

THE SECTION AT SCHOHARIE, N. Y.

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CONTENTS

	PAGE
Introduction	361
The Hudson; its relation to the Medina Formation at southern localities	362
The Niagara	363
The Onondaga; represented by the Waterlime; and its relation to the Niagara and to the Helderberg series.	364
The Helderberg; its subdivisions	366
The Oriskany; its relation to the Helderberg	374
The Corniferous [Onondaga]; and its subdivisions	375
The Hamilton	377
List of localities for collectors	377
Appendix: Glacial action in the Schoharie Valley, by Archibald E. Stevenson	378

INTRODUCTION

The Schoharie River rises on the easterly side of the Catskill mountains, flows westwardly across the rugged area, then turns northwardly and finally enters the Mohawk river near Amsterdam, about one hundred miles from its source. It cuts the Helderberg escarpment at little more than a mile below the village of Schoharie in the county of the same name.

The Helderbergs are practically the northwestern border of the mountainous synclinal area known as the Catskills, the southeasterly border being the Shawangunk mountains. The section shown in the wall, as seen for many miles along the Delaware and Hudson railway, extends from the Hudson to the Hamilton, while the Chemung is reached at from one to four miles from the escarpment's edge. The succession is shown in such detail at many places that this Helderberg scarp from near

Albany to Sharon Springs has always been a favorite ground for students. Prof. James Hall made his first journey along its face in 1832 and three generations of Gebhards have followed him as industrious collectors along the Schoharie and its tributaries. Recent studies have been made by Prof. C. S. Prosser and Mr. N. H. Darton, which have gone far toward removing uncertainty respecting the relations of some of the beds.

Schoharie Valley is a broad indentation of the Helderbergs extending without material contraction for about five miles above Schoharie village. At that distance, however, the Marcellus has passed under the stream, and the hard beds of the Hamilton form the walls of the valley. The writer's study was confined to the immediate vicinity of Schoharie village, where, on both sides of the valley, the section extends from the Hudson to the Corniferous, while the Hamilton can be reached at barely a mile away. The object of the study was to compare the section below the Corniferous with that in south-central Pennsylvania. Many details were obtained during the examination, which are given here for the use of collectors who may visit the locality.

THE HUDSON, MEDINA AND CLINTON

The **Hudson** is represented indifferently at Schoharie, the exposures on the west side near the bridge and near the edge of the escarpment as well as the outcroppings along the east side of the valley north from the village being insignificant. But the beds are better shown along the Delaware and Hudson railway from Central Bridge to Esperance in this county where they are grayish to drab shales and sandstones, making up the low rounded hills northwestward from the escarpment. The thickness is very great, for, according to Mr. Darton, a boring near Altamont showed it 3,480 feet.

The **Medina** is unrepresented, and the **Oneida**, so massive in the Shawangunk, is wanting. The **Hudson** is succeeded by a shale, which is well shown on the west side of the river at a little way above the bridge, but very imperfectly on the valley road and on the point of West mountain. This, regarded as the

equivalent of the Clinton, is somewhat variable in color, weathers dirty white and contains much nodular pyrite accompanied by barite. The same characteristics appear at Howe's cave, five miles west from Schoharie. The pyrite was mined near Schoharie thirty years ago, but the venture proved unprofitable. The exposures at Schoharie are incomplete but the thickness cannot exceed thirty feet.

There is here a very striking contrast with the section of southern Pennsylvania and of other localities farther southward.

The Hudson shales, in Evitts mountain, Bedford county, Penn., mostly yellow in color, contain some sandstones near the top, where the color changes and physically there is a gradual passage to the lower or red Medina. *Rafinesquina alternata*, *Plectambonites sericea*, *Rhynchotrema capax* and *Leiopteria radiata* pass upward into the red Medina. The conditions in southwestern Virginia are the same. On the northern side of Big Walker mountain in Bland county, near Sharon Springs, as well as in Lyons gap through the same mountain in Smyth county and Hayer's gap through Clinch mountain in Russell county, exposures are especially good, as they show a fossiliferous bed at about one hundred feet below the white Medina, in which *Rhynchotrema capax*, *Actinopteria emacerata*, *Leiopteria radiata*, a *Modiolopsis* a large linguloid form and fragments of *Orthoceras* occur abundantly. The Oneida seems to disappear in south-central Pennsylvania and thence southward the passage from Ordovician to Silurian is gradual at most of the exposures.

