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JOHN M. CLARKE, Director

Bulletin 118
PALEONTOLOGY 18

GEOLOGIC MAP AND DESCRIPTIONS
OF THE
PORTAGE AND NUNDA QUADRANGLES

INCLUDING A MAP OF LETCHWORTH PARK

BY

JOHN M. CLARKE & D. DANA LUTHER

ACCOMPANIED BY A REPORT ON THE

PLEISTOCENE HISTORY OF THE GENESEE VALLEY

BY

HERMAN L. FAIRCHILD

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New York State Education Department
Science Division, March 7, 1907

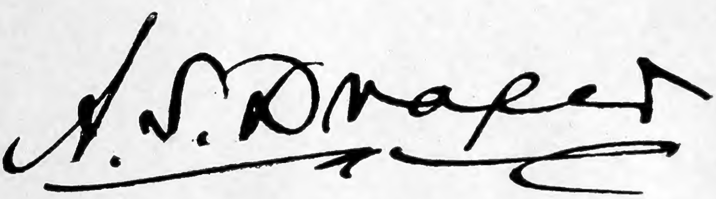
Hon. Andrew S. Draper LL.D.
Commissioner of Education

My dear sir: I communicate herewith, for publication as a bulletin of the State Museum, geological maps on the scale of 1 mile to 1 inch, of the Nunda and Portage quadrangles, accompanied by a description of the geological structure of these regions and including also a map of Letchworth Park with its geology and a report on the Pleistocene History of the Genesee Valley in the Portage District.

Very respectfully yours
John M. Clarke
Director

State of New York
Education Department
commissioner's room

Approved for publication this 9th day of March 1907



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GEOLOGY OF THE PORTAGE AND NUNDA QUADRANGLES

INTRODUCTION

The region whose geological structure is here described in detail is not alone celebrated in the history of New York geology for the completeness of its presentments, the uniformity of its stratigraphy and the fullness of its ancient faunas, but its human history is romantic and its scenic features singularly attractive. The Nunda and Portage quadrangles cover a territory 17 miles long from north to south and 26 miles wide, through which in winding course runs the great gorge of the Genesee river, extending from Portage down to Mount Morris, a distance of 18 miles by the stream. Along the vertical walls of the canyon the cliffs rise from 200 to 350 feet displaying the even, regular beds of the rock formations so elaborately and lucidly as to invite the attention of the geological student, while all the attendant phenomena of the erosion of the gorge and the history of this great drainage way throughout its many vacillations afford subjects of added interest. The Genesee river crossing the entire State from north to south is the line of most continuous meridional section through the geological formations of western New York. Very naturally then, when the Geological Survey of New York was organized (1836) and the fourth or western district erected (1837), the rock exposures of this stream invited immediate attention. Not only has this trunk stream cut deep into the rock strata but its contributories, Cashaqua creek, Wolf creek, Buck run, Silver lake inlet and Wiscoy creek add other means of completing the details of geological structure so that data are not lacking on every hand to solve the problems of geological history. Public attention and interest has been recently drawn to this region by the erection within its boundaries of a new public preserve — Letchworth Park — the beneficent gift to the people of the State of New York by the Hon. William Pryor Letchworth, to whose munificence and long public service the place will be a perpetual monument. This beautiful property embraces the three cataracts of the Genesee river and the banks adjoining. It is with some satisfaction that, with the aid of Mr Letchworth, we are enabled here to present a special map of this park with its geology given in detail.

HISTORICAL

Bibliography

The rocks and fossils of this portion of the Genesee river section have been the subject of, or have contributed freely to many of the publications of the New York survey. It is not the purpose here to review these in detail as this publication is chiefly designed to explain the accompanying maps. Students will find more or less adequate accounts of the geology and paleontology of the formations involved in the works here cited.

1 The original and fundamental documents upon the region are the Second and Fourth Annual Reports (1836, 1838) and the final report of the geologist in charge of the fourth geological district (1843), James Hall.

PROFESSOR EBEN N. HORSFORD'S GEOLOGICAL MAP OF THE GENESEE RIVER 1838

"The accompanying map is an application of the principles of isometrical projection to geological drawings. . . The plan was conceived and the map constructed by Prof. E. N. Horsford of the Rensselaer Institute." [Hall, Second Annual Report, Fourth Geological District, 1838]

The first of these was accompanied by a perspective map (here reproduced) of the Genesee river prepared by Eben N. Horsford, assistant to Professor Hall and then a resident of Moscow.[1]

2 Palaeontology of New York, v. 5, 6, 8.

In these volumes are descriptions of many of the fossils occurring in the rocks of these quadrangles.

3 The Higher Devonian Faunas of Ontario County, N. Y. John M. Clarke. U. S. Geol. Sur. Bul. 16. 1885.

Though chiefly concerned with the stratigraphy and paleontology in a section further to the east this treatise applies to and in considerable measure was based upon the Portage group of the Genesee river.

4 Faunas of the Upper Devonian, Genesee Section of New York. H. S. Williams. U. S. Geol. Sur. Bul. 41. 1888.

5 Stratigraphic Value of the Portage Sandstones. D. D. Luther. N. Y. State Mus. Bul. 52. 1902. p. 616-32.

Traces the upper sandstones of the Upper Falls at Portage eastward and shows their continuity with the High Point sandstones of Ontario county. In the same paper J. M. Clarke shows that the fauna of this sedimentation unit is entirely different at the east from that in the Genesee valley, at the former containing a Chemung brachiopod assemblage, in the latter the typical Portage fauna with cephalopods and lamellibranchs.

6 Geologic conditions at the Site of the Proposed Dam and Storage Reservoir on the Genesee River at Portage. John M. Clarke. An. Rep't State Engineer and Surveyor for 1896, p. 106-22.

7 Naples Fauna in Western New York. John M. Clarke. pt 1. N. Y. State Geol. 16th An. Rep't. 1898; pt 2. N. Y. State Mus. Mem. 6. 1903.

This work describes and illustrates the fauna of the Portage group in its entirety, discusses its bionomic relations and elucidates the stratigraphy of the formation.

8 Stratigraphy of the Portage Formation between the Genesee Valley and Lake Erie. D. D. Luther. N. Y. State Mus. Bul. 69. 1903. p. 1000-29.

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[1] Mr Horsford, after serving as a teacher at Geneseo and at Albany, became the distinguished Rumford professor of chemistry at Harvard University. The rocks and fossils of the Genesee valley have inspired other men to distinction. Maj. John W. Powell, late director of the United States Geological Survey was a native of Mount Morris, and the eminent paleontologist Prof. O. C. Marsh was born on the richly fossiliferous rocks crossing the lower Genesee and not far from its western boundary.

Classification

The rock strata of the Genesee river section have been broadly classified and generally known under the names "Genesee," for the black shale at the mouth of the gorge, "Portage" for the shales and sandstones displayed above in the walls of the gorge, and "Chemung" for the sandstones and shales exposed in the ravines and along the river bed south of Portage to the State line, names applied at the time of the first geological survey of the State, 1837 to 1843.

In this bulletin the precise and detailed classification of these rocks defines more exactly the significance of each of these appellations, as explained under the appropriate titles. Of most commanding importance in the rock succession of this region is the series of strata historically known as the "Portage Group." To validate the integrity of this term against incursion its origin and purpose are here briefly recalled.

The name "Portage" was first used in connection with the geological series of the State by James Hall in 1840 (Fourth Annual Report on the Fourth Geological District), when describing with some detail the rock section exposed in the Genesee River gorge between Mount Morris and Portageville. The following divisions were made: Cashaqua shale, Gardeau or Lower Fucoidal group and Portage or Upper Fucoidal group.

The last division included the strata between the Table rock at the top of the Lower Portage falls and the top of the heavy sandstones above the Upper falls, an aggregate of 425 feet of which 210 feet are shales and flags, not essentially different either in lithology or fossils from the beds below the Table rock and included in the Gardeau group, except as to the presence in the upper of Fucoides verticalis.

In 1843 (Final Report on the Geology of the Fourth District, page 224), Professor Hall dropped the terms "Upper Fucoidal" and "Lower Fucoidal," and the expression "Portage or Nunda group" is employed to include "Cashaqua shale," "Gardeau shale and flags" and "Portage sandstones," no change being made in the descriptions of these members of the Portage group.

It thus appears that the word "Portage" was first used as a group term, not as the description of a member of a group or unit. It was so employed by Hall in all subsequent writings.

The introduction of the name "Nunda" as an alternative term was unfortunate and is not now easily explainable, as the town of Portage was set off from the town of Nunda, March 8, 1827, and the new town included all of the territory along the banks of the Genesee river previously lying in the town of Nunda; but in April 1846, that part of Portage township on the west side of the river with a strip taken from the town of Pike, was erected into a new town and named Genesee Falls.

Of the units composing the Portage group, the Cashaqua shale is not exposed at all within the present limits of the township of Nunda, and the Gardeau shale and flags as delimited by Hall appear in but a few small isolated exposures, the heavy sandstones (Portage sandstones) at the top being the only part of the group that can be said to be fairly well exposed in the town and only to these can the name Nunda with any propriety be applied.

The term "Portage group" has been in use for more than 60 years by students of geology and has acquired recognition by the general public as the designation of the strata between the Genesee black slate and the Chemung sandstones. Historically, logically and legitimately it is substantially fixed.

Exhaustive studies of the stratigraphy and paleontology of the rock section in the Genesee gorge have shown that Table rock at the top of the Lower falls, differs from other sandstones above and below it only by being slightly harder and more calcareous, and by a more abrupt transition to soft shale in the upper surface, the sedimentation above it up to nearly the top of the Upper falls being of the same character as the beds below it down to the mouth of Wolf creek; the same fossils occur above and below it. Therefore recent publications by this department have fixed the upper limit of the Gardeau flags at the base of the heavy sandstones near the top of the Upper falls.

To avoid the confusion by duplication of the original group term "Portage" with the later unit term "Portage sandstones," we shall here substitute for the latter the term "Nunda sandstone" as the designation for the upper terminal member of the Portage group as Hall defined it.

Description of formations

All the geologic formations represented on the area here considered belong to the upper division of the Devonic system.

The following is the succession in descending order and the formations are considered in order from bottom to top.

Neodevonic	Chautauquan	Upper	Chemung sandstones and shales	425[1]
		Lower		400[1]
		Wiscoy shale		190[1]
	Senecan	Nunda sandstone		215[1]
		Gardeau flags and shale		344[1]
		Grimes sandstone		25[1]
		Hatch flags and shale		204[1]
		Rhinestreet black shale		53[1]
		Cashaqua shale		125[1]
		Middlesex black shale		35[1]
		West River black shale		65[1]
		Genundewa limestone		8[1]
		Genesee black shale		5[1]

The aggregate thickness of the beds here described is 2142 feet. The difference in altitude between the Genesee river bed at the north line of the Nunda quadrangle and the highest point near the southwest corner of the Portage quadrangle is 1565 feet and 578 feet additional are brought up by the elevation of the strata toward the north and east.

Genesee shale

The lowest rock exposure on this area is the Genesee black shale.

Historical. This formation was first described in the 3d Annual Report by Hall, 1839, page 301, under the title "Upper black shale," beginning, "Reposing upon the Tully limestone we have a thickness of 150 feet of shale exhibiting throughout a uniform color, and slaty structure" etc.

The black shale is mentioned several times in this report, as occurring in Seneca, Yates and Ontario counties, but no more specific name is applied to it. It is also referred to in the 4th Annual Report.

In the final report of 1843, page 218, the name Genesee slate is substituted for Upper black shale, and the opening of the gorge of the Genesee river at Mount Morris is said to be the place of its greatest development in the district.

As usually described in the annual and final reports it immediately overlies the Tully limestone or, when that is wanting, the Moscow shale, and is succeeded by the beds of greenish shale afterward given the name Cashaqua shale, but on page 422 of the report for 1839, after mentioning the localities of several exposures of the Upper black shale in the vicinity of Moscow and Geneseo, including the one at Fall brook, where it is stated "the water leaps a hundred feet from the top of this rock," Hall says: "In this neighborhood the black shale is succeeded by a stratum of thin limestone."

In the final report on the fourth geological district, page 227, where describing the Cashaqua shale he says: "On tracing it (the Cashaqua shale) west of the Genesee, it constantly presents the same features as on the Cashaqua creek, though the lower part is sometimes dark colored and separated from the Genesee slate by a thin calcareous band," evidently referring to the limestones at the top of the falls at Fall brook and in the ravine of Little Beards creek at Moscow which also appear in all exposures of this horizon between Ontario county and Lake Erie, and are now known as the Genundewa limestones, more fully described in the succeeding pages. That it is the stratum referred to by Hall is made certain by the fact that there is no other continuous limestone above it in the Genesee river section, nor elsewhere in this State west of Ontario county.

There are 83 feet of Genesee black shale between the horizon of the Tully limestone and the Genundewa limestone at Fall brook and 100 feet of dark and black shales between the Genundewa limestone and the base of the Cashaqua shale at the mouth of the gorge. The latter beds have been commonly known as Upper Genesee, but the difference in the character of the shale above and below the Genundewa limestone, and in their faunas, has made it proper, as further explained in New York State Museum bulletin 63, page 25, to restrict the use of the name "Genesee" to the beds between the horizon of the Tully limestone and the Genundewa limestone.

As thus defined the only exposure of this formation on these quadrangles is at the west end of the highway bridge over the Genesee river at Mount Morris in the lower part of a small outcrop on the north side of the bridge. At times of low water the exposure is 15 to 20 feet long and 6 to 8 feet high.

The shale here is very dark, but somewhat more calcareous and less bituminous than the beds below, which are, for the most part, densely black and on exposure become very fissile and split into large flat plates. Spherical concretions are common throughout the Genesee shale.

Fossils are very rare in this formation, specially in the more bituminous beds. Drifted land plants and conodont teeth sometimes occur in the black shale, and the more calcareous layers toward the top contain:

Pleurotomaria rugulata *Hall*
Styliolina fissurella (*Hall*)
Pterochaenia fragilis (*Hall*)
Lingula spatulata *Hall*
Orbiculoidea lodensis (*Vanuxem*)
Liorhynchus quadricostatus *Hall*
Probeloceras lutheri *Clarke*
Bactrites aciculum (*Hall*)

The entire section of the Genesee slate is well exposed in several ravines north of Moscow and in the Fall brook ravine at Geneseo below the top of the falls and in numerous other localities along its line of outcrops, which extends from Chenango county to Lake Erie.

Genundewa limestone

The stratum of impure limestone referred to by Hall as succeeding the Genesee slate in the vicinity of Moscow and Geneseo, is the heaviest of a series of similar character that seems to have escaped farther notice until 1882, when it was described by Clarke, in United States Geological Survey bulletin 16, as the "Styliola band."

