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The University of the State of New York

New York State Museum

JOHN M. CLARKE, Director

THE MINING AND QUARRY INDUSTRY OF NEW YORK STATE

REPORT OF OPERATIONS AND PRODUCTION DURING 1915

BY

D. H. NEWLAND

UNIVERSITY OF ILLINOIS

	PAGE
Introduction	7
Mineral production of New York	10
Cement. R. W. JONES	12
Clay. R. W. JONES	14
Production of clay materials	14
Common building brick	16
Front brick	22
Common hollow brick	22
Fireproofing	23
Paving brick	23
Terra cotta	24
Drain tile	24
Pottery	24
Crude clay	25
Feldspar	26
Garnet	28
Graphite	29
Gypsum	31
Iron ore	34
Millstones	38
Mineral paint	39
Mineral waters	40
Natural gas	43
Petroleum	46
Salt	48
Sand and gravel	52
Stone	56
Production of stone	57
Granite	58
Limestone	60
Marble	68
Sandstones	71
Trap	75
Talc	77
Zinc	79
Index	87

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The University of the State of New York
New York State Museum
JOHN M. CLARKE, Director

GEOLOGY OF THE VICINITY OF OGDENSBURG

(Brier Hill, Ogdensburg and Red Mills Quadrangles)

BY H. P. CUSHING

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	PAGE
Introduction	7
Location and character	8
General topography	9
Glacial deposits	10
General geology	12
Descriptive geology	12
Precambrian rocks	12
Igneous rocks	17
Structures of the Precambrian rocks	22
Paleozoic rocks	23
Character of the Precambrian surface under the Paleozoics	24
Cambrian (Ozarkian) formations	25
Theresa formation	28
Ordovician formations	35
Tribes Hill formation	35
Ogdensburg formation	37
Structures of the Paleozoic rocks	52
Historical geology	53
Precambrian time	53
Cambrian time	55
Ordovician time	56
Later Paleozoic history	57
Mesozoic history	58
Tertiary history	58
Quaternary history	59
Index	63

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GEOLOGY OF THE VICINITY OF OGDENSBURG

BY H. P. CUSHING

INTRODUCTION

The chief purpose in mind in undertaking the areal mapping of the district here reported upon was to make a careful study of the Beekmantown formation in the district of the upper St Lawrence, in order to see how fully it was represented and how it compared with the formation in the Champlain valley. Between Ogdensburg and Morristown excellent sections of the formation are shown so that, in so far as the lower portion of the formation is concerned, the work was very successful. Down the river from Ogdensburg, however, the glacial drift is very widespread and heavy, and rock exposures are infrequent and scant; so much so that it is highly questionable whether a satisfactory idea of the higher beds of the formation can be obtained.

Prof. G. H. Chadwick was engaged in mapping the Paleozoic rocks of the Canton quadrangle, at the same time that our work was in progress, giving opportunity for us to keep in touch with each other, and to make a definite comparison of results. This has proved of especial help since, owing to heavy drift, the rocks east of Ogdensburg on the Ogdensburg quadrangle are almost completely covered up, and a formation wedges in there and appears strongly on the Canton quadrangle, where Professor Chadwick recognized it, which would probably have entirely escaped our notice on Ogdensburg.

In 1913 both Dr E. O. Ulrich and Dr R. Ruedemann spent two or three days with me at Ogdensburg, looking over the section with me and giving indispensable assistance. They have also spent much time in determination of the fossils collected, hence a large part of such merit as the report may have is owing to their aid.

LOCATION AND CHARACTER

The district here reported upon comprises the Brier Hill, Ogdensburg and Red Mills quadrangles of the topographic map sheets. The southwestern margin of the Brier Hill sheet overlaps by a trifle the northeastern corner of the Alexandria Bay sheet, so that the mapping is a continuation, down the river, of the work done in the Thousand Islands region.[1] In the latter territory the Paleozoic rocks found are chiefly those to the south of the Frontenac axis, as the belt of crystalline rocks which comes down to and crosses the river at the Thousand Islands is called. In the Ogdensburg district the Paleozoics are those to the north of this axis, and the contrast between the two will be subsequently shown.

The mapped area extends from longitude 75° 15′ to 75° 45′ W. and from latitude 44° 30′ to the St Lawrence river. It is of triangular shape, since the river flows northeast. At the west edge of the Brier Hill sheet the river crosses the parallel of 44° 30′; at the east edge of the Red Mills sheet the south bank of the river is about at latitude 44° 52′. The area included is about 320 square miles.

The district lies entirely in the topographic province of the St Lawrence plain, though its southern margin might be said to belong to the northwest edge of the Adirondack highland. On the northwest there is not the sharp junction between these two topographic provinces that there is farther east, but a very gradual drop from the one to the other.

The district lies also on the boundary between two geologic provinces, which correspond in a general way with the topographic. The crystalline rocks of the Adirondack highland descend to low levels in this vicinity, and cross into Canada at the Thousand Islands in a narrow belt, furnishing an isthmianlike connection between the great area of these rocks in the Adirondacks, and the vastly greater area in Canada. Below the Thousand Islands the river flows through a country of low altitude whose rocks are flat-lying formations of early Paleozoic age, and crystalline rocks do not reappear along the river west of Quebec. The general breadth of this Paleozoic plain of the St Lawrence valley, which separates the Adirondack highland from the Canadian highland, is from 60 to 70 miles, but three-fourths of this breadth, and of the plain, lies on the Canadian side of the river.

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[1] N. Y. State Mus. Bul. 145.

GENERAL TOPOGRAPHY

The mean level of Lake Ontario and of the St Lawrence through the Thousand Islands is 246 feet above tide. At Ogdensburg it is only 2 feet lower than this, but on the 12 miles of river across the Red Mills quadrangle there is a rapid drop at the Galop rapids, from 244 feet above the rapids to 228 feet at Rockaway point, 16 feet in 8 miles. The levels of the river are the lowest levels in the area mapped.

The highest land on the Ogdensburg quadrangle is around Dekalb Junction in the extreme southeast corner where an elevation of 470 feet is reached. This gives for the quadrangle an extreme of relief of only 225 feet, a very small amount; and the bulk of the quadrangle lies between 300 and 400 feet altitude. On the Brier Hill quadrangle it is even less, since 400 feet is exceeded in only two places, and 440 feet is the highest point, only 200 feet above the river.

The minor relief on the Brier Hill sheet is considerable, much of the surface consisting of slopes; there are many rock exposures, and hence very little guess work is necessary in working out the geology. But the entire northern half of the Ogdensburg quadrangle consists of a plain with little relief, and so covered with glacial drift that rock exposures are very infrequent, and the mapping of formation boundaries is a very uncertain matter.

Drainage. The mapped area drains entirely into the St Lawrence, the chief stream being the Oswegatchie river, which is one of the five good-sized streams which drain out from the Adirondacks to the northwest, the others being the Black, Grass, Raquette and St Regis. Five miles south of Ogdensburg, Black lake, which is nothing but an expansion of the waters of the Indian river into a lake, empties into the Oswegatchie. The Indian river is a considerable stream, but not comparable to the others in size.

The general slope of the district is to the northwest, toward the St Lawrence. This is, however, at right angles to the geologic grain of the country which trends northeast. Most of the preglacial valleys of the district have this northeast trend. Black lake lies in a preglacial valley; and the adjacent valleys of Fish creek and Beaver creek have the same trend and are small preglacial valleys. South of Rensselaer Falls the Oswegatschie is now occupying the preglacial valley of a small stream; but below that point its course seems entirely postglacial, and it has no valley worthy of the name,

but flows in a shallow trench cut chiefly in glacial deposits, with rock seldom showing, and with rapids in the stream wherever it is on bedrock.

The St Lawrence, in its course across the Brier Hill sheet, seems to be occupying an old valley; at least there is a well-defined valley rock wall on the New York side. But below Ogdensburg it has the same characteristics as the lower Oswegatchie, no well-defined valley, low banks of drift with no rock showing, and rapids in the river whenever it discovers rock ledges in its bed, as at the Galop rapids.

GLACIAL DEPOSITS

All the surface of the district is below the levels of the bodies of standing water which existed in the region during the closing stages of the Glacial Period, and practically all of it is beneath the level of the marine waters which invaded the St Lawrence valley when the final melting away of the ice sheet cleared a way for their passage. On the Brier Hill sheet the wave action of these water bodies swept away most of the glacial deposits from the higher rock surfaces and into the old depressions, which are deeply filled with them. The low grounds which comprise all the north half of the Ogdensburg are so drift-covered that rock outcrops are exceedingly scarce, but the drift has comparatively little surface relief, was probably all laid down under standing water, and has since all been wave-washed.

A well-defined morainic belt extends across the Ogdensburg and Red Mills sheets, parallel to the river. It has a breadth of several miles and seems to be broadening eastward, with the widening of the Paleozoic plain. But the moraine has a very subdued relief, the knobs being low and of gentle slope, with seldom a relief of as much as 40 feet above the low grounds. Nor does the material appear to be particularly thick; we doubt if it would average 40 feet thick.

This moraine does not extend far west on to the Brier Hill sheet, on which rock exposures abound and drift is heavy only in the preglacial valleys. On the south half of the Ogdensburg sheet, also, there is no widely spread drift cover. The rock relief is greater there than to the north and the drift is solely in the depressions. The depressions are often marshy.

The morainic belt is, to a considerable extent, drowned beneath the clay plain formed by deposit in the standing waters, so that the

general surface is a clay flat, above which the higher knobs of the moraine project.

The only considerable drift hill in the whole mapped district is the rather boldly projecting ridge known as Mount Lona, about 2 miles south of Heuvelton, midway of the Ogdensburg sheet. Its north front is at the river edge, at the sides it rises rather abruptly from low, flat country, it trends southwest, parallel with the general direction of ice motion, has a length of about a mile and one-half, and a breadth of one-half of a mile. Its summit has an elevation of 466 feet, the highest point on the map with the exception of one or two of the granite knobs near Dekalb Junction, which are a few feet higher. It towers 160 feet above the country on the north and east, and 100 feet above that on the southwest.

The ridge is entirely composed of bouldery drift, probably morainic. It stands on a sandstone plain, with rock near the surface, and occasionally outcropping around the margins of the knob. A low moraine stretches from it toward the southwest, but a moraine of no particular bulk or prominence. The hill somewhat suggests a drumlin, though somewhat more abrupt, more prominent and more elongated than the usual drumlin. The lack of other hills of the same type in the district tends to throw doubt on such a classification also. We were unable to devote any particular attention to the drift deposits of the region, and simply chronicle this hill as an interesting point for study. Because of its prominence it was thought that perhaps shore line features would be shown upon it, but we could detect none, and apparently the marine waters must have overtopped it somewhat.

A much smaller and less conspicuous hill of similar type is that at Lost village, 5 miles south of Ogdensburg, on the west side of the Oswegatchie at the point where Black lake outlet empties into it; this is also a purely morainic hill, resting on bedrock, and with no particular connection with a morainic belt.

Though the general surface of the Ogdensburg quadrangle consists of a clay plain, above which low, morainic summits rise, locally considerable sand rests upon the surface. Much of the sand is in the lee of the moraine knobs, in the fashion of sand spits, similar to the many occurrences of the same sort on the Theresa and Alexandria Bay quadrangles. But there is also much sand as knolls mingled with the moraine knobs, which seem to be of the kame type, and the chief moraine is probably a kame moraine, its features masked because of its subaqueous formation.

GENERAL GEOLOGY

The rocks of these three quadrangles consist of (*a*) crystalline rocks of Precambrian age and (*b*) early Paleozoic rocks of the St Lawrence trough which lie upon the Precambrian rocks. The Precambrian rocks are the characteristic rocks of the Adirondack region, are as old as any rocks of which we have knowledge, consist in part of sediments and in part of igneous rocks, and have but small extent on the sheets here reported upon, occupying about one-fourth of the area of the Ogdensburg sheet, and occurring in the southeast corner of the Brier Hill sheet. On the Hammond and Gouverneur sheets, next south, however, they occupy most of the territory. The overlying Paleozoic rocks extend solidly along the St Lawrence in a strip a few miles in breath, and the lowermost member, the Potsdam sandstone, is also found in outlying patches within the area of the crystalline rocks. The crystalline rocks are much older than the Paleozoics, venerable as the latter are, and in the time interval between the two sets of rocks the region existed as a land area for a very long period, during which time much rock material was slowly worn away from its surface. It is upon this worn and somewhat irregular surface of the crystalline rocks that the Paleozoic rocks rest. They have remained comparatively undisturbed since their deposition, and still lie nearly flat and unbroken, as laid down, presenting the strongest kind of a contrast to the greatly deformed Precambrian rocks.

DESCRIPTIVE GEOLOGY

PRECAMBRIAN ROCKS

The Precambrian rocks of northern New York comprise an old series of sedimentary rocks, known as the Grenville series, which are the oldest known rocks of the region, and various masses of igneous rocks, all of which cut the Grenville rocks intrusively and are therefore younger than they are. The older set of these intrusives consists chiefly of granite, while a younger set consists of granites, syenites, gabbros and anorthosites. Where both sets are present and in contact with one another, as is the case in the Thousand Islands region, it is possible to class them in their appropriate groups, on the evidence of their structural relations to one another. But where such contacts can not be found, such classification is a difficult and hazardous matter. To the older set of

these intrusives the name of Laurentian is applied; for the younger set certain of the Canadian geologists have recently suggested the name "Algoman." It is not certain to which of these groups the granites in Dekalb and in Macomb belong. But both granites and syenites are well represented in the small Precambrian area which the maps contain.