THE NIAGARA

The **Niagara** limestone is represented by the Coralline limestone of the older reports, which, at the complete exposure on Schoharie river above the bridge, is a massive rock in three layers, averaging in all six feet. The upper portion is very dark on fresh surface, the lower portion less so, but both weather light gray. This limestone is well exposed along the west side of the river for an eighth of a mile above the bridge and at several points below the bridge; it can be followed easily to Howe's cave,

where it underlies the "Cement rock" of the Waterlime. The only exposure on the east side is that near the African church, but the rock is present along this hill northward and in the Fox-kill valley eastward, as the stone fences hold fragments of it in abundance. Some portions are crowded with *Favosites niagarensis* and *Stromatopora concentrica* but other forms are rare. Occasionally one finds a nest of *Rhynchonella lamellosa* with *Atrypa reticularis* and *Pterinea securiformis*, all well preserved. Besides these are some univalves and cephalopods but for the most part they are indefinite and in some cases even the genus cannot be determined satisfactorily.

THE ONONDAGA

The **Onondaga**, of Dana, is represented only by the **Waterlime**. The Salina shales, so thick in western New York and persistent in southward even to the Baltimore and Ohio railroad¹ in Maryland, have no representative here. The physical change from Coralline (Niagara) to Waterlime is sufficiently sharp in that the color changes abruptly from very dark brown (the "blackrock" of the Cement quarries) to dark gray or dull brown while the fracture becomes more earthy and ragged, though the weathered surface of the two rocks is very similar.

The **Waterlime** is not well exposed at any point near Schoharie. The space between the Coralline and the Tentaculite on the east side is apparently not more than 15 feet, but it is certainly greater on the west side of the river upon the Gebhard farm, where there is a good exposure for more than six feet above the Coralline. The succession is fairly well shown at the Howe's cave cement tunnel, where, in descending from the Tentaculite limestone, one finds

1. Flaggy and shaly limestone.	31'
2. "Blue rock"	2' 6"
3. "Cement rock"	6'
In all	39' 6"

¹ As ascertained by I. C. White.

The upper portion of No. 1 is shown at the entrance to Howe's cave, and at the grinding mill as well as in an excavation near by once occupied by a kiln. The middle portion for about 6' is concealed, while the lower portion is exposed at the tunnel. The flaggy layers are from 6" to 1' thick and hard, yielding a good building stone, which was used in the older part of the Cave hotel. The greater part of the mass, however, is made up of layers from one to two inches thick, separated by laminae of shale. The rock weathers light gray with trace of blue, but is brownish gray on the fresh surface. The "blue rock" is evidently a hydraulic limestone, light blue in color, with irregular fracture and too calcareous for cement. The "cement rock," which forms the base of the mass, varies little from 6' and is in three layers. It is darker than the last, more ragged in fracture and is the cement rock of the works in Ulster and Schoharie counties.

At Howe's cave, calcite occurs in little patches between the "Blue" and "Cement," sometimes in sufficient quantity to be annoying. Near Schoharie, it has been obtained at Clarke's cave as well as near the Table rock, both on the west side of the river. Near the latter locality, strontianite is associated with the calcite. Several tons of the former mineral were shipped, but the deposit did not prove to be of economic importance as the streaks are too variable. No attempt has been made at Schoharie to utilize the rock in the manufacture of cement, though the character is apparently the same as at Howe's cave, where preparations are making for an output of 2,000 barrels per diem.

While the color and composition of the rock prove a decided change in physical conditions from those prevailing during the Niagara, still that change must have been comparatively unimportant, since it did not suffice to cause local destruction of the fauna. At Howe's cave, *Favosites niagarensis* passes upward from the Coralline and persists in the lower three feet of the "cement," being so abundant in some of the headings as to unfit the rock for use. According to Professor Hall, *Halysites catenularia* passes from Niagara to Waterlime in Herkimer county. At Schoharie, Mr. W. D. Gebhard has obtained some of his best

"Coralline" forms from the lower layers of the Waterlime; and certainly some specimens in the New York University museum, collected many years ago by John Gebhard, Jr., are in rock showing the color and fracture not of Coralline but of Waterlime. It is sufficiently evident that, while the great mass of Salina shale was in process of deposit in central New York and in much of the Appalachian region, the conditions within this portion of New York changed so gradually as to bring about only a slow disappearance of the fauna. There is a steady increase of calcareous matter from the bottom to the top of the Waterlime. No fossils were found in the lower portions of No. 1, but, above the middle, *Spirifer vanuxemi* and *Leperditia alta* were obtained from the thicker layers, showing that the passage to Helderberg was quite as gradual as that from Niagara.

