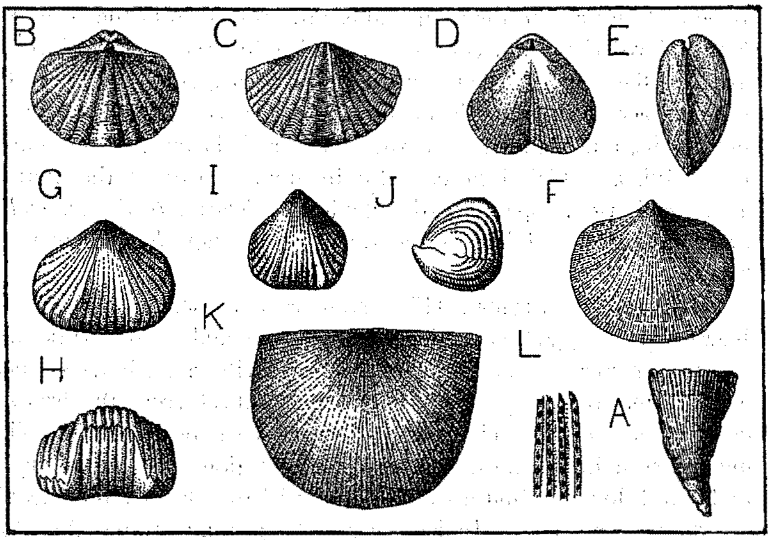


Figure 36 Kalkberg and New Scotland limestone fossils. (Kalkberg only, *D*. Coral, *A*; brachiopods, *B-L*). *A Streptelasma* (*Enterolasma*) *strictum*, x ¾. *B, C Spirifer cyclopterus*, x ¾. *D Bilobites varicus*, x 2. *E, F Dalmanella perelegans*, x ¾. *G, H Uncinulus abruptus*, x ¾. *I, J Uncinulus nucleolatus*, x ¾. *K, L Strophonella punctulifera*, x ¾, with enlargement.

tions were brought in from there. He has estimated (from the reports on Paleontology, volumes 3, 4 and 7, and Director's reports) the numbers of species of each class collected from the New Scotland beds around Clarksville, as follows (*ref. cit.*, p. 51)

Calcareous algae (Ischadites, Receptaculites)	2
Sponges	1
Corals	10
Bryozoans	71
Brachiopods	62
Lamellibranchs	9
Gastropods	21
Conularids	1
Trilobites	7
Cephalopods and ostracods	0
	184

The conclusion drawn is that "the two outstanding classes in this fauna are the bryozoans and brachiopods; the mollusks are only well represented by the gastropods; the trilobites are prominent as a faunal element, not so much by variety of species as by number of individuals, but they are far surpassed by the bryozoans and brachiopods" (*ref. cit.*). The lists from the Indian Ladder and other regions would add to the total number of species from the New Scotland. Two of the old collecting spots of interest in the Clarksville area are the "Brad" Allen farm, two miles east of the village, where the field across the road from the house was strewn with weathered-out fossils, and along the Onesquethaw creek below the old Slingerland Mill, at which locality (also in stone fences in the vicinity) a fine collection, especially of trilobites (*Lichas pustulosus, Dalmanites pleuroptyx, Acidaspis tuberculatus, Phacops logani* etc.), was made.

From the Countryman Hill (New Salem) section Prosser and Rowe ('99, p. 339) have listed 26 species; and in the same work (p. 350) record 43 species from the Clarksville area, but, as Ruedemann points out, they made no effort to collect from the bryozoan beds. These authors cite as "one of the best localities for collecting yet seen in the northern Helderberg region" the one along the highway below the house of K. P. Parrish on the old road leading up from New Salem. In later years the ground around the Voorheesville water works below the house has been a much frequented collecting ground. For the Schoharie region Grabau ('06, p. 321) records 115 species, including 5 corals, 6 bryozoans, 8 crinoids, 38 brachiopods, 15 pelecypods, 28 gastropods, 4 cephalopods, 2 conularids, and 9 trilobites.

The new road to John Boyd Thacher Park (Indian Ladder region) above New Salem passes through the entire thickness of the New Scotland, outcrops of these beds occurring for much of the way, and an almost complete section of the formation is exposed in the park along Rock road above the "Bungalow." Both these sections, but especially the latter, furnish excellent collecting. The writer has collected the following species (figures 37, 38) from the Rock road section:

Sponges

Hindia sphaeroidalis *Duncan*

Corals

Streptelasma (Enterolasma) strictum *Hall*
Favosites helderbergiae *Hall*
F. sphaericus *Hall*
F. conicus *Hall*
Michelinia lenticularis *Hall*

Crinoids

Edriocrinus pocilliformis *Hall*
Aspidocrinus scutelliformis *Hall*
Stems and joints

Bryozoans

Fenestella *cf.* compressa *Hall*
F. crebipora *Hall*
F. *sp.*
Paleschara incrustans *Hall*
Trematopora *sp.*
Ceramopora maculata *Hall*
Lichenalia maculosa *Hall*

Brachiopods

Spirifer perlamellosus (*Hall*)
S. macropleura (*Conrad*)
S. cyclopterus *Hall*
Leptaena rhomboidalis (*Wilckens*)
Atrypa reticularis (*Linnaeus*)

Brachiopods (continued)

Eatonia medialis (*Vanuxem*)
E. peculiaris (*Conrad*)
Meristella laevis (*Vanuxem*)
M. princeps *Hall*
M. arcuata *Hall*
Stropheodonta becki *Hall*
Strophonella headleyana *Hall*
S. leavenworthana *Hall*
S. punctulifera (*Con.*) *Hall*
Rhipidomella oblata *Hall*
Dalmanites perelegans *Hall*
D. subcarinata (*Hall*) *H. & C.*
D. planoconvexa *Hall*
Trematospira multistriata *Hall*
T. globosa *Hall*
Uncinulus abruptus *Hall*
U. vellicatus *Hall*
U. nucleolatus *Hall*
Nucleospira ventricosa *Hall*
Atrypina imbricata *Hall*
Orthothetes woolworthanus (*Hall*) *H. & C.*
Stenoschisma formosum (*Hall*)
Parazyga deweyi (*Hall*)
Rhynchonella bialveata *Hall*
Orbiculoidea discus (*Hall*)
O. *cf.* conradi (*Hall*)
O. *sp.*
Lingula rectilatera *Hall*
L. perlata *Hall*
L. spathata *Hall*

Pelecypods

Actinopteria textilis *Hall*
Aviculopecten tenuilamellata (*Hall*)

Gastropods

Platyceras ventricosum *Conrad*
P. gebhardi *Hall*
P. spirale *Hall*
P. platystomum *var.* alveatum *Hall*
P. unguiforme *Hall*
P. (Igoceras?) elongatum *Hall*

Conularids

Hyolithes centennialis *Barrett*

Pteropod

Tentaculites elongatus *Hall*

Cephalopods

Orthoceras *cf.* helderbergiae *Hall*
O. rude *Hall*
O. *sp.*

Trilobites

Dalmanites pleuroptyx (*Green*)
Lichas pustulosus *Hall*

The lower 20 feet of the New Scotland beds here are less shaly and have fewer fossils, only three species of *Lingula* and an *Orbiculoidea* having been collected. Seams of black chert were found in the upper 20 feet or so. At the four corners is shown the contact between the New Scotland beds and the overlying Becraft limestone (figure 39). The transition from the New Scotland to the Becraft is not sharp, since the lower Becraft has partings of shale and in the uppermost New Scotland occur limestone bands that are packed with crinoidal fragments.

An excellent section in the New Scotland, but not affording such good collecting, may be studied by following up the left branch of Outlet creek, just south of Rock road. This stream and the next two branches of Black creek to the south in the John Boyd Thacher Park area in their courses cross a section extending from the Indian Ladder beds to the Onondaga limestone, although the New Scotland section is not so good along the second (Minelot creek) and third streams. A little over a mile west of West Berne where the state road approaches close to the Fox kill the upper New Scotland beds and the transition to the typical Becraft are well shown along the stream. There are good exposures of New Scotland in the ravines joining the Fox Kill valley, but in general exposures of this formation are less frequent in the western part of the quadrangle.

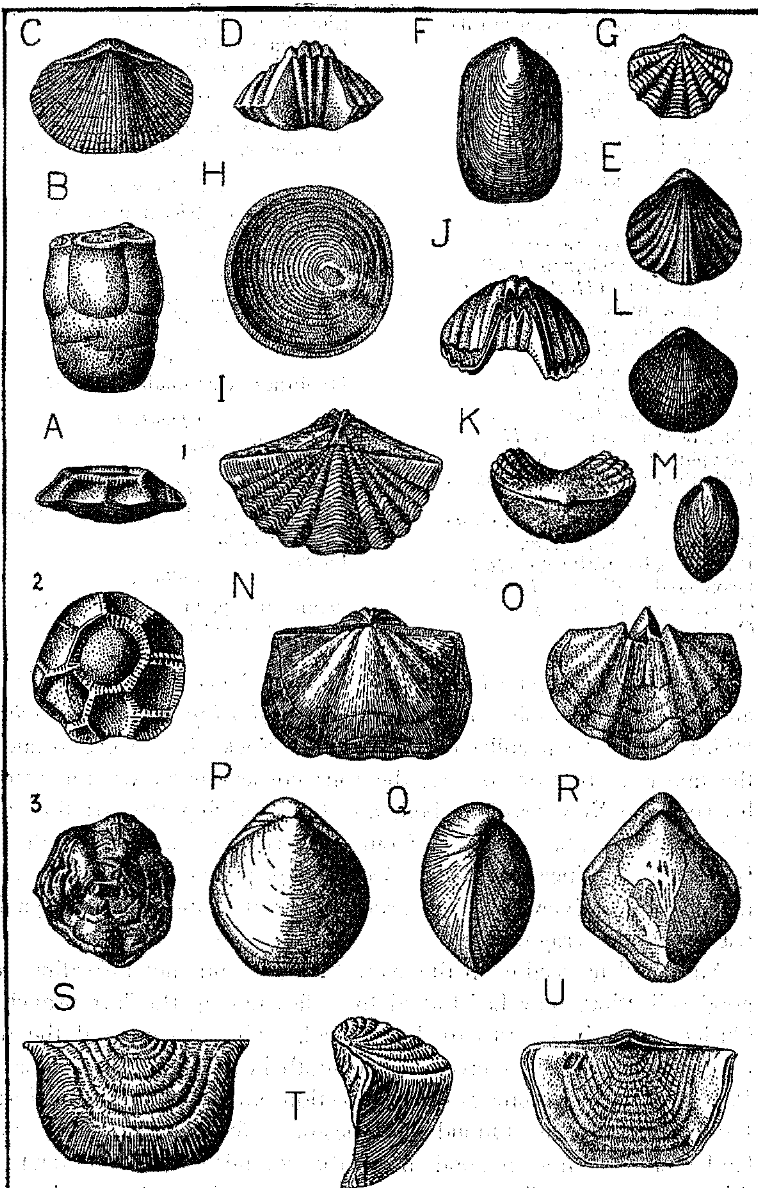


Figure 37 New Scotland limestone fossils. (Coral, *A*; crinoid, *B*; brachiopods, *C-U*). *A, 1, 2, 3 Michelinia lenticularis. B Edriocrinus pocilliformis*, x ¾. *C Trematospira multistriata*, x ¾. *D, E Stenoschisma formosum*, x ¾. *F Lingula rectilatera*, x ¾. *G Atrypina imbricata*, x ¾. *H Orbiculoidea discus*, x ¾. *I Spirifer perlamellosus*, x ¾. *J, K Eatonia medialis*, x ½. *L, M Parazyga deweyi*, x ¾. *N, O Spirifer macropleura*, x ½. *P, Q Meristella laevis*, x ¾. *R M. princeps*, x ¾. *S, T, U Leptaena rhomboidalis*, x ½.

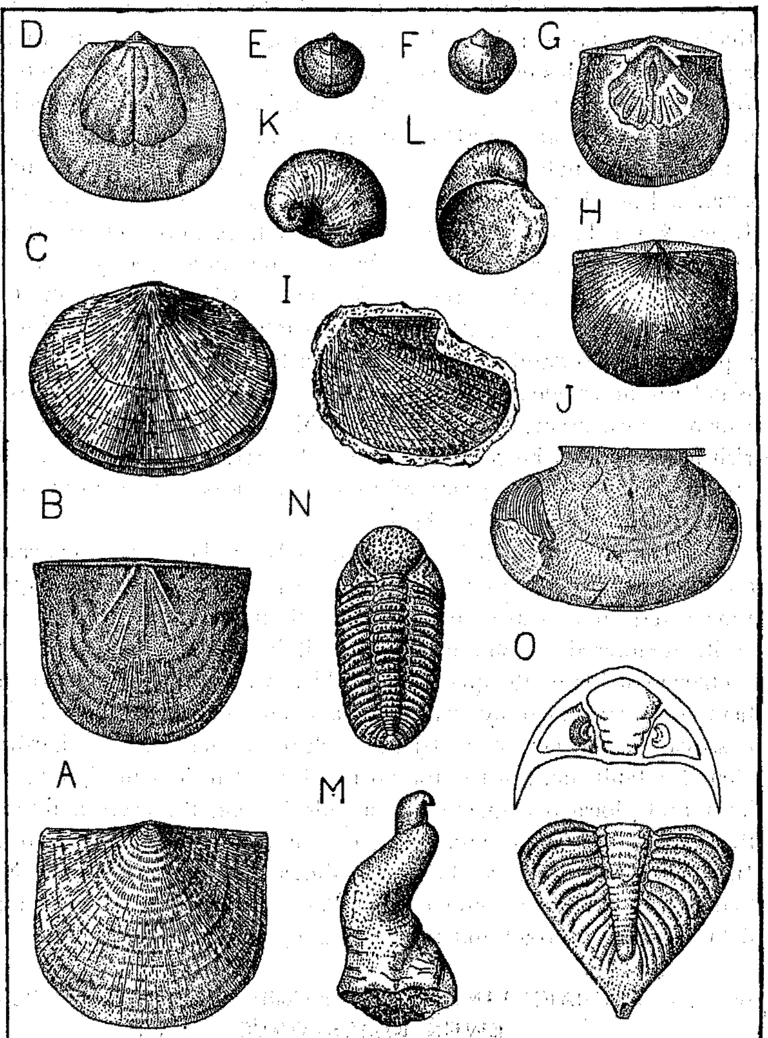


Figure 38 New Scotland limestone fossils. (Brachiopods, *A-H;* pelecypods, *I. J;* gastropods, *K-M;* trilobites, *N, O*). *A. B. Leptostrophia (Stropheodonta) becki,* x ¾, x ½. *C, D Rhipidomella oblata,* x ¾, x 1. *E, F Nucleospira ventricosa,* x ½. *G, H Schuchertella woolworthana,* x ¾. *I Actinopteria textilis,* x ¾. *J Actinopteria tenuilamellata,* x ¾. *K, L Platyceras ventricosum. M P. spirale,* x ½. *N Phacops logani,* x ¾. *O Dalmanites pleuroptyx,* x ½.

Darton ('94, p. 440) in his preliminary report on the geology of Albany county concludes that the shaly limestone has an average thickness of 100 feet throughout, and measurements made in various regions confirm his conclusion. Grabau ('06, p. 141, 254) found 115 feet in the Schoharie region (128 feet in West hill and Dann's hill) and 70 to 75 feet at Becraft mountain ('03, p. 1034). At Catskill the thickness is thought to be about 100 feet (G. H. Chadwick); and is estimated as about the same for the Kingston-Rondout area (Van Ingen & Clark, '03, p. 1180; Darton, '94, p. 498: 60 to 70 feet average for Ulster county). Prosser measured 120 feet in the Countryman hill section and 127 feet in the Clarksville region ('99, p. 337, 348). Some of the above measurements were made for the typical New Scotland and the transition beds (now separated as the Kalkberg limestone). The writer and Doctor Ruedemann found (aneroid measurement) 105 feet of this formation below the Parrish house where the contact with the Becraft limestone is exposed, and the writer obtained practically the same measurement in the Rock road section above the Kalkberg.

The New Scotland shaly limestone beds of the Berne quadrangle and the northern and middle Helderberg region of the Albany quadrangle rest in a nearly horizontal position and are very soft and easily weathered. "Where, however, it has been folded, as in the southern portion of the quadrangle (Albany), south of South Bethlehem, it is traversed by slaty cleavage and much harder. It also possesses a distinct slaty fracture cleavage and greater hardness along the fault south of the Indian Ladder" (Ruedemann, '30, p. 50). This fault, located a quarter of a mile beyond the eastern limit of the Berne quadrangle, and about one and a half miles east of the Indian Ladder (Rock road) is well shown in a road cut in the New Scotland. Exposures showing the slaty cleavage are found in the field between the road and the cliff edge, south of the fault.

10, 11, 12 BECRAFT LIMESTONE (including ALSEN(?) and PORT EWEN LIMESTONES)

This limestone in the earlier reports was known as the "Scutella" or "Encrinal" limestone, from the presence of numerous crinoid bases or Scutellas, and also as the "Upper Pentamerus" limestone because of the occurrence of the brachiopod *Pentamerus* (now *Sieberella*) *pseudogaleatus*. The name "Becraft limestone" was given to this formation by N. H. Darton ('94) with the approval of James Hall, and was derived from the exposure in the Devonian outlier, known as Becraft mountain, near Hudson (Columbia county).

The Becraft in the earlier correlations formed the top of the Silurian; later it became the uppermost member of the Helderbergian (Lower Helderberg) limestones; finally the overlying Alsen and Port Ewen limestones, represented on the Berne quadrangle, if at all, only toward the western boundary, were included in the Helderbergian group.

The rock is very coarse-grained and not infrequently has the character of a shell rock or coquina. Although usually somewhat darkened on weathering, the rock, typically, is light-colored with pinkish and light gray, sometimes yellowish tints. It is a very pure limestone on the whole and massive, forming conspicuous ledges. Chert is unusual. The lower part of the formation is thinner-bedded with seams of silicious shale, sometimes of a greenish color, one to several inches thick. These seams have an abundance of silicified fossils among which *Atrypa reticularis* is common. As pointed out above, there is no sharp transition from the New Scotland. This may be seen in the Indian Ladder area in the cut (nine feet) at the four corners on Rock road, (going west), where partings of shale in the lower Becraft and limestone bands with crinoidal fragments in the upper New Scotland are clearly seen (figure 39). A distinct disconformity with the overlying Oriskany is also shown here.

This formation does not have its typical development, either in thickness or, entirely, in character on the Berne quadrangle (figures 12, 16). It thickens southward and in the type section at Becraft mountain near Hudson, where it is extensively quarried for Portland cement, has a thickness of 40 to 45 feet (Grabau, '03, p. 1034). At Rondout there are 35 feet of this limestone (Van Ingen & Clark, '03, p. 1180) and Grabau ('06, p. 154, 254) measured 15 to 21 feet in the Schoharie region (West hill, Dann's hill). In the Helderberg area the beds vary from nine to 27 feet, only the lowest beds (nine feet) with shale seams appearing in the Indian Ladder area. Prosser and Rowe ('99, p. 336, 348) record 13 feet in the Countryman Hill section and 20 feet around Clarksville, but Doctor Ruedemann and the writer measured 27 feet two and a quarter miles south-southeast of New Salem. In the Altamont section Prosser ('00, p. 59) measured 10+ feet. In a quarry north of the state road, about one and a half miles east of Knox village, the writer measured 15½ feet of Becraft (figure 40) with 20 inches of Oriskany on top; and at Knox, just north of the four corners about 10 feet are exposed. In a cut along the state road about a mile northwest of West Berne 15 feet of the rock exposed have been identified as Becraft. Good exposures are to be found in some of the ravines joining the Fox Kill valley between West Berne and Gallupville. Outcrops of Becraft are fairly frequent throughout its extent on the Berne quadrangle, but of course somewhat less so in the more till-covered area toward the western portion of the quadrangle. In the upper beds of the West Berne-Gallupville region and along the Altamont-Knox state road the Becraft has a more typical character than in the Indian Ladder area.

The West Berne cut shows a good contact with the underlying New Scotland and about five feet of transition beds. The contact with the New Scotland is also well shown south of our area, just below the Parrish house, along the old road leading around Countryman hill. The Becraft spreads out in back of the house forming a fairly broad flat of bare rock showing well the joint system of the formation, and here is still recognizable the old "Beaverdam road," which was the first road that led from Schoharie to Albany. In spite of its small thickness the formation is prominently exposed and in places, as the above, spreads out to form flats of distinct breadth, as southeast of New Salem on the Albany quadrangle and to the north and west of the Indian Ladder area, particularly west of Knox.

The Becraft limestone, like the Coeymans below and the Onondaga above, is traversed by a system of joints which may be observed more or less well-developed on any of the Becraft flats. The series of joints have a northeast-southwest and northwest-southeast direction. Two groups seem to be the most prominent and to the southeast of the Indian Ladder area characteristic measurements are N. 7° to 17° E. and N. 38° to 48° W.; to the northeast (north of the four corners on Rock road) the measurements taken are N. 41° to 47° E. and N. 43° W. The joint fissures are widened by solution and deep circular and elliptical holes are formed. This typical limestone erosion is seen along the road (east) about a mile and a half southeast of the Indian Ladder. Here "karst" features, due to solution in limestone areas, are very well shown on a small scale. At this locality, also, 20 inches of Oriskany are seen at the bottom of the Esopus cut, and on the east side of the road the Becraft and Oriskany in contact. The disconformity is shown only by the missing beds. Here is a welded contact marked by an irregular line with a sharp change in sediment. The Oriskany surface has many rounded grains with dull, opaque surfaces which suggest that they are wind blown.

Sinkholes, another characteristic feature of a karst topography, are not commonly found in the Becraft. An interesting one, 100 feet or so in diameter, was discovered two and a quarter miles northeast

Figure 39 Cut at the four corners on "Rock road" (old Indian Ladder—Thompsons Lake road), showing the contact between the New Scotland and Becraft (at left, marked by hammer) and between the Becraft and Oriskany (at right, marked by tin cup). The débris has now been cleared away. (Photograph by E. J. Stein)

Figure 40 Quarry along (north of) Altamont-Knox road, about three-quarters of a mile west of the junction with the Thompsons Lake road, showing 15½ feet of Becraft limestone capped by 20 inches of Oriskany sandstone. (Photograph by E. J. Stein)

of Gallupville at the junction of the road to East Township with a road from the north (shown on the geological map as a small patch of New Scotland within the Becraft area). The full thickness of the Becraft is shown and its contact with the New Scotland. A small stream tumbles over the Becraft cliff on the east rim and disappears underground in the bottom of the bowl through the New Scotland beds.

Although composed of crinoid parts, shells and shell fragments, the Becraft has not furnished a very large fauna. There are some very characteristic fossils (figure 41) such as the shieldlike crinoid

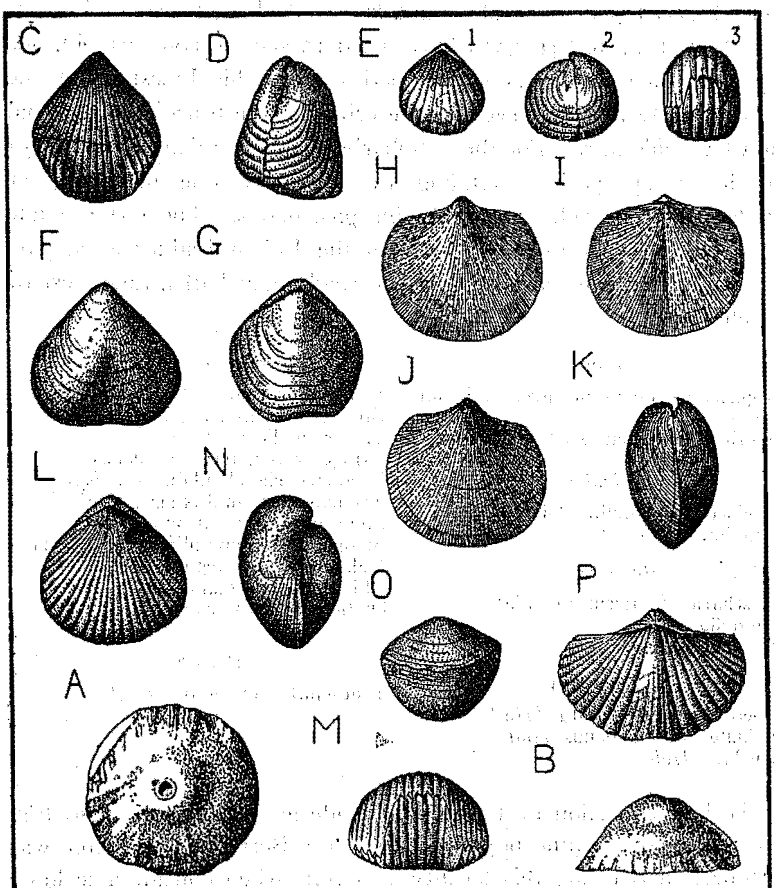


Figure 41 Becraft limestone fossils. (Crinoid base, *A, B*; brachiopods, *C-O*). *A, B Aspidocrinus scutelliformis. C, D Uncinulus campbellanus,* x ¾. *E 1, 2, 3 Wilsonia ventricosa,* x ¾. *F, G Meristella arcuata,* x ¾. *H, I Dalmanella subcarinata,* x ¾. *J, K Schizophoria multistriata. L, M Uncinulus nobilis,* x ¾. *N, O Sieberella pseudogaleata,* x ¾. *P Spirifer concinnus* x ¾.

base or anchor *Aspidocrinus scutelliformis* which is found throughout the Becraft, sometimes in great abundance, and also occurs in the upper New Scotland. These fossils give a very characteristic appearance to the rock, especially when seen in cross section, since they are rendered crystalline by secondary infiltration and are often of a pinkish or glistening white color. The Becraft may be seen in typical development, full of Scutellas, along the state road from Albany to Clarksville, a mile and a quarter east of the village and just before the intersection with the road connecting with the Feura Bush-Indian Fields state road. The brachiopod *Sieberella* (*Pentamerus*) *pseudogaleata* is also abundant and characteristic. Prosser and Rowe ('99, p. 341, 351) have listed 15 species (one crinoid, one bryozoan, two corals, 11 brachiopods) from this limestone at the Parrish house and ten species (one crinoid, nine brachiopods) from the Clarksville area. For the Schoharie region (Grabau, '06, p. 323) has listed 24 species including two crinoids, one pteropod, 11 brachiopods, one pelecypod and nine gastropods. The writer made the following collection of fossils in the Indian Ladder area, particularly at the four corners on Rock road about half a mile west of the cliff:

Corals

Streptelasma (Enterolasma) strictum *Hall*
Favosites sphaericus *Hall*

Crinoids

Aspidocrinus scutelliformis *Hall*
Stem joints

Bryozoans

Paleschara *cf.* incrustans *Hall*
Fenestella *sp.*
Bryozoan *sp.*

Brachiopods

Sieberella pseudogaleata (*Hall*)
Uncinulus campbellanus *Hall*
U. nobilis *Hall*

Brachiopods (continued)

Schizophoria multistriata *Hall*
Spirifer concinnus *Hall*
S. perlamellosus (*Hall*)
Atrypa reticularis (*Linnaeus*)
Leptaena rhomboidalis (*Wilckens*)
Trematospira multistriata *Hall*
Stenoschisma formosum (*Hall*)
Strophonella punctulifera (*Conrad*)
Dalmanella perelegans *Hall*
Rhipidomella oblata *Hall*
Orthothetes woolworthanus *Hall*

Pteropod

Tentaculites elongatus *Hall*

The best collection of fossils was made at the cut along the Fox Kill road about a mile northwest of West Berne. The writer was fortunate in reaching this locality at a time when considerable loose material at both sides of the road facilitated collecting.

Crinoids

Aspidocrinus scutelliformis *Hall*
Stems and joints

Bryozoans

Lichenalia (Fistulipora) torta (*Hall*)
Bryozoan *sp.*

Brachiopods

Sieberella pseudogaleata (*Hall*)
Wilsonia ventricosa (*Hall*)
Uncinulus nobilis *Hall*
U. campbellanus *Hall*
Schizophoria multistriata *Hall*
Spirifer concinnus *Hall*

Brachiopods (continued)

Meristella arcuata *Hall*
Trematospira multistriata *Hall*
Parazyga deweyi (*Hall*)
Atrypa reticularis (*Linnaeus*)
Leptaena rhomboidalis (*Wilckens*)
Meristella princeps *Hall*
M. laevis (*Vanuxem*)
Spirifer perlamellosus (*Hall*)
Dalmanella subcarinata *Hall*
Strophonella punctulifera (*Conrad*)
S. *sp.*
Rhynchonella *sp.*

The **Alsen limestone** comprises the cherty limestones which overlie the Becraft and bear the same relation to it as the Kalkberg does to the Coeymans. It was originally included in the Port Ewen as a basal phase, and was named (Grabau, '19) from the section at Alsen, N. Y. (where the Port Ewen is absent). Like the Kalkberg, it is a more impure limestone than the beds below, finer grained, dark blue-gray in color (except a lighter basal portion), often weathering into buff color. The limestone has a thickness of 20 to 50 feet or so; about 30 feet at Port Ewen, 20 feet in the Catskill area, 25 feet at Becraft mountain. The fauna is a modified Becraft fauna, and the fossils are more silicified than in the Becraft below.

The **Port Ewen beds** are a series of shaly limestone similar in character and fossil content to the shaly limestones (New Scotland) underlying the Becraft. The fauna is a mixture of New Scotland and prenuncial Oriskany forms. The sea withdrew from part of the Appalachian trough at the end of the Helderbergian epoch and in the erosion that followed much of the Helderberg deposits were removed in some areas. The lime sediments from this erosion, during the retreat of the sea in late Helderbergian, locally accumulated in depressions and formed a detrital lime rock, the Port Ewen beds.

When first shown to be a unit these beds were described as the "Upper Shaly beds" (Davis, '83). Later Clarke and Schuchert ('99) changed the name to Kingston beds, but as the name was preoccupied they were later called Port Ewen beds (Clarke, '03) from the town of that name, opposite Rondout, where they are best exposed. They have their best development in southeastern New York, where the maximum thickness is about 200 feet. At Rondout there is a thickness of about 150 feet; 30 to 35 feet in the Saugerties region and five or six feet in Austin's Glen, Catskill.

The **Alsen** and **Port Ewen limestones** are missing in the Helderberg sections northwest of the Catskill area until one approaches the Schoharie region (figures 12, 16). The easternmost exposure, showing one or the other or both of these formations, occurs on the Berne quadrangle in the road cut in the Fox Kill valley, west of West Berne. In the Schoharie region (West hill) Grabau ('06, p. 154) found 30 feet between the New Scotland and the Oriskany; 15½ feet of typical Becraft, 5½ feet of similar rock, then finer grained, darker and more compact limestones with fewer organic remains. In the section for West hill (*ref. cit.*, p. 254) he includes 21 feet in the Becraft and 9½ feet in the Port Ewen which he later regarded as Alsen ('19, p. 470). In the Fox Kill Valley cut there are about 20 feet of rock exposed and a total of 30 feet have been measured (aneroid) between the top of the New Scotland and the Oriskany, exposed in the bed of a side stream. We have here five feet of the lower, less typical Becraft (as in the Indian Ladder area); five feet of typical light gray Becraft with pinkish calcite; 34 inches of darker, finer grained limestone with Becraft fossils (full of *Sieberella pseudogaleata* but with fewer Scutellas); above this, 27 inches of finer grained, dark limestone with chert (one band thickening to four and a half inches, four or five inches from top); then 27½ inches of a drab, shaly limestone, resembling the New Scotland and with New Scotland fossils; finally, about 33 inches of dark, fine-grained limestone with a sparse fauna.

The writer collected from the drab-colored shaly band:

Corals

Streptelasma (Enterolasma) strictum *Hall*
Favosites sphaericus *Hall*
F. *sp.*

Bryozoans

Monotrypella *sp.*
Fenestella *sp.*
Bryozoan *sp.*

Brachiopods

Leptaena rhomboidalis (*Wilckens*)
Atrypa reticularis (*Linnaeus*)
Eatonia medialis (*Vanuxem*)
Spirifer perlamellosus (*Hall*)
S. concinnus *Hall*
S. cyclopterus *Hall*
S. *cf.* murchisoni *Castelnau*
Schizophoria multistriata *Hall*

Brachiopods (continued)

Strophonella punctulifera (*Conrad*)
Meristella laevis (*Vanuxem*)
M. arcuata *Hall*
Rhipidomella oblata *Hall*
Dalmanella subcarinata *Hall*
Trematospira multistriata *Hall*
Uncinulus *sp.*
Rhynchonella *sp.*
Stenochisma formosum (*Hall*)
Stropheodonta *cf.* becki *Hall*

Pelecypods

Actinopteria textilis *Hall*
A. communis *Hall*
Pterinea *cf.* schohariae *Hall*

In the dark, fine-grained limestone just below the shaly bed were found the brachiopods *Spirifer concinnus, Wilsonia ventricosa, Atrypa reticularis, Dalmanella* cf. *perelegans, Parazyga deweyi, Meri-*

stella laevis, M. arcuata and crinoid joints. From the fine-grained, dark limestone above the shaly band were collected some chert, the corals *Streptelasma strictum* and *Favosites* sp., numerous crinoid joints and stems, and the brachiopods *Spirifer concinnus, Wilsonia ventricosa, Atrypa reticularis, Stropheodonta* cf. *becki, Rhipidomella* sp., *Meristella* sp.

The writer is inclined to believe that in this Fox Kill Valley cut there are 15 feet of Becraft and the balance is Port Ewen, with the dark, finer grained limestone considered as transitional. If, the dark finer grained limestone with chert is regarded as Alsen then there is about 13 feet of Becraft followed by an interfingering of Alsen and Port Ewen, for the drab shaly bed as shown by the character of the rock and the fossils, is surely Port Ewen.