Much later in Precambrian time came renewed igneous intrusion, and black, heavy lavas, so-called trap rocks, rose toward the surface. Such traps are well represented in the Thousand Islands, but in the district here mapped but two small dikes of this rock have been seen.

The Grenville rocks in considerable diversity are found in the southern part of the Ogdensburg quadrangle. They are cut by granitic, syenitic and gabbroic eruptives, and by trap dikes.

The Precambrian rocks exposed within the mapped area cover such a trifling amount of territory, being the mere northern fringe of the great and well-exposed areas of these rocks on the Gouverneur and Hammond sheets next south, that it seems unwise to attempt any elaborate investigation of them until these sheets have also been studied. Since it is our present plan to commence study of the Gouverneur area, the detailed report upon the Ogdensburg Precambrian will be left until that work is completed.

Grenville series. The Grenville series in the Adirondacks exhibits an enormous but unknown thickness of limestones, quartzites and various sorts of schists and gneisses. These are water deposited rocks and were unquestionably deposited in great thickness over the entire region. Not long after their deposit, however, they were invaded from beneath by huge masses of molten granite; and at a subsequent time by even greater masses of a variety of igneous rocks. This action broke up the old series into a group of disconnected blocks and patches, separated by masses of the intrusives, so heated and compressed the sediments as to cause complete recrystallization of their constituent parts, and vastly changed their appearance. The pure limestones were changed into white marbles, with scales of yellow mica and of graphite always present. The less pure limestones are full of other silicates in addition, chiefly pyroxenes and scapolite. The sandstones were changed into quartzites and quartz schists. The shales were altered to schists of various sorts. Contact rocks were produced at the contacts of many of the igneous rocks, and these also have been recrystallized to schists and gneisses. Often there is great difficulty

in determining just what the nature of the original rock may have been.

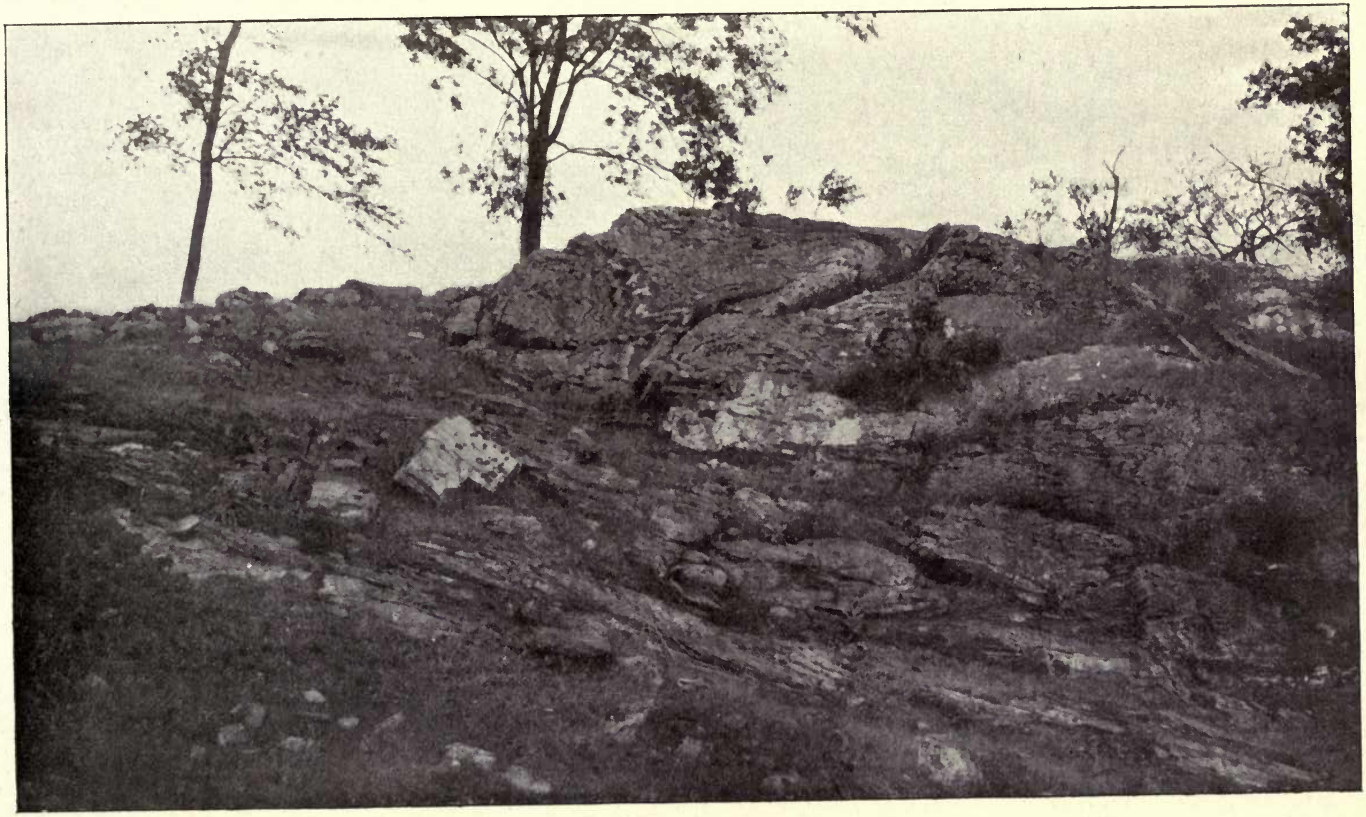
Limestone. An unusually large proportion of the exposed Grenville on the Ogdensburg sheet consists of limestone. A great belt of limestone comes on to the sheet at its southwest corner and the rock is magnificently exposed along the east side of Mud lake, and runs northeast from there in a prominent belt more than a mile in width, its western portion overlapped and covered by Potsdam sandstone. The Grenville limestone is a weak rock in its resistance to erosion, tends to form low grounds and to be heavily covered with soil, so that outcrops are scarcer than in most of the Grenville rock belts, that is, belts of other rock. To the east of this belt are two narrower belts, one east and one west of the Oswegatchie, but in these the limestone is less pure and alternates with thin bands of quartzite and of schists. The areal distribution of the limestone suggests a series of folds pitching to the northeast.

Frequent knobs of granite are found cutting through the limestone, especially in the belt which borders the Oswegatchie on the east. These are more resistant to erosion than the limestone and form the more prominent outcrops in the limestone belts; in fact the great majority of the limestone outcrops are found on their borders. These granite knobs in every case consist of *white* granite, though the granite masses elsewhere are red. It seems to be the same sort of bleaching of the granite at limestone contacts as has been described in the Thousand Island region.

Quartzite. There is no considerable belt of quartzite in the Grenville series of the Ogdensburg quadrangle, though there are narrow belts of it involved with impure limestone in alternating layers, too narrow to map on this scale as separate from the limestone. There is still more of it in narrow bands interbedded with amphibolite and rusty gneiss, all too narrow to map separately and hence mapped simply as Grenville schist. The quartzite is thin bedded, is really quartz schist, and exhibits everywhere minute folding and puckering, showing these features much better than any other rock in the district (plates 1 and 2).

Schists. The larger portion of the area which is mapped as Grenville schists is occupied by the dark-colored rock conveniently known as amphibolite, and made up chiefly of feldspar and hornblende, often with some pyroxene as well and commonly with black mica in addition. When the mica becomes prominent the rock cleaves readily and becomes rather weak. From these thinly

Plate 1



H. P. Cushing, photo, 1913

Closely folded Grenville quartzite, two miles south of Kindrews Corners

H. P. Cushing, photo, 1913

Closely folded Grenville quartzite, two miles south of Kindrews Corners

foliated mica schists there are all gradations into a solid, massive black rock, fairly coarse grained, and with a poor foliation, which is a rather typical amphibolite.

The amphibolites found in the Adirondack Precambrian look much alike, but have originated in at least three quite different ways and from rocks which were originally unlike. In part they represent metamorphosed calcareous shales, which occur in beds within the Grenville series and are an integral part of that series. They are also produced from somewhat impure limestones as a result of the contact action of granitic intrusion upon these limestones. Such amphibolites are found only at such contacts, and should show a gradation back into limestone as we recede from the contact. In still other parts the amphibolites are produced from original basic igneous rocks, gabbros, due to recrystallization under the conditions of heat and pressure which have so profoundly changed all these old rocks from their original condition.

There are probably amphibolites of all three origins within the Ogdensburg quadrangle, but much uncertainty prevails in regard to most of the occurrences. The belt of schists at the eastern margin of the sheet, between the granite and the Potsdam, consists of a jumble of thin beds of many sorts of rock, much folded and contorted and following one another in rapid succession. Thin limestones and quartzites are interbedded with impure limestones, garnet schists, amphibolites and other schists in such wise that they could be separately mapped only on a very large scale map with the aid of multitudinous exposures. The amphibolites here, however, seem certainly to be metamorphosed shales.

Midway of the southern margin of the Ogdensburg sheet is a broad belt of Grenville amphibolite much involved with porphyritic granite. The granite occurs in long, narrow tongues in the amphibolite, but these hold many inclusions of amphibolite. The amphibolites are cut by a multitude of narrow dikes from the granite, and in places are much granulated and soaked by the granite, with the production of mixed rocks. The granite also carries much black mica, and is thoroughly foliated, so that, in the places where the porphyritic crystals of feldspar fail, it looks not unlike some phases of the amphibolite. The main granite tongues can be mapped, and the chief amphibolite masses are readily differentiated from them, but there remains much mixed material, here mapped with the amphibolites, which forms a very puzzling combination. The amphibolite itself also varies greatly. The central part of the mass, that

between the two inner granite tongues, is a solid, massive rock which we can interpret only as an intrusion of altered gabbro. It shows two phases, a fine-grained, pepper and salt combination of feldspar and hornblende in about equal quantities; and a coarser, more blotchy looking rock, of similar composition. This central area has been definitely mapped as gabbro, though its boundaries are very indeterminate. The marginal portions of the mass are more micaceous, much better foliated and less massive, much cut up by granite and quartz veins and dikes, and locally soaked by the granite. Here much of the rock is so exactly like the amphibolites interbedded in the Grenville and considered to be metamorphosed shales, that we are in doubt how to class them. They have the gabbro on one side of them, and Grenville limestones on the other. All are cut by, and therefore older than, the granite.

All the granites of the region contain frequent inclusions of the Grenville rocks, and in almost every case these inclusions consist of amphibolite, and inclusions of limestone are never found. Beyond doubt some of these amphibolite inclusions represent altered limestone fragments; but with this exception no amphibolite was seen within the mapped area which definitely suggested such an origin.

In the variety of other schists shown in the region, mention may be made of the garnetiferous schist, for the reason that Doctor Martin has found this rock in considerable quantity on the Canton sheet, next east, and has separately mapped the belts of it there found. But two exposures of this rock have been found on Ogdensburg, one near the east margin, which is in direct prolongation of the belt on the Canton sheet, and the other in a disconnected patch near the south margin. The rock is a heavy, solid one, chiefly composed of feldspar of greenish-gray color, some quartz, much graphite in small flakes, a small quantity of black minerals, and very numerous purplish-pink garnets, averaging one-quarter of an inch in diameter.

Rusty gneiss. A very characteristic Grenville rock in all districts where they are exposed is a peculiar, weak gneiss, which weathers rapidly to a rusty-looking rock of a peculiar yellowish shade. It is usually a highly quartzose rock, holds much pyrite, whose decomposition is chiefy responsible for the peculiar appearance of the weathered rock, contains considerable graphite, as do many of the Grenville schists, and in addition certain rarer minerals, such as sillimanite. Thin bands of this gneiss are found in many

places associated with the limestones, on the Ogdensburg quadrangle, but the bands are quite too thin to map separately on this scale.

Associated with the limestones, especially as marginal phases, are dark-colored, heavy gneisses, composed largely of pyroxene, usually with much graphite also, which apparently represent rather impure limestones. These rocks, when heavily metamorphosed, lose their carbon dioxide to a large extent, and the lime combines instead with the silica present to form various lime silicates, mostly pyroxene.

IGNEOUS ROCKS

Three different varieties of igneous rocks have been mapped on the quadrangle, namely, granite, syenite and diabase. The rock mapped as syenite is really a granite, but because it differs markedly from the general granite of the region and is precisely like rock which elsewhere occurs as a marginal phase of the general syenite of the region, it is so mapped here. It occurs in long, narrow tongues which may be dikelike projections from a larger syenite body to the south on the Gouverneur sheet which is not yet mapped; or there may possibly be such a body to the north, under the Paleozoic rock cover.

A fourth variety of igneous rock should be added, namely, the solid variety of the amphibolite, already described, which is regarded as probably a metamorphosed gabbro.

Granite. Two considerable areas of granite-gneiss are exposed within the mapped district, the one in Dekalb, in the southeast corner of the Ogdensburg sheet, and the other in Macomb, in the corresponding corner of the Brier Hill sheet. A third small area is shown in Hammond, on the south margin of the Brier Hill sheet, and this is of interest as being the extreme northeast prolongation of the granite mass described as the Alexandria bathylith, in the description of the geology of the Alexandria quadrangle in the Thousand Islands report.[1] From Chippewa bay this granite extends to the northeast, up the valley of Chippewa creek, flanked by Potsdam sandstone on both sides, across the northwest corner of the Hammond sheet to the Brier Hill sheet, before the adjacent Potsdam closes around it from the sides and hides its further extent. It shows on Brier Hill in but a single outcrop, but the particular interest which it has for us here is that it is a part of

[1] N. Y. State Mus. Bul. 145, p. 36–38.

the granite mass whose relations to other rocks on the Alexandria sheet seemed to indicate a Laurentian age for it. Its termination here is due to its disappearance under the Paleozoics, which have bordered its sides all the way from Chippewa bay, and which here meet over it. Its further extent to the northeast is purely problematical. It is, however, quite possible that the granite mass in Macomb, east of Black lake, is a part of the same bathylith. The Macomb granite runs out to the northeast in the same manner, namely, by having the bordering Potsdam close around and cover its prolongation. It is, however, very like the rock of the main Alexandria bathylith in character; we regard it as quite probably a part of it, and are disposed to class it as of Laurentian age, along with the Alexandria rock. Even without including it, the Alexandria granite extends for 25 miles in a northeast-southwest direction, to which must be added at each end an unknown amount under the Paleozoic cover which hides its continuation. This continued extent enables us to state that, on the Brier Hill sheet, a granite is present whose proved relations to other rocks strongly suggest its Laurentian age. Evidence of similar sort on the Ogdensburg sheet itself regarding the age of the granites there present, is lacking.

