Education Department Bulletin

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New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 153

GEOLOGY OF THE BROADALBIN QUADRANGLE, FULTON-SARATOGA COUNTIES, NEW YORK

BY

WILLIAM J. MILLER

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ALBANY

UNIVERSITY OF THE STATE OF NEW YORK

1911

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New York State Education Department

Science Division, June 23, 1911

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

My dear sir:

I have the honor to transmit herewith the manuscript of a report entitled *The Geology of the Broadalbin Quadrangle,* accompanied by a geological map. This report has been prepared under my direction by Professor William J. Miller, and is recommended for publication as a bulletin of the State Museum.

Very respectfully

John M. Clarke

Director

STATE OF NEW YORK

EDUCATION DEPARTMENT

COMMISSIONER'S ROOM

Approved for publication this 27th day of June 1911

A. S. Draper

Commissioner of Education

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INTRODUCTION

The Broadalbin quadrangle (see map in pocket of back cover) represents about 218 square miles and is bounded by latitude lines 43° and 43° 15′ N., and longitude lines 74° and 74° 15′ W. The geographic position is along the southeastern border of the Adirondacks with the Fulton-Saratoga county line passing nearly north and south through the middle of the territory. A few square miles of the northwest corner lie in Hamilton county. The principal villages are Northville and Broadalbin in Fulton county, and Batchellerville and Galway in Saratoga county. Sacandaga Park, the well-known summer resort, is located just across the river from Northville. The Fonda, Johnstown and Gloversville Railroad has its terminal at Northville which village, during the summer season, is an important gateway to the southern Adirondacks. The region was formerly heavily forested but practically all of the first growth timber has been removed. The highlands of the north, which are in most respects typically Adirondack in character, are still pretty densely covered with second growth. These highlands are very sparsely settled while the lowlands are mostly well occupied. Next to farming, perhaps the chief industry is the manufacture of gloves, factories being located at both Northville and Broadalbin.

GENERAL GEOGRAPHY AND GEOLOGY

In general the quadrangle presents a fairly rugged topography and for some portions the term mountainous might well be applied. The maximum range in altitude is from less than 720 feet, where the Sacandaga river leaves the sheet, to over 2020 feet about two and one-half miles west of Northville.

As shown on the topographic map, two mountain masses stand out conspicuously in the northwestern and the northeastern portions of the quadrangle respectively. The importance of these features may be best appreciated by viewing them from the low divide between Northville and Edinburg, from where they appear like mountain ridges rising abruptly above the surrounding country. The western highlands show elevations commonly from 1800 to 2000 feet, while the eastern highlands generally run from 1600 to 1800 feet above the sea.

Between the highlands lies a broad lowland district (elevation 720 to 850 feet) extending from Northville southward nearly to Broadalbin. The lowest part is occupied by a great level stretch of swamp land known as the "Vly" and by the Sacandaga river flats. The central northern portion, between Northville and Edinburg, is hilly with altitudes of from 900 to 1300 feet. The southern portion of the quadrangle is mostly covered with deep drift and is characteristically hilly with elevations of from 800 to 1200 feet.

The drainage of the district presents some unusually interesting features. The largest stream is the Sacandaga river, a branch of the Hudson, which enters the sheet from the northwest. At Northampton this river suddenly swerves sharply to a north-northeast course which is held for the eight miles past Batchellerville to the map limit, whence it cuts across a wide belt of Precambric rock to empty into the Hudson at Luzerne. Little less remarkable is the course of Kennyetto creek which has its source in the western part of the Saratoga sheet and, after a west-southwesterly course for some fifteen miles to Vail Mills, suddenly swerves to the north-northeast for over eight miles to empty into the Sacandaga at Northampton. Hans creek also shows a similar change in its course. This remarkable tendency of the streams to turn back on their courses will be explained in a later portion of this report [see page 54].

The watershed or division of drainage between the Sacandaga and Mohawk rivers passes across the southern part of the sheet so that only about one-third of the map area drains into the Mohawk.

The largest south flowing stream is Chuctanunda creek which reaches the Mohawk at Amsterdam.

Geologically considered the district shows a great variety of rock formations and structures. The highlands of the north consist of rocks which belong to the oldest (Precambric) known formations of New York State. They comprise very ancient sediments and igneous rocks which have been profoundly changed from their original condition. No less than four distinct types of these rocks have been recognized within the quadrangle.

Another great set of formations younger in age and resting upon the Precambric belongs to the Paleozoic system. All the lowlands of the district are occupied by these formations which are ancient sediments such as limestones, sandstones and shales and which have not been greatly changed from their original condition.

The most recent deposits of the quadrangle are of Pleistocene age.[1] They are vastly younger than the Paleozoics and include the most recent deposits of the earth. They are merely superficial deposits of sand, gravel and clay irregularly scattered over the country and were formed either during or after the Glacial epoch (Ice age) when New York was buried under a great sheet of ice.

The structure or arrangement of the rock masses has been very noticeably affected by displacements or faulting of the earth's crust. The quadrangle is unusual for its number of faults, no less than fourteen with considerable displacement having been located. The most prominent topographic features of the quadrangle are due to faulting as, for example, the steep fronts of the highland masses already described.[2]

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[1] A chapter on the Pleistocene (glacial) geology of the quadrangle has not been included in this bulletin because Professor Brigham, who has carefully studied the glacial history of this and the neighboring Gloversville, Amsterdam, and Fonda sheets, has already presented a brief report (see paper below cited) and a more elaborate account will soon be forthcoming.

[2] The following list comprises the principal papers having a bearing upon the geology of the quadrangle:

1823. Steele. Geology of Saratoga Co. Mem. Board Agric. State N. Y. Vol. 2.

1842. Vanuxem. Geology of the 3rd Dist. N. Y.

1843. Mather. Geology of the 1st Dist. N. Y.

1893. Darton. Geology of the Mohawk Valley, 13th An. Rept. N. Y. State Geologist.

1894. Darton. Faulted Region of Herkimer, Fulton, Montgomery, and Saratoga Counties. 14th An. Rept. N. Y. State Geologist.

1899. Kemp & Hill. Precambric Formation in parts of Warren, Saratoga, Fulton, and Montgomery Counties. 19th An. Rept. N. Y. State Geologist.

1900. Cumings. Lower Silurian System of Eastern Montgomery Co. N. Y. State Mus. Bul. 34.

PRECAMBRIC ROCKS

The most ancient rocks, which are of Precambric age, occupy about two-fifths of the area of the quadrangle. The term "Precambric" is used because these rocks have not, as yet, been correlated with either the Archean or the Algonkian. They include both sediments and igneous masses which have been highly metamorphosed, and represent a portion of the southern border of the large Precambric area of the Adirondacks and underlie all the Paleozoic rocks of the quadrangle.

GRENVILLE SERIES

The rocks of the Grenville series are the most ancient of the Precambrics and consist of highly metamorphosed sediments. These rocks represent old sandstones and shales together with some limestones which have been so thoroughly crystallized and foliated that most of the original sedimentary characters have been obliterated. Within the quadrangle proofs of the sedimentary origin of the Grenville consist in the occurrence of many layers of widely different composition; of crystalline limestone and quartzite strata; and of graphite and garnet crystals. While in the field the writer particularly observed the relation of the Grenville to the other rock masses, but not even a suggestion of any older formation could be found.

Varieties of Grenville. The Grenville, which is so abundantly and magnificently shown and which presents extreme variations in mineralogy, is exhibited under so many different facies that it would be hopeless to attempt a description of them all. After studying many specimens and microscopic sections, a careful selection of the most characteristic facies has been made and the descriptions of these immediately following will perhaps give the best idea of the Grenville within the quadrangle:

1 Crystalline limestone. This rock, which is medium to coarse grained and calcitic, is sometimes pure and white but it is often mottled with green serpentinous material (ophicalcite) which is probably derived by the decomposition of pyroxene. It is in thin layers

1900. Prosser. Notes on Stratigraphy of Mohawk Valley and Saratoga Counties. N. Y. State Mus. Bul. 34.

1908. Brigham. Glacial Geology of Amsterdam, Fonda, Gloversville and Broadalbin quadrangles, N. Y. State Mus. Bul. 121, p. 21–31.

1910. Ulrich & Cushing. Age and Relation of the Little Falls Dolomite of the Mohawk Valley. N. Y. State Mus. Bul. 140, p. 97–140.

1911. Miller, W. J. Preglacial Course of the Upper Hudson River. Geol. Soc. Am. Bul. 22:177–186.

Plate I

W. J. Miller, photo

Grenville gneiss showing stratification and steep dip. The rock is chiefly quartzite interbedded with thin layers of gray gneiss. Three-fourths of a mile north-northeast of Batchellerville.

and closely involved with thin-bedded, gray, feldspathic and quartzitic gneisses. The only outcrop actually observed is in the bed of Cadman creek just below the bridge three-fourths of a mile north-northwest of Barkersville. Although other small occurrences may have escaped notice, it is certain that the limestone is present only in small amount.

2 Quartzite. The rock from one and one-quarter miles northeast of Batchellerville is perhaps the most typical and is coarse grained, light brown to almost white, and made up of nearly pure quartz with occasional very thin layers containing small flakes of badly decomposed mica. The rock is foliated, highly granulated and often stained with iron oxid. A thin section shows[1] 96 per cent quartz; 2 per cent orthoclase; 1 per cent biotite mostly changed to chlorite; and small amounts of epidote, zircon, apatite and zoisite. The epidote occurs in fine euhedral prismatic crystals which are sometimes distinctly twinned and show a pleochroism from greenish yellow to reddish brown to lavender blue. A thin section from north of Northville shows a total absence of feldspar. In some cases, as one mile northwest of Mosherville, the quartzite is quite feldspathic and filled with graphite flakes.

3 A dark to pinkish gray, distinctly banded gneiss rich in garnet, sillimanite and pyroxene. Under the microscope the rock shows 20 per cent orthoclase; 5 per cent plagioclase (chiefly andesine); 25 per cent garnet; 20 per cent quartz; 10 per cent pyroxene — pale brown, euhedral, monoclinic crystals — probably augite; 10 per cent sillimanite in long slender prisms; 5 per cent biotite; 2 per cent magnetite; 1 per cent pyrite and chalcopyrite; and 1 per cent each of epidote and graphite. The garnets are as large as one-quarter of an inch across, of very clear amethystine color, and distributed through the whole rock. The biotite is largely concentrated in distinct layers. This rock outcrops finely at Glenwild. Rocks very similar to these except for lack of pyroxene are prominently exposed two and one-half miles northwest of Cranberry Creek and two miles northeast of Northville.

4 A very straight, light and dark banded, highly feldspathic gneiss which in thin section shows 60 per cent orthoclase, microcline, and microperthite in about equal amounts together with a little plagioclase; 20 per cent quartz; 10 per cent biotite; 5 per cent sillimanite; 5 per cent garnet of amethyst color; and a little zircon.

[1] Only a close approximation to the mineral composition (volumetric proportions) is intended in this and the following sections of Precambric rocks.

The whole rock shows decided evidence of severe dynamic metamorphism, the feldspars especially being crushed and granulated. Such rock is common on the mountain side one and one-half miles south of Batchellerville.

5 A light gray, medium-grained, rather massive looking gneiss occurring in abundance one and one-half miles southeast of Fox Hill and consisting of 30 per cent orthoclase; 15 per cent plagioclase-oligoclase to andesine; 40 per cent quartz; 10 per cent garnet; 5 per cent biotite; and a little zircon. Other gneisses similar to this but very fine grained and lacking garnet are prominent at the base of Bald Bluff and also two miles west of Cranberry Creek.

6 Light gray leaf gneiss. This rock is medium to coarse grained, highly granulated, and contains 25 per cent orthoclase; 20 per cent microcline; 5 per cent microperthite; 10 per cent oligoclase; 35 per cent quartz; 4 per cent biotite; and traces of magnetite, garnet, zoisite, and zircon. It is a fine example of leaf gneiss, the quartz crystals being drawn out into long flat forms. Good outcrops occur two miles south of Batchellerville and similar rocks, but containing some garnet, occur well up the face of Bald Bluff and along the road one-half mile northwest of Northville.

7 A distinctly straight and thin banded, dark, hornblendic gneiss in large exposures three miles northeast of Northville. It contains 18 per cent microperthite; 15 per cent orthoclase; 10 per cent microcline; 5 per cent plagioclase (mostly oligoclase); 20 per cent hornblende in fine green pleochroic crystals; 18 per cent quartz; 5 per cent biotite; 5 per cent garnet; 2 per cent magnetite; 1 per cent zoisite; and small amounts of zircon, pyrite, and apatite. A rock similar to this but not clearly banded and richer in plagioclase feldspar is abundant along the northern border of the Grenville area southwest of Sacandaga Park.

8 A highly schistose rock showing thin, white and dark gray bands and containing 15 per cent orthoclase; 8 per cent plagioclase (oligoclase to andesine); 50 per cent quartz; 10 per cent garnet; 15 per cent biotite; and 2 per cent epidote and zircon in fine crystals. The garnet and biotite are present in tiny specks and flakes respectively. This is a fine illustration of a highly granulated and dynamically metamorphosed, banded sedimentary rock. Large exposures occur two miles west-southwest of Cranberry Creek and one mile east of Fox Hill.

9 White feldspar, quartz gneiss from large outcrops toward the top of Bald Bluff. It is characterized by the total absence of dark colored minerals and consists of 34 per cent orthoclase; 20 per cent

microcline; 10 per cent microperthite; 5 per cent plagioclase; 25 per cent quartz; 5 per cent garnet; and a very little zircon. The rock is pretty well granulated and is perfectly white except for an occasional large, light amethyst-colored garnet which stands out prominently in the white matrix.

Igneous rocks in the Grenville. Closely involved with the true Grenville sediments are occasional masses of what appear to be undoubted igneous rocks. A fine illustration occurs on the mountain side one and one-half miles due south of Batchellerville where there is a considerable belt (about ten feet wide) of very porphyritic, dark, hornblendic, thoroughly gneissoid rock included within typical Grenville and parallel to its foliation. The thin section shows 20 per cent plagioclase (oligoclase to labradorite); 10 per cent orthoclase; 50 per cent hornblende; 10 per cent biotite; 8 per cent quartz; 2 per cent magnetite; and a little apatite and zircon. It is holocrystalline and has the composition of a quartz diorite. The phenocrysts are sharp edged crystals of feldspar often an inch long and mostly arranged parallel to the foliation but some are at various angles.

Another igneous looking rock occurs in the Grenville toward the top of Bald Bluff. This rock is very dark grey, medium grained and distinctly gneissoid. It contains 10 per cent orthoclase; 20 per cent plagioclase (chiefly labradorite but with some andesine); 30 per cent hypersthene (brown pleochroic); 20 per cent green hornblende; and 20 per cent biotite. Still another rock from two miles northeast of Northville is similar to this except that it is richer in feldspar and hypersthene and lacks the biotite. These last two rocks have the composition of hypersthene gabbro or norite.

The examples above cited are illustrations of others which have been noted in the field and the composition, texture, and field appearance all strongly argue for their igneous origin. The texture and field relations show the intrusive character of the rocks and that the intrusions probably took place practically parallel to the bedding planes of the sediments. The gneissoid structure proves that the intrusions must have occurred well before the cessation of the dynamic forces of compression which developed the foliation of the Grenville. On the other hand these rocks are older than the nonmetamorphosed dike rocks below described.

Areal distribution of the Grenville. The Grenville is by far the most widespread formation of the quadrangle, its areal extent of over sixty square miles being much greater than that of all the other Precambrics combined. In addition to this the Grenville is also prominent in the areas of mixed gneisses below described but it is there too intimately associated with the other rocks to admit of separate mapping. Even in the areas actually mapped as Grenville the rock is not always pure because at times small masses of igneous rocks are intimately associated. In such cases the writer has mapped as Grenville all areas where the sediments greatly preponderate. On the adjoining Saratoga sheet the Grenville is also extensive so that it is much more prominent along the southeastern than the southwestern border of the Adirondacks.

As shown on the accompanying geologic map the Batchellerville-Barkersville area is the largest within the quadrangle. A strike of from north 30° to 50° east with southerly dip of from 30° to 60° is very common over all the area except the northeast portion where the strike is north 80° east with dip 20° south and the extreme south where the strike is north 80° east with dip nearly vertical. Nearly all the varieties above described are to be found, the feldspar-quartz-biotite-garnet gneisses being by far the most common. As already stated, limestone has been observed at but one locality and such a small amount in this large Grenville mass is not a little surprising. Quartzites, which must have been derived from very pure sandstones, are quite common and three fairly well-defined belts are especially noteworthy [see map]. One of these belts, about a mile long and a third of a mile wide, lies just to the northeast of Batchellerville. Much of the quartzite is very pure and in thin to thick beds with strike north 30° west, dip 30° south and apparently showing a thickness of hundreds of feet. The second quartzite belt, about two miles long and one-half mile wide, lies southeast of Fox Hill. The rock is thin-bedded and much like a quartz schist with frequent thin layers of mica. It strikes mostly north 70° west dip 20° south. A third belt comprises all of the Grenville tongue just north of North Galway. It is a very pure quartzite and the beds, which stand nearly vertical, strike north 80° east. The four inliers[1] in the vicinity of North Galway are also of quartzite. Throughout this great area the Grenville is unusually pure and free from closely involved igneous intrusions except around Johnnycake lake and in the region to the east of Parkersville, but even in these cases the sediments greatly preponderate.