13 ORISKANY SANDSTONE

Partly because of the fine collections of remarkable fossils that have been obtained from it, partly from its geological position at the base of the series of formations formerly known as the upper Helderberg group (now Oriskanian and Ulsterian series), the Oriskany is one of the formations best known to paleontologists and geologists. In the early days of the Survey under the leadership of James Hall it was regarded as the base of the Devonian (in America); now with the Esopus grit it forms the Oriskanian which with the Helderbergian series below constitutes the Lower Devonian. At the type locality, Oriskany Falls, Oneida county, from which it derives its name (Hall, '39; Vanuxem), the Oriskany sandstone consists of a nearly pure, white fossiliferous quartz-sand rock, 20 feet in thickness. In the Helderberg region this formation is represented by a very dark, bluish gray to blackish, hard quartzose sandstone with a strong admixture of calcareous matter that increases southward but is variable in the Helderbergs.

This sandstone represents shore deposits of the transgressing sea in Oriskany time. The early Oriskany sea was restricted to the eastern part of the present Helderberg area. When the westward transgression of this sea occurred the subsiding land surface was more or less irregular due to elevation and erosion at the end of Helderbergian time. In the east the lower Oriskany beds overlie the Port Ewen, the uppermost member of the Helderbergian series. In the northern Helderbergs the Oriskany rests upon the Becraft, in the Schoharie area on the Alsen, at Litchfield in Herkimer county on the Coeymans, in central New York on the Manlius and in western New York and Canada on the Cobleskill. From Manlius (Onondaga county) westward the so-called Oriskany sandstone occurs as a series of thin lentils, sometimes does not appear at all or is represented only by scattered sand grains or sand filling in crevices in the rock below. Some (E. O. Ulrich) consider this the clastic initial deposit of the Onondaga.

In the east the Oriskany formation is represented by both arenaceous and calcareous sediments. In the Cobleskill-Schoharie area the rock is a mixture of quartz and lime grains. Where the rock is exposed the lime is commonly dissolved out leaving a brown, porous sandrock in which the fossils are beautifully preserved as both internal and external molds. In this area the formation has a maximum thickness of five or six feet (West hill), in some places being only one or two feet or less thick, perhaps missing in others (Grabau, '06, p. 158). In the northern Helderberg area the rock is similar with a maximum thickness of about four feet and an average of only one or two feet (figures 12, 16). Darton ('94, p. 439) gives the thickness in Albany county as varying from one to four feet with an average of about three feet for the greater part of the area. He also notes the absence of the formation for several miles south of Callanans Corners (near South Bethlehem). Prosser ('00, p. 56, 59, 61) has recorded a thickness of one foot to one foot four inches south of the Indian Ladder cliff, one and three-quarters to two feet in the Altamont section and 2+ feet (very fossiliferous) in the Knox area. The writer found 42 inches of this formation just north of the crossroads in the village of Knox; 33 inches in the woods along the road a mile or so to the northeast; 20 inches capping the Becraft limestone in the quarry along the Altamont-Knox state road (figure 40); 33 inches in the cut at the four corners (Rock road) about half a mile west of the Indian Ladder cliff (figure 39) and 18 to 20 inches in the base of the Esopus gravel pit about one and a half miles southeast of the Indian Ladder. In the last-named locality a welded contact (p. 116) with the underlying Becraft is shown (east side of road). Here the contact with the overlying Esopus shale is likewise sharp, even though the lower Esopus beds are flinty in character and quite similar to the Oriskany. Prosser and Rowe ('99, p. 336) measured two feet of Oriskany in the Countryman hill section and one foot around Clarksville. Ruedemann ('30, p. 57) cites three feet one inch occurring as a ledge that crosses the Onesquethaw creek one and a half miles below Clarksville.

Going southward from the Helderberg area the rock soon changes in character and becomes a chert or cherty limestone. In the Catskill area in Greene county it no longer has its typical appearance,

Figure 42 Oriskany terrace traversed by the road leading north from the four corners on "Rock road" (old Indian Ladder-Thompsons Lake road). (Photograph by E. J. Stein)

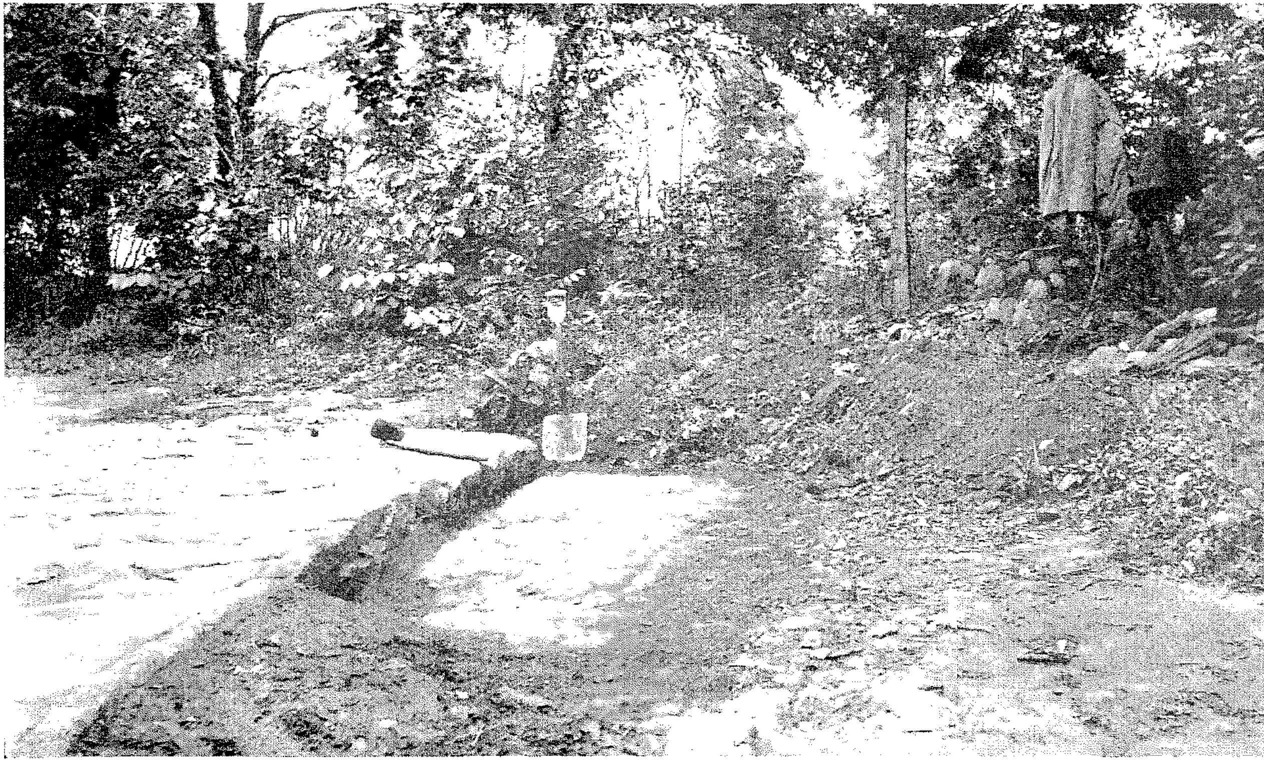


Figure 43 One of the "step faults" in the Oriskany sandstone. North of the four corners on the old Indian Ladder-Thompsons Lake road ("Rock road"). (Photograph by W. F. Winter)

although characterized, as the typical beds, by the brachiopod *Spirifer arenosus*. Farther southward it thickens more and more and highly fossiliferous limestone beds (*Glenerie limestone;* Chadwick, '08) come in at the top and still farther south a basal pebble conglomerate (*Connelly conglomerate; ref. cit.*), 18 to 20 feet thick, also of Oriskany age. In Orange county the beds representing Oriskany were divided (Shimer, '05) into Lower Oriskany (30 feet; *Port Jervis limestone*) or *Dalmanites dentatus* zone with Helderbergian and Oriskany species; and the Upper Oriskany (150 feet), the zone of *Spirifer murchisoni*. The deposits of Oriskany age in southeastern New York (Port Jervis region) are considered as representing a deep-water or calcareous phase of the shallow-water, typical Oriskany sandstone. Certain of the large typical Oriskany fossils (as *Rensselaeria ovoides, Hipparionyx proximus*) are absent from the Port Jervis region, which might be accounted for by depth of water (Shimer, '05), and there is also a persistence of Helderbergian species in this region to the beginning of the Esopus.

Because of its flinty nature the Oriskany is very hard and resistant and, therefore, wherever the beds are more or less horizontal, as in the Helderberg area, even though of little thickness, it forms a distinct broad platform or terrace, the softer Esopus above having been eroded away. Such a terrace is well shown in the Countryman hill area in back of the barn of the Parrish house and north of the house continuing for a considerable distance along the old road; in the Indian Ladder region in the woods and field south of Rock road, in the woods just back (west) of the park superintendent's house, and especially along the old road leading north from the four corners on Rock road (figure 42). By far the best exposures of Oriskany terraces occur to the east and west of Knox. The Altamont-Knox road leads for some distance over one of these platforms, which is also well exposed in the woods at the north. The surface of the Oriskany in most exposures is seen to be covered with the characteristic worm burrows, *Taonurus cauda-galli*, which also mark the bedding planes of the Esopus shales and which because of their appearance were termed "Cock-tails."

The Oriskany is broken up into blocks by a system of intersecting joint fissures; and this has been a factor in making the sandstone so satisfactory for use in the old stone fences. These joint fissures are noticeable in all Oriskany exposures. Their direction has been measured along the road leading north from the four corners on Rock road (three-quarters of a mile northwest of the Indian Ladder cliff). As in the case of the Becraft and Coeymans limestones, the two main groups run northeast-southwest (N. 40° to 45° E.) and northwest-southeast (N. 43° to 57° W.). In this area, where the road leads through the woods, are shown a series of at least four small faults, known as "step faults," varying from a few inches to at least ten inches in displacement (figure 43). Faulting has taken place along the northeast joint planes and in places has been seen to cut across glacial striae demonstrating that the faults are postglacial in age.

In the fresh rock it is difficult to distinguish the Oriskany fossils; but they are beautifully preserved as internal and external molds in the decayed rock, and splendid collections were obtained in the old days largely in the old stone fences around Schoharie and in the Helderbergs. The State Museum has a fine collection obtained later from weathered joint cracks in the Glenerie limestone at Glenerie, near Kingston in Ulster county. Among the most common and characteristic fossils (figure 44) to be found in the Helderberg region are the brachiopods *Spirifer arenosus* and *S. murchisoni*, *Hipparionyx proximus*, *Rensselaeria ovoides*, *Leptocoelia flabellites* and the gastropod *Platyceras nodosum*. The worm burrows, *Taonurus cauda-galli* Vanuxem, or "Cock-tails," are also characteristic on exposed surfaces. The best collecting places on the Berne sheet are the cut at the four corners on Rock road, about half a mile west of Indian Ladder cliff, the stone fences along the road leading north from there and, particularly, the stone fences along the Altamont-Knox road to the east of the village. Prosser ('00, p. 59) collected eight Oriskany brachiopods in the Altamont section:

Rensselaeria ovoides (*Eaton*)
Spirifer murchisoni *Castelnau*
S. arenosus (*Conrad*)
Eatonia peculiaris (*Conrad*)
Rhipidomella musculosa (*Hall*)
Metaplasia pyxidata (*Hall*)
Hipparionyx proximus *Vanuxem*
Meristella lata *Hall*

The writer made the following collection in the Indian Ladder area, at the four corners on Rock road:

Brachiopods

Rensselaeria ovoides (*Eaton*)
Hipparionyx proximus *Vanuxem*
Spirifer arenosus (*Conrad*)
S. murchisoni *Castelnau*
Leptostrophia *cf.* magnifica (*Hall*)
Anoplotheca (Leptocoelia) flabellites (*Conrad*)
Eatonia peculiaris (*Conrad*)

Pelecypods

Actinopteria textilis *var.* arenaria *Hall*

Gastropods

Diaphorostoma ventricosum *Conrad*
Platyceras nodosum *Conrad*
P. *sp.*

Prosser and Rowe ('99, p. 341) list 12 brachiopods and two gastropods from the Countryman hill section in the vicinity of the Parrish house, and Grabau ('06, p. 324), for the Schoharie region, has a

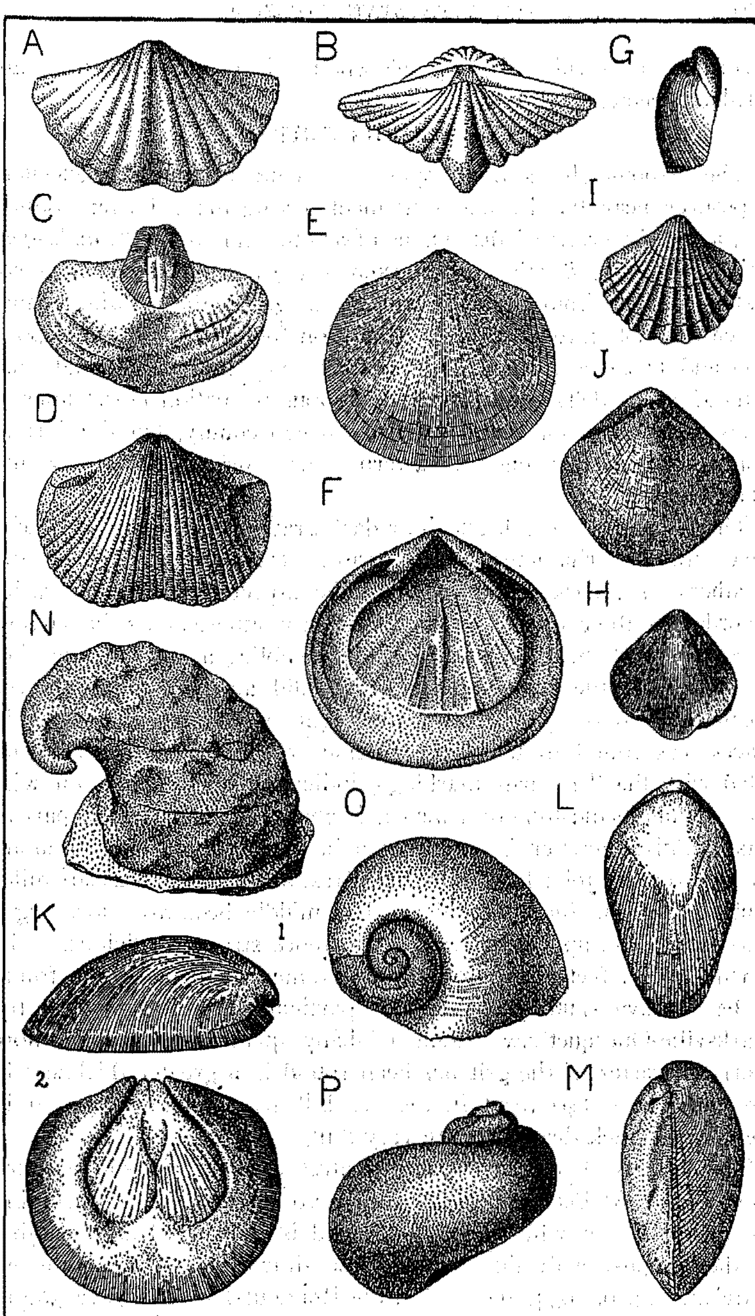


Figure 44 Oriskany sandstone fossils. (Brachiopods, *A-M*; gastropods, *N-P*). *A, B Spirifer murchisoni*, x ¾. *C, D S. arenosus*, x ½. *E, F Rhipidomella musculosa*, x ¾. *G, H Eatonia peculiaris. I Leptocoelia flabellites. J Meristella lata*, x ¾. *K 1, 2 Hipparionyx proximus*, x ½. *L, M Rensselaeria ovoides*, x ½. *N Platyceras nodosum*, x ½. *O, P Diaphorostoma (Platystoma) ventricosum*, x ¾.

record of 19 brachiopods, five pelecypods, six gastropods, one conularid, one cephalopod.

14 ESOPUS GRIT

The Esopus shales or Esopus grit, named from the excellent exposures near the Esopus settlement (Kingston), Ulster county, and along the creek of that name (Darton, '94), is the *"Cauda-galli grit"* or *"Cock-tail grit"* of Vanuxem ('42) and other earlier geologists, so-called from the abundant markings on the bedding planes which resemble a rooster's tail. Elevation followed Oriskany deposition and in eastern New York we have only the coarse sands and grits of a mud delta constituting the Esopus formation (Oriskanian). These shales are not found west of Otsego county, but the formation is a persistent one in eastern New York, New Jersey and Pennsylvania.

The Esopus grit is a blackish or dark gray grit or sandy shale of a very uniform character which readily crumbles to gravel and weathers to a dark brown color. The aspect of this rock varies according to the character of the cuts. In weathered cuts the surface is covered with small, cubical blocks, resembling a pile of stone, but in other cuts the rock appears very solid and resistant. In the northern Helderberg area the lower eight or ten feet of the grit in places was found to be highly silicious or flinty (figure 45) and filled with the Taonurus markings, indicating a close relation with the Oriskany sandstone of which it is considered a facies, in part at least. This character is well shown in a road metal quarry along the new road to John Boyd Thacher Park, about one and a half miles southeast of the Indian Ladder. The middle beds are more argillaceous and the uppermost beds again more strongly silicious. The last five or six feet of this formation in a number of places are found to be a heavy sandstone, which is particularly well shown in the Clarksville-Onesquethaw region (Albany quadrangle). The more cherty character of the grit has been found in a greater thickness in the lower beds (40 feet) in the Catskill area (Chadwick) and in the Esopus creek these beds are very flinty.

The Esopus shales have their greatest thickness in southeastern New York. At Becraft mountain there are about 300 feet, including the Schoharie, of which about one-third is considered as belonging to the Esopus, with the dividing line drawn on lithic characters (Grabau, '03, p. 1034, 1069). In the Rondout-Kingston area 300 to 325 feet have been measured (Van Ingen & Clark, '03, p. 1204; Darton, '94, p. 497) and at Port Jervis 550 to 700 feet (Shimer, '05, p. 192), whence it extends into New Jersey and Pennsylvania. In

Figure 45 Stream over the Esopus grit along (west side of) the John Boyd Thacher Park road. The lower more silicious beds forming the falls are well shown. (Photograph by E. J. Stein)

Figure 46 Cut in Esopus grit along (west side of) the John Boyd Thacher Park road. The jointing of the rock is well shown and also the ease with which it breaks up into a gravel. (Photograph by E. J. Stein)

the northern Helderbergs there is a thickness of 100 to 120 feet, while toward the Schoharie area (Grabau, '06, p. 170) the formation loses in thickness (80 to 90 feet), disappearing farther west in Otsego county.

Darton ('94, p. 438) found the thickness of the formation averaging about 100 feet in Albany county. Doctor Ruedemann and the writer measured 120 feet just below the O'Connell house along the new road to John Boyd Thacher Park, 100 feet above the Parrish house and 105 feet on the southeastern slope of Countryman hill. Prosser and Rowe ('99, p. 348) record 121 feet for the Clarksville and Countryman hill sections. For that portion of the Helderberg area covered by the Berne quadrangle the writer found the Esopus with a thickness of about 80 to 100 feet. In the Indian Ladder region 100 feet were measured. Prosser ('00, p. 55, 61) records the same measurement for the Indian Ladder section and 83 feet for the section near Knox.

Because of its softer character and the fact that it lies in a practically undisturbed area, the Esopus grit forms a very characteristic slope between the terraces formed on the Oriskany sandstone below and the Onondaga above and is in its broader areas often given up to grazing, though the vegetation is sparse in places. In much disturbed areas the Esopus becomes harder and develops a strong slaty cleavage with the result that it stands out in very sharp ridges of barren aspect, as seen on the Albany quadrangle two miles south and southwest of South Bethlehem and thence southward (Ruedemann, '30, p. 60). The jointing in the Esopus is prominent and characteristic. The rock when viewed at one of these joint surfaces gives the appearance of being very massive and hard (figure 46). In this system of intersecting joints usually two groups are more prominent and their direction is much the same as in the lower formations (N. 27° to 33° E.; N. 58° to 63° W.).

There are a number of cuts on the Berne quadrangle, accessible for study. In the Indian Ladder area there are good sections along the courses of the three streams south of the Indian Ladder (Rock road) in the park, particularly south of the superintendent's house (third stream south). About one mile and a quarter southeast of the Indian Ladder (just outside the Berne quadrangle, near the fault) a little south of the road is an excellent exposure showing the general character of the rock and the jointing; and a quarter of a mile farther southeast is the road metal quarry with the Oriskany forming the floor. Another good exposure in the area is found in the road cut north of the upper end of Thompsons lake, and the rock also outcrops on the northwest shore of the lake. On the south side of the Altamont-Knox state road, beyond the junction with the Thompsons lake road are a number of good exposures, several of them in road metal quarries along the road. West of Knox, as the till covering becomes heavier, outcrops are fewer and likely to be found only in occasional road cuts and deeper ravines.

Two of the best Esopus sections are found south of our area on the Albany quadrangle and both are very accessible. An almost complete section is now exposed in a road cut along the New Salem-Wolf hill state road about two and a half miles south of New Salem. Vertical glaciated surfaces may be seen in the upper part of the section, along the right side of the road. The finest and most striking exposure (practically the complete thickness) is found in the gorge of the Onesquethaw below Clarksville.

Except for the worm burrows, *Spirophyton (Taonurus) cauda galli,* the Esopus grit is remarkably barren of organic remains. These markings (figure 47) were formerly regarded as impressions of

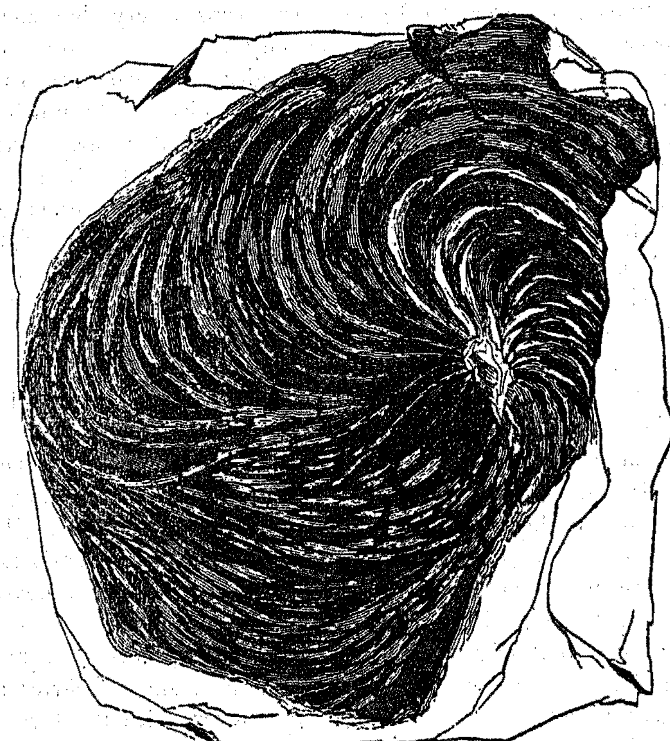


Figure 47 Esopus grit fossil. The worm burrow or "Cock-tail," *Taonurus cauda-galli.*

"fucoids" or seaweeds, and more recently (Grabau, '06, p. 168) have been considered "inorganic, representing wave-marks of a peculiar type." They have since been shown (Sarle) to be produced by mud-swallowing worms and Ruedemann ('30, p. 59) notes the presence in the State Museum collection of two specimens of a Taonurus from the Hamilton shale of Western New York which "actually shows the worms in place at the outer edge of the markings."

No fossils were found in the Esopus shales of the Schoharie region (Grabau, *ref. cit.* p. 170) or the Port Jervis area (Shimer, '05, p. 192). In the Esopus creek (Rondout-Kingston) area a few brachiopods have been collected (Van Ingen & Clark, '03, p. 1204), namely: *Anoplotheca (Leptocoelia) acutiplicata* (Conrad), *Atrypa spinosa* Hall, and an obscure Discinoid brachiopod. A few fossils, mostly brachiopods, have been found in the lower silicious beds of the Catskill area (G. H. Chadwick, in conversation and manuscript): *Anoplotheca (Leptocoelia) flabellites* (Conrad) var., *Chonostrophia complanata* Hall and *Orbiculoidea* sp. among the brachiopods, the gastropod *Platyceras* sp. and, doubtfully, land plants. Chadwick suggests that the lower fossiliferous portion may eventually require a separate name. A small brachiopod has been collected in the Helderbergs (Ruedemann; Albany quadrangle).

15 SCHOHARIE GRIT

The Schoharie grit is of somewhat local development, and receives its name (Vanuxem, '40) from the type locality in Schoharie county (at Schoharie) where it is characteristically developed. It occurs also in Albany and Otsego counties and in the Hudson valley, but is apparently not everywhere continuous, as the Onondaga and Esopus in places (west of Callanans Corners; north and west of Clarksville) in the Capital District have been found in direct contact (Ruedemann, '30, p. 60, 62; Darton, '94, p. 438).

In its characteristic development in the Schoharie valley this formation 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 Schoharie area the Schoharie grit has a thickness of five to eight feet (Grabau, '06, p. 180, 254); in the northern Helderberg and Capital District area it varies from nothing to a thickness of about eight feet. Farther east, or southeast, the formation thickens. A thickness of about 100 feet has been found in the Catskill area, and there it is more of the nature of a fine-grained impure limestone (G. H. Chadwick). At Becraft mountain 150 to 200 feet of shale are referred to the Schoharie, because some of the characteristic fossils have been found in it, though in rock aspect the shale is more similar to the Esopus (*ref. cit.* p. 181; '03, p. 1069). The variable occurrence of the Schoharie grit and its character in the northern Helderberg and Capital District area suggest that it is a sandy facies of the Onondaga. Not only is it found merging into the overlying Onondaga (as already noted by Darton), with the lower Onondaga somewhat sandy, but interfingering of the grit and the limestone has been observed and fossils (corals and cephalopods) have been found passing freely across the welded contacts. Doctor Ruedemann and the writer found two large boulders showing the alternation of the Onondaga limestone and the Schoharie grit. One along the east (left) side of the state road, one and a quarter miles south of Keefers Corners, showed two layers of the Schoharie grit (seven and five inches thick) separated by a band of Onondaga limestone (11 inches thick) which in turn has a two inch band of Schoharie grit in the middle (see Ruedemann, '30, p. 60, figure 55). The second block is located in front of the N. Blair house just opposite the Hannacrois falls along the state road to Westerlo. Similar boulders were found in the upper Onesquethaw creek and fossils (corals and cephalopods) were observed passing freely across the contacts. There is no doubt that these boulders are of local origin and come from the Helderberg region. While mapping with Doctor Ruedemann on the Albany quadrangle an outcrop was studied near the Callanans Corners-Coeymans road, about three-quarters of a mile from the junction, in the woods at the west. Here was found the greatest thickness (six to eight feet) of the Schoharie in the Helderberg area, showing interfingering of the Schoharie and Onondaga, with the lower Onondaga somewhat sandy (*ref. cit.* p. 61). On the other hand, disconformities at the top and bottom of the Schoharie grit, indicated by the presence of glauconite, have been reported from the Catskill region (G. H. Chadwick, in conversation and abstract of Geological Society Meeting, '27).

There are few exposures of the Schoharie grit in the northern Helderberg area. Prosser ('00, p. 55) for the Indian Ladder region, cites this formation as "shown on a south road at the base of the light gray Onondaga limestone," and has measured three and a half feet. The writer found a fair exposure along the old road following the upper course of Minelot creek (forming second falls east in Indian Ladder gulf) at and near the spring flowing out beneath the Onondaga along the road at the right. This is believed to be Prosser's locality, but the thickness could not be measured. Good specimens of both cup and compound or head corals have been found here.

Anyone interested in studying the Schoharie grit will find good exposures just to the south of our area on the Albany quadrangle (Ruedemann, '30). Prosser and Rowe for the Countryman Hill section record ('99, p. 336) two feet ten inches of "an impure, dark gray limestone which weathers to a buff, porous sandstone, shown in places at the base of the Onondaga limestone on the cliff south of west of the house of Mr K. P. Parrish." A more accessible exposure occurs along the old road leading over the southern slope of Countryman hill, less than half a mile from the junction with the Parrish hill road. Here 22 inches are fully exposed at the foot of the Onondaga cliff at the north side of the road and fossils may be collected. In the woods at the north along the New Salem-Wolf Hill state road, just where the road leads up over the hill onto the Onondaga terrace, a thickness of about three feet is exposed, with fossils. Ruedemann (*ref. cit.*, p. 60) and Darton ('94, p. 437) find that the best exposures of the Schoharie grit in the Capital District (Albany quadrangle) occur around Clarksville, and in the Callanans Corners-South Bethlehem area (p. 136). Prosser and Rowe ('99, p. 348) measured three feet for the Clarksville-Onesquethaw creek section at the foot of the upper gorge and the top of the lower. Doctor Ruedemann and the writer found here, on the south side (near the top) of the gorge below the falls, two feet seven inches of typical Schoharie and below this one foot of gritty, shaly layers weathering like the Schoharie grit and transitional to the Esopus below. There is a sharp contact above with the Onondaga limestone, the bottom layer of which is soft and weathered out. The upper two feet of the Schoharie grit are very fossiliferous with corals abundant in the upper eight inches.

Although for much of its extent a thin formation, the Schoharie grit is remarkable for its great wealth of fossils (figure 48). The Schoharie-Helderberg area has furnished 123 species of fossils including 2 bryozoans, 33 brachiopods, 14 pelecypods, 12 gastropods, 2 pteropods, 44 cephalopods, 16 trilobites (Grabau, '06, p. 327). Although no corals are listed by Grabau, Ruedemann (*ref. cit.*, p. 62) and the writer in the mapping of the Albany and Berne quadrangles have found both corals and cephalopods abundant. Species of *Zaphrentis* and *Favosites* have been collected in the Indian Ladder region and Prosser and Rowe (*ref. cit.*, p. 352) cite *Zaphrentis* as common and *Streptelasma* as abundant in the Clarksville section. Ruedemann (*ref. cit.*) in his discussion of the fauna remarks:

The largest biota of this fauna is the cephalopods which prevail so much in individuals and species, as well as size of the fossils, that the Schoharie grit is a distinct cephalopod facies. To this must be

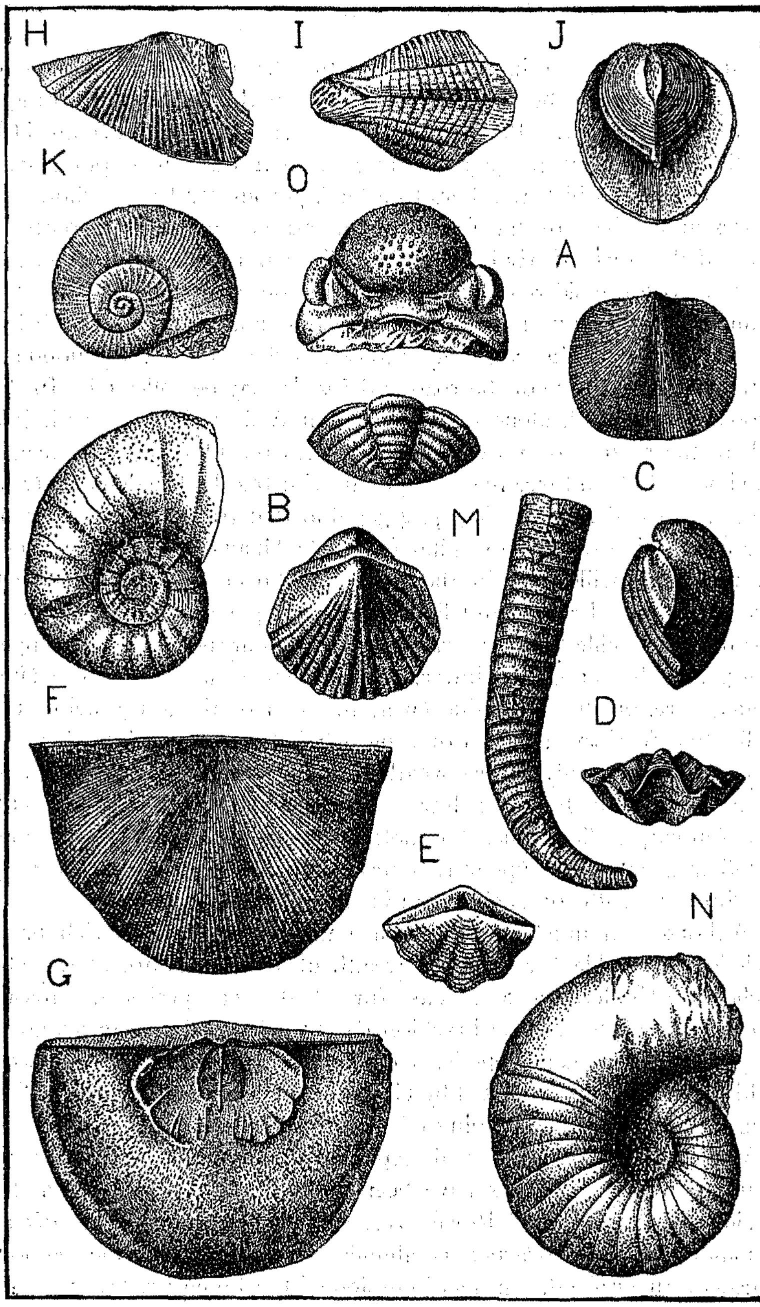


Figure 48 Schoharie grit fossils. (Brachiopods, *A-G*; pelecypod, *H-J*; gastropod, *K*; cephalopods, *L-N*; trilobite *O*). *A Rhipidomella alsa*, x ¾. *B, C Pentamerella arata. D, E Spirifer raricostatus*, x ¾. *F, G Strophonella ampla*, x ¾. *H-J Conocardium cuneus*, three views, x ¾. *K Pleurotomaria arata*, x ½. *L Trochoceras discoideum. M Cyrtoceras (Ryticeras) eugenium*, x ½. *N. Trochoceras eugenium*, x ½. *O Phacops cristata:* head, x ¾; pygidium.

added that there appear a number of species that are rare in general, as seven species of *Gomphoceras*, two of *Gyroceras* and no less than nine species of the aberrant *Trochoceras* whose shells are coiled in gastropod fashion and which is known practically only from this formation. To these may be added 16 species of trilobites, among them such monstrous and rare forms as *Lichas (Terataspis) grandis* Hall and *Lichas (Conolichas) hispidus* Hall & Clarke. No wonder the Schoharie grit has been the stamping ground of collectors from all over the world, especially in the Schoharie valley, and is yet as far as the increasing rarity of stone fences and of favorable outcrops does not discourage or stop the pursuit.