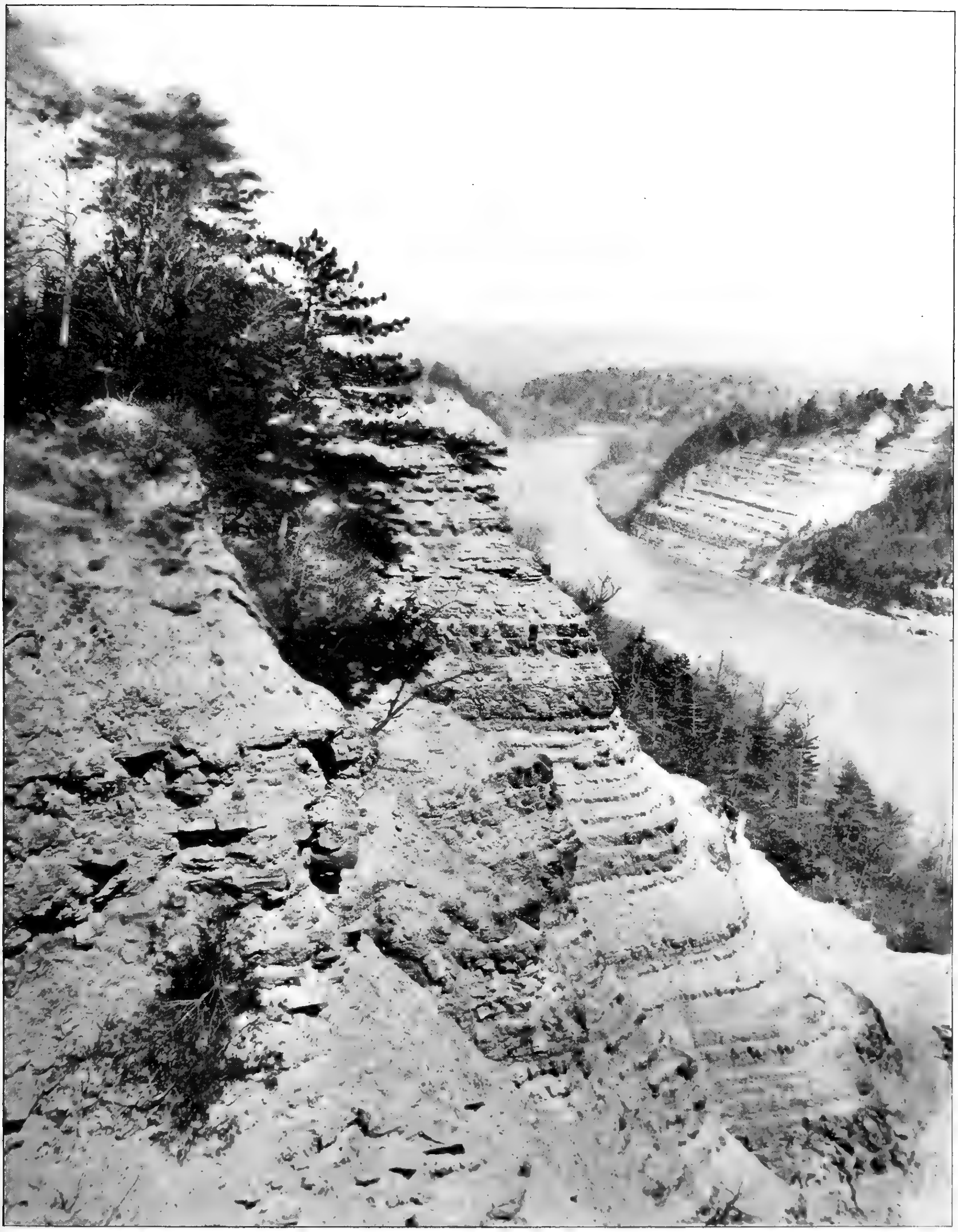
In New York State Museum memoir 6, *Naples Fauna in Western New York,* pt 2, Clarke, 1903, and in Bulletin 63, Clarke and Luther, 1904, it is more fully described as a unit of sedimentation in the Genesee beds and designated Genundewa limestone on account of its very favorable exposure at Genundewa Point on the east side of Canandaigua lake.

This horizon is quite calcareous and concretionary as far east as Cayuga lake, but the limestone first appears as distinct layers in Gorham, Ontario co., when westward it is continuous to Lake Erie, its peculiar structure making it easy of recognition wherever exposed.

In the Genesee valley region it is composed of five layers of dark gray bituminous limestone from 2 to 14 inches thick separated by layers of dark shale from 1 to 6 inches thick. Some of the limestones are even and flaggy, while others are concretionary and the laminations of the intervening shale are bent to conform with their very uneven surfaces.

The entire band was formerly exposed at the west end of the Pennsylvania Railroad bridge over the river at Mount Morris,

Plate 1



View of lower part of the Genesee gorge from the High banks. Looking toward the northeast. Rhinestreet black shale in front; lower part of cliff in distance is Cashaqua shale

but since the erection of the dam below it only appears at the west end of the highway bridge immediately north of the dam, where the lower layers may be seen above the outcrop of black Genesee slate previously mentioned.

Fossils are abundant and peculiar, the purer limestone being composed almost wholly of the minute shells of the pteropod Styliolina fissurella (Hall) and the entire fauna has very close relations with that peculiar to the Portage beds above. It is the earliest appearance in New York of the Naples fauna or the world-wide zone of Manticoceras intumescens.

The following are common species, but for the full list with descriptions and illustrations consult *Naples Fauna in Western New York,* pt 1 and 2.

Manticoceras pattersoni (*Hall*) *var.* styliophilum *Clarke*
Gephyroceras genundewa *Clarke*
Tornoceras uniangulare (*Conrad*)
Phragmostoma natator *Hall*
Honeoyea styliophila *Clarke*
Buchiola retrostriata (*v. Buch*)
Pterochaenia fragilis (*Hall*)
Aulopora annectens *Clarke*
Melocrinus clarkei *Williams*

In the vicinity of these quadrangles favorable exposures of the Genundewa limestone may be found in several ravines along the west side of the Delaware, Lackawanna and Western Railroad between Moscow and Greigsville, also at the top of the falls in the Fall brook ravine at Geneseo and along the east and west road ¾ miles south of the same falls.

It causes cascades in many ravines in Livingston and Ontario counties and is well exposed in the bed of Murder creek at Griswold, Wyoming co.

West River shale

A bed of dark to black shale about 100 feet thick succeeds the Genundewa limestone in this section. The lower part is covered by the water above the Mount Morris dam but the upper part is finely exposed in the cliff on the east side of the mouth of the gorge.

For about 62 feet next above the limestone the shales are mainly dark gray or blue black with thin layers of densely black and slaty bituminous shale 4 to 6 inches thick occurring at intervals of 2 to 6 feet, producing in this and other cliffs of these beds a distinct banded effect.

These shales are contrasted with the Genesee shale below by their generally lighter color and less bituminous character. They are also more fossiliferous, though the number of species represented is but slightly increased by the addition of a few of the forms that first appear in the Genundewa limestone.

The following are the more common fossils:

Bactrites aciculum (*Hall*)
Pleurotomaria rugulata *Hall*
Pterochaenia fragilis (*Hall*)
Buchiola retrostriata (*v. Buch*)
Lingula spatulata *Vanuxem*
Orbiculoidea lodensis (*Vanuxem*)

Spheric and oblong concretions occurring singly or in rows are common and have been collected in many places on account of their symmetry or their sometimes curious forms suggestive of "petrified turtles," "Indian skulls," "stone hats," "stone ducks" etc.

No exposure of these beds but the one at the mouth of the gorge, which is continuous up the river for about a mile, is found on these quadrangles, but they may be seen to good advantage above the falls in the Moscow ravine, 3 miles farther north and in the upper part of the Fall brook gully.

The name "West River shales" was first applied to these beds above the Genundewa limestone by Clarke and Luther in Bulletin 63, 1904, on account of their abundant exposure in the ravines of the West river valley in Yates county and to meet the requirements of a stratigraphic term for the residuary member of the old Genesee division.

Standish shale

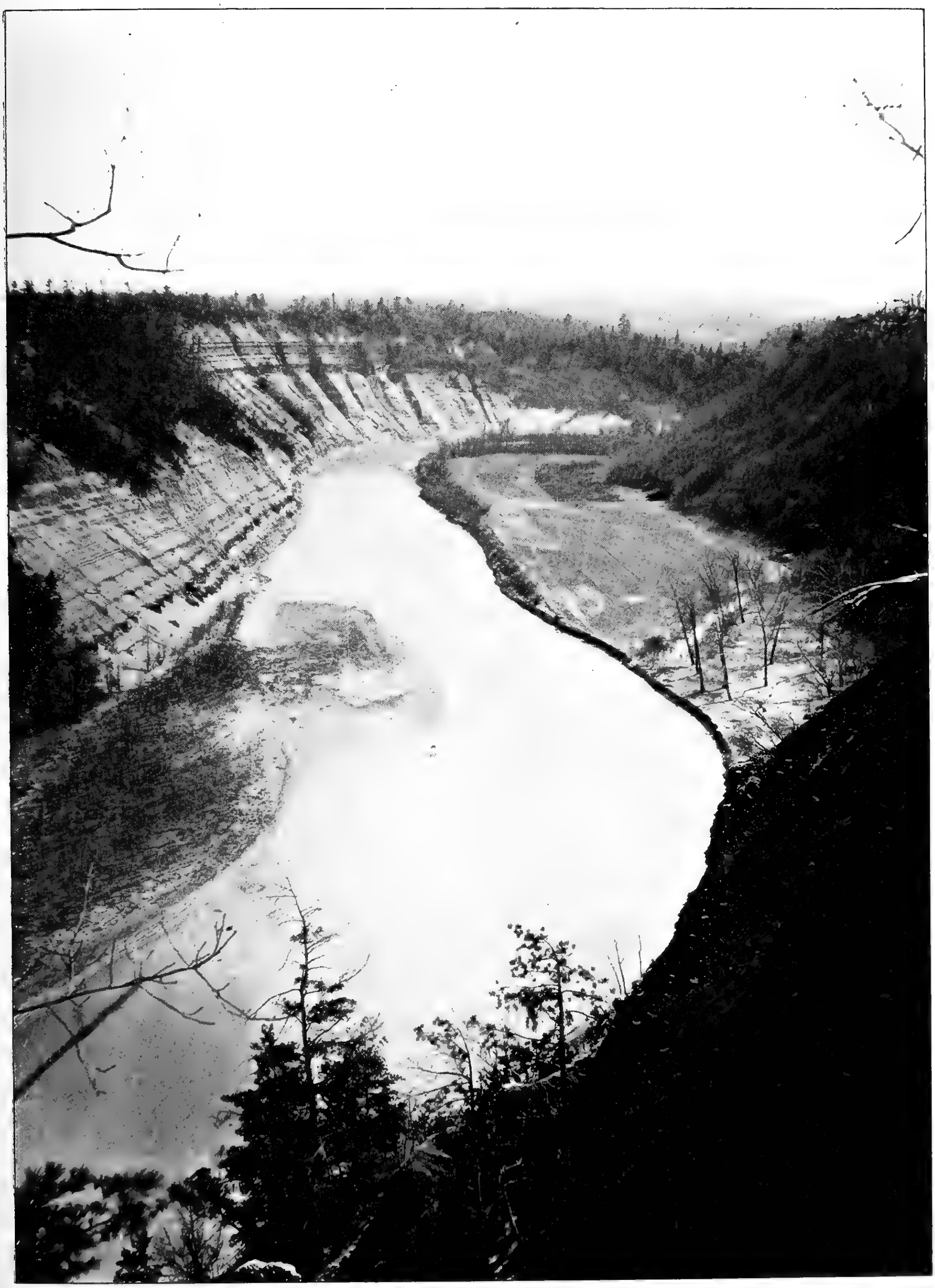
At the top of the West River beds there are in this section a few lighter colored layers, some clayey, others slightly arenaceous, altogether about 3 feet in thickness.

This lighter band which has the lithic characters of the shales and flags of the Portage group and contains a few fossils from both the Genesee and Portage faunas, is hardly noticeable here, is more fully developed in the Canandaigua lake valley and is known as the Standish shales and flags. It is not represented in the coloring on this map.

Middlesex shale

This passage bed is succeeded by 32 feet of densely black bituminous slaty shales that show a marked contrast to the West River shales lithologically and in being almost entirely barren of fossils except lignites, which are common, and a few fish plates and scales, which are very rare. A few small lingulas found in this horizon at the mouth of Pike creek on Lake Erie are the only other fossils collected from these beds in the western part of the State and they belong to the species found in similar black shales higher in the Portage group, L. ligea Hall and L. spatulata Vanuxem.

Plate 2



Cashaqua beds in the river gorge near Mount Morris. Upper part of cliff in distance. Rhinestreet black shale

In the early reports of the Geological Survey this black shale band was considered as the upper part of the Genesee black slate. In United State Geological Survey bulletin 16, 1885, J. M. Clarke, for the reasons above stated, separated it from the Genesee slate and considered it as a member of the Portage group under the name "Lower black band." In New York State Museum bulletin 63, 1904, it was designated the Middlesex shale, from its abundant exposures in the town of Middlesex, Yates co., from which locality it is continuous westward maintaining its general characteristics, but diminishing in thickness to 6 feet on the shore of Lake Erie, where it is well exposed in the bed of Pike creek near its mouth in the town of North Evans, Erie co.

The exposure of the Middlesex black shale in the cliff at the mouth of the gorge is continuous in both banks for about 2 miles, the dip bringing it down to the river level on the south side of the "Hogsback." Other outcrops may be seen in the lower part of the ravine 2 miles northwest of Mount Morris, at the mouth of Buck run ravine, and on Cashaqua creek at the foot of the cliff at Sonyea.

Cashaqua shale

The beds included in this division were first described in the Third Annual Report on the Fourth District, 1838, as they appear succeeding the Genesee black slate in Yates and Seneca counties.

The name Cashaqua shales first appears on page 390 of the Fourth Annual Report on the Fourth District for 1839, where it is said: "The group mentioned in the report of last year as succeeding the upper black slate, becomes on the Genesee a mass of green crumbling shale of 110 feet thickness. It is exposed on Cashaqua creek, hence the name Cashaqua shale."[1]

In the final report of 1843, pages 226 and 227, after more fully describing this division as it appears in the Genesee section, it is added: "At the eastern extremity of the district and on the shores of Seneca lake at Penn-Yan and other places, this rock consists of a green shale with thin flagstones and interlaminated sandy shale. It contains the same fossils; and holding the same position as on the Genesee it can be regarded only as the same rock. . . . Farther east it is not recognized as shale at all, the mass consisting of thinly laminated sandstones." Tracing it west of the Genesee, it con-

[1] This Indian name derived from Gah-she-gwah, a spear, is also spelled Coshaqua, Kishaqua, Kushaqua, Keshequa and Keshaqua. It is retained here in the form used by Hall which is the spelling adopted in the geological literature of New York for 70 years. The word is pronounced *Kish-e-quay*.

stantly presents the same features as on the Cashaqua but thins down to 33 feet on the shores of Lake Erie.

The passage from the Middlesex to the Cashaqua shale is through several alternations of light and dark layers in a few feet above which horizon the black layers are infrequent and thin. They reappear toward the top and after a few alternations like those at the base become the homogeneous mass of black shale constituting the Rhinestreet black shale, the succeeding member of the Portage group. Fossils are not abundant in any part of the Cashaqua shale, but a few may be found in all of the lighter beds and in the upper and more calcareous olive shales they are fairly common. Some large cephalopods are finely preserved in flat concretions 20 to 40 feet below the top of the formation.

Concretions usually a foot or more in diameter in a row at the top of these shales in this section and further east have a layer of calcareous matter 1½ to 2 inches thick at the base composed of fossils, sometimes in fine condition.

This is approximately the horizon of the Parrish limestone, a thin calcareous layer of concretionary structure, continuous from Canandaigua lake valley to Seneca lake and a reliable datum point in the stratigraphy of that region.

The fauna of the Cashaqua shale is diverse and interesting. This horizon is the normal seat of the peculiar fauna of the Portage group, which is continued eastward without much variation but at the west shows differences of composition [*see* Clarke, Naples Fauna of Western New York].