In the area northeast of Northville no limestone and little or no quartzite has been noted. Frequently granitic and syenitic rocks

[1] The term "inlier" is here used as defined in Scott's Geology, 2d edition, p. 384.

in small masses have been encountered, as e. g. one and one-half miles west and two and one-half miles northwest of Edinburg, but, on the whole, the rocks are decidedly Grenville and have been so mapped. For the most part they are feldspar-quartz-biotite-garnet gneisses with occasional hornblende or sillimanite gneisses. The strike is generally northeast and dip from 20 to 40° south.

Two small outcrops of the quartzite may be seen along Butler creek (below the falls) at Edinburg where the creek has just cut through the Potsdam, but they are too small to be shown on the geologic map.

North of Northville the small area shows chiefly feldspar-quartz-garnet-gneisses with a distinct belt of pure quartzite along the northern border. These rocks strike east-west and dip 45° south.

The Grenville area southwest of Sacandaga Park is characterized chiefly by feldspar-quartz-biotite-garnet gneisses and schists. Toward the west these rocks are rather massive looking, dark gray and rich in hornblende; while toward the northeast and south they are clearly banded, contain sillimanite and lack hornblende, and frequently have in them small outcrops of granitic and syenitic rocks. The strikes and dips of this area are very variable.

In the area west of Cranberry Creek the rocks are, toward the north, mostly thin bedded, very schistose, granulated, and severely dynamically metamorphosed. Toward the south, in the Precambric tongue, they are mostly thin-bedded feldspar-quartz-garnet gneisses, at times associated with small masses of good porphyritic syenite or granite. Throughout this area the strike is fairly constant north 40° east, dip 30° south.

Stratigraphy and thickness of the Grenville. From the above it is evident that the great bulk of original Grenville sediments were shales, often sandy and carbonaceous, and that these were associated with smaller amounts of pretty pure sandstone and impure limestone. It was hoped that the largest Grenville area might furnish some clew to the stratigraphy of these ancient sediments and, although no conclusive results have been obtained, some suggestive observations have been made. From a point three-quarters of a mile north-northeast of Batchellerville to a point one and one-half miles southeast of Fox Hill is four miles and the line connecting these points passes, at right angles to the strike, over an apparently regular succession of Grenville strata. The dip of the beds is from 20° to 30° to the southeast. Taking the average dip as 25° the thickness of the Grenville in this partial section would be nearly 10,000 feet which is very small compared with recent estimates of Professor Adams for the Grenville of Canada. Beginning at the west the base of this section is quartzite, in thin to thick beds, about 800 feet thick, which grades into graphitic (feldspar-quartz-garnet-biotite) rather thin-bedded gneisses approximately 1500 feet thick. Then come something like 6000 feet of thicker bedded feldspar-quartz-garnet-biotite gneisses which are succeeded by about 500 feet of thin bedded quartzites. Finally, at the summit of the section, come at least 1000 feet of gray garnet gneisses. The upper quartzite is not thought to be a repetition of the lower quartzite because it is thinner bedded, more impure, and is not succeeded by the graphitic beds. There is, of course, the possibility that profound faulting has affected the section but there is no evidence for this in the field.

SYENITE

The syenite as here described is regarded as being of the same age and general character as similar rocks so common in the Adirondacks. Within the quadrangle the rock shows its igneous origin by its composition and uniform character in large masses as well as by its relation to the Grenville. It is clearly intrusive into, and therefore younger than, the Grenville as proved by frequent inclusions of the latter rock within its mass. In the field the homogeneous appearance of the syenite is in marked contrast to the variable Grenville. The rock always shows a distinct gneissic structure which is often so straight and well developed as to give a schistose appearance. The color of the fresh rock is greenish to light gray and it weathers to a light brown. The main mass of the rock is usually medium grained but it is frequently fairly porphyritic with phenocrysts (up to one-half inch) of feldspar more or less drawn out parallel to the foliation. In thin section the syenite is usually highly granulated and this, together with the frequent schistose character, indicates that it has been subjected to very intense compression.

Perhaps the best representative of the average syenite of the quadrangle is the mass forming the high hill to the north of Northville. Under the microscope slides from this rock contain on an average: 25 per cent orthoclase; 18 per cent microperthite; 8 per cent plagioclase (oligoclase); 22 per cent quartz; 15 per cent hornblende; 6 per cent garnet; 5 per cent magnetite; together with a little apatite, zircon and zoisite. This rock is much like Cushing's typical Loon lake syenite except that the pyroxene is here entirely replaced by hornblende. This rock is greenish gray and fine grained except for occasional small porphyritic feldspars. The garnet and magnetite are very fine grained and scattered through the rock.

An extreme variation of the syenite from near the top of Buell mountain is notable for high quartz (25 per cent), magnetite (10 per cent) and biotite (15 per cent) and failure of hornblende.

Another variation of the rock which in the field, two and one-half miles north-northeast of Batchellerville, looks like typical syenite shows in the slide: 45 per cent orthoclase; 10 per cent plagioclase (andesine to oligoclase); 20 per cent quartz; 20 per cent hornblende (changing to chlorite); 5 per cent magnetite; and small amounts of zircon, apatite and zoisite. This variety is notable for its high hornblende content and lack of microperthite. In still other cases biotite and hornblende occur in the same slide.

The failure of green pyroxene in the syenite here harmonizes with the observations of Cushing regarding the Adirondack syenites in general, namely, that in the more quartzose varieties the hornblende is likely to predominate even to the complete exclusion of the pyroxene.

The syenite from the Round lake area is generally pretty quartzose, has biotite instead of hornblende, and is unusually massive in appearance though clearly gneissoid. It is certainly an intrusive rock of syenitic or granitic makeup and in the absence of evidence to the contrary is classed with the other syenite of the quadrangle.

In the small area directly west of Cranberry Creek the rock is a pure syenite but very porphyritic and gneissoid.

The following analysis of what is regarded as the most typical syenite, from the quarry, near the river, one mile northwest of Northville, has been made for the writer by Professor E. W. Morley:

$Si\ O_2$	66.35
$Al_2\ O_3$	14.09
$Fe_2\ O_3$	1.81
$Fe\ O$	4.49
$Mg\ O$	1.05
$Ca\ O$	3.16
$Na_2\ O$	3.32
$K_2\ O$	4.08
$H_2\ O$	.35
$Ti\ O_2$	1.00
$P_2\ O_5$	.40
$Mn\ O$	.17
S	.04
Cl	.02
F	.03
$Ba\ O$	.03
$Zr\ O$	trace
	100.39

The norm and position of this rock in the quantitative classification are as follows:

	Per cent	Mol.	Ilm.	Apat.	Orth.	Alb.	An.	Mag.	Diop.	Hyp.	Qtz.
SiO_2	66.35	1.106	....	....	254	318	82	....	12	63	377
Al_2O_3	14.09	.138	....	....	44	53	41	....	....	....	.....
Fe_2O_3	1.81	.011	....	....	....	....	....	11	....	....	.....
FeO	4.49	.063	13	....	....	....	....	11	3	36	.....
MgO	1.05	.026	....	....	....	....	....	....	2	24	.....
CaO	3.16	.056	....	10	....	....	41	....	5	....	.....
Na_2O	3.32	.053	....	....	....	53	....	....	....	....	.....
K_2O	4.08	.044	....	....	44	....	....	....	....	....	.....
H_2O	.35	....	....	....	....	....	....	....	....	....	.....
TiO_2	1.00	.013	13	....	....	....	....	....	....	....	.....
P_2O_5	.40	.003	....	3	....	....	....	....	....	....	.....
MnO	.17	.003	....	....	....	....	....	....	....	3	.....
S	.04	....	....	....	....	....	....	....	....	....	.....
Cl	.02	....	....	....	....	....	....	....	....	....	.....
F	.03	....	....	....	....	....	....	....	....	....	.....
BaO	.03	....	....	....	....	....	....	....	....	....	.....
ZrO	trace	....	....	....	....	....	....	....	....	....	.....

$$\left.\begin{array}{ll} \text{Qtz...} & 22.62 \\ \text{Orth..} & 24.46 \\ \text{Alb...} & 27.77 \\ \text{An...} & 11.40 \end{array}\right\} \text{Sal.} = 86.25$$

$$\left.\begin{array}{ll} \text{Diop..} & 1.17 \\ \text{Hyp..} & 7.45 \\ \text{Mag..} & 2.55 \\ \text{Ilm...} & 1.98 \\ \text{Apat..} & .93 \end{array}\right\} \text{Fem.} = 14.08$$

100.33

$$\text{Class, } \frac{\text{Sal.}}{\text{Fem.}} = \frac{86.25}{14.08} < 7/1 > 5/3 = \text{II, Dosalane}$$

$$\text{Order, } \frac{Q}{F} = \frac{22.62}{63.63} < 3/5 > 1/7 = 4, \text{ Austrare}$$

$$\text{Rang, } \frac{K_2O + Na_2O}{CaO} = \frac{97}{56} < 7/1 > 5/3 = 2, \text{ Dacase}$$

$$\text{Subrang, } \frac{K_2O}{Na_2O} = \frac{44}{53} < 5/3 > 3/5 = 3, \text{ Adamellose}$$

The Sal-Fem ratio brings the rock pretty close to the Persalane class, while the alkalicalcic ratio closely approaches that of Rang 3 (Tonalase) and the Subrang approaches Dacose.

Mode calculated from measured sections

	Total diameters	Relative volumes	Sp. gr.	Units by weight	Percentage weights
Microperthite	1687	19.68	2.6	4386	18.10
Orthoclase	1824	21.28	2.6	4742	19.57
Plagioclase	1243	14.49	2.63	3269	13.48
Hornblende	1248	14.54	3.2	3994	16.48
Quartz	1935	22.57	2.65	5128	21.17
Magnetite	240	2.80	5.25	1260	5.20
Garnet	330	3.84	3.7	1221	5.04
Zircon	9	.10	4.5	41	.17
Apatite	17	.20	3.2	54	.22
Zoisite	40	.47	3.26	130	.54
	8573	99.97		24225	99.97

This rock which, under the old classification, is a quartz-hornblende-syenite is, under the new classification, a hornblende-adamellose.

The high magnetite content of the measured sections calls for more iron oxid than is shown in the analysis, but it must be remembered that the amount of magnetite varies notably even in very short distances so that in the particular slides measured it runs higehr than in the material analyzed. Also the titanium most likely replaces iron oxid in the magnetite to form a titaniferous magnetite thereby lessening the necessary amount of iron oxid.

A comparison of this syenite with the granite porphyry and with certain other Adirondack rocks is given in a table on page 21.

GRANITE PORPHYRY

The typical granite porphyry presents a striking contrast to the typical syenite as regards texture, mineralogical composition, and general appearance in the field. It is an unquestioned igneous rock of gray to pinkish gray color, thoroughly gneissoid, homogeneous in large masses, and intrusive into the Grenville. Three minerals — feldspar, quartz, and biotite — are always prominent to the naked eye. In the typical rock a finely developed porphyritic texture never fails, the phenocrysts of feldspar, often an inch or more in length, being more or less flattened out parallel to the foliation. These phenocrysts are imbedded in a fine-grained mass of feldspar, quartz and biotite. Often quartz also occurs in large crystals (phenocrysts) which have been so thoroughly flattened out parallel to the foliation as to present a decided leaf-gneiss effect. The rock, in thin section, always shows evidence of severe crushing and granulation. The granulation of the feldspar phenocrysts is often visible to the naked eye.

The features will perhaps be best brought out by a description of the most representative rock from each of the areas shown on the geologic map. What may be regarded as the most typical granite porphyry of the quadrangle occurs in the area one and one-half miles north of Northville and contains on the average about: 20 per cent microperthite; 20 per cent microcline; 12 per cent orthoclase; 10 per cent oligoclase to andesine; 30 per cent quartz; 6 per cent biotite; 1 per cent magnetite; and small amounts of apatite, zircon and zoisite. This rock is light pinkish gray and with phenocrysts of microcline. The analysis and quantitative classification of a sample rock from this area is given below.

A representative granite from two and one-half miles west-southwest of Sacandaga Park is similar in composition to the rock just described except that it is slightly richer in microperthite and quartz and lower in orthoclase. This rock is gray weathering to brown, thoroughly gneissoid and granulated, and with phenocrysts of microperthite. The leaf-gneiss structure is beautifully developed owing to the flattening out of quartz into large plates.

Very similar in composition to these rocks is that from the small area east of Batchellerville, except for a high biotite content and the presence of 1 or 2 per cent of garnets scattered through the mass. This granite is thoroughly gneissoid and granulated but exhibits nothing of the leaf-gneiss effect. The reason for the garnets here is not at all certain, but they may be due to a slight assimilation of the surrounding Grenville by the molten granite.

From these descriptions it is seen that the typical granite porphyry differs from the typical syenite chiefly in its prominent porphyritic character, higher quartz and biotite content, presence of microcline, and total absence of hornblende.

Perhaps the best illustration of granite porphyry which presents certain features very similar to the syenite is that from the area just west of Sacandaga Park. A slide shows: 35 per cent orthoclase; 12 per cent microperthite; 18 per cent oligoclase to andesine; 25 per cent quartz; 7 per cent biotite; 2 per cent magnetite; and 1 per cent zoisite, zircon, apatite and garnet. Mineralogically this rock is almost exactly like the more acid syenite except for the substitution of biotite for hornblende. The boundary line between the granite and syenite here can not be drawn with accuracy because of the apparent gradation of the one rock into the other and this fact, together with the failure to find any evidence of one of these rocks cutting the other, leads to the belief that the granite and syenite are of practically the same age and that they are differentiation products of the same magma.

The following analysis of what is regarded as the most typical granite (above described), from one and three-fourths miles north-northwest of Northville, has been made for the writer by Professor E. W. Morley:

Plate 2

W. J. Miller, photo

Granite porphyry showing a typical outcrop with its jointing. One-half mile southwest of Sacandaga Park.

$Si\ O_2$	71.45
$Al_2\ O_3$	13.83
$Fe_2\ O_3$	1.10
$Fe\ O$	1.91
$Mg\ O$	.56
$Ca\ O$	1.44
$Na_2\ O$	2.62
$K_2\ O$	6.09
$H_2\ O$	.32
$Ti\ O_2$	.42
$P_2\ O_5$	.03
$Mn\ O$	.17
$Ba\ O$	.02
S	.02
Cl	.03
F	.01
$Zr\ O$	.02
	100.04

The norm and place of this rock in the quantitative chemical classification are calculated as follows:

	Per cent	Mol.	Ilm.	Apat.	Orth.	Alb.	An.	Cor.	Mag.	Hyp.	Qtz.
$Si\ O_2$	71.45	1.191	....	....	390	252	50	....	....	31	468
$Al_2\ O_3$	13.83	.135	....	....	65	42	25	3	....	....	.....
$Fe_2\ O_3$	1.10	.007	....	....	....	....	....	....	7	....	.....
$Fe\ O$	1.91	.026	5	....	.....	....	....	....	7	14	.....
$Mg\ O$	.56	.014	....	....	....	....	....	....	....	14	.....
$Ca\ O$	1.44	.026	....	.7	....	....	25	....	....	....	.....
$Na_2\ O$	2.62	.042	....	....	....	42	....	....	....	....	.....
$K_2\ O$	6.09	.065	....	....	65	....	....	....	....	....	.....
$H_2\ O$	.32	....	....	....	....	....	....	....	....	....	.....
$Ti\ O_2$	.42	.005	5	....	....	....	....	....	....	....	.....
$P_2\ O_5$	.03	.0002	....	.2	....	....	....	....	....	....	.....
$Mn\ O$	.17	.003	....	....	....	....	....	....	....	3	.....
S	.02	....	....	....	....	....	....	....	....	....	.....
Cl	.03	....	....	....	....	....	....	....	....	....	.....
F	.01	....	....	....	....	....	....	....	....	....	.....
$Ba\ O$	.02	....	....	....	....	....	....	....	....	....	.....
$Zr\ O$	.02	....	....	....	....	....	....	....	....	....	.....