The Macomb granite, which we regard as very probably a part of the Alexandria bathylith, is in large part a fine-grained, red orthogneiss, composed chiefly of feldspar and quartz, but with a variable amount of black mica. Exposures are very frequent in the entire rugged district which it occupies. Coarse phases appear, especially at the margins, and there are frequent pegmatite and quartz veins. In the vicinity of limestone its color is bleached from red to white as described for the granites on the Alexandria sheet, and the granite knobs and dikes found cutting the limestone are all of white color. Inclusions are frequent, especially at the east and south, on approach to the bordering Grenville belts there, and, as usual, the inclusions are always of amphibolite, no matter what the nature of the bordering Grenville rock is. In this particular area, however, most of the inclusions are sharply bounded and show little sign of becoming soaked by the granite and converted into mixed rocks, as so many of the inclusions in the granites of the Alexandria Bay region do. This we take to indicate that we are here comparatively near the margin of the bathylith, and that the inclusions had been incorporated in the igneous mass in its late stage, when its fluidity was much diminished.

A narrow belt of Grenville gneiss margins the Macomb bathylith on the south and just beyond appears the northern edge of a mass of granite, which runs widely to the south on the Gouverneur sheet and which must be studied there. It is a coarser granite than the other, holds but few inclusions, and quite probably belongs to the later intrusives which we have mapped as syenite. Its precise relations must be determined by work on the Gouverneur area.

The Dekalb granite, which occupies the southeast portion of the Ogdensburg sheet, extends to the northeast onto the Canton quadrangle, where it has been mapped and studied by Martin, and also runs southwest for an unknown distance on Gouverneur. Its full breadth of about 4 miles is shown, as Grenville rocks adjoin it to the southeast just at the sheet corner.

In so far as most of the granite is concerned it is a fine-grained, red orthogneiss, quite like that at Macomb and Alexandria, chiefly a feldspar-quartz rock, with very little mica, and with inclusions of amphibolite solely, so that we should have little hesitation in correlating it also with the Laurentian, except for two things. At the western edge it becomes fairly coarse grained and, though quite gneissoid, is a quite different looking rock from the ordinary orthogneiss. At the extreme southeast outcrop on the sheet also the rock is of different character, much more micaceous than normal and resembling a mashed porphyry; in other words, bearing some resemblance to the porphyritic granites here mapped as syenite and regarded as belonging unquestionably to the later group of intrusions. One of the peculiar things about the Precambrian geology of the Ogdensburg sheet is the manner in which these long tongues of porphyritic granite appear cutting the Grenville rocks, but, so far as observed, never invading the adjacent granite-gneiss bodies. It is one of the problems on which we hope to get some light from the study of the wider exposures on the Gouverneur sheet to the south. We are in doubt as to the age of this particular granite, as to whether it should be classed with the earlier or the later group of intrusions.

The bulk of the Dekalb granite consists of finely granular orthogneiss, composed almost wholly of quartz and feldspar, and very similar to the Macomb and Alexandria rocks. Along its western margin, where it is coarse, it directly adjoins a belt of solid Grenville limestone, yet it remains of red color and shows no indication of the bleaching to white which the general Laurentian granites show in like situation. Nor does it show any bleaching near the

long limestone tongue which lies within the granite. The coarser phase of the rock is that portion which lies between these two limestone belts, and it may be a wholly different mass from the orthogneiss which lies east of it. In our experience with the two granites of the region, the older or Laurentian is the one which loses its red color at limestone contacts, and we have not yet met with the younger one affected in the same way. Nor, in our laboratory experiments on the question, did we succeed in bleaching it.[1] We are here simply trying to marshal the arguments for and against an age classification of this granite, and, as stated, we are in doubt. If it consists of two separate granites we should have no hesitation in correlating the western portion with the later, and the eastern portion with the earlier granite. But we have little direct evidence of an age difference between the two masses.

In the eastern portion of the mass we came upon evidence of bleaching of granite adjoining amphibolite inclusions, evidence chiefly obtained from a quarry opened near Dekalb Junction to obtain material for use on the state road under construction. It may be remarked that such granite gneiss makes about the poorest possible rock for road making, being exceeded in badness among the local rocks only by the Potsdam sandstone. In this quarry the granite was bleached for a few inches around many of the amphibolite inclusions. This is not a common feature of granite-amphibolite contacts and suggests that these particular inclusions are altered limestones.

Syenite. The rock mapped as syenite and regarded as a member of the later group of intrusives is, so far as its occurrence within the Ogdensburg quadrangle is concerned, not a syenite at all but a granite, and its classification is based solely on its lithologic character, as compared with rocks elsewhere in the Adirondacks. It is a porphyritic granite of a peculiar and definite type, a rock which is of fairly common occurrence in the Adirondack region and which, in our experience, occurs only as a marginal, granitic phase of the syenite bodies of the region. It is because of this that it is mapped as syenite here, and separated from the other granites, and because of this that it is regarded as belonging to the later set of intrusives. In the region here the two sets are not in contact and there is no direct evidence of their relationship to each other.

These peculiar granites are always porphyritic and often coarsely

[1] N. Y. State Mus. Bul. 145, p. 177–80.

so, feldspar crystals of an inch or more in length being not uncommon. They are always prominently gneissoid, with a conspicuous development of black mica, the feldspar crystals are strung out parallel to the foliation, and are themselves often granulated or mashed, sometimes completely, sometimes only partially. The mashed feldspars are always red, while the unmashed are lighter colored, usually gray. The rock is therefore usually a mottled looking, red and black rock, the drawnout, mashed feldspars furnishing the red constituent, and the intervening, fine-grained, micaceous portions the black. The rock is not so siliceous as the usual granite of the region, usually running about 68 per cent of silica as against some 72 per cent for the other. There is considerable quartz in the rock, but probably the quartz and much of the mica develop from recrystallization of original feldspar during metamorphism.

As they occur on the Ogdensburg sheet, the distribution of these syenite masses is peculiar. They occur as a series of disconnected, tonguelike masses, drawn out parallel to the general trend of the neighboring Grenville rocks through which they cut. Eight such separate tongues are mapped within a comparatively small area on the southern part of the Ogdensburg sheet, and there are others to the southwest on the Gouverneur and Hammond sheets. They have not been traced to any connection with a mass of ordinary syenite. Such a mass may be found on these sheets when they are mapped, from which these tongues may be dikelike offshoots. But they do not produce the impression of dikes, nor are their contacts with the Grenville of the type which would normally come with dikes. These contacts are not sharp, but exceedingly blurred. The adjacent Grenville rocks are cut by a multitude of narrow dikes running out from these tongues, so that there is a considerable intermediate zone of mixed rock around each one of them. The relations suggest the influence of a large mass of hot molten rock, much larger than indicated by the present surface exposures. It is therefore quite possible that these tongues are mere upshoots from a large mass of syenite beneath, hidden from view by the Grenville cover, but not far beneath the present surface. This suggestion is, of course, speculative, but would explain the present surface relations, and is opposed by no facts known to us.

Diabase. Only one trap dike has been seen within the mapped limits. This is found in Dekalb, about 2 miles south of Kindrews Corners and just west of the Oswegatchie. It is a large dike, 45

feet wide where measured, bears N. 25° E. and seems quite vertical. No very fresh material could be obtained from it and the alteration which it has undergone has changed its original black color to a dark green. Like all the wide dikes it is of sufficiently coarse grain so that the different minerals may be made out by the eye. Very fresh, glittering, lath-shaped feldspar crystals are abundant, along with much coarser feldspar which is somewhat altered and dull. No olivine can be seen, and the rock is the ordinary feldspar-augite-magnetite mixture usual in these dikes.

The dike does not trend with the rock strike of the adjacent rocks which, at the locality, is north-south. Where seen it cuts across Grenville quartzite and amphibolite and adjacent syenite.

Structures of the Precambrian Rocks

The Precambrian rocks are exposed over such a comparatively small area that study of the structures shown leads to little that is of value and nothing that is new. Their most prominent structure is foliation. The Grenville rocks are believed to be greatly folded, but little that is definite concerning the folds can be made out from the study of such a small area.

Foliation. In the Ogdensburg region the foliation cleavage which has been developed in the Grenville rocks under metamorphism is closely parallel to the bedding, and this seems to be the case throughout the Adirondack region. Strike and dip readings on the one therefore correspond to those on the other.

The general strike of the Grenville rocks of the district is northeast-southwest. But there is much local variation from this general direction. Our readings vary from N. 10° W. to N. 85° E. Often there is rapid local variation due to folding. Along the Oswegatchie nearly north-south strikes prevail; along the east margin of the Ogdensburg sheet the strike has swerved to the northeast and beyond, and so continues on to the Canton sheet; passing westward toward and on to the Brier Hill sheet, it has gone back to the northeast. This is also its general direction in the Thousand Islands region.

The general dip is to the northwest. It is usually steep, in excess of 45°, and locally becomes vertical. Locally also it varies, passing from northwest to southeast and back again within narrow limits, indicative of local plications. The only part of the area within which southeast strikes prevail is a narrow belt on the east side of the Oswegatchie, on the south margin of the Ogdensburg sheet.

Folds. If the Grenville rocks are folded, as they assuredly are, the folding must be of the close and overturned type in order to give rise to dips so prevailingly in one direction as they in general present in northern New York. The general northwesterly dip in this district, for example, seems to us to imply that the folds are all tipped over toward the southeast, so that the dips on both limbs incline to the northwest. The distribution of the limestone on the Ogdensburg quadrangle suggests that we are dealing with one great bed of limestone, pinched into a syncline, the two sides diverging southward, meeting and joining on the north, and hence indicating that the syncline pitches to the southwest, and that the inclosed amphibolite is younger. But the mapped area is too small, the adjacent area too little known, and the structure too complicated, to warrant anything more than this suggestion, to be confirmed or disproved by later work.

The very contorted and complex crumpling and plication which certain beds of the Grenville show, is of itself indication of larger scale folding. Of all the rocks of the group the thin-bedded quartz schists best exhibit such plications. Plates 1 and 2 are from photographs of such quartzite, 2 miles south of Kindrews Corners.

Close folding is also shown in the combination of thin-bedded impure limestones, pyroxene schists and garnet gneisses which occur north of the Dekalb granite on the east margin of the Ogdensburg sheet.

PALEOZOIC ROCKS

General statement. The Paleozoic formations found within the mapped area are the Potsdam and Theresa formations, of upper Cambric age, and the Tribes Hill and Ogdensburg formations, of Lower Ordovician (Beekmantown) age. They rest with marked discordance on the irregular surface of the Precambrian rocks. There is some evidence that still another formation will have to be separated from the upper part of the Theresa, including what we have mapped as the Heuvelton sandstone lentil of the Theresa formation, the beds between this sandstone and the base of the Tribes Hill, and the 30 feet (more or less) of sandy beds just under this sandstone. But the evidence is not yet decisive, and lithologically the beds are much like those of the Theresa, with which they form a convenient lithologic unit.

It is quite possible that beds of later Ordovician age, Chazy, Black River, even Trenton and Utica beds, may have once been deposited in the district, but if so, erosion has left no trace of them.

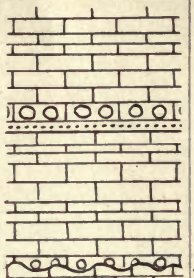
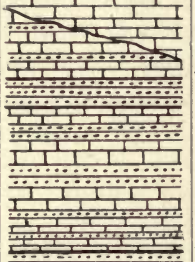
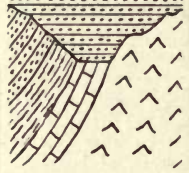
SYSTEM	FORMATION	SYMBOL	SECTION	THICKNESS	CHARACTER OF FORMATION
Ordovician (Beekmantown)	Ogdensburg formation	Oo		120′+	Alternating beds of massive, blue-gray, granular dolomite, and thin-bedded, iron-gray, fine-grained dolomite: with an occasional bed of gray, calcareous sandstone
	Tribes Hill formation	Ot		0′–40′	Thin-bedded, blue, sandy limestones above and below, with an intermediate, more sandy member
Cambrian (Ozarkian)	Theresa formation	Ch Ct		(20′) 120′	Alternating beds of white sandstone, gray calcareous sandstone, and blue sandy limestone, with a 20′ sandstone member, the Heuvelton sandstone, near the summit
	Potsdam formation	Cp		0–60′	Mostly white, vitreous sand stone
Precambrian	Grenville series and igneous rocks	Gl Gs gr sy			

Fig. 1 Generalized columnar section of the rocks of the Brier Hill, Ogdensburg and Red Mills quadrangles

Character of the Precambrian surface under the Paleozoics. It has been shown in many of the recent New York reports that Paleozoic deposition commenced upon a Precambrian surface which was characterized by considerable irregularity. This irregularity seems to have been most pronounced on the northeastern margin of the Adirondacks, in Clinton county, and to diminish in amount both to the south and to the west. On the southwest, in

Herkimer county, the irregularity is least, and there, in fact, the surface is quite smooth. Because of abundant rock exposures the phenomena are much better exhibited in the Thousand Islands region than elsewhere, and were described at length in the report on that district.[1] These irregularities amounted to differences of altitude of at least 100 feet in the various parts of the Precambrian surface, the limestones and weaker schists forming the depressions, and the granites and quartzites projecting as the knobs and ridges. This irregularity in surface is just about equal to the greatest thickness of the Potsdam sandstone, the first Paleozoic formation to be deposited upon it, so that the sandstone is very thin on the higher parts of this surface, and the very highest may even project through it.