In the general section the more common forms are:

Manticoceras pattersoni (*Hall*)
Probeloceras lutheri *Clarke*
Tornoceras uniangulare (*Conrad*)
Bactrites aciculum (*Hall*)
Orthoceras pacator *Hall*
O. ontario *Clarke*
O. filiosum *Clarke*
Phragmostoma natator *Hall*
Lunulicardium (Pinnopsis) acutirostrum *Hall*
L. (Pinnopsis) ornatum *Hall*
Pterochaenia fragilis (*Hall*)
P. cashaqua *Clarke*
Honeoyea major *Clarke*
Ontaria suborbicularis (*Hall*)
O. accincta *Clarke*
Buchiola retrostriata (*v. Buch*)
Paracardium doris *Hall*
Palaeoneilo petila *Clarke*
Lingula ligea *Hall*
Aulopora annectens *Clarke*
Melocrinus clarkei *Williams*

The Cashaqua shale is exposed in the walls of the gorge from near the mouth where the base is seen over the black beds for 6 miles to the north end of Smoky Hollow where the southwestern dip brings it down to the river level. Opposite the lookout stations along the "High Banks" where the cliffs are 300 to 350 feet high,

View of the "Hog-back" at bend in Genesee river 2½ miles above Mount Morris dam; looking east from the High banks. The ridge is composed of Cashaqua shales, capped by black Rhinestreet shales

the formation is displayed in a most striking manner, as a heavy band of light blue gray in the middle of the wall contrasting strongly with the black bands above and below it.

The mass of the unique "Hogback" is composed of this shale capped by the black Rhinestreet shale.

The ravine at Gibsonville affords an excellent opportunity for examination of the upper beds and good exposures of the entire formation may be found in the ravine 1 mile west of the mouth of the gorge; in Buck run ravine, 1 mile southeast of Mount Morris; along Cashaqua creek for 2 miles south of Sonyea, and on the east side of the Canaseraga valley in the large ravines nearly opposite Sonyea. The smaller ravines on both sides of the valley present many good exposures of the upper beds and the contact with the Rhinestreet shale appears at the roadside on the hill 1¼ miles southeast of Groveland station, near the east line of the Nunda quadrangle.

Rhinestreet black shale

The Cashaqua beds from Schuyler county on the east to Lake Erie are succeeded by a band of black shale with a few thin lighter and mostly arenaceous layers intercalated at some localities altogether differing materially in both structure and fauna from the Gardeau group in which it was formerly included as described in the reports of the Geological Survey of the fourth district. Its strong contrast with the light blue Cashaqua beds below it, and the flags and sandy ferruginous shales above it, makes it a distinct and noticeable feature in the stratigraphy of western New York. It was referred to by Clarke in United States Geological Survey bulletin 16, as the "Second Black Band" in the Portage group. In New York State Museum bulletin 63, it is described as a Portage unit, and on account of its constant exposure in the vineyard region north of Naples known as "Rhinestreet" the name here used was applied to it.

It is 21 feet thick at Naples, but increases toward the west at an average rate of about 2 feet per mile and on Lake Erie has a thickness of 185 feet. In the Genesee river section the assigned thickness is 53 feet.

Fossils, except lignites, fish remains, conodont teeth and occasionally a Spathiocaris and a few small lingulas are almost entirely absent from these beds. The lighter interlaminated shales at the top and bottom occasionally contain specimens from the Cashaqua fauna.

The Rhinestreet black shale is finely displayed in the walls of the gorge from the top of the north end of High Banks continuously for 8 miles southward to the north end of the St Helena or Gardeau Flats.

It is the cap rock of the "Hogback" and is finely exposed at Gibsonville, also on Buck run at and above the cascade and in adjacent ravines; on Cashaqua creek for a mile midway between Sonyea and Tuscarora; and in the ravine 2 miles northwest of Mount Morris.

On the east side of the valley it appears in several ravines 1 to 3 miles north of Groveland station and in the rock cut of the Delaware, Lackawanna and Western Railroad, 1½ miles southeast from Groveland station. Very fine fish remains have been collected from this locality.

The list of fossils contained in the Rhinestreet black shale comprises the following species:

Palaeoniscus devonicus *Clarke*
Pristacanthus vetustus *Clarke*
Acanthodus pristis *Clarke*
Polygnathus dubius *Hinde*
Prioniodus spicatus *Hinde*
P. erraticus *Hinde*
Spathiocaris emersoni *Clarke*
Lingula ligea *Hall*

Hatch flags and shale

In the rather meager description of the "Gardeau flagstones and shales" in the reports on the geology of the fourth district some reference is made to the difference between the character of the lower and upper beds of the division.

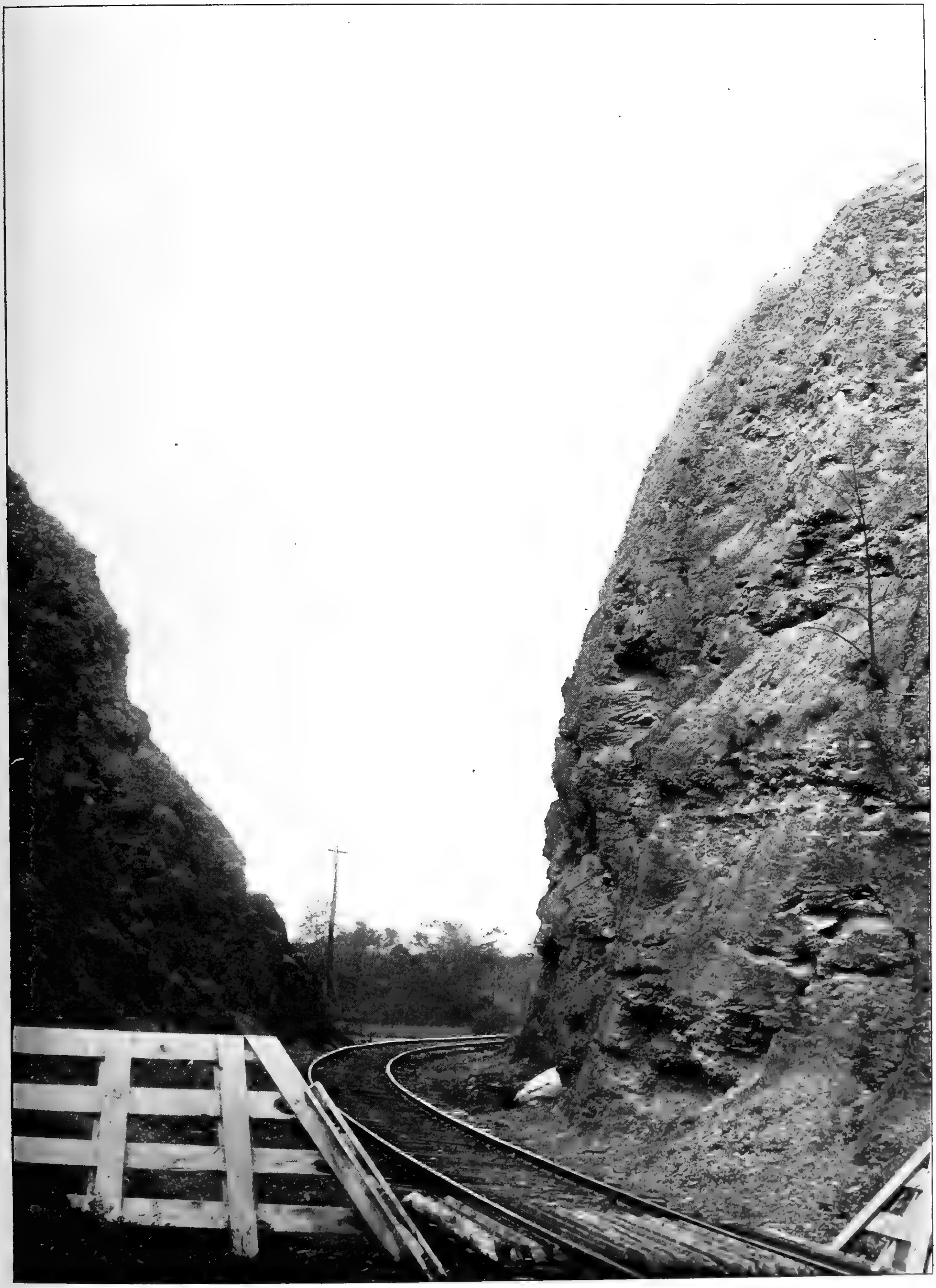
This difference is more manifest in the Naples section specially in regard to the faunas and the horizon of the change is marked by a series of heavy sandstones that have produced an escarpment on Hatch hill 275 feet above the Rhinestreet shale as exposed at the foot of the hill.

In State Museum bulletin 63, the intervening shales and flags between these sandstones and the Rhinestreet shale were fully described and designated the "Hatch flags and shale."

In the Genesee section the formation is included between the Rhinestreet black shale and the bank of thin sandstones that is seen in the cliff on the east side of the Gardeau Flats, coming down to 60 feet above the river at the east end of the St Helena bridge and to the river level at the mouth of Wolf creek, embracing 209 feet of shales and flags. The shales are in thin layers many of them being black and slaty, others blue and fissile or olive, coarse and sandy. The general aspect of the rock walls in this part of the

Southeast side of the "Hog-back." The contact of the Cashaqua shales and the overlying Rhinestreet black shales is distinctly shown

Plate 5



Rock cut in Cashaqua shales. Cashaqua creek

gorge is made dark and rusty by the ferruginous characters of the coarser shales and sandstones.

The flags in these beds are smooth and even on the lower surface except for the presence of casts of depressions in the soft mud beneath, on which they were deposited in the shape of short straight ridges lying at all angles. These bodies have been known as Fucoides graphica. The upper surface of the flags is usually shaly. Fossils except plant remains are very rare, though some of the lighter colored shales in the lower part contain:

Manticoceras pattersoni (*Hall*)
Probeloceras lutheri *Clarke*
Orthoceras pacator *Hall*
Phragmostoma natator *Hall*
Ontaria suborbicularis (*Hall*)
Palaeotrochus praecursor *Clarke*
Buchiola speciosa (*v. Buch*) and a few other forms.

Besides the exposure of these Hatch beds for 8 miles in the cliff along the river from opposite Gibsonville to the mouth of Wolf creek, they may be seen along the Silver lake outlet 2 miles below Perry; in the upper part of the ravine 2 miles northwest of Mount Morris; along Buck run above the falls to the first highway bridge; on Cashaqua creek and at Tuscarora a mile below; also in the ravines at West Sparta and in nearly all of the ravines on the east side of the Canaseraga valley within the limits of the Nunda quadrangle.

Grimes sandstone

At the mouth of Wolf creek a band of thin sandstones separated by hard dark shales, altogether about 25 feet thick, overlying the Hatch flags and shales comes down to the bottom of the cliff. It is 60 to 85 feet from the base of the cliffs at the east end of the St Helena bridge and is prominent in the eastern rock wall opposite the Gardeau Flats, 1 to 2 miles below St Helena.

It is here essentially barren except for plant remains, and it is not a very well defined nor significant feature of the Portage section on the Genesee river or further west, but toward the east in the Springwater and Naples valleys the sandstones are much heavier and contain brachiopods and other forms not found in the Portage beds of the western part of the State, though most of them are common in the "Ithaca" beds of this horizon and that of the Hatch flags and shales in Tompkins county and farther east.

At Naples the characteristic lamellibranchs and many of the other forms composing the Naples fauna that occur more or less abundantly up to the base of this band have not been found above it.

This formation was first described as a member in the Portage group in State Museum bulletin 63, and designated Grimes sandstone from its exposure in Grimes gully at Naples, N. Y.

Other outcrops of these sandstones may be seen in several small ravines west of Smoky Hollow and on the Silver lake outlet 1½ miles below Perry, also in the gullies north of Groveland station and south of West Sparta.

Gardeau flags and shale .

As considered in this bulletin, this formation consists of an extensive series of flags or thin sandstones and shales occupying that part of the river section between the Grimes sandstone at the mouth of Wolf creek and the base of the heavy sandstones at the top of the Upper falls, with an aggregate thickness of 344 feet.

These rocks constitute the most striking part of this famous canyon. On the south side of the mouth of the Wolf creek ravine the vertical cliffs rise 250 to 300 feet in which the bands of black, blue gray and olive shales, and the greenish or blue sandstones of varying thicknesses and in irregular succession are displayed in the most effective manner.

The lower beds, principally shales, are accessible in times of low water in the lower part of the Wolf creek ravine, and some of the lighter colored layers are fossiliferous.

Midway in the cliffs for 2 miles south of Wolf creek the even stratum of sandstone that is the platform of Table rock at the top of the Lower falls, 70 feet high, is seen. Below this stratum down to the bottom of the falls, there are five layers of black shale aggregating 9 feet in thickness, intercalated at irregular intervals in 57 feet of gray shale and a few thin flags. Above it the sandstones are more frequent and increase in thickness, and in the walls below the Middle fall compose a considerable portion in the sedimentation. They are mostly not more than a foot or two in thickness, however, and layers of both light and dark shales recur up to the top of the formation.

In the broad slope of rock on the west side of the river extending from the top of the Middle to the bottom of the Upper falls 19 feet of shales and flags are accessible and 20 feet more on the west side of the waterfall can easily be reached.

For 51 feet above the bottom of the Upper fall the rock is principally soft with seven thin layers of dark or black shale interstratified between light shales or thin flags. One stratum of rather shaly sandstone 2 feet, 5 inches thick is 19 feet above the base of the section and is separated from a similar but slightly more com-

Gorge below Lower falls, Glen Iris. Gardeau flags and shales

Plate 7

Cathedral rock, below the Flume, Glen Iris. Gardeau flags and shales

pact layer 3 feet, 6 inches thick by 5 feet, 4 inches of soft shale mostly dark.

This sandstone is succeeded at the top of the formation by 19 feet, 8 inches of light and dark shales with a few thin flags, overlain by the stratum of light blue gray sandstone 7 feet thick that is the basal layer of the next higher member of the Portage group, the Nunda sandstones. The Gardeau flags and shales are the lowest rocks exposed on the Portage quadrangle in the Oatka creek or Warsaw valley. In the large ravine of Stony creek or Fall brook, ½ miles southwest of Warsaw 235 feet of these beds are finely exposed below the Erie Railroad. They are, as a whole, noticeably softer than in the Genesee river section and there are fewer sandstones except at the top of the falls, where a hard stratum 1 foot thick has been denuded of shale for the space of a few square rods, and is locally known as Table rock. It is not, however, in the same horizon as the Table rock at the Lower Portage falls.

In Gibson's glen, near South Warsaw, 150 feet of the upper beds are exposed, and a somewhat less thickness of the same up to the top of the formation in the ravine of Oatka creek between Newburg and Rock Glen.

In the Nunda or Cashaqua creek valley the small ravines on the side of East hill opposite Nunda and on the west side below Brooks grove, show partial sections of these beds, and Wildcat gully cuts through the entire formation.

The upper parts of the rock gullies on the west side of the Canaseraga valley above West Sparta and nearly up to Byersville are in the Gardeau beds, and they are exposed under similar conditions on the east side above Groveland station.

The fauna of the Gardeau beds on these quadrangles is not an extensive one, but it is made specially interesting by the fact that it is composed of several species that first appeared in the Genundewa limestone and were more or less common in the Cashaqua, with additions from the Portage fauna on Lake Erie, and, east of the river, some members of the Ithaca fauna that do not appear in the exposures in the gorge, nor in this horizon further west.