Qtz.	28.08	
Orth.	36.14	
Alb.	22.01	Sal. = 93.49
An.	6.95	
Cor.	.31	
Hyp.	3.64	
Mag.	1.62	Fem. = 6.08
Ilm.	.76	
Apat.	.06	
	99.57	

$$\text{Class, } \frac{\text{Sal.}}{\text{Fem.}} = \frac{93.49}{6.08} > 7/1 = \text{I, Persalane}$$

$$\text{Order, } \frac{Q}{F} = \frac{28.08}{65.10} < 3/5 > 1/7 = 4\text{, Brittanare}$$

$$\text{Rang, } \frac{K_2O + Na_2O}{Ca\ O} = \frac{107}{26} < 7/1 > 5/3 = 2\text{, Toscanase}$$

$$\text{Subrang, } \frac{K_2O}{Na_2O} = \frac{65}{42} < 5/3 > 3/5 = 3\text{, Toscanose}$$

The potash-soda ratio is such that the rock comes close to subrang 2, Dellenose.

Mode calculated from measured sections

	Total diameters	Relative volumes	Sp. gr.	Units by weight	Percentage weights
Microperthite	1788	19.50	2.6	4648	18.95
Orthoclase	1155	12.64	2.6	3003	12.24
Microcline	1810	19.74	2.6	4706	19.18
Plagioclase	1014	11.06	2.63	2667	10.87
Quartz	2717	29.63	2.65	7200	29.35
Biotite	500	5.45	3.00	1500	6.12
Magnetite	90	.98	5.25	473	1.93
Zoisite	60	.65	3.26	196	.80
Zircon	21	.22	4.5	94	.38
Apatite	13	.14	3.2	42	.17
	9168	100.01		24529	99.99

According to the old classification this rock is a biotite-granite-porphyry while under the new classification it is a biotite-granophyro-toscanose.

From the above it is seen that the Northville syenite and granite, though in different classes, fall in exactly corresponding orders, rangs, and subrangs and this, together with the fact that the syenite is close to the Persalane border, shows that these two rocks are closely related in the quantitative chemical classification. Thus the field relations, examination of thin sections and chemical composition of these two rocks, which present such a marked difference in appearance, afford practically conclusive proof that they are of the same age and represent differentiation products from the same magma, the granite representing merely somewhat more salic (richer in quartz and feldspar) portions of the cooling magma.

In the following table the Northville syenite and granite are compared with certain other carefully studied Adirondack rocks:

	1	2	3	4	5	6	7
SiO_2	66.35	64.47	62.41	61.01	71.45	66.72	68.50
Al_2O_3	14.09	10.51	18.75	15.36	13.83	16.15	14.69
Fe_2O_3	1.81	1.11	2.49	2.98	1.10	1.23	1.34
FeO	4.49	7.37	4.91	7.77	1.91	2.19	3.25
MgO	1.05	5.21	.61	.78	.56	.73	.26
CaO	3.16	3.10	3.17	4.05	1.44	2.30	2.20
Na_2O	3.32	2.21	3.09	3.68	2.62	4.36	3.50
K_2O	4.08	3.63	4.25	3.90	6.09	5.66	5.90
H_2O	.35	.93	.41	.49	.32	.77	.40
TiO_2	1.00	.....	.....	.....	.42	.....	......
P_2O_5	.40	.25	.....	.....	.03	.....	.03
MnO	.17	.....	.....	.08	.17	.07	.10
S	.04	.12	.....	.....	.02	.....	......
Cl	.02	.....	.....	.....	.03	.....	......
F	.03	.....	.....	.....	.01	.....	......
BaO	.03	.....	.....	.....	.02	.....	.05
ZrO	trace	.....	.....	.....	.02	.....	......
CO_2	.....	.58	.....	.....	.....	.....	......
	100.39	99.49	100.09	100.10	100.04	100.18	100.22

1 Quartz-hornblende-syenite (Adamellose) from 1 mile northwest of Northville. E. W. Morley, analyst.
2 Syenite, gneissoid (Adamellose). Whitehall, N. Y. W. F. Hillebrand, analyst. N. Y. State Mus. Bul. 138, p. 45.
3 Augite-syenite (Adamellose). Ticonderoga, Essex co. M. K. Adams, analyst. N. Y. State Mus. Bul. 138, p. 45.
4 Augite-syenite (harzose). 3½ miles north of Tupper Lake Junction. E. W. Morley, analyst. N. Y. State Mus. Bul. 115, p. 514.
5 Biotite-granite-porphyry (Toscanose). 1¾ miles north-northwest of Northville. E. W. Morley, analyst.
6 Augite-syenite (Toscanose). Little Falls, N. Y. E. W. Morley, analyst. N. Y. State Mus. Bul. 115, p. 514.
7 Quartz-syenite (Toscanose). 2½ miles south of Willis pond, Altamont, Franklin co. E. W. Morley, analyst. N. Y. State Mus. Bul. 115, p. 514.

These analyses represent rocks of the syenite-granite series from widely separated places in the Adirondacks and they serve to illustrate the close chemical relationship existing between the rocks of the series. Still other analyses may be found in Museum Bulletins 115 and 138.

Numbers 1, 2, 3, and 4, in the quantitative system, all belong in class 2 (Dosalane) and order 4 (Austrare). The first three are in rang 2 (Dacase) and subrang 3 (Adamellose) while the fourth is in rang 3 (Tonalase) and subrang 3 (Harzose).

Numbers 5, 6, and 7 are all in class 1 (Persalane) ; order 4 (Brittanare) ; rang 2 (Toscanase) ; and subrang 3 (Toscanose).

Thus, according to the chemical classification, the only important difference between the first four and the last three is that of class and even this is not always sharp as shown in the cases of the Northville syenite and granite.

MIXED GNEISSES

Under this heading are included various gneisses but chiefly more or less intimate mixtures of Grenville, syenite, and granite. For most part the Grenville appears to predominate but because of the presence of so much other rock it is thought best to map these mixed gneisses separately. It is often difficult to draw the boundary lines between these gneisses and the other rocks because anything like sharp contacts are wholly lacking. The Grenville has been much cut up by intrusions of syenite or granite so that small masses of good igneous rock and good Grenville often exist in close proximity. At times rather clear-cut inclusions of Grenville occur within the igneous masses. Again, gneisses are commonly seen which could scarcely be called good Grenville nor yet good syenite or granite, but which in every way look like rocks which may have resulted from the incorporation, by fusion, of Grenville into the molten masses. The more the writer observes these mixed gneisses along the western and southern border of the Adirondacks, the more is he impressed with the very strong evidence in favor of assimilation.

A great variety of gneisses is shown in the area northeast of Batchellerville. Grenville is present to a greater or less extent throughout the area and is at times very pure as, for example, where it forms the wall rock of the feldspar mine on the south side or just east of the end of the branch road shown on the map. Porphyritic granitic looking gneiss is abundant from the mine northward, while syenite shows in large exposures one-third of a mile south of the mine. South of the branch road gray, rather massive, granitelike gneisses are common.

Due north of Northville the mixed gneiss area, with numerous outcrops, affords a fine illustration of intimately associated Grenville, syenite, and granite. The continuation of this area to the west of the river well shows the passage of the mixed gneisses into pure syenite through uninterrupted exposures. The Grenville generally preponderates but often massive syenitic rocks are present. One and one-quarter miles due north of Buell mountain a mass (forty or fifty feet across) of typical thin-bedded Grenville quartzite forms a clearly defined inclusion in the syenite.

In the area west-northwest of Cranberry Creek the Grenville is frequently intimately associated with masses of granite porphyry or syenite. The Grenville is often badly twisted and looks like inclusions or masses more or less melted in with the igneous rock.

PEGMATITE DIKES

Numerous pegmatite dikes have been found cutting through the Grenville, syenite, and granite. A few of the larger and more accessible ones are located as follows: At the feldspar mine two and one-half miles north-northeast of Batchellerville; two miles north of Edinburg; two miles northeast of Northville; and about two miles west of Sacandaga Park. These dikes are apparently all nonmetamorphosed and they cut through the country rock in very irregular shaped masses and stringers. A description of the pegmatite at the feldspar mine north of Batchellerville will be fairly illustrative of the other occurrences. This rock has recently been described by Mr E. S. Bastin of the U. S. Geological Survey and the following extracts are from his report:[1] " The rock is a granite pegmatite which has been worked from two open pits. Quartz occurs in pure masses several feet across and also in graphic intergrowth with feldspar. The feldspar is light gray microcline, finely intergrown with small amounts of albite. It occurs in pure masses, the largest four feet across, and the feldspars of some of the coarser phases of the graphic granite are three feet across. The finer grained parts of the pegmatite contain ' books ' of muscovite oriented in every direction. Biotite is not abundant, but one flat crystal observed was four feet long and three feet wide. Beryl, of dark blue-green color, translucent to transparent, is moderately abundant. The pegmatite for two or three feet next to the contact of the pegmatite with the schist at this pit is an irregular or arborescent intergrowth of quartz and feldspar inclosing some large muscovite ' books.' The pegmatite is intrusive, with sharp contacts with a light gray to dark gray quartz-biotite-feldspar gneiss of variable character. The contact in some places parallels the foliation and in other places cuts sharply across it."

Whether the pegmatite is older or younger than the black basic dikes below described has not been determined within the quadrangle. However, just beyond the map limits, and in an abandoned feldspar mine two and one-half miles west-northwest of Cranberry Creek, a pegmatite and a basic (diabase?) dike may be seen in sharp vertical contact and the basic rock cuts the pegmatite thus proving the greater age of the latter in this case at least.

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[1] Feldspar Deposits of the United States, U. S. G. S. Bul. 420.

GABBRO AND DIABASE DIKES

With one or two possible exceptions, these black dike rocks represent the latest igneous activity of the district. Some are true gabbros while others are diabases. In all, nine of these dikes — four west of Northville, four in the vicinity of Batchellerville and one at Barkersville — have been noted, but more than likely others occur in the woods. The dike at Barkersville is somewhat gneissoid and for this reason is rather doubtfully classed with the other eight, all of which appear to be entirely devoid of metamorphism. In all cases the rock is hard and fresh, due to the fact that the decomposed material has all been removed by ice erosion. These basic rocks are certainly younger than the Grenville, syenite, or granite since these latter have all been cut by the dikes. Also the eight non-metamorphosed dikes were certainly intruded after the cessation of the pressure which produced the foliation of the Precambric rocks. That they are of Precambric age has not been proved within the quadrangle itself, but their close similarity to such rocks occurring in the Adirondacks, and the fact that no such rocks have been seen cutting the Paleozoic in this part of the State, leaves little room for doubt regarding their Precambic age. The gneissic structure of the Barkersville dike suggests that it is older than either the nonmetamorphic basic dikes or the pegmatite, but its mineral composition is almost precisely like that of the Batchellerville dikes.

The variations in these rocks will perhaps be best shown by describing several types. A thin section from the dike one mile northeast of Batchellerville shows: 60 per cent lath-shaped plagioclase (andesine to labradorite); 25 per cent hypersthene (faintly pleochroic); 10 per cent biotite (much changed to chlorite); and 5 per cent magnetite (much changed to leucoxene). This rock is a true hypersthene diabase with the ophitic texture beautifully shown. The dike is about 400 yards long and of varying width up to 100 feet. The rock is fine to medium grained, weathers brown on the immediate surface, shows no sharp contacts, and strikes parallel to the general foliation of the Grenville. In close proximity to the dike the Grenville is usually badly twisted, probably due to the force of intrusion of the molten rock. The composition of the dike at Barkersville is almost exactly like this except for a little hornblende and pyrite.

The dike three-quarters of a mile west-northwest of Northville shows about: 50 per cent basic plagioclase; 25 per cent hyper-

Plate 3

W. J. Miller, photo

Dikes of basic rock (norite) cutting hornblende syenite. One mile north-northwest of Northville and at the edge of the river.

sthene; 15 per cent hornblende; 5 per cent biotite; and 5 per cent magnetite. This rock is a non-metamorphosed, medium grained hypersthene gabbro or norite which, in every way, greatly resembles the dike gabbros of the North Creek sheet now being studied by the writer and which, in that region, seem to be older than the fine grained diabases.

A slide from the basic dike rock one mile north-northwest of Northville contains: 35 per cent plagioclase (labradorite with some andesine); 15 per cent orthoclase (some with albite twinning); 20 per cent hypersthene (pale green to reddish brown pleochroism); 25 per cent hornblende; 5 per cent magnetite; and a little pyrite and zircon. The rock shows a fine grained granitoid texture which, because of its unusual composition, should be called a hornblende-orthoclase-hypersthene gabbro or norite. At this locality there is not a single dike but rather a number of small branching tongues which are beautifully shown in relation to the syenite. Some of the branches cut through the syenite very irregularly while others are perfectly parallel to the gneissic bands. There is no sign of contact metamorphism along the very sharp contacts with the greenish gray syenite.

PALEOZOIC ROCKS

The Paleozoic formations, which are all of Cambric and Ordovicic ages, occupy about three-fifths of the area of the quadrangle. Because of their distinct stratification, fossil content, and lack of metamorphism they present sharp contrasts to the Precambric rocks. These strata have been little disturbed by folding or tilting except near the faults where the dip is often pronounced. Because of the faulting the general Paleozoic dip can not be well determined, but from Barkersville southward it is something like seventy-five or eighty feet per mile southwestward.

POTSDAM SANDSTONE

The Potsdam sandstone, which is of upper Cambric age, is the oldest Paleozoic formation of the district. It everywhere rests upon the Precambric, being separated from the ancient gneisses by a profound unconformity. The absence of Lower Cambric strata here and their presence along the eastern border of the State clearly shows that the Cambric sea encroached upon the land from the east. Speaking of the Potsdam sandstone of the Adirondack region Cushing says:[1] " It is thickest on the northeast, thinning out to disappearance both to the south and west. As, furthermore, it appears to be the upper beds which persist, and the lower ones which disappear in these directions, it seems certain that, so far as the immediate region is concerned, the marine invasion came on it from the northeast." This accounts for the fact that, in the Broadalbin region, the Potsdam is so thin and represents only the upper part of the formation. In Clinton county it is thickest, being certainly over one thousand feet. The evidence is clear and concise that, within the quadrangle, the Potsdam was deposited on a fairly uneven surface [see page 51] which accounts for the rapid local changes in the strata from place to place. Although the formation is widespread under cover of later sediments, the present outcrops are limited to a few comparatively small areas as shown on the geologic map.

The base of the Potsdam in the southeastern portion of the quadrangle is characterized by a coarse conglomerate of unusual interest. The best exhibitions of this basal member are in the vicinity of Kimball's Corners one-half mile northeast of North Galway. Here are fine exposures of Grenville quartzite and the conglomerate, resting upon the Grenville, shows in large almost continuous outcrops for nearly half a mile. The actual contact may be seen at one or two points as shown in plate 5. The conglomerate varies in thickness from nothing to eight or ten feet and the grayish-white fragments, ranging in size up to two or three feet, are often angular so that the term breccia might well be applied. The fragments are imbedded in a matrix of sand and are all of quartzite which have been directly derived from the immediately underlying Grenville by wave action. The surface on which the conglomerate was deposited was locally very irregular and the large boulders seem to have got into the small depressions along the shore as shown by the occurrence of heavy beds of conglomerate either side of a little tongue or ridge of Grenville near Kimball's Corners. Only at times is there evidence for very crude stratification and this, together with the large size and angular character of the fragments suggests a rapid deposition of the material. Above the conglomerate there is very little sandstone, the succeeding passage beds being within a few feet, so that the Potsdam is represented nearly altogether by the conglomerate.

Smaller outcrops of similar conglomerate practically in contact with the Grenville occur one-third of a mile southeast of North

[1] N. Y. State Mus. Bul. 95, p. 354.

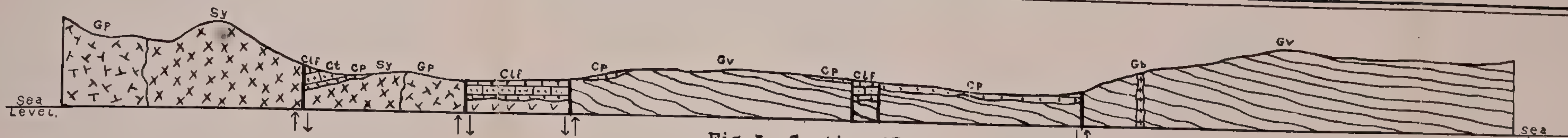

Fig. I. Section AB.

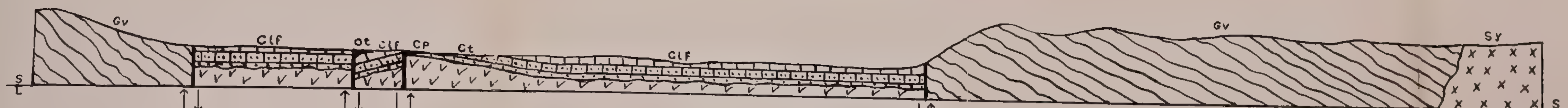

Fig. 2. Section CD.