Since no considerable collections have been made on the Berne quadrangle a typical collection (Prosser and Rowe, '99, p. 352) from a near-by area in the Helderbergs (Clarksville section) is here listed:

Corals

Zaphrentis *sp.*
Streptelasma *sp.*

Brachiopods

Strophonella ampla (*Hall*)
Atrypa reticularis (*Linnaeus*)
Pentamerella arata (*Conrad*)
Meristella nasuta (*Conrad*)
Pentagonia unisulcata (*Conrad*)
Centronella glans-fagea *Hall*
Rhipidomella peloris *Hall* (?)
R. alsa *Hall*
Schizophoria propinqua *Hall* (?)
Spirifer raricostatus (*Conrad*)
S. duodenarius (*Hall*)
S. fimbriatus (*Conrad*)
Orthothetes pandora (*Billings*)

Brachiopods (continued)

Chonetes hemisphericus *Hall*
Cyrtina hamiltonensis *Hall*
Stropheodonta perplana (*Conrad*)
S. inaequiradiata *Hall*
S. demissa (*Conrad*)
Coelospira camilla *Hall*
Amphigenia elongata (*Vanuxem*)

Pelecypods

Cypricardinia planulata (*Conrad*)
Conocardium cuneus (*Conrad*)

Cephalopods

Orthoceras zeus *Hall* (?)
Orthoceras *sp.*
Cyrtoceras *cf.* eugenium *Hall*

Trilobites

Phacops cristata *Hall*
Dalmanites anchiops (*Green*)

16 ONONDAGA LIMESTONE

This formation, deriving its name from its occurrence in Onondaga county (Hall, '39), has a very wide distribution, far surpassing that of the other Helderberg formations. It extends with very uniform character of rock and fauna from New Jersey in the southeast across the State into Ontario, Canada. The present name, proposed by Hall, now includes all divisions of the formation to which the names "Onondaga" (Hall), "Corniferous" (Eaton) and "Seneca" (Vanuxem) limestone were applied in western New York by geologists of the first survey. The "Corniferous" was the cherty division and the purer upper limestone was the "Seneca."

The Onondaga forms the third limestone terrace and the second great cliff of the Helderberg escarpment, fairly half way up, and is seen from the Albany lowland as a conspicuous gray band more interrupted than the one below formed by the Coeymans-Manlius limestones. Because of the difference in resistance to weathering between the hard, compact Onondaga limestone and the black Marcellus shale, the overlying softer shales have been extensively eroded away from the limestone leaving it as a continuous terrace along the Helderbergs. In the Countryman Hill section and northwest nearly to the Indian Ladder region the terrace is not very wide, but it "becomes more than a mile wide south of Countryman hill and forms the broad stretch of good farming land, on which the village of Clarksville and the hamlet of Onesquethaw stand. The map (Albany quadrangle) also shows distinctly how the roads follow this terrace, often running for miles on the bare rock, as for example the Clarksville-Onesquethaw road and Onesquethaw-Callanans Corners road at the foot of Copeland hill" (Ruedemann, '30, p. 65). On the Berne quadrangle the Onondaga terrace broadens to a width of more than a mile to the east (including the Indian Ladder region) and west of Thompsons lake, and farther west, between Berne and West Berne where it forms the floor of the Fox Kill valley, there is a maximum breadth of over three and a half miles.

The Onondaga 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 occur (figure 50), particularly in the lower part of the formation, but its distribution is very irregular and it has been found to be abundant in some places, sparse in others. The uppermost beds ("Seneca") are free from chert, and often the lowest beds. According to Prosser and Rowe ('99, p. 347), a well record in the Clarksville area showed the upper nine feet entirely clear of chert; below this, 15 feet with chert very abundant; in the lower part of the formation, chert encountered but in rather small quantities. The chert lenses or bands are shown wherever the upper beds of the formation outcrop, but they are studied to best advantage in quarries. In the town of New Scotland road metal quarry, situated on both sides of the New Salem-Wolf Hill state road, is an excellent exposure showing fine chert bands, each four to six inches thick. Along the Berne-West Berne state road (left), just outside the village of Berne is another quarry in the upper Onondaga, providing a good study locality (figure 49). In the lower 15 feet here are four distinct chert bands from a few inches to eight inches in thickness. The upper six feet or so show no chert. The chert bands and lenses here are bordered by a black calcite up to an inch in thickness and there is interfingering of the chert and the calcite, both of which are of secondary origin.

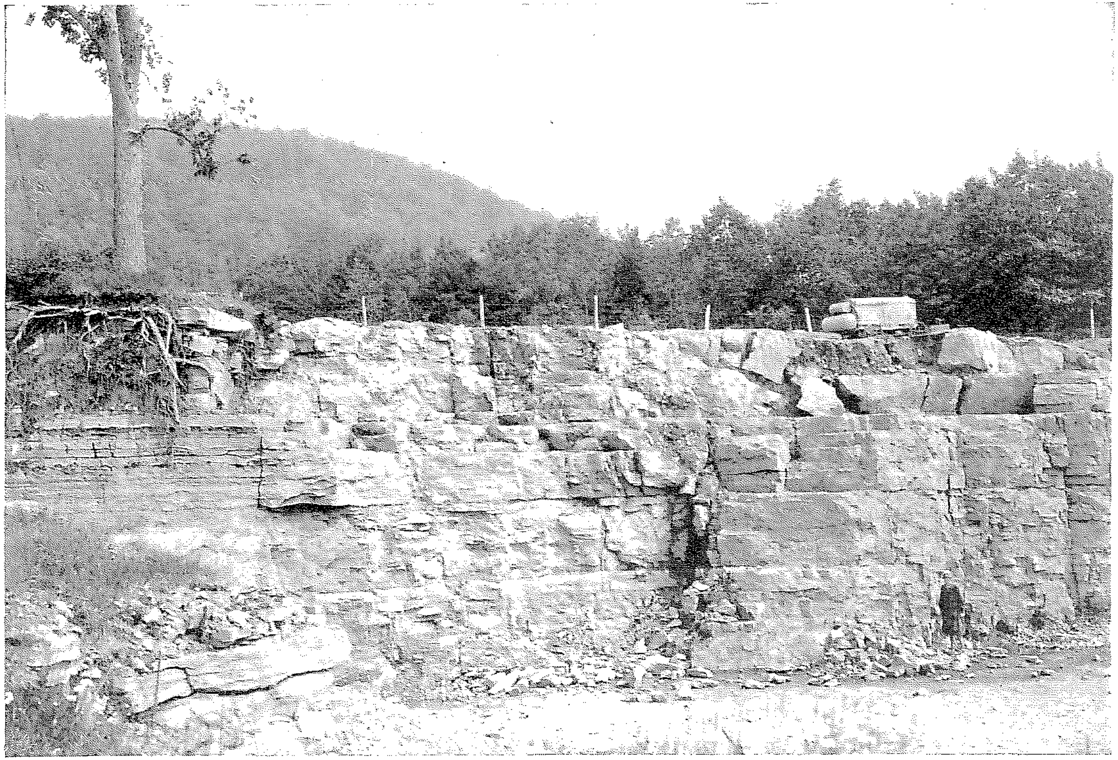


Figure 49 The upper Onondaga limestone in the Berne town quarry just beyond (west of) the village of Berne, showing the character of the bedding and, at the left, the characteristic chert bands. (Photograph by E. J. Stein)

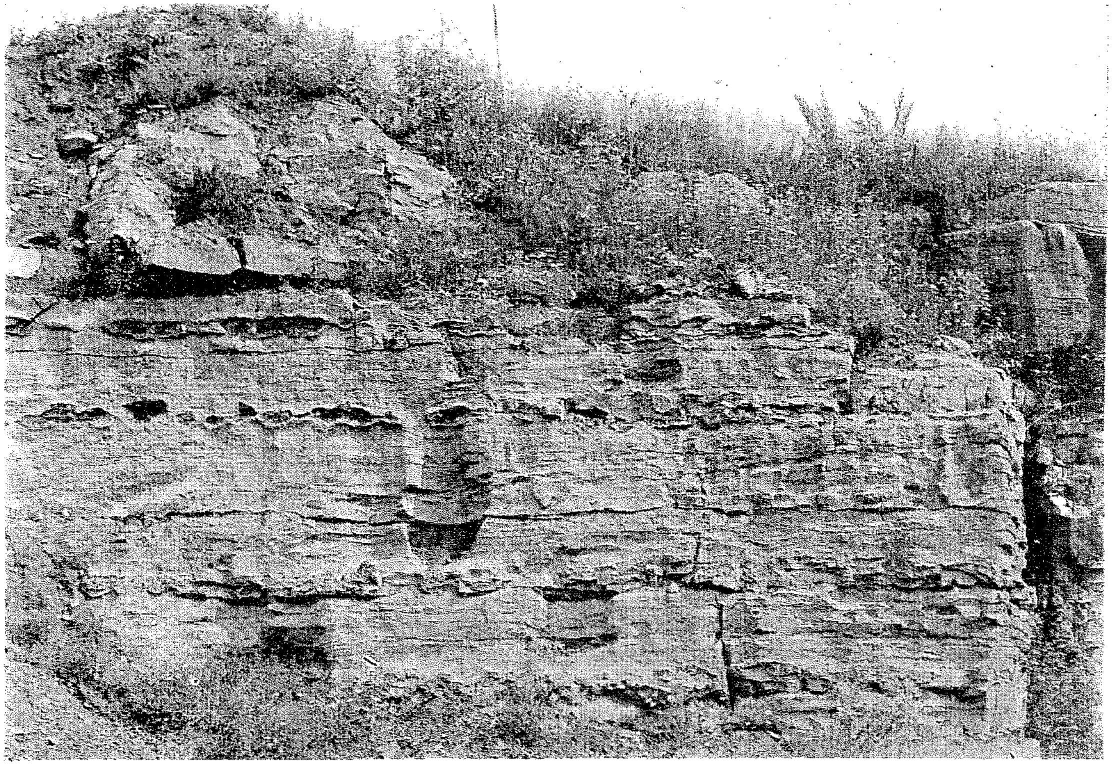


Figure 50 Near view of chert bands in the upper Onondaga limestone. Berne town quarry, west of village of Berne. (Photograph by E. J. Stein)

The maximum thickness of the Onondaga in the western part of the State is between 150 and 200 feet. Prosser measured 95 feet at East Cobleskill, and Grabau records about 100 feet (Dann's hill 105 feet) for the Schoharie region ('06, p. 193, 254). The thickness in the northern Helderberg area is 85 to 100 feet and southward from this it thins somewhat until in southeastern New York (Kingston area) it has a thickness of 50 feet or more (Van Ingen and Clark, '03, p. 1180). At Becraft mountain (Hudson) there is only a thickness of 20 to 25 feet, but the Schoharie sandy phase is about 200 feet thick here (Grabau, '03, p. 1034). In the Catskill area the thickness is not a great deal less than in the Helderbergs, as it has been computed as exceeding 75 feet and perhaps nearly 100 feet (G. H. Chadwick). Prosser and Rowe ('99, p. 336, 347) measured 100 feet in the Countryman Hill section and 85 feet in the Clarksville-Onesquethaw creek area. The writer has measured 100 feet (aneroid) for the Indian Ladder region and Prosser ('00, p. 56) records 98 feet for the same section.

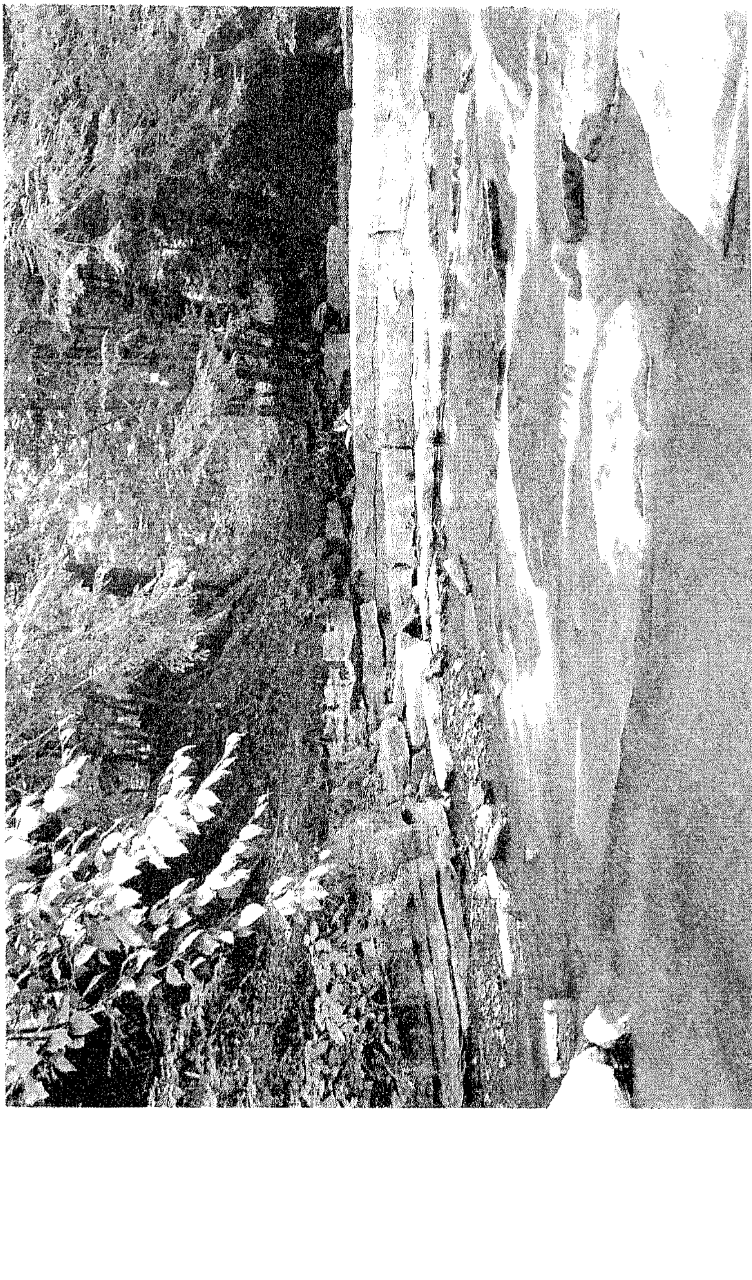
The Onondaga, like the other Helderberg limestones, the Coeymans and Becraft, is everywhere traversed by a very perfect system of joint fissures which help to produce the cliff by the breaking away of the rock along the vertical joints. The direction of these fissures is northeast-southwest by northwest-southeast. The main fissures run N. 31° to 32° E. and N. 68° W.; others N. 47° E., N. 23° W., N. 88° W. Weathering through solution has produced broad deep fissures in this relatively pure limestone and developed underground drainage with caves and sinkholes (due to cave-in of the surface through underground solution). The sinkholes, or depressions in which the drainage of a greater or less area disappears, are fairly frequent in the Onondaga limestone of the Thompsons Lake-Indian Ladder area. Thompsons lake itself (figure 51) occupies the northern end of such a sinkhole and its outlet is underground, with the waters appearing at the surface again about a mile and a half to the southwest on the Pitcher farm, (p. 24). Underground solution in places has caused slumping to such an extent that the Onondaga surface is much broken up and irregular. This is well shown south of the Indian Ladder cliff in the vicinity (north) of the little schoolhouse along the old Parrish Hill-Thompsons Lake road and the area shows caves and "sinks" as well. Such phenomena developed in limestone regions are known as "karst phenomena" from their occurrence in the Karst region of the Dalmation Alps along the eastern coast of the Adriatic.

The Onondaga limestone stretches over such broad areas that it may be found outcropping in numerous places. Outcrops are more frequent in the eastern portion of our area; but, even though the till covering is heavier toward the west, they are not infrequent in the southern slope of the Fox Kill valley between West Berne and Gallupville. The broad exposure of this formation stretching north and south between Berne and West Berne is fairly well covered with till and alluvium, although outcrops occur at the northern and southern (Berne) limits and at the east and west (stream bed in West Berne).

The two road metal quarries referred to above are both excellent for study. The one along the New Salem-Wolf Hill road, although south of our area, is worth visiting. Here 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 well shown in the floor of the quarry on the south side of the road. In the Berne quarry some very fine coral specimens have been found and a fair collection of fossils may be made here. An old quarry and a ravine just southwest of the hotel at Thompsons lake show the uppermost Onondaga and the contact with the black Marcellus shale above. The expanse of Onondaga terrace exposed east of Thompsons lake and south of the Indian Ladder cliff is splendid for study of "karst" features. A new road metal quarry was opened recently in the Indian Ladder area about three-quarters of a mile along the road leading directly south from the four corners on the old Indian Ladder-Thompsons Lake road (Rock road). This quarry, on the west side of the road (near Suto's gas station), is located in the lower beds of the Onondaga not much above the Esopus, in an area that has yielded fine specimens of corals. Fifteen to 18 feet of very pure thin-bedded limestone are exposed and the collecting is good. Very little chert was found and only in the bottom of the quarry. It is bluish gray in color and distinguished with difficulty from the limestone.

The Thompsons Lake area is splendid for the collection and study of corals. A variety of corals may be seen in the rock (reef rock) along the shore of the lake near the hotel boat landing, 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 the lake is situated in this rock east of the hotel in the southeast corner. Another good exposure where corals may be collected is on the south

Figure 51 Onondaga limestone along the southern shore of Thompsons lake, showing the character of the bedding. (Photograph by E. J. Stein)



side of the old Thompsons Lake-Indian Ladder road (Rock road) about one-eighth of a mile from the junction with the state highway.

The fauna and coral reef origin of the Onondaga limestone is discussed by Ruedemann ('30, p. 65) in his bulletin of the Capital District:

The fauna is characterized by the corals; not so much in species as in individuals. Much of the Onondaga limestone was undoubtedly formed by coral reefs. Such reef rock filled with corals is well shown at the boat landing of Thompsons lake and in the cliffs south of it. The State Museum contains a restoration of a portion of such a reef, built from large coral stocks obtained about Le Roy south of Rochester. These coral stocks show the size to which the corals grew. The abundance of the corals and the purity of the limestone indicate that the Onondaga sea offered very congenial conditions for coral growth and marine life in general in this region. Grabau ('06, p. 328) extracted a list of 57 species for the Onondaga limestone of the Schoharie region. Of these species are: corals, 5; bryozoans, 3; brachiopods, 27; pelecypods, 1; gastropods, 3; pteropods, 1; cephalopods, 7; trilobites, 10. While numerically the brachiopod species prevail, in individuals the corals are the most prominent element of the fauna. They are species of *Favosites, Zaphrentis* and *Cyathophyllum*. Among the brachiopods very large forms as *Stropheodonta hemispherica, Spirifer divaricatus* and the index fossil of the Onondaga, *Amphigenia elongata,* testify to the favorable life conditions. The pelecypods, which, as a rule, prefer muddy bottoms, are little represented. Among the gastropods we find again large and strikingly spinose forms as *Platyceras dumosum,* which is represented in the case of restorations of Helderberg life in the State Museum. The cephalopods show, in distinction to the prevailingly straight form (*Orthoceras*) of the Schoharie grit, curved (*Cyrtoceras*) or involute forms (*Gyroceras*); and also the trilobites have afforded peculiarly spinose (*Conolichas eriopis, Ceratolichas gryps, C. dragon*) forms and the largest known representative of the genus *Dalmanites* (*D. myrmecophorus*), all facts which point to an extremely rich invertebrate life. Besides, remains of fish have also been obtained in the Onondaga limestone.

Prosser and Rowe ('99, p. 352) have recorded 16 species from the Onondaga limestone of the Clarksville-Onesquethaw Creek section, including two corals, one bryozoan, nine pelecypods, one gastropod, one cephalopod and two trilobites. This would seem to indicate a not very rich fauna in the Capital District, but there is no mention of the very rich fauna, including especially genera of corals (*Zaphrentis, Cyathophyllum, Syringopora, Eridophyllum* etc.) that flourished in the Thompsons Lake region. The writer collected in a short time from the lower beds exposed in the quarry near Suto's gas station south of the four corners on Rock road (Indian Ladder-Thompsons Lake road) the following (figures 53, 54):

Corals
Zaphrentis prolifica *Billings*
Favosites basalticus *Goldfuss*
Favosites *cf.* helderbergiae *Hall*

Crinoids
Stem joints

Brachiopods
Spirifer duodenarius (*Hall*)
S. raricostatus *Conrad*
S. varicosus *Hall*
Pentagonia unisulcata (*Conrad*)?
Orthothetes *sp.*

Brachiopods (continued)
Pentamerella arata (*Conrad*)
Stropheodonta *cf.* patersoni *Hall*
S. inaequiradiata *Hall*
S. *cf.* concava *Hall*
Atrypa reticularis (*Linnaeus*)
Leptaena rhomboidalis (*Wilckens*)

Gastropods
Platyceras dumosum *Conrad*
Diaphorostoma *cf.* lineatum (*Conrad*)

Trilobites
Dalmanites *cf.* anchiops *Hall*
Dalmanites *sp.*

From the road-metal quarry on the outskirts of the village of Berne the writer collected:

Corals
Zaphrentis prolifica *Billings*
Favosites epidermatus *Rominger*

Brachiopods
Spirifer duodenarius (*Hall*)
S. raricostatus *Conrad*
S. varicosus *Hall*
S. divaricatus *Hall*
Pentamerella arata (*Conrad*)
Stropheodonta inaequiradiata *Hall*
S. hemispherica *Hall*
S. concava *Hall*
Atrypa reticularis (*Linnaeus*)
A. *cf.* spinosa *Hall*

Brachiopods (continued)
Leptaena rhomboidalis (*Wilckens*)
Meristella nasuta (*Conrad*)
M. *sp.*

Pelecypods
Pterinea *sp.*

Gastropods
Platyceras dumosum *Conrad*
Diaphorostoma *sp.*
Euomphalus decewi *Billings*

Cephalopods
Gyroceras paucinodum *Hall*

Trilobites
Dalmanites *cf.* anchiops *Hall*
Proetus *cf.* clarus *Hall*
Proetus *sp.*

17, 18 HAMILTON BEDS (including MARCELLUS BLACK SHALE)[1]

The Hamilton shales and flags constitute the rock of the southern half of the Berne quadrangle with "Oneonta" sedimentation appearing in the southwest corner, mainly between Rensselaerville and the Little Schoharie valley. The Hamilton beds were named originally from typical exposures at West Hamilton, Madison county (Vanuxem, '40). These beds, which are represented in the East by sands and arenaceous shales and in the West by black shales, calcareous shales and limestones, are on the whole richly fossiliferous. The Hamilton beds form a thick wedge of clastic materials which thins westward with numerous accompanying shifts or facies both in the character of the rock and the fauna. Hall and Vanuxem in their final reports included in this group the Skaneateles shale, Olive shale,

[1] See supplementary note, page 186.

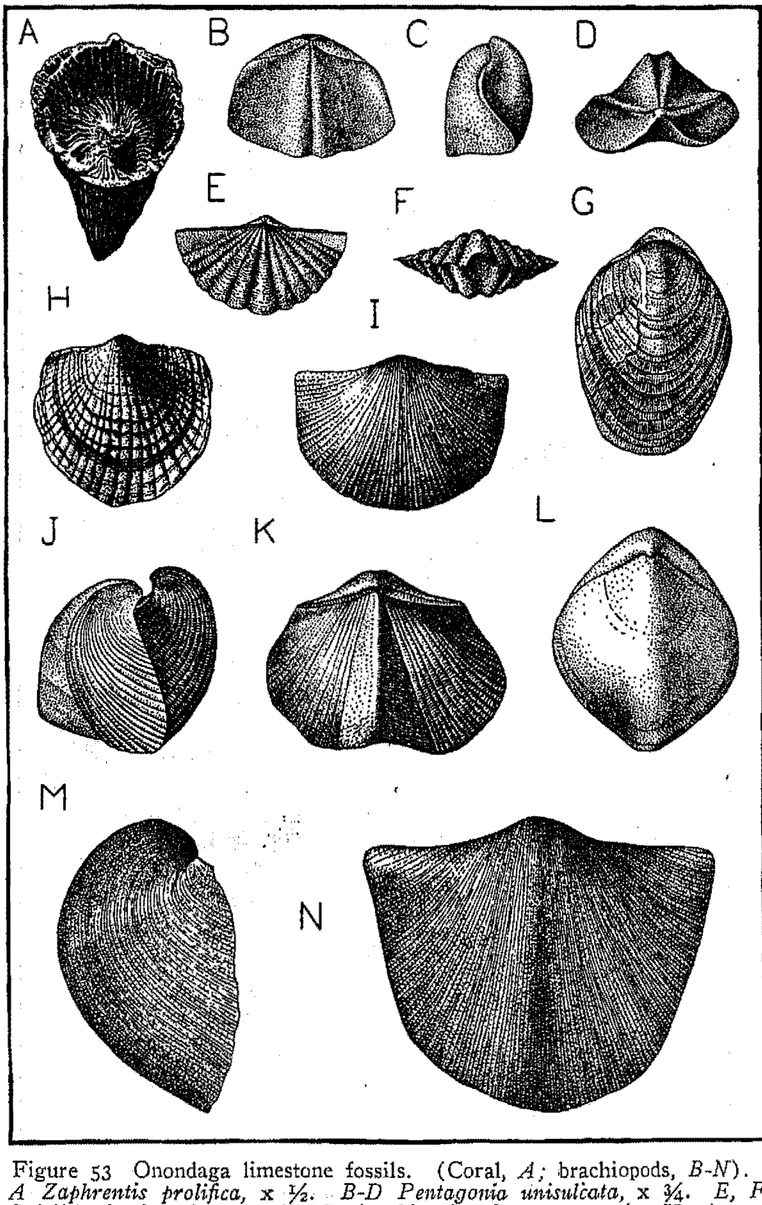


Figure 53 Onondaga limestone fossils. (Coral, *A*; brachiopods, *B-N*). *A Zaphrentis prolifica*, x ½. *B-D Pentagonia unisulcata*, x ¾. *E, F Spirifer duodenarius*, x ¾. *G Amphigenia elongata*, x ½. *H Atrypa spinosa*, x ¾. *I Stropheodonta inaequiradiata*, x ¾. *J, K Spirifer acuminatus*, x ¾. *L Meristella nasuta*, x ¾. *M, N Stropheodonta hemispherica*, x ¾.

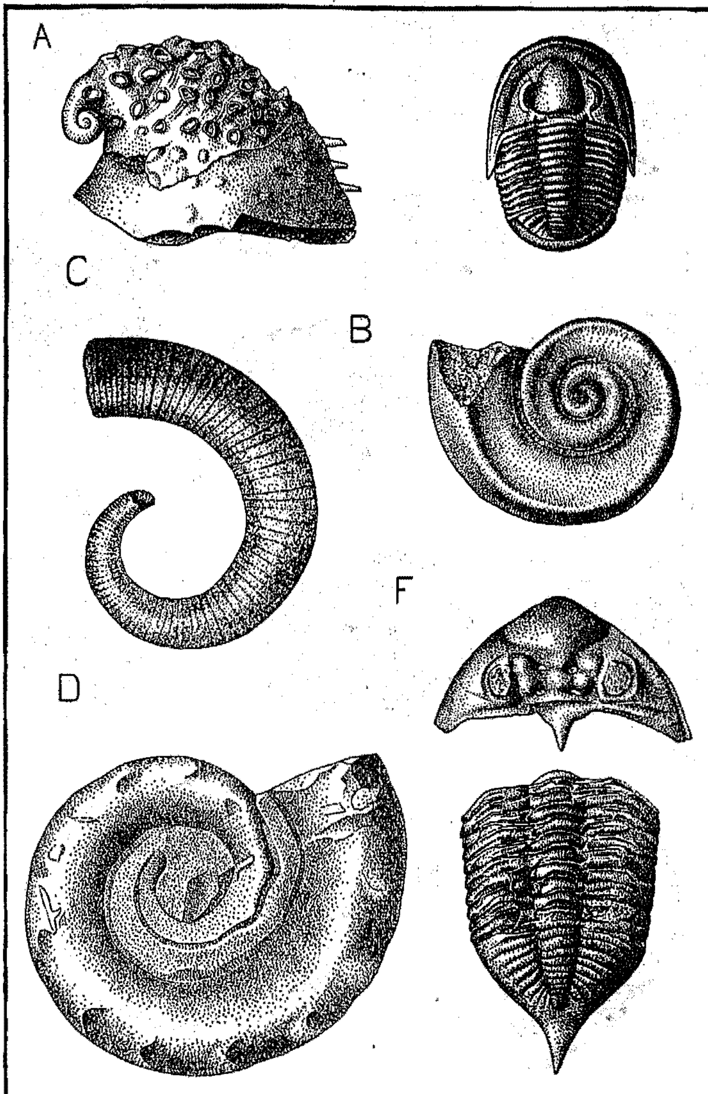


Figure 54 Onondaga limestone fossils. (Gastropods, *A, B*; cephalopods, *C, D*; trilobites, *E, F*). *A Platyceras dumosum*, x ¾. *B Euomphalus decewi*, x ½. *C Ryticeras (Gyroceras) trivolve*, x ⅓. *D Gyroceras paucinodum*, x ½. *E Proëtus clarus*, x ¾. *F Dalmanites anchiops*, x ½.

Ludlowville shale, Encrinal limestone and the Moscow shale. Dana, in his "Manual," enlarged the term to include the Marcellus shales and the Tully limestone. Until recently the term has been used to include everything between the Cardiff (upper Marcellus) shales and the Tully limestone, that is, the Skaneateles, Ludlowville and Moscow formations. Very recent studies of the Hamilton beds have shown the necessity for some revision, and for details the reader is referred to the paper embodying the results (Cooper, '30). These studies have shown "that the black muds of the Marcellus, often affiliated with the Onondaga, thicken eastward and are gradually replaced by gray arenaceous shale. Concordantly the Marcellus fauna grades eastward into one of Hamilton aspect. These phenomena have made it necessary to place the Marcellus formation in the Hamilton group, which, therefore, now consists in ascending order of the Marcellus, Skaneateles, Ludlowville and Moscow formations. The Skaneateles formation and several members in the higher formations show a similar westward shift of faunal facies from one of Hamilton aspect in the east to a modified Marcellus fauna in the west" (Cooper, '29; Geol. Soc. meeting abstract).

Our Hamilton shales in the East have not yet been divided. Doctor Cooper expects in the near future to carry his Hamilton studies into the East (see page 186) and the results are awaited with interest. In the Capital District and northern Helderberg area, Darton ('94) in his Preliminary Report on the Geology of Albany County divides the beds between the Onondaga limestone and the "Oneonta" formation into the Hamilton black shales (lower 600 feet) and the Hamilton flags and shales. Prosser and Rowe ('99) and Prosser ('99; '00) recognized the Marcellus shale and the Hamilton shales in this same area, and these divisions are used by Ruedemann ('30) in his Capital District bulletin. Prosser also saw in the nonmarine shales and flags between the marine Hamilton and "Oneonta" of this area an eastern representation of the Sherburne sandstone. Darton, as shown by recent field investigations, has correctly described and mapped these beds as Hamilton.

The **Marcellus black shale** with a thickness of 170 to 180 feet in our region constitutes the lowest member of the Hamilton beds, tentatively referred to the Chittenango (see Berne member, page 189). The Marcellus formation (Hall, '39) was named from exposures at Marcellus, Onondaga county, and now includes the black shales and the Cherry Valley limestone (Clarke, '03). At the type locality there is an upper division of gray shale (Cardiff shale of Clarke and Luther, '04). The Marcellus black shale of the Capital

District and northern Helderberg area follows the Onondaga quite abruptly. These shales represent the mud deposits that succeeded the coral reefs of Onondaga time. In western New York the boundary is not so sharp owing to the presence of calcareous beds in the Marcellus. Clarke ('01, p. 115–38) regarded the lower part of the Marcellus in eastern New York as the equivalent of the Upper Onondaga limestones of western New York; that is, it is believed (see Cooper, '30, p. 123) that "the Onondaga limestone grades upward into the Marcellus shale with the Marcellus overlapping the Onondaga toward the west." Chadwick, on the other hand, (abstract for Geological Society meeting, '27) reports an unconformity between the Onondaga and the Marcellus in the Catskill region which to his mind "appears to dispose finally of the theory of 'contemporaneous overlap' " of the Marcellus black shale.

Typically this 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 (*Bakoven* of Chadwick, '33) and extends across the State, thinning westward. Grabau ('06, p. 206) measured 180 feet of black fissile shales in the Schoharie area. In this region 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 east of the Schoharie 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.