The Waterlime is the cave rock of this region.

THE HELDERBERG

The Helderberg (**Lower Helderberg**) was divided by the older geologists into

1. **Tentaculite Limestone.**
2. **Lower Pentamerus Limestone.**
3. **Catakill or Delthyris Shaly Limestone.**
4. **Scutella Limestone.**
5. **Upper Pentamerus Limestone.**

The succession being in ascending order.

This succession is distinct in southern Pennsylvania and even in southwest Virginia, though in the latter area the upper beds are quite silicious. The formation is termed the Lewistown limestone in the Pennsylvania reports.

1. The Tentaculite Limestone

The passage from **Waterlime to Tentaculite** is marked in the Schoharie region by an abrupt change in color, the latter being the "Blue limestone," with blue so deep in the lower layers as to appear almost black. The succession in descending order is

Tentaculite limestone.

- | | |
|--|--------|
| 1. Limestone, bluish, irregularly bedded, layers 2" to 4" thick..... | 2' 6" |
| 2. Limestone, bluish, irregularly bedded, often sub-concretionary, the layers separated by very thin shales..... | 13' 6" |
| 3. Limestone, deep blue, in two layers, 2' 3" and 2' 6", separated by 2" of clay, massive, brittle, conchoidal fracture, fetid odor..... | 4' 11" |
| 4. Limestone, thin layers with laminae of shale... | 5' |
| 5. Limestone, blue to bluish-black, massive..... | 2' 5" |
| 6. Limestone, bluish, irregular, sub-concretionary structure..... | 2' |
| 7. Limestone, thin bedded, with laminae of shale | 5' 8" |
| 8. Limestone, in layers about 1" thick..... | 1' |
| 9. Limestone, bluish-black, ragged fracture, massive, in three layers..... | 8' 5" |

in all 45' 5" thick.

This section is seen in an almost continuous exposure on the east side, where quarries have been worked for a quarter of a mile below Schoharie village, and there are many partial exposures within half a mile above the village. The only complete exposure on the west side is along the road ascending West Mountain. Occasional outcrops were seen on Foxkill and Cobleskill east and west from the Schoharie and the great quarries at Howe's cave exhibit the same order. At one time, the massive beds were quarried either for building or for ornamental stone, but they are used no longer, as planes of bedding developed on exposure and caused unsightly seams. The weathered surfaces in the quarries show that the massive beds are laminated though the surface of fresh fracture shows no trace of such structure.

The lowest bed was quarried most extensively as it yields blocks of large size. The rock is brittle, rings when struck but has a very ragged fracture. Fossils are comparatively rare, only *Spirifer venuzemi* and *Leperditia alta* having been seen. But the half-burned rock is clearly a mass of fossils, mostly of the

forms mentioned with some *Tentaculites*. No. 8 varies little in thickness and not at all in character. The upper surfaces of the layers are crowded with *Tentaculites gyracanthus*, which at many localities are in perfect condition. No. 7 is more irregular in its bedding. Thin laminæ of limestones in the shales separating the thicker layers are crowded with fossils, seldom in good condition. The predominating forms are *Zaphrentis*, *Stromatopora*, *Spirifer vanuxemi*, *Leiopteria aviculoidea*, *Tentaculites gyracanthus*, *Leperditia alta*, *Beyrichia* and minute univalves. The delicate crinoid, *Homocrinus scoparius*, is said by W. D. Gebhard to belong in the upper portion of this division, but no fragments of it were found. No. 6 contains many *Stromatopora*, some of which are large, one colony having been seen which weighed more than 75 pounds. No. 4 resembles No. 7 and contains the same fossils in the same condition. No. 3 resembles Nos. 5 and 9. It yields the *Spirifer* and *Leiopteria* well preserved but *Tentaculites* is rare. No. 2 is very fossiliferous, and the specimens obtained from the harder parts are very good; *Strophodonta varistriata* occurs abundantly and a fine pygidium of *Dalmanites micrurus* was found near the top. No. 1 contains few fossils aside from fragments of crinoidal stems, which are shown on the weathered surface. Besides the forms mentioned, some of the massive beds contain *Orthoceras*; no specimens were found in place but several were obtained from the waste piles. Irregular markings occur on the surfaces of the higher beds which may be looked upon as mats of fucoids, shrinkage cracks or trails; all appear to be chafed or water-worn as though the rock had been at the water's edge.