Since the Alexandria Bay quadrangle corners on Brier Hill at the southwest, it is to be expected that these phenomena will be repeated in the Ogdensburg region. But they are by no means so well shown. The Potsdam seems no thicker here than there, and the irregularity in Precambrian surface seems somewhat greater here. On the Brier Hill sheet, near the river and 3 miles southwest of Morristown, is a small exposure of Precambrian rock, a hard, pyroxenic Grenville quartzite, entirely surrounded by exposures of the Theresa formation, nearly 40 feet above the summit of the Potsdam. This is the only observed case within the limits of the map of Theresa beds on Precambrian, but the Potsdam is very thin, not over 20 feet thick, on the Macomb granite, and it also seems to be thin as the Canton sheet is approached. On the other hand, through Depeyster where it lies on Grenville limestone, it seems at least 80 feet thick.

CAMBRIAN (OZARKIAN) FORMATIONS

Potsdam sandstone. The Potsdam occurs in two different situations, the one as a continuous belt of sandstone bordering the Precambrian rocks on the north, and the other as outliers of sandstone, within the Precambrian area. As the rock characters differ somewhat in the contrasted situations, they are best described separately.

The belt which borders the crystallines is a very irregular one, because of the irregular surface on which it was deposited. The thickness varies greatly, only the upper beds overriding the Pre-

[1] N. Y. State Mus. Bul. 145, p. 54–60.

cambrian ridges, while the lower beds are limited to the depressions. The bulk of the rock is a hard, white, sugary-looking sandstone, locally with a brown tint, composed of nearly pure, quartz sand, thoroughly cemented by silica. The majority of the exposures are of low, flat, glaciated surfaces, and cliffs, or exposures showing any considerable thickness of the formation, are very exceptional. Excellent exposures may be seen to the south of Brier Hill Station, and these expand into a broad sandstone platform to the south on the Hammond sheet. There are excellent exposures also along the west shore of Black lake, above the narrows. Good exposures also occur at the northeast end of the Macomb granite mass, though here the formation shows only the upper 20 feet. Here also are the only actual contacts with the underlying Precambrian which were seen within the map limits. On the Ogdensburg quadrangle, great, bared exposures occur 2 miles south of Heuvelton, and from there run southwest for 3 miles, or rather for several miles, for the same belt continues down into Macomb, giving way to Precambrian just about at the southern edge of the map.

Interbedded with the sandstone on the Alexandria quadrangle is a peculiar conglomerate, whose pebbles are large sized cobbles rather than pebbles, which may reach a foot in diameter and often show a diameter of 3 inches. The pebbles are almost exclusively of Grenville quartzite, and are usually subangular, though well-rounded ones also occur. They are set in a matrix of sand, and the whole is bound together by a cement which is more often calcareous than siliceous, though both sorts occur. Where the cement is calcareous, as it is in the cliff along the St Lawrence below Chippewa bay, the cobbles weather out rather rapidly; where it is siliceous the rock is very resistant. This conglomerate is usually not basal in the formation, but has a varying thickness of ordinary sandstone underneath it. It is a most astonishing formation and difficult of explanation.

This river cliff, containing the conglomerate, continues on to the Brier Hill sheet, in Hammond, as far as Oak Point, beyond which it also appears intermittently. There is a fine exposure of it near Point Comfort, 3 miles southwest of Morristown, where a small fault runs east from the river bank and brings up the conglomerate on its north side, well above the river. It shows precisely the same characters as in Alexandria. Not far beyond the Potsdam dips beneath the bed of the river, after which the Theresa beds are at the river level for several miles. Underneath the conglomerate at

Point Comfort is a 25 foot thickness of Potsdam sandstone to the river level, with the base not reached, a greater thickness of sandstone than was noted anywhere under the conglomerate on the Alexandria sheet. It seems to vary in horizon, instead of being a persistent band, and to exist in the sandstone after the fashion of large channel-fillings. Above it there is a 20 foot thickness of Potsdam sandstone, making altogether a 50 foot section of the sandstone, with the base not seen. This is the thickest continuous section of the formation that we have seen within the map limits.

There is locally a little hard, red sandstone, mixed with the ordinary white and buff rock, more particularly in the exposures along Black lake, but there is no great amount of it anywhere.

At the extreme summit of the Potsdam a thickness of some 10 feet of beds is slightly calcareous. The calcareous cement occurs in rounded patches which have a light, pinkish gray tinge in contrast with the dead white of the rest of the rock, in fresh specimens. But in the ordinary exposures this cement has been leached out, leaving brown-stained spots in the rock. This brown-spotted sandstone is a characteristic feature of the upper beds. It is also characteristic of the sandstones of the Theresa formation above.

The Potsdam sandstone of the occasional outliers in the Precambrian rocks frequently shows phases quite unlike those of the general mass of the rock in the continuous belt. In this respect it accords closely with the outliers on the Alexandria and Theresa sheets which have already been described.[1] Occasional patches of a red, very quartzitic sandstone were found, resting upon Grenville rocks, usually limestone, and extending down into the limestone along joint cracks which had been widened by solution. Other patches of basal conglomerates of the Potsdam were found which contained, along with numerous pebbles of Grenville quartzites, pebbles of this red, quartzitic sandstone. There is no rock in the Precambrian series which is anything like this red sandstone, and the occurrences distinctly suggested a sandstone, older than the ordinary Potsdam, which had largely been eroded away before ordinary Potsdam deposition began.

The Potsdam outliers on the Ogdensburg sheet, which are rather remote from the main mass of the formation, are chiefly found on the surface of the Grenville limestone belt which the Oswegatchie follows for the first 4 miles of its course on the quadrangle. Two

[1] N. Y. State Mus. Bul. 145, p. 61–63.

or three of these outliers consist of red, flinty sandstone quite like that on the Theresa and Alexandria sheets. There are also associated masses of very flinty conglomerate, full of pebbles of Grenville quartzite, and quite like the conglomerate previously described, except for their more excessive induration. These beds certainly appear somewhat older than the Potsdam of the border belt. But there is as yet no decisive evidence of any material difference in age.

No fossils have been noted in the Potsdam of the mapped area. The nearest point at which we have collected them is at Clayton, where Lingulella acuminata was found.

Theresa Formation

General statement. A series of "passage beds" of alternating sandstone, calcareous sandstone and dolomite beds overlies the Potsdam everywhere in the circum-Adirondack region. To these beds we have been applying, for mapping purposes, the name of the Theresa formation. In the eastern sections these beds have large thickness, 150 to 200 feet, and are followed by the Little Falls dolomite, the three together forming the upper Cambrian (Ozarkian) series of northern New York. Deposition was seemingly continuous between these formations, and they grade into one another, without sharp boundaries, so that their separation from one another is largely a matter of convention, though they constitute three contrasted, lithologic units.

In mapping the Thousand Islands region we encountered difficulties with this classification. The Potsdam was, as usual, followed by a series of passage bed character, to which we gave the name of Theresa, but no representative of the succeeding Little Falls dolomite is present. In the lower half of the Theresa we found Lingulella acuminata in several localities. In the upper half, however, we did not find this fossil but did find in several places a coiled gastropod and occasional cystid plates. These Ulrich identified with forms found in the Tribes Hill limestone of the Mohawk valley, a formation which there lies unconformably on the Little Falls dolomite, and which Ulrich regards as the lowest formation of the New York Beekmantown. The beds containing these fossils were quite similar to the lower ones containing the Lingulella and we were unable to detect any break between the two, and hence mapped them together as a single lithologic unit, the two together not exceeding 60 to 70 feet in thickness.

This statement is regarded as necessary here since, in following these beds on to the Brier Hill and Ogdensburg sheets, and tying them up with Professor Chadwick's work on the Canton sheet, it is found that they have greatly thickened, have changed somewhat in character, and that apparently another formation has wedged in between the lower and upper parts of the formation, as shown in the Thousand Islands region. Furthermore the upper part, the Tribes Hill, is shown very sparingly and erratically in the district here, but reappears on the Canton sheet in even greater force than on Theresa. We seem to be dealing with the thin, near-shore edges, of several formations, very similar lithologically, whose thorough discrimination and description is going to be a very difficult matter, and can not yet be successfully attempted, chiefly because of the lack of well-preserved fossils.

Description. As here mapped, the Theresa formation contains at least two different elements. The lower portion of the formation consists chiefly of thin-bedded calcareous sandstones and sandy limestones, blue-gray and very hard when fresh, but weathering rapidly to yellow-brown, porous rocks, such as usually appear in outcrop. Occasional thin beds of white sandstone, usually brown-spotted after the fashion of the uppermost beds of the Potsdam, occur with the others. This material has a general thickness of from 25 to 30 feet, and seems to be the exact equivalent of the typical Theresa of the Theresa quadrangle. It is on the same horizon and looks the same. But we have found no fossils whatever in it in this district, though it should hold *Lingulella acuminata* if our correlation is correct. The zone is, however, seldom well exposed here, and good opportunity for search for fossils is therefore lacking.

Above this thin-bedded zone there is a recurrence of thick-bedded material, with much increase in the amount of sandstone. This is quite foreign to our experience with this passage bed zone elsewhere in New York. In general there is a steady diminution in the amount of sandstone, going up in the section. But here the increase is so marked that, in many exposures, it would be an exceedingly difficult matter to discriminate these beds from the Potsdam, were not the horizon definitely determined. Midway of the zone is a solid mass of sandstone, 20 feet thick, which is so prominent a feature in the geology of the district that we have given it a separate mapping. Professor Chadwick had independently recognized this sandstone on the Canton quadrangle and has suggested

the name of Heuvelton sandstone for it. It is, however, but one out of several thick sandstones zones in the formation; there are three or four others with a thickness of from 8 to 10 feet, which may readily be mistaken for the other where outcrops are poor. Nevertheless the Heuvelton is far the thickest and most prominent of these sandstones, and forms a conspicuous bench wherever rock outcrops are at all plentiful, so that it is readily mapped all across the district, except for that part of its course across the Ogdensburg sheet northeast of Heuvelton, where heavy drift conceals all rock.

Above the 20 foot (Heuvelton) sandstone, beds of sandstone are not so prominent and thick as they are below it, though they persist to the summit of the formation. The chief constituent here, however, is massive beds of hard, blue, coarsely crystalline limestone, full always of sand grains, and of irregular, black seams, or films, of uncertain nature.

Direct contacts of the Theresa with the Potsdam are to be seen at several points along the river cliff above Holmes point and on the south margin of the sheet 3 miles southwest of Brier Hill, and also on the hillside above Black lake, 2 miles west of Kings Corners, at the west edge of the Ogdensburg sheet. These show, in every case, the thin-bedded, alternating sands and calcareous beds of the typical Theresa, with a thickness of about 30 feet. In the latter instance the Heuvelton sandstone directly follows these thin beds. In the other sections a thickness of from 20 to 30 feet of the more sandy, heavy beds lies between. In still other sections this is increased to 40 feet or more. This considerable variation in the thickness of the beds between the Potsdam and the Heuvelton, together with the fact that, in the thinner sections, the beds which are absent are the upper ones, suggests a break between the thin-bedded zone and that which overlies; and it is our belief that such a break exists. But it is a difficult one to locate satisfactorily and, in most sections, we are unable to fix it definitely.

Of the many sections in these upper, sandy beds, containing the Heuvelton sandstone, much the best and most complete one we have seen is the one along the river road, as it climbs the hill just out of Morristown going east. Recent road-making operations there have resulted in exposing an almost continuous section in the road gutter. Necessarily it will show less well as the years go by, but just now it is a very satisfactory exhibition. As our work and that of the road makers was in progress at the same time we had

the additional advantage of having a large quantity of freshly thrown-out rock material to examine. From the river level to the summit of the hill, one mile east of Morristown, a 90 foot thickness of rock is shown in the section, but only the upper 60 feet is in the continuous section. The whole is so homogeneous in its alternations of sandstone, calcareous sandstone, and sandy limestone, that it seems better to generalize and simplify it, than to give the entire, detailed section.

Generalized section at Morristown

7.	6′	Thin-bedded, light-gray, somewhat magnesian limestone, with frequent sand grains; finely granular; frequent nodules of flesh-colored crystalline calcite, usually small and elongated parallel to the bedding, but sometimes an inch or more in diameter; top not seen; an occasional thin layer of hard, calcareous sandstone is interbedded with it.
6.	8′	Thick-bedded, dark blue-gray, very sandy limestone, alternating with grayish white calcareous sandstone, both showing frequent cleavage surfaces of calcite, due to crystalline orientation of the calcite cement; the blue beds are full of thin black films of uncertain nature, irregular but roughly parallel to the bedding; the sandstones are full of fucoidal markings, and both show occasional, large, coiled gastropods.
5.	7′	Limestone similar to that above, but alternating with beds of white sandstone which are only slightly calcareous; the calcareous cement is present only in spherical spots, and elsewhere the cement is siliceous; the calcareous cement weathers out, leaving brown, discolored, weathered spots on the otherwise white surface; at many horizons the sandstone is full of films of fine-grained, greenish material resembling clay.
4.	20′	Thin-bedded white sandstone, siliceous, but with spots of calcareous cement which weather out leaving round, brown spots; Heuvelton sandstone.
3.	10′	Alternating white sandstone and blue calcareous sandstone, the former much in excess; a bed of calcareous sandstone at the base of the 20 foot sandstone, and three others in the interval; remainder all white sandstone.