Prosser and Rowe ('99, p. 335) in the Countryman Hill section did not attempt the separation of their Marcellus and Hamilton divisions and in the Clarksville-Onesquethaw Creek section (*ref. cit.,* p. 346) 300+ feet are referred to the Marcellus shales. These authors point out the difficulty to be found in separating the Marcellus and Hamilton shales, and mention the gradual change in lithologic characters from one to the other and the change in thickness westward. Prosser ('00, p. 56) ascribes 170 feet to the Marcellus black shale in the Indian Ladder section and the writer found a thickness of 170 to 180 feet here and elsewhere on the Berne quadrangle. Doctor Ruedemann and the writer measured exactly 170 feet (aneroid) in the Onesquethaw Creek-Wolf Hill section. In the vicinity of the falls the contact between the Marcellus black shales and the Hamilton

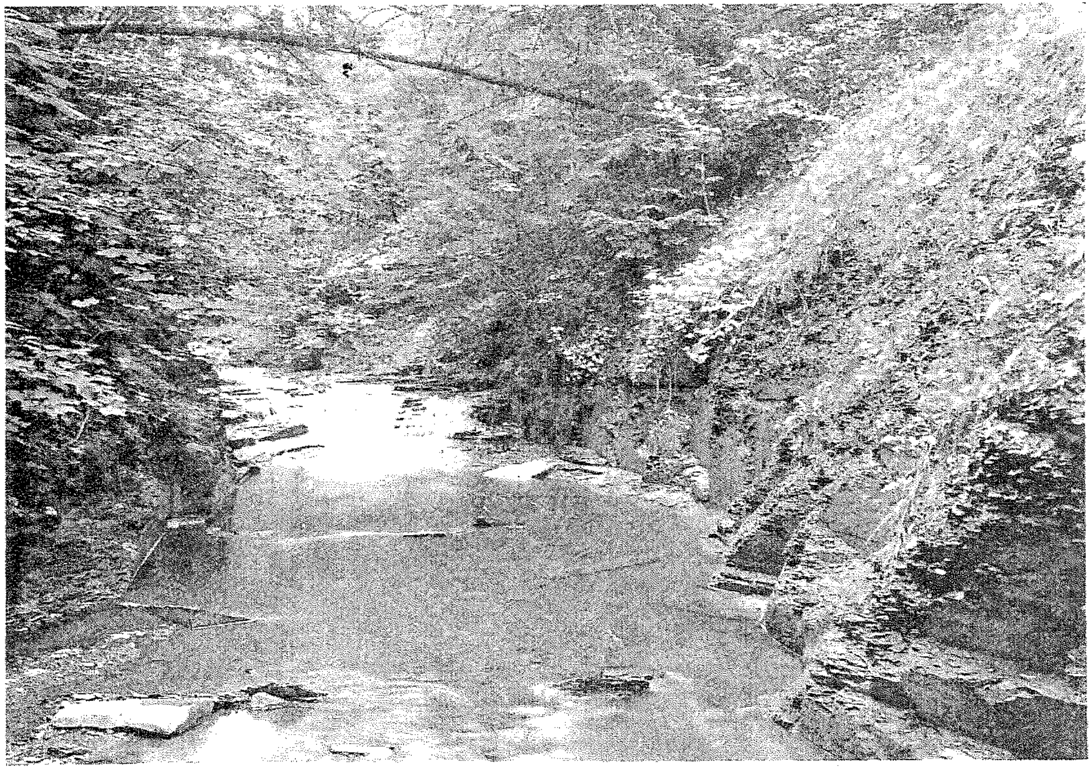


Figure 55 Marcellus black shale (Hamilton beds) in Onesquethaw creek, Wolf Hill section, showing the characteristic jointing. (Photograph by E. J. Stein)

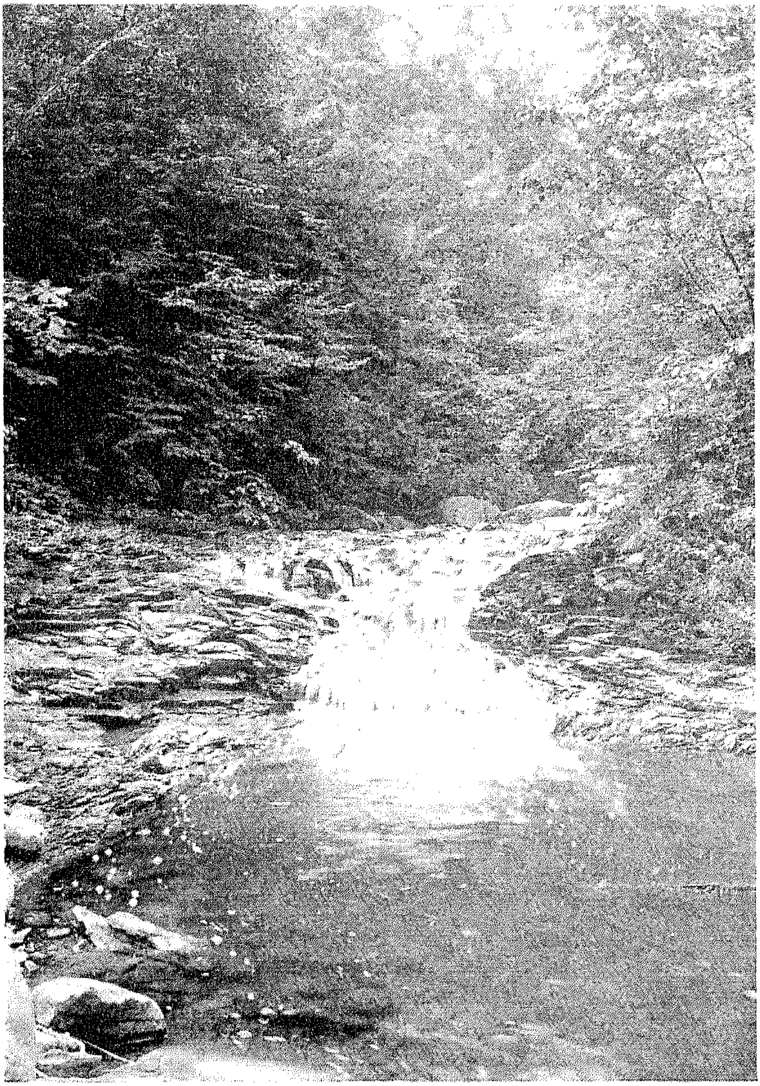


Figure 56 Crumpling in Marcellus black shale (Hamilton beds) due to nearly horizontal thrust faulting. Onesquethaw creek, Wolf Hill section. (Photograph by E. J. Stein)

shales above is very sharp. The shales here are pyritiferous and their very fissile, very carbonaceous soft character is well shown.

The Marcellus black shales are not extensively exposed, for on all hillsides they are so much weathered that the outcrops are covered with soil. They form the gentler slopes in the hillsides above the Onondaga terrace that are used as pasture land. Outcrops are to be looked for in stream valleys, road cuts and road metal quarries. Doctor Ruedemann and the writer in field investigations in the Capital District area found that 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 (near Camp Pinnacle). This feature, south of our area, is shown to a certain extent in Countryman hill, but extremely well in the Clarksville area and southward, in Bennett, Copeland and Blodgett hills.

The best and most accessible exposures of the Marcellus black shale are found in the eastern portion of the quadrangle. From the Switz Kill Valley area westward the heavier till covering excludes the possibility of many outcrops. An excellent exposure is shown south of the Indian Ladder cliff in the cut made by the old and new roads leading to Camp Pinnacle from the old New Salem (Parrish hill) road running north of Countryman hill to Thompsons lake over the Onondaga terrace. Here an almost complete section is exposed in a short distance and there is good collecting. As mentioned above (p. 144), the contact between the Marcellus and Onondaga is shown in a small ravine southwest of the hotel at Thompsons lake. There is a good exposure of these shales in the ravine (best reached from the side road) slightly southeast of East Berne, and in a road metal quarry a mile and a half directly east of East Berne the upper portion of the Marcellus black shale is shown and the gradation into the dark Hamilton shale above. A fair exposure is found in the ravine along (west of) the road leading south up the hill rising above the village of Berne.

By far the finest section is exposed just at the eastern limits of the Berne quadrangle in the gorge of the upper Onesquethaw creek north of Wolf hill and the state highway. Here is found a continuous section from the Onondaga contact to the contact with the Hamilton shales and flags at the falls (figures 55, 58). The 170 feet of

Marcellus measured here consist of black fissile, carbonaceous shales ending abruptly with an earthy, pyritiferous soft black shale against the heavy sandstone bed that forms the waterfall. In this section a few sandy beds are shown in the lower five feet and the upper half, the rest is all black fissile shale. The lowest sandy beds are quite fossiliferous (*Leiorhynchus limitaris* and *L. mysia* especially noted). In the upper part of the section, about 35 to 40 feet below the top is an horizon with large calcareous nodules two to four feet in diameter and a foot or less in thickness. A second course of these nodules occurs at an horizon about 55 feet from the top. The lowest part of this section shows an almost horizontal thrust fault in the Marcellus black shale at the right a short distance above the bridge (figures 52, 56). The Onondaga limestone is involved in this disturbance and farther upstream small folds or swells in the limestone are seen. A similar section in the Marcellus black shale is shown in the branch of the Onesquethaw coming in from the north. The Wolf Hill branch of the Onesquethaw in its course by way of Clarksville to the old Slingerland milldam (Albany quadrangle) about a quarter of a mile southeast of the Feura Bush-Indian Fields state highway (a distance of about five miles in direct line) passes over a section from the New Scotland beds to and including the Hamilton shales and flags.

The Marcellus black shale in the northern Helderberg area has in general been found to yield a meager fauna. Ruedemann notes the occurrence of a good fauna in the Lawson Lake region of the Albany quadrangle ('30, p. 69) and cites abundant *Styliolina fissurella* and small lamellibranchs (*Lunulicardium marcellense*). Prosser and Rowe ('99, p. 353) have recorded from the Clarksville region of the Capital District: *Chonetes mucronatus* Hall, *Glyptocardia speciosa* Hall, *Coleolus tenuicinctus* Hall and *Goniatites (Parodiceras) discoideus* Conrad. The first two are listed as abundant, the last as common, the conularid as rare. For the Schoharie region Grabau ('06, p. 329) lists 12 species from the Marcellus black shale (four brachiopods, one pelecypod, two pteropods, five cephalopods) and 11 species from the Agoniatite limestone (one brachiopod, two pelecypods, eight cephalopods). The Agoniatite (Cherry Valley) limestone in the Schoharie region and westward carries a striking fauna of large cephalopods not found anywhere else.

The writer was fortunate in visiting the Camp Pinnacle section at the time when work on the new road was under way. From the new and old cuts a very presentable collection of fossils (figure 57) was made, indicating that at least locally in the Helderberg area

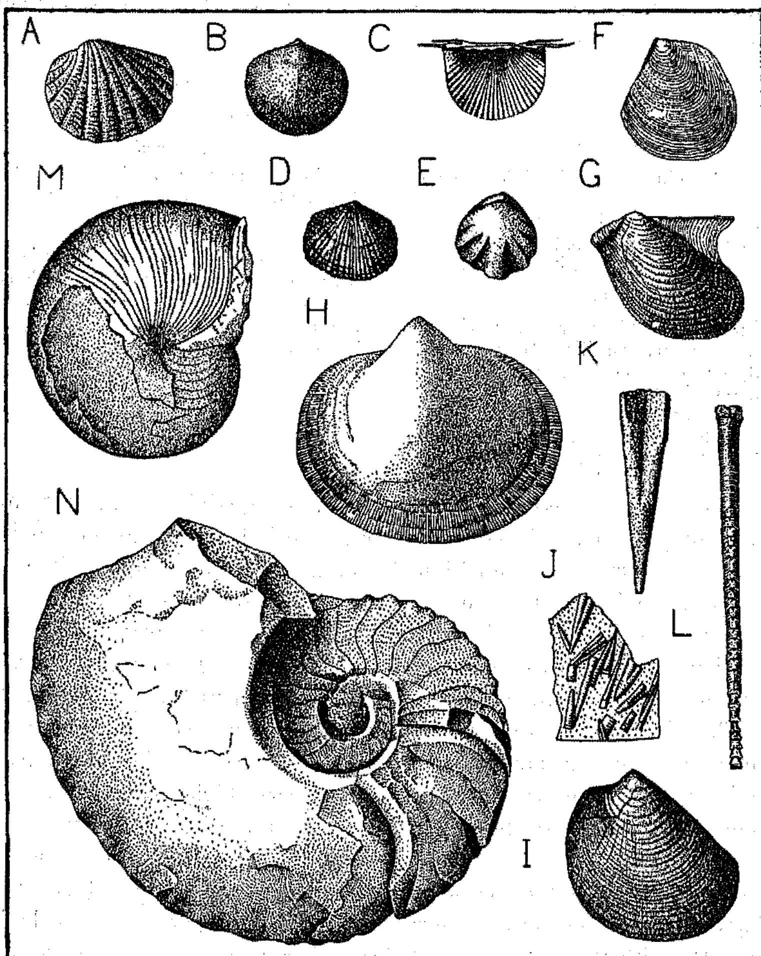


Figure 57 Marcellus black shale (Hamilton), fossils. (Brachiopods, *A-E*; pelecypods, *F-I*; pteropod, *J, K*; cephalopods, *L-M*). *A Glyptocardia speciosa*, x 1. *B Nucleospira concinna*, x ¾. *C Chonetes mucronatus*, x ¾. *D Leiorhynchus limitaris*, x 1. *E L. Mysia*, x 1. *F Pterochaenia fragilis*, x 2. *G Leiopteria laevis*, x 2. *H Panenka ventricosa*, x ¾. *I Lunulicardium marcellense*, x ¾. *J, K Styliolina, fissurella*, x 3, with enlargement, x 6. *L Bactrites clavus*, x ½. *M Parodiceras discoideum*, x ¾. *N Nautilus (Discites) marcellensis*, x ½.

there is a fair fauna. The shale here, however, shows less of its typical character and, particularly in the new cut, seems much more sandy (Cardiff lithology; see page 186). The collection made here consists of:

Bryozoans

Bryozoan *sp.*

Brachiopods

Leiorhynchus limitaris (*Vanuxem*)
L. mysia *Hall*
Nucleospira concinna *Hall*
Chonetes *cf.* mucronatus *Hall*
Lingulodiscina *cf.* exilis (*Hall*)

Pelecypods

Nucula *cf.* bellistriata (*Conrad*)
Pterochaenia fragilis (*Hall*)
Glyptocardia speciosa *Hall*
Leiopteria laevis *Hall*
Leptodesma *cf.* rogersi *Hall*
Modiella pygmaea (*Conrad*)
Panenka *cf.* ventricosa *Hall*

Conularids

Conularia *sp.*

Pteropods

Styliolina fissurella *Hall*
Tentaculites gracilistriatus *Hall*

Cephalopods

Parodiceras discoideum (*Conrad*)
Nautilus (Discites) marcellensis *Vanuxem*
Bactrites clavus *Hall*
Orthoceras *sp.*

The minute, needlelike pteropod shells, *Styliolina fissurella,* are extremely abundant in certain layers, especially in the lower portion of these beds. The brachiopod *Chonetes cf. mucronatus* is very small and quite common in certain layers throughout the formation. *Parodiceras discoideum* is very small in the lower more argillaceous portion and the pelecypods tend to be small. The large *Panenka* was found in the upper portion of the section in the new road cut.

The **Hamilton shales and flags** comprise a series of sandstones and sandy shales largely of marine origin but with nonmarine beds appearing above them in the northern Helderberg area (see pages 164, 186). In the Helderbergs of the Capital District area (Ruedemann, '30) the marine Hamilton beds form the tops of the highest hills. On the Berne quadrangle the nonmarine shales and flags appear in the southwestern corner. The upper Hamilton beds, together with the "Oneonta" shales and sandstones (see pages 181, 186) and the great mass of the Catskill beds above, must once have spread with their thickness of thousands of feet over the entire Helderberg region and beyond and have been extensively eroded and carried away by the rivers as waste.

The lower few hundred feet of the marine beds consist of dark to black argillaceous (clayey) shales with intercalations of dark, slightly calcareous sandstone and are in general not very fossiliferous. The shales contain enough sand to cause them to break blocky, a noticeable feature of the lower beds that is even more characteristic 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. Ruedemann (*ref. cit.*, p. 70) notes that fossils "appear in large numbers about 300 feet above the base, where the shales have become greenish and bluish." The sandstone beds are not evenly distributed and vary greatly in thickness from an inch or less to 10 to 15 feet and more. The heaviest beds occur in the upper portion of the formation. The sandstone and shale intercalations there 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 or are reddish (Reidsville quarry). 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 Reidsville (Albany County Bluestone Quarry; six-inch curbing and flagstones for crosswalks to New York and Philadelphia).

As pointed out by Darton ('94, p. 434) and later by Ruedemann ('30, p. 70), "the sandstones and shales change into each other horizontally in a very irregular manner. This fact as well as the cross-bedding observed at times, and the prevalence of brachiopods and lamellibranchs in the fauna (see below) indicate shallow muddy water with frequent changes in direction of currents. In western New York the Hamilton beds are more calcareous, the formation consisting of calcareous shales and limestones; eastward it becomes arenaceous, until along the Hudson river arenaceous shales and sandstones prevail." In numerous places the writer has noted in the more flaggy portions of these beds layers filled with mud pebbles and the sandstones show ripple marks, tide markings, rill markings and other shore phenomena. These characters are well shown in the Reidsville quarry. Here, too, the heavy sandstone beds are seen to be filled with plant remains, and except in thin bands near the top of the quarry other fossils are not found. The sandstone here is very coarse, blue-gray in color with a two or three inch band of reddish, very coarse sandstone in the upper part of the section. The coarsest sandstone is as coarse as some of the Chemung and Normanskill grit.

Darton in his Preliminary Report on the Geology of Albany County (*ref. cit.*, p. 432) estimated 600 feet for his Hamilton black shales division and 700 feet for the Hamilton shales and flags. Allowing 170 feet for the Marcellus black shale would give 1130 feet for the Hamilton shales and flags as here treated. Ruedemann (*ref. cit.*) has estimated that, of the total thickness of the Hamilton shales and flags "probably not much more than 600 feet are present in the highest ridge on the Albany quadrangle, the Helderberg mountain which continues northward into Wolf hill and Countryman hill. Prosser found in the Clarksville section to the top of Wolf hill 300 feet of Marcellus and 490 feet of Hamilton shales. Assigning about 170 feet to the Marcellus, there would be about 620 feet of Hamilton in that section, as we define it." The writer has estimated the thickness of the fossiliferous Hamilton shales and flags (including the Marcellus black shale), on the basis of a dip of 100 feet to the mile, as about 800 feet in the eastern portion of the Berne quadrangle and 1100 feet in the Rensselaerville area. On the basis of a dip of 117 to 120 feet to the mile, as estimated by Prosser (p. 189) for the Rensselaerville area, there would be a thickness of marine Hamilton in that region of about 1300 feet. The maximum thickness of the marine Hamilton (including the Marcellus black shale) in the western part of the Berne quadrangle, southwest of West Berne (Bradt hill), has been estimated as 1415 to 1720 feet, (Prosser, '99, p. 243), in the Schoharie valley (Middleburg) as 1685 feet (*ref. cit.*, p. 190; Grabau, '06, p. 213). (See supplementary note, page 186).

There are a number of good exposures of fossiliferous Hamilton shales and flags on the Berne quadrangle, but the best, both for study and collecting, are found in road cuts and quarries. One of the finest exposures, giving a section of about 300 feet of Hamilton shales and sandstones above the Marcellus black shale, is found along a side road (southwest of East Berne) which turns south from the state highway and climbs up onto the Hamilton hills. By continuing along the roads to the west and east particularly, the section may be carried through a thickness of about 500 feet (reckoning with dip, about 600 feet). A fair collection of fossils may be made here in a short time. The Reidsville quarry is a very accessible place for the study of the character of the flags (figure 61). Plant remains are found here in abundance in some layers. In the upper five feet of the section are two layers of a few inches in thickness that are so packed with small brachiopods (mainly *Camarotoechias: C. congregata, C. prolifica; Spirifer* cf. *mucronatus*) as to form a shell limestone layer. While fossils are rare in these flags, from the

Figure 58 Falls of Onesquethaw creek, Wolf Hill section. The falls is capped by the harder Hamilton shales and flags, sharply set off from the underlying black argillaceous Marcellus (Hamilton) shales. The jointing of the black shale beds is well shown. (Photograph by E. J. Stein)

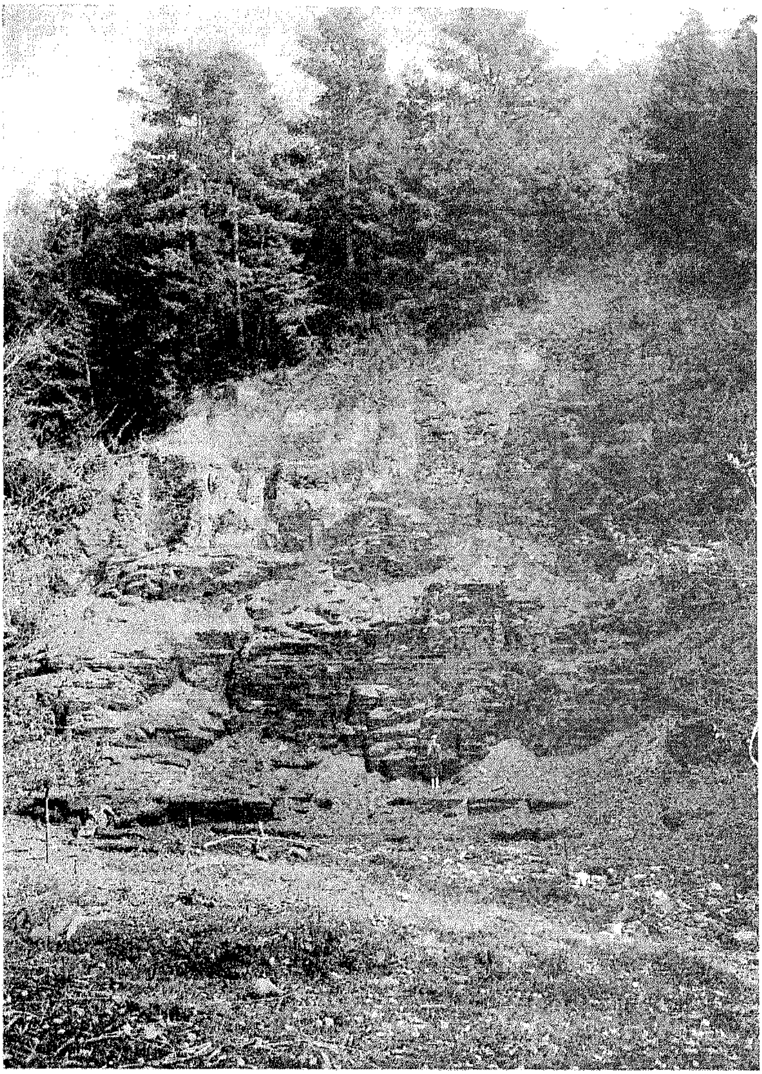


Figure 59 Lower 80 feet of Hamilton shales and flags, above the black Marcellus (Hamilton) shale, showing the thin sandstone beds in the shales. First gorge joining the Switz kill from the north, going upstream. (Photograph by E. J. Stein)

dump were collected besides the above the brachiopods, *Chonetes coronatus, Tropidoleptus carinatus, Eunella* cf. *lincklaeni* and the pelecypod *Glyptodesma erectum.*

Two road metal quarries, respectively one-half mile and one mile south of Westerlo, have afforded excellent collecting, as have also exposures one-half mile and one mile west of Westerlo along the Westerlo-Van Leuvans Corners road. There are certain layers in the Hamilton here that are literally packed with a great variety of pelecypods and brachiopods. In the first quarry south of Westerlo certain surfaces were covered with the brachiopods *Spirifer mucronatus* and *Chonetes coronatus.* A few specimens of *Schizophoria* cf. *striatula* were found here but in the second quarry (beds just below nonmarine shales and flags) it is fairly abundant in a layer about four feet above the base. To the knowledge of the writer (also Cooper), *Schizophoria* has not been reported before this from the New York Hamilton. The Schizophorias in the second quarry are associated with *Nyassa arguta, Orthonota undulata* and *Atrypa reticularis,* an association, according to Cooper (conversation, 1931), totally unknown in the Hamilton. Cooper also drew the writer's attention to the fact that in this quarry is found the assemblage listed by Prosser for the Stroudsburg region, Pennsylvania.

Along the Rensselaerville road, about two miles northeast of the village and about a mile and a half northeast of Van Leuvans Corners, are road metal quarries where good collections may be made, particularly in the former, where collections included two genera of crinoids, so rare in our eastern Hamilton. In an area within three miles north of the second quarry are numerous exposures, and the terraces formed by the outcropping heavier sandstone beds are well shown here, and also in the region to the east and southeast of Reidsville. At Rensselaerville falls there is likewise good collecting, but it is limited by the fact that a considerable area here has been set aside as a park by the Huyck family of Rensselaerville and Rensselaer. About one mile north of Rensselaerville a road turns to the north. Beyond the four corners on this road are exposed good sections of the nonmarine beds and over 100 feet of the marine Hamilton shales and flags immediately beneath, affording good collecting.

The ravines joining the Switz Kill valley (figures 59, 60) from the north and south (particularly the third from the south) give very good sections for the study of the lithology of the Hamilton. These ravines are good examples of hanging valleys, and their streams join the main stream by a series of falls formed upon the heavier sandstone beds. Although they are till-covered, there are numerous exposures in the fields and along the roads on top of the Hamilton hills, until the western border of the quadrangle is reached where the heavier till covering has considerably lessened the possibility of outcrops both in stream valleys and on hilltops. The Bradt Hill section, southwest of West Berne, is recommended for a study of the Hamilton of the western portion of the quadrangle. This section was studied by Prosser ('99, p. 241) and from his measurements here were made estimates of the total thickness of the Hamilton (see above p. 160).

Nonmarine flags and shales are found above the marine Hamilton beds on the Berne quadrangle. For a thickness of 65 to 80+ feet they consist of bluish or greenish sandstones, sometimes quite coarse, alternating with smooth, greenish or olive colored shales, often blocky. Prosser ('99) described and mapped these beds as Sherburne sandstone but recent field investigations have brought to light new facts which prove that these beds represent simply another phase of Hamilton sedimentation, a conclusion previously reached by Darton ('94). Chadwick (summer 1931) took the writer over a portion of the area covered by the Durham quadrangle immediately south of the Berne area and called attention to a fresh road cut in typical Hamilton beds, with fossils, that unquestionably hold a position above these nonmarine flags and shales. How much higher Hamilton sedimentation continues is a problem outside the province of the writer (see supplementary note, page 186). These nonmarine beds, as is to be expected, are unfossiliferous, carrying only plant remains. Some of the beds are very coarse with layers of pebbles, and strong cross-bedding is characteristic and very striking on weathered surfaces. The olive shale beds in places show sun-crack surfaces. These nonmarine flags and shales occur only in the southwestern portion of our quadrangle.

There are three places where good exposures may be studied, the most accessible being Rensselaerville falls (figure 65), where the top of the marine Hamilton marks the top of the first small falls above the foot bridge (elevation 1415 feet A. T.). The writer measured here 65 feet up to the heavy red sandstone bed marking the base of "Oneonta" sedimentation (see Prosser, '99, p. 251). Thirty-five feet above the fossiliferous Hamilton occur three feet of black shale with interbedded sandstone. *Beyrichia* sp. was found at this horizon; 15 feet below this, just above the sun-cracked olive beds, is a 12-inch black shale bed, consisting of two inches of shale, four inches of sandstone, six inches of shale. The lower shale carries *Beyrichia* sp.,

Figure 60 Hamilton shales and flags, showing heavy sandstone beds. Third gorge joining the Switz kill from the north, going upstream. (Photograph by E. J. Stein)

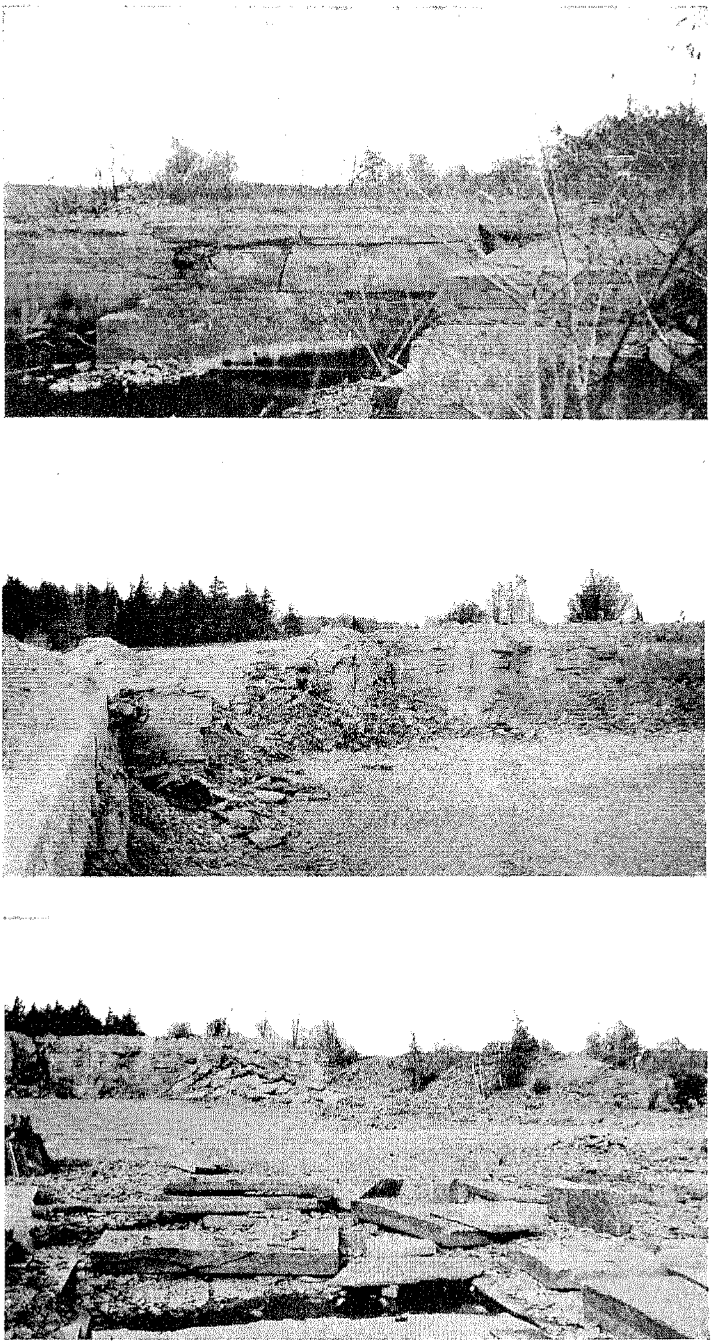


Figure 61 Three views in the quarries at Reidsville, showing the heavy sandstone beds of the Hamilton and flagstones that have been taken out. (Photographs by W. Goldring)

the upper *Estheria membranacea* Pacht. Chadwick has called the writer's attention (in field, 1931) to the occurrence of three such black shale beds with Beyrichia, Estheria or Beyrichia and Estheria, on the Durham quadrangle. Two of these beds may be represented in the lower occurrence at Rensselaerville falls. The writer has, however, found a black shale band half way between the two noted above, although neither Beyrichia nor Estheria was found. These occurrences of phyllopods (Estheria) and ostracods (Beyrichia) with no other fossils indicate invasions of brackish water, through change in elevation. The second exposure is found two and a half miles northwest of Rensselaerville along the first side road to the north. East of the four corners on this road nonmarine flags and shales are well exposed in the woods north of the crossroad and the cross-bedding is well shown. Less than a third of a mile beyond the four corners there is a good cut on the east side of the road and splendid outcrops showing cross-bedding in the hillside to the west. The third exposure is on the east side of the ridge just east of the village. Almost the full section is exposed here in road cuts and ditches.

The changes in Hamilton lithology discussed above may be explained by the conditions under which sedimentation took place. Indications are that deposition took place in a bay widely open to the west with the source of sediments to the north and east. Thus coarser sediments should be expected eastward, nearer the source of supply. Enormous quantities of materials were deposited and the bay landward was gradually being filled in by nonmarine deposits, in the process becoming narrower and shorter. These deposits, therefore, encroached upon previous marine deposits. At times changes in level permitted marine waters to cover areas of previous nonmarine sedimentation with the deposition again of beds with marine fossils.