There is no transition from the **Tentaculite** to the **Lower Pentamerus**. The former is blue, brittle, laminated or thin-bedded; the latter is bluish gray, massive, extremely tough and refractory. The best blocks of Tentaculite bear little strain; some, 15 inches thick, in the Schoharie cemetery have broken on irregular foundations under the weight of comparatively small monuments, but the Lower Pentamerus is reported to bear a pressure of 19,000 to 26,000 pounds to the square inch.

2. Lower Pentamerus Limestone

The **Lower Pentamerus** consists of 33 feet of hard, massive limestone below and 32 feet¹ of alternating hard and somewhat softer limestones above. The lower portion forms a bold cliff, which is distinct on both sides of the Schoharie valley to two miles above the village, where it passes under the river at less than half a mile below Davis's dam. It is equally distinct westwardly to Howe's cave and eastwardly along the face of the Helderberg for many miles. The rock is excessively hard, or better, tough, very difficult to break with the hammer. The bedding is evident, but there is a subordinate structure, so that the rock seems to be made up of irregular lenses separated by coatings of clay. This structure is very apparent on the weathered surface, and is recognizable without difficulty in the unweathered rock. The weathered surface is very irregular and suggests a loose structure, but in Mix & O'Reilly's quarry at Schoharie, building-stone of the best quality has been obtained at five feet back from the face. The rock has been exposed to attack from both sides in that quarry, for the joint planes have been converted into open fissures, whose sides are weathered as thoroughly as is the exposed cliff. The clay film may be a cementing material for the lenses. The color is dull grayish on the cliff face, which is often coated with drip lime, but internally the color has more of blue, though wholly different from the blue of the Tentaculite. The full thickness of this portion is not shown on the east side, but is exposed on the west side of the valley, along the road ascending West mountain. The character of this portion is the same as at Howe's cave, where, however, no use is made of the rock except in preparation of road metal.

The upper portion of the **Lower Pentamerus** is not exposed in satisfactory detail near Schoharie. An imperfect exposure was found in a dry waterway in the park back of Schoharie village on the east side, and another in a similar waterway on the west side, about 200 yards south from the schoolhouse.

¹ These measurements are by barometer.

The succession at both places is that of thin limestones varying in hardness but with very little trace of shale. No exposures were seen in open fields on the east side, but the harder beds are shown on the schoolhouse hill south from the waterway just mentioned, where the decayed outcrop gives opportunity to see the fossils.

The toughness of the lower portion is such that fossils can be obtained in very few places; even where decay has gone on for a long period, the result is little more than mere separation of the lenses, leaving the limestone itself as refractory as before. A few layers, however, are more readily treated and yield numerous strophomenoid forms, one of them being evidently the *Stropheodonta* of the Tentaculite. *Sieberella galeata* is found abundantly with the valves separate. *Uncinulus mutabilis*, *Atrypa reticularis* are common; rude fragments of *Orthoceras* and pygidia of *Dalmanites* occur, and fragments of crinoidal stems are not rare. In the upper division the same forms are present, but the *Sieberella* is less common. A layer within two or three feet from the top is characterized by the *Lepadocrinus gebhardi*. A continuous outcrop of more than 200 feet in the field south from the schoolhouse shows the stems in great abundance, but complete specimens are very rare, barely a dozen examples having been obtained during almost seventy years of collecting by three generations of Gebhards. This horizon is exposed in the park near Schoharie village. One of the higher layers contains great numbers of *Mariacrinus* stems, some of which are more than a foot long.

3. The Delthyris or Catskill Shaly Limestone

The immediate contact between the Lower Pentamerus and the Delthyris was not seen, there being a concealed interval of from two to five feet between characteristic beds. The thickness of the Delthyris by barometer is from 85 to 95 feet. The mass is a succession of limestone beds, one to three feet thick separated by beds of calcareous shale varying in like manner. The limestones are bluish to dark gray, some of them very light gray. Many of them are somewhat argillaceous and most of

them weather light gray. The shales are hard but weather readily. As a whole the rocks wear away easily so that the place of the *Delthyris* is marked by a slope between cliffs made by the Lower and the Upper Pentamerus. This slope on the east side of the valley is long and gentle so as to be cultivated and there are few satisfactory exposures; but the slope is comparatively steep on the west side and an almost continuous exposure is found on the schoolhouse hill in a little waterway. Imperfect exposures only were found on West mountain near Murphy's, though there one finds the best exhibition of the uppermost beds. The most extensive exposure is on the west side of Schoharie river below Davis's dam, where one sees all the beds, except the topmost, as they descend to the river; when the water is low, a horizontal space of 25 to 100 feet is bare.