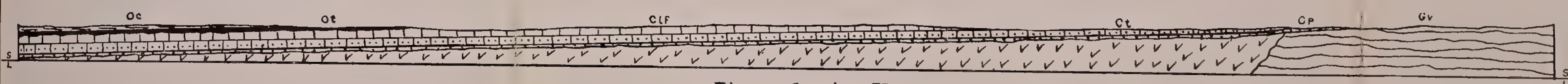

Fig. 3. Section EF.

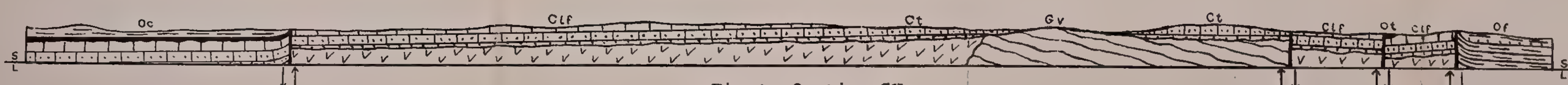

Fig. 4. Section GH.

Figures 1-4 Structure sections across the Broadalbin quadrangle. The positions of the sections and the meaning of the symbols is shown on the accompanying geologic map. Vertical scale is twice the horizontal.

Galway and at the edge of the Amsterdam reservoir. A fine exposure of the coarse conglomerate occurs in the bed of the small stream (wrongly placed on the map) one-third of a mile due north of Barkersville. Other outcrops are one-quarter of a mile west of the last named locality and along the creek one-half mile southwest of Barkersville.

A very similar conglomerate, at the base of the Potsdam, has been described by Smyth[1] as occurring at several points on Wells and Grindstone islands in the Thousand Island region. Cushing[2] has also described a coarse conglomerate at the base of the very thick Potsdam in Clinton county but there the rock is red and contains much comparatively fresh feldspathic material.

Three-fourths of a mile southwest of Barkersville, and along the road, there is a large outcrop of typical Potsdam sandstone which is gray, fine-grained, thin-bedded, and frequently ripple-marked. In the creek one mile north-northeast of Mosherville typical Potsdam sandstone is exposed and though no contact is visible the rock doubtless comes against the Hoffman's Ferry fault.

An excellent Potsdam section may be seen along the creek at Edinburg. The section comprises chiefly typical looking sandstone but there are certain notable variations. The lowermost layer exposed (just below Latcher's falls) is a hard, gray, quartzitic rock which greatly resembles the Grenville. This layer is practically in contact with Grenville quartzite which may be seen in a very small outcrop about one hundred feet below the falls. In the lower portion of the falls there are two distinct beds of sandy conglomerate from one to three feet thick and containing pebbles as much as one or two inches in diameter. Between the conglomerate beds there is a distinct shaly layer containing the fossil shells of Lingula. At the crest of the falls there are two or three thin layers of good dolomitic limestone. The thickness of Potsdam below the highway bridge at Edinburg is estimated at from forty to fifty feet with a general dip of from two to four degrees to the southeast. Just above the bridge about ten feet of typical thin-bedded sandstones are exposed.

A mile west of Edinburg, and on the same creek, is a large outcrop of thin-bedded Potsdam sandstone in actual contact with the Grenville. The lowest beds are dark gray, quartzitic, and look much like the Grenville. The dip is 15 degrees to the southeast.

Half a mile east-southeast of Northville are numerous exposures

[1] 19th An. Rept. N. Y. State Geologist, 1899, p. 299.
[2] N. Y. State Mus. Bul. 95, p. 355.

of the sandstone in close proximity to the Precambric. Conglomerate was not observed here but dolomitic and calcitic beds even within a few feet of the Precambric are more prominent than at Edinburg. The dip varies considerably but is mostly toward the southeast and apparently some thirty or forty feet of Potsdam is present. The sandstone containing rotten calcareous beds may be seen along the road due east of Northville. Typical sandstone outcrops one and one-half miles southeast of Northville and also in the south end of Gifford valley where the dip is about 4 degrees southwestward.

On Bunker hill the sandstone is finely exposed in a quarry where a thickness of about fifteen feet of the rock is shown. Certain beds are beautifully ripple-marked and occasionally there are yellowish to reddish-brown iron stained layers. The dip is 10 degrees southeast.

On Roberts creek, two and one-half miles southwest of Cranberry Creek village, and also three-fourths of a mile due south of this locality there are good outcrops of typical thin-bedded Potsdam near the Precambric and dipping five degrees to the southwest. The thickness is estimated at about forty feet.

From the above description it is seen that the Potsdam varies in thickness from nothing to about fifty feet and that the lithologic character changes rapidly in short distances.

THERESA FORMATION

The Theresa formation constitutes a perfect transition series between the Potsdam sandstone and the Little Falls dolomite. It was named by Cushing three years ago in the Thousand Islands region and, as modified from its original usage, it now applies only to the Potsdam-Little Falls passage beds so commonly present in New York. Lithologically the formation consists of alternating beds of pure, gray, fine-grained sandstone and bluish-gray, fine-grained, dolomitic limestones. The beds are seldom more than a foot thick. The sandstone layers bear a remarkable similarity to the underlying Potsdam, while the limestone layers are practically indistinguishable from those of the overlying dolomite formation. Cavities, lined with calcite and quartz crystals and similar to those of the Little Falls formation, are frequently found in the limestone beds. The sandstone beds often, and the limestone beds sometimes, show cross-bedding and ripple marks. Toward the base of the formation the limestone layers are occasionally sandy and contain pebbles up to half an inch in diameter.

Plate 4

N. H. Darton, photo

Glaciated surface of Potsdam conglomerate. The largest boulders are nearly three feet across. One and one-half miles a little south of west of Mosherville.

Plate 5

N. H. Darton, photo

Potsdam conglomerate on Grenville quartzite. One and one-half miles a little south of west of Mosherville.

Plate 6

W. J. Miller, photo

Potsdam sandstone at Latcher's falls in the village of Edinburg

Downward the Theresa formation is in no sense sharply separated from the Potsdam and no distinct line can be drawn. Even in what must certainly be regarded as Potsdam, an occasional thin layer of limestone occurs. Upward the transition to the Little Falls dolomite is less gradual, the top of the Theresa, within the quadrangle, apparently being marked by a rather massive bed of sandstone of unusual thickness (five feet) and prominence. This sandstone bed, which has heretofore been mistaken for the Potsdam, outcrops one-half of a mile south of Mosherville; one-fourth of a mile southwest of Parks Mill; one and one-third and two miles west and one and one-half miles southwest of Galway; one-half of a mile north-northeast of West Galway; in the northern end of Gifford valley, etc. What appear to be small cryptozoon forms, not over an inch in diameter, have been noted one-fourth of a mile east of North Galway; one mile northwest and one and one-half miles southwest of Galway. Oolite has been observed one-fourth of a mile east of North Galway and also in drift fragments three-fourths of a mile east of Northampton.

Within the map limits no fossils (except cryptozoon) have been found and the relation of these beds to the fossiliferous Hoyt limestone of the Saratoga region is not exactly known. While it is possible that the upper part of the Broadalbin passage beds may correspond to the Hoyt limestone of Saratoga, it is certain that the Hoyt limestone, as such, does not reach the Broadalbin sheet nor do any of its fossils so far as known. In view of these facts the writer finds it necessary to class together all the transition beds as Theresa and so map them on the Broadalbin sheet.

No continuous section has been found within the map limits but a mile south of East Galway, there is an excellent section showing all but the uppermost beds in nearly continuous outcrop down to the Potsdam. The thickness is here approximately two hundred feet with perfect transition to the Potsdam well shown. Westward from this locality to Parks Mill and Mosherville there are many outcrops of the Theresa formation. Another excellent display of the formation is in the ridge between Galway and the Amsterdam reservoir where the lowest beds are not visible but the thickness must be nearly two hundred feet.

According to Ulrich and Cushing[1] the Hoyt limestone, close to one hundred feet thick near Saratoga, is regarded as a basal phase of the Little Falls dolomite and the Theresa (passage) beds are

[1] N. Y. State Mus. Bul. 140, p. 99, 112.

there a little over fifty feet thick. On this basis the passage beds rapidly thicken westward to two hundred feet on the Broadalbin sheet. If, however, we regard the Hoyt limestone as an upper phase of the passage series, and this is a very possible view since Ulrich and Cushing say that the same trilobite fauna ranges through both the Hoyt and the Theresa, the strata between the Potsdam and Little Falls show an increased thickness of only fifty feet westward to the Broadalbin sheet.

In the vicinity of North Galway there are many good outcrops of the Theresa formation and this locality is of special interest because there the passage beds may be seen resting directly upon the Precambric. Three-fourths of a mile northeast of North Galway dolomitic limestone beds, with occasional small quartz pebbles, are practically in contact with the Grenville while two hundred yards west of this a two foot layer of sandstone occurs very close to the Grenville. It is clear that the Potsdam is not present here and that the passage beds rest directly upon the Precambric. The significance of this overlap is discussed on page 51.

Along the road just east of North Galway the section is as follows:

Feet	
1.	Oolitic and cryptozoon limestone beds
14.	Alternating dolomitic limestone and sandstone beds
7.	Interval — but doubtless alternating limestone and sandstone
3.	Thin-bedded sandstone, rather calcareous
25.	Dolomitic limestone, sometimes sandy to pebbly
	Potsdam conglomerate not exposed and very thin if present
	Precambric Grenville quartzite

Between Northampton and West Galway the line separating the Theresa and Little Falls formations is difficult to draw because of heavy drift. One mile south-southeast of Northville there are large exposures of typical passage beds. Near Edinburg no outcrops were noted but, judging by the distribution of Potsdam and dolomite ledges and the drift fragments, the Theresa formation must swing around something as shown on the geologic map. In Gifford's valley upper beds of the formation are well exposed, especially along the road by Mr Gifford's house, where the heavy bed of sandstone and immediately overlying dolomite are shown. Two miles north-northwest of Cranberry Creek a small area of these rocks comes against the Noses fault. One and one-half miles northeast of Mayfield, and along Roberts creek, the formation is pretty well exposed and the transition character of the beds is shown. The dip is from 3 to 5 degrees southwestward and the thickness is estimated at 150 feet.

LITTLE FALLS DOLOMITE

Of the Paleozoic formations, the Little Falls dolomite (upper Cambric) is the most prominent and widespread within the quadrangle. With certain minor exceptions the formation presents a remarkably uniform character throughout. Typically the rock is pale bluish-gray, fine-grained, crystalline, dolomitic limestone, which when freshly broken exhibits a glimmering surface. The rock is often rather arenaceous and in a few cases a pale pink tint has been noted. The weathered surface is generally light gray to pale buff in color. The rock is distinctly bedded, the layers ranging in thickness from less than an inch to eighteen inches, with a usual thickness of six to twelve inches. A striking feature, which may nearly always be observed in the outcrops, is the occurrence of cavities lined with quartz crystals and frequently accompanied by dolomite or calcite crystals. The quartz crystals, remarkable for clearness and perfection of form, are popularly but erroneously called diamonds.

A rather persistent feature of the dolomite is the presence of angular chert fragments about twenty to forty feet above the base of the formation. This chert is sometimes white and sometimes dark colored and is often a prominent constituent of the rock through a thickness of several feet. Some of the localities where the chert is well shown are: in the creek at Parks Mill and on the hillside just to the south; two-thirds of a mile west of Galway; one mile east-northeast of Mayfield; on the west side of Bunker hill; two miles northwest of Cranberry Creek; just southeast of Northville; in the north end of Gifford valley; on the river two miles south-southeast of Northville; and two and one-half miles north of Batchellerville.

A mile east, as well as a mile and a half southwest, of Galway several feet of thin calcareous, sandy shaly beds have been noted near the summit of the formation and these are probably the same as similar beds described in other sections of the lower Mohawk valley.

Since no complete section of the Little Falls dolomite is exposed within the map limits the thickness can only be approximated. Eastward from Galway the dip and extent of the formation appear to indicate a thickness of at least 200 feet. Northeastward from Mayfield there is a thickness of 160 feet with neither top nor bottom shown. Thus the thickness is practically the same as for the region around Saratoga (if the Hoyt limestone be excluded).

Among the many excellent outcrops in the region are the following: northeastward from Mayfield; the vicinity of Cranberry Creek; two miles north-northwest of Cranberry Creek; the west side of Bunker hill; in Gifford valley; just southeast, and two miles south-southeast, of Northville; two and one-half miles north, and one and one-half miles southwest, of Batchellerville; at Northampton and one mile northward; at Union Mills and one mile south-southeastward; three-fourths of a mile west, and two and two and one-half miles east, of Broadalbin; at several points between Perth and West Galway; on the road east of West Galway; and at many places within the dolomite areas around Galway.

An important feature of the dolomite formation is the existence of a distinct erosion surface at its summit. Within the quadrangle, with one or two possible slight exceptions, the Tribes Hill limestone is absent and the Black River-Trenton limestone (generally the Lowville) everywhere rests upon the eroded surface of the dolomite. Near Rock City Falls (Saratoga sheet) such Ordovicic (Black River) limestone clearly rests upon an eroded surface of the dolomite. One and one-half miles southwest, and one mile south, of Galway similar phenomena may be observed and, at the first named place, a few pieces of the dolomite are included in the overlying limestone. Along Kennyetto creek, two miles east of Broadalbin, the Trenton-Lowville is practically in contact with the dolomite and the very perceptible dip of both formations to the west shows clearly that the Trenton-Lowville occupies a depression in the surface of the dolomite. Three-fourths of a mile east of Mayfield and also at Kegg's quarry (just east of Cranberry Creek) the Lowville is practically in contact with the dolomite although at the latter place a slight touch of the Tribes Hill limestone may be present.

TRIBES HILL LIMESTONE

The Tribes Hill limestone as recently named by Ulrich and Cushing[1] comprises essentially the "fucoidal beds" so long known in the Mohawk valley and is to be correlated with the lower portion of the Beekmantown of the Champlain valley. According to

[1] N. Y. State Mus. Bul. 140, p. 99.

these authors the old Beekmantown or Calciferous of the Mohawk valley should be divided into a lower mass of Little Falls dolomite (Upper Cambric) and an upper mass of Tribes Hill limestone (Ordovicic), the two being separated by a distinct unconformity.

This Tribes Hill limestone, which attains a thickness of 168 feet at Cranesville on the Mohawk river, is almost, if not entirely, absent from the Broadalbin sheet. Just off the map, and close to the Haines quarry, one and one-half miles north of Mayfield, there are a few feet of bluish-gray, fine-grained, thin-bedded, fucoidal layers clearly underlying the Black River-Trenton limestone near the quarry. These fucoidal layers the writer regards as Tribes Hill. Near Kegg's quarry, one-half mile east of Cranberry Creek, the Lowville is almost in contact with the dolomite. The quarry itself was filled with water at the time of the writer's visit but specimens of the gasteropod (Ophileta) so common to the Tribes Hill formation were found in limestone fragments about the quarry and this strongly suggests the presence of a touch of the Tribes Hill here. Along the creek, two miles east of Broadalbin, the Lowville is almost in contact with the dolomite so that very little, if any, Tribes Hill comes in here. In other parts of the quadrangle there is no positive evidence of the occurrence of Tribes Hill limestone.

The unconformity between the Little Falls and the Tribes Hill in the Mohawk valley is of considerable consequence because it shows that the Cambric period in this part of the State, at least, closed with the land above water and undergoing erosion. Again, Ulrich and Cushing have shown that the summit of the Tribes Hill in the Mohawk valley is also marked by an eroded surface thus producing an unconformity between the Tribes Hill and the overlying Black River-Trenton. Thus the Chazy is absent from this part of the State and during Chazy time the land must have been above water and suffering erosion. This fact is especially significant with reference to the Broadalbin sheet because the Tribes Hill, though doubtless originally present in considerable amount, has been almost, if not completely, removed during this erosion period so that with the inauguration of Black River-Trenton time those limestones were deposited directly upon the Little Falls dolomite.

BLACK RIVER–TRENTON LIMESTONES

As a result of recent changes in the nomenclature of the Lower Paleozoic formations of northern New York, the term " Black River " is no longer applied to a single limestone formation but rather to a group of three formations. The Black River group, as now recognized by the Survey, comprises the Lowville, Watertown, and Amsterdam limestones and of these only the Lowville and Amsterdam limestones appear to be present in the lower Mohawk valley. The missing Watertown corresponds to the well known Black River limestone of the Black River valley. Because of the thinness and small areal extent of the Black River-Trenton limestones they are shown together on the accompanying geologic map.