Ruedemann ('30, p. 71) sums up the fauna of the Hamilton shales and flags (figures 62–64) as follows:

The fauna of the Hamilton beds is exceedingly rich and it may with more detailed study permit the division of the formation into life zones. Grabau ('06, p. 329–31) has enumerated 123 species from the Hamilton of the Schoharie region; in central New York the fauna is still larger. Of these are: wormtrails, 1; brachiopods 27; pelecypods, 76; gastropods, 9; pteropods, 3; cephalopods, 2; trilobites, 4. The Hamilton is therefore a typical pelecypod or lamellibranch facies. It has furnished the multitude of mussels so beautifully illustrated by Hall in volume V of the Paleontology, with their striking species of Aviculopecten, Liopteria, Modiomorpha, Goniophora, Palaeoneilo, Grammysia, Sphenotus and Orthonota. I

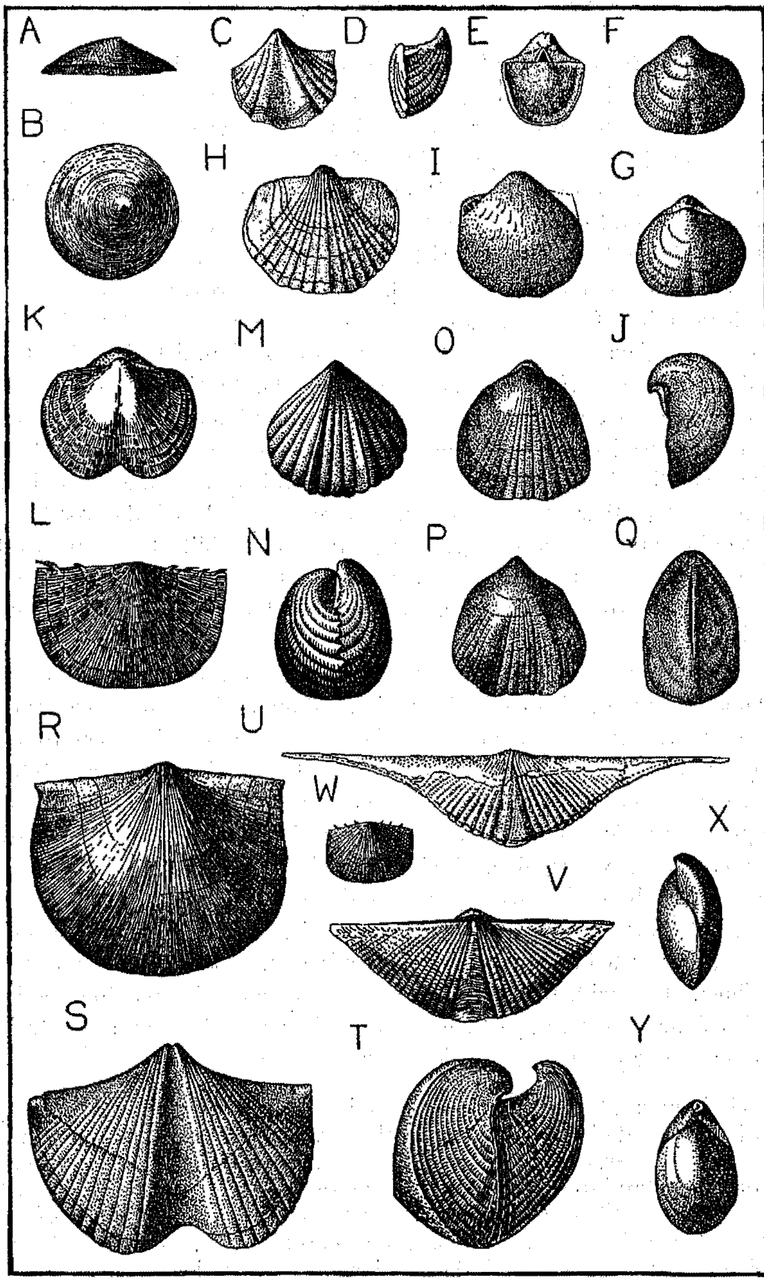


Figure 62 Hamilton (Cardiff) shale fossils. (Brachiopods). *A, B Roemerella grandis*, x ¾. *C, D Cyrtina hamiltonensis. E Ambocoelia umbonata. F, G Athyris cora. H Tropidoleptus carinatus*, x ¾. *I, J Productella dumosa. K Schizophoria striatula*, x ¾. *L Chonetes coronatus. M, N Camarotoechia congregata. O, P Leiorhynchus laura*, x ¾. *Q Dignomia alveata*, x ¾. *R Stropheodonta demissa*, x ¾. *S, T Spirifer granulosus*, x ¾. *U, V S. mucronatus*, x ¾. *W Chonetes scitulus. X, Y Eunella lincklaeni.*

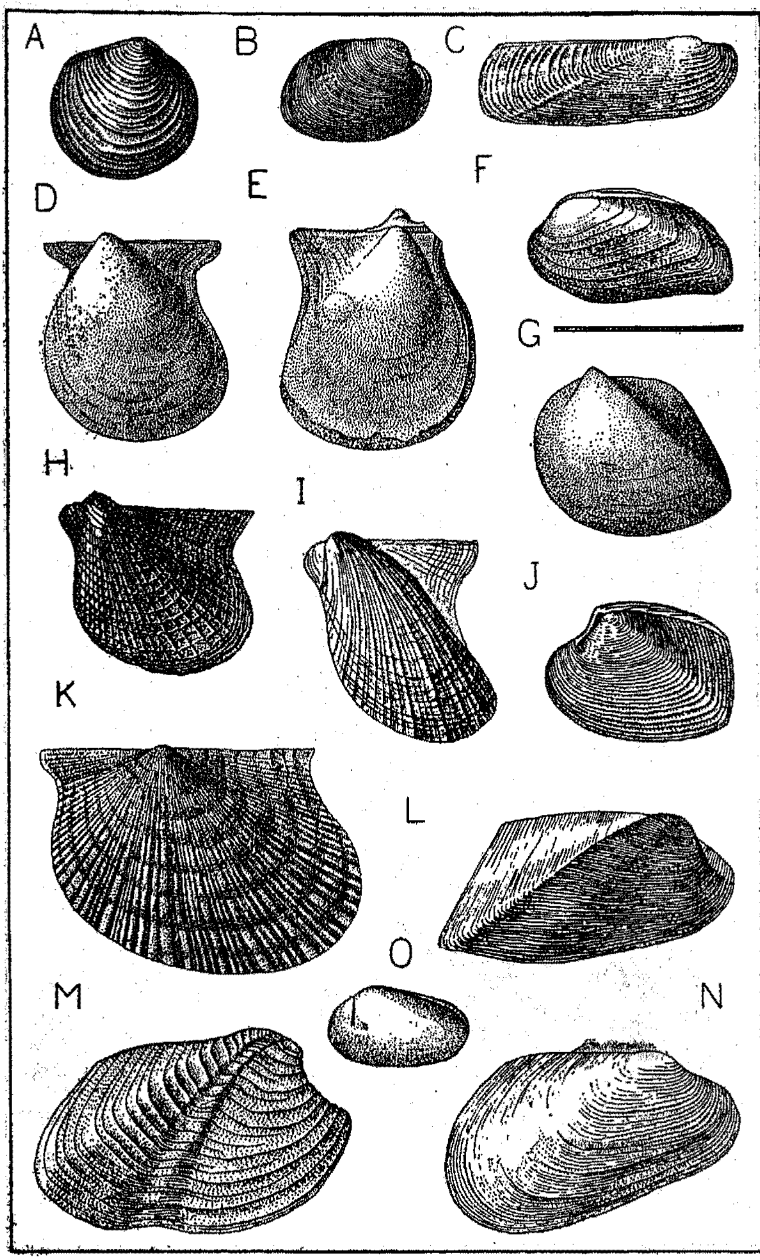


Figure 63 Hamilton (Cardiff) shale fossils. (Pelecypods) *A Paracyclas lirata*, x ¾. *B Nucula bellistriata*, x 1. *C Orthonota undulata*, x ½. *D, E Glyptodesma* (*Actinodesma*) *erectum*, x ½. *F Nyassa arguta*, x ¾. *G Schizodus chemungensis*, x ¾. *H, Actinopteria boydi*, x ¾. *I Pterinea* (*Cornellites*) *flabellum*, x ½. *J Cypricardella bellistriata*, x ¾. *K Pterinopecten vertumnus*, x ¾. *L Goniophora hamiltonensis*, x ¾. *M Grammysia bisulcata*, x ¾. *N Modiomorpha mytiloides*, x ½. *O Nuculites oblongatus*, x ¾.

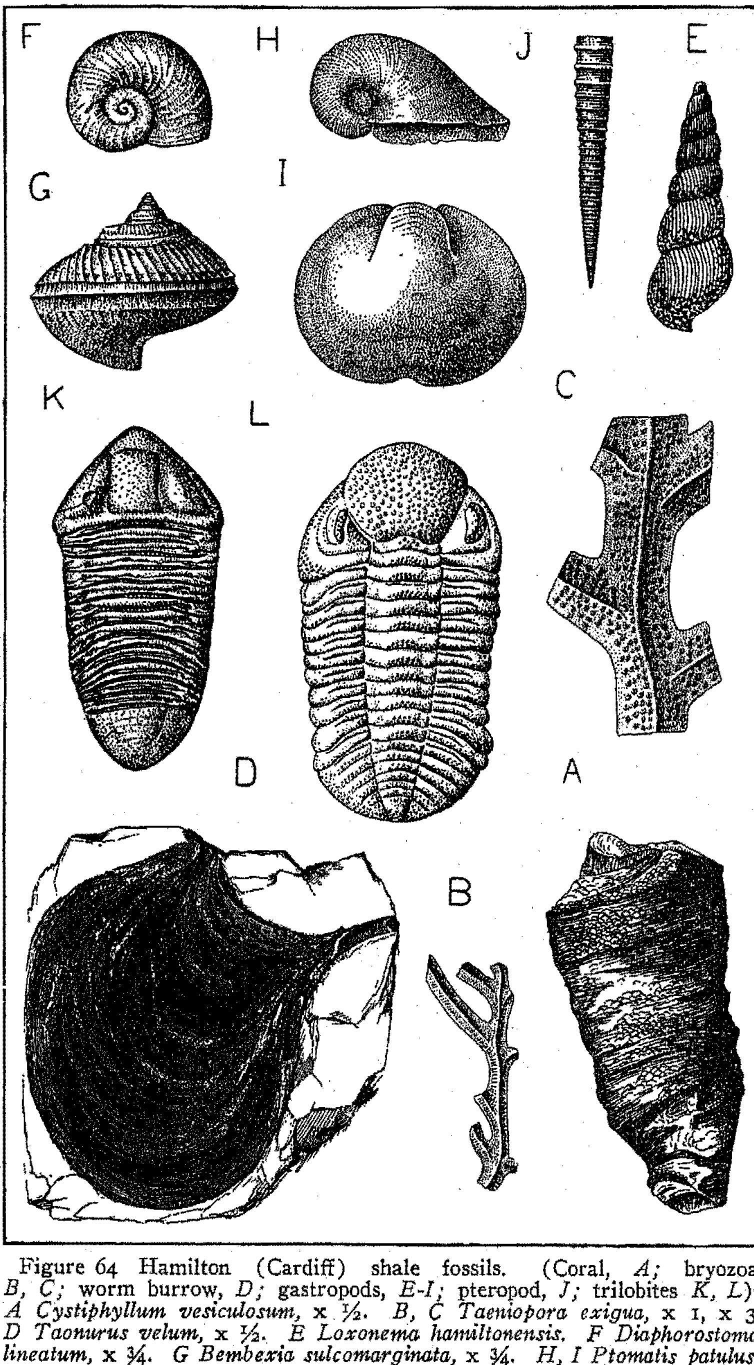


Figure 64 Hamilton (Cardiff) shale fossils. (Coral, *A;* bryozoan, *B, C;* worm burrow, *D;* gastropods, *E-I;* pteropod, *J;* trilobites *K, L*). *A Cystiphyllum vesiculosum,* x ½. *B, C Taeniopora exigua,* x 1, x 3. *D Taonurus velum,* x ½. *E Loxonema hamiltonensis. F Diaphorostoma lineatum,* x ¾. *G Bembexia sulcomarginata,* x ¾. *H, I Ptomatis patulus,* x ¾. *J Tentaculites bellulus. K Homalonotus (Dipleura) dekayi,* x ⅜. *L Phacops rana,* x ½.

have heard members of the old Survey, as R. P. Whitfield and G. B. Simpson, tell with enthusiasm of their lamellibranch hunting expeditions into the Hamilton in preparation of volume V. Many of the figured specimens are exhibited in the Hamilton cases in the State Museum. The brachiopods, which prevail in the limestone formations, are the next in abundance, but attain only one-third the number of the lamellibranchs.

The writer has made very full collections at a number of localities on the Berne quadrangle, and it has seemed advisable to give full lists for several localities, since they may be of use in future studies of the Hamilton of the east. In the lower blocky Hamilton (Cardiff) beds the fauna is small. North of Wolf hill along the old road leading south from the new Camp Pinnacle road across the Onesquethaw to Countryman hill a small collection was made between 30 and 50 feet above the contact with the black Marcellus shale, including plant remains; the brachiopods *Chonetes* sp. (small form, very abundant), *Nucleospira* cf. *concinna*; the pelecypods *Nuculites triqueter* (next in abundance to Chonetes), *N. oblongatus, Lunulicardium marcellense*; the conularid *Conularia* sp.; the pteropod *Tentaculites gracilistriatus* and the cephalopod *Nautilus* (*Discites*) *marcellensis*. About 200 feet above the contact with the black Marcellus shale in the first two cuts at the south along the Wolf Hill state road were collected crinoid stems; the pelecypods *Nuculites triqueter* and *Palaeoneilo* cf. *perplana*; the pteropod *Tentaculites* cf. *hamiltonensis*; the cephalopods *Orthoceras* sp., *Parodiceras* sp., *Spyroceras* sp. In the hill at the left (east) of the Rensselaerville road, a short distance beyond the junction with the East Berne state road, the following collection (besides plant remains) was made about 400 feet above the black Marcellus shale:

Brachiopods

Spirifer *sp. near* consobrinus *d'Orbigny*
S. audaculus (*Conrad*)
Chonetes coronatus (*Conrad*)
C. scitulus *Hall*
C. mucronatus *Hall*
Camarotoechia *sp.*
Lingula *cf.* punctata *Hall*
Lingula *sp.*
Orbiculoidea *sp.*

Pelecypods

Paracyclas lirata (*Conrad*)
Nucula bellistriata (*Conrad*)
Nuculites oblongatus *Conrad*
Nuculites triqueter *Conrad*
Tellinopsis subemarginata (*Conrad*)
Orthonota undulata *Conrad*
Palaeoneilo *cf.* perplana *Hall*
Grammysia *sp.*
Sphenotus *sp.*

Cephalopods

Orthoceras *sp.*

In the road cut one and a half miles southwest of East Berne the writer has made collections for every 20 feet for a section taking in about 500 feet of thickness (aneroid; calculation for dip about 600 feet). The section begins just above the top of the Marcellus black shale (about 1200 feet A. T.). The lower 30 feet of blocky shales are very barren, and only plant remains, the pteropod *Styliolina fissurella* and the cephalopods *Orthoceras* sp. and *Parodiceras* sp. were found. Concretions are abundant. In the next 20 feet were found plant remains; the brachiopods *Spirifer audaculus, S. mucronatus, Chonetes scitulus, Nucleospira concinna, Camarotoechia* sp., *Orbiculoidea* sp.; the pelecypods *Nucula bellistriata, Nuculites triqueter, Modiomorpha* cf. *mytiloides, Orthonota undulata*; the cephalopods *Orthoceras* sp., *Parodiceras discoideum, Nautilus* (*Discites*) *marcellensis*. Thin sandstone bands have become frequent with a ten-inch band near top. Joint planes (see page 190) are beautifully shown here and in the section immediately above (N. 47°E., N. 77°E., N. 63°W., due E-W etc.). In the next 50 feet fossils become more abundant. Sixty-five feet above the base in the upper 12 inches of a heavy bed of sandstone (seven feet thick) is an abundance of corals (both cup and compound). Three feet below the coral layer is a belt of 12 inches with numerous *Chonetes* cf. *vicinus*. Both the corals and some brachiopods continue for three feet above this zone (see page 190). The upper part (20 feet) of this second 50 feet is blocky with thin sandstone layers near the top, fossils are sparse and concretions are quite noticeable. The writer collected from this 50 feet:

Corals

Zaphrentis *cf.* prolifica *Billings*
Cystiphyllum vesiculosum *Goldfuss*
Cystiphyllum *sp.*
cf. Cyathophyllum *sp.*
Streptelasma (Enterolasma) rectum *Hall*
Favosites *sp.*

Bryozoans

Fistulipora *sp.*

Brachiopods

Chonetes *cf.* vicinus (*Castelnau*)
C. mucronatus *Hall*
Spirifer mucronatus (*Conrad*)
S. audaculus (*Conrad*)
S. divaricatus *Hall*
S. *sp. near* consobrinus *d'Orbigny*
Athyris cora *Hall*
Meristella *sp.*
Atrypa reticularis (*Linnaeus*)
Tropidoleptus carinatus (*Conrad*)
Leiorhynchus *sp.*
Stropheodonta (Leptostrophia) perplana (*Conrad*)

Pelecypods

Nucula bellistriata (*Conrad*)
Nuculites triqueter *Conrad*
Nuculites *sp.*
Actinopteria boydi (*Conrad*)
Modiomorpha mytiloides (*Conrad*)
M. *sp.* (young)
Paracyclas lirata (*Conrad*)
Pterinopecten *cf.* undosus *Hall*
Grammysia *sp.*
Palaeoneilo *sp.*

Gastropods

Ptomatis patulus (*Hall*)

Conularids

Hyolithes *sp.*

Cephalopods

Orthoceras *sp.*
Parodiceras discoideum (*Conrad*)

The second 100 feet did not yield a large fauna. The lowest beds are blocky and rather barren. Near the middle of this section the beds become more sandy and heavier bedded, and a knotty appearance is given by layers of concretions. Fifty feet up the worm burrow *Taonurus velum* (Vanuxem) was found covering certain surfaces. Heavier sandstone beds appear near the top. Fossil layers are most frequent in the sandstone bands. The fauna as collected is:

Plants

Protolepidodendron sp.

Brachiopods

Spirifer mucronatus (*Conrad*)
S. audaculus (*Conrad*)
Chonetes *cf.* vicinus (*Castelnau*)
C. *sp.*
Camarotoechia *sp.*
Athyris cora *Hall*

Pelecypods

Nuculites triqueter *Conrad*
Nucula lirata (*Conrad*)
N. bellistriata (*Conrad*)
Paracyclas lirata (*Conrad*)
P. tenuis *Hall*
Nyassa arguta *Hall*
Pterinea (Cornellites) flabellum (*Conrad*)

Gastropods

Bembexia sulcomarginata (*Conrad*)

Cephalopods

Orthoceras *sp.*

The third 100 feet is most fossiliferous in the upper portion. Heavy sandstone beds are found there and the fossils are more abundant, including a number of pelecypod genera. The heavy beds break into large blocks. The lower portion of the section (partly covered) is in the main sparsely fossiliferous. *Taonurus velum* surfaces are exposed near the top. The fossils listed are:

Crinoids

Stems

Worms

Taonurus velum (*Vanuxem*)

Brachiopods

Spirifer mucronatus *Hall*
S. audaculus (*Conrad*)
S. acuminatus (*Conrad*)
Chonetes coronatus (*Conrad*)
C. *cf.* vicinus (*Castelnau*)
Productella dumosa *Hall*
Rhipidomella vanuxemi *Hall*
R. sp.
Camarotoechia *cf.* prolifica (*Hall*)
C. *sp.*
Athyris cora *Hall*
Tropidoleptus carinatus (*Conrad*)

Pelecypods

Grammysia bisulcata (*Conrad*)
G. *cf.* circularis *Hall*
M. concentrica (*Conrad*)
M. *sp.*
Nyassa arguta *Hall*
Pterinea (Cornellites) flabellum (*Conrad*)
Cypricardella bellistriata *Conrad*
Paracyclas lirata (*Conrad*)
Parallelodon hamiltoniae *Hall*
Sphenotus *sp.*
Nucula bellistriata (*Conrad*)
Palaeoneilo *cf.* tenuistriata *Hall*

Gastropods

Bembexia sulcomarginata (*Conrad*)
Euryzone *cf.* lucina (*Hall*)
Ptomatis *sp.*

Above the third 100 feet the beds are distinctly flaggy with some very heavy beds. The fossils are abundant in certain sandy layers throughout the fourth 100 feet and near the middle of the fifth 100 feet, beyond which, where exposed, there are mainly unfossiliferous flags. At the top of this last section over 20 feet are exposed in a quarry (see page 190), where the blocky shales appear again with the sparse fauna characteristic of those beds. The species found there are plant remains, the brachiopods *Spirifer mucronatus, Spirifer* cf.

granulosus, Chonetes sp., *Camarotoechia congregata* (large) and the pelecypods *Pterinea (Cornellites) flabellum* and *Paracyclas lirata.* At the top is a six to eight-inch sandstone bed with the surface covered with clay balls. Two or three inches below the top is a layer literally packed with macerated plant remains and numerous small clay balls, with some specimens of *Spirifer mucronatus.* From the fourth 100 feet were collected:

Crinoids

Stems

Brachiopods

Lindstroemella aspidium *Hall & Clarke*
Spirifer mucronatus (*Conrad*)
S. audaculus (*Conrad*)
S. *cf.* acuminatus (*Conrad*)
Chonetes coronatus (*Conrad*)
C. *sp.*
Camarotoechia *cf.* congregata (*Conrad*)
C. *sp.*
Rhipidomella vanuxemi *Hall*
Tropidoleptus carinatus (*Conrad*)
Athyris cora *Hall*
Orbiculoidea *cf.* humilis (*Hall*)

Pelecypods

Modiomorpha *cf.* mytiloides (*Conrad*)
M. concentrica (*Conrad*)
Orthonota undulata *Conrad*
Glyptodesma (Actinodesma) erectum (*Conrad*)
Pterinea (Cornellites) flabellum (*Conrad*)
Grammysia circularis *Hall*
Nucula bellistriata (*Conrad*)
Nuculites oblongatus *Conrad*
Paracyclas lirata (*Conrad*)
Goniophora hamiltonensis *Hall*
Leiopteria *cf.* dekayi *Hall*
Palaeneilo *sp.*

Gastropods

Bembexia sulcomarginata (*Conrad*)
Ptomatis patulus (*Hall*)

The fifth 100 feet yielded the following forms:

Brachiopods

Spirifer mucronatus (*Conrad*)
S. granulosus *Conrad*
Chonetes coronatus (*Conrad*)
C. *cf.* vicinus (*Castelnau*)
Camarotoechia *cf.* prolifica (*Hall*)
C. congregata (*Conrad*), large form
Tropidoleptus carinatus (*Conrad*)

Pelecypods

Modiomorpha mytiloides (*Conrad*)
M. *sp.* (large form)
Grammysia *sp.*
Glyptodesma (Actinodesma) erectum (*Conrad*)
Nyassa arguta *Hall*
Cypricardella gregaria *Hall*

Pelecypods (continued)

Cimitaria corrugata (*Conrad*)
Goniophora hamiltonensis *Hall*
Pterinopecten vertumnus *Hall*
Aviculopecten princeps (*Conrad*)
Lyriopecten interradiatus *Hall*
Paracyclas lirata (*Conrad*)
Nucula bellistriata (*Conrad*)
N. lamellata *Hall*
Nuculites oblongatus *Conrad*

Gastropods

Bembexia sulcomarginata (*Conrad*)

Pteropods

Tentaculites *sp.*

Cephalopods

Nephriticeras *sp.*

The species recorded in the following lists were collected from the uppermost (100 to 150 feet) marine beds. In the quarries south of Westerlo and the exposures to the west the collections were made 100 feet or less below the nonmarine beds; in the quarry cited along the Rensselaerville road about the same; at Rensselaerville falls immediately below the nonmarine beds; in the road cut between two and a half to three miles north of Rensselaerville, along a north-going side road, about 50 to 150 feet below the nonmarine beds.

In the quarry one-half mile south of Westerlo, besides plant remains were found:

Crinoids

Stem joints

Brachiopods

Spirifer mucronatus (*Conrad*)
S. granulosus *Conrad*
Chonetes coronatus (*Conrad*)
C. scitulus *Hall*
C. mucronatus *Hall*
Camarotoechia congregata (*Conrad*)
C. prolifica (*Hall*)
Stropheodonta (Leptostrophia) perplana (*Conrad*)
Cyrtina hamiltonensis *Hall*
Dignomia alveata *Hall*
Schizophoria *cf.* striatula Schlotheim

Pelecypods

Glyptodesma (Actinodesma) erectum (*Conrad*)
G. circularis *Hall*
G. nodocostata *Hall*
Goniophora hamiltonensis *Hall*
G. glauca *Hall*
Modiomorpha mytiloides (*Conrad*)
M. subalata (*Conrad*)
Cypricardella complanata *Hall*
Sphenotus cuneatus (*Conrad*)

Pelecypods (continued)

Schizodus chemungensis (*Conrad*)
Paracyclas lirata (*Conrad*)
P. tenuis *Hall*
Nucula bellistriata (*Conrad*)
N. lirata (*Conrad*)
N. *cf.* varicosa *Hall*
Palaeoneilo maxima *Conrad*
Nuculites oblongatus *Conrad*
Prothyris lanceolata *Hall*
Pterinea (Cornellites) flabellum (*Conrad*)
Actinopteria boydi (*Conrad*)
Leiopteria dekayi *Hall*
L. greeni *Hall*
Pterinopecten vertumnus *Hall*
Lyriopecten interradiatus *Hall*

Gastropods

Bembexia sulcomarginata (*Conrad*)
Ptomatis patulus (*Hall*)
Pleurotomaria *cf.* filitexta *Hall*

Pteropods

Tentaculites bellulus *Hall*

Cephalopods

Orthoceras *sp.*

In the quarry about one mile south of Westerlo (somewhat higher in the formation than the above) were collected:

Crinoids

Ancyrocrinus bulbosus *Hall*
Stem joints

Bryozoans

Fenestella *sp.*

Brachiopods

Spirifer mucronatus (*Conrad*)
S. granulosus *Conrad*
S. *sp. near* consobrinus *d'Orbigny*
Chonetes coronatus (*Conrad*)
C. scitulus *Hall*
Camarotoechia *sp.*
Athyris cora *Hall*
Cyrtina hamiltonensis *Hall*
Schizophoria *cf.* striatula *Schlotheim*
Tropidoleptus carinatus (*Conrad*)
Stropheodonta demissa (*Conrad*)
S. inaequistriata (*Conrad*)
S. (Leptostrophia) perplana (*Conrad*)
Atrypa reticularis (*Linnaeus*)
Orbiculoidea *sp.*

Pelecypods

Grammysia bisulcata (*Conrad*)
G. *sp.*
Orthonota undulata *Conrad*
Modiomorpha mytiloides (*Conrad*)
M. subalata (*Conrad*)
Goniophora hamiltonensis *Hall*

Pelecypods (continued)

G. glauca *Hall*
Nyassa arguta *Hall*
Cimitaria *cf.* elongata (*Conrad*)
Sphenotus *sp.*
Pholadella radiata (*Conrad*)
Paracyclas lirata (*Conrad*)
P. tenuis *Hall*
Nuculites oblongatus *Conrad*
Nucula bellistriata (*Conrad*)
N. *cf.* varicosa *Hall*
Pterinopecten vertumnus *Hall*
Gosseletia triquetra (*Conrad*)

Gastropods

Ptomatis patulus (*Hall*)
P. rudis
Platyceras thetis *Hall*

Pteropods

Tentaculites bellulus *Hall*

Conularids

Coleolus tenuicinctus *Hall*
Hyolithes aclis *Hall*

Cephalopods

Orthoceras *sp.*

Trilobites

Phacops *cf.* rana (*Green*)

Along the Westerlo-Van Leuvans Corners road within about one mile and a quarter west of Westerlo were collected a few forms not found in the above-mentioned quarries: the bryozoan *Taeniopora exigua* Nicholson; the brachiopods *Productella dumosa* Hall, *Eunella lincklaeni* Hall; *Roemerella grandis* (Vanuxem), *Lingula punctata* Hall, *Rhipidomella cyclas* Hall; the pelecypods *Gosseletia triquetra* (Conrad), *Phthonia* cf. *nodicostata* Hall, *Tellinopsis subemarginata* (Conrad), *Nucula corbuliformis* Hall.

The quarry along the Rensselaerville road, about two miles northeast of the village, yielded the following fauna:

Corals

Favosites *sp.*
Cystiphyllum *sp.*

Crinoids

Camerate genus
Inadunate genus
Stem joints

Bryozoans

Taeniopora exigua *Nicholson*
Fenestella *sp.*

Brachiopods

Spirifer mucronatus (*Conrad*)
S. *cf.* audaculus (*Conrad*)
S. *sp. near* consobrinus *d'Orbigny*
Productella dumosa *Hall*
Eunella lincklaeni *Hall*
E. *sp.*
Pholidops hamiltoniae *Hall*
P. *sp.*
Cyrtina hamiltonensis *Hall*
Chonetes *cf.* setigerus (*Hall*)
Rhipidomella cyclas *Hall*
Stropheodonta demissa (*Conrad*)
S. *sp.*
Camarotoechia congregata (*Conrad*)
Lingula *sp.*

Pelecypods

Glyptodesma (Actinodesma) erectum (*Conrad*)
Modiomorpha mytiloides (*Conrad*)
M. *sp.*
Goniophora hamiltonensis *Hall*
G. glauca *Hall*
Nyassa arguta *Hall*
Grammysia nodocostata *Hall*
Schizodus chemungensis (*Conrad*)
Phthonia sectifrons *Conrad*
Sphenotus *cf.* solenoides *Hall*
Prothyris lanceolata *Hall*
Paracyclas lirata (*Conrad*)
P. tenuis *Hall*
Nucula bellistriata (*Conrad*)
Nuculites oblongatus *Conrad*
Cypricardella bellistriata *Conrad*
Pterinea (Cornellites) flabellum (*Conrad*)
Pterinopecten vertumnus *Hall*
Actinopteria boydi (*Conrad*)
Leiopteria dekayi *Hall*
Lyriopecten interradiatus *Hall*

Gastropods

Loxonema hamiltoniae *Hall*
Ptomatis patulus (*Hall*)

Trilobites

Phacops rana (*Green*)
Cryphaeus boothi *Green*

From a near-by cut an additional fauna was collected: the brachiopods *Atrypa reticularis* (Linnaeus), *Strophalosia truncata* (Hall), *Tropidoleptus carinatus* (Conrad), *Lingula punctata* Hall; the pelecypod *Palaeoneilo* sp.; the gastropod *Bucanopsis leda* Hall; the pteropod *Tentaculites bellulus* Hall.

At Rensselaerville, from the section above the lower falls and bridge and extending to the foot of the principal fall, Prosser ('99, p. 256) collected:

Bryozoans
Taeniopora exigua *Nicholson*

Brachiopods
Spirifer mucronatus (*Conrad*)
S. granulosus *Conrad*
Chonetes setigerus (*Hall*)
Camarotoechia prolifica (*Hall*)

Pelecypods
Goniophora hamiltonensis *Hall*
Grammysia magna *Hall*
Palaeoneilo constricta (*Conrad*)

Pelecypods (continued)
Orthonota undulata *Conrad*
Nyassa arguta *Hall*
? Sphenotus truncatus (*Conrad*)
Pterinea (Cornellites) flabellum (*Conrad*)
Actinopteria boydi (*Conrad*)

Gastropods
Loxonema hamiltoniae *Hall*

Pteropods
Tentaculites attenuatus *Hall*

At the very top of the marine beds (1415 feet A. T.) the writer found the brachiopod *Camarotoechia* sp. and the pelecypods *Modiomorpha mytiloides, Actinopteria boydi* and *Nucula* sp. A ripple-marked surface is well shown here. In the ten feet below this the writer, alone and with Doctor Cooper, collected the brachiopods *Productella dumosa, Eunella lincklaeni, Camarotoechia,* sp., *Schuchertella* sp.; the pelecypods *Goniophora hamiltonensis* and *Pterinea* (*Cornellites*), *flabellum* (both abundant), *Nyassa arguta, Pterinopecten macrodonta, Goniophora* (*Cosmogoniophora*) *truncata, Actinodesma* sp., *Grammysia* sp., *Sphenotus* sp.; the pteropod *Tentaculites* sp.; the cephalopod *Orthoceras* sp. and a trilobite referred to *Phacops rana.*

In the road cut between two and a half to three miles north of Rensselaerville, 50 to 60 feet below the nonmarine beds in heavy bedded sandstones were collected:

Brachiopods
Spirifer mucronatus (*Conrad*)
S. *cf.* audaculus (*Conrad*)
S. *sp. near* consobrinus *d'Orbigny*
Tropidoleptus carinatus (*Conrad*)
Eunella lincklaeni *Hall*
Athyris cora *Hall*
Chonetes coronatus (*Conrad*)
Camarotoechia congregata (*Conrad*)
Ambocoelia umbonata (*Conrad*)

Pelecypods
Goniophora hamiltonensis *Hall*
Glyptodesma (Actinodesma) erectum (*Conrad*)
Orthonota undulata *Conrad*
Pterinea (Cornellites) flabellum (*Conrad*)
Nuculites triqueter (*Conrad*)
Nucula bellistriata (*Conrad*)
Palaeoneilo maxima *Conrad*
Paracyclas lirata (*Conrad*)
Cypricardella gregaria *Hall*

Gastropods
Diaphorostoma sp.

In blocky beds 140 to 150 feet below the top of the marine beds the brachiopods *Spirifer mucronatus, Chonetes coronatus* and the pteropod *Tentaculites* sp. were found. The fauna is sparse in this part of the section, but abundant above where the heavy sandstone beds come in 90 to 100 feet below the nonmarine beds, with a predominately pelecypod fauna:

Crinoids

Stems

Bryozoans

Taeniopora exigua *Nicholson*

Brachiopods

Spirifer *cf.* granulosus *Conrad*
Camarotoechia congregata (*Conrad*)
Productella dumosa *Hall*
Tropidoleptus carinatus (*Conrad*)
Dignomia alveata *Hall*

Pelecypods

Modiomorpha mytiloides *Conrad*
Goniophora hamiltonensis *Hall*
Glyptodesma (Actinodesma) erectum (*Conrad*)

Pelecypods (continued)

Grammysia bisulcata (*Conrad*)
Pterinea (Cornellites) flabellum (*Conrad*)
Actinopteria boydi (*Conrad*)
Aviculopecten princeps (*Conrad*)
Leiopteria dekayi *Hall*
Sphenotus cuneatus (*Conrad*)
Parallelodon hamiltoniae *Hall*
Nyassa arguta *Hall*
Paracyclas lirata (*Conrad*)
P. tenuis *Hall*
Nucula bellistriata (*Conrad*)

Gastropods

Platyceras *cf.* thetis *Hall*

In the Bradt hill section, about three and a half miles south-southwest of West Berne, the difference in altitude gives a thickness of 940 feet for the Marcellus-Hamilton formations, but, as pointed out above, the dip of 1½° to 2½° a mile to the southwest would add 475 to 780 feet, making a thickness of the formation between 1415 and 1720 feet (Prosser, '99, p. 243). At an elevation of 835 feet above the Onondaga, Prosser collected in an exposure of fine, bluish argillaceous shales containing plenty of fossils (*ref. cit.*):

Bryozoans

Taeniopora exigua *Nicholson*

Brachiopods

Spirifer mucronatus (*Conrad*)
S. granulosus *Conrad*
S. audaculus (*Conrad*)
Tropidoleptus carinatus (*Conrad*)
Chonetes coronatus (*Conrad*)
Camarotoechia sappho (*Hall*)
C. congregata (*Conrad*)
Eunella lincklaeni *Hall*
Productella *sp.*
Lingula *sp.*

Pelecypods

Palaeoneilo constricta (*Conrad*)
Nuculites triqueter *Conrad*
Tellinopsis subemarginata (*Conrad*)
Sphenotus truncatus (*Conrad*)
Orthonota undulata *Conrad*
Goniophora hamiltonensis *Hall*
Cimitaria elongata (*Conrad*)
Modiomorpha subalata (*Conrad*)
Elymella levata *Hall*
Cypricardella tenuistriata *Hall*
Actinopteria boydi (*Conrad*)
Liopteria dekayi *Hall*
Pterinopecten vertumnus *Hall*
Nucula corbuliformis *Hall*

Trilobites

Homalonatus dekayi (*Green*)

About 90 feet above this zone were found bluish shales with quite a number of specimens of small Hamilton pelecypods. They were especially common in a thin layer at the base of the shales while a little higher in a thin layer of calcareous shell rock numerous specimens of *Camarotoechia* sp. were found. The fauna collected by Prosser here is:

Brachiopods	*Pelecypods*
Atrypa reticularis (*Linnaeus*)	Orthonota undulata *Conrad*
Spirifer mucronatus (*Conrad*)	Nuculites oblongatus *Conrad*
S. granulosus *Conrad*	Palaeoneilo constricta (*Conrad*)
Chonetes setigerus (*Hall*)	Grammysia bisulcata (*Conrad*)
	Pterinopecten vertumnus *Hall* (?)