The lower portion for about fifteen feet is silicious and contains much chert. It is shown on the schoolhouse hill where it can be followed for a long distance; but a proper understanding of the structure of this portion can be gained only at the Davis dam locality, where the broad surface shows the interlacing of the cherty masses. The fossils in this part are numerous and beautifully preserved; they are all silicified but cannot be removed except by weathering. The rock is refractory and is apt to break at the wrong place for the collector. The highest beds are soft calcareous shales best shown on West mountain at the Murphy place, where for a hundred feet or more they have rotted away leaving a recess under the *Scutella*-*Pentamerus* cliff.

The *Delthyris* is fossiliferous throughout and in many of the beds perfect specimens are the ordinary condition. Owing to the readiness with which the softer beds weather, specimens are set free in great number. Some forms are present throughout. At Davis' dam *Spirifer macropleura* makes its appearance in the cherty beds and persists to the top of the series. It was not found in the highest shales at the Murphy locality. *Atrypina imbricata* and *Coelospira concava* are rare in the upper shales though abundant in the beds below. The most characteristic forms occurring throughout the *Delthyris* are *Zaph-*

rentis helderbergiae, *Leptaena rhomboidalis*, *Strophodontia beckii*, *Orthothetes woolworthiana*, *Rhipidomella oblata*, *Dalmanella subcarinata*, *Spirifer macropleura*, *S. cyclopterus*, *S. perlamellosus*, *Meristella arcuata*, *Eatonia medialis*, *Stenochisma formosa*, *Uncinulus nucleolatus*, *Platyceras elongatum*, *Phacops logani*, *Dalmanites* and *Lichas* in fragments. *Orthoceras* fragments are many but obscure.

4. The Scutella Limestone

Resting upon the shales closing the Delthyris is a limestone, eight feet thick, light blue, slightly granular and containing vast numbers of crinoidal stems, whose white color contrasts markedly with the blue of the rock. For two feet at the bottom this **Scutella limestone** is in layers one to two inches thick, but, above, it becomes more nearly massive. It forms the lower part of the upper limestone cliff, which stands out on both sides of the valley to a short distance above Davis' dam, about two miles and a half above Schoharie village. This cliff is less conspicuous than that below, as the rock is less resistant, but its place is distinct. The most notable fossils are the shield-like bodies of *Aspidocrinus scutelliformis*, which in some cases are almost three inches in diameter. The stems accompanying them are from one-fifth to one-third of an inch in diameter, but they can hardly belong to *Scutella*, as in that form the pit for attachment is very small. Other fossils are abundant, most of them forms which are found in the Delthyris. The brachiopods, except *Atrypa reticulatus*, usually have the valves separated.

5. The Upper Pentamerus Limestone

This has been united by Professor Hall with the Scutella under the name of Becraft limestone, as the two limestones appear to be hardly distinct enough in some other localities to deserve separate names. In the Schoharie area, however, they are easily distinguished by the color of the fresh surface, although the weathered surface shows no difference. The Upper Pentamerus forms the upper portion of the second cliff on both sides of the valley and can be reached at many places up to its disap-

pearance above Davis' dam. The color is bluish gray, much darker than that of the Scutella but much lighter than that of the Lower Pentamerus. Like the latter, it is somewhat irregular and roughly lenticular in structure, but less so. The upper layers are easily broken and resemble the Scutella in color as well as in general appearance. They are crinoidal and carry *Zaphrentis* almost to the top, where they seem to contain little more silica than the lower beds. These upper layers include some thin shaly beds, thus differing from the lower portion, which at most localities is rather massive. The thickness as measured on the schoolhouse hill is approximately 22 feet. Exposures on the east side of the valley are not complete, only the lower portion being shown at most localities. Erosion on that side both before and during the glacial period was much more extensive than on the west side. Good measurements can be obtained on the Schoolhouse hill and on West mountain, both on the west side.