2.	20′	Similar to the division above but with the calcareous sandstone much more prominent, so that it forms half of the thickness; the two alternating in divisions which average 5 feet thick.
1.	20′	Alternating hard, white sandstone, softer, brown-spotted sandstone, gray, calcareous sandstone, and blue, sandy limestone, in part thin-bedded; less sandy than the divisions above; complete section nowhere shows; this division seems to represent the upper half of the 30 foot division of thin-bedded material at the base of the Theresa; at least it seems to grade into this when followed up the river.

In this section the basal 30 feet of thin-bedded material can not be made out, and the precise horizon of the base determined. But study of the exposures up the river from Morristown suggest that division no. 1 in this section represents the upper half of the 30 foot division, somewhat changed in character and more massive, and that the base of the sections is about 20 feet above the Potsdam.

Judging from the fossil evidence, the upper part of this section should represent a different formation from the true Theresa, and also a different formation from the Tribes Hill, which directly overlies the Theresa in the Theresa region. It is, however, very like the Theresa lithologically and was classed with it while the field work was in progress. In this section our notion is that the 20 feet of beds of no. 1 would be classed certainly as Theresa; that beds nos. 2–6 likely belong to this new formation, and that no. 7 is perhaps Tribes Hill. The large gastropods which are the characteristic fossils of this new division have been found in beds nos. 3–6, so that really the only doubtful division is no. 2. In this connection it is of interest to note possible evidence of a break at this horizon, shown in a railroad cut one and one-half miles southeast of Morristown. The cut shows a 12 foot thickness of beds belonging apparently to the horizon of division 2 of the Morristown section; massive calcareous sandstone at the base, followed in turn by white sandstone and by thin-bedded, calcareous sandstone, and capped by coarse, white sandstone. Following around to the north face of the exposure, these beds are seen to be cut out by a mass of coarse conglomerate, full of sandstone pebbles up to 2 inches in diameter (figure 2). In the field we interpreted this as a channel-filling, but, when taken together with the varying thickness of the

beds between the Heuvelton sandstone and the Potsdam, the 30 feet of divisions 3 and 4 being absent at Black lake, a break is suggested, and probably will be demonstrated on further search.

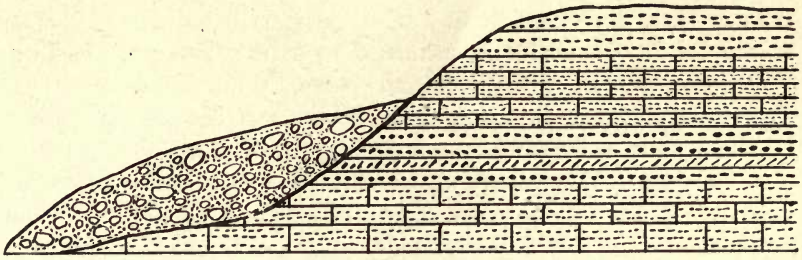


Fig. 2 Exposure in upper Theresa formation 1½ miles southeast of Morristown, showing the sandstones and calcareous sandstones cut out by a coarse conglomerate. Only one side of this channel-filling can be seen, as the exposure gives out to the east, only a small portion of the original mass of the conglomerate showing.

The fossils. As has been stated, not only the Heuvelton sandstone, but also the beds both above and beneath contain large but poorly preserved gastropods sparingly. So far as our evidence goes, the same fauna runs through all of them. We are much indebted to Dr E. O. Ulrich for the examination of these fossils, upon which he reports as follows:

"The fossils in zones 1–3 (the Heuvelton sandstone and the beds just beneath and above) though poor, indicate at least three, and possibly five species of gastropods: (1) a fragment of a Sinuopealike shell suggesting nothing else so much as a new species of *Sinuopea* from the Upper Ozarkian, Chepultepec dolomite of east Tennessee. Nothing like it is known to me from the Lower and Middle Ozarkian; (2) a narrow, whorled gastropod belonging to a new genus allied to *Liospira*. This species resembles the "Pleurotomaria hunterensis" but has a flatter top. A more similar, possibly identical, shell, occurs in the Chepultepec, and in the corresponding Gasconade and Oneota formations, respectively of Tennessee, Missouri, and Minnesota-Wisconsin; (3) a second Liospiralike shell, closely simulating a Chepultepec-Gasconade fossil. It also recalls a species of the Beekmantown and Cotter (both Canadian, the latter a new Arkansas-Missouri formation); (4–5) two other, both wider-whorled, Liospiralike shells are indicated. Both may be compared with Gasconade species, but similar types also occur in the Canadian and Ordovician."

"As it stands, the faunal evidence indicates almost conclusively that zones 1–3 can not correspond in age to the typical Theresa. The former can scarcely be older than the Gasconade-Chepultepec-Oneota (=Upper Ozarkian), while the latter is surely not younger than early, or early Middle Ozarkian. Apparently zones 1–3 belong to the Little Falls dolomite rather than to the Theresa. If Little Falls — or better, late Ozarkian — overlap took place in the Ogdensburg region, the ensuing sediments would naturally partake of and simulate the sandstone land there prevailing." [1]

According to this report of Ulrich's, the fossils point to a late Ozarkian (or Upper Cambrian) age, or else to a Canadian (earliest Ordovician) age. But the remainder of the section here definitely affirms the former as the true solution, since these beds are unconformably overlaid by beds of Tribes Hill age, the Tribes Hill formation being the oldest known formation of the New York Ordovician. Though we have mapped the beds with the Theresa, the Heuvelton sandstone and the beds over that all belong in this new division, as well as a varying thickness of the underlying beds, from 0 to 30 feet in thickness. It will probably be wise to extend the name Heuvelton to include the whole. This division occupies the same interval as that occupied by the Little Falls dolomite of the Mohawk valley, but it is as yet premature to say that it should be correlated with that. The Little Falls follows the Theresa without a break, while there seems to be a break between this Heuvelton and the underlying Theresa.

It is, however, not certain that the Little Falls itself is a single, indivisible formation. The upper, cherty beds at Little Falls and eleswhere contain occasional fossils, especially in the cherts. It was these upper cherts which furnished the fossils described by Hall in volume 1 of the New York Paleontology. The beds contrast rather sharply with the great mass of unfossiliferous dolomite below, and also with the Tribes Hill above. An unconformity separates them from the Tribes Hill. Ulrich has a suspicion that these cherty beds are separable from the Little Falls proper as an upper division, and that a break may occur between them and the main mass of the Little Falls. He is also disposed to correlate the Heuvelton beds with these upper, cherty beds of the Little Falls, because of similarity in the fossils. We have seen all the sections together and I think that this view of Ulrich's has much

[1] Letter of October 17, 1914.

to commend it. But additional work needs to be done before this can be put forward as anything more than a working hypothesis. As such, however, it needs to be kept in mind by future workers in the field.

ORDOVICIAN FORMATIONS

Tribes Hill formation

General statement. Blue, sandy limestones containing as fossils "Pleurotomaria hunterensis" and cystid plates, identical with forms found in the Tribes Hill formation of the Mohawk valley, were found, with a thickness of some 30 feet, in the Thousand Islands region, and correlated with the Tribes Hill. We were accordingly on the lookout for this formation, while the work on the Brier Hill sheet was in progress, and were much surprised to find little or no trace of it in the excellent sections east from Morristown, while we found instead the considerable thickness of sandy beds containing the Heuvelton sandstone, which have just been described. The small thickness of gray, calcareous beds, no. 7 of the section described on page 31, suggested Tribes Hill, but no fossils were found, and the zone was very thin. Scraps of limestone were also found in poor exposures in the heavily drift-covered portion of the Ogdensburg sheet, also with no fossils. Hence we came to the conclusion that the formation had nearly or quite disappeared in the interval between Theresa and Morristown. In his work on the Canton quadrangle, however, Professor Chadwick found a considerable thickness of beds at this horizon, from which he collected fossils, and for which he suggested a Tribes Hill age. His fossils were determined by Doctor Ruedemann, and subsequently Doctor Ulrich also examined a portion of his collection, and both gentlemen agree in their determination of these beds as of Tribes Hill age. We have therefore mapped a belt of this formation across the Ogdensburg quadrangle, to include the scattered outcrops of limestone. The mapping is, however, of the most perfunctory character since, in that drift-covered belt, no accurate mapping is possible, and geologic boundaries can be delineated only in a most general manner. On the Brier Hill sheet the formation, if present, is so thin and so patchy in distribution that it is impossible to map it on this scale.

This variable distribution of the formation definitely suggests one of two things: either the Tribes Hill shore line in this part of the State was irregular, setting back into embayments on the

Theresa and Canton sheets while the Brier Hill sheet was barely reached by its waters; or else it was deposited on the Brier Hill sheet, and eroded away before deposition of the Ogdensburg division of the Beekmantown commenced. The evidence for deciding between these two views is not at hand. But certain facts do suggest the first view rather than the second. The first of these is that the lithologic character of these beds differs quite materially on Theresa and on Canton; the second is the considerable difference in thickness, coupled with the fact that the beds at Theresa more strongly resemble the middle division of the formation at Canton than they do the basal; whereas if they represented parts of a continuous formation whose summit had been eroded away to varying degree, the remnant left at Theresa should be the basal portion. Our preference therefore is for the view that the Tribes Hill formation is absent from the Brier Hill sheet because it was not deposited there. It should also be noted that Chadwick describes the Tribes Hill base on the Canton quadrangle as coming down almost, locally quite, to the Heuvelton sandstone, while on Brier Hill, 15 to 20 feet of calcareous Heuvelton beds overlie the sandstone. In other words, the Tribes Hill base rests on quite different beds as it is followed across the district, so that the evidence of a considerable break at its base is quite clear. At Theresa it rests on the normal Theresa; at Morristown a considerable thickness of the Heuvelton beds rests on the normal Theresa, and the Tribes Hill, if present at all, rests on the Heuvelton; on the Canton quadrangle it rests on the Heuvelton sandstone, the upper Heuvelton beds being absent, presumably because of erosion antedating the Tribes Hill deposition.

Since the Tribes Hill formation on the Ogdensburg sheet is almost completely drift-covered, a description of the formation can not be written from the exposures here present, and hence we present a short account of the formation as shown on the Canton sheet, which we owe to the courtesy of Professor Chadwick.

Three divisions of the formation are recognized. The lower division consists of mostly thin-bedded, more or less calcareous sandstones, gray when fresh, but weathering to rusty rotten stone. They are ripple-marked, have fucoidal markings on their surfaces, are fine-grained, and vary considerably in the amount of lime, some beds having very little, and some having the characteristic "sand crystal" cleavages which characterize all the rocks from the Theresa up, when the calcareous cement is abundant. Their thickness runs from 15 to 25 feet.

No such beds as these have been seen anywhere on the Brier Hill quadrangle, and they are believed to be totally absent there. It is quite possible that they may exist on the eastern half of the Ogdensburg quadrangle, but no outcrops have been seen, and they are probably wholly covered by drift.

The middle division consists of more massive, less sandy beds, some of which are blue and strongly dolomitic, suggesting the character of the overlying Ogdensburg formation, though everywhere more sandy than the Ogdensburg beds. These beds have a thickness of some 10 feet, and are capped by a hard layer of white vitreous sandstone. Fossils are most numerous and varied in this division.

The upper division consists again of thin-bedded, fucoidal, sandy and siliceous dolomites, quite similar to the beds of the lower division, but more magnesian and less calcareous. They also contain fossils, but less abundantly than the middle division. They have a thickness of at least 25 feet.

In the Raquette river section, at Hewittville, Professor Chadwick finds an additional thickness of some 9 feet of somewhat argillaceous, firm, fine-grained, light-gray limestones and dolomites, with sand grains only in streaks, quite different looking beds from the Tribes Hill beneath, and lying beneath the Ogdensburg beds. They have furnished no fossils. They seem to wedge in toward the east and to be absent in the remainder of the district. It may be suggested that here is the extreme westerly edge of that portion of the Champlain Beekmantown which underlies the Ogdensburg division in those sections.

Ogdensburg Formation

General statement. As has been stated in the preface to this report, the study of the Beekmantown formation of the region was the principal object of the field work. The other formations appearing were known to be those which had already received detailed study elsewhere. But none of the Beekmantown of New York has ever been studied in the desirable detail requisite to furnishing a good idea of its history and its fauna, and almost no study whatever had been previously given in the State to the formation as shown in the St Lawrence valley. It was known to be less fully shown here than in the Champlain valley, and we had predicted that the lower beds would be absent, on the basis of the belief

that the formation overlapped into the district from the east.[1] This proves to be true, in a way, but in a way somewhat more complex than was supposed, owing to the unexpected appearance of the Tribes Hill formation, which we believe to be of oldest Beekmantown age. We do not yet know whether the Tribes Hill formation gets into the Champlain valley at all or not. It is certainly absent at Saratoga, and is apparently absent at Ticonderoga. On the other hand, the lower divisions of the Champlain Beekmantown, division B, division C and the lower portion of division D, are certainly absent at Ogdensburg, as we had predicted.