Lowville limestone. The Lowville (former "Birdseye") formation is commonly present within the map limits, but it is never more than a few feet thick. The following description of this limestone by Darton[1] for the Mohawk valley well applies to the Broadalbin district: "The Birdseye is in greater part an impalpably fine-grained, light dove-colored limestone more or less filled with dark-colored, vertical, columnar fucoidal stems. It weathers to white or a light ash gray tint, which is an especially characteristic feature. Owing to its very fine grain and compact structure its fracture is smooth or conchoidal and the texture of the rock is rather brittle. The ends of the dark fucoidal stems which are spotted over the surface of the bedding planes resemble birds' eyes, and from this feature the [old] name of the formation is [was] derived. It is in moderately heavy, regular beds and has a vertical cleavage [jointing]." The so-called fucoidal stems have, in recent years, been referred to the genus Tetradium of the branching corals. Within the map limits these stems are replaced either by calcite or sandy clay and are not always present.

The Lowville is well exposed at two points on Kennyetto creek two miles east of Broadalbin where a few feet of the typical rock may be seen in layers less than a foot thick and containing rather imperfect coral stems. In the vicinity of Kegg's quarry, east of Cranberry Creek, the rock is well developed showing a thickness of a few feet of dove-colored, very compact limestone with many large, yellowish, vertical coral stems. Near the limekiln these beds are seen to alternate with dolomitic beds which bear a close resemblance to the Little Falls dolomite. Similar alternating beds are also shown close to the map edge east of Mayfield. Along the eastern border of the Black River-Trenton area at Galway the Lowville is thinly present but the exposures are not so good. In a quarry beyond the map limit and two miles south-southeast of Perth several feet of typical Lowville beds are exposed.

The Lowville is always thin (generally under ten feet) in the

[1] 47th An. Rept. N. Y. State Mus. p. 616.

lower Mohawk valley and is sometimes absent altogether, as at Canajoharie. Around Little Falls the thickness is from twenty to twenty-five feet, while in the Black river valley it shows a thickness of fifty or sixty feet and is always present and characteristically developed.

Amsterdam limestone. The Amsterdam limestone, though generally under ten feet in thickness, appears to be very persistent over the region and is usually easily recognizable both faunally and lithologically. It comprises chiefly the pure, massive, gray, crystalline limestone which has been so much quarried in the district and which directly underlies the very typical Trenton. This massive limestone apparently continues eastward across the Saratoga sheet and to Glens Falls where it is quarried as marble. The relation to the Trenton is finely shown in Christie's quarry (at the map edge) one-half of a mile east of Mayfield where three feet of heavy bedded Amsterdam limestone is in contact with the Trenton. In the Haines quarry (off the map) north of Mayfield fine large specimens of the characteristic columnar coral (Columnaria alveolata) occur in the Amsterdam limestone.

Within the quadrangle good outcrops of the Amsterdam occur along the fault east of Mayfield; in quarries one and three-fourths miles southwest, three-fourths of a mile east, and two miles north-northeast of Cranberry Creek; in a quarry two miles east of Broadalbin; one-fourth of a mile and one and two-thirds miles east, one mile south, and one and one-half miles southwest of Galway. At most of these places the overlying Trenton is shown. At the localities east of Cranberry Creek and Broadalbin the cup coral (Streptelasma) has been noted in the formation.

Trenton limestone. This formation, which is clearly of lower Trenton age, is easily recognizable by its lithologic character and the abundance of its characteristic fossils. It always consists of dark, thin-bedded, irregular, compact limestones with distinct shale partings. The Trenton outcrops at all the localities above cited for the Amsterdam limestone. In addition to these there is an excellent exposure of about fifteen feet of Trenton along the creek at North Broadalbin which is a fine place for collecting fossils. Also in Christie's quarry, at the map edge east of Mayfield, there is an excellent exposure showing three feet of Amsterdam limestone capped by twelve feet of dark, thin-bedded Trenton with distinct shale partings and here, too, is a good place for fossil collecting.

The Trenton attains a maximum thickness of at least twenty feet with the summit not present as shown in the quarry one and two-third miles east of Galway. The contact with the overlying shale is nowhere visible so that any accurate determination of thickness can not be made.

Among the fossils noted in the Trenton limestone of the area are: the coral — Monticulipora (Prasopora) lycoperdon (Say); crinoid segments; bryozoa; brachiopods — Orthis (Dalmanella) testudinaria (Dalman) and Rafinesquina alternata (Con.) Hall and Clarke; gastropod — Murchisonia bellicincta (Hall); and the arthropod — Trinucleus concentricus (Eaton).

In the Black River-Trenton area south of Broadalbin it is impossible to accurately place the boundary lines because of heavy drift deposits, but this limestone is certainly present here between the Little Falls dolomite on the east and the Canajoharie shale on the west. Along the creek one-half mile north of Vail Mills fragments of Lowville in the drift show nearness to rock in place and in the quarry two miles south-southeast of Perth the rock is exposed.

CANAJOHARIE SHALE

The shales of the lower Mohawk valley have recently been carefully studied by Doctor Ruedemann of the New York Survey and certain important results which have been obtained will be published in a forthcoming paper. Doctor Ruedemann has very kindly given the writer advanced statements regarding the shales of the Amsterdam-Broadalbin region and in a letter dated November 16, 1910 he says: " The real Utica shale is in the lower Mohawk valley underlain by about three hundred feet of black shale that has a different fauna and belongs with the uppermost Trenton. This shale I propose to call from its best outcrop the Canajoharie shale." Heretofore all of the black shale of this region has been called Utica. The shales of the southwestern portion of the Broadalbin sheet, which rest directly upon Lower Trenton limestone, are certainly of Canajoharie age.

The formation consists of dark gray to black, fine-grained, thin and straight bedded shales usually rather calcareous, especially toward the base. The dark color is due to the presence of finely divided and partially decomposed organic matter, though nothing like a workable coal bed is known to exist in the formation.

On the geologic map the only Canajoharie shale area extends from North Broadalbin westward to the vicinity of Munsonville and thence southward to the map corner and represents the northeastern extension of the great shale area around Amsterdam and Gloversville. South of Vail Mills and in the vicinity of Munsonville no outcrops occur because of heavy drift covering, but the presence of underlying shale is proved by the numerous shale fragments in the drift.

Good exposures have been found in the creek just east of Mayfield station; on Kennyetto creek one mile west, one mile northwest, and two miles north of Broadalbin; three miles west-southwest of Broadalbin; at the lower road crossing on Beaver creek; and in the creek just west of North Broadalbin. A mile south of North Broadalbin the Canajoharie and Trenton are almost in contact but the exposures are poor. Along Kennyetto creek, west of Broadalbin, the shale beds are strongly disturbed and show dips up to 25 or 30 degrees in varying directions. This disturbance is doubtless due to proximity to the Broadalbin fault.

Nothing like a complete section occurs within the quadrangle so that the thickness of the formation can not be accurately determined. The summit is nowhere present, but judging by the dip and relation to the other formations there are probably at least one hundred feet of the shales here.

Graptolites are common near the base of the formation, especially along the creek just east of Mayfield station.

UTICA SHALE

The one small area of Utica shale is shown near the southeast corner of the geologic map. Lithologically the Canajoharie and Utica shales are indistinguishable but the recent work of Doctor Ruedemann shows an important faunal distinction based largely upon the graptolites. The thickness of the Utica, within the map limits, can not be determined because only the upper portion is present and this is practically in contact with the overlying Frankfort. The small area of the map is merely a tongue of the great shale area extending for miles eastward. Good exposures occur along the small creek a mile east of Galway. The shale mass here lies against Galway fault no. 1 and close to the fault the strata dip from 25° to 30° southeastward and away from the fault due to the updrag as a result of the displacement.

FRANKFORT SHALE

The Frankfort formation is represented by a single small area on the geologic map and this at the extreme southeast corner where it is sharply faulted against the Little Falls dolomite. The formation consists of alternating thin beds of shale and sandstone, the shale bearing a close resemblance to the Utica and the sandstone layers being dark gray, fine grained and weathering to yellowish-brown. A yellow sandy clay soil is characteristic of the Frankfort area. There is no sharp line of demarkation between the Utica and Frankfort but, in passing upward, the beginning of the sandy layers is taken to mark the base of the Frankfort. Doctor Ruedemann states, in a letter to the writer, that the Frankfort which shows a thickness of about three hundred feet at its type locality swells to a thickness of fifteen hundred feet or over in the lower Mohawk valley.

FAULTS

The Broadalbin quadrangle is of unusual interest because of the number of well-defined faults. They belong to the well-known series of the Mohawk valley although several of the faults within the quadrangle are here described for the first time. All are of the normal or gravity type with displacements usually ranging from about one hundred feet to over fifteen hundred feet. So far as can be determined the hade is always very steep if not vertical and with but two or three exceptions the strike is north-northeast. The topography of the district is largely dependent upon the faulting. The age of the faults is not precisely known but they are usually considered to have been formed during the great Appalachian revolution which so profoundly affected the physiography of the eastern United States, producing the Appalachian mountains and causing a general uplift, above sea level, of the Paleozoic sediments in New York State.

THE NOSES FAULT

From the standpoint of both length and amount of displacement this is one of the two greatest Mohawk valley faults. Where it crosses the Mohawk river, near Yosts or about five miles below Canajoharie, a picturesque gorge has been cut through the uplifted Little Falls dolomite. The sharp high cliffs along the fault and on opposite sides of the river have given rise to the name "Noses." According to the measurements of Prosser and Cumings[1] the thick-

[1] 15th An. Rept. N. Y. State Geologist, p. 643-44.

Plate 7

W. J. Miller, photo

A portion of the " Noses " fault scarp as shown by Buell mountain two and one-half miles west of Northville. The Little Falls dolomite, lying at 800 feet, is sharply faulted against the syenite of the mountain which rises to 2020 feet. View taken from the south end of Gifford valley.

ness of the formations at this point shows that the displacement is at least five hundred feet. The fault line is not straight but its general course is northward to northwestward from the Mohawk river to where it cuts across the northwestern corner of the Broadalbin quadrangle. This fault has been traced for a distance of at least thirty miles.

The Noses fault enters the sheet two and one-half miles north-northeast of Mayfield from which point it strikes north-northeast along a fairly straight line through Gifford's valley and thence off the map. The upthrow side is on the west. Because of heavy drift piled against the fault scarp the fault plane is at no point visible, but the line of fracture can be pretty accurately traced. Every evidence points to a very steep if not vertical fault plane. A good idea of the amount of displacement may be obtained in Gifford's valley where the base of the Little Falls dolomite is sharply faulted against the Precambric under Buell mountain. The base of the dolomite here lies at an elevation of 800 feet, but there are something like 200 feet of Paleozoics below the dolomite so that the Precambric surface is about 600 feet above sea level. On top of Buell mountain the Precambric lies at 2020 feet which makes a difference of 1420 feet in elevation of the Precambric on opposite sides of the fault, all due to faulting. If we add the unknown thickness of Precambric eroded from the mountain top since the faulting occurred we get a total displacement of the fault here of at least 1500 feet. The dolomite beds dip toward the fault plane at angles of from five to twenty degrees and this is quite the reverse of the updrag effect in the shales along this fault west of Johnstown as well as along most of the Mohawk valley faults. A small but very distinct fracture, which appears to be a branch of the main fault, runs through Gifford valley. This fault is clearly traceable by means of the topography and by the brecciated zone, and although its throw could not be exactly determined, it is probably not over fifty feet. It downthrows to the east.

The presence of this little outlier of Paleozoics in Gifford valley is due to the fact that the sediments have been sharply faulted against the base of the mountain and have thus been protected against entire removal by erosion since the faulting.

On the divide, about a mile south of Gifford valley, the throw of the Noses fault has diminished by two or three hundred feet. Two miles south of the valley a small wedge of the Theresa formation lies against the fault plane. West of Cranberry Creek the base of the dolomite comes against the fault at about 800 feet elevation which means that the Precambric rock surface on the east side of the fault lies at an altitude of something like 600 feet. But the Precambric just west rises to 2140 feet so that the amount of displacement is here at least 1540 feet.

JACKSON CREEK FAULT

One and one-half miles west-northwest of Cranberry Creek a fault, apparently a branch of the Noses fault, strikes southwest through the Precambric and has its upthrow side on the west. It has been traced for two miles as a distinct topographic feature and by occasional outcrops of brecciated Grenville. Such brecciated Grenville is beautifully exhibited where the fault runs parallel to the private road near the map edge. This fault probably joins the Noses fault to the east of Jackson summit on the Gloversville sheet.

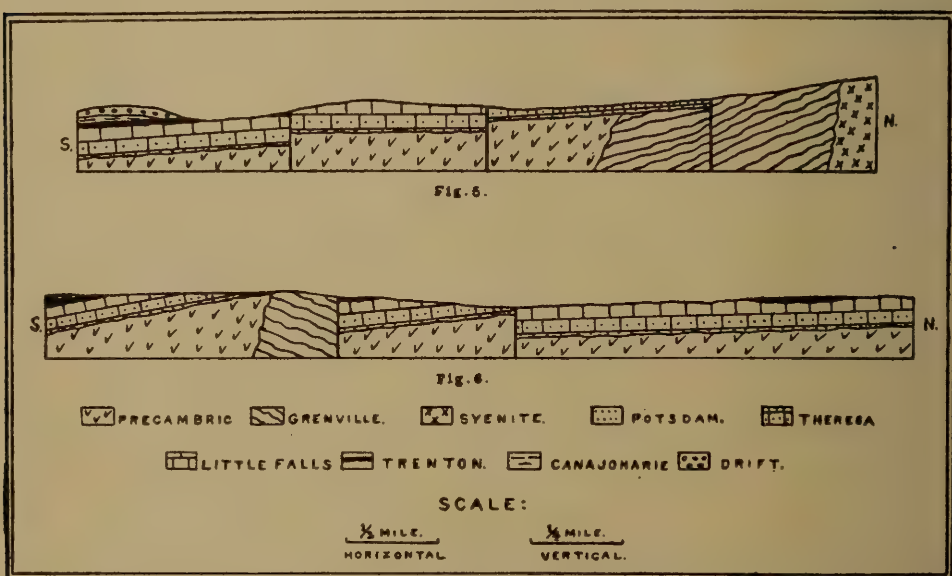

Fig. 5 North south section from a point two miles west of Cranberry Creek to a point one-half of a mile southeast of Mayfield station

Fig. 6 Northeast-southwest section from a point one mile east-northeast of Cranberry Creek to a point one and one-half miles due north of Mayfield

ROBERTS CREEK FAULT

One and one-half miles west of Cranberry Creek another distinct fracture branches off the Noses fault. It strikes a little east of south and can be traced for about two miles after which its course is uncertain. The upthrow side is on the west which accounts for the presence here of the tongue of Grenville gneiss extending out from the main Precambric area. Potsdam sandstone rests upon the Grenville on the west side and this is followed by the Theresa formation which, on the Gloversville sheet, is followed in regular order by the Little Falls dolomite, Black River-Trenton limestone, and Canajoharie shale. These strata all show a dip of several degrees westward due to the faulting. On the downthrow side a wedge of Black River-Trenton limestone is faulted against the Grenville, this limestone in turn being followed in regular order (downward) by the Little Falls dolomite and Theresa formation. The displacement, where the section (fig. 6) crosses the fault, is about four hundred feet.

SACANDAGA PARK FAULT

This, the most important branch of the Noses fault within the quadrangle, leaves the main line of fracture at a point about one and one-half miles southwest of Sacandaga Park. The place of divergence is wholly obscured by drift but the fault, which strikes north-northeast, is readily traceable along the eastern foot of the ridge of porphyritic granite at Sacandaga Park, thence through the western edge of Northville and along the eastern foot of the high hills north of Northville. The upthrow side on the west consists wholly of the various Precambric formations as shown on the map. The downthrow side, so far as can be determined, consists of Little Falls dolomite, but heavy drift completely conceals all Paleozoic rocks near the fault. The nearest outcrops are dolomite, such as those on the western side of Bunker hill (along the railroad) and in the little creek at the southeast edge of Northville. The best evidence to show the character of the rock on the downthrow side close to the fault comes from a deep well along the river at the west edge of Northville. This well was drilled to a depth of several hundred feet and the first rock struck is reported to have been a limestone which is doubtless the Little Falls dolomite. The displacement of the fault has not been accurately determined, but, comparing the altitudes of the Precambric rock on opposite sides, it must be at least five or six hundred feet.

MAYFIELD FAULT

This is a small fracture which can be distinctly traced from a point just northeast of Mayfield for one and one-half miles along a north 70° east strike. It probably passes through the northern part of Mayfield village but is there drift covered. The fault plane is almost vertical and the scarp is much more clearly shown in the field than on the map. The upthrow side is on the north and consists of Little Falls dolomite which, near the fault, contains white chert and is more or less broken. Dolomite also makes up the downthrow side except for a long narrow wedge of Trenton limestone with more or less Lowville limestone. This limestone wedge, which is never over seventy-five yards wide, is badly broken and shows varying dips. The Little Falls dolomite here shows a thickness of about one hundred and fifty feet and, at the map edge, the Trenton is sharply faulted against its base so that the displacement is approximately one hundred and fifty feet. This fault seems to cross the Roberts creek fault at right angles near the railroad but the relations are here wholly uncertain because of heavy drift.