Fifteen feet above the base of this zone and 940 feet (altitude) above the top of the Onondaga in coarse, bluish, arenaceous shales Prosser found a bryozoan; the brachiopods *Chonetes coronatus, Spirifer mucronatus;* the pelecypods *Pterinea* (*Cornellites*) *flabellum, Actinopteria boydi, Nuculites oblongatus.* Prosser regarded these shales, the highest rocks of the section, as forming the top of the formation (our marine Hamilton).

As pointed out above (page 151), in the eastern part of the State the Hamilton beds above the Marcellus black shale have always been discussed as a unit, the Hamilton shales and flags. Cooper ('30) has worked out the stratigraphy of the Hamilton as far east as the Unadilla Valley east of which the stratigraphy is not well known in detail, although "the Hamilton of the Schoharie valley and the narrow belt along the Hudson are partially known through the writings of Prosser, Grabau and Darton" (*ref. cit.*, p. 233). In Ulster and Greene counties, the Hamilton above the Marcellus black shale (*Bakoven* of Chadwick, '33) has been divided into two formations. The lower formation includes the fossiliferous marine beds, 400 to 500 feet thick, and is designated as the *Mount Marion beds* (Grabau, '19) from Mount Marion west of Saugerties; the upper formation contains nonmarine, nonfossiliferous, flagstone-bearing beds, with a thickness of 500 to 600 feet, and has been termed the *Ashokan shales and flags* (Grabau, '19). Cooper in his Stratigraphy of the Hamilton Group ('30) suggested that the nonmarine Ashokan beds may represent all of the upper Hamilton and the marine Mount Marion beds the Cardiff shales; or that the former are the time equivalent of the Moscow and Ludlowville and the latter, of the Cardiff and Skaneateles (see supplementary note, page 189; upper Hamilton found in "Oneonta" beds). Later (in the field, fall 1931) he expressed to the writer his view that the Mount Marion beds are wholly Cardiff. The *Cornwall shale* (Hartnagel, '07; for Darton's "Monroe shale") was named from exposures found at the town of Cornwall, Orange county. These shales, 200 feet thick, extend through the town of Monroe into New Jersey and carry fossils indicative of Hamilton age. The *Bellvale shale* (Darton, '94) also occurs in Orange county and New Jersey, overlying the Cornwall shale. These beds have a thickness of 1300 to 2000 feet and the plant remains found indicate Middle Devonian age, with the upper beds perhaps as late as Portage. They were named from Bellvale mountain in Orange county.

Cooper believes that the true top of the Hamilton in the Schoharie valley is not now known ('30, p. 233). The highest Hamilton shales in Schoharie county have been found to carry what is believed to be the Skaneateles fauna, and it is suggested that at least part of the Sherburne sandstone in the Schoharie valley is of Hamilton age (Cooper; Chadwick, in conversation 1931) and represents the Moscow and at least a portion of the Ludlowville (see supplementary note, page 186). The westward disappearance of successive faunal zones at the top of the Hamilton indicates unconformable relations between the Hamilton and the Upper Devonian (Cooper, *ref. cit.*).

Doctor Cooper visited with the writer a number of the fossiliferous localities on the Berne quadrangle, and studied the full collections made during the course of field investigations in the area. He then expressed his belief that the Skaneateles formation was represented by marine beds on the Berne quadrangle, if at all, only in the region south-southwest of West Berne (Bradt hill section) and that farther east there was nothing higher than the Cardiff (upper Marcellus formation). Cooper thought the beds in the quarry one-half mile south of Westerlo resembled the top member (Pecksport) of the upper Marcellus formation, but did not consider the fossil assemblage Pecksport. *Pterinopecten macrodonta* has been found by Cooper in the upper Skaneateles on the Morrisville quadrangle, but the fact that a specimen referred to this species has been collected at Rensselaerville falls does not mean, according to him, that we have Skaneateles beds there. As to the lower part of the Marcellus formation indications are that the 170 to 180 feet of black fissile shale belong to Cooper's Chittenango member (above the Cherry Valley limestone and the Union Springs member consisting of thin alternating beds of black limestone and sooty shale, overlying the Onondaga westward). In a letter to Doctor Ruedemann (February 22, 1931) relative to his Capital District bulletin ('30), Chadwick, discussing Hamilton relationships in the Schoharie region and on the Albany quadrangle, expresses himself as follows:

Cooper has pointed out that the Moscow fauna is missing at the top of the Schoharie section, and the above correlation agrees with his idea. The next point is this: the 668 feet of dark shales from the Onondaga limestone up to the top of the Bridgewater [= lowest member of Cardiff, upper Marcellus] are strikingly suggestive of Darton's 600 feet of "Hamilton black shales" in the Helderbergs, all of which would then be Marcellus (with Cardiff) as Cooper has thought. From the absence of anything to call Cherry Valley in the Albany county section, I now suspect that your 170–180 feet of black Marcellus shale on Albany sheet, and my possible 200 feet of same on Catskill sheet, are the Chittenango only, and that your remaining 600–700 feet of marine Hamilton, my 800? feet of Mount Marion, are wholly Cardiff, or at most Cardiff and some Skaneateles, as Cooper has argued.

Just how far above the marine beds exposed on the Berne quadrangle Hamilton sedimentation continues remains to be decided by the work of Cooper (see supplementary note, page 186), who is tracing the formations of the Hamilton eastward, and Chadwick, who is working to the south and east of our area. Chadwick (see page 164) has found on the Durham quadrangle, just south of our area, marine beds with Hamilton fossils above the nonmarine flags and shales overlying the marine Hamilton of the Berne quadrangle.

19 "ONEONTA" BEDS[1]

The Oneonta formation or Oneonta sandstone received its name from the city of Oneonta, Otsego county (Vanuxem, '40). It is the "Montrose sandstone or Sandstone of Oneonta" of Vanuxem. "Oneonta" beds are found on the Berne quadrangle in the southwestern corner in the high ridge just to the east of Rensselaerville and in the region to the west (figures 66, 67) and to the northwest as far as the Little Schoharie valley and the divide between the headwaters of that creek and a branch of the Switz kill. These beds are nonmarine in origin and consist of coarse dark grayish to greenish gray flaggy sandstones with intercalations of red and green or mottled red and green shales. The red shales are a conspicuous feature of the formation, constituting beds of one to 30 feet or more in thickness. Red sandstone beds are also characteristic and thin beds of dark gray or black shales are found infrequently and with no great thickness.

Prosser, in discussing these beds ('99, p. 313) states:

From the Chenango valley eastward the Ithaca is capped by the Oneonta formation which is composed of red and green shales, reddish sandstones and coarse grained grayish to greenish gray sandstones. These rocks are nearly unfossiliferous, containing only an occasional specimen of *Archaeopteris* and *Amnigenia catskillensis* (Van.) Hall. The formation has a thickness of 550 feet in the Chenango valley and as the physical conditions under which the

[1] See supplementary note, page 186.

Oneonta was deposited appeared earlier to the eastward it gradually thickens in that direction till in Albany and Greene counties it completely replaces the Ithaca formation.

Darton ('94, p. 434) has estimated the thickness of the "Oneonta" beds in Albany county (see page 189) as about 1000 feet. Higher beds come in southward in the front of the Catskills giving there an estimated thickness for the formation of 2000 to 3000 feet. Besides *Archanodon* (*Amnigenia*) *catskillensis* and remains of the tree fern *Archaeopteris,* plant remains such as the club mosses *Sigillaria*(?) and *Protolepidodendron* and the seedfern *Eospermatopteris* occur.

The "Oneonta" beds constitute a "red" facies in the east representing the time equivalent of marine beds farther west (see page 186). The basal portion has been considered as probably equivalent in time to the higher Ithaca beds (Portage) of the central part of the State. Prosser, as indicated by the quotation above, apparently recognized the earlier age of these beds in the East. The field investigations of G. H. Chadwick indicate that both the Oneonta (see below) and the Catskill sedimentation above begin in the East at an earlier time than supposed (abstracts, Geological Society meetings, 1930, 1931). Chadwick in a letter to the writer (October 8, 1931) inclosed the statement: "This name (Catskill formation) has been widely extended over red beds locally topping the Devonic and now known to be of progressively later age from east to west. The type area in the Catskill Mountain front, at the east, is not younger than Portage in age."

As pointed out by Darton ('94, p. 433), "in the highlands northwest of Rensselaerville the Oneonta formation thickens rapidly and is spread out over a wide area extending far into Schoharie county." Although there are considerable areas of drift where the formation is concealed, exposures are fairly abundant in the southwest corner of the Berne quadrangle and Darton also notes (*ref. cit.*) the very extensive exposure of these beds in the southern part of Rensselaerville township "in the deep valleys and along the hill slopes which characterize this region." Outcrops are well shown south and west of Rensselaerville, along the road to Crystal lake (figure 66) and particularly the road just south which branches from it about a quarter of a mile out of the village. West of Connersville, about a half mile from the boundary of the quadrangle, a ravine joining the valley from the north gives a good section. There is nothing in the lithology of the rocks in the lower section of this ravine to indicate whether they belong with the "Oneonta" red beds or whether the

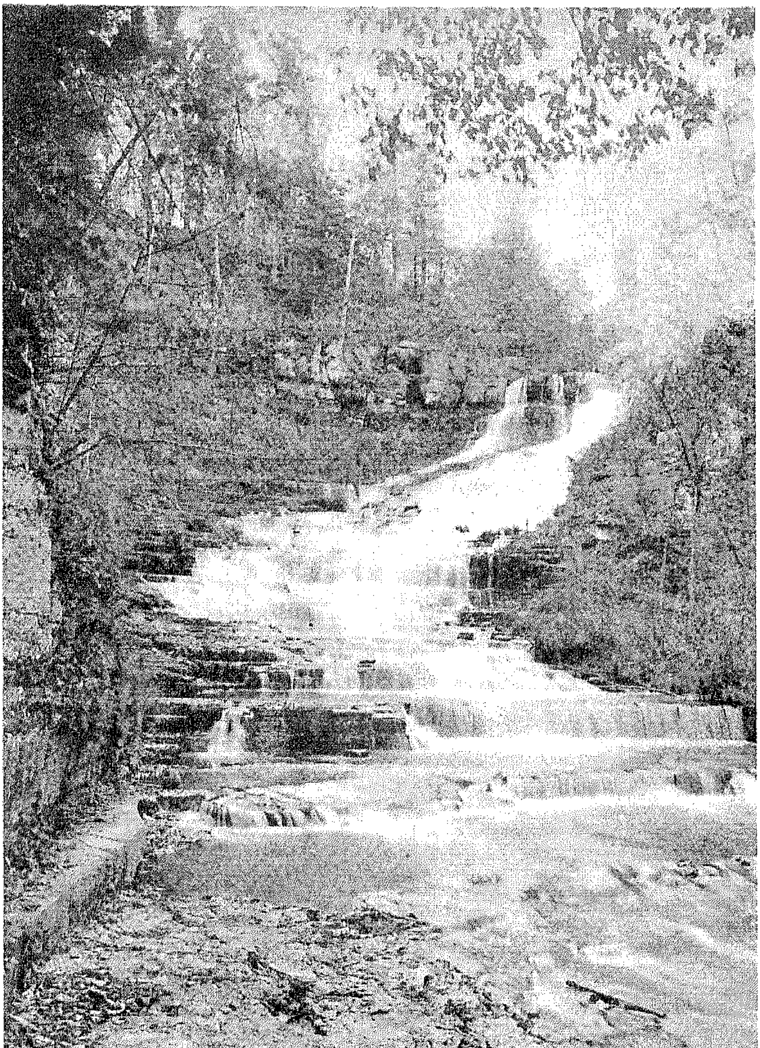


Figure 65 Rensselaerville falls, Tenmile creek, over the "Oneonta" (Hamilton red) beds (upper section) and the lower nonmarine Hamilton beds. (Photograph by E. J. Stein)

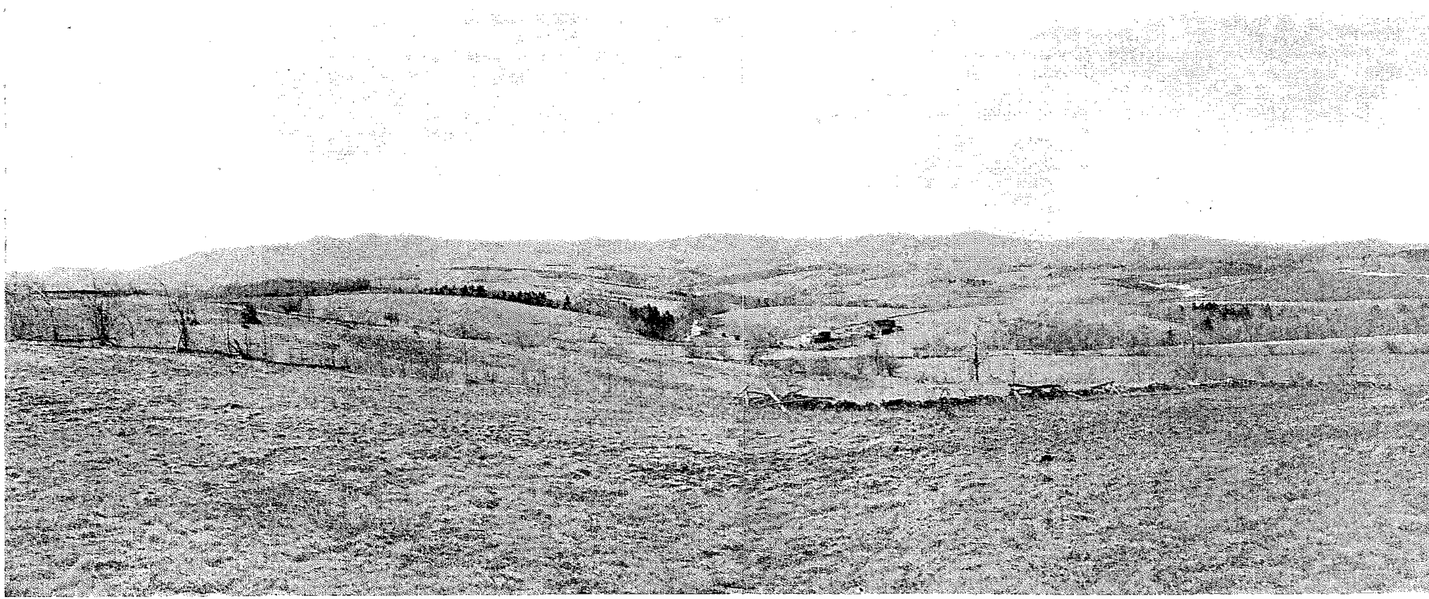


Figure 66 View from hill two miles west of Rensselaerville, looking across the dissected Tertiary peneplane ("Oneonta" hills) to the Catskills showing in their even tops remnants of the Cretaceous peneplane. (Photograph by E. J. Stein)

stream has cut into lower beds, but when the dip is taken into account anything below the red beds would seem to be excluded. Good exposures are found along the roads to the west and north of Myosotis lake and just above (south of) Triangle lake (figure 67); along the northern limits of the formation, particularly in ditches and cuts along the road leading down to Huntersland in the Little Schoharie valley and along the roads in the region to the south and east of the headwaters of the southern branch of the Little Schoharie.

By far the best exposure of the "Oneonta" in our area for a study of the character of the rocks is found in the postglacial gorge at Rensselaerville (figure 65) where in the falls is found a complete section from the uppermost marine Hamilton flags and shales through 65 feet of nonmarine bluish and greenish Hamilton flags and shales and 35 feet of "Oneonta" red beds (continuing higher in the sides of the gorge). In mapping, the writer, as did Darton (*ref. cit.* 434), drew the base of the "Oneonta" at the bottom of the heavy red sandstone layer which is followed by red shales, since it is the only distinguishing feature that can be used as a guide. A heavy bed of green shale comes in near the top and the falls is capped by a ten-foot bed of greenish or greenish gray sandstone showing some cross-bedding. Only macerated plant remains have been found in the "Oneonta" here. As one looks up or down the gorge shutting one's eyes to the color of the rocks, there is apparent a striking resemblance between the lithology of the "Oneonta" beds and that of the marine Hamilton flags and shales below. Chadwick referred to this resemblance while in the field with the writer in 1931, and suggested that the color might be in part, at least, secondary, that is, a surface feature. We know that marine Hamilton sedimentation in our area does not extend above the Cardiff (upper Marcellus formation) and that the bluish and greenish nonmarine flags and shales above are a phase of Hamilton sedimentation, partly because of their lithology and partly because shown to be overlain by typical Hamilton beds with fossils in the area (Durham quadrangle) to the south (see page 164). These facts together with the lithological character of the "Oneonta" beds are suggestive of the possibility that this "red" facies may include sedimentation of Hamilton time. Whether Hamilton sedimentation above the Cardiff is included in these red beds and to what extent is a problem the solution of which depends upon the field investigations of Cooper and Chadwick who are working in the area to the south and west of ours. It is to be hoped that their results may soon be published (consult supplementary note below).

SUPPLEMENTARY NOTE ON HAMILTON (including "ONEONTA") BEDS

Some time after this bulletin was submitted for printing, the writer had the privilege of working (fall, 1932) in the Hamilton beds with Dr G. Arthur Cooper, of the United States National Museum, at Cooperstown and Richmondville, through the Schoharie valley and to a certain extent on the Berne and Durham quadrangles, in the last-named area with Professor G. H. Chadwick of Catskill. This work has shown that the thickness of the Hamilton beds (including the Marcellus black shale or Chittenango) in the Schoharie valley is somewhere in the neighborhood of 2500 feet, the Hamilton there comprising beds previously described as Sherburne and Ithaca. This makes the famous seed-fern (*Eospermatopteris*) forests, reproduced in the Gilboa group in the State Museum, Middle Devonian (Hamilton : Moscow) in age instead of Upper Devonian. In conversation with the writer (June 1933) Doctor Cooper stated that the beds in which *Spirifer mesastrialis* is so abundant along the road to Grand Gorge, a little southwest of Gilboa, are either highest Tully or Geneseo. It appears then that the highest marine beds (sandstones and shales) in the Schoharie valley, the uppermost beds of the so-called "Ithaca," represent older than Ithaca sedimentation and all the true Ithaca is to be found in the red Oneonta beds above (*Onteora* of Chadwick, '33). The 250 feet below these highest marine beds (elevation 1406 feet A. T.) represent the combined Tully and part of the Geneseo (*Gilboa beds;* Cooper, '33, '34) and are exposed in the hills to the north of Gilboa and along the shores of the reservoir south of the Gilboa dam. In the Catskill front the Ithaca is to be looked for in the "Catskill" beds (true Oneonta, in part, at least; see Chadwick, '32, Geological Society meeting abstract; also, '33). The thickness of the Hamilton in the Helderberg area and southward is at least as much as that in the Schoharie valley and a greater thickness is to be expected. The green and red nonmarine beds in the southwestern portion of the Berne quadrangle, previously described as Sherburne and Oneonta, are of Hamilton age.

The lithology of the lower Hamilton beds, known and described as the Marcellus black shale and referred to the Chittenango, varies in different localities both in the Schoharie valley and in the Helderberg area (see page 158), in places showing a distinct Cardiff character. Doctor Cooper believes that this is explained by an interfingering in the East of the black Chittenango type of lithology with the Cardiff type. For the interval between the Onondaga and the

Detached Oversized Item
Previously Located at this
Position

To View:
See Image 2
In Bulletin Folder

Meristella bed at the base of the Otsego member (page 191) of the Hamilton he has proposed ('33) the name *Berne member*. The shale of this interval is the equivalent, on the Berne and Albany quadrangles, of the Union Springs, Cherry Valley and Chittenango members, and has been estimated by Cooper to have a thickness of 280 feet (see page 172).

The marine beds above the Berne member in the Berne area are probably no higher in the Hamilton than the Marcellus formation, except perhaps in the Bradt Hill section where there is an estimated thickness for the Hamilton of 1415 feet, with a dip of 1½° (see page 160). There is an estimated thickness of about 800 feet between the top of the Onondaga and the top of the fossiliferous Hamilton south of Westerlo; approximately 1100 feet to the top of the fossiliferous Hamilton in the falls at Rensselaerville. These estimates were made on the basis of a dip of about 100 feet to a mile (Onondaga dip), which both Doctor Cooper and the writer feel is low for the Hamilton beds where higher and more variable dips come in. Estimates made with a higher dip of 120 feet to the mile, as found in some places in the Schoharie valley and in the Rensselaerville area (page 160), give a thickness for the Hamilton of about 1000 feet to the top of the fossiliferous beds in the Westerlo area and something over 1300 feet in the Rensselaerville area. The Hamilton continues into the nonmarine green sandstones and shales (65 to 80 feet thick), formerly considered Sherburne, and on into the red and green or grayish "Oneonta" sandstones and shales, which on the Berne quadrangle (estimated thickness here 1000 feet) must comprise at least the Skaneateles formation and farther south the higher Hamilton formations also. To these Hamilton "reds" in the Catskill front has been given the name *Kiskatom beds* (Chadwick, '32; Geological Society meeting abstract). The fossiliferous Hamilton of the Berne area is probably the equivalent of the Mount Marion and Ashokan beds, which would place the Mount Marion no higher in the Hamilton than the Bridgewater (lower Cardiff: Otsego member) and probably not all of that member of the Marcellus formation is represented.

The road cut (South Berne road) one and a half miles southwest of East Berne (see pages 171–174) was restudied with Doctor Cooper in the light of results obtained in the Schoharie valley. This section begins in the Hamilton in the upper portion of the Berne member, at an elevation of about 1204 feet A. T. (aneroid and hand level).

Seventy-six feet up in the section Doctor Cooper located the top of the *Meristella zone,* which measures ten feet in thickness. Four feet above the base of this zone is a three-foot coral bed (see page 172), the lower two feet of which are calcareous and the upper one foot the main coral zone. The upper three feet of the Meristella zone consist of crumbly and powdery shale. Among the corals found in the coral bed are species of *Zaphrentis, Cystiphyllum, Favosites* (branching form), *Cladopora* and an Auloporoid form. Other fossils of the Meristella zone are the bryozoan *Fenestella* sp.; the brachiopods *Spirifer divaricatus* (an Onondaga form), *S. audaculus* (abundant), *Meristella* sp. (large form), *Athyris cora, Chonetes* sp. *Reticularia fimbriatus, Atrypa reticularis, Trematospira gibbosa, Rhipidomella vanuxemi, Leptostrophia perplana, Leiorhynchus* sp., *Ambocoelia* sp.; the pelecypods *Palaeoneilo fecunda, Actinopteria boydi;* the gastropods *Loxonema* sp. (very abundant) and *Lophospira trilix*. Doctor Cooper considers this fauna, both the corals and the other fossils, as suggestive of the Onondaga as of the Hamilton. This Meristella zone corresponds to the Meristella bed just above the Chittenango (Marcellus black shale) in the Schoharie valley. This would mean that the Chittenango as defined for the Schoharie valley thickens eastward, and that there is a change in the lithologic character of the rock. These beds (Berne member) carry the Cardiff lithology: dark gray color with white or gray streak, chunky blocks breaking with conchoidal fracture and irregular, many-directioned joint surfaces, seen particularly well in the lower part of the section (see page 172).

Thirty feet above the Meristella zone, a little more than 100 feet up in the section, *Spirifer audaculus* was found in great abundance in a one-foot heavy bed of sandstone, weathering shaly. With this form occurred the brachiopod *Athyris cora;* the pelecypods *Nyassa arguta, Aviculopecten* sp.; the gastropod *Bembexia sulcomarginata;* the conularid *Coleolus tenuicinctus;* a straight shelled cephalopod and the worm burrow *Taonurus velum. Spirifer acuminatus* comes in about 250 feet up in the section. About 350 feet up (elevation 1555 feet A. T., aneroid and hand level) were found most of the species listed from the fourth 100 feet on page 174.

This section, as stated above (page 173), terminates in a road quarry the floor of which is at an elevation of 1655 feet A. T. (aneroid and hand level) or about 450 feet up in the section. In the top of the cross-bedded sandstone forming the floor of the quarry were found the brachiopods *Spirifer mucronatus, Chonetes coronatus, Tropidoleptus carinatus, Camarotoechia* sp. (small) and the pelecypods *Nyassa arguta* and *Cypricardella gregaria.* This sandstone is followed by 19 feet of dark blue-gray shaly sandstone with the brachiopods *Camarotoechia congregata* (large), *Spirifer mucronatus, Chonetes coronatus, C. scitulus, Spirifer* cf. *granulosus* and the pelecypods *Pterinea* (*Cornellites*) *flabellum, Paracyclas lirata.* Doctor Cooper stated in the field that he felt reasonably sure that the base of the quarry, that is, the bed below the shaly sandstone, represents the top of the *Athyris zone.* The combination of large *Camarotoechias* and *Paracyclas lirata* found in the shaly sandstone is that found elsewhere above this zone. Taking the dip into consideration, the top of the Athyris zone in this section would be about 800 feet up in the Hamilton beds. There would be, then, approximately 300 to 500 feet between the top of the Athyris zone here and the top of the marine Hamilton in the Rensselaerville falls. Therefore, the top of the marine Hamilton could be stratigraphically the top of the Marcellus (Cardiff).

In his short report ('33) Doctor Cooper has given the name *Otsego member* (from the type section at Otsego lake) to that part of the Hamilton beds included between the Meristella bed and the top of the Athyris zone, which on the Berne quadrangle has an estimated thickness of 505 feet. The shale and sandstone between the top of the Otsego member and the Portland Point or basal Moscow has been named the *Panther Mountain shale and sandstone* from the type section in Panther mountain, Schoharie valley. This member includes shales and sandstones of the upper part of the Marcellus, the Skaneateles and the Ludlowville which cannot be separated lithologically. The Portland Point has been located on the Durham quadrangle in the vicinity of Potter Hollow, giving an estimated thickness for the Panther Mountain on the Berne-Durham quadrangles of 1400 to 1500 feet, mostly red beds.

On the geological map accompanying this bulletin the writer has drawn the boundary between the marine Hamilton and the nonmarine green sandstones and shales with interbedded dark shales carrying *Estheria* and *Beyrichia;* between the latter and the nonmarine "Oneonta" red beds above. These boundaries, drawn on lithology and fossil content, are somewhat artificial, as the nonmarine beds appear at a lower horizon in the Hamilton in the eastern part of the quadrangle than in the western part; but it has seemed advisable to make these distinctions on the map. As mapped, the Marcellus black shale comprises the greater part of Cooper's Berne member; the Cardiff Marcellus, his Otsego member and part of his Panther Mountain shale and sandstone which also is represented by the nonmarine beds above.

The results of the studies made in the Schoharie valley and in the Helderberg area and southward are embodied in the shorter report on the Hamilton of New York by Doctor Cooper ('33, '34) and a detailed report now in preparation.

STRUCTURAL GEOLOGY

The folding and faulting of the Capital District, described fully by Doctor Ruedemann ('30) in his bulletin covering the geology of that area, dies out just east and south of the area covered by the Berne quadrangle, the structural geology of which, therefore, is very simple. Because of the relation of the Berne quadrangle to the Capital District, particularly the Albany quadrangle, it seems advisable to include here a brief summary of the structural geology of the Capital District area.

THREE STORIES OF FOLDING IN THE CAPITAL DISTRICT

Ruedemann ('30, p. 130–57) recognizes three distinct stories of folded rocks in the Capital District, "one above the other and each separated from the preceding by a distinct plane of unconformity and erosion." The first period of folding was Precambrian in age and resulted in the formation of "several long barriers running in north-northeast to south-southwest direction across the district and forming two or more troughs," two of which, characterized by their entirely different geologic series of formations (see page 55), have been positively recognized and designated as the eastern or Port Levis trough (Ulrich and Schuchert, '02) and the western or Chazy trough of which the southern extension has been termed the Lower Mohawk trough (Ruedemann '14, p. 140). These troughs persisted from Precambrian through Ordovician times. The formations of the two troughs are now in close contact due, principally, to the fact that folding and faulting along numerous fault planes has carried the rocks of the eastern trough westward.

The second folding (strike N. 20° E.) affecting the rocks of the Capital District took place at the end of the Ordovician period, according to the general assumption, and was termed the Taconic folding from the Taconic mountains on the New York-Massachusetts boundary line. Cambrian to Ordovician rocks were affected. The Precambrian rocks, stiffened by their previous folding, were little affected by the later folding. Ruedemann points out ('30, p. 132–37) that

> . . . the rocks of the eastern trough are everywhere intensely folded; those of the western trough are only faulted or but slightly folded, as in the Helderbergs, by a later post-Devonian revolution . . . .

The folding dies out gradually towards the west. While Albany stands on steeply inclined and intensely folded beds, the shales along the Vly below Voorheesville are for the most part in flat position, but there are still fault-lines and small anticlines and synclines but a few feet high seen at the upper rapids below the mill. An excellent section from the folded into the unfolded region was formerly displayed along the canal and the Mohawk river between Cohoes and Rexford. The damming of the river for the barge canal has unfortunately submerged many of the best outcrops. Here could be seen the close, crumpled folds in the eastern section, with occasional broader folds where harder beds were involved, and the gradual opening of the folds westward, until they disappeared rather abruptly near the boundary of the Snake Hill and Schenectady beds, where evidence of overthrust fault-lines becomes visible. West of this zone the Schenectady beds are undisturbed . . . . .

At the end of the Taconic folding, or rather as a special phase of it, extensive overthrusting took place. We have recognized two major thrust planes in the capital district.

Again a great plane of unconformity and erosion, now seen at the base of the Helderberg cliff, cut off this second story of folding and "upon this rests the third story of folding, that of the Appalachian revolution, shown in the Helderberg and the Rensselaer plateaus. This folding probably also had but little effect upon the already closely folded underlying rocks. It strikes nearly north and south (*ref. cit.*, p. 157). . . . The Appalachian folding and thrusting of late Carboniferous to Permian age, which has affected the Rensselaer grit plateau and the Helderberg rocks of the Middle Hudson valley is but feebly displayed in the southernmost part of the Helderberg rocks of the capital district" (*ref. cit.* p. 151).

Darton ('94, p. 447) has already described this region and he writes:

As the formations of the Helderberg mountains are brought down to the general country level, they extend to the east and south into a flexed region. The first features noticeable are a series of gentle undulations which broaden the outcrop areas of the limestones and indent their edges into a series of *en echelon* offsets. These undulations enter the Helderberg area in succession from west to east, as it extends southward, along axes striking south ten degrees west, approximately, and pitching slightly in the same direction, which is diagonal to the general inclination of the monocline. I have attempted to illustrate the nature of these features in the limestone area, for they are an interesting example of the beginning of the series of flexures and they explain the singular distribution of the Helderberg rocks in this portion of Albany county.

. . . The undulations increase in steepness to the eastward and finally become a succession of steep parallel folds which are of true Appalachian type.

Darton (*ref. cit.*) describes a small overthrust on the Sprayt creek (Feuri Spruyt), about three-quarters of a mile west-southwest of the village of South Bethlehem as among the gentle flexures near the northern edge of the disturbed area in the Helderberg rocks. Ruedemann (*ref. cit.* p. 156) refers to this interesting little overthrust as "on a small scale, a duplication of the greater overthrusts described by Davis ('84) from Catskill; by Van Ingen and Clark ('03) from the Vlightberg at Rondout; and by Chadwick from Canoe hill at Saugerties ('10)." Ruedemann continues:

There is no doubt that small overthrusts are more frequent in the southern part of the capital district in connection with the folding than can be observed on the surface. For instance, two small overthrusts are well exposed in Callanan's quarry in South Bethlehem. . . . Two very distinct overthrust planes are now seen in the face of the South Albany quarry. . . . Other small folds in the Helderbergs have been observed by Prosser at Clarksville . . . . ('99, p. 343) . . . . . The last and northernmost fold, a low anticline, is seen in the town of New Scotland quarry east of Wolf hill. A little to the south of the capital district, as in the "High Cliff" near Coxsackie, the folds have already become so sharp that the beds approach in places a vertical position and the folds are of the type of closed folds, perhaps in connection with strike faults.

A small, almost horizontal, thrust fault was discovered by Doctor Ruedemann and the writer in the lowest part of the Marcellus black shale section in the upper Onesquethaw creek north of Wolf hill and the state highway (see p. 156). The Onondaga limestone, which is involved in this disturbance, is thrown into small folds or swells farther upstream.

THE NORTHERN HELDERBERGS

As pointed out above, folding and faulting are feebly developed in the southernmost part of the Helderberg rocks of the Capital District and practically die out just to the east of the southern portion of the Berne area. The structure here is almost monotonously simple (figure 68).

Strike and dip. Ruedemann, in discussing the strike and dip of the rocks of the Capital District, states ('30, p. 158):

The folded and overthrust rocks of the eastern trough show a general strike to north-northeast (N. 20° E.) and of course, a great variety of dips. As the folding dies out toward the west, the dip becomes more regular, and finally along the western margin of the capital district it can be considered as fairly steady.