Nomenclature. The type region for the New York Beekmantown is the Champlain valley, and the work of subdividing and naming the Beekmantown formations of the State should be done in that valley. The work of Brainard and Seely, recognizing five divisions of the formation, which they lettered from "A" to "E," was done a quarter of a century ago, and we do not known whether those subdivisions fulfil modern requirements or not; the faunal zones have not been thoroughly worked out, and the formations have not been named. It was therefore our purpose in this report simply to call the Ogdensburg exhibition of the formation by the group name "Beekmantown," and to leave the application of a name to the future, when it was hoped that a Champlain valley name would be available and applicable. This laudable purpose was defeated by the unexpected presence of the Tribes Hill formation, a Beekmantown formation which had already received a name. In other words, there are two Beekmantown formations here at Ogdensburg, requiring separate mapping and separate designation. Since both are Beekmantown it would be incongruous to apply that name to but one of them. We therefore are proposing the name "Ogdensburg formation" for the upper and more important of the two formations; though we do it most unwillingly, with a premonition that the name will arise to plague us, when the Champlain valley work is done.

Description. By far the best and most complete section of the Ogdensburg formation is that shown along the river west of Ogdensburg, more particularly along the river road, and reaching to within 4 miles of Morristown, where its base is exposed. The most westerly section, shown just north of the roadway, 4 miles northeast of Morristown, is as follows:

[1] N. Y. State Mus. Bul. 145, p. 78, footnote.

3. 15″ Gray, granular dolomite, capped by a 3-inch layer of dark blue, magnesian limestone which contains many gastropods; the 3-inch layer is solidly welded to the gray bed beneath.

---

2. 13″ Dark blue, sandy limestone, very full of rounded quartz grains, with calcareous cement showing frequent "sand crystal" cleavages; nearly half of the rock consists of quartz sand.

---

1. 12″ Gray dolomite, with frequent sand grains, and with some calcareous cement.

These appear to be the very basal beds of the formation. The contact does not show here, but undoubted beds of the Heuvelton calcareous sands come in not far below and, as the Ogdensburg beds are more resistant to erosion, it is probable that this is the very bottom. The sand grains in the two lower layers show that it is near the base, at least. Furthermore, outcrops of the upper Heuvelton in the road gutter, a short distance to the west, show a slightly irregular upper surface, in the depressions of which are patches of sandy dolomite, which are precisely like the basal bed of the section, and which contain, in addition, pebbles of the underlying Heuvelton. These relations indicate an erosional unconformity between the two formations. And this would naturally be expected since, farther east, the Tribes Hill formation wedges in between the two, with indication of a break between it and the Ogdensburg. The so-called upper Heuvelton here consists of a three or four foot thickness of thin-bedded, sandy dolomite which may possibly be itself of Tribes Hill age. No fossils were seen in it and the reference is uncertain. If really Tribes Hill it is but a trifling wedge of the formation, and the break indicated by the exposures is the one between the Tribes Hill and the Ogdensburg, rather than one at the summit of the Heuvelton.

These first exposures of the Ogdensburg formation are about 4 miles northeast of Morristown. Following along to the east no exposures appear within the next mile, owing to a thin, morainic covering, after which they reappear and, except for occasional short gaps, continue all the way to Ogdensburg. The first outcrops, north of the road, show a thickness of 16 feet of the basal beds

of the formation, above the Heuvelton, but the actual base is not well shown. Beyond, the road has an up grade for a mile and an additional 30 foot thickness of higher beds is shown, bed by bed, in the road gutter. Then a rapid down grade, about half way between Morristown and Ogdensburg carries us back through the same beds and, at the foot of the grade a considerable quarry has been opened in the formation, enabling accurate measurement of the beds. The section in the quarry and just above is as follows:

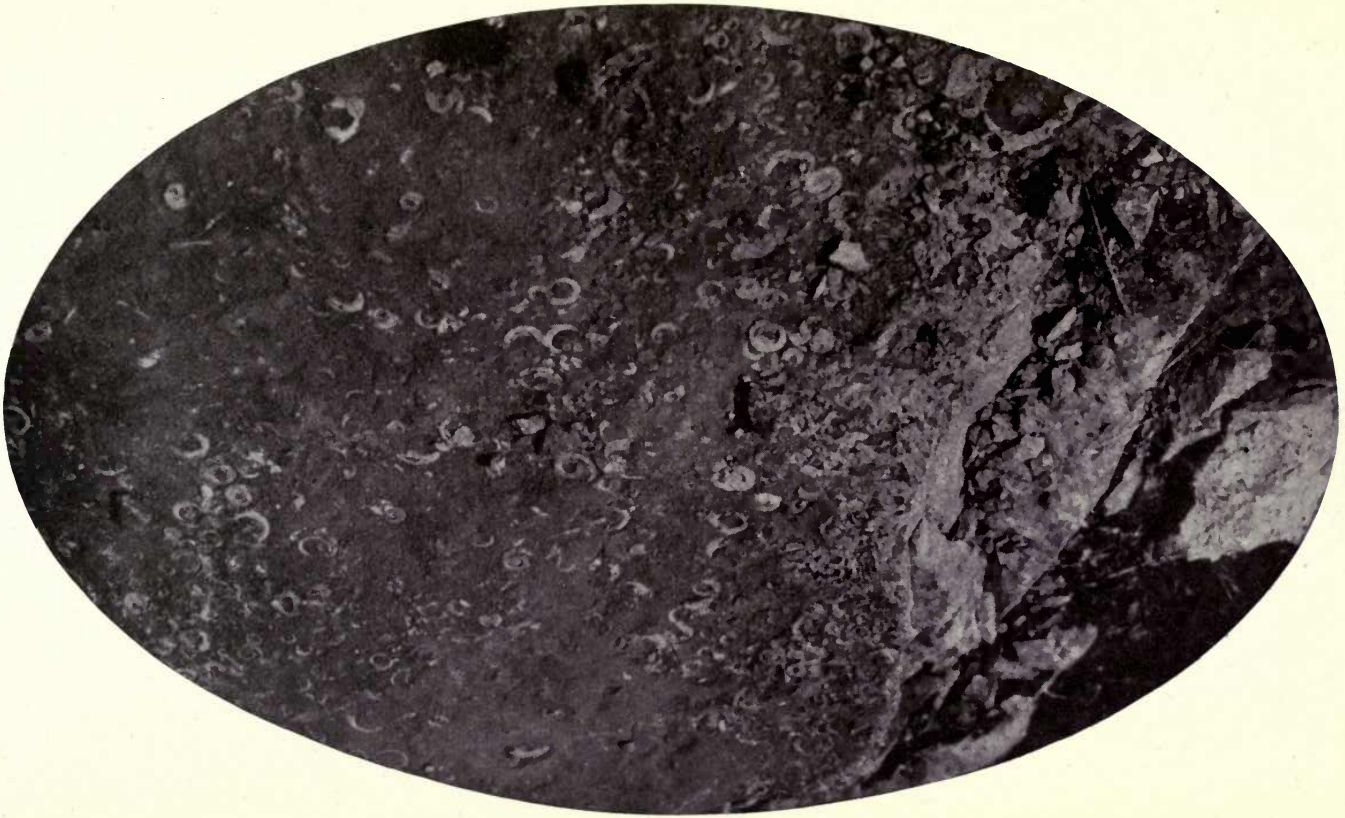
7.	12′	Thin, to very thin-bedded, gray, flinty dolomites, with occasional thin bands of blue, crystalline dolomite; occasional fossils, chiefly Ophiletas.
6.	5′	Thin-bedded, gray, flinty dolomite, weathering yellow-brown; often laminated though somewhat irregularly; often thin partings of blackish shale between the beds.
5.	2′ 1″	Two massive beds of gray, subgranular dolomite with frequent nodules of coarsely crystalline white and gray calcite.
4.	3′ 10″	Thin-bedded, gray dolomite quite like no. 6 above.
3.	1′ 4″	Gray, granular dolomite, similar to no. 5 except that the calcite nodules are of smaller size.
2.	7′ 4″	Dark-blue, finely granular dolomite, often with calcareous cement, "sand crystal" fashion, and with nodules of flesh-colored, coarsely crystalline calcite, often of large size; thick-bedded, seven beds in all; thin partings of blackish shale between the beds.
1.	1′ 9″	Gray, finely crystalline dolomite; base not seen; lowest layer contains sand grains; irregularly laminated.
	33′ 4″	total thickness

Plate 3 is a view of the beds at this quarry, the massive beds below, and the thinner-bedded material above.

H. P. Cushing, photo, 1913

Quarry showing the lower beds of the Ogdensburg formation, river road, half way between Ogdensburg and Morristown. Beds 1 to 5 of the section in midview, beds 6 and 7 above at the left

Plate 4



H. P. Cushing, photo, 1913

Weathered surface of Maclurea layer in Ogdensburg formation in beds just above those shown in plate 3; river road half way between Ogdensburg and Morristown

The actual base of the formation is not here reached, but the sand grains in the lowest layer distinctly suggest nearness to the base, certainly not more than 10 feet above it. All the beds contain fossils, the massive blue beds much more abundantly than the thin-bedded gray ones. But the quarry sections are much less favorable places for their observation and collection than are the ledges along the roadway and in the fields. The thin-bedded, gray dolomites at the summit of the quarry contain occasional Ophiletas, and are followed above by beds of granular, blue dolomite, some of which are crammed with Maclureas and other gastropods, usually in a bad state of preservation (plate 4). They are vastly more fossiliferous than the gray, thin-bedded material beneath. These upper beds are well shown along the road both east and west of the quarry.

It is hardly worth while to describe all the outcrops along the road, and we shall pass over the intermediate ground to a group of quarries, situated about one mile west of Ogdensburg, at varying levels above the river, which when taken together give a nearly complete section of the formation at that point. The two lower quarries are north of the Pythian Home, between the roadway and the river. Beds in the road and near by at the south are added for completion of that part of the section. The other two quarries lie to the east of these and nearer Ogdensburg, and their sections overlap the others.

Section at the Pythian Home

23.	2′	6″	Exceedingly massive bed of finely granular, gray dolomite, banded and laminated; forms a massive bench back in the field well to the south of the road; no fossils seen.
			Gap, with beds unexposed, except that midway of the interval is a bed of finely granular, gray dolomite with calcite cement, weathering light brown, and full
22.	8′	0″	of small gastropods, Hormotoma and allied forms, the only horizon of these seen in the formation; the bed was not seen in place but the material was excavated from a post hole, around which it lay.
			Coarsely granular, dark-blue dolomite with calcite cement of extraordinary coarseness of crystallization, forming "sand crystals" often 2 inches in diameter; the
21.		9″	layer is full of rounded masses of Cryptozoon, which weather more rapidly than the surrounding rock, leaving circular holes which imitate pot holes; the bed is very

fossiliferous above the Cryptozoon, chiefly Eccyliopterus, and the fossils are unusually well preserved.

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20. 2′ 6″ Light-gray to white dolomite, full of quartz sand grains, and with a small amount of calcareous cement; fairly thick-bedded.

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19. 1′ 8″ Massive layer of granular, blue dolomite, with calcite cement and fossiliferous.

These upper beds are shown in the road gutter and the field south of the road, just west of the Pythian Home; the beds below are shown in the quarry directly north of the road; the Cryptozoon bed at the summit of the quarry section shows also in the road gutter, and ties the two together.

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18. 1′ 3″ Very finely granular, blue-gray dolomite, with very little calcareous cement; frequent small nodules of coarsely crystalline calcite; full of masses of Cryptozoon, a different species from the Cryptozoon of the Eccyliopterus bed above.

---

17. 1′ 1″ Solid white sandstone with calcareous cement; it will be noted that each Cryptozoon bed is directly underlaid by sandstone.

---

16. 6′ 0″ Massive 18 inch beds of blue, granular dolomite, with calcareous cement, weathering sandy-looking, and showing irregular lines and bunches on weathered edges.

---

15. 3′ 8″ Massive blue, granular dolomite quite like that above; nodules of crystalline calcite; weathers sandy looking; has an irregular upper surface with a shale parting between it and the beds above.

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14. 1′ 9″ Thin-bedded, very finely granular, blue to brown dolomite, with wavy lamination; weathers irregularly.

---

13. 1′ 11″ Massive, white sandstone, only slightly calcareous; cross-bedded; irregular upper and lower surfaces, and welded to the dolomite both above and below.

H. P. Cushing, photo, 1914

Higher beds of the Ogdensburg formation in quarry near Pythian home, showing beds 10 to 16 of the section; the sandstone bed, no. 13 is the second above the quarry floor

H. P. Cushing, photo, 1914

Nearer view of the quarry shown in plate 5, showing beds 11 to 16, the sandstone in midview

12.	2′ 5″	Massive blue, granular dolomite, weathering brown.
11.	11″	Thinner layer of gray, flinty dolomite.
10.	2′ 3″	Massive gray, granular dolomite, to base of quarry.

Views of this upper quarry are shown in plates 5 and 6. Directly beneath it, and extending down nearly to the river level is another quarry, carrying the section down.

9.	13′	Estimate of gap between last, and exposures beneath.
8.	2′ 6″	Heavy bed of gray, finely granular dolomite; weathers brown, with lined edges.
7.	1′ 2″	Thin-bedded dolomite and shale, poorly exposed.
6.	1′ 9″	Massive bed of hard, iron-gray, finely granular dolomite, weathering thin bedded.
5.	7′ 6″	Very solid, massive beds of dark-blue, granular dolomite, beds splitting when weathered; near base a laminated bed, and a shale parting at base.
4.	2′ 1″	A single massive layer like that above, also with a 1 inch shale parting at base.
3.	2″	Thin layer of flinty, gray dolomite, fucoidal markings on surface, and an irregular base with a shale parting.
2.	1′ 2″	Layer of blue, finely granular dolomite, with Ophiletas; a thin shale parting beneath.
1.	2′ 6″	Massive, blue, granular dolomite, to bottom of quarry.
	68′ 6″	total thickness.