CRANBERRY CREEK FAULT

This interesting dislocation runs nearly parallel to the Noses fault, the writer having traced it with considerable certainty along a north-northeast strike from a point about one mile north-northeast of Mayfield, past the village of Cranberry Creek, to a point about one and one-half miles south of Sacandaga Park. Its northern extremity is obscured by drift. Between Cranberry Creek and Mayfield the relations are somewhat complicated because of the Roberts creek cross fault which causes the upthrow side to be now on one side and now on the other, due to tilting of the strata during the adjustment of the earth blocks and we have here a fine illustration of pivotal faulting.

One mile north-northeast of Mayfield the upthrow is on the east with lower Little Falls dolomite (containing chert) faulted against upper dolomite. Fault breccia is here shown and the throw of the fault must be something over one hundred feet. A mile farther northwestward the dolomite comes against the Grenville so that here the upthrow side is on the west with an amount of throw probably in the neighborhood of two hundred feet. Just after crossing the Roberts creek fault the relation is again changed and the upthrow is on the east because of the wedge of Black River-Trenton on the west side. Where the fault crosses Jackson creek the relation changes again so that the upthrow side is on the west. This is shown by the small area of the Theresa formation. From here northward the upthrow continues on the west. Where the fault crosses Cranberry creek the strata are disturbed and good exposures of the cherty beds of the lower Little Falls dolomite are seen on the upthrow side. From a point about a mile north of

Cranberry Creek village the fault is clearly traceable as a topographic feature and by frequent outcrops of fault breccia. On the west side of Bunker hill a small mass of Trenton limestone is faulted against lower (cherty) beds of the dolomite so that the amount of displacement is here approximately represented by the thickness of the dolomite formation or about two hundred feet.

NORTHVILLE FAULT

This fault passes through the depression just east of the village of Northville. Its strike is nearly north and south and the upthrow side is clearly on the east. The relations are well shown at only one point and this is along the creek at the southeastern edge of the village. Here are exposed about twenty-five feet of horizontal, cherty Little Falls beds, the rocks being considerably broken or brecciated. Within two hundred yards eastward and on the hillside are large outcrops of Precambric. Immediately to the north and to the south of these Precambric ledges, Potsdam sandstone outcrops close to the fault on the upthrow side. Three-fourths of a mile south of these Precambric ledges the Theresa formation is well shown on the upthrow side.

This fault probably connects with the Sacandaga Park fault in the depression north of Northville but the relations are wholly obscured by drift. The amount of the dislocation at the southeast edge of the village is probably about two hundred feet since the lower dolomite is there faulted against the Precambric.

BUNKER HILL FAULT

This fault, showing a strike of north 40° east, passes across the top of Bunker hill and has its upthrow side on the east. Where it crosses the road on the hill, Potsdam sandstone is exposed in a large quarry and shows a dip of 10° toward the southeast. To the east and south of the quarry no outcrops were found but the passage beds of the Theresa formation are thought to come in as shown on the map. Within a few hundred yards to the west of the quarry upper dolomite and Trenton limestone are exposed. Since the Potsdam is brought up to the level of the Trenton, the amount of displacement must be measured by the combined thickness of the Little Falls and Theresa formations which here are approximately three hundred feet. This fault is probably only a southward extension of the Northville fault but the utter lack of outcrops across the river makes it impossible to positively connect the two. Southwest of Bunker hill the course is purely conjectural but it may connect with the Cranberry Creek fault as shown on the map.

BATCHELLERVILLE FAULT

The Batchellerville fault is here described for the first time, and considering the boldness of topographic form due to the faulting it is not a little surprising that earlier observers have not called attention to it. From the standpoint of amount of displacement, and possibly also of length, this fault takes rank as one of the greatest along the southern border of the Adirondacks. The upthrow side is on the east and this is of particular interest because we have here by far the greatest of the few Mohawk valley faults which show upthrow on the east side.

From a point two and one-half miles southeast of Northampton the fault is clearly traceable northward along the base of Bald Bluff where it gradually changes strike to the north-northeast and then passes on a nearly straight line along the base of the mountain through Batchellerville and to the map limit. The northern extension of the fault has not been investigated but it certainly runs some two or three miles beyond the map. The southern extremity of the fault is completely drift covered so that the relations there are not well shown. In spite of the fact that the actual fault plane is everywhere talus or drift covered it can be pretty accurately mapped.

Except for a small area to the north, the upthrow side consists of a great block of Grenville gneiss which everywhere dips at angles of from 15° to 30° away from the fault. Close to the fault on the downthrow side, east of Northampton, there are no actual outcrops but the numerous drift fragments make it quite certain that the Theresa transition beds are present as shown on the map. From Bald Bluff northward all the available evidence points to the presence of Little Falls dolomite on the immediate downthrow side except possibly near Batchellerville where the Potsdam or passage beds from the vicinity of Edinburg may reach across the river. The dolomite, which outcrops at several places along the western side of the river, always dips at a low angle toward the fault. On the mountain side, just above the feldspar mine (two and one-half miles north-northeast of Batchellerville) fault breccia indicates minor fracturing which most likely accompanied the major faulting.

The amount of dislocation may be fairly well determined by comparing the altitude of the Precambric on each side of the fault.

Plate 8

W. J. Miller, photo

The Batchellerville fault scarp as seen toward the northeast from Northampton. The crest of the scarp is about 1000 feet above the valley.

The crest of the Grenville fault block, between Bald Bluff and Batchellerville, rises to eighteen hundred feet or over within a mile of the fault. On the downthrow side the Little Falls dolomite lies at an altitude of seven hundred feet but the Precambric is buried under the Potsdam and Theresa formations and a part of the dolomite. The thickness of these formations here is not exactly known but to say that the Precambric near the fault is buried three hundred feet is approximately correct. This means that the Precambric on the downthrow side is now at an altitude of four hundred feet or fourteen hundred feet lower than that on the upthrow side. Thus if we allow for even a small amount of erosion along the crest of the fault-block, the displacement is in the neighborhood of fifteen hundred feet.

A feature of interest in connection with this fault is the rapid diminution of throw along the southern portion. On the western side of Bald Bluff the throw reaches nearly its maximum, while, in spite of the heavy drift, it is certain that the fault has completely disappeared within two or three miles southward.

EDINBURG FAULTS

The faults here described are named from the fact that they occur in the town of Edinburg and near the village of the same name. The writer is indebted to Mr J. W. Latcher of Edinburg for assistance in locating certain important outcrops in this vicinity. That at least two dislocations occur approximately as shown on the map is quite certain, but very accurate work is impossible because of the deep drift and scarcity of exposures.

Of these two faults the more prominent one follows along the eastern base of Fraker mountain (Stony Creek sheet) and thence strikes nearly southwest to cross Butler creek about one mile west of Edinburg. Farther southward the region is heavily drift covered. North of Fraker mountain the fault has not been studied. The upthrow side is on the west and the Grenville, in great ledges, forms a pretty distinct fault-scarp. Heavy drift almost completely conceals the downthrow side but the rock appears to be chiefly Little Falls dolomite. A good dolomite outcrop occurs just below the road crossing on a little creek near the map edge and two and one-half miles north-northeast of Edinburg. This rock dips slightly eastward and is within one-third of a mile of the fault at the base of Fraker mountain. The thickness of the Paleozoics here is probably in the neighborhood of two hundred feet which means that the

Precambric surface lies at about five hundred feet. The Precambric on the west side (Fraker mountain) of the fault rises to over fifteen hundred feet so that, disregarding subsequent erosion, the amount of displacement near the map edge is approximately one thousand feet. Dolomite was formerly exposed near the road one mile northeast of Edinburg. Black shale fragments may be seen along the road one-half mile north of Edinburg and this suggests that shale may now exist under cover of the drift or a small shale mass may have been completely removed by ice erosion.

The second and much smaller fault passes just north of Edinburg and strikes a little to the north of east. Its exact location and relations are rather obscure, except that the upthrow side is on the south and at the village are excellent exposures of Potsdam sandstone dipping toward the southeast.

HOFFMAN'S FERRY FAULT

This has long been known as one of the greatest Mohawk valley faults and as usual the upthrow is on the west. Just north of Hoffman's Ferry (on the Mohawk river) the displacement is estimated at 1300 feet by Cumings[1] and at 1600 feet by Prosser.[2]

Where this fault enters the Broadalbin quadrangle, one and three-fourths miles southwest of Galway, Black River-Trenton limestone may be seen sharply faulted against the upper portion of the Theresa formation and the amount of displacement is estimated at two hundred and fifty feet. The limestone is in the form of a narrow wedge crowded against the fault plane and showing varying dips. One-half of a mile west-northwest of Galway lower dolomite beds containing chert are faulted against lower beds of the Theresa formation and the displacement is about equal to the height of the hill here, or two hundred feet. East of North Galway the dolomite comes against the Precambric so that the displacement is about two hundred and fifty feet. [*See* fig. 7.] The occurrence of the small separated masses of Precambric against the fault in this vicinity is due to the faulting and later erosion of the scarp. A mile north of Mosherville Potsdam sandstone outcrops in the creek with Precambric a little to the north. The relations of the fault are here not clearly shown but judging by the elevation of the Precambric just to the north, the throw is probably in the

[1] N. Y. State Mus. Bul. 34, p. 450.
[2] *loc. cit.* p. 476.

neighborhood of two hundred feet. This fault continues on a north-northeast course across the Saratoga sheet toward Corinth. The throw increases northward until, in the town of Corinth, it reaches a thousand feet or more.

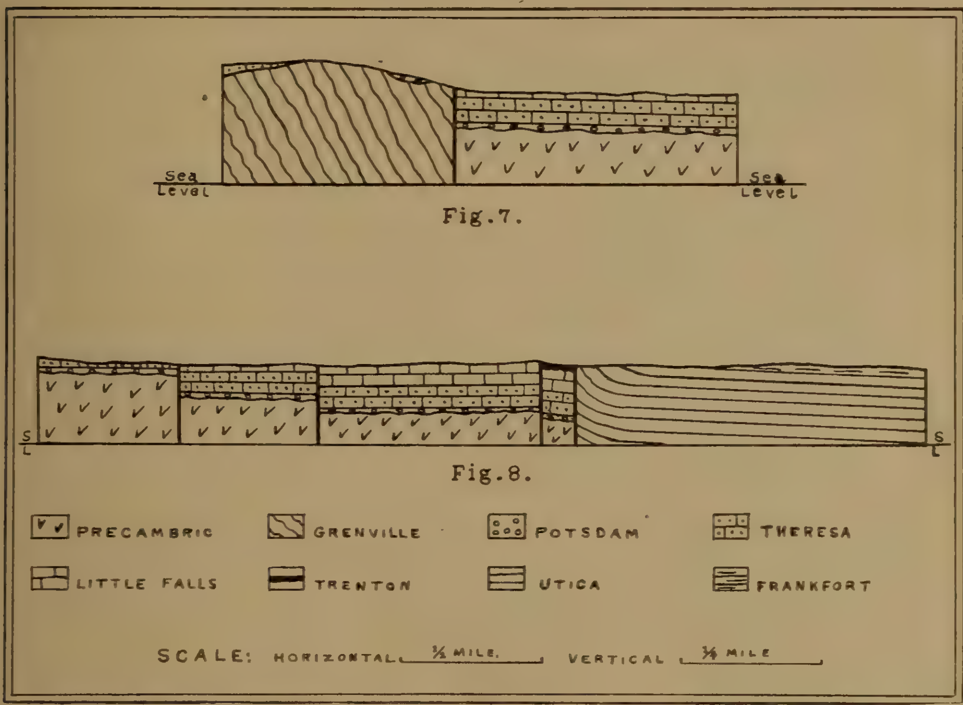

Fig. 7 Northwest-southeast section across the Grenville tongue and the Hoffman Ferry fault three-fourths of a mile east of North Galway
Fig. 8 Section passing through Parks Mill and to a point at the map edge two miles east-southeast of Galway

GALWAY FAULT NO. I

According to the geologic map of the Amsterdam quadrangle this important fault is a branch of the Hoffman's Ferry fault. It enters the Broadalbin sheet one and one-fourth miles south of Galway and, after continuing northwesterly for two and one-half miles, leaves the map one and two-thirds miles east of Galway. The upthrow side is on the west. South of Galway Frankfort shales are faulted against upper Little Falls dolomite. Thus the displacement must be measured by the combined thickness of Black River-Trenton limestone, black shale, and a small portion of the Frankfort. In the vicinity of Amsterdam the black shale is from twelve hundred to fourteen hundred feet thick and although it is probably less here the displacement of the fault no doubt is more than one thousand feet.

East of Galway a small fracture branches off on the north side and in about a mile again joins the main fault. A well-defined block of Black River-Trenton limestone is included between the main fault and this branch and where the branch crosses the road near the four corners the fault plane is exposed showing Trenton in contact with dolomite. On the downthrow side of the main fault here Utica black shale comes against the Black River-Trenton and the shale dips 25 degrees away from the line of fracture due to updrag during the faulting [*see* fig. 8].

GALWAY FAULT NO. 2

This is another branch of the Hoffman's Ferry fault which enters the sheet one and one-third miles south-southwest of Galway; passes through the eastern edge of the village of Galway; and leaves the map two-thirds of a mile east-southeast of Parks Mill. About a mile still farther eastward it seems to join Galway fault no. 1. The upthrow side is on the west and from Galway southward a large wedge of Black River-Trenton limestone is faulted against the dolomite. The amount of throw is not definitely known but at Galway it is quite certainly under one hundred feet. The relations are well shown near the schoolhouse in Galway village. Where the fault leaves the map the Little Falls dolomite comes against the Theresa formation and the throw has increased to over one hundred feet.

About a mile northeast of Galway a small branch fracture strikes north-northeast through Parks Mill and then dies out rapidly. The fault plane is exposed in the bed of Glowegee creek where the lower dolomite beds (with chert) are in contact with the passage beds of the Theresa formation.

BROADALBIN FAULT

The Broadalbin fault strikes northeast-southwest along a very straight line past the northern edge of the village of Broadalbin, and is one of the few Mohawk valley faults with upthrow on the east side. The fault plane is nowhere visible but the outcrops are so distributed as to permit fairly accurate mapping. The downthrow side is entirely of Canajoharie shale which outcrops near the fault one and one-half miles west, and in the creek three-fourths of a mile north, of Vail Mills; and one mile south of North Broadalbin. In large outcrops west and northwest of Broadalbin the shale beds are considerably tilted. On the upthrow side the Little Falls dolomite is exposed at only one place, three-fourths of a mile west of Broadalbin. In the village, however, the dolomite was struck under thirty feet of drift in a well on the Husted place. A mile south of North Broadalbin Trenton and Canajoharie outcrop close together. Where the fault crosses Kennyetto creek numerous fragments of the Trenton and Lowville limestones make the presence of these formations almost certain here. The southward extension of the fault is completely drift covered but it probably disappears near the map edge. Northward it has disappeared before reaching the point one mile south of North Broadalbin where Trenton and Canajoharie are in normal position. Just west of Broadalbin the dolomite lies about sixty feet above the Canajoharie shale and to this must be added the whole thickness of Black River-Trenton limestone and an unknown thickness of shale in order to give the amount of dislocation. Darton estimates the throw here at two hundred feet and it is quite certainly not more than this.

TROUGH FAULTING

The Batchellerville and Noses faults run approximately parallel and are about six or seven miles apart, the great escarpment of Precambric rock of the one fault facing the equally great escarpment of the other. In other words we have here a fine illustration of trough faulting, the whole country between the Batchellerville and Noses faults being a great depressed block much of which now lies fully one thousand feet below the level of the scarps on either side. A glance at the Broadalbin sheet will show the extent of this fault block which occupies at least seventy-five square miles or all of the region between the following points: Three miles north of Batchellerville; two and one-half miles northwest of Northville; two miles west of Mayfield; and two miles southeast of Northampton. On the State geological map the deep indentation caused by the northward extension of the Paleozoic rocks to Northville roughly corresponds to this depressed block, although recent mapping by the writer shows that the Paleozoics should extend at least six or eight miles farther northward along the Sacandaga river. This great trough block is not perfectly simple because, on the west side especially, a number of minor fractures have considerably modified it and some of these minor faults are so arranged, as at Northville, that small trough fault blocks are included between them.

Eastward from the great trough block and lying between the Batchellerville and Hoffman's Ferry faults is a great upraised block (horst) of Precambric rock covering at least one hundred square miles and including all of the high country in the northeastern portion of the Broadalbin and the northwestern portion of the Saratoga quadrangles. It comprises the large tongue of Precambric rock shown on the State geologic map between Saratoga Springs and Northville.