Fossils except plant remains are usually almost entirely absent from these sandstones on the Portage quadrangle but Table rock in the Fall brook ravine, Warsaw which is in two parts, separated by a thin seam of shale, bears on the surface of the lower part scores of the little lamellibranch Buchiola retrostriata and several other species abundantly. Some flattened concretions in a bed of soft shale at the mouth of Gibson's glen contain some beautifully preserved fossils, mostly small specimens of Manticoceras rhynchostoma Clarke and similar concretions occur elsewhere in this horizon but by far the larger part of the fossils collected from the Gardeau beds have been found in layers of light blue or olive soft shale, generally but a few inches thick. But few of them are conveniently accessible to collectors, but the lower one may be reached at the mouth of Wolf creek and others a mile farther up the ravine.

At the top of the Lower Portage fall, a 10 inch layer immediately beneath Table rock is quite fossiliferous and a thinner layer 10 feet lower contains a few lamellibranchs and Manticoceras rhynchostoma occurs though very rarely, just above the 12 inch sandstone at the top of the Flume.

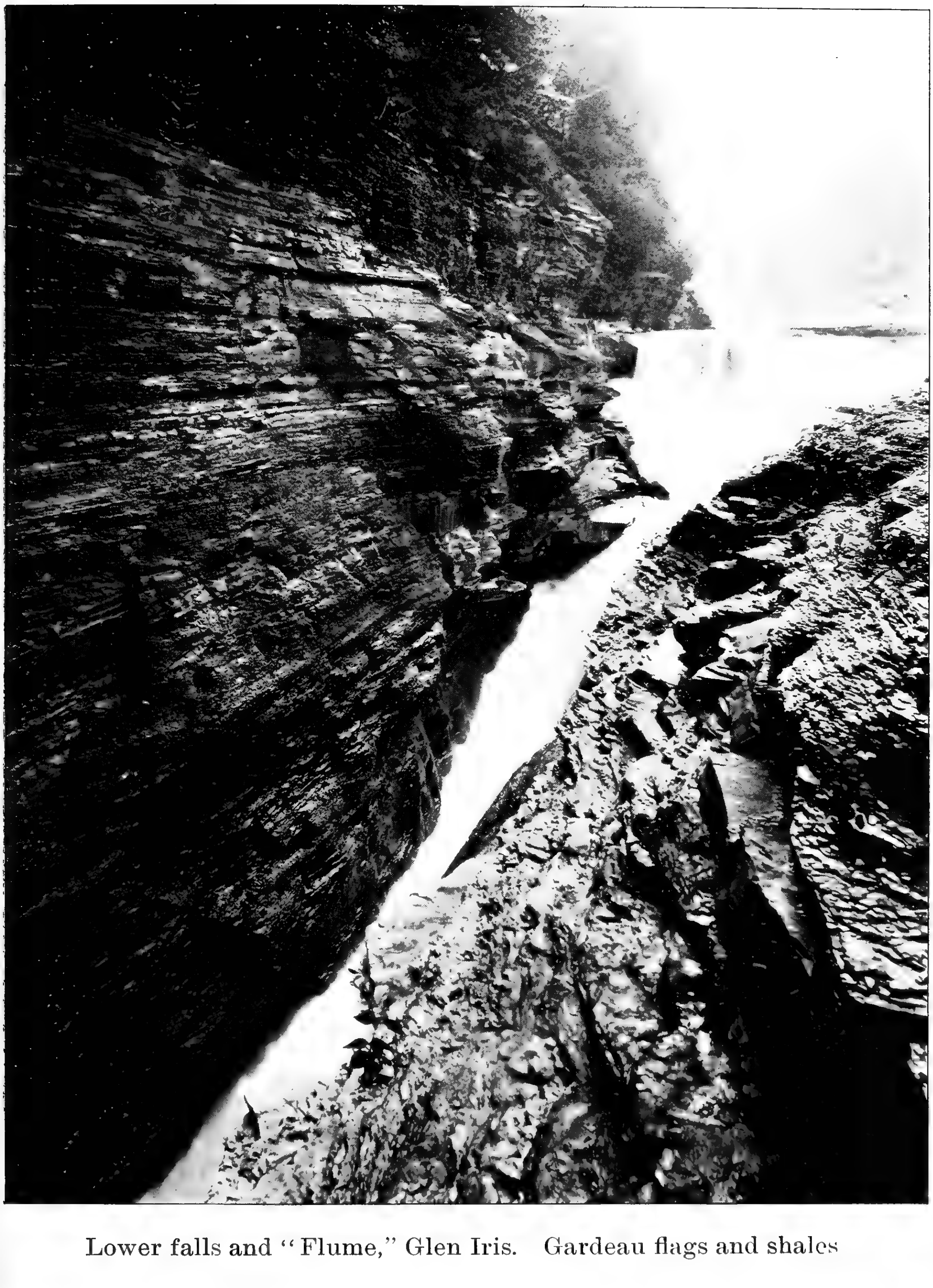
In 1906 a fall of rock from 60 feet up in the cliff on the east side 40 rods above the Lower fall, brought down a part of an extensive bed of plant remains in which were many fragments of lepidodendron. A thin layer at water level half way between the Middle and Upper falls has afforded a number of fine specimens of Manticoceras oxy Clarke and other species, while similar layers occur a few feet higher.

Although no brachiopods have been found in these beds in the gorge it is quite possible that some of the considerable number common in this horizon in the Naples valley may have extended as far west as this and their remains be buried in the inaccessible strata of the cliffs. A thin calcareous seam exposed by the roadside on Quarry hill 1 mile south of Nunda and stratigraphically near the top of the Gardeau beds, is composed of crinoid stems and fragments of brachiopods, and a calcareous sandstone 3 inches thick exposed by the side of the river road 2 miles north of River Road Forks and in the lower part of this formation contains Ambocoelia in large numbers, also Chonetes and fragments of Leptostrophia less abundantly, all exceedingly small.

The following is a list of the more common fossils in the Gardeau beds on these quadrangles:

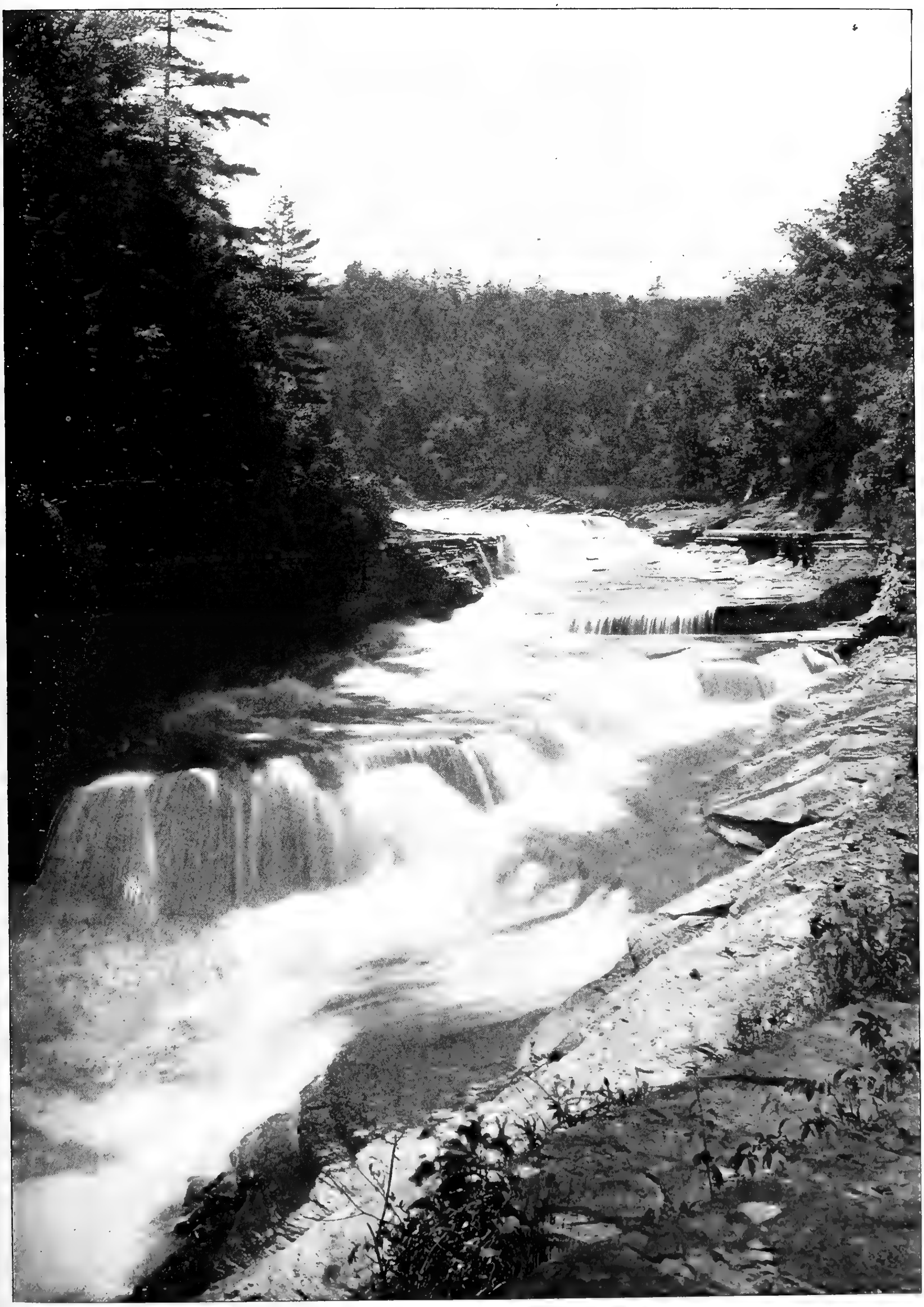
Entomis serratostriata *Sandberger*
E. variostriata *Clarke*
Manticoceras pattersoni (*Hall*)
M. oxy *Clarke*
M. rhynchostoma *Clarke*
Tornoceras uniangulare (*Conrad*)
Orthoceras pacator *Hall*
Bactrites aciculum (*Hall*)
Styliolina fissurella (*Hall*)
Phragmostoma natator *Hall*
Loxonema multiplicatum *Clarke*
Palaeotrochus praecursor *Clarke*
Lunulicardium bickense *Holzapfel*
Honeoyea erinacea *Clarke*

Plate 8



Lower falls and "Flume," Glen Iris. Gardeau flags and shales

Plate 9



Part of the Lower falls at Portage from Table rock.   Gardeau flags and shales

H. major *Clarke*
H. desmata *Clarke*
Posidonia attica (*Williams*)
Ontaria suborbicularis (*Hall*)
O. clarkei (*Beushausen*)
Euthydesma subtextile *Hall*
Buchiola retrostriata (*v. Buch*)
B. lupina *Clarke*
Paracardium doris *Hall*
Pterochaenia fragilis (*Hall*)
Cladochonus
Lignites
Fucoides graphica *Hall*
F. verticalis *Hall*

Nunda sandstone

A stratum of sandstone 7 feet thick, the bottom of which is 28 feet below the top of the Upper fall is the basal layer of this subdivision. It is succeeded by 7 feet of shales and thin flags, overlain by the somewhat shaly sandstone 13 feet, 6 inches thick seen at the crest of that fall.

A bed of hard blue shale 4 feet, 4 inches thick overlies this sandstone, another 12 feet higher is 2 feet thick and a third 70 feet above the top of the falls is 6 feet thick with an 8 inch layer of sandstone in the upper part.

Except these three beds of shales and a few thin shaly partings between the heavy layers the formation as exposed in the Genesee river gorge section is composed entirely of light blue gray sandstone in layers from 3 to 10 feet thick, some of which are calcareous to a greater or less degree, and hard, while others are schistose or coarsely shaly in many laminations. Large and usually obscurely defined concretions or burls occur in some of the layers.

The cliffs at Portageville by long exposure have weathered to a yellowish or olive-gray color, and that is commonly the color of these beds in old outcrops everywhere, but when newly quarried the rock has a handsome blue gray tint and is popularly known as "bluestone." The more compact layers are extensively quarried on the west side of the river 1½ miles south of Portageville by the Portageville Bluestone Co., and at Bluestone by the Genesee Valley Bluestone Co., and near Rock Glen by the American Bluestone Co., and the Warsaw Bluestone Co., sawed into flagging and house trimmings, the handsome color of the rock combined with its durable character making it extremely popular for such use and of considerable importance economically.

The 6 foot bed of shale seen at the line of the Pennsylvania Railroad at the south end of the high Erie Railroad bridge, contains large numbers of small irregularly shaped calcareous concretions that give the bed a distinctly nodular expression not seen in shales east of these quadrangles but common in the western part of the State. This band appears in the quarries at Portageville and also at Rock Glen, and may serve as a datum by which to determine the place, in the series, of the more valuable quarry stone layers. It may be seen on Quarry hill at Nunda at the reservoir. A thinner layer of the same character appears high up in the quarry wall here, but it thins out toward the west and is scarcely noticeable in the river gorge. The nodules are common also in the 2 feet of shale near the bottom of the formation at Portageville.

Next to that of the gorge section and the quarries mentioned the best exposure of the Nunda sandstone on these quadrangles is on Quarry hill 1 mile south of Nunda and along the road to Dalton. It crops out occasionally on the hill east of Nunda along the wall to Byersville and in small ravines and is well displayed in Wildcat gully in the northeast corner of the town.

It is exposed along Wolf creek below Castile and for a mile west of the Erie Railroad along Relyea creek and Stony creek near Warsaw.

Lignitic plant remains are common in the sandstones, sometimes in sufficient quantity as to form thin coaly seams of small extent. The lignites are usually fragmentary and rarely well enough preserved to allow identification of species.

Manticoceras oxy Clarke, M. rhynchostoma Clarke, Aulopora, Orbiculoidea sp. Crinoid stems, Fucoides verticalis and a few small representatives of the Gardeau fauna, constitute the fauna of this formation in the river section, but in the eastern part of the Nunda quadrangle thin seams of the comminuted shells of brachiopods occur and in the Naples valley these rocks contain a well developed Chemung fauna.

The Nunda sandstones are prominent in the stratigraphy of western New York from Chemung county to Lake Erie. The formation, while retaining its character as a mass of homogeneous barren sandstones, thins out rapidly west of Wyoming county and on the shores of Lake Erie south of Portland harbor where it dips under the water it is but a few feet thick.

Toward the east it becomes gradually less homogeneous and more assimilated to the adjacent formations, but may be traced in numerous outcrops as far east as Chemung county. In the vicinity of Naples these sandstones contain calcareous masses of fossils, mostly belonging to the fauna of the Chemung rocks. One of these outcropping in High point, a rock bluff 3 miles west of the village,

Plate 16

Upper end of Lower falls, Portage. Gardeau flags and shales

Plate 11

The gorge between the Middle and Lower falls. The rock wall is a little more than 200 feet high. Gardeau flags and shales

contains 22 species of brachiopods among them Spirifer disjunctus Sowerby, besides many other forms, and another lentil 3 miles south is a mass of fossil sponges and Chemung brachiopods, forms that did not appear in the Genesee valley section till after more than 200 feet of sediment had been deposited above this horizon. The sandstones at the top of the formation here pass gradually into soft sandy shales. The exact point of contact with the succeeding formation is covered at Portageville but is slightly exposed by the side of the Quarry hill road 1½ miles south of Nunda. The strata included in the Nunda sandstones as considered in this bulletin have an aggregate thickness of 215 feet.

In various recent publications the singularly interesting fact has been brought to notice that an essential difference in classification of the upper rocks of this Devonic series results from the independent consideration of the stratigraphic and the paleontologic evidence. In paleontology the Portage group here extends upward to include a mass of olive shales with some sand having a thickness of several hundred feet, and the upward extent of this fauna in the Genesee section is characteristic of its range throughout the region farther west in the State. But at the east, in the Canandaigua-Naples meridian, this fauna disappears practically or entirely at a horizon below that of the Nunda sandstones. These sandstones have been traced almost foot by foot between these meridians, and the stratigraphic continuity of the Nunda sandstones of the Genesee section with the High Point sandstone of the Naples section is beyond question. The seeming inappropriateness of a twofold designation for the same geologic horizon is dispelled by the entire difference in the contained faunas at these distant sections. In paleontology the High Point sandstones carrying a brachiopod fauna with Spirifer disjunctus are of Chemung age, the Nunda sandstones of Portage age. We therefore have in the Nunda sandstones of the Genesee valley a member of the Portage group which lies at the base of the Chemung group farther east. Another and still higher member of the Portage group is also present in this section and its presence and probable value were indicated by Hall in 1839 [Annual Report, p. 392].

The two groups just described (Gardeau and Portage) occupy a thickness of more than a thousand feet and are interposed between the Cashaqua shale and the Chemung group. Indeed, if we consider the Chemung group as commencing with the occurrence of its characteristic marine fossils, then several hundred feet more of rocks may be noticed as intervening between the upper Portage rock and that group. The rock succeeding the upper Portage rock consists of greenish olive, sandy shale, or very shaly sandstone, never slaty. The only fossils seen in this rock is a species of fucoides with a striated surface, and these are by no means numerous. This is succeeded by a dark, nearly black sandy, highly micaceous shale with septaria. It contains iron pyrites and where exposed is of an iron rust color externally. Some thin masses of gray sandstone are interstratified which contain fossils referable to the Chemung group.

[p. 402] Succeeding the black micaceous shale are the sandstones and shales constituting the Chemung group which is everywhere visible in the ravines and banks of streams. Its northern limit extends through the southern part of the towns of Centerville, Hume, Grove and Burns. In this county more particularly along the Genesee river and west, the group differs in lithological characters and consequently in some degree from the same rocks in Steuben and Chemung.

From these quotations it is clear that though Hall conventionally classified all of the rocks succeeding the Portage (Nunda) sandstones for a thickness at least as great as appears on these quadrangles, as belonging to the Chemung group, he directed attention to the fact that they might be subdivided as follows:

1 Olive shales and shaly sandstones at the base.

2 Micaceous shales with thin sandstones containing brachiopods.

3 Heavy sandstones and shales which, lithologically are very similar in character to the strata referred to as constituting the Chemung group at the type locality.

Sufficient data have not yet been obtained on which to decide whether divisions 2 and 3 should be considered as separate geological units, but it is not improbable that further invesigations may demonstrate that they are such.

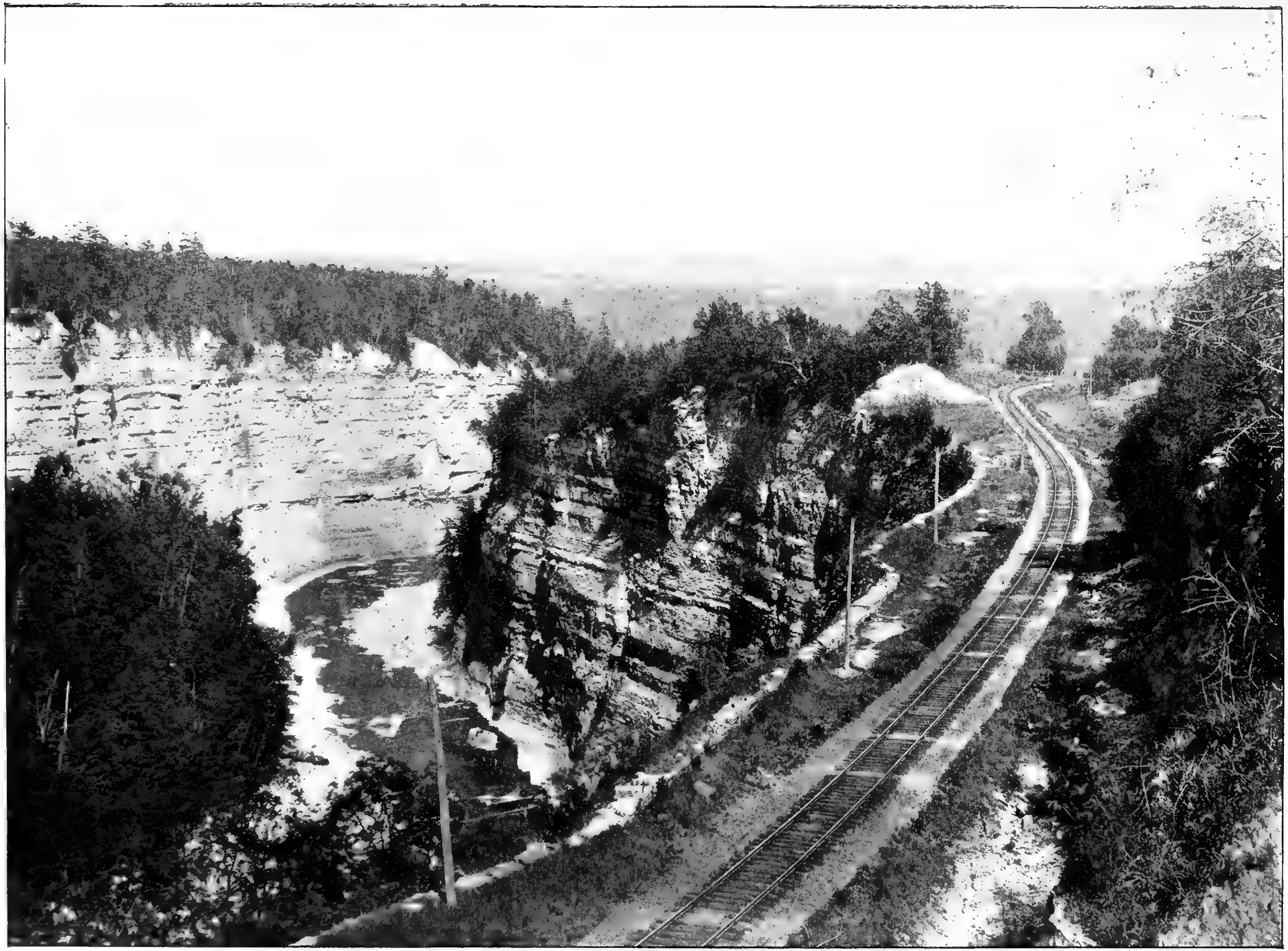
The beds of division 1 are known as the

Wiscoy shales and sands

These shaly olive beds were described as a unit in the New York geological series, and the relations of the fossils found in them discussed by Clarke in the 16th Annual Report of the State Geologist of New York, 1898, and the name "Wiscoy shales and sands" applied to them on account of their favorable exposure at the falls of Wiscoy creek at Wiscoy, N. Y.

The stratigraphy of these beds was shown in detail in diagrams accompanied by description, by Luther in New York State Museum bulletin 69, 1903.

Plate 12



Gorge between the Middle and Lower falls. In the upper part of the Gardeau flags and shales

Plate 13

The Middle falls at Glen Iris. Gardeau flags and shales

South of the sandstone cliffs at Portageville the course of the Genesee river winds through a broad valley in which the only exposures of these soft beds are to be found in the various excavations in the adjacent hillsides.

The basal layers may be seen in the ravine ½ mile south of Bluestone; and at the falls of Wiscoy creek at Wiscoy the floor and walls of the ravine display 135 feet of the middle and upper beds. Near the top of the north walls above the falls the calcareous sandstones occur that succeed this formation and are the lowest of the "coarse sandstones with fossils of the Chemung group," referred to by Hall, in the Genesee river section. This band of sandstones comes down to the river level 5 miles south of Wiscoy and 1 mile south of Fillmore at Long Beards Riffs where it makes a low cascade and is exposed on both sides of the river. It was described and the designation "Long Beards Riffs sandstone" applied to it by Luther in New York State Museum bulletin 69, 1903. The lower beds of the Wiscoy division are mostly coarse blocky shales or soft sandstones with an occasional flagstone. In the middle and upper parts the sedimentation is generally finer, and there are several layers of black slaty shale one of which is 6 feet thick. An 8 foot bed of nodular shales lies next below this black bed and concretions from an inch to 3 feet in diameter occur throughout the entire formation.

Nearly all of the beds are calcareous to a greater or less degree and on the whole greatly resemble the Cashaqua shale. This resemblance becomes even stronger toward the west, but is lost to a certain extent toward the east owing to the increase of arenaceous matter.

The exposure at Wiscoy and in the ravines on the east side of the valley 1 to 3 miles farther south afford the best opportunities for examination of the Wiscoy beds. They are also exposed along Stony creek 2 miles west of Warsaw and slightly along the upper reaches of Relyea creek and Oatka creek, also east of the Genesee valley for ¼ mile north of Hunts along the Nunda road, and by the roadside 1 mile southwest of Dalton. Small outcrops are common by the roadsides and in the ravines on the slopes of the hilly region east of Nunda.

In Steuben county where these beds are coarser they contain many Chemung brachiopods and it is probable that the same species occur in this horizon in the eastern part of the Nunda quadrangle, though owing to a lack of favorable exposure they have not been observed.

The fauna of the Wiscoy is a sparse one in both species and individuals.

The following have been collected from Wiscoy creek ravine and the gullies on the east side of the valley 2 to 4 miles farther south:

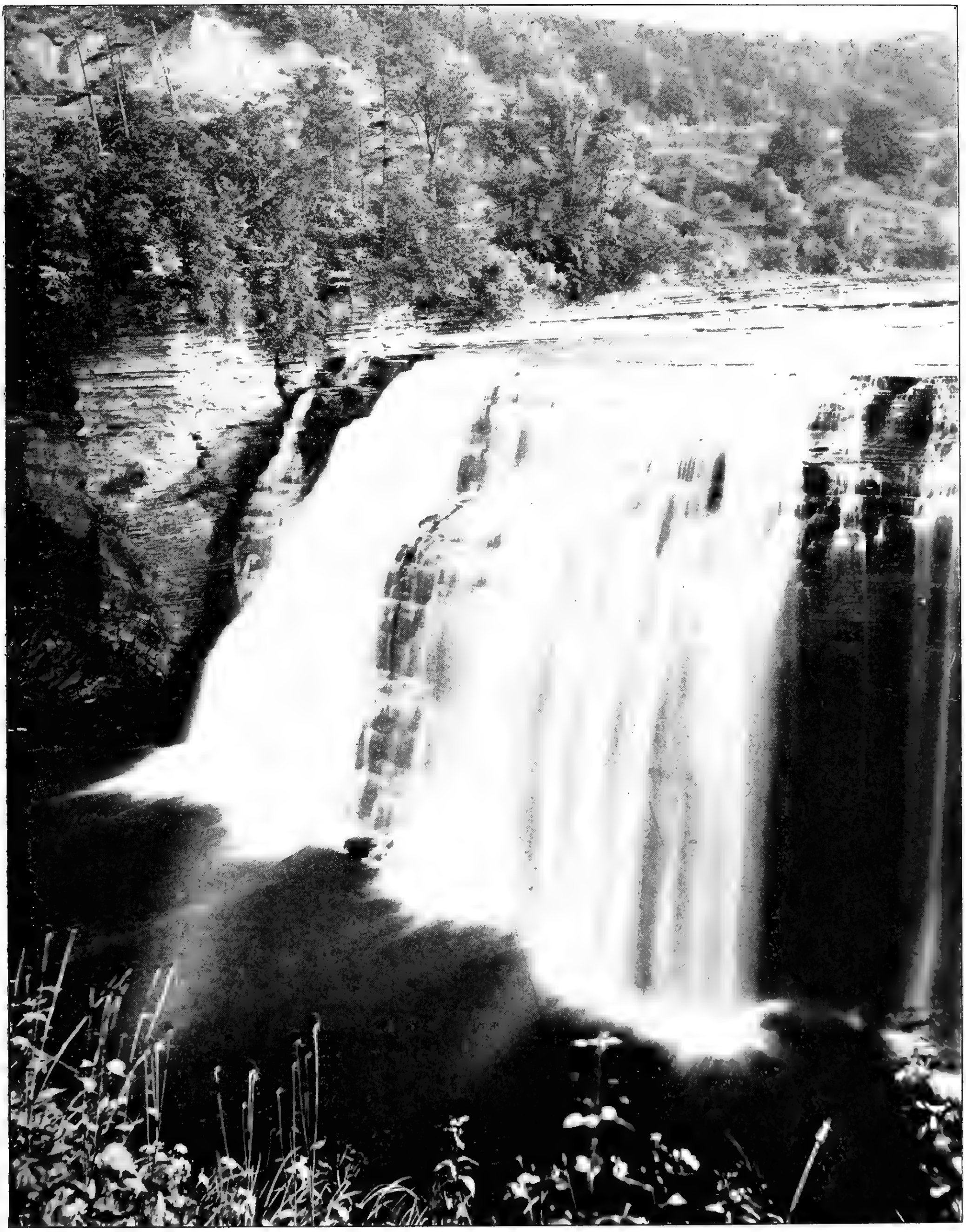
Manticoceras oxy *Clarke*
M. rhynchostoma *Clarke*
Orthoceras *sp.*
Pleurotomaria *sp.*
Hyolithus neapolis *Clarke*
Buchiola retrostriata (*v. Buch*)
Lunulicardium (Pinnopsis) wiscoyense *Clarke*
Paracardium doris *Hall*
Zaphrentis *sp.*
Lingula ligea *Hall*

Chemung group

In discussing this division in Museum bulletin 81, 1905, (Watkins and Elmira Quadrangles) the following commentary was made on the general value of the term:

The term Chemung has been applied with such a breadth of meaning in New York stratigraphy that faunally and stratigraphically it no longer meets the requirements of precise expression. The formation has been, in a general and vague way, regarded as that mass of arenaceous deposits lying above the Portage of western New York and the Ithaca of central New York, from which there is, as is now known, a transition lithologically so gradual as to make a separation a pure convention. In respect to fauna the "Chemung group" has been commonly regarded as well defined by the presence of a notable series of species specially brachiopods, lamellibranchs and dictyosponges, all of which have been in a way regarded as centered about the species Spirifer disjunctus and the horizon, as a whole, including a thickness of from 1000 to 1500 feet of strata, regarded as the horizon of Spirifer disjunctus. This conception, as we have heretofore explained, is misleading, vague and inaccurate. The horizon of Spirifer disjunctus follows close on the change from the Naples fauna in western New York at a high altitude above the base of the Portage formation. In central New York there is no such change but the gradation from the Ithaca fauna out of the Hamilton fauna upward into the association which carries species elsewhere concurrent with Sp. disjunctus is very easy and it is extremely difficult to draw a division plane anywhere except on the basis of refined distinctions into successive faunules. Spirifer disjunctus in this eastern region did not appear till this period of "Chemung" deposition was well nigh over. For a precise use of this term Chemung therefore we are thrown back on the

Plate 14



Middle falls at Glen Iris, from the west side. Gardeau flags and shales

The Middle falls and the gorge below. The Erie Railroad bridge above the Upper falls in the background. Letchworth park on the right. Gardeau flags and shales

original employment of the name and we here cite the explanation of the term as first used by Professor Hall, taken from the Third Report on the Fourth Geological District, 1839, pages 322-24:

"The tops of the hills and high grounds in the towns of Erin, Veteran and Catlin, display a group of rocks and fossils very distinct from those last described. The essential difference is the lithological characters of the sandstone of this group in the absence of argillaceous matter in most of the layers, these being nearly a pure silicious rock, harsh to the touch, and generally of a porous texture; while still a large proportion of the mass consists of compact shales and argillaceous sandstones of a softer texture than those below. The surface of the sandstone layers is rough, while those below are smooth and glossy, and being never rippled, prove that the rocks were deposited in a quiet sea."

In the previous chapter we have referred to an already recognized necessity of removing from the Chemung division of the Genesee valley a lower portion which Professor Hall himself anticipated might have to be excepted therefrom on stratigraphic grounds only. With the Wiscoy beds eliminated there remains thereabove in this section 400 feet of sandstones and shales, not differing greatly from the Portage beds in appearance nor lithologically, though the sandstones are usually light olive-gray in color and more micaceous.

Thin layers of impure limestone resulting from aggregations of brachiopods and other fossils occur occasionally in the sandy layers but are most common in the upper beds. The shales are in all variations and shades of color from light blue gray and olive to deep black. Rows of small calcareous concretions occur in some of the lighter shales, and larger, but less clearly defined masses of concretionary character are in a few of the heavier sandstones.

The stratum containing brachiopods at Long Beards Riffs and Wiscoy falls is in the lower part of a band of sandstones and shales exposed at Mill's Mills and along East Koy creek, a mile north of Lamont. Soft shales prevail in the succeeding 400 feet of strata though there are several lentils of sandstone embraced in this part of the section. Exposures of this horizon in the vicinity of Pike, show mostly light shales that become rusty on exposure between thin rough flags 1 to 3 feet apart. In the Dingman quarry 1 mile north of Pike a 12 foot band of sandstones is exposed that is about 200 feet higher in the strata than the Long Beards Riffs lentil. These sandstones are also exposed along the Allegany road a mile southwest of Pike, where one of the layers contains a calcareous mass of fossils and after long exposure weathers dark brown.

There are many small exposures of this part of the Chemung group along the roadsides and in small gullies on these quadrangles, but none that show more than a fraction of the rock section. It is well displayed, however, along Caneadea creek and in other ravines on the next quadrangle south of the Portage.

At 1700′ A. T. on the Allegany road 4 miles southwest of Pike there is manifest a considerable change in the conditions of sedimentation, soft shales no longer predominating, but a series of flags and sandstones, many of which contain brachiopods in large numbers, appears and is exposed along the roadside showing a thickness of 150 feet or more, above which the rocks are covered by drift, but blocks of compact quartzitic gray sandstone, very coarse in structure and in some parts having the composition of a fine conglomerate, are scattered over the fields or built into the fences in such quantities as to make it evident that it is the bed rock in the vicinity of the crossing of the Allegany road and the east and west road near the south line of the quadrangle. There is no other favorable exposure of these sandstones on these quadrangles but they are amply displayed in the Belfast quadrangle.

Fossils are not abundant in the strata succeeding the Wiscoy shales for 400 feet except in a few thin seams in the lightest shales and in the heavier of the sandstones. The following species have been collected from the stratum succeeding the Wiscoy shale as Long Beards Riffs and Wiscoy:

Spirifer disjunctus *Sowerby*
S. mesacostalis *Hall*
Liorhynchus multicosta *Hall*
Productella lachrymosa *Conrad*
P. speciosa *Hall*
P. hirsuta *Hall*
Atrypa aspera *Hall*
Camarotoechia *sp.*
Orbiculoidea alleghania *Hall*
Orbiculoidea *cf.* media *Hall*
Ambocoelia umbonata (*Conrad*)
Lingula *cf.* melie

and several unidentified species. These are the prevailing forms that appear in the lower Chemung beds on these quadrangles and most of them continue up into the heavy sandstones where they are much more abundant and where other species are added to the fauna.

Dip

The rocks of these quadrangles show very little evidence of disturbance except in an even gentle dipping toward the south-southwest. The line of contact between the Moscow shales and Genesee slate has a westward declination of about 10 feet in the 55 miles

Plate 16

View of the Upper Falls and the Erie Railroad bridge. Upper Gardeau flags and shales

between its exposure at Moscow and on the shore of Lake Erie. This westward dip is increased by the thinning out of the Genesee and Portage beds, producing a different rate for each contact line. For the top of the Nunda sandstones the average is about 8 feet per mile with considerable variations due to slight undulations.

The average southern dip is 20 to 22 feet a mile and toward the south-southwest 30 feet a mile. This appears to be slightly increased in some of the quarries, possibly due to the relief from pressure following the excavation of the deep valleys on the sides of which they are located.

PLEISTOCENE HISTORY OF THE GENESEE VALLEY IN THE PORTAGE DISTRICT

BY

HERMAN L. FAIRCHILD

Evolution of western New York drainage

Any adequate discussion of the preglacial history of the Genesee river in its broader relations would involve the whole problem of the changes and adjustment in the drainage of the area of western and central New York and northern Pennsylvania during all time since the later Paleozoic. This is a large problem which has not been seriously attacked and one which requires much study. For the purpose of the present writing we shall be content with the briefest presentation of the elements of the problem.

It would seem certain that the primitive and consequent drainage of the western half of the State, along with the northern and western part of Pennsylvania, must have been southward or southwestward when the region was slowly uplifted from the seas as a coastal plain, bordering the old lands of Canada and the Adirondacks. Such elevation probably occurred not later than the Subcarboniferous. Many of our broader valleys, specially those with a southward or southwestward trend, are probably an inheritance from that earliest drainage across the uplifting plain. In the course of time the attitude, structure and composition of the rock strata, along with the up and down movements of the land, influenced the disposition of the drainage.

In the Ontario region a great thickness of weak rocks permitted the secondary or subsequent streams having east and west courses, along the strike of the strata, to develop and strengthen at the expense of some of the older and trunk streams. Eventually some of these subsequent streams united to make a great main or trunk stream, flowing either east or west, and so there was developed by atmospheric and stream work the great Ontario depression. With the deepening of the east and west Ontario valley the drainage along the southern side was reversed by streams developing northward flow toward the Ontarian river. In later geologic time probably most or all of central New York was included in this reversed (obsequent) drainage, having northward flow down the inface of the Allegheny table-land. The valleys of the Finger lakes represent the work of such northward drainage,[1] but the most conspicuous and the longest example is the Genesee river.

During the long process of adjustment of the drainage there were great changes not only in land altitude but also in the climatic factors. Recently the Pleistocene ice sheets have plowed across the region and in a capricious manner have left some valley stretches filled with rock rubbish while other long stretches have been unfilled, or even scoured and cleared. Not only has the preglacial topography been thus obscured and the drainage diverted, but still greater interference with the old drainage was produced by the damming effect of the ice itself, in forcing the drainage into new lines, either southward or in directions along the ice front.[2]

The Genesee, as above noted, is the longest stream in New York which retains its preglacial northward course. It has persisted in its northerly course in spite of obstructions and diversions, for a little thought makes it evident that the damming and diverting effect of the glacier must have been to destroy the original northward flow rather than to produce such flow.

Diversions of the river. Buried channels

In the course of the Genesee river there are three stretches where its valley shrinks to a narrow steepwalled ravine or canyon. One is at Portage, a second near Mount Morris, and a third at Rochester. The first two are parts of a single diversion of the river. Above Portageville and below Mount Morris the valley is broad and flaring and is evidently the result of weathering, storm wash and stream transportation during millions of years. The canyons represent the same kind of geologic processes as the open-valley stretches but only a small fraction of the time. Quantitatively the canyons are inharmonious with the rest of the valley, and have long been recognized as the very recent or postglacial work of the river where it has been forced from its old valley into a new path.

Logically it must follow that for each of the new stretches of the river course there must be a corresponding deserted stretch of the ancient valley. As to the cause of the changes in the river's course there is no disagreement among geologists, it being the interference

[1] See N. Y. State Mus. Bul. 45, p. 31-54; Geol. Soc. Am. Bul. 16: 55-56.

[2] For illustration of such glacial drainage *see* N. Y. State Mus. Bul. 106.

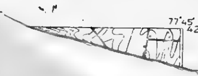
of the ice sheet, as described above. The deserted and more or less drift-buried stretches of the older valley must connect the existing open, mature stretches, passing around the new, ravine stretches.

The criteria for locating the abandoned stretches are as follows: (1) Direction: which would be expected to lie in fairly direct line connecting the open or unobstructed stretches. (2) Width: which should correspond to that of the old, open valley, making allowance for any difference in the character of the rocks. (3) Walls: which should have slope and height similar to the open stretches. (4) Depth: the original bottom of the deserted stretches must have been in accord or graded with that of the open parts. In want of deep borings sufficient to fully prove the location, depth and form of the buried stretches we have to rely at present on the general form and relation of the broader valley features and the exposures of rock. While these are not entirely satisfactory yet they are probably sufficient to show the main facts of the preglacial drainage.

Rochester district. Somewhere between Avon and Rochester the Genesee river leaves its old valley and enters its modern course, which becomes at Rochester a rock canyon with three cataracts, cut in Niagara, Clinton and Medina strata. The ancient and wider channel must have had a northward trend and somewhere must have crossed the Niagara scarp in order to join the river or lake which occupied the Ontario depression. From the St Davids valley to Sodus bay there is no break in the horizontal strata which could possibly have carried a large stream for a long time except the gap now occupied by Irondequoit bay (or lake). Here is an open valley over a mile wide, in hard rocks, and extending southward as a traceable depression some 15 miles. The depth of the Irondequoit valley to rock is unknown but the depth of water is given as 87 feet. The rock bottom of the old valley must be graded to the depth of the Ontario basin which runs into hundreds of feet a few miles out from the south shore.

The conclusion is unavoidable that here we have a portion of the old, preglacial Genesee valley, and the most northerly stretch now above the waters of Ontario. From the neighborhood of Fishers, in the Irondequoit valley, westward to the Genesee valley near West Rush, or to the mouth of the Honeoye creek, the old valley is so completely obscured that no confident suggestion of its course can be based on surface features. It appears most probable that the course of the river had been adjusted to the underlying rocks and

Nunda and part of Portage quadrangles.



Nunda and part of Portage quadrangles

Preglacial drainage in Portage district: hypothetical

that a few miles north of Avon the channel bent eastward along the outcrop of the very soft Salina shale, similar to the present streams on the latitude parallel between Buffalo and Syracuse. This east and west stretch of the ancient valley, lying athwart the direction of the ice movement, was the part most filled by the glacial drift.

Portage-Mount Morris district. The canyons at Portage and Mount Morris together with the 8 miles of narrow intervening valley represent a single diversion of the river. Evidently the ravine-like valley from St Helena to Gibsonville is older than the canyons at the two ends, being V-shaped and flaring, although the rocks are as resistant as those of the Mount Morris canyon, locally called the "High Banks." Yet this valley is decidedly too narrow to have been a part of the Genesee valley, and is entirely out of harmony with the open valley above Portage and below Mount Morris. We must conclude that the St Helena valley belonged to some smaller or tributary stream.

The St Helena creek, as we may name the preglacial tributary, probably flowed south and entered the Genesee river 2 miles east of the Portage viaduct, near the Lewis corners [*see* map]. In a similar relation the depression followed by the Erie Railroad north to Silver Springs and including the valley of Silver lake probably drained south and joined the Genesee valley north of Portage by the break in the west wall at that point. This gap in the rock wall is too small to represent the old valley of the river, as suggested by Grabau,[1] but undoubtedly is the junction of a tributary valley. His suggestion that the old valley led northwest and comprised the Warsaw-Wyoming or Oatka creek valley can not be maintained. First, the break in the rock wall at Portage is insufficient to represent the river valley. Second, the gross topography indicates no sufficiently capacious valley leading toward Warsaw, and the obscuring drift is scanty. Third, while the Oatka has a handsome valley from Warsaw to Pavilion this has neither the size, form nor altitude that would represent the lower stretch of the river valley on that meridian, in soft shales. Fourth, rock appears at Castile in the bed of Wolf creek, at about 1260 feet altitude; and at the railroad station rock underlies the surface at near 1400 feet, thus effectually closing any river escape in that direction. Fifth, the head of the Warsaw valley, at Rock Glen, is in rock on both sides of the valley axis, at 1200 and 1300 feet. Sixth, the Oatka valley quite

[1] Bost. Soc. Nat. Hist. Proc. 1894. 26: 359-69.

disappears toward Leroy and the creek falls over the limestone in a mere notch. Seventh, the Onondaga limestone has a practically continuous outcrop from east of Batavia to the Genesee east of Caledonia, and no heavy stream ever crossed its scarp in that region in preglacial time.

In attempting to locate the ancient valley for the interval from Portage to Mount Morris we must apply the criteria as noted above and use the principles and argument as in the Rochester district. Assembling the topographic sheets it becomes apparent that only one valley is found on the map which meets the conditions. The valley of Nunda, now occupied by Keshequa[1] creek, and lying east of the present river, has fair direction, sufficient size and the proper depth where unfilled. The extensive moraine between Portage and Oakland is evidently the barrier between the Portageville and Nunda sections of the great valley. North and northeast of Portageville the walls of the valley are only drift and no rock is found anywhere in that district. On the steep slope south of Hunt (cut by the outflow of the fifth stage of the glacial waters as described below), in the creek gorge at Hunt's Hollow, and on the slope northeast, the rocks appear, but they mark only the eastern wall of the ancient valley. On the north no rock is found until the hill is reached north of Oakland. The old valley is very wide here and was probably broadened by the junction of four streams: (1) the Genesee, passing northeast; (2) the Silver lake-Castile affluent, from the northwest; (3) the St Helena tributary, from the north; and (4) the Dalton or upper Keshequa waters, from the southeast. This relation is indicated in the accompanying map.

Downstream, or northeast of Nunda, toward Tuscarora and Sonyea the higher and broader cross-section of the old valley is very satisfactory. From Nunda to Union Corners the eastern wall is plainly the slope of a great valley. The western wall is equally conspicuous though partially dissected by a shallow north and south valley northwest of Tuscarora. From Tuscarora to Sonyea the bottom section of the old valley is obscured by drift and is not so satisfactory. Rock appears at Sonyea station and half a mile east, on the 600 feet contour, and in the 2½ miles of the creek canyon south of Sonyea. Rock also appears north and south of Tuscarora, but probably leaves a channel a mile wide.[2]

[1] See footnote on page 53.

[2] Mr. Charles Haggardorn of Tuscarora, who has bored many wells in the Nunda district, informs the writer that borings at Nunda were in the drift to depth of 103, 97 and 73 feet. A mile east of Nunda Junction wells go to depths of 80 and 100 feet without reaching rock; and in Tuscarora the drift is not less than 100 feet deep.

The junction of the Genesee and Dansville valleys is not so clear and satisfactory as we might expect. The rock exposures restrict the valley width and the Genesee is made apparently a tributary to the Dansville river. But this seems to be the only possible outlet.

It is probable that the preglacial Genesee river with its full length had not been in its acquired channel a great period of time, or in other words was not a very ancient stream. The river had been produced by the diversion or capture or union of different minor streams, and had only in later time become adjusted to the course in which the glacier found it. The Dansville river was probably the older stream, though possibly smaller in volume. Before the ice sheet interfered with it the Dansville river probably collected the drainage from a large territory on the east of Dansville and south of the western members of the Finger lakes, including the upper Cohocton valley. Some of this drainage was inherited from the earliest time, and probably the valley had become mature while the Genesee was young. The glacial drift cuts off the former upper waters and sends them over southward by the Cohocton river, so that the Dansville stream is today only the Canaseraga creek. The greater maturity of the Dansville-Avon valley was noted by Dr Grabau.

It must be noted that the present floor of the Dansville-Avon valley is not the bottom of the old river valley, but only the top of the deep filling left by the glacier and the glacial lakes, with some contribution by the present streams.

Glacial waters and canyon cutting

The initiation of the postglacial canyons and the history of their cutting is intimately tied in with the glacial lakes held in the valley. The various benches along the new channels of the river and the many terraces and plateaus of sand and gravel can not be understood without a knowledge of the lake history of the valley. And this drainage history of the Genesee valley is one of the most remarkable and dramatic stories in geologic literature.

During the long time, to be counted as many thousands of years, while the south edge of the ice sheet was slowly receding or backing away, from south to north, across New York State, the waters over the Genesee area were held up to high levels, being forced to overflow east or west. In the successive lowering of the waters by the opening of more northward outlets at least seven great river systems have received (and some of them more than once) the contribution of Genesee waters. In order of time these are as follows: (1) Pine creek-Susquehanna. (2) Allegheny-Ohio-

Mississippi. (3) Canisteo-Chemung-Susquehanna. (4) Glacial lakes Warren and Chicago to Mississippi. (5) Mohawk-Hudson (6) Gilbert gulf (sea level waters in Ontario basin). (7) St Lawrence.

In the present knowledge of the glacial and postglacial history of the Genesee drainage the writer recognizes at least 17 distinct stages or episodes. The first three stages involve only the upper (southern) part of the valley, the Portage district being then under the glacier. The Portage-Mount Morris region is involved in the history of stages 4 to 13. The subsequent stages concern only the valley north of Mount Morris. The history will be given very concisely in its relation to the district under present study.

Stage 4. Belfast-Fillmore lake.[1] Outlet was at Cuba, to the Allegheny-Ohio-Mississippi. Present altitude of outlet 1496 feet. Present altitude of the lake plain on the Portage parallel about 1530 feet.

During this stage the ice front receded as far as Portage, and lingering there deposited the Portage moraine which blocks the old valley in that district. South of Portage the valley was occupied by the lake which has left conspicuous evidences of its presence in the many water-leveled plains and terraces in the upper valley, with deltas at the mouths of side streams, having elevations of 1500 feet and upward.

Stage 5. Portage-Nunda lake. Outlet was by the Dalton-Swains rock gorge to the Canisteo-Chemung-Susquehanna. Altitude of the channel head, at Rosses, 1320 feet.

This stage endured while the ice front receded from Portage, Hunts and Dalton to Union Corners and Tuscarora, or through about 5 miles of meridional distance. However, the time involved was sufficient to allow the escaping waters to cut the steep rock bluffs south of Hunts and southeast of Dalton and the splendid rock gorge leading through Rosses and Swains to Canaseraga. As an example of an abandoned glacial river channel these features are unusually fine.

During this stage the Portage district was submerged in the lake waters which by their leveling action produced the level stretches and terraces of sand and gravel at and east of Portage with elevation from 1300 to 1325 feet. The plain at the Erie Railroad viaduct, 1325 feet, belongs in this category. The erosion plane of this lake extends up the valley to Belfast, and being lower and nearer the

[1] A fuller description of these early stages is printed in Geol. Soc. Am. Bul. 7:436-43.

middle of the valley they are the most conspicuous levels visible from the railroad between Portageville and Belfast.

Stage 6. Dansville lake. Outlet was at Burns past Arkport and Hornell to the Canisteo-Chemung-Susquehanna. Present altitude of the head of channel about 1210 feet. Present altitude of the lake plane at Portage about 1230 feet.

The first cutting by the waters as they fell below the fifth stage level is to be seen on the north point of the high ground in West Sparta and about one mile southeast of Union Corners. Here was the critical locality where the Portage lake waters first escaped between the receding ice wall on the north and the land slope on the south. The notching on the nose of the hill is evident, though not very conspicuous, at about 1300 feet and downward. When the waters came to a standstill as the Dansville lake, they produced the smoothing, leveling and shoreline work that is plainly seen at about 1200 feet around the nose of the hill.

This sixth stage lasted until the ice receded so as to uncover ground below 1210 feet in the vicinity of Linden and Attica, south of Batavia. As this new escape is on a meridian so far away from the Burns outlet no estimate of the duration of the waters can be made based on distance of the ice front retreat. Undoubted terraces of this level may be seen about Glen Iris at 1240 and higher; on the delta of Wolf creek at 1220 to 1240; and a plateau east of Bishop Corners and east of the river at 1230.

Portageville morainal lake. With the fall of the glacial waters below the Portage terraces, about 1320 feet, a local lake was left in the valley above Portage, being held up by the drift barrier. This water we have called the Portageville morainal lake. It was contemporaneous with the sixth stage of the glacial waters (lying northward), which from this time touch only the areas on the north.

It will now be seen that the gorge cutting at Portage began only with the overflow of the Portageville morainal lake, and that the glacial Dansville waters had no relation to the gorge except as possibly determining the base level for the stream and as the receiving body for the detritus. The initiation of the gorge cutting probably began at about 1320 feet, as it seems likely that the viaduct plain originally extended entirely across the valley. The top of the rock at the head of the canyon is at about 1240 to 1250 feet.

It will also be seen that the Portage river, draining the morainal lake, could not cut its channel lower than about 1230 feet during the life of the Dansville glacial waters, or only some 10 or 20 feet into the rock. The stream detritus was dropped immediately northward in the Dansville water, to be largely picked up in later stages of the lowering waters and transported farther north.

The numerous lower terraces in the valley from Portageville up as far as Caneadea, and ranging from 1270 down to 1160, belong to the morainal lake.

Stage 7. Mount Morris-Geneseo lake. Outlets were by a series of channels on the meridian of Batavia and lying between Linden and East Bethany. The flow was west, across the Oatka and Tonawanda valleys to the great glacial lake Warren, with ultimate escape by Chicago to the Mississippi. The elevation of the outlet channels declines from 1200 to 1000 feet.

The former stages were comparatively steady levels of the waters, with only slow lowering as a permanent outlet was downcut. But this stage, and subsequent stages, comprise a series of falling water-levels as the receding ice front opened lower and lower passes on the north-facing slopes.

The several terraces north of the lower falls, with elevations of 1180, 1140 and 1090, may be correlated with these seventh stage waters. They represent remnants of the deltas built in the Mount Morris-Geneso lake by the river while it was cutting the Portage canyon.

Stage 8. Lake Hall. Outlets were between East Bethany and Batavia with elevations from 1000 down to 900 feet, the waters escaping to Lake Warren the same as in stage 7.

So far as direction of escape is concerned this stage is only a continuation of the stage 7, the outlet channels forming a continuous series [*see* N. Y. State Mus. Bul. 106, pl. 6]. It is made a separate stage because the Genesee glacial waters are now blended with the glacial waters of central New York. This stage is the successor in the central part of the State to the glacial lake Newberry, which had its outlet south by Horseheads and Elmira to the Susquehanna. This body of water is named after James Hall.

The water-leveled areas which correlate with this stage are the terraces east of Bishop Corners, at 940, 900 and 860 feet; and the extensive delta plain at Nunda, declining from 940 to 860 feet. Also the broad summit plateau at 900 feet at the top of the Mount Morris canyon, the "High Banks."

Stage 9. Lake Vanuxem. Outlets were at Syracuse to the Mohawk-Hudson, at elevation of 900 feet and declining.

While the ice was resting against the salient at Batavia it receded from the hills south and west of Syracuse permitting the impounded glacial waters to escape eastward, a direction of outflow contrary to the former stage. The waters are named for Lardner Vanuxem, whose district in the early Geological Survey of New York comprised the central portion of the State.

The higher terraces on the delta either side of the canyon at Mount Morris, at 840, 800 and 740, may have been made during this stage; also the deposits about the mouth of the Keshequa, and the lower terraces east of Bishop Corners, at 825 and 750.

St Helena-Gibsonville morainal lake. When the waters fell below 900 feet on the Mount Morris parallel the valley above the "High Banks" was left holding a local lake, which we name as given above. In preglacial time this valley probably opened to the south [*see* p. 73] as the walls at the north are rock. The lake may be called morainal, however, since the south end was blocked by the Portage moraine.

The St Helena-Gibsonville morainal lake (or St Helena lake for brevity) was contemporaneous with the Lake Vanuxem and later waters. The initial height of the lake is definitely shown by the broad gravel plain, coinciding with the top of the rock, at the "High Banks" at 900 feet; and the extensive delta plateau opposite the Silver lake outlet also at 900 feet. All terraces in the St Helena Valley below 900 feet must belong to the local lake and correlate with the downcutting of the Mount Morris canyon.

As the crest of the lower Portage falls is only 850 feet in altitude they could not have been initiated until the "High Banks" outlet and St. Helena lake was lowered to that level.

Tuscarora morainal lake. With the falling of the waters in the Dansville valley below 800 feet a local morainal lake was left in the lower or northern part of the Nunda valley, due to the drift blockade south of Sonyea. This local water did not reach as far as Nunda but covered the site of Tuscarora.

The point of lowest escape was north of the moraine, and north of the ancient valley. Falling on the rock the outlet was compelled to cut the shallow canyon, about 100 feet deep, southwest of Sonyea now occupied by the Keshequa creek and utilized by the railroad. During stages 9 to 12 the cutting must have proceeded, but with interruptions as the base level waters in the Dansville valley changed their level.

Stage 10. Avon lake. Outlets were at Honeoye Falls, Rush and Mendon, at 700 down to 580 feet, eastward to the Mohawk-Hudson.

Following the Vanuxem stage the ice at Syracuse receded so as to allow free river-flow through the site of that city and there was no extensive lake then held in central New York. But in the Genesee Valley the ice lay so far to the south that a local lake was held in the valley with its levels determined by the outlets noted above. The highest of these channels lies 2 miles west of Honeoye Falls and the lowest is the excellent abandoned channel followed by the Lehigh Valley Railroad through Rush to Mendon, at 580 feet. This Avon lake flooded the Dansville valley.

Stage 11. Second Lake Vanuxem. The relationship of phenomena in the Genesee and Batavia region theoretically requires a readvance of the ice at Syracuse and the restoration of the glacial Lake Vanuxem.[1]

It is not determined to what height the second Vanuxem rose, but it may have reached an altitude approaching 840 feet on the Mount Morris parallel. While this water lay over the Genesee region the ice backed away from the Batavia salient sufficient to allow Lake Warren to spread in from the west, and we have stage 12.

Stage 12. Lake Warren. Outlet was across the State of Michigan into the glacial lake Chicago and out to the Mississippi. Altitudes of the Warren beaches are generally about 880 feet in central New York, but on the Mount Morris parallel the plane is about 840 feet.

Stage 13. Lake Dana. Outlet was eastward toward the Mohawk-Hudson, at elevation about 700 feet, or about 660 feet on the Mount Morris parallel.

Lake Dana was only the longest of the pauses in the lowering of the Warren waters toward the Iroquois level. It is one phase of the Hyper-Iroquois waters.

The filling of the Genesee valley from Dansville to Scottsville with lake silts and smoothing them to the present form has been a process in activity since the sixth stage, and is now carried on by the present streams.

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[1] The discussion of the glacial lake history of central New York and description of the drainage channels and lake phenomena will be found in a forthcoming bulletin of the State Museum.

Later stages

Other stages now recognized are those of the Scottsville lake; Lake Iroquois; Gilbert gulf (sea level waters); and Lake Ontario. As water planes they lie inferior to the valley bottom at Mount Morris and therefore do not properly appear in this connection.

Epitome of the history

Stage 4 Belfast-Fillmore lake. Outlet at Cuba; 1496 feet. Portage moraine formed.

Stage 5 Portage-Nunda lake. Outlet at Swains; 1320 feet. Erie viaduct terraces formed.

Stage 6 Dansville lake. Outlet at Burns; 1210 feet. Portageville morainal lake and beginning of the Portage canyon. Delta terraces at Glen Iris and mouth of Wolf creek.

Stage 7 Mount Morris-Geneseo lake. Outlets at Linden-Bethany; 1200–1000 feet. Delta terraces about the lower falls.

Stage 8 Lake Hall. Outlets at Batavia; 1000–900 feet. Terraces east of Bishop Corners; Nunda plain.

Stage 9 Lake Vanuxem. Outlets at Syracuse; 900 and declining. St Helena-Gibsonville morainal lake and beginning of the "High Banks" canyon. Tuscarora morainal lake and beginning of the Sonyea ravine. Upper terraces on Mount Morris delta.

Stage 10 Avon lake. Outlets at Honeoye Falls-Rush; 700–580 feet. Filling in Dansville-Avon valley.

Stage 11 Second Lake Vanuxem. Outlets at Syracuse; 700 feet and rising.

Stage 12 Lake Warren. Outlet via Chicago to Mississippi; about 840 feet on the Mount Morris parallel.

Stage 13 Lake Dana. Outlet toward the Mohawk-Hudson; about 660 feet on the Mount Morris parallel.

Canyons and cataracts

The Portage canyon was cut by the outflow of the morainal lake held in the valley above Portageville, the earlier flow being into the glacial waters of stages 6–8, described above, and the later flow into the St Helena morainal lake.

The ravine and cataracts were not produced by free and uninterrupted flow of the river, with deepening of the whole ravine from north to south, or upstream. The cutting of the canyon progressed downward from the top and from south to north. The upper cataract was established first and independently before the lower or deeper portion of the canyon had any existence. The down cutting of the canyon proceeded only as the receiving waters (stages 6–8) were lowered. The quantitative or progressive relationship of the two factors is uncertain, but it is quite possible that the glacial waters were so long-lived that the canyon cutting kept pace with or were even limited by the falling baselevel waters.

This relation of river and lakes explains the existence of three cataracts instead of only one, as would probably have been the case if the river could have fallen freely through the whole distance from Portageville to St Helena and the canyon cutting could have progressed normally and without vertical limitation. In rocks of variable hardness or resistance a stream might alone develop multiple cataracts, but the variation of the strata in the Portage section is not sufficient to cause three cataracts with the spacing that now exists.

When the Portageville morainal lake came into independent existence by the fall of the broader glacial waters below the level of the Erie Railroad viaduct plain, stream outflow began, probably at about the position of the railroad viaduct. The fall of the stream, however, was limited by the level of the receiving waters, and during the long life of the Dansville and Mount Morris-Geneseo lakes (stages 6 and 7) the river work was restricted to the higher part of the canyon. The lower part of the canyon, including the middle and lower contracts, did not then exist, being covered and protected by the lake waters. The upper and south cataract was independently initiated and established, and probably receded some distance, before the lower and northern part of the gorge had any existence. Eventually the falling of the glacial waters through the stages 6 and 7 brought the river into play in the horizon of the middle cataract.

As the crest of the third and youngest cataract is only about 850 feet elevation it is below the top of the High Banks canyon at Mount Morris, and it is therefore evident that the lowest part of the Portage canyon and the lowest cataract came into existence only as the High Banks was cut.

On account of the changes which have been produced subsequent to the initiation of the cataracts and the withdrawl of the glacial waters it is not possible to correlate with precision the production of the cataracts and the limiting lake waters. The upper cataract correlates with the Mount Morris-Geneseo lake, though the beginning of the canyon was during the life of the Dansville lake. The middle cataract, with a crest altitude of 1005 feet, seems to belong with the Lake Hall stage. The lower cataract correlates with Lake Vanuxem and later stages. The initiation of the Portage canyon was an interrupted process, covering a varied lake history and a long period of time.

The Mount Morris or High Banks canyon is in shales of such weakness and uniformity that probably no large cataract was ever produced. The river rapidly removed all obstructions to its flow and acquired a uniform or graded slope. The initiation of the gorge was probably during the closing phase of Lake Hall, and the gorge may have been entirely cut during the life of the first Lake Vanuxem and the Avon lake. The gorge was cut from the top downward, and probably the erosion kept pace with the fall of the waters in the Dansville valley. If the strata were as hard as the Portage rocks probably cataracts would occur here also.

The history of the Rochester canyon is similar to that of the Portage. The upper cataract was established during the life of Lake Iroquois, the plane of which was nearly 200 feet above that of Lake Ontario. With the falling away of the Iroquois waters the lower and northern part of the gorge, with the middle and lower cataracts, came into existence.

Deformation of the lake planes

In making close correlation of the lake phenomena and drainage it is necessary to take into the account the warping or tilting of the land which has occurred since the glacial time, and the consequent rise to northward which has been given to all the planes of the ancient lakes. The amount of deformation of the Portage-Mount Morris district is not known with precision but probably it is not far from 2 feet per mile.

The difference in the height of the correlating features according to latitude has not been regarded in the above description, except in a few cases. The figures used in the description are the altitudes which the features have as they stand today. In order to find the correlating planes for localities of different latitude 2 feet per mile should be added for northing or substracting for southing.[1]

[1] Some discussion of the matter of deformation of the lake planes is given in N. Y State Mus. Bul. 106, p. 76–79.

For close correlation of the lake-level features some allowance should be made for the depth of water in the outlet channel, and for the down cutting of the outlet during the life of the lake.

Detrital filling of the valleys

All the ancient valleys have been so filled with glacial drift and lake sediments that in the absence of borings the grade slopes of the streams can not be determined. The localities of diverted drainage have been blocked by morainal drift, while the more open stretches of the valleys are more or less filled with stream detritus and lake silts, which may overlie glacial deposits.

The old valley above Portage has been considerably filled with glacial rubbish and later by lake sediments during the lacustrine stages 4 and 5.

The St Helena valley was largely filled with delta stuff during the stages 6 to 8, and during the life of the St Helena-Gibsonville morainal lake. With the cutting down of the "High Banks" it has been reexcavated. Any flooding during the stages 11 to 13 that overtopped the outlet stream must have produced deposition with subsequent reexcavation.

The Nunda valley was subject to lake deposition during the stages 6 to 9, and stages 11 and 12.

The old and broad valley from Dansville to Avon has evidently been subject to lake filling during all the stages from 6 to 13, and stream aggradation is still active.

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New York State Education Department

New York State Museum

JOHN M. CLARKE, Director

PUBLICATIONS

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These reports are made up of the reports of the Director, Geologist, Paleontologist, Botanist and Entomologist, and museum bulletins and memoirs, issued as advance sections of the reports.

Director's annual reports 1904–date.

These reports cover the reports of the State Geologist and of the State Paleontologist. Bound also with the museum reports of which they form a part.

Report for 1904. 138p. *20c.* 1905. 102p. 23pl. *30c.* 1906. 186p. 41pl. *35c.*

Geologist's annual reports 1881–date. Rep'ts 1, 3–13, 17–date, O; 2, 14–16, Q.

In 1898 the paleontologic work of the State was made distinct from the geologic and was reported separately from 1899–1903. The two departments were reunited in 1904, and are now reported in the Director's report.

The annual reports of the original Natural History Survey, 1837–41, are out of print.

Reports 1–4, 1881–84, were published only in separate form. Of the 5th report 4 pages were reprinted in the 39th museum report, and a supplement to the 6th report was included in the 40th museum report. The 7th and subsequent reports are included in the 41st and following museum reports, except that certain lithographic plates in the 11th report (1891) and 13th (1893) are omitted from the 45th and 47th museum reports.

Separate volumes of the following only are available.

Report	*Price*	*Report*	*Price*	*Report*	*Price*
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14	.75	18	.75	22	.40
15, 2v.	2	19	.40	23	.45
16	1	20	.50	[*See* Director's annual reports]	

Paleontologist's annual reports 1899–date.

See first note under Geologist's annual reports.

Bound also with museum reports of which they form a part. Reports for 1899 and 1900 may be had for 20c each. Those for 1901–3 were issued as bulletins. In 1904 combined with the Director's report.

Entomologist's annual reports on the injurious and other insects of the State of New York 1882–date.

Reports 3–20 bound also with museum reports 40–46, 48–58 of which they form a part. Since 1898 these reports have been issued as bulletins. Reports 3–4, 17 are out of print, other reports with prices are:

Report	*Price*	*Report*	*Price*	*Report*	*Price*
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5	.25	11	.25	18 (" 17)	.20
6	.15	12	.25	19 (" 21)	.15
7	.20	13	.10	20 (" 24)	.40
8	.25	14 (En 5)	.20	21 (" 26)	.25
				22 (" 28)	.25

Reports 2, 8–12 may also be obtained bound separately in cloth at 25c in addition to the price given above.

Botanist's annual reports 1867–date.

Bound also with museum reports 21–date of which they form a part; the first Botanist's report appeared in the 21st museum report and is numbered 21. Reports 21–24, 29, 31–41 were not published separately.

Separate reports for 1871–74, 1876, 1888–98 are out of print. Report for 1899 may be had for 20c; 1900 for 50c. Since 1901 these reports have been issued as bulletins [*see* Bo 5–9].

Descriptions and illustrations of edible, poisonous and unwholesome fungi of New York have also been published in volumes 1 and 3 of the 48th (1894) museum report and in volume 1 of the 49th (1895), 51st (1897), 52d (1898), 54th (1900), 55th (1901), 56th (1902), 57th (1903) and 58th (1904) reports. The descriptions and illustrations of edible and unwholesome species contained in the 49th, 51st and 52d reports have been revised and rearranged, and, combined with others more recently prepared, constitute Museum memoir 4.

Museum bulletins 1887–date. O. *To advance subscribers,* **$2** *a year or* **$1** *a year for division* (1) *geology, economic geology, paleontology, mineralogy; 50c each for divisions* (2) *general zoology, archeology and miscellaneous,* (3) *botany,* (4) *entomology.*

Bulletins are also found with the annual reports of the museum as follows:

Bulletin	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*
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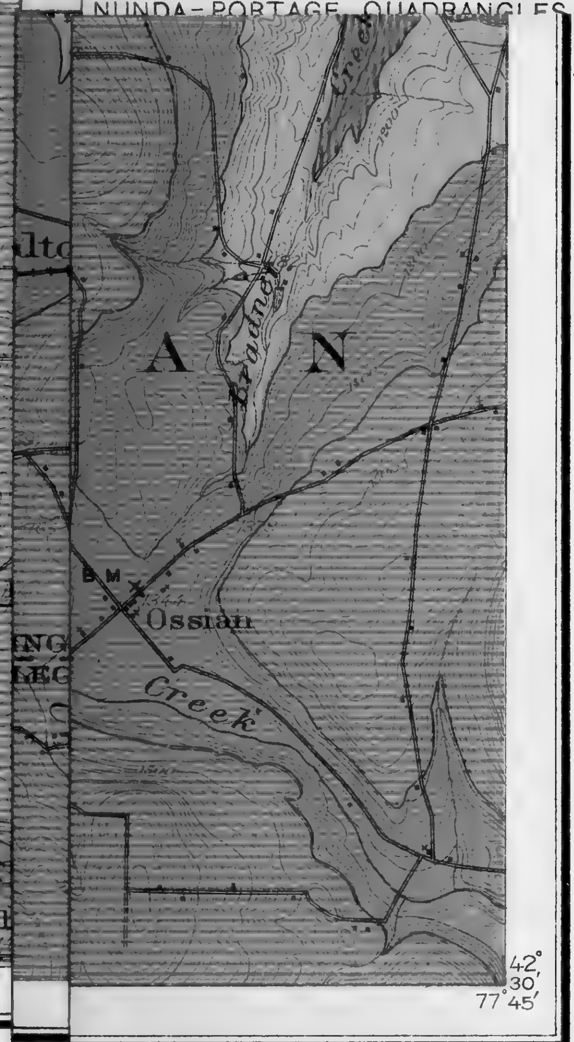

Geology by D. D. Luther.

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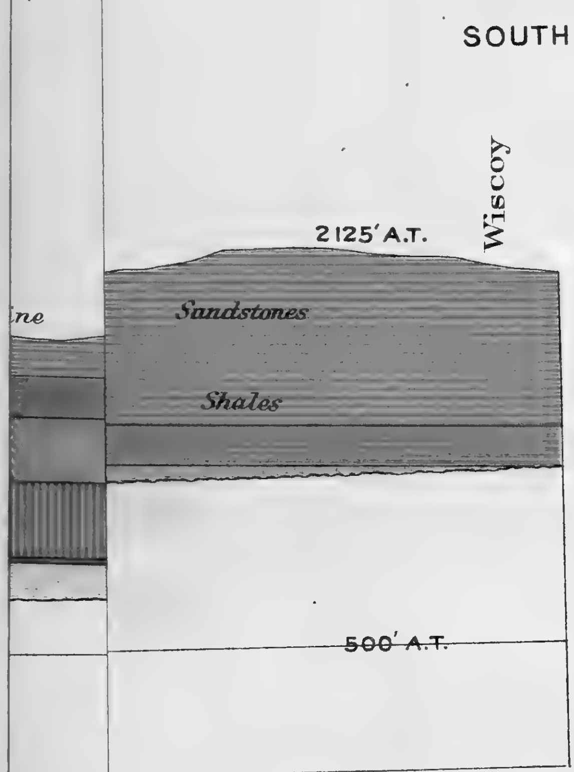

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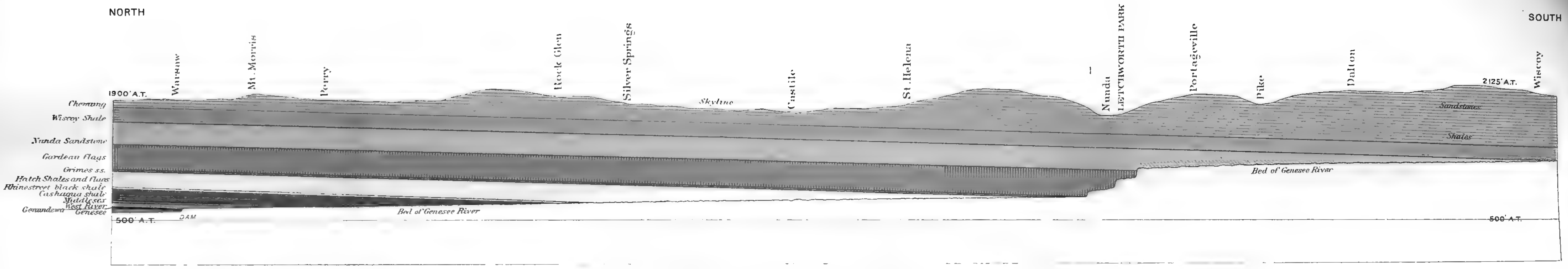
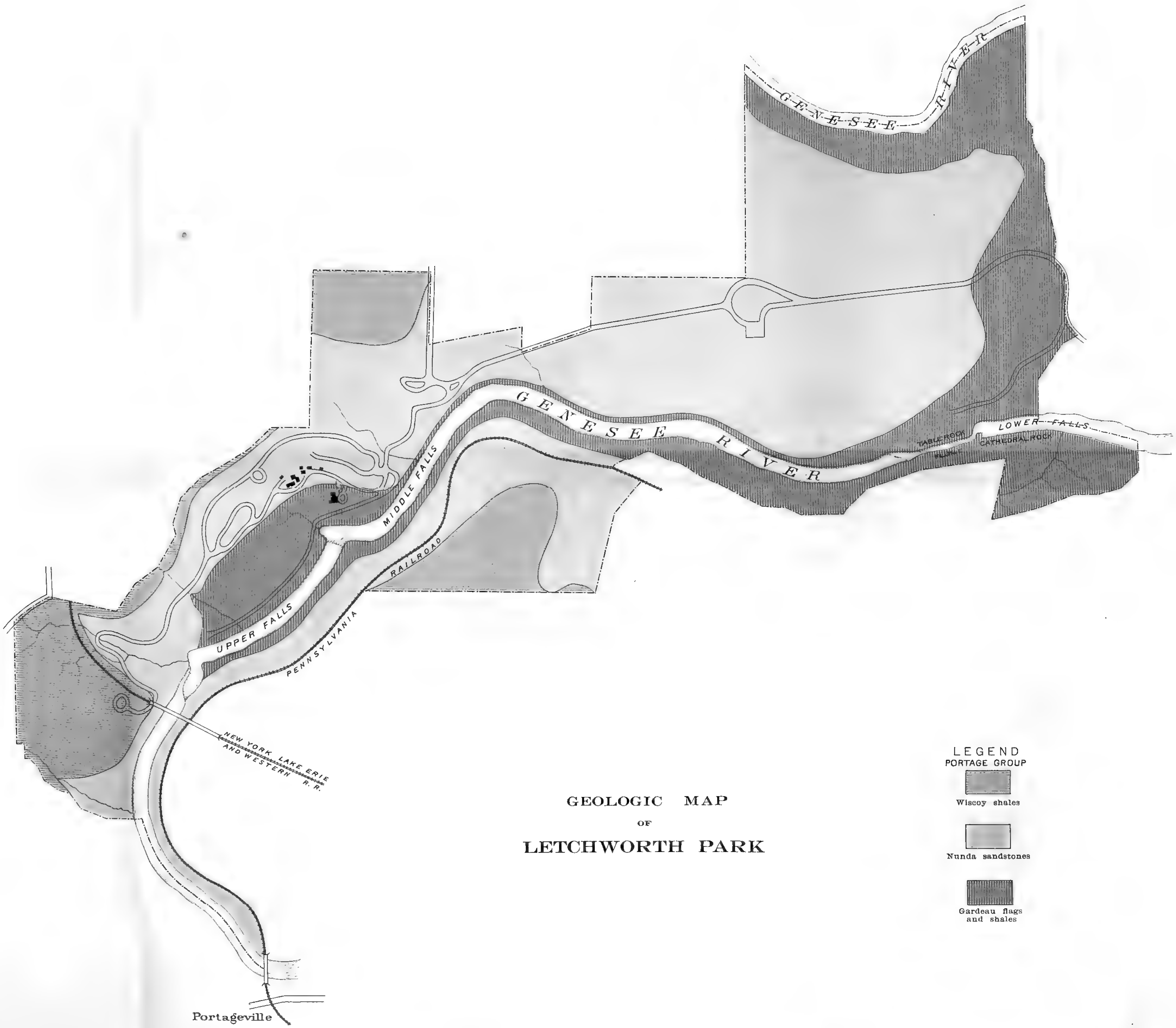


DIAGRAM SHOWING ROCK SECTION EXPOSED ON NUNDA AND PORTAGE QUADRANGLES IN THE GENESEE RIVER VALLEY

VERTICAL SCALE 1 INCH = 1000 FEET
HORIZONTAL " 1 " = 1 MILE

118



GEOLOGIC MAP OF LETCHWORTH PARK