The **Upper Pentamerus** is richly fossiliferous; in some layers only separated valves even of *Atrypa* and Rhynchonelloid forms can be obtained, but in others the specimens are well preserved and abundant. Some forms are present throughout; *Leptæna rhomboidalis*, *Schizophoria multistriata*, *Spirifer concinnus*, *Meristella princeps*, *Atrypa reticularis*, *Wilsonia ventricosa*, *Stenoclisma formosa*, *Uncinulus nobilis*, *Sicberella pseudogaleata*; but beside these are many forms, the writer having obtained *Renssæleria*, 2 sp.; Rhynchonelloid forms, 4; *Meristella*, 3 sp.; *Spirifer*, with *Orthis*, *Leptæna*, *Stropheodonta*, *Platyceras*, *Orthoceras*, *Trochoceras*, *Favosites*, *Chaetetes*, *Stromatopora* and *Lichenalia*. The *Favosites helderbergiæ* is most abundant about midway and is often associated with chert. Where the rock is in proper condition, as at the Brown farm northeast from Schoharie and above Davis' dam, the Upper Pentamerus affords a series of fossils as interesting and as well preserved as those of the Delthyris. Specimens rarely weather free in good condition as they are not silicified, but the limestone is much more tractable than the Delthyris and specimens can be broken from the rock, almost as good as those of the Delthyris.

THE ORISKANY SANDSTONE

The **Oriskany** is thin at Schoharie, not more than ten feet. The contact with Upper Pentamerus was not seen but on the schoolhouse hill and on West mountain the concealed space is not more than 18 inches. The rock is rarely found in place as it decays readily and the crop becomes covered. One exposure on the schoolhouse hill shows 7 feet. On West mountain the interval from the highest observed layer of the Pentamerus to the top of the Oriskany is barely 12 feet. The rock is bluish gray, slightly calcareous sandstone with much ferruginous matter as cementing material. Unweathered, it is very hard, but weathered it is rusty yellow and very tender.

The change from Helderberg to Oriskany is abrupt at Schoharie and according to Mr. Darton's observations it seems to be equally so throughout the region. Professor Hall once stated in conversation that the break at this horizon is one of the best defined in the State of New York. But the case is different farther south in the Appalachian region. The transition is very gradual in southern Pennsylvania, there being as the transition bed a silicious limestone, 20 feet thick, very cherty, whose whitened fragments occur abundantly on every **Oriskany** ridge in Bedford county. This bed contains the Helderberg *Favosites* along with such typical Oriskany forms as *Spirifer arenosus* and *Platystoma ventricosum*. The section is almost complete at Hyndman, where the quarries are extensive. This transition bed is persistent southward, being present as the attenuated representative of the Oriskany and Helderberg at several localities in the Valley of Virginia, where those formations thinned out against the old shore-line. The intimate relation between these formations seen in southern Pennsylvania is equally clear in southwestern Virginia, where, however, the Helderberg becomes silicious in the upper portion and the Oriskany contains so many Helderberg forms that the writer during his first examination of the region thought it the Helderberg. In New York the Oriskany does not contain crinoids, but such forms are by no means rare in Maryland and southward.

Fossils abound in some layers of the **Oriskany**. They are not obtained readily from unweathered rock and the weathered rock affords usually only casts, which, however, show the interior structure with extreme accuracy. Sometimes where the decay has not caused complete removal of calcareous matter, exquisite specimens are found, showing shell structure and internal appendages of brachiopods. The forms are not numerous at Schoharie, but many of them are such as to be attractive museum specimens. Those commonly obtained are *Spirifer arenosus*, *S. arrectus*, *Metaplasia pyxidata*, *Meristella lata*, *Rensselaeria ovoides*, *Megalanteris ovalis*, *Rhipidomella musculosa*, *Eatonia singularis*, *Stropheodonta magnifica*, *Hipparionyx proximus*, *Anoplotheca flabellites*, *Platystoma ventricosum*.

Lamellibranchs are not rare, but they are seldom obtained in good condition. The only forms passing up from the Helderberg are the *Eatonia* and *Leptæna rhomboidalis*, the latter very rare.

THE CORNIFEROUS

Everywhere throughout this region there rests upon the Oriskany a mass of shale, grayish, from 95 to 105 feet thick (by barometer). This is the **Cauda Galli grit**, the **Esopus shales** of Darton, and forms the slope above the Upper Pentamerus cliff on both sides of the Schoharie valley. Its bottom layer, 3 to 5 inches, is hard and forms the floor of the bench, protecting the softer Oriskany, whose wasting has formed a subordinate slope. Much of the shale is fissile, this being shown on West mountain where the slope is abrupt; the upper portion is rather harder and is jointed so as to come out in blocks, 3 or 4 feet by about 2 feet and 8 to 12 inches thick. The *Spirophyton* is most abundant in the upper part. The exposures near Schoharie are all imperfect, the best being on West mountain: there are very few on the east side where the pre-glacial erosion was very extensive.