We are unable definitely to tie up this section with that 4 miles to the southwest, and given on page 40. We miss here the 20 foot thickness of the flinty, thin-bedded dolomites at the top of that quarry. Beds 3 to 9 of this section may represent this thin-bedded

zone, on the supposition that the thinness of the bedding is only apparent, and due to splitting on weathering, instead of being original. If this be correct, then bed no. 1 of this section corresponds to the upper part of no. 2 of the previous section. In an effort to demonstrate the equivalence, these lower beds were traced southwest for 4 miles along the river and railroad, but a drift-covered belt a mile or more in width intervenes between the two sets of exposures. The heavy blue beds of the base of the section are, however, shown to have a thickness of from 6 to 8 feet and to be full of fossils, chiefly Maclureas, and to be underlaid by thin, flinty gray beds, which seem to be the same as those in the quarry section given on page 40, though the full thickness is not shown. Also the Maclurea zone above seems to correspond with the very fossiliferous beds above the thin beds of that section, yet it is the summit of this Maclurea zone that forms the basal layer (no. 1) of this Pythian Home section. Our opinion therefore is that the one section is entirely below the other, and that the base of the Pythian Home section is some 40 feet above the base of the formation.

In the quarries to the east of the Pythian Home, and on the west edge of Ogdensburg, yet higher beds appear, and the following section was measured:

18.	2′ 6″	Thin-bedded, finely crystalline, sandy-looking dolomite, of light color slightly tinged with pink; small drusy cavities with tiny quartz crystals; summit beds of the southerly quarry, and above anything in the other.
17.	1′ 1″	Thin-bedded, blue, granular dolomite; summit bed of the northerly and largest quarry.
16.	6′	Thin-bedded, finely crystalline, gray dolomite with calcareous cement of the sand crystal type; many of the beds contain nodules of varying size of white, coarsely crystalline calcite.
15.	1′ 9″	Massive layer of dark-blue, granular dolomite, calcareous cement of sand crystal type and dark colored.

14. 2′ 1″ Light-gray, finely granular dolomite, with calcite nodules.

13. 1′ 1″ Massive bed of dark-gray, granular dolomite with irregular upper surface.

12. 5′ 10″ Massive beds of dark-blue, granular dolomite with calcareous cement of coarse "sand crystal" type; nodules of coarsely crystalline calcite in most of the beds which reach very large size in the top bed, many of 8 to 10 inches in diameter, of very coarsely crystalline calcite, much of which is of brown color; holds Eccyliopterus.

11. 4″ Thin bed of flinty, gray, laminated dolomite with very bunchy, irregular upper surface; forms floor of upper division of quarry.

10. 1′ 1″ A 5-inch bed of blue and an 8-inch bed of gray, flinty, brittle dolomite.

9. 6″ Cryptozoon layer of dark-blue, granular dolomite with coarse sand-crystal cleavages; undersurface very irregular and welded to bed beneath.

8. 1′ 10″ White sandstone with calcareous cement, also with very irregular lower surface, making a 6 inch variation in thickness.

7. 2′ Two 1 inch beds of light-gray, granular, porous dolomite.

6. 9″ Thin beds of gray dolomite like that just above.

5. 2′ 2″ Subcrystalline dolomite, iron-gray color and full of ramifying streaks of light gray with a reddish tinge; very brittle and massive; fucoidal markings on upper surface; shale parting beneath.

4. 1′ 11″ Massive bed of dark-gray, finely granular dolomite.

3.	1′ 6″	Light-gray sandstone with a slight reddish tinge; full of round, floated sand grains set in calcite cement; the layer above should be a Cryptozoon horizon, but none shows here.
2.	1′ 2″	Dark-blue, granular dolomite, calcareous cement, occasional sand grains.
1.	2′ 1″	Massive, dark-blue, finely granular dolomite, resting on a bunchy-surfaced layer which forms floor of quarry.
	35′ 8″	total thickness.

It is believed that these two sections, the one just given and the one at the Pythian Home, can be definitely correlated by means of the two sandstone horizons. The upper sandstone, with the overlying Cryptozoon bed, nos. 8 and 9 of this section and 20 and 21 of the Pythian Home section, seems a definitely identifiable horizon. The lower sandstone bed is not so certain, as the thickness of intermediate beds is not the same in the two sections. The sandstones are very irregular and seem to shift horizon. Bed no. 13 would seem to be the same as the gray bed at the summit of the Pythian Home section, though thinner here, and there is a thickness of some 13 feet of higher beds, giving a measured thickness of 82 feet for the formation, plus the amount, estimated at 40 feet, which is lacking at the base, but appears in the more westerly sections.

Generalizing the section it may be said that it consists chiefly of three types of rocks, the granular, dark-blue beds with calcareous cement, and with the most frequent fossils, the finer grained, dark-gray beds, and the thin-bedded, flinty dolomites. A small thickness of basal, sandy beds is followed by a thickness of some 15 feet of the blue beds, above which is a prominent zone of thin-bedded dolomite some 20 feet thick, while the remainder of the section consists chiefly of alternations of the dark-blue and dark-gray beds, together with an occasional thin sandstone, generally in association with a Cryptozoon bed. The zone of these sandstones, and the 20 foot zone of thin-bedded dolomites near the bottom, are the only ones of sufficient definiteness to be used in horizon determinations. For the remainder the beds are very uniform in their character and their alternations, and the horizon of isolated outcrops is invariably a very uncertain matter.

In regard to their fossil contents also, the comparatively few forms which are abundant seem to run through the whole section, and fossil zones which are sufficiently restricted and sufficiently individualized to serve as markers for a particular horizon in the formation do not seem to be common. Ulrich went over the section from Morristown to Ogdensburg with us, collected fossils from it which he has compared with the material in his own large collections from Missouri and elsewhere, and generously contributes the following report upon them.

Zone 1 (zone 4 of Ulrich's section, zones 1–3 being in the Heuvelton beds below) of fossils from the quarry section of the lower beds, given on page 40, and chiefly from the thin-bedded, upper portion:

Lingula sp. undet.

"Ophileta" grandis Ulrich. A widely distributed species marking the Roubidoux (basal Canadian) formation in Missouri. Shell larger, whorls expand more rapidly, and carina more nearly peripheral in position than in O. compacta Salter (=O. complanata Whitfield, not Vanuxem).

Generically undetermined trilobite. (Collected by Chadwick, only one specimen seen.)

This is not the lowest fauna of the formation, since the heavy, blue beds beneath contain a fairly abundant fauna, which is, however, difficult of collection and determination, since seen only on glaciated surfaces. The species seem the same as those of zone 2. My own collection shows that "Ophileta" compacta Salter occurs in zone 1, in addition to the forms listed. "Ophileta" grandis Ulrich is the commonest fossil, however.

Zone 2 (zone 5 of Ulrich), the blue beds which follow above the thin-bedded dolomites of the previous zone, and are crammed with fossils, usually poorly preserved (plate 4).

Tryblidium cf. ovatum Whitfield

Maclurea (?) cf. transitionis Billings

Maclurea (?) cf. oceana Billings

Maclurea (?) cf. affinis Billings

Liospira (?Ophileta) aff. hunterensis Cleland

Liospira (?Ophileta) sp. cf. Raphistoma praevium Whitfield

Liospira sp. 3 (has more rapidly expanding whorls and smaller umbilicus than two preceding species)

"Ophileta" compacta Salter

In addition, a few feet above the most fossiliferous bed of this zone is a thin bed (zone 2a, 5a of Ulrich) filled with Syntrophia lateralis Whitfield.

Above zone 2 fossils are comparatively scarce, though apparently of these same species through a thickness of some 30 feet of beds, when the two Cryptozoon horizons are reached (beds 18 and 21 of the Pythian Home section). From bed 18 we collected no fossils aside from the Cryptozoon. But bed 21 contains the best preserved fossils obtained from the entire section, lying above the Cryptozoon masses, and evidently inhabiting the reef. Good material can be collected only from somewhat weathered rock. In freshly quarried material the fossils break across.

Zone 3 (zone 6 of Ulrich) Eccyliopterus zone.

Cryptozoon sp. undet. (cf. C. minnesotensis Winchell)

Eccyliopterus planidorsatus Ulrich

Eccyliopterus planibasalis Ulrich

Endoceras montrealense Billings

Cameroceras (?) (siphuncle only, strongly annulated)

Involute cephalopod of undetermined genus

Of this fauna E. planidorsatus is the common form, outnumbering E. planibasalis by 5 or 6 to 1. Annulated cephalopod fragments are not scarce, but the Eccyliopterids are the abundant fossils.

Zone 4 (7 of Ulrich), Hormotoma zone, only a few feet above zone 3.

Hormotoma gracilens Whitfield,

Turritospira cf. anna Billings and confusa Whitfield.

This thin layer is crammed full of these small gastropods, and likely several other species can be identified when the fauna is thoroughly studied.

Ulrich comments on the fossils as follows: "Apparently all these zones belong above division C and beneath division E of the Champlain section. Stratigraphically then, they occupy the position of division D. The fauna of division E is not even suggested, while none of the species are of those which particularly characterize the fossil beds at Fort Cassin. The latter, I believe, belong between typical D and E. Hence the Ogdensburg dolomite seems to correspond exactly, or at least essentially, to division D."[1]

[1] Letter of January 13, 1915.

It was our hope that, by carrying our work down the river below Ogdensburg, this section could be extended upward. In this respect we were completely disappointed. The drift is so heavy below Ogdensburg, and the outcrops so rare and so poor that, with the lithologic similarity of the beds, no certainty as to their position could be arrived at. The best section seen east of Ogdensburg is at Red Mills, 6 miles farther down the river, where a 20 foot thickness is exposed, the basal layer appearing in the river bed and causing the Galop rapids in the river. The section here is:

10.	4′ 8″	Four solid layers of blue, finely granular dolomite, weathering on edges in horizontal, wavy lines; small calcite nodules; much coarser grained than the beds below.
9.	1′ 8″	Blue-gray, hard, flinty dolomite, thin-bedded, upper 2 inches very shaly.
8.	2′ 4″	Two beds of massive dolomite, otherwise like that above.
7.	2′ 1″	Light-gray, hard, *very* finely granular dolomite, with small drusy cavities containing calcite; weathers drab; two beds.
	1′ 6″	Unexposed.
6.	1′ 3″	Light-gray, flinty dolomite, excessively fine grained.
5.	3′ 4″	Dark-blue, flinty dolomite, of very fine grain, in 6 inch layers.
4.	10″	Gray, fine-grained dolomite, weathering yellow-brown; irregular surface.
3.	1′ 1″	Hard, dark-blue dolomite, like no. 5; finer grained than no. 4.
2.	1′	Unexposed.
1.	1′ 1″	Single layer of thick, hard, *very* finely granular, gray dolomite at river edge and in river; base not seen.
	20′ 10″	total thickness.

This section does not correlate with any of the beds seen in the Ogdensburg section, where there is nothing resembling such a thickness of thin-bedded, flinty dolomites, wholly unmixed with the granular, dark-blue beds with calcite cement which make the larger part of the upper section there. We are therefore forced to conclude that this section lies above anything seen at Ogdensburg, and that it can not be much higher. The dip in the district is to the north, as will be shown; but it is not high. Red Mills is about 3 miles farther north than Ogdensburg, and 6 miles farther east. The summit beds of the section at Ogdensburg are 80 feet above the river. Judging from the rate at which the Heuvelton and the lower Ogdensburg beds pass beneath the river level between Morristown and Ogdensburg, and assuming that the rate remains the same below Ogdensburg, the upper beds of the Ogdensburg section should have just about reached the level of the river at Red Mills. We feel therefore reasonably secure in stating that this thin-bedded dolomite zone at Red Mills almost directly overlies the beds of the Ogdensburg section, and that their 20 foot thickness should be added to the thickness of the formation.

Elsewhere on the Red Mills sheet outcrops are exceptional and show no great thickness of rock. But all the outcrops seen are of the same type of rock as at Red Mills, hard, flinty, fine-grained dolomite. The rock is very unfossiliferous, not a sign of a fossil having been seen on the Red Mills quadrangle. In this respect also the rock differs from the lower beds shown west of Ogdensburg. The most northerly exposure seen, on Rockaway point, north of Tilden, is nearly 5 miles farther north than the section at Red Mills, and should therefore represent a considerably higher horizon. A single, massive bed of gray, flinty dolomite is, however, all that is shown.

Summary of section of Ogdensburg formation. The reporting of detailed sections furnishes a dreary job for the general reader, hence the details are here briefly summarized.

Between Morristown and Ogdensburg all the beds of the lower portion of the formation are shown, with a thickness of some 120 feet. The base lies unconformably on the underlying beds, and the lower beds contain sand grains. Some 15 feet of granular, blue, calcareous dolomites follow, then 20 feet of thin-bedded, fine-grained, gray beds, weathering brown. Above come 80 feet of alternating dark-blue, granular beds, and dark-gray, more finely granular beds, of dolomite with calcite cement. All the beds are

fossiliferous, sometimes abundantly so. Above these, separated by an unknown but probably small interval, follow the gray, flinty beds of the Red Mills quadrangle, very unfossiliferous and of unknown thickness. The section shown seems to correlate with division D of the Champlain section. Further work down the river may show somewhere a good section of the higher beds, so that the section may be completed and the full character of the Beekmantown group of this district shown, but the whole valley is so heavily drift-covered that we are not sanguine that this can be successfully done. The formation extends down the river for many miles more before the overlying Chazy beds appear, the Ottawa basin Chazy. It is very doubtful if these beds get over into New York at all. But in any event the indications are that a considerable thickness of Beekmantown beds higher than those in the Ogdensburg region must be present.