It was found by Cumings ('00, p. 462) that the rocks west of the capital district dip south at the rate of 140 feet a mile. Farther

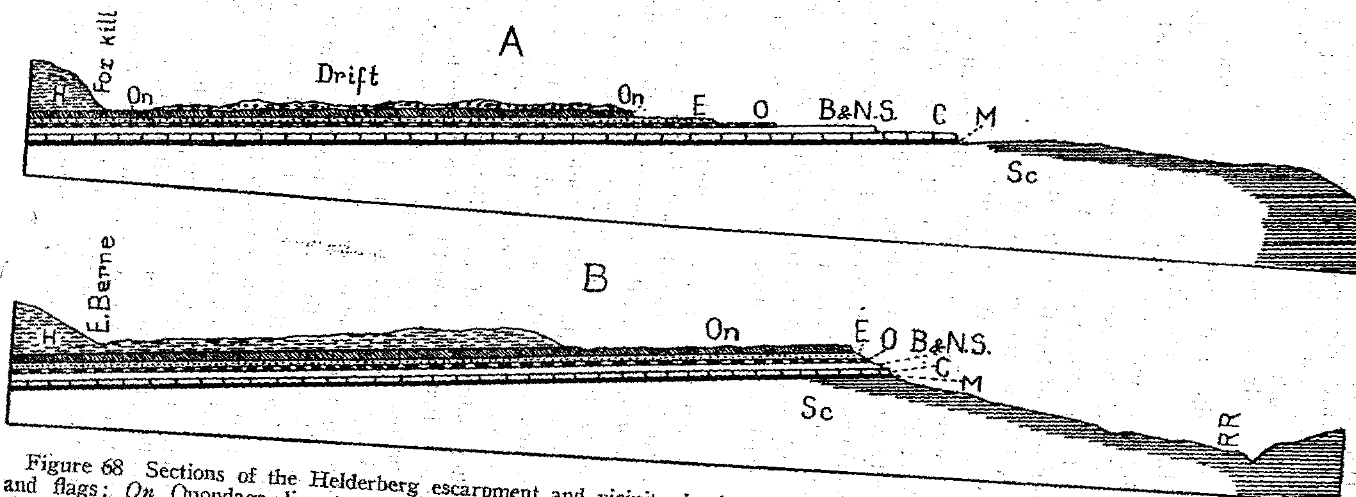


Figure 68 Sections of the Helderberg escarpment and vicinity in the northwestern part of Albany county. *H* Hamilton shales and flags; *On* Onondaga limestone; *E* Esopus grit; *O* Oriskany sandstone; *B & N. S.* Becraft limestone and New Scotland shaly limestone (including Kalkberg); *C* Coeymans limestone; *M* Manlius limestone, including Rondout waterlime; *Sc* Schenectady beds. (After Darton, 1904)

east, approaching the Helderbergs in Albany county, the dip gradually changes to the southwestward, changing the east-west direction of the Helderberg escarpment, west of Albany, to a southeast direction east of Altamont. This southwest dip (amounting to 1° to 2°) is also found in the Schenectady beds of the district.

Prosser measured the dip of the rocks in various places on the Berne quadrangle. In Knox township in a hill south of the Altamont-Knox state highway and one and a half miles east of the village he found the dip of the Onondaga to be 2° S. 38° W. ('00, p. 61). In the Bradt hill section the dip is given as 1½° to 2½° SW.; in Agrippa hill east of South Berne and the Switz kill, 1° to 1½° SW.; in the Reidsville quarries an average of 3° S. 10° W. (also 4° SW. and 2° to 2½° W.); in the southwestern part of Berne township and west of Rensselaerville, approximately 120 feet to a mile and SSW.; in the ridge east of Rensselaerville, 117 feet to a mile and directly south; in the Dormansville flagstone quarries, to the east of Westerlo and a short distance beyond our eastern boundary, between 2° and 2½° S. about 40° W.; three miles northeast of South Westerlo (southwest of Westerlo and just south of our area), in a hill east of Basic creek, probably 100 feet to a mile ('99, p. 243–62).

The writer has taken various measurements of the dip on the Berne quadrangle. In the Schenectady beds in the Bozen Kill valley the dip is 1° to the southwest. In the same beds in the Indian Ladder gulf the dip was found to be 1° and S. 37° W. In general the dip in the immediate vicinity of the Indian Ladder is 1° or less. Just to the east of our area along the new Indian Ladder road a dip of 1° to 1½° S. 7° to 17° W. was found in the Becraft. In the road cut in the Hamilton southwest of East Berne the dip is 1° to 1½° SW. and locally 2°. Just back (north) of the superintendent's house in John Boyd Thacher Park (near our eastern boundary) steeper dips (3° to 5° S. 27° E.) were measured. This dip is local and appears to be due to a monocline developed in connection with the fault to the east. On top of the terrace north of the house the dip is normal again. Three-quarters of a mile northwest of the Indian Ladder cliff along the road leading north from the four corners on Rock road (old Indian Ladder-Thompsons Lake road), steeper dips are also found in the region of the step faults (3° to 4° S. 38° W.). Prosser calls attention, south of Altamont, to "a conspicuous point of the Helderbergs, known as High Point, where the trend of the escarpment turns from a northwesterly to a westerly direction" ('00, p. 56). This point owes its prominence to the rocks being pushed up in this area, giving a steeper dip to the beds. The dip is still comparatively steep a mile west of High Point where in the Coeymans cliff a dip of 4° S. 8° W. was measured.

Darton ('94, p. 446–47) in discussing the northwestern area of Albany county, which includes the Berne quadrangle says:

> The amount of dip appears to be not over 100 feet to a mile . . . To the eastward about Thompson's lake and Indian Ladder the dip is reduced to an amount not over thirty-five feet per mile, but there is some evidence that it is more variable in this section than it is to the westward . . . . .

He discusses the succession of rocks in the eastern face of the Helderberg escarpment, particularly in the vicinity of New Salem (southeast of our area), and continues:

> The dip averages 112 feet per mile and south ten degrees west in direction. This carries the outcropping edges of the formation gradually downward along the face of the mountain, from an altitude of 1100 [1200 to 1300] feet above tide south of Altamont to about 1000 [1100] feet at Indian Ladder and 660 feet a mile south of New Salem. To the southward about Clarksville, the rate of dip gradually decreases to sixty feet per mile, and its direction changes to due west. As the formations of the Helderberg mountains are brought down to the general country level, they extend to the east and south into a flexed region. The first features noticeable are a series of gentle undulations . . . . .

Folds, faults, cleavage. The folding of the northern Helderberg area has already been touched upon (page 194). The small anticline shown in the New Scotland town quarry in the Onondaga limestone along the New Salem-Wolf Hill road and the small folds or swells in the Onondaga (figure 52) in the upper Onesquethaw creek in the Wolf Hill area are the most northern occurrences of folding (Albany quadrangle).[1] In John Boyd Thacher Park (Indian Ladder area) near the eastern boundary of the Berne quadrangle and just north of the superintendent's house a small monocline has been developed in the Oriskany terrace in connection with the fault less than a half a mile to the east on the Albany quadrangle. A small anticline is found in the field about a quarter of a mile along the road turning north from the four corners on Rock road (old Indian Ladder road). The anticline was probably formed in connection with the development of the step faults in the Oriskany terrace in this area. There

[1] J. H. Cook in the summer of 1934 called the writer's attention to an overthrust shown in a new cut in the Esopus just south of the southern branch of Outlet creek (Indian Ladder area), three-tenths of a mile south of Rock road near the town boundary.

appears to be a slight fold in the bed of the Bozen kill about a mile northwest of Altamont where the road approaches close to the stream. These occurrences on the Berne quadrangle are all obviously of a minor nature.

The thrust fault noted above as occurring in the Marcellus black shale (figure 56) is the upper Onesquethaw in the Wolf Hill region (Albany quadrangle) is also visible in the branch of the Onesquethaw (north of Wolf hill) coming in from the north at the edge of the Berne quadrangle. Slickensides and crumpling are shown in the main valley and side gorges about 400 feet above the bridge and northward. In the third gorge entering the Switz kill from the south (three-quarters of a mile southwest of Myrtle) is a very good example of recent folding, accompanied by slickensides and crumpling in the stream bed. This is due to release of pressure after the stream had cut its valley.

In discussing the normal faults of the western troughs Ruedemann writes ('30, p. 159):

We have finally as a last manifestation of the unrest of the crust in this region the normal or gravity faults in the western or otherwise undisturbed belt . . . .

Into this group . . . . . . fall several normal faults that we have observed in the Helderbergs. Several of these escaped notice until the new state road to the Indian Ladder exposed them.

The first of these is about one and one-half miles from the Indian Ladder not more than one-quarter of a mile from the edge of the capital district. This fault runs in a little ravine. It is distinctly seen at the edge of the cliff, where on the east side of the fault the top of the Coeymans is at 1155 feet, while at the west it is at 1095 feet. There is thus a drop of 55 to 60 feet, the western side having been dropped. The fault runs about N. 30°–40° E. (magnetic). The fault line can be seen in the cliff, where about a decade ago a long section of the cliff broke off along a joint plane, producing a bare exposure and a long talus slope or rock slide, now visible from the roads in the plain. An interesting feature of this fault is the strong vertical cleavage that has developed in the Coeymans limestone and New Scotland beds along the fault and that is especially well seen in small cliffs in the woods a little ways back of the edge of the escarpment and to the east of the ravine.

Another small disturbance that is visible directly from the road, is situated three-quarters of a mile from the preceding locality in the direction toward New Salem. Here a block of Becraft limestone, about 90 feet wide, and bounded by two faults, running in northeast direction, has dropped 20 feet into the New Scotland beds on either side. At the edge of the cliff, where there is a reentrant distinctly visible from the plain and situated under Daniel O'Connell's house one can also see the New Scotland dropped 20 feet into the Coeymans.

He continues with a discussion of similar faults in the Clarksville and Feura Bush regions, and in conclusion states (p. 161):

The age of these small faults is not known. They may be contemporaneous with the Carboniferous folding of the Helderbergs, but are more probably of much younger age and connected with adjustments that took place in Mesozoic time to the east and west of the Appalachian fold system, as shown by the sunken fault blocks in the Champlain basin and the Connecticut valley.

Ruedemann further points out that "there is no doubt that faulting on a small scale takes place to this day," and cites a series of small step faults in the Capital District (Hudson valley) which, appearing in glaciated rock surfaces, must be of postglacial age. The writer's attention was first called by Professor John H. Cook, then superintendent of the John Boyd Thacher Park, to a series of such postglacial faults (figure 43) just outside of the park area about three-quarters of a mile northwest of the Indian Ladder (Rock road). They are seen in the Oriskany terrace crossing the road leading north from the four corners on Rock road, and the largest one occurs just before the road leaves the woods (about a quarter of a mile from the corners). These faults have been observed cutting across glacial scratches, and they occur along joint planes running northeast-southwest (N. 40° to 45° E.). At least four such step faults occur here with displacements of ten, five and a half, five and a half and four inches, making a total displacement of over two feet. Professor Cook also called the attention of Doctor Ruedemann and the writer to "such a fault, with a throw of about one foot, ... discovered by him in the lower reaches of the Onesquethaw in the Oriskany sandstone, about two miles east of Clarksville. The fault forms a step of about a foot in the stream bed, so recent that it has not even been channeled by the stream . . . . It is believed by Professor Cook that there are numerous such small postglacial faults which if studied in detail might give important clues to the postglacial doming of the country" (*ref. cit.*).

HISTORICAL GEOLOGY

The geological history of the Capital District has been very fully treated by Doctor Ruedemann ('30, p. 162–81). As this practically covers the area of the Berne quadrangle the history given here will be based, especially for the earlier periods, largely upon his. A brief survey of the pre-Ordovician history of the Capital District has been considered necessary, although middle Ordovician rocks are the oldest exposed in our area (see table, page 56).

PRECAMBRIAN HISTORY

In discussing the Precambrian, Ruedemann writes (p. 162):

> There are at present no Precambrian rocks exposed in the capital district, but we have not far to go for the granites and gneisses of the Adirondacks, which come down to the northern outskirts of Saratoga Springs . . . . There is no doubt that the Precambrian granites and gneisses underlie our district at a depth of 4000 to 5000 feet (counting the thicknesses of the formations of the eastern trough at Albany).

The Precambrian rocks wherever known, in the Adirondacks and elsewhere, are intensely folded. Ruedemann has shown ('22) that the folds have an orderly arrangement and that the arrangement is connected with the original form of the continent, "the folds having arranged themselves parallel to the outline of the continent, and the compressing force having acted from the heavier bottom of the nearest ocean" ('30, p. 163). In the Adirondacks the Precambrian folds strike in a northeast direction, and Ruedemann believes this is true also of the folding deep under the Capital District. The existence of distinct geosynclines or long depressions in North America in the last division of the Precambrian era (Proterozoic time) has been demonstrated by recent researches (Schuchert, '23). As they became filled with sediments from the neighboring mountain ranges they were submerged and sank, and finally were themselves folded into long mountain ranges. One of these long depressions "extended the whole length of the continent inside of the borderland from Newfoundland, or even beyond, to Alabama. The Capital District formed just a small sector of this great Precambrian geosyncline" (*ref. cit.*).

As pointed out before (page 55), as a result of Precambrian folding, several long barriers or ridges were produced, separating the troughs or basins that are found in early Cambrian time. Two of these basins have been positively recognized and designated as the western or "Chazy" basin, comprising the Champlain-Mohawk trough, and the eastern or "Levis" basin, and these are the ones that concern us here (figure 69). These two troughs persisted through Ordovician times, and were involved in frequent oscillations throughout this time. Invasions and withdrawals of the sea "did not take place simultaneously in both basins but at different times and apparently independently of each other," so that one could be drained while the other was inundated. "These basins were sometimes inundated partly or wholly from the northern Atlantic and sometimes the sea came in from the south, and sometimes the sea spread beyond them into the interior of the continent" (*ref. cit.*).

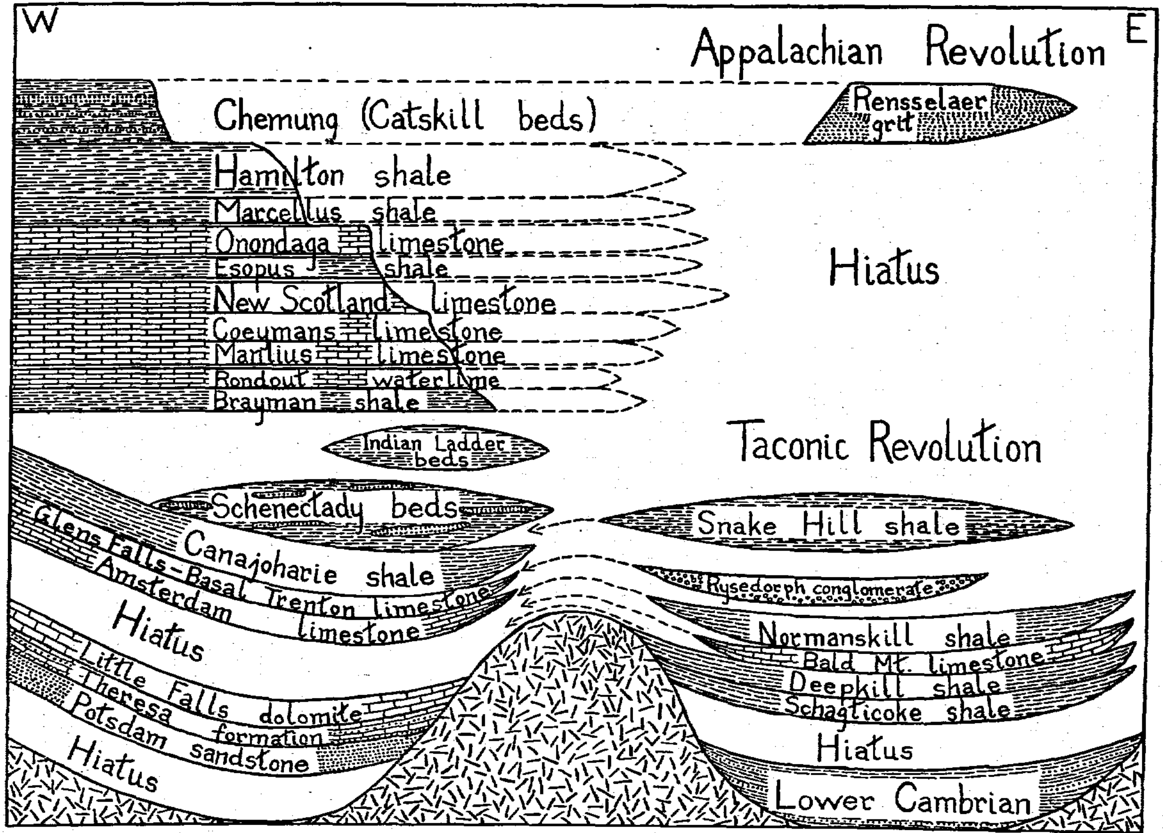


Figure 69 Diagram of successive events in the geologic history of the Capital District, showing the Precambrian barrier and the eastern and western troughs of Cambrian through Ordovician age with their deposits, the hiatuses of nondeposition, the Silurian and Devonian deposits and their probable extension and the time of the orogenic revolutions. (After Ruedemann, 1930)

CAMBRIAN AND OZARKIAN HISTORY

The sea was entirely drained from the western trough during Lower and Middle Cambrian time while at the same time, through an invasion of the sea (for the most part, quite shallow) from the north, "a great mass of sediments was deposited to the east, the Lower Cambrian rocks in the Levis trough, and the Middle Cambrian or Acadian beds in still more easterly troughs, and possibly also to a limited extent in the Levis trough . . . . At the close of Lower Cambrian time the sea retreated northward and a crustal movement folded these sediments. The new land surface was exposed to atmospheric erosion during the long intervals of Middle and Upper Cambrian time and considerably leveled. At the close or shortly before the close of the Cambrian [Ozarkian] time, the basin became again submerged and the Schaghticoke graptolite shales [Canadian] were deposited" (*ref. cit.* p. 165).

Until Ozarkian time the western trough remained dry. The first deposits in this trough were coarse quartzose sands and gravels, the Potsdam sandstone, the accumulation of which (in shallow marine waters) started in the northeast in Clinton county and continued progressively to the west and to the south, barely entering into the Capital District (Saratoga region). Ruedemann describes the climate as arid and the land as a desert without vegetation. "The land to the west and south had strong relief, and vigorous currents transported the coarse sands and gravels into the basin" (p. 166).

In the Saratoga region the Potsdam sandstone is followed without any sign of break by two marine formations, the Theresa formation, consisting of alternating sandstones and dolomites and the Little Falls dolomite. The bordering lands of the Potsdam sea were lowered through erosion and the sea extended around and over the Adirondack plateau in the north and south. Dolomite began to be deposited as less and less sand was brought down from the lowered border lands, and as "the sands steadily diminish in frequence and thickness. . . . The Theresa formation grades upward into the Little Falls dolomite" (with basal Hoyt limestone as local phase), characterized by great reefs of the calcareous alga *Cryptozoön* (seen in Lester Park and Ritchie Park, Saratoga Springs) "which seem to indicate the likelihood of a congenial climate and abundant life."

These three formations are the only Ozarkian deposits (lowest Ozarkian of Ulrich; uppermost Cambrian of authors) that were laid down in the Chazy or Champlain trough. This deposition was followed by mild uplift, "the troughs came above sea level, existed as land for a time, and were somewhat eroded. This erosion gently leveled off the surface instead of deeply cutting into it, which suggests that the land was of low altitude" (p. 166).

CANADIAN AND ORDOVICIAN HISTORY

The above-mentioned uplift, representing elapsed time of unknown length, marks the dividing line between the Ozarkian and the Canadian (uppermost Cambrian and Lower Ordovician of authors). The western or Chazy trough was again depressed and occupied by marine waters that bordered the Adirondacks on all four sides and in which were deposited the various dolomites and limestones of the Beekmantown group, "thickest and most complete in the Champlain trough." These deposits do not occur in the southern continuation of the trough in the Saratoga region and Capital District either because, as Ruedemann points out, the submergence fell short of covering this district or (barely possible) the formation was thin here and subsequently entirely worn away.

In the eastern or Levis trough the sea in Beekmantown time spread from the north as far as the Capital District and beyond and during this time were deposited thick masses of shales and grit carrying no other faunas but graptolites and, rarely, stragglers from other classes. These deposits constitute the Schaghticoke and Deepkill shales. Ruedemann calls attention to the fact that graptolites were deposited in dead ground; that they were "planktonic or pseudoplanktonic (attached to floating seaweeds) in habit [and] dropped into these depths from the higher regions after death, or when they were torn from the seaweeds by storms." He states that "they were brought into the trough from the open ocean, which was their home" and believes that the rich graptolite zones of the above-mentioned shales and the Normanskill shale require the existence of "channels with exits at both ends, to allow strong surface currents to bring in the graptolite faunas" (p. 167). The deposition of the Bald Mountain limestone north of the Capital District and a similar limestone farther south in the Poughkeepsie region in late Beekmantown time indicates, according to Ruedemann, the appearance in the eastern trough of conditions congenial for organic bottom life.

The graptolite-bearing marine invasions in the eastern trough continued into the Lower Ordovician (Chazy time) with the deposition of uppermost Deepkill and Normanskill shale, at which time the Levis trough undoubtedly extended the full length of the Appalachian geosyncline and permitted the sea to sweep freely through it. Ruedemann calls attention to two shorter intervals of withdrawal, as "between the Deepkill and Normanskill invasions, and possibly between the lower and upper Normanskill invasions, the latter probably of Black River age" [lower Middle Ordovician]. The Rysedorph conglomerate at the top of the Normanskill "indicates a period of great erosion or working up of various rock formations by an advancing sea with strong currents" which, as indicated by the age of the included pebbles (Chazy and Black River: Lowville limestone), must have taken place in early Trenton time (Middle Ordovician). "Then followed throughout the rest of Trenton time the Snake Hill invasion, which deposited a great mass of shale with some grit, probably the full length of the eastern or Levis channel. The eastern trough must have been rapidly sinking to allow the accumulation of 3000 feet of shales and grits" (largely graptolite fauna, but with another fauna of small mud-loving pelecypods). The Tackawasick limestone, unless it has "been pushed over by overthrusting from a still more easterly basin" shows that "in this time. . . . there were also places in the Levis channel where better conditions existed and calcareous Trenton beds could be formed. . . The Snake Hill closes the Ordovician series and the eastern basin was apparently completely drained during Utica and Lorraine [Upper Ordovician] time" (p. 168).

In the western or Chazy trough the Chazy or Lower Ordovician invasion advancing from the north fell short of the Saratoga region and Capital District. The Amsterdam limestone in Black River (lower Middle Ordovician) time "was deposited in the Saratoga region and it undoubtedly also extended into the Capital District" (p. 169). A slight uplift was followed by an invasion of the Trenton (upper Middle Ordovician) sea with the deposition first of the Glens Falls limestone, which is deeply buried under the Schenectady beds of the Capital District, and then, with the influx of much mud, probably from the north, of the Canajoharie black shale with a thickness of over 1000 feet and containing graptolites, small cephalopods and pelecypods that could live under the unfavorable conditions. This sea extended not only all through the Champlain basin and down through the whole Chazy channel, but "it also spread westward beyond the trough over the southern slopes of the Adirondack plateau. Toward the west the Canajoharie shale is replaced by the Trenton limestone, which indicates the clear marine conditions farther out in the shallow epicontinental Trenton sea" (p. 169).

The Canajoharie shale grades upward into the still thicker Schenectady formation (over 2000 feet thick), with its persistent hundredfold alternation of shales and sandstones, also mainly of Trenton age. Ruedemann in his discussion of this bed writes (*ref. cit.* p. 170):

> It seems, therefore, that these beds were formed in a fast sinking basin that was rapidly filled with sediment. Shifting currents deposited sands along the coast in times of greater velocity and muds in such of lesser velocity. The formation is not known to extend far north or west and it disappears under the Helderbergs in the south. We therefore do not know whence the invasion came or how far it extended. There is no doubt that owing to a long interval of emergence, the greater part of the Schenectady beds was eroded again, at least in the north. The Schenectady is a distinctly clastic shore formation that may pass westward and northward into upper Canajoharie shale and finally into Trenton limestone; or in other words, the same Trenton sea may have deposited Schenectady beds in the capital district, black shales in the near north and west and Trenton limestone farther away. This deposition may have continued even into early Utica time. The principal portion of Utica time is, however, not represented in either the eastern or western basin, and the true Utica shale is found only in the middle and upper Mohawk valley. If there was any coarser shore deposit of the Utica other than the upper Schenectady, it has been entirely eroded away.

The Indian Ladder beds constitute the last Ordovician formation of the western trough. This formation, consisting of alternating shales and thin sandstone slabs, calcareous in the lower part, is of very local development, only exposed between Altamont and New Salem as a narrow belt under the Helderbergs. It, however, attains considerable thickness in the Indian Ladder region. Ruedemann interprets this as deposition "in a narrow trough that sagged rapidly in the middle and extended for an unknown distance from north to south." He continues (p. 170):

> It is connected by its fauna, a pronounced microfauna indicating unfavorable life conditions, more closely with the Eden shale of Cincinnati and the middle division of the Martinsburg shale in Pennsylvania and more remotely with the Frankfort shale in New York. It was therefore undoubtedly formed by an invasion advancing from the south in the western trough, to an unknown distance north beyond the Indian Ladder. Whatever there was of it north of the Indian Ladder has long ago been carried off to the ocean, for there followed an exceedingly long interval of emergence in both the eastern and western basins, comprising all the upper Ordovocian time, as well as the Ordovician-Silurian intersystemic interval of general emergence and the earlier Silurian time.

In this long interval of emergence the Taconic Revolution took place, during which time were formed the Taconic mountains on the New York-Massachusetts boundary line. The rocks of the eastern trough were first thrown into a system of folds and then followed extensive overthrusting of the folded mass successively in a number of plates westward, "so that finally the Snake Hill beds of the eastern trough came to rest against the Schenectady beds of the western trough and the Lower Cambrian beds came to rest, in part at least, upon rocks of Ordovician age, notably the Normanskill and Snake Hill formations" (p. 171). The Taconic Revolution is placed at the close of the Ordovician era or in the Ordovician-Silurian interval of continental emergence. This was followed by a long interval of intense erosion of the elevated region which was reduced to a peneplane when the sea again advanced in Silurian time.

SILURIAN HISTORY

As a result of this folding, overthrusting and erosion, the Silurian and Devonian rocks of the Helderbergs are found resting partly on rocks of the western trough (Schenectady and Indian Ladder beds), partly on rocks of the eastern trough (Snake Hill and Normanskill beds). In the latter case the more or less undisturbed Helderberg formations rest very unconformably upon highly folded and tilted beds below (especially the Normanskill). Both the eastern and the western trough had entirely ceased to function as depressions by the end of the Ordovician and the invasions of Silurian and Devonian seas extended more or less far east over them. As Ruedemann points out, "Becraft mountain, a small outlier of Silurian and Devonian rocks east of Hudson, affords the best evidence of the distance to which the Helderberg rocks extended eastward, some farther, some not so far. Still farther east, at the margin of the capital district, the upper Devonian Rensselaer grit rests directly upon Lower Cambrian rocks, thereby proving that either the Helderberg rocks never extended thus far, or that whatever thin sheets may have reached there had been eroded again before a new longitudinal trough was formed, in which the Rensselaer grit came to rest" (p. 171). Ruedemann's Silurian history of the Capital District (p. 172) follows:

The long interval of emergence and erosion that followed the small Indian Ladder invasion was finally terminated by a sea that came in from the southeast, where the Atlantic ocean, or its predecessor, the Poseidon, had closely approached to the present coast line. The thin bed of pyritiferous Brayman shale, may, as we have pointed out before, be a residual soil of the long era of weathering, reworked and redeposited by the advancing shallow Salina sea. The following Rondout waterlime deposited after another emergence, is clearly a marine sediment, formed by chemical deposition in a shallow epicontinental sea that extended from the Atlantic to Michigan and in a narrower embayment southward into Virginia. The greater thickness and development of the Salina formations eastward and especially westward seem to indicate that there was a barrier in the capital district and its neighborhood, which frequently interrupted the ingress of the sea, from the southwest, about where New Jersey is today. As a result of this very incomplete connection with the ocean, the Salina beds are very unfossiliferous and great deposits of salt and gypsum have formed in the shifting salt pans from western New York to Michigan. The climate was evidently an arid one, so that this more or less land-locked sea received but irregular drainage.

The next or Manlius sea, of similar extent, had, however, free connection with the ocean and a marine fauna of corals, pteropods, brachiopods, pelecypods and trilobites flourished in a broad expanse of sea that spread westward to Michigan and southward in a narrow trough to Tennessee. How far this, as well as all the following Helderberg formations, extended, we do not know. There is, however, no doubt that they reached not far up onto the southern slopes of the Adirondack massif. They have weathered back over the broad inner lowland to the present escarpment (also called cuesta) of the Helderbergs, the "Helderberg Cliff" exposing the Ordovician rocks at the bottom.

In the capital district the Manlius sea was extremely shallow. We have described before the evidence of tide flat conditions seen in the New Salem quarry and elsewhere. The thin-bedded Manlius limestones with their tentaculites, ostracods, small spirifers and lamellibranchs, mud cracks and mud pebbles, and their association with the Stromatopora beds, suggest that these limestones are principally lagoon deposits on tide flats, formed between and behind the coral reefs (ref. cit. p. 173).

DEVONIAN HISTORY

In accordance with the view of those interpreting the entire Manlius as Silurian (see page 92) the Manlius sea of the Capital District, as indicated by the transition beds, seems to have changed gradually into the Coeymans sea. A disconformable contact with pebbles noted at the Indian Ladder and in the vicinity of the village of Catskill at the base of the Coeymans would seem to indicate local elevation or stronger erosion by currents. If, in accordance with the other view (Ulrich), the two to 15 feet of limestone in the Schoharie and Indian Ladder areas, long distinguished as transition beds, are of Devonian (Keyser of Maryland and Virginia) age, there must have been a withdrawal of the Manlius sea with an interval of emergence and erosion.[1] This was then followed by an

[1] See footnote at end of discussion of Manlius limestone, page 92.

invasion of the Keyser Devonian sea which gradually changed into the Coeymans sea. Ruedemann continues the discussion (p. 173):

The Coeymans sea was not greatly different in general outline from the Manlius. In New York it extended westward from the Helderbergs not quite so far as did the Manlius sea, and eastward it had about the same extent. The sea in the Helderberg portion of the capital district was deeper than before and produced a fairly pure limestone, containing principally brachiopods. Farther west, in Herkimer county, plantations of crinoids and cystids are found, suggesting quiet waters.

The Coeymans beds are again connected by transition beds with the overlying New Scotland beds, proving a gradual change of conditions. The New Scotland sea lacked the westward extension of the Coeymans and Manlius seas, but it extended southward in the Appalachian region and it found a passage eastward across the Taconic region into a narrow area that extended to the St Lawrence country and beyond the Newfoundland region to the Atlantic. The condition had changed in the capital district in that there was a much greater influx of mud, so that the New Scotland beds are impure shaly limestones and calcareous shales. On the other hand, a much richer fauna than before flourished in this sea, a fauna that consists of 184 species in the capital district, comprising sponges, corals, bryozoans (71 species), brachiopods (62 species) lamellibranchs, gastropods and trilobites. It is a fauna of the littoral region, but not of the tide flats, the preponderant bryozoans indicating deeper and quieter waters.

The transition beds referred to constitute the Kalkberg and it was toward the end of this time that bryozoans, indicating deeper and quieter waters, became so abundant. Parallel seams of chert occurring in these beds may represent secondary induration of the limestone or, possibly, a silicious gelatinous mass or "gel" deposited on the bottom of the sea through the chemical action of bacteria on the marine waters.

As pointed out in the discussion of the formations, in the Capital District and northern Helderberg area the transition from the New Scotland to the Becraft is not sharp. The lower part of the Becraft is thinner bedded with seams of silicious shale and in the upper New Scotland occur limestone bands that are packed with crinoidal fragments. This indicates a gradual change from the New Scotland to the Becraft sea. Possibly a shifting of barriers and currents produced a mud-free clear sea, in which was deposited a limestone largely composed of crinoid stems and plates and brachiopods. "This sea formed but a narrow arm in New York, but it extended far down to Virginia and across the southern Taconic region into an eastern trough that led, as in New Scotland time, to the lower St Lawrence (Gaspé) country and Newfoundland" (*ref cit.*).

The sea withdrew from part of the Appalachian trough at the end of the Helderbergian epoch and in the erosion that followed much of the Helderberg deposits were removed in some areas. The lime sediments from this erosion, during the retreat of the sea in late Helderbergian time, locally accumulated in depressions and formed a detrital rock, the Port Ewen beds. At the same time deposition continued in the northern area of the trough forming the thick Lower Devonian series at Gaspé. In the Capital District and northern Helderberg area (in general) a break between the Becraft and Oriskany formations represents the Port Ewen beds that were deposited farther south (Catskill area and southward) with their best development in southeastern New York, where the maximum thickness is 200 feet. This indicates that the sea withdrew from the Capital District area and, for the most part, from the country to the west of it. West of West Berne on the Berne quadrangle and in the Schoharie region is found a thin representation of Alsen limestone (formerly regarded as basal Port Ewen; now transitional beds above Becraft) or Port Ewen beds, or both, which means that the earliest stage of the Alsen-Port Ewen sea occupied this limited area.

During the period of withdrawal of the sea at the end of Helderbergian time the eroded land surface was accumulating sand from various sources so that when the Oriskany sea flooded the Appalachian trough again and spread westward over this eroded surface these sands were reworked by the waves and deposited as the Oriskany sandstone, which is very fossiliferous in places. Ruedemann points out (p. 174) that:

The Oriskany sandstone is characterized by its thick-shelled fossils and sandy limestone, changing to pure quartz-rock at Oriskany; there is no doubt that the turbulent sea near the northern shore line deposited these beds. The Oriskany sea, that like all the preceding seas had an oceanic connection in New Jersey, spread westward in a narrow embayment into Ontario and like the preceding seas over the Taconic region into Massachusetts and thence northward into the Gaspé country, where thick calcareous beds (Grand Grève) were deposited. The broad access of the northern Atlantic in the Gaspé region and in Nova Scotia brought in the North Atlantic fauna with European relations (Clarke's Coblenzian invasion), that furnishes the typical Oriskany brachiopods, in contrast to the preceding faunas that had southern Atlantic characters.

Southward (Ulster county) highly fossiliferous limestone beds at the top (Glenerie limestone) and a basal pebble conglomerate (Connelly conglomerate) represent Oriskany time; in Orange county the beds representing Oriskany have a thickness of about 200 feet. The deposits of Oriskany age in southeastern New York (Port Jervis region) are considered as representing a deep-water or calcareous phase of the shallow-water, typical Oriskany sandstone. Certain of the large typical Oriskany fossils (as *Rensselaeria ovoides, Hipparionyx proximus*) are absent from the Port Jervis region, which has been accounted for by depth of water, and there is also a persistence of Helderbergian species in this region to the beginning of the Esopus.

The thick mass of blackish, gritty or sandy Esopus shale bears a close relation to the Oriskany sandstone of which it is considered a facies. At the end of Oriskany deposition the Cumberland area of the Appalachian trough was elevated and in eastern New York we have only the coarse sands and grits of a mud delta constituting the Esopus formation (Oriskanian). Submergence became pronouncedly positive in late Lower Devonian (late Oriskanian) time and continued to the maximum flooding of the continent in late Middle Devonian (Hamilton) time.