The **Schoharie Grit**, between the Cauda-Galli and the Corniferous limestone, is rarely more than 6 feet thick and is exposed at very few localities. It is an excessively hard silicious limestone, containing much ferruginous matter and dark brown

on the fresh surface. Weathered, it resembles the Oriskany, but is darker. It is so hard as to suggest that silica is the cementing material. But the iron leads to disintegration and the rock wastes away, so that its outcrop is concealed by heavy blocks of Corniferous, between which debris has accumulated. The only outcrop discovered is on the northwest face of West mountain, but the presence of the rock is shown on both sides of the valley by the fragments strewn about the fields. The unweathered rock is so hard as to yield nothing to the collector, but several layers are extraordinarily rich in individuals of a few types, which can be procured easily from weathered fragments. The ordinary forms belong to *Stropheodonta*, *Pentamerella*, *Atrypa*, *Orthoceras*, *Cyrtoceras*, *Trochoceras* and *Gomphoceras*. Cephalopods are the prevalent forms. *Atrypa reticularis* is the most common of the brachiopods and its casts as well as those of *Stropheodonta* are in admirable condition for study.

The **Corniferous** limestone caps West mountain and the schoolhouse hill on the west side of the valley and is easily followed to where it passes under the river near Borst's dam, about four miles above Schoharie. It is quarried extensively at the lime-kilns below the dam. It is imperfectly shown on the east side at several places within two miles and a half above Schoharie village, but, above that, the valley is eroded in Cauda-Galli and the bluff is covered with debris from the Hamilton. The Corniferous is known as the "Top gray limestone." It is gray, brittle and contains much chert in lenses and irregular layers. The older geologists divided it into Onondaga and Corniferous, but chert appears to be characteristic of both divisions and the older name should be applied to the whole. The thickness in schoolhouse hill is not far from 30 feet but it is greater at the limekilns where the whole is shown. Fossils are abundant but only a few forms are likely to be obtained by the collector. Cyathophylloid corals, *Favosites* and *Syringopora* are the characteristic types; *Gyroceras trivolvis* is obtained occasionally at the limekilns; *Atrypa reticularis* attains large size as it does also in the same limestone further west in this State. Some of the layers contain many trilobites.

THE HAMILTON

The Hamilton is reached on the west side at little more than a mile above Schoharie, while on the east side it caps the hill at about the same distance east from Schoharie. The Marcellus with its Goniatite limestone comes down to the river at Middleburg, five miles above Schoharie, where the Hamilton sandstones form a bold cliff. The shales contain *Liorhynchus limitaris* in profusion while the limestone is rich in *Goniatites*, *Orthoceras* and *Nautilus*. The Hamilton sandstones have yielded many species of lamellibranchs. No measurements of these beds were made.

LOCALITIES FOR COLLECTORS

The impression prevails that as the Schoharie region has been a collecting ground for three-fourths of a century, it must be practically exhausted; but this is wholly erroneous. It is quite true that weathered specimens free from the rock are no longer to be had plentifully but the writer discovered that the old localities repay careful work as well as they did thirty years ago, when he first collected there.

The **Coralline** limestone is well shown near the African church in Schoharie and fragments of the rock in excellent condition are plentiful in stone fences along the lower road leading northward from the village.

The **Tentaculite** is fully exposed in the long line of old quarries from the cemetery northward, in all of which the waste piles are very large. The *Tentaculites* are in best condition in an old quarry at the south end of the village.

The **Lower Pentamerus** cliff is broken at several places between the cemetery and the point where it crosses the Middleburg road, less than a mile south from Schoharie, and it is quarried extensively just north from the village. The upper layers are shown on the west side in a field barely one-fourth of a mile south from the schoolhouse.

The **Delthyris** gives good returns on the road leading to Mr. Brown's house, northeast from the village; in a watercourse

near the schoolhouse on the west side, and especially in the long exposure on the west side of the river below Davis's dam; the topmost shaly beds are best reached under the Upper Pentamerus cliff on the Murphy farm, West mountain.

The **Scutella** is available on the Brown property, at the upper side of the "Gallows field" and on Stony run, all on the east side; at Murphy's and the schoolhouse hill on the west side.

The **Upper Pentamerus** is well shown and easily worked on the Brown property, and especially at the "Rocks" above Davis's dam, on the east side; while the exposure on the schoolhouse hill on the west side is especially good, as the individual layers are exposed over a broad space.

The **Oriskany** is best on the schoolhouse hill where large weathered fragments occur along a line of more than a quarter of a mile. But one needs heavy tools here, as the smaller fragments have been utilized.