In New York State Museum Bulletin 145 we made certain predictions concerning the age of the Beekmantown formation of the St Lawrence valley based on the results of the Thousand Islands work and of our much earlier reconnaissance work farther east, particularly around Potsdam.[1] The results just outlined in the discussion of the Ogdensburg formation seem to us to fulfil those predictions. We argued that the first Beekmantown to appear down the river from the Thousand Islands should not be the lowest division of the formation in the Champlain valley, but of higher beds. The basal beds prove to be of the age of division D, with divisions C and B entirely lacking. There is also a break between them and the beds directly underneath, as we argued should be the case, a break not only shown by a basal conglomerate and sand grains in the basal dolomite, but also by the fact that the beds just underneath vary much in horizon across the district. So far the results of this study accord with expectation. The unexpected results are the continued presence of the Tribes Hill formation underneath, and the entirely new division represented by the Heuvelton beds. Our work has shown an unconformity between the Ogdensburg and the Tribes Hill, and Chadwick's work on the Canton sheet shows a break between the Tribes Hill and the underlying Heuvelton. We have not demonstrated a break between the Heuvelton and the underlying Theresa, and have mapped them together, but it is quite likely that a break exists. The work of

[1] Pages 92–96.

the past fifteen years on the Paleozoic rocks which rim the Adirondacks has shown clearly that they consist largely of the thinned, near-shore edges of a great number of formations, and that there is a great lack of correspondence between the formations on the different sides of the region. The Heuvelton division found here adds yet another unexpected member to the group. Or, as Ulrich writes, "Evidently the western flank of the Adirondack uplift carries more of these thin wedges than we supposed." No doubt yet others remain to be found.

Structures of the Paleozoic rocks

Dip. The dips of the Paleozoic rocks of the Ogdensburg region are low, seldom exceeding 5°, and are in a general northerly direction. On the Brier Hill quadrangle they average somewhat to the west of north; on Ogdensburg they are more nearly north. Along the river between Morristown and Ogdensburg the Heuvelton and Ogdensburg beds disappear under the river at a rate of from 25 to 30 feet a mile; that is, a mile in a northerly direction; in the northeasterly direction of the river's course the rate is slower. This is not a high dip, but a very low one, and has no particular interest except in its contrast with the southwest dip which the Paleozoic rocks of the Theresa and Clayton quadrangles, on the other side of the Frontenac axis, possess.

Folds. In the Thousand Islands report it was shown that the gently inclined Paleozoic rocks of the region had been somewhat folded, and that there were two sets of gentle folds whose axes cut one another almost at right angles, the one set trending somewhat east of north, and the other somewhat north of west.[1] The effect of this double folding was to produce an alternating series of low domes and low basins in the rocks, domes at the intersections of anticlines, and basins at the intersections of synclines of the two sets of folds.

This same type of folding carries over into the Ogdensburg region, though the evidence is not so clean-cut here because of less frequent exposures. But low domes of rock, from the summit of which the dip falls away to all points of the compass, are of quite frequent occurrence. The corresponding basins, occupied by outliers of younger formations, which were such a feature of the geology of the Theresa and Clayton sheets, are not easily detected

[1] N. Y. State Mus. Bul. 145, p. 112–15.

about Ogdensburg, partly because sharply contrasting, thin formations are not present here, and partly because of drift-covering. The areal mapping suggests that the axes of the folds have swung to northeast and northwest directions, and that the northeast set is much more prominent than the northwest set in the Ogdensburg region.

Faults. Faults are scarce in the Paleozoic rocks of this northwestern region, though they increase in number and importance in passing to the east. In the Ogdensburg region we have noted but one fault of any prominence, at Point Comfort, 3 miles up the river from Morristown, Brier Hill sheet. The fault bears east and the south is the downthrow side. Above Point Comfort the river cliff is composed of the Potsdam and Theresa formations, 10 feet of Potsdam which has increased to 20 feet at Oak point, overlaid by the thin-bedded, calcareous sandstones of the typical Theresa. This is the section south of the fault, the downthrow side. North of the fault the Potsdam extends up to 50 feet above the river, with a great bed of its characteristic coarse conglomerate, the same bed that occurs in the river cliff in Hammond township. At the fault 25 feet of sandstone show below it, and 20 feet above it, followed by the Theresa. The throw of the fault here is about 40 feet. The fault zone shows no outcrops but is occupied by a drift-filled depression, as is apt to be the case. It can not be definitely traced inland, away from the river because of infrequent outcrops and of similar Theresa beds on both sides. But 2 miles to the east, along its supposed trend, there is evidence of misfit in the strike of the bed of 20 foot (Heuvelton) sandstone, on the two sides of the line, so that in all likelihood the fault extends east at least to this point.

A very trifling fault is shown along the river road 2½ miles below Morristown, where the road runs over a shallow gully and small stream. The 20 foot sandstone of the Heuvelton is dropped in level about 15 feet on the east side of the gully as compared with its level on the west side, and is apparently faulted down. It is a trifling break and can not be traced to the south.

Except for these two, no faults have been noted.

HISTORICAL GEOLOGY

PRECAMBRIAN TIME

Recorded geologic history began in New York with the deposition of the Grenville series. That this was not the actual beginning of the history of the region is shown by the fact that the Grenville,

a series of water-deposited rocks, must have been laid down on some floor of preexisting rocks. So far as we can find, no trace of this floor remains and we are in entire ignorance as to its nature. That there must have been a long period of time anterior to this in the earth's history, we are certain, but we entirely lack direct evidence regarding it.

The Grenville is an enormously thick sedimentary series, comprising masses of limestone, of shale and of sandstone. It is so thick and so varied that it is quite probable that it comprises more than one formation. To deposit such a thick accumulation of sediments must have required a very great lapse of time. The Grenville is as old a rock series as is anywhere known.

Following the Grenville the region was invaded from beneath by enormous masses of molten rock which were working their way upward toward the surface. They badly broke up the Grenville deposits, thrusting their way through them, pushing them aside, and likely wholly engulfing great masses of them. This intrusion, and those which followed, are no doubt chiefly responsible for the disappearance of the old floor of deposit of the Grenville. The intrusive consisted of granite. It greatly added to the pressures and the temperature of the invaded rocks, and was an important factor in changing them into the crystalline rocks of which they, today, consist. The Grenville rocks today invariably rest upon these intrusives, which are nevertheless younger, in spite of the fact that they underlie them.

The Grenville rocks and the Laurentian granites (as these early granitic intrusives are called) are early Precambrian. Elsewhere, in Ontario and the States which border on Lake Superior, other and younger Precambrian formations are found; at least three great series of formations younger than the Grenville, aggregating many thousand feet in thickness, and separated from one another by profound unconformities, representing times of uplift and of erosion, times apparently as long as those in which the deposits were being laid down. Erosion is a slow process; so is deposition; yet thousands of feet in thickness of deposits were formed, and a vast amount of material was eroded during that part of the Precambrian which followed the Grenville.

These younger Precambrian rocks, that is, younger than the Grenville and the Laurentian granite, are, in their turn, accompanied by, or cut by, intrusives, which are younger than they are. Younger intrusives are also present in the Adirondacks, though the sediments are lacking. A great series of intrusives, anorthosite,

syenite, granite and gabbro, have wide extent in the Adirondacks, particularly on the east and south. They aided in altering and metamorphosing, as well as in breaking up and destroying, the older Grenville and Laurentian. The small masses, mapped as syenite, on the Ogdensburg quadrangle, we refer to this second period of eruptive action.

The latest of the Precambrian rock series of the upper lake region is accompanied by great flows and sheets of trap. The trap dikes of late Precambrian age in the Adirondacks are of similar rock and are naturally correlated with them. Only one such dike has been found in the Ogdensburg region, but they are abundant farther up the river, in the islands. Not only do they cut all the other Precambrian rocks, but they are entirely unmetamorphosed, indicative of a long time gap between them and the older rocks.

There is no evidence that any of these later series of Precambrian sediments were ever deposited in the Adirondack region, though it is entirely possible that some of them may have been laid down, and subsequently completely removed by erosion. There is no evidence to controvert the statement that the Adirondack region was a land area throughout all the great lapse of Precambrian time following Grenville deposition, and that this portion of its history is one of erosion rather than of deposition. A great thickness of Grenville and of igneous rock was worn away, and the region was reduced to the condition of a comparative plain, whose surface irregularities were of a minor sort, and seem not to have exceeded 200 feet in amount. Within this minor degree, however, the surface was fairly rough, the weak rocks worn down into valleys and the more resistant ones projecting as low hills and ridges. The intrusion of the traps came toward the latter end of this long period.

CAMBRIAN TIME

The erosion period just mentioned involved the greater part of Cambrian time in addition to the long Precambrian interval. But in the latter part of the Cambrian all four sides of the Adirondack region became depressed and deposits began to form on the old erosion surface. Deposit began on the northeast, with coarse conglomerates, followed by sand, forming the initial deposits of the Potsdam sandstone. These early deposits have furnished no marine fossils and strongly suggest continental formations. In their lack of thorough decay they also suggest climatic aridity. As time went on the deposits gradually extended to the south and the west of

the initial region, up the Champlain and the St Lawrence troughs. And these upper beds of the formation are marine in origin, as their fossils show. In the Ogdensburg region only a thin, upper portion of the formation was deposited, its thickness barely equalling the irregularity of the floor on which it was laid down, so that is does not appear at all on the higher parts of the old, Precambrian surface.

The passage to the Theresa was a gradual one, the sand supply lessening, and calcareous matter increasing. The fauna remained substantially the same.

The Theresa *seems* to graduate upward into the Heuvelton without any break; at least we have, so far, failed to detect one. But there is a prominent change in the fauna, which Ulrich compares to that of the uppermost portion of the Little Falls dolomite of the Mohawk valley. We are still in doubt as to just what the history was at this stage. The fauna is a comparatively unknown one in New York, and there is nothing in the St Lawrence region which can be directly correlated with the thick Little Falls dolomite of the Mohawk and Champlain valleys, which there follows the Theresa without a break. Whether the Heuvelton is a thinned representative of the Little Falls, of quite different lithologic character because of deposit in a separate basin, whether it is younger than most or all of the Little Falls and represents a deposit of an age hitherto unknown in the New York section with a break between it and the Theresa representing Little Falls time, or whether there is no break, and the Potsdam and Theresa of this region were being deposited at the same time that the dolomite was forming in the Mohawk region, can not yet be told. One or the other of the three no doubt represents the true condition of affairs.

ORDOVICIAN TIME

There is a distinct break between the Heuvelton and the overlying Tribes Hill formation in the Ogdensburg region, and such a break seems everywhere to mark the close of the Cambrian in New York. We are therefore justified in concluding that marine waters were completely withdrawn from the region for a time. Slight warping of the surface took place and a very moderate amount of wear occurred, so moderate as to indicate that the land was of low altitude. Then the sea returned and Tribes Hill deposition commenced. This formation runs all through the Mohawk valley with considerable prominence. It is absent in the Black river valley, but reappears as a thin wedge in the Theresa region, is absent on Brier

Hill and again returns with increased prominence east of Ogdensburg, running at least as far as the Raquette river. How much farther down the St Lawrence valley it may go, is today unknown. The formation is not known in the Champlain valley, though it may exist there. But it is now certain that the Tribes Hill waters bordered the Adirondacks on the south, west and north sides.

At the close of the Tribes Hill there was oscillation of the district, bringing the whole above sea level following which the Champlain valley region alone was depressed, and deposition of Beekmantown divisions B and C began there. As Beekmantown time went on this Champlain depression began also to involve the St Lawrence trough, extending westerly up that trough until the Ogdensburg region was reached, and deposit of the Ogdensburg formation, division D, began. This depression no doubt continued through the remainder of Beekmantown time, the Champlain and St Lawrence valleys below, the Black and Mohawk valleys above sea level, all Beekmantown formations other than the Tribes Hill being absent on the south and west sides of the Adirondacks. At the close of the Beekmantown the sea was withdrawn from the whole region.

There is no direct evidence of the deposit of any of the later Ordovician formations in the Ogdensburg region, but it is highly probable that the thinned edges of several of them were laid down here. The Pamelia formation of the Theresa region may have come as far east as this; outcrops of the Ottawa Chazy come in above the Beekmantown not a great many miles down the St Lawrence on the Canada side, and may well have reached farther west. Some of the various Black River and Trenton formations may likewise have been laid down, and this is also possible in regard to the upper Ordovician shales. But the Frontenac axis was early outlined as a barrier between the St Lawrence and Black river troughs of deposit, and it is not believed that any of these formations could have had any large thickness in the Ogdensburg region. So far as now known there is not a scrap of reason for believing that any Paleozoic marine rocks younger than the Ordovician were ever laid down here.

LATER PALEOZOIC HISTORY

During Silurian, Devonian and Carboniferous times the region no doubt experienced oscillations of level, as during its previous history. But the downward movements do not seem to have carried it below sea level. It seems to have persisted as a low altitude area, so low that erosion of its surface was but slight, but not low

enough for marine invasion. From time to time it may have received a coating of continental deposits, in fact the Oswego sandstone may have been deposited here in considerable thickness; but all trace of these is now gone. We are, however, obliged to assume the original presence here of formations younger than the Beekmantown for the reason that some considerable thickness of rock has certainly been eroded away from the region in the vast lapse of time since the Ordovician. The most probable of such formations are those whose present-day outcrops lie nearest the region, such as the Pamelia, Chazy, Black River and Trenton, Lorraine and Oswego.

During all of Paleozoic time the Adirondack region seems to have persisted as a continuous land area, submerged frequently on one or more sides; seldom or perhaps never on all four sides at once, and the interior probably never submerged at all.

No doubt the district participated in the considerable uplift of the eastern part of the continent at the close of the Paleozoic, the so-called