The profound influence of trough faulting upon the topography in this region strongly suggests the occurrence of similar phenomena well within the Adirondacks. As Professor Cushing stated several years ago, the topography of the eastern Adirondacks often suggests faulting of this sort but positive proof has heretofore failed. The finding of such a large and clear-cut trough fault at the southern margin of the Precambric area greatly strengthens the belief that faulting of this kind has had an important influence upon the topography of the eastern Adirondacks.

PHYSIOGRAPHY

PRECAMBRIC PHYSIOGRAPHY

During Grenville times the physiography was very simple, the whole Adirondack region being covered by ocean water and receiving an immense accumulation of sediments. Then came a time of intrusion of tremendous igneous rock masses into the Grenville. The whole region was uplifted some thousands of feet above sea level. We have no knowledge of the character of the topography of this land mass when it was high above the sea, but we know that it underwent erosion for a vast length of time extending into the early Paleozoic era.

PALEOZOIC PHYSIOGRAPHY

It is certain that, during the Lower and Middle Cambric, the Adirondack region was above water and suffering erosion because Lower and Middle Cambric strata are everywhere absent from the region and there is not the slightest evidence that they ever were present. During the long Prepotsdam time the ancient Adirondack land mass had become worn down to the condition of a peneplain or almost smooth surface and the Potsdam (Upper Cambric) sea encroached from the northeast upon this peneplain during its gradual subsidence. By the work of Kemp, Smyth, Cushing, and the writer it is now known that the surface of this peneplain was more or less uneven, the greatest unevenness being along the northeastern border of the Adirondacks and the smoothest surface along the southwestern border. The smoothest surface on the southwest is just what would be expected because that region was longest a land surface, thus affording opportunity for cutting away nearly all irregularities. Within the Broadalbin quadrangle all but a few miles of this ancient shore line have been lost to view due to the extensive faulting and the portions not thus faulted out are most heavily drift covered. However, certain phenomena are very clearly exhibited, especially between Barkersville and North Galway, and give us important additional information for the southern Adirondacks.

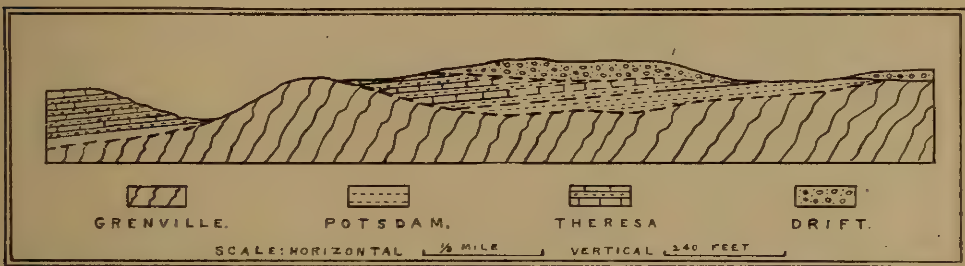

Fig. 9 Section passing from a point two-thirds of a mile south of Barkersville south-southwestward through North Galway. The overlap of the Theresa transition beds upon the Precambric hillock is clearly shown

In the vicinity of North Galway the evidence is conclusive that the Precambric surface on which the Potsdam was deposited was fairly uneven. The tongue of Grenville quartzite which extends out so prominently here is very significant because the same quartzite stood out as a ridge in the shallow Potsdam sea and was never covered with Potsdam sandstone or conglomerate. So far as can be determined the Potsdam is wholly absent around this Grenville tongue except along the east side of the southern border where it is entirely represented by the coarse conglomerate. Elsewhere the passage beds of the Theresa formation rest directly upon the Grenville, thus overlapping the Potsdam. This feature is perhaps best shown along the road three-fourths of a mile northeast of North Galway where the passage beds are practically in contact with the Grenville and show a low southwesterly dip. [*See* fig. 9.] On the south side of the Grenville tongue the passage beds show a southwesterly dip of three or four degrees. The sandstone, and even limestone, layers close to the Grenville contain quartz pebbles up to one-half inch in diameter which were derived from the Grenville and deposited in the encroaching sea. The Grenville here certainly projects upward as much as fifty feet into the passage beds which means that, at the height of the Potsdam sea, this Grenville rose fully fifty feet above sea level. If we add to this the thickness of the Potsdam sandstone as shown in the nearby areas, it seems clear that this Grenville mass must have risen fully seventy-five feet above the surrounding country (peneplain) just before Potsdam submergence. About two-thirds of a mile south-southwest of North Galway the passage beds are practically in contact with the Precambric so that we have here another, but smaller, hillock. The relations are not so well shown around the Grenville area on the west side of the Amsterdam reservoir but doubtless this, too, represents a low knob which rose above the general level of the peneplain. The locations of these knobs or hillocks have no doubt been largely determined by the very hard and resistant character of the quartzite which, of all the Grenville rocks, would stand out longest against atmospheric action prior to, and wave action during, Potsdam submergence.

North of Barkersville the mapping suggests an uneven surface but positive evidence was not found. In the small Potsdam area just east of Northville the beds are practically horizontal and they appear to occupy a depression in the Precambric but, because of nearness to the fault, the amount of unevenness can not be satisfactorily determined. Elsewhere within the quadrangle the character of the Precambric surface can not be studied.

During the early Paleozoic there were certain minor oscillations of level (already referred to) when at times the region was a low lying land area undergoing erosion. For most part, however, the whole district was under water and remained so until after the deposition of all the Paleozoic sediments when a great uplift, without folding but with some tilting of the strata, brought the whole Adirondack region (then mantled with sediments) well above the water. This uplift probably occurred at the close of the Paleozoic era. The simple elevation of this ocean bottom would have given rise to a comparatively smooth and featureless topography, but it is generally considered that the faulting of the eastern Adirondacks accompanied the uplift. As Cushing says:[1] "The forces which folded the region to the eastward affected the Adirondack district but slightly and the rocks are not folded. But in the reaction of the region from compression, tension faulting took place on a large scale, and its eastern portion was sliced by a series of meridional faults which cross it." According to this the topography of the Broadalbin district was that of the uplifted sediments which were greatly dissected and increased in ruggedness by the faulting.

[1] N. Y. State Mus. Bul. 95, p. 421–22.

POSTPALEOZOIC PHYSIOGRAPHY

In the northern Appalachians and in southern New England the great areas upraised at the close of the Paleozoic underwent vast erosion during the Mesozoic era so that by its close the well-known Cretaceous peneplain had been developed. There is considerable reason to think that this Cretaceous peneplain was developed more or less perfectly over the Adirondack region although there is no evidence in favor of this view within the Broadalbin quadrangle itself. Granting the presence of this peneplain, the topography of the Broadalbin district must have been rather smooth and featureless with the fault scarps practically removed by erosion.

This great peneplain was elevated about the close of the Mesozoic era and thus the region of the Broadalbin quadrangle was rejuvenated and the revived streams vigorously renewed their work of erosion which has continued to the present time. The present topography of the quadrangle, except for the local glacial deposits, is the result of this long period of erosion and most of the faults have again been made prominent as topographic features by the unequal erosion of the harder and softer rocks on opposite sides of the faults.

The detailed topography of the district has, of course, been quite appreciably affected by the distribution of glacial drift.

PRESENT SLOPE OF THE PRECAMBRIC SURFACE

The extensive faulting has precluded the possibility of studying the slope of the Precambric surface except in a limited way in the southeastern portion of the quadrangle. At Barkersville the Precambric surface clearly slopes southwestward at the rate of over one hundred feet per mile. From just north of Barkersville to the north end of the Amsterdam reservoir is about four miles and the difference in elevation of the Precambric is fully four hundred feet so that the general slope southwestward along this line is at least one hundred feet per mile. Similar results have been obtained by Professor Cushing and the writer in the Little Falls and Trenton Falls districts and also two or three miles northwest of Saratoga Springs. Thus we see that a southwestward slope of a little over one hundred feet per mile of the Precambric surface under the Paleozoics appears to be general along the southern Adirondacks.

One-half of a mile south of Round lake the Precambric lies at about 1550 feet while just north of Barkersville, and three miles distant, it lies at 1250 feet thus giving a southwestward slope of 100 feet per mile where the Precambric is not now covered by the Paleozoic. The slightly lessened slope in this case has been due to a reduction of level by erosion since the removal of the Paleozoic sediments. The Hoffman's Ferry fault may have somewhat affected the Precambric slope here but more than likely not enough to make any material difference in the result. In other portions of the quadrangle the faults have so affected the slope that any results are unsatisfactory.

DRAINAGE OF THE QUADRANGLE[1]

Sacandaga river. As a result of the Ice age the drainage of the quadrangle, including the four largest streams, has been very notably affected. The most striking change has taken place in the course of the Sacandaga. This river, after emerging from the Adirondacks, enters the Paleozoic lowland between Northville and Northampton and at the latter place turns back sharply (north-northeastward) on its course past Batchellerville and Day and then across a divide in the Precambric at Conklingville soon to enter the Hudson at Luzerne. It is certain that, before the Ice age, the Sacandaga river continued southward from Northville and was tributary to the Mohawk. Its preglacial channel doubtless passed between Broadalbin and Mayfield, because here the Paleozoic rocks are the lowest within the quadrangle. That the course past Conklingville is postglacial is proved by the gorge at that village; the almost imperceptible gradient of the river between Northampton; and by the perfectly aggraded character of the river channel between the two villages just named. The remarkable deflection of the course of this river was due to the great accumulation of glacial drift, especially in the interlobate moraine, acting as a dam across the southern portion of the Broadalbin sheet. The deflection was aided by the presence of the deep trough of the Batchellerville fault and also probably by a comparatively low preglacial divide at Conklingville.

According to borings for a dam site made by the New York Water Commission in the bed of the river at Conklingville, rock was not struck within two hundred feet. If the channel is thus drift filled it clearly means that the rock channel was cut prior to the last ice invasion. This seems to imply at least one earlier advance and retreat of the ice over the region since it is pretty cer-

[1] See paper by writer entitled Preglacial Course of the Upper Hudson River, in Geol. Soc. Am. Bul. 22:177–86.

tain that the river did not occupy this course in preglacial time. It would seem that the rock channel which may have been cut during an interglacial epoch was drift filled during the last ice invasion

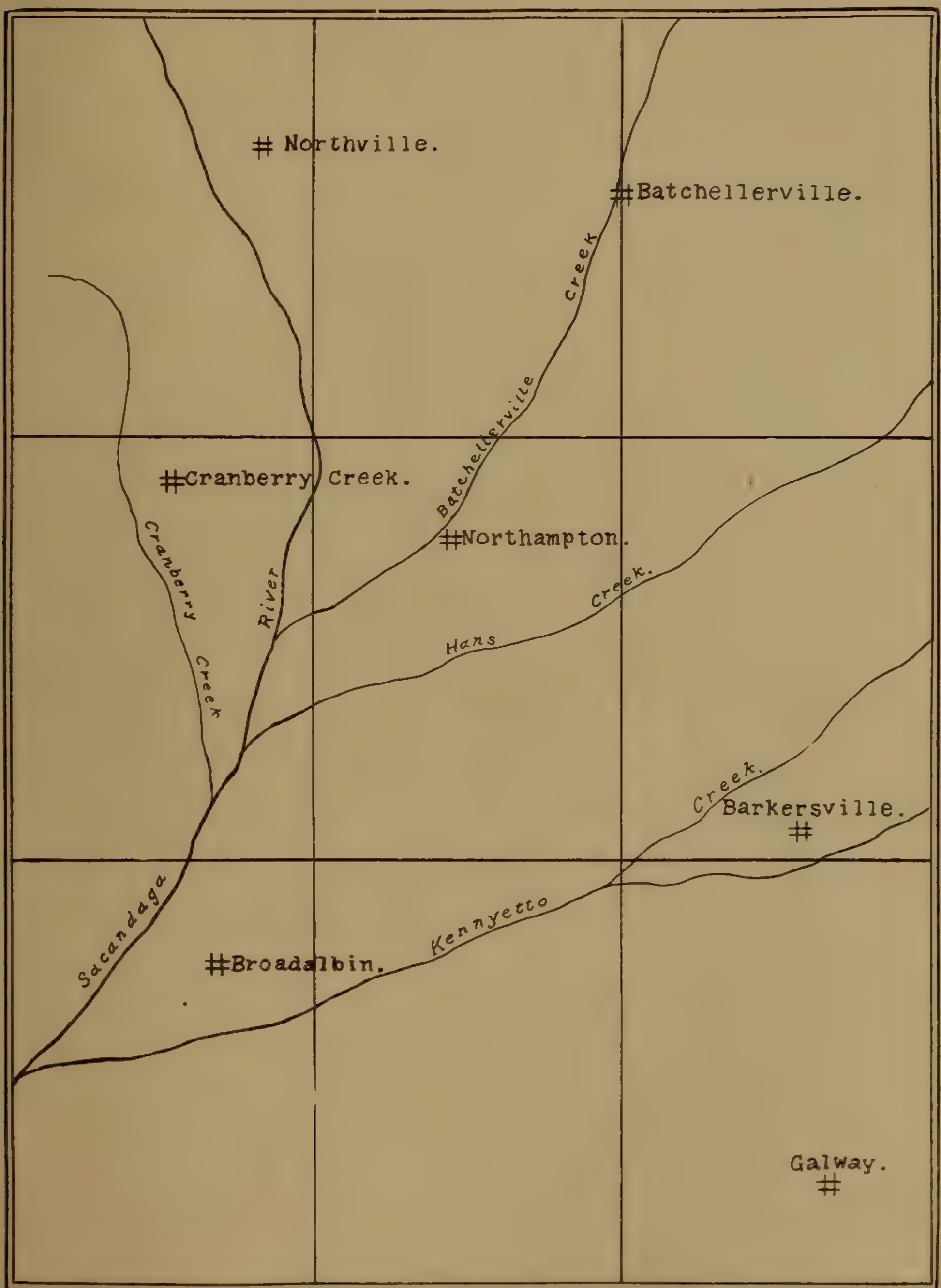

Fig 10 Sketch map showing the principal preglacial drainage lines of the Broadalbin quadrangle

and that the river has not yet removed this filling. This whole question, however, needs to be more carefully studied.

Kennyetto creek. The peculiar course of this stream has already been referred to. After flowing southwestward for many miles to

Vail Mills it turns back on itself by making a sharp swerve northward and then northeastward to empty into the Sacandaga river. The course of Hans creek is similar though not quite so striking. In preglacial time these streams were doubtless tributary to the Sacandaga when it flowed southward into the Mohawk (*see* figure 10). The accumulation of drift across the southern border of the quadrangle, which caused the northeastward deflection of the Sacandaga, also caused a deflection of Kennyetto and Hans creeks by forcing them to flow northward down the slope of the great drift dam (interlobate moraine).

Mayfield creek is postglacial in origin and has come into existence by finding a northeasterly channel down the slope of the morainic belt.

Batchellerville creek. During preglacial time the Batchellerville fault trough had in it a considerable stream (Batchellerville creek) which flowed south-southwestward, past Batchellerville and Northampton, as a tributary of the Sacandaga. The filling up or aggrading of this preglacial channel during the Ice age and the deflection of the Sacandaga northward through this filled channel affords a fine illustration of complete reversal of drainage.

Lake Sacandaga. Immediately after the final disappearance of the great ice sheet from this region, all of the present river flat area as well as the area of the great swamp known as the "Vly" were covered by the waters of Lake Sacandaga which has been named and described by Professor Brigham.[1] It is interesting to note that the great Sacandaga reservoir proposed by the State would almost exactly restore what was once a natural lake.

SUMMARY OF GEOLOGIC HISTORY

Because of the variety and complexity of the geologic problems involved it seems advisable to give, in regular order, a summary of the geologic history as exhibited within the quadrangle as well as some idea of the relation of this history to that of the Adirondacks in general.[2] The combination of such a variety of rock formations is due to the favorable situation along the border of the Adirondacks where the Precambric crystalline rocks are overlapped by the unaltered Paleozoic sediments.

The definitely known history of the quadrangle begins with this

[1] N. Y. State Mus. Bul. 121, p. 26.

[2] For this broader outlook upon the subject the writer feels especially indebted to Professor H. P. Cushing who, for many years, has so zealously and ably labored to unravel the intricate history of the Adirondack region.

district, as well as the whole Adirondack region, covered by ocean water. We know this because the most ancient formation, the Grenville, is sedimentary in origin and is abundantly represented, not only within the map limits, but also throughout the Adirondacks and in Canada. We have every reason to believe that the Grenville sediments were sandstones, shales and limestones of the ordinary kinds. Judging by the great but unknown thickness of the formation we are led to the conclusion that the oceanic conditions persisted for a great length of time which must be measured by hundreds of thousands, if not some millions, of years. The Grenville belongs to the most ancient rock group in New York State, or, so far as we know, in the world and, though any attempt to fix its age in years must be very general, it is certain that many millions of years have passed since its formation. The still more ancient land mass from which these sediments were derived and the very ancient ocean bottom upon which they were deposited have as yet not been recognized. That life of some kind was fairly abundant in the Grenville ocean is proved by the presence of graphite which is of organic origin.