The **Schoharie** grit can be found on the northwest side of West mountain and in the fences on the east side along Stony brook. The best localities for **Corniferous** are on West mountain, schoolhouse hill and the limekilns.

As a locality for study of simple stratigraphy, preliminary to the study of more complicated structure such as that of Kingston and Rondout, the Schoharie valley is unexcelled, and it is to be commended to the attention of instructors in field geology.

APPENDIX

Glacial Action in Schoharie Valley

ARCHIBALD E. STEVENSON

The hills on each side of Schoharie valley rise about 500 feet above the river. The slopes on the western side are very steep, even those of the Delthyris and Caudi Galli being climbed with some difficulty; but the slopes on the eastern side, with the exception of the Pentamerus cliffs, are so gentle that they are cultivated.

Above Schoharie the contrast is not so strong, for there cultivated benches are seen also on the west side. For the most part, the river runs near the foot of the western hills. The valley contracts at five miles above Schoharie, where it is enclosed in the harder rocks of the Devonian.

Messrs. Mix and O'Reilly recently opened a quarry at a little north from Schoharie, where the stripping exposed a glaciated surface of the Lower Pentamerus, and showed well the character of the till.

The striæ are shallow, some as slight as though they had been made with a pin. The strongest scratches are not more than $1/20$ of an inch deep, and $1/10$ of an inch wide. The general surface is highly polished. The striæ appear to be in two systems, the stronger of which varies from N. 55° E. to N. 73° E., the most marked running N. 66° E. The other is not so strong, its striæ varying three or four degrees north or south of east.

An interesting feature of the surface in this quarry is the occurrence of two abrupt steps, one about $2\frac{1}{4}$ feet high, running N. 45° E., and the other, not so high, N. 66° E. These must have existed before the ice invasion, as the former is but slightly rounded at the upper edge, while the face is unpolished, whereas the face of the latter is highly polished.

The extreme thickness of till shown is ten feet; the bowlders are large in the lower part, often two feet in diameter, but decrease in size toward the top, where they are mere pebbles of two or three inches. They are of foreign material, the large ones being gneiss, while very many of the smaller ones are apparently from the Hudson shales, which are exposed within a mile or so northward; all are more or less water-worn.

The clay is slightly calcareous, and small stalactitic deposits are frequently found in its cavities. This till was followed up the valley to the old cemetery quarry, where it rests upon the Tentaculite limestone, which, also, is covered with striæ.

The Upper Pentamerus, on this side, at more than 100 feet further up the hill, shows also a glaciated surface on the Brown property with striæ following the same general directions as those on the Lower Pentamerus.

On the west side of the valley, a striated surface of Lower Pentamerus, corresponding to that on the east side, is reached at less than half a mile north from the bridge; while the till is shown at about the same distance south, on the Middleburgh road, where it makes a very cold soil. On this side an angular boulder of much sheared gneiss, measuring 4 by 6 by 5 feet, was seen, at 370 feet (by barometer) above the river, on the Caudi Galli slope and near it another of gneiss, about half as large. Water-worn fragments of gneiss are scattered over the surface everywhere from the river to the hill tops, while angular fragments of transported rocks seem to be rare.

The distribution of the till and the direction of the striæ seem to show that the valley, as it now appears, has practically the same shape as before the ice invasion. The several benches of harder rock must have existed in the earlier time as now on the east side, where they are separated by the long gentle slopes of softer rocks; for, far back from the river, the Upper Pentamerus bench is scratched, while lower down and nearly one third of a mile nearer the river we have the Lower Pentamerus beautifully striated, while lower yet we have the benches of Tentaculite and Coralline well polished and covered with till. The cutting done by the ice must have been comparatively small; bowlders of Pentamerus and Tentaculite were not seen up the valley above the horizons of those rocks. This weakness in cutting is shown also by the peculiar form of the benches in Mix and O'Reilly's quarry.

NOTE.—Since this paper was read, Messrs. Clarke and Schuchert have published their scheme of the New York Series, in which are revived some of the older names, for which certain terms used in this paper will become synonyms. "Hudson" is synonymous with "Lorraine"; "Waterlime" is the "Rondout Waterlime" of Clarke and Schuchert; "Tentaculite" is synonymous with "Manlius" Vanuxem; "Lower Pentamerus" and "Delthyris" will be replaced by the newer terms "Coeymans" and "New Scotland" of Clarke and Schuchert.

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J. J. S.

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