The writer agrees with Ruedemann in regarding the Schoharie grit as "but a local development or sandy facies of the lower Onondaga limestone, indicating a great influx of sandy material in the region from Albany county to Otsego county." Ruedemann continues (p. 174):

In spite of this sandy admixture to the calcareous mud, the formation has furnished a large fauna (of 123 species), indicating congenial conditions, especially for brachiopods (33 species), cephalopods (44 species) and trilobites (16 species). It is a distinct cephalopod facies, many of which, as the Trochoceras and Gyroceras forms, were undoubtedly bottom-crawlers. It was altogether the rich benthonic life of the zone below the tides. This cephalopod facies of the Schoharie grit marked only a restricted area in the great Onondaga sea, that spread far to the west to the Great Lakes region, sending a broad arm north to Hudson bay, and another south to the Gulf of Mexico, as well as a narrow blind arm through the old eastern trough to the St Lawrence region.

The open Onondaga sea that followed the short Schoharie grit episode was part of the great submergence of the Middle Devonian. The interior sea of North America was again established and in it was accumulated the Onondaga limestone, which with its wealth of corals and brachiopods indicates a warm clear sea surrounded by lowlands, and it must have been of long duration. The warm waters brought many coral species and an abundance of corals first from the North Atlantic and Gulf of Mexico and later from the Arctic sea that advanced southward. These corals built extensive reefs in the limestone deposits, such as the famous occurrence at the Falls of the Ohio, Louisville, Ky., which are seen on a smaller scale in western New York and to a certain extent, also, in the northern Helderberg area. The Onondaga limestone in New York stretches from the Hudson river across the State, continuing into Canada.

As Middle Devonian time continued there was an alteration of conditions in the northeastern part of the continent bringing about a change in the character of the deposits. The land here was elevated resulting in the rejuvenation of the streams which brought into the sea large quantities of mud and silt (Hamilton beds), checking the deposition of limestone. These deposits are thick in the East and grow thinner westward. The accumulation of limestone continued in the Mississippi valley and even in New York State thin limestone beds occur at intervals in the thick mass of Hamilton shales. The uplift converted the Gaspé area into a coastal lagoon in which swift streams deposited great masses of sand, these continental deposits containing fossils of land plants and giving indications of occasional invasions of the sea. The deposits in New Brunswick and Nova Scotia are also sandstones and shales. Part of the Middle Appalachian area that was uplifted at the end of the Lower Devonian was now occupied by an extension of the interior sea (western Maryland and adjoining parts of Virginia). At the close of the Middle Devonian there was a further shrinking of the seas coincident with the further rise of Appalachia, and the rejuvenated streams continued to build great deltas in the northern part of the Appalachian trough (as the Ashokan bluestone delta in New York). The seaways from the North Atlantic through Acadia connecting the interior sea with the St Lawrence trough were forever destroyed by the Acadian Disturbance which resulted in the elevation and folding of the Acadian land throughout New England and the Maritime Provinces of Canada. This disturbance started in the Middle Devonian but continued even to the end of Devonian time. Meanwhile through the later Middle Devonian the western (Cordilleran) sea was spreading eastward bringing in its waters immigrants from Asia by way of Alaska. The Middle and Upper Devonian beds are separated by an erosion interval indicating the withdrawal of the sea at the end of Hamilton time.

Ruedemann describes (p. 175) the Hamilton sea as spreading "from its entrance at the St Lawrence and New Jersey regions across the continent with arms extending to the Gulf of Mexico and north through the Mackensie region to the Arctic ocean." He continues:

In New York this sea deposited several thousand feet of shales and sandstones teeming with life, especially brachiopods and lamellibranchs, adapted to the muddy sediments. In the east the faunas entered from the Atlantic, carrying the characteristic Atlantic brachiopod *Tropidoleptus carinatus,* that is found as far south as South Africa, and the Falkland Islands. In the western portions of the great inland sea, Arctic and Pacific faunas are found. Even if the deposition of the beds took place much faster than that of the limestones, the great thickness of the formation and the wide extent of the sea indicate that it must have persisted over a long period of time.

The Hamilton beds of New York, represented in the East (see supplementary note, page 186) by sands and arenaceous shales (1500 to 1700 feet) and in the West by black shales, calcareous shales and limestones, form a thick wedge of clastic materials which thin westward with numerous shifts or facies both in the character of the rock and the fauna. Recent studies have shown "that the black muds of the Marcellus, often affiliated with the Onondaga, thicken eastward and are gradually replaced by gray arenaceous shale. Concordantly the Marcellus fauna grades eastward into one of Hamilton aspect. . . . The Skaneateles formation and several members in the higher formations show a similar westward shift of faunal facies from one of Hamilton aspect in the east to a modified Marcellus fauna in the west" (Cooper, '29).

The Onondaga limestone of the northern Helderberg area is abruptly followed by about 200 feet of black fissile shale, the lowest Hamilton (referred to the Chittenango member of Marcellus formation) of this area, characterized by a diminutive fauna which "came from the southeast, having wandered into this region from the southern Atlantic by way of the Appalachian interior sea. . . . The sea, when these muds were being deposited along the eastern and northeastern shore lines, was already beginning to spread far to the west, even beyond the Onondaga sea. The source of the black muds must be sought in the higher lands bordering the sea in the east and north" (Ruedemann, *ref. cit.* p. 175). Going west from the Helderberg area these beds are found to become more and more calcareous with thin limestone intercalations; and at least the lower 50 feet in eastern New York have been generally regarded as the equivalent of the upper Onondaga limestone of western New York, which would make the Marcellus, in part at least, a muddy facies of the Onondaga sea. There is to be considered, however, the unconformity between the Onondaga and Marcellus reported from the Catskill region which Chadwick believes "appears to dispose finally of the theory of 'contemporaneous overlap'" of the Marcellus black shale ('27).

In Schoharie county in eastern New York, the highest Hamilton beds have been found to carry what is believed to be the Skaneateles fauna, and it is suggested that at least part of the Sherburne sandstone in the Schoharie valley is of Hamilton age and represents Moscow and at least a portion of the Ludlowville (see supplementary note on Hamilton, including "Oneonta," page 186). In the northern Helderberg region the highest marine Hamilton appears to be no younger than Cardiff (upper Marcellus), and above these beds occurs a certain thickness of nonmarine deposits. In the southeast, in Ulster and Greene counties, the lower marine beds, Mount Marion beds, are now believed to be entirely Cardiff in age with the nonmarine Ashokan beds above representing higher Hamilton beds (see page 189). These changes in Hamilton lithology may be explained as due to deposition in a bay widely open to the west with the source of sediments to the north and east. As enormous quantities of materials were deposited the bay was gradually filled landward; becoming narrower and shorter. Nonmarine deposits, therefore, would encroach upon previous marine deposits in the east.

In New York State the Upper Devonian beds of the east are mainly nonmarine, becoming increasingly red toward the top, while in the west they are marine with practically no red beds and in between intermediate conditions are seen. In the northern Helderberg area "Oneonta" red beds (see page 186; nonmarine Hamilton) are found above the green nonmarine Hamilton sandstones and shales (formerly called Sherburne). In discussing the beds above his Hamilton Ruedemann (p. 176) remarks:

> While it is true that the Hamilton beds are the highest that we find now in the capital district, there is not the least doubt that the Devonian beds that overlie the Hamilton beds in the eastern belt of New York and south of the capital district, once extended entirely over the district to the southern slopes of the Adirondack plateau. They have been entirely eroded away.

The Devonian beds referred to are the "Oneonta" and "Catskill" beds with a thickness of several thousands of feet of shales and sandstones (see page 186).

The Tully limestone marking the base of the Upper Devonian is a locally developed limestone in western New York State [represented by a considerable thickness of sandstone and shale in the east (Cooper field work 1932)]. Following the close of the Middle Devonian and at the beginning of the Upper Devonian part of the interior of the country was submerged and received deposits of black fissile shale as did western New York (Genesee black shale). The absence of these beds and the earlier Portage formations in the northeast indicates a withdrawal of the sea there at that time. The Genesee black shales are followed by shales largely arenaceous and constituting the Portage beds, which in western New York carry a characteristic fauna (Naples fauna) of goniatites and pelecypods which has little in common with the Hamilton but is well marked in many parts of the world, having been traced by way of our northwest through Russia into Westphalia (Germany). In New York it was an alien fauna. To the eastward it is replaced by the Ithaca fauna of Hamilton aspect (Sherburne-Ithaca beds).

In the northeast corner of the Portage sea a broad bay, Albany bay, existed, into which a river or rivers, most probably coming down from the North, emptied and deposited sand and plant fragments. These nonmarine beds were deposited while the Naples fauna in western New York and the Ithaca fauna farther east flourished in the Portage sea. From Chenango county eastward occur nonmarine beds of red and gray or greenish shales carrying plant remains at intervals, the "Oneonta" series (2000 to 3000 feet). The basal portion of these beds has been considered as probably equivalent in time to the higher Ithaca beds of the central part of the State, but it is now believed (Chadwick) that they may prove to be older (see supplementary note, page 186; "Oneonta" beds of Albany, Greene and Ulster counties entirely or largely of Hamilton age).

There is reason to believe that the Albany bay in the northeast of the Portage sea "was now more sharply separated from the sea than before, probably by a bar projecting southward from the coast line in the north" (Ruedemann, p. 177, see Clarke, '09). Under these conditions was deposited above the "Oneonta" series the thick mass of sandstones and shales, chiefly red beds, known as the Catskill formation (3000 feet). These beds contain plant remains and at some horizons fresh or brackish water clams which would indicate that heavy drainage from the land had changed the bay into a large fresh water or brackish lagoon or estuary. The "Catskill" red beds represent a nonmarine facies. Their deposition has generally been accepted as beginning in Portage time and continuing through the Upper Devonian, even into early Mississippian in Pennsylvania. Of the Catskill beds Chadwick writes (letter, 1931): "This name (Catskill formation) has been widely extended over red beds locally topping the Devonic and now known to be of progressively later age from east to west. The type area in the Catskill mountain front, at the east, is not younger than Portage in age." Ruedemann believes (p. 177) that the Rensselaer grit was deposited by a great river coming from the north into the changed Albany estuary "along the edge of the capital district in a sinking trough at the same time that farther down in the bay the Catskill beds were formed."

During the Upper Devonian the continental seas were gradually withdrawn, first from the southern Mississippi valley area and then from the interior and the Cordilleran areas, until at the end of Devonian there was a practically complete emergence of North America.

POST-DEVONIAN HISTORY

The episodes touched upon above marked the end of marine deposition of which we have direct record in this part of the State. In the **Mississippian** and **Pennsylvanian periods** (Carboniferous), there was again an invasion of marine waters in which were deposited the great series of formations seen in southwestern New York and Pennsylvania. Carboniferous strata are only sparingly represented in New York and they consist of outlying masses of oldest Mississippian unconformably overlain by oldest Pennsylvanian. The extent of the Carboniferous seas over southern New York is not known. Ruedemann (p. 177) in discussing these Carboniferous periods writes:

> The rich coal beds of Pennsylvania were formed in this time. There is no doubt that a large portion of these formations, also, once extended into our district, and that for all we know luxuriant swamp forests of the coal period may have flourished here as well as in Pennsylvania, for if we consider that the capital district was exposed to the gradational work of wind and weather ever since the Carboniferous period, that is, for 300 millions of years as geologic time is figured now, it is readily seen that an enormous amount of material above the Catskill beds must have been removed in this long time.

The close of the Paleozoic is marked by mountain-making disturbance of almost world-wide occurrence, beginning with late Mississippian. This disturbance reached its culmination at the end of the Permian (late Carboniferous), when the deposits of the Appalachian geosyncline were elevated into the Appalachian mountains. The folding extended in a northeast-southwest direction from Nova Scotia southward into Alabama and the Ouachita mountains of Arkansas.

Eastern New York again suffered folding which threw the Rensselaer grit plateau into a series of anticlines and synclines, but died out rapidly westward. In the Helderberg area (Albany quadrangle) of the Capital District are seen the small folds that represent the last vestiges of this folding. Ruedemann continues (p. 178):

And then began the great process of removal of the pile of rocks which from the top of the Catskills to the base of the Cambrian amounted to over a mile of rock, and at the beginning probably to a mile and a half. Considering that this mass was folded in the eastern portion of the capital district and raised into mountain ranges, it is not too much to say that there were possibly as much as two miles of rock above the site of Albany that have been carried off to sea since Paleozoic time. The process began in the north on the slope of the rising Adirondack plateau and worked backward and southward in a series of terraces and escarpments, until now everything of Silurian and Devonian age is eroded away north of the Helderberg escarpment, and the older Ordovician and the very oldest Cambrian rocks have come to the surface. Above the receding Helderberg cliff the enormous pile of rock that we see rising farther south in terraces to the top of the Catskills has already been worn away. It is due to this far-reaching erosion that the capital district furnishes a section from the Lower Cambrian to the Upper Devonian rocks.

During the **Mesozoic era** most of the eastern part of the United States was undergoing erosion which resulted in the reduction of the country to a more or less perfect peneplane, known as the Cretaceous peneplane because it was best developed in that period. So far as known, there is a complete absence of marine Triassic sediments in the eastern half of North America. The coast line was farther to the east and the lands were undergoing erosion. Along the eastern margin of the Appalachian region certain troughs subsided and in these troughlike depressions continental deposits were accumulated to great thickness. The Newark series of New York and New Jersey (named from Newark) are such beds of continental origin, deposited in upper Triassic times and some even believe that the deposition continued into Jurassic time. No rocks of Jurassic time occur in New York State. The area during this period was undergoing erosion so that by the end of the period this region and the entire Atlantic slope had been worn down practically to peneplane conditions. No marine deposits of the Lower Cretaceous or Comanchean occur along the Atlantic coast, but there are deposits of gravel and clays laid down as deltas and flood plains or in marshes or shallow lakes which extend from Martha's Vineyard, Mass., to Georgia. The Upper Cretaceous was a time of great subsidence, during which the sea spread over the coastal plains of the Atlantic states. Cretaceous deposits in New York occur on Long Island and Staten Island. The nonmarine Lower Cretaceous beds are found only along the northwestern border of Long Island and were deposited when slight subsidence produced low-lying flats. Reelevation and erosion were followed by the Upper Cretaceous subsidence of the coastal plain area, permitting marine deposition in a shallow sea. This subsidence included most of Long and Staten Islands.

There is only negative data for the *Mesozoic history of the Capital District.* The absence of any trace of deposition in this area would indicate that this region was land throughout the entire era. Ruedemann in speaking of the Triassic troughs points out that "if such later troughs had been formed in the capital district, the Helderberg region would preserve a record in some sagging of the beds. The Helderberg rocks, however, exhibit fairly regular strike, with the exception of minor faults and folds". He continues (p. 179):

Cushing and Ruedemann ('14, p. 144) have argued that the great normal faults of the Champlain basin and the Saratoga region are the result of repeated dislocations that began with the sagging of the western trough in early Paleozoic time and the tendency of the Adirondacks in the west to rise, and may have well continued into Mesozoic time, for "the faults of the eastern Adirondack region are normal with nearly vertical fault planes, and these certain Mesozoic faults are of similar type" (as for instance those delimiting and transecting the Connecticut Triassic basin). It is quite possible that the Saratoga fault, which enters the capital district and passes along Ballston lake, is of Mesozoic age, and likewise the small faults found in the Helderberg cliff.

The peneplane of late Mesozoic (Cretaceous) age, mentioned above, extended generally throughout the Appalachian region and eastern Canada and, as Ruedemann points out, "it is quite reasonable to assume that it was also produced here." Ruedemann also (p. 180) in reconstructing the events of this era calls our thoughts to "the strange world that . . . existed at the beginning perhaps two miles above the present site and level of Albany; . . . the strange and gigantic reptiles, the tracks of which are still found in continental deposits of the Connecticut valley, that once wandered about in equally weird forests and swamps high above our present city."

The close of the Jurassic time in western United States was marked by a period of mountain-building (Sierra Nevadas particularly). The closing stages of the Upper Cretaceous are marked by great crustal disturbances which resulted in mountain building from Alaska to the southern end of South America. It was during this time that the Rocky mountains were formed. North America became practically dry land and the Atlantic and Pacific coasts extended farther out than in Tertiary time following.

Cenozoic deposits in New York State are mainly Quaternary. The earliest Tertiary deposits do not occur on Long or Staten Island, but Middle or Late Tertiary deposits are found.

Marine Tertiary deposits occur along the Atlantic and Gulf coasts from Martha's Vineyard island into Texas. Toward the end of Tertiary time there was a period of widespread elevation (Pliocene) and the eastern coast of North America became practically the same as today. North of New York the coast extended farther out than at present and the greater part of Florida was under water. During the Tertiary there were periods of mountain building (Coast and Cascade ranges, reelevation of Sierra Nevadas and Rockies) and igneous activity (Oregon, Washington, Idaho and Pacific ranges in California). Late Tertiary and early Quaternary was a time of elevation. The continents stood higher than now and there were broad land connections permitting migrations of the animals between the continents. Later, elevation ceased and with subsidence these land connections were broken. The cooling of the climate of Tertiary time culminated in the Pleistocene or Glacial Period, during which time vast ice sheets spread over much of northern North America and Europe.

New York State has a variety of glacial deposits (continental), but there are also marine and brackish water deposits of gravel, sand and clay found in the St Lawrence, Champlain and Hudson valleys. These deposits contain fossil shells of animals that live in the sea today. During the Pleistocene there was a great subsidence of the northeastern Atlantic coast and marine waters spread over the St Lawrence valley and Lake Ontario area and through the Lake Champlain and Hudson valleys. It was during the period of the Champlain subsidence that the sea coast acquired nearly its present position. Following the subsidence was the very recent gradual elevation which expelled the Champlain sea. Marine and brackish waters also disappeared from the St Lawrence and Hudson valleys, leaving New York State as it is today.

Ruedemann points out that the Cenozoic history of the Capital District is the same as that for the Saratoga region described by Cushing and Ruedemann ('14, p. 145) who in their description state:

At the close of the Mesozoic the region was again uplifted. The low altitude peneplane which had been produced over the Adirondack region was elevated some 1500 feet or more, and rapid erosion of its

Figure 70 Glacial plain fronting the Helderberg scarp below the Indian Ladder gulf, located on the Ten Eyck farm. The plain was formed between stagnant masses of ice. The prominent hill, on the south side of the Voorheesville-Altamont road, is an outlying "kame" associated with an earlier and higher level of construction. (Photograph by E. J. Stein)

surface began. Stream valleys were cut down and broadened. It is the depth of the valley cutting below the old peneplane level which enables us to estimate the amount of the uplift. This old peneplane surface is readily made out over most of the Adirondack region.

Continuing his Cenozoic history, he remarks ('30, p. 181):

During the first part of the Cenozoic, the Tertiary, minor oscillations of level took place in the region, but we lack the precise knowledge of just when and what they were. Later in Tertiary time an additional uplift took place, considerably increasing the altitude of the region, not improbably with renewed faulting. The peneplane that had formed during the preceding Tertiary time and that was now uplifted, is recognized in the Tertiary peneplane of the Helderberg mountains and the Rensselaer plateau, . . . A still lower peneplane began then to form in the inner lowland of the Helderberg and Rensselaer plateaus; this is the Albany peneplane. It is still growing into the surrounding plateaus.

The final chapter in the geological history of the Capital District and northern Helderberg area is invasion by the ice sheets of the glacial period. The Pleistocene or glacial geology of the northern Helderberg area will be described in the following chapter by my colleague, Professor John H. Cook, who wrote for Doctor Ruedemann the Glacial Geology of the Capital District ('30, p. 181–99).

THE GLACIAL GEOLOGY OF THE BERNE QUADRANGLE

By John H. Cook

The last movement of glacial ice across the area of the Berne quadrangle was part of a larger movement which, however initiated and maintained, has left a reasonably clear record of its direction and extent. Still it is necessary to recognize that that record was made by what may be called *bottom currents,* streaming of ice in contact with the lithosphere, and that such "currents" would, whatever the thickness of the overlying mass, be affected most strongly by the topographic relief of the rock basement. Thus we are left to deduce as best we may from our limited knowledge of existing bodies of land ice (none of which appear to be in the advancing hemicycle of glaciation) what, if anything, the striae, flutings and drumlin forms indicate with regard to the upper ice at the time when they were made.

First we are impressed with the continuity of the evidence as showing the result of powerful pressure exerted against the northeastern Adirondacks setting the ice in motion around the western flanks of those mountains at about the same time that it began to move southward between the Adirondacks and the Green mountains. This easterly branch of the movement was (at the bottom) directed along the great trough formed by the basin of Lake Champlain and the Hudson River valley; but there is almost everywhere on the higher slopes, evidence of a tendency to find paths of pressure relief directed away from the trough in a direction somewhat to the west of south. In consonance with this tendency the ice was forced diagonally across the lowland of the upper Hudson basin and against the rather formidable barrier of the Alleghany plateau.

Of this plateau the Berne quadrangle is the northeastern corner; and on it are recorded marked changes in the direction of the ice movement. A line drawn through Dunnsville, Knox Village and West Berne (see figure 72) will represent approximately the dominant southwest trend and will indicate the actual course of any boulders from the north chancing to enter the area along that line. But it will also show the *only straight course* which a boulder could follow in crossing the sheet, for all the ice lying to the right of this reference line (as one faces southwest) swung away in long sweeping arcs until it passed off the map going westward; and all the ice to the left of the line curved (somewhat more gently) to the left and passed out of the map moving southward.

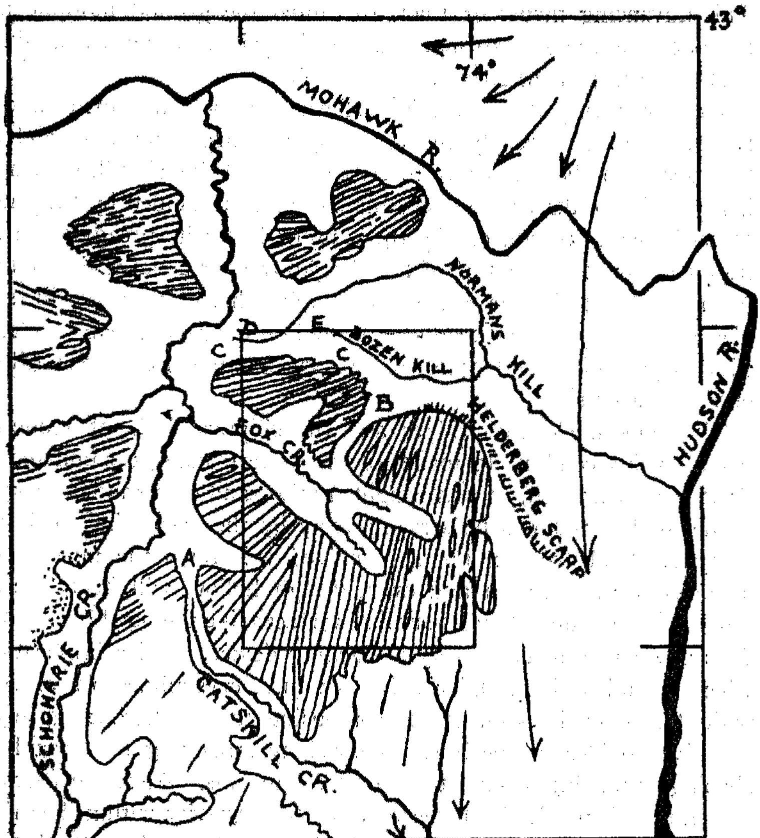


Figure 71 Drainage of the plateau north of the Catskill mountains. The Berne quadrangle is outlined.

Had the land ice maintained a receding barrier wall across the basins of the Mohawk river and Schoharie creek during its disappearance, lake waters would have been held up in the Schoharie basin to approximately 1170 feet (areas above 1200 feet are shaded) with outlet at point *A* into the Catskill creek basin. The recession of such a barrier would open successively lower outlets at *B* (1160 feet); down the slope at *C-C* (from 1160 to 840 feet); into the Normanskill at *D* (with a possible temporary course through the Bozen Kill valley at *E*) where the Schoharie lake would have been held at approximately 840 feet until lower levels were open in the Mohawk valley.

The evidence does not justify the ice wall theory of retreat. Stagnant ice appears to have lain over the area protecting the land surface from both erosion and sedimentation while the larger streams resulting from the melting of the ice coursed over or through the ice. The few accumulations of recessional drift were deposited in the presence of unmelted remnants of the stagnant mass.

The generalized directions of movement of the last thrust of live ice are indicated by the lines shading areas over 1200 feet and by arrows. (J. H. Cook)

This advancing thrust of thick ice fluted the ground moraine and the softer bedrocks so strongly that all the principal lines of its divergent flow can be read from the topography.

By discounting the preglacial valleys and the land forms due to rock structure, especially the two major escarpments (the Helderberg scarp southeastward from Altamont, and the Hamilton scarp), it is possible to discern the very distinct pattern molded by this latest glaciation and brought out by the contour lines; it spreads from the northeast corner like a leaf of the Gingko tree, or a fan with outcurving ribs. To assist the reader to visualize this pattern, the lines of glacial topography have been represented on the sketch map by elongated loops while the terrace and valley features have been differentiated variously.

The smooth elongate ridges and the elliptical hills of moderate height which combine to make up the pattern may be simulated by dragging a fair-sized canvas weighted with sand over muddy ground. Some of the mud will be scraped away by the overriding load; but every small obstruction not so removed will form the nucleus for an denisciform elevation and every rough hollow will be converted into a trough bounded by streamline surfaces like the bowl of a spoon. This procedure, being merely a teaching device, carries implications which are misleading. Glacial ice is a pure crystalline rock and the paths taken by the sand grains composing the incoherent aggregate can give no idea of the lines followed by streaming ice crystals in shaping or passing around these denisciform hills. Also, the forward movement of such ice is always a response to gravity within the mass; whenever the attraction of the earth overcomes the complex of molecular powers (forces) which expresses itself as *rigidity,* movements of readjustment begin, tending to create a form which is in equilibrium (motionless). The steeper the declivity of the rock floor supporting the ice mass, or the higher the temperature, the more easily is this mass-rigidity overcome. The thickness which has been attained by certain existing ice caps in high latitudes without initiating such movements is instructive, especially in those cases where the rock basement is rather flat or where its irregularities have been overwhelmed. These considerations are not even suggested by the action of the sand-weighted canvas.

Where the action of the ice modeled the ground moraine about a core of concentrated boulders such a hill is a true drumlin, a constructional form; and where sufficiently yielding bedrock has made it possible for the ice to trim away the asperities and reduce a rock hill to the shape of a drumlin, such a hill is termed a drumli-

Detached Oversized Item Previously Located at this Position

To View:
See Image 3
In Bulletin Folder

noid or roc-drumlin, a sculptured form. The distinction is not important when the problem is merely that of tracing the ice currents and determining the direction of movement, for in both cases the longer axis of the mound, hill or ridge indicates the course of the flow. Moreover the interior of apparent drumlins is commonly not open to inspection, and where roadcuts have exposed the material under the veneer it appears to be indifferently bedrock, hard-pan or loose till.

The pattern to which the reader's attention has been called is helped out here and there by ice-ploughed cols (low points in the divides between stream basins), such as the trough occupied by a marsh one and one-half miles north-northwest of Reidsville; and by the strong fluting of hillsides which have presented rock-benches of variable hardness to the pressure exerted against them. Examples of this benching are found on both sides of the trough just mentioned, and again, in much greater strength, on the valley side showing along the eastern margin of the sheet from latitude 42° 35′ southward to Hannacrois creek.

The outstanding problem presented is to account for the bifurcation of the ice stream coming into the sheet from the northeast. The problem is not at all simple although the topography appears to offer a satisfactory solution in the angular barrier presented by the corner of the plateau with the lowland of the Mohawk basin running westward not far to the north, and the trough of the Hudson valley running southward not far to the east. And in addition to these topographic controls was the steep climb from the preglacial Mohawk channel northeast of Altamont (now filled) to the top of the plateau west of Rensselaerville, a lift of some two thousand feet in less than 20 miles. But it must be borne in mind that the control of the movements in a sheet of land ice is partly exercised by the form and thickness of the ice itself, and that, as far as any one avenue along which pressure is being relieved is concerned, all of the remaining ice may be regarded as part of the topography. Any given "lobe" projected beyond the neighboring edge of the ice has its general course predetermined by the stresses and strains set up by changing conditions within the mass of the ice. To the normal axiradiant spread of such a lobe the land topography offers resistance in proportion to the strength of its relief and the thickness of the ice, but its control is never absolute as is that of the walls which confine and guide a mountain glacier. Such a lobe will stagnate and begin to ablate *whenever it ceases to represent the path* *of least resistance for the pressure which has kept it in motion*, and it is not improbable that an ice sheet may reach a stage of maturity where vast areas of the marginal zone lie stagnant for no more recondite reason than that the maximum snowfall is no longer able to furnish alimentation to the enlarged periphery.

It is proper at this point to take notice of Professor Hobbs' theory of the glacial anticyclone as developed in his book Characteristics of Existing Glaciers (Hobbs, '11*a*) and in other writings (Hobbs, '11*b* and '34), according to which an ice cap eventually becomes large enough to maintain above it an anticyclone in the atmosphere; that air, cooled by contact with the ice, periodically slides outward to the periphery carrying with it most of the snow and rime precipitated on the isblink (central dome or plateau); that air drawn downward from the higher levels of the atmosphere by the outrush of the centrifugal winds supplies most, perhaps all, of that precipitation; and that movements of the glacial ice are, in consequence, confined to the marginal zone where the blown snow accumulates and the edge of the isblink affords slopes of greater pitch.

It seems to us that, in his interpretation of the Pleistocene glaciation of North America, the author fails to make due allowance for certain necessary qualifications of the theory which he has advanced, even the qualifications expressed and implied in his own publications.

This is not the place to offer an extended criticism of the quoted conclusions on the importance of the rôle played by the glacial anticyclone and the isblink wind system. But since our task is the interpretation of topography as it appears on the Berne quadrangle (and necessarily all of the topography immediately related thereto), we are constrained to record that, in the prosecution of that task, the theory of *motion confined to the marginal zone* has not been helpful. So powerfully does the accumulated evidence from the field once occupied by the southern limb of the Wisconsin ice sheet (from Indiana to Nova Scotia) appeal to us as indicative of broad, continuing movement under deep ice, initiated back of the "appreciable slopes" of the ice front, that we are unable to put aside our hard-won picture of this particular Pleistocene continental glacier formed, no doubt, before due consideration had been given to the results of studies made on existing continental glaciers. We are impelled rather to reexamine the theory and its implications as they may apply to the southern edge of a middle latitude ice sheet beset by a series of cyclonic storms under conditions *not obtaining for the existing continental glaciers*.

These general considerations have place here because it is evident that on the Berne quadrangle we are dealing with forms produced under ice so thick that it was still able to shape drumlins 1700 feet above its deepest portion and to drumlinize hilltops of soft rock some hundreds of feet higher. It seems evident that the control exercised by the strong relief of the region was reduced to a minimum, that we are not dealing with the advancing margin of an ice cap but with phenomena within the ice field at some (perhaps a considerable) distance back from the free edge. The northern or west-moving branch can be traced to a point somewhat beyond Utica; there is no competent topographic control along its southern side to hold it to such a course, and there is no morainic dump to outline its limits. The south-moving branch passed down the Hudson valley and spread southeastward over New England as well as southwestward once it had rounded the Catskills.

The late Professor Albert P. Brigham, who gave much time and attention to the Mohawk "lobe" (an unfortunate designation for the west-moving current, of which impropriety the author was quite conscious; see Brigham, '11, p. 18) was led to conclude after many years of study that: "We are compelled to accept a late and strong westward movement in the Mohawk Valley. We have given reasons for believing, however, that, at the time, the Adirondacks were not an island in the ice, but were largely covered with a thick mass of ice mostly stagnant. If the same conditions of stagnation obtained on the northern slopes of the Catskill-Alleghany plateau from the Berne quadrangle westward, then we have the Mohawk lobe, vigorous as it was, gradually giving up its motion in the presence of retarding frictional conditions" (Brigham, '29). In reporting on field work done for the New York State Museum in 1919 the present writer stated that he had been led to the same conclusion, and, later, he was able (to his own satisfaction at least) to demonstrate that this west-moving current invaded an ice field—presumably quiescent—which already occupied the plateau to a considerable depth (Cook, '24).

Because the ice sheet was an integrated whole as far as the dynamics of its movements are concerned, and no one part can be fully understood without reference to its relations to the rest, the writer refrains from expanding this short chapter to discuss the Late-Wisconsin invasion at greater length, and refers the interested reader to the bulletin already quoted (Brigham, '29, p. 15–17) for a description of the bottom currents along the southern limb of the ice sheet and the interpretation usually given to them.

This, then, is very nearly all that can be deciphered of the glacial geology of the Berne quadrangle. There are scattered heaps of "moraine" and some crude terraces to be associated with the dissipation of the ice, most of them located within the drainage basin of Fox creek, but they are inconsequential and by themselves tell us very little of the history of the ice sheet in the last stages of its disappearance. It would seem that the ice which molded the drumlins pushed forward to the limit required to establish equilibrium, stagnated and melted off in place. If, as has been contended, this great movement centering in the lower St Lawrence valley was the last movement of glacial ice across the quadrangle, it may well represent the first adjustment of the ice mass to a climate become suddenly warmer and unable to maintain its former depth at the higher temperature. In this case we could hardly expect further evidences of motion because the retreating hemicycle of glaciation was beginning. Probably the comparatively clean ice which swept across the region and its position far above sea level served to prevent the floods due to the melting of the ice from mutilating or burying under sediments the exceptionally fine example of glaciated land which this very last movement of the latest ice sheet created here.

The criterions for distinguishing areas from which stagnant ice has melted off will be found most lucidly set forth in Professor R. F. Flint's article on the Stagnation and Dissipation of the Last Ice-Sheet (Flint, '29) ; and as far as the argument there expanded applies to the region covered by this report, the rather negative evidence can be appreciated by reference to the accompanying diagram (figure 71) with its explanatory notes.

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INDEX

Detached Oversized Item Previously Located at this Position

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Map 1 Geologic Map of the Berne Quadrangle