After the Grenville sediments were deposited the whole Adirondack region, including the Broadalbin quadrangle, was elevated some thousands of feet above sea level. Tremendous masses of molten rock were intruded into the Grenville just before, during, or after the uplift. It is highly probable that the intrusion occurred during the uplift because the force of elevation might also well have pushed the molten masses upward. These igneous rocks are represented within the quadrangle by the syenite and granite. In some cases the Grenville was left practically intact as, for example, the large area on the eastern side of the map; while in other cases it became more or less involved with the molten flood to give rise to a series of varied rocks as illustrated by the Grenville-Syenite areas on the map.

After this igneous activity all of the rocks were severely metamorphosed or changed from their original character by being compressed, folded and converted into gneisses. Thus we explain the gneissic or banded structure of all the rocks and the complete crystallization of the sediments.

Immediately after the great elevation above referred to, the whole land mass began to be eroded and this period of erosion extended over an immense length of time when rock materials of thousands of feet in thickness were removed. This we know because the folded and gneissic structures now at the surface must have been developed at great depth (thousands of feet) below the surface. Judging by the present rate of erosion of rock masses we believe that the erosion period had a duration of at least several million years extending into the early Paleozoic era.

Toward the close of this erosion period minor igneous intrusions occurred, such as are represented by the small dikes of gabbro or diabase of the quadrangle. These rocks are certainly much younger than the rocks already referred to as shown by their occurrence in the form of dikes and by their lack of metamorphism. Their fine-grained texture shows that they were cooled much nearer the surface than were the syenites and granites.

As a result of the vast erosion the whole land mass was worn down to near the sea level and presented only a moderate relief. Then a gradual sinking took place when the sea steadily encroached upon the land and caused a deposition of one layer of sediment (Paleozoic) after another upon the former land surface. The whole area of the quadrangle as well as most, if not all, of the Adirondack region was thus submerged. The deposition of these sediments, largely derived from a wearing away of the sinking land, upon the ancient gneisses has given rise to the profound unconformity now existing between the Paleozoic and Precambric.

The first deposit to form upon the sinking Precambric rocks of the quadrangle was the Potsdam (Upper Cambric) sandstone. The coarse conglomerate and sandstone now seen at the base of the Potsdam literally represents the boulders and sand accumulated along the encroaching shore line those millions of years ago. With a deepening of the water came the deposition of the alternating sandstones and limestones of the Theresa formation and above these the Little Falls dolomite (Upper Cambric).

After the deposition of the Little Falls there was a gentle upward oscillation of the area above sea level so that the Little Falls dolomite suffered erosion. This old eroded surface may be seen throughout the Mohawk valley and marks (by unconformity) the boundary between the Cambric and Ordovicic systems.

Next came a sinking of the land below the ocean surface when the Tribes Hill (Ordovicic) limestone was formed. This was followed by another gentle emergence of the land above the sea when a notable amount of erosion again took place. This emergence and consequent erosion is shown by the distinct unconformity now existing between the Tribes Hill and overlying Black River-Trenton in the Mohawk valley as well as by the practical absence of the

Tribes Hill from the Broadalbin sheet because it was removed during this time of erosion.

Another downward movement brought a return of marine conditions when the Black River-Trenton (Ordovicic) limestones were laid down. The profusion of animal life in the ocean of that time is proved by the abundance of fossils embedded in the rocks of Black River-Trenton age. After this the waters became muddy when the Canajoharie and Utica black shales were deposited and then the alternating sandstones and shales of the Frankfort (Ordovicic). Although the Frankfort is the youngest Paleozoic formation of the quadrangle, it is quite certain that still later sediments were here deposited but have since been removed by erosion.

After Paleozoic sedimentation there was a great uplift, most likely at the close of the Paleozoic era, which raised the region high above the sea level. Thus another vast erosion cycle was established to extend through all the millions of years to the present time. There is no evidence whatever that the region was ever again submerged below the ocean level. The Paleozoic sediments have been completely removed from those portions of the quadrangle where the Precambric rocks are now exposed, while they have suffered great erosion over the Paleozoic area itself.

Postpaleozoic erosion must have been vigorous during the long time of the Mesozoic era and there is good reason to think that, by the close of that era, the whole region was reduced to the condition of a fairly good peneplain (part of the well-known Cretaceous peneplain of the Appalachians) and that at the close of the Mesozoic the peneplain was upraised. According to this the present major topographic features are the result of erosion since this late Mesozoic uplift or rejuvenation of the region.

Another feature of great importance in the history of the quadrangle is the faulting or fracturing of the earth's crust which occurred sometime after the deposition of the Frankfort, since that formation is involved in the faulting. The exact date of this faulting is not known but it probably took place at the time of the great uplift at the close of the Paleozoic.

The most recent event of special interest in the history of the quadrangle was the existence of the great ice sheet during the Glacial epoch. Extensive superficial deposits and rock scorings bear testimony to the vigorous glaciation of the quadrangle. From the geologic standpoint this ice sheet was present only very recently and covered most of New York State.

ECONOMIC PRODUCTS

ROAD METAL

Road metal of good quality is abundant within the borders of the quadrangle. To get the best results a road metal should be homogeneous, hard and possess a good binding or cementing power. Among the Precambric rocks the Grenville is perhaps least valuable because the rocks of that formation are mostly micaceous and the presence of the slippery mica flakes in the crushed stone tends to prevent a proper binding. The porphyritic granite is also not a first class road metal because of the mica content. The syenite, though still little used, should furnish very satisfactory road material since the rock is hard, pretty homogeneous, free from mica, and rich in iron minerals. The iron minerals on decomposition would supply a cement. During the summer of 1910 a large quarry, for State road work, was opened in the syenite along the river road just north of Northville.

By far the best rock in the whole district for road building is the gabbro or diabase which occurs in the small dikes shown on the map. The supply of this rock is not large but enough is available to build many miles of highway. This rock, commonly called "trap rock," is black, hard, very homogeneous and very rich in iron minerals. Its durability and binding power are scarcely surpassed by any other kind of road rock.

Among the Paleozoic rocks the Potsdam sandstone and the passage beds of the Theresa formation are of little value as road metal because of the tendency to crumble under the traffic. The Little Falls dolomite, especially where freest from sand grains, is better adapted for road work. A large quarry in the dolomite has been opened on the George Close farm about one and one-half miles east of Mayfield and on the railroad. The rock is crushed at the quarry and shipped for road metal and is said to be of good quality. Some of the beds here have a pink color and all of the rock is very compact and homogeneous. The Trenton limestone has been considerably used, especially on the State road between Amsterdam and Broadalbin. A large quarry for this purpose was opened in the Trenton about two miles south-southeast of Perth. The rock gives good satisfaction except perhaps that it is too soft.

In the State road work during 1909 glacial boulders or erratics were largely used in the vicinity of Broadalbin. Although fairly good results seem to be obtained with this readily available material, the chief objections are the heterogeneous character of the material and the presence of so much mica which affects the binding power.

BUILDING STONE

Building stone of good quality is common throughout the Precambric areas, but the comparatively slight demand for such stone has prevented any extensive exploitation. One and one-half miles north-northeast of Northville a quarry has been opened in the mixed gneisses. This rock, though called granite, is really a Grenville facies of the mixed gneisses. It is a gray, medium grained rock, rich in feldspar, quartz, biotite, mica and garnet. The rock takes a high polish and has been used in Northville especially for tombstones in the cemetery on the north side of the village.

Building stone of fine quality may be obtained from the Potsdam, especially where the sandstone beds are regular and the cementing material is silica. There is a large quarry in such rock on Bunker hill and the nearness to the railroad affords good shipping facilities. Stone from the Trenton and Little Falls formations has been locally used to a small extent.

LIMESTONE FOR QUICKLIME

An excellent limestone used in the production of quicklime is obtained from the Amsterdam formation. A number of quarries have been opened and in nearly every case this heavy bedded, pure, crystalline limestone just below the Trenton is preferred. The only quarry and kiln now in operation within the map limits is three-fourths of a mile east of Cranberry Creek. This is known as the Kegg quarry. Mr Haines owns two quarries, one just off the map and one and one-half miles north of Mayfield and now in operation, while the other is two miles southwest of Cranberry Creek and temporarily closed.

Other quarries in the Amsterdam formerly worked are: In the small area east of Mayfield; on the west side of Bunker hill; two miles east of Broadalbin; and one and three-fourth miles east of Galway.

On the Beecher farm, one and one-fourth miles north of Northampton, the Little Falls dolomite has been tried for quicklime. This rock is said to make a lime which sets very hard but is objectionable because hot water is necessary for slaking.

FELDSPAR

Although feldspar is the most common mineral among the Precambric rocks it is never likely to become commercially important except in the pegmatite dikes or veins [*see* page 23]. Feldspar is a valuable mineral used in the manufacture of porcelain and chinaware. During 1909 the only mine in operation was the one owned by the Claspka Mining Co.[1] of Trenton, N. J., and situated two and one-half miles north-northeast of Batchellerville. Many acres in this vicinity are rich in pegmatite veins although mining has been carried on at but two points. The feldspar is very pure and the deposit is no doubt a large one, but the mineral is generally so intimately associated with quartz that a considerable expense is involved in separating them. The feldspar is drawn to Northville, from which point it is shipped to Trenton, N. J.

MICA

Mica is very commonly distributed through the Precambric Grenville rocks in small flakes but only the large, clear (muscovite) mica is valuable. Much prospecting has been done for this mineral but no mine has been successfully operated. A mine was operated for a time two miles north-northeast of Northville and just beyond the map limit.

GRAPHITE

Graphite, or so-called black lead, has been frequently noted in the form of small flakes in the Grenville. So far as observed it is most bundant in the rocks to the northeast of Batchellerville and, about one and one-fourth miles east-northeast of that village, a prospect cut some thirty or forty feet long has been run into the Grenville, but real mining has never been attempted. The graphite occurs irregularly in flattened masses, sometimes five or six inches long and half an inch thick, between the layers of thin-bedded Grenville. The Grenville rocks east of Batchellerville are much like those farther eastward in Saratoga county where graphite is being mined and it is quite possible that a workable deposit may sometime be found.

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[1] This property has recently been acquired by the Adirondack Spar Co. of Glens Falls.

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New York State Museum

JOHN M. CLARKE, Director

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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.

1904. 138p. 20c.
1905. 102p. 23pl. 30c.
1906. 186p. 41pl. 35c.
1907. 212p. 63pl. 50c.
1908. 234p. 39pl. map. 40c.
1909. 230p. 41pl. 2 maps, 4 charts. *Out of print.*
1910. 280p. il. 42pl. 50c.

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.

Geologist's annual reports 1881–date. Rep'ts 1, 3–13, 17–date, 8vo; 2, 14–16, 4to.

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*
1	$.50	11	$.25	19 (Bul. 76)	$.15
2	.30	12	.25	20 (" 97)	.40
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8	.25	16 (" 36)	.25	24 (" 134)	.35
9	.25	18 (" 64)	.20	25 (" 141)	.35
10	.35			26 (" 147)	.35

Reports 2, 8–12 may also be obtained bound in cloth at 25c each 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.

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), in volume 4 of the 56th (1902), in volume 2 of the 57th (1903), in volume 4 of the 58th (1904), in volume 2 of the 59th (1905), in volume 1 of the 60th (1906), in volume 2 of the 61st (1907), 62d (1908), 63d (1909) 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. 8vo. *To advance subscribers,* $2 *a year or* $1 *a year for division* (1) *geology, economic geology, paleontology, mineralogy;* 50c *each for division* (2) *general zoology, archeology, miscellaneous,* (3) *botany,* (4) *entomology.*

Bulletins are grouped in the list on the following pages according to divisions.

The divisions to which bulletins belong are as follows:

1	Zoology
2	Botany
3	Economic Geology
4	Mineralogy
5	Entomology
6	"
7	Economic Geology
8	Botany
9	Zoology
10	Economic Geology
11	"
12	"
13	Entomology
14	Geology
15	Economic Geology
16	Archeology
17	Economic Geology
18	Archeology
19	Geology
20	Entomology
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25	Botany
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19 Merrill, F. J. H. Guide to the Study of the Geological Collections of the New York State Museum. 164p. 119pl. map. Nov. 1898. *Out of print.*

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Catalogue of the Cabinet of Natural History of the State of New York and of the Historical and Antiquarian Collection annexed thereto. 242p. 8vo. 1853.

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—— Map of the State of New York Showing the Location of Quarries of Stone Used for Building and Road Metal. Mus. Bul. 17. 1897. Free.
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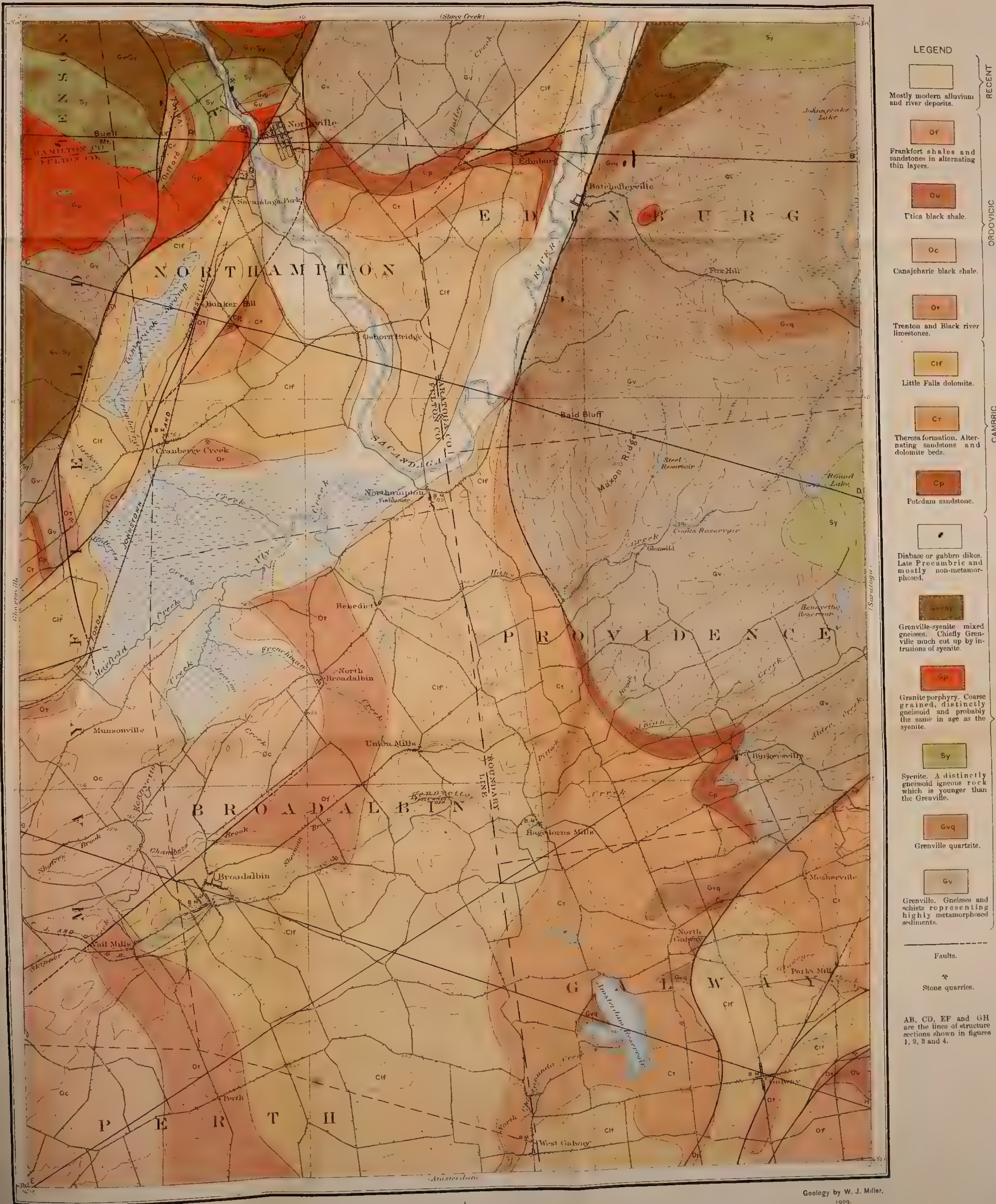

Geology by W. J. Miller.
1909.

Scale 62500

Contour interval 20 feet.
Datum is mean sea level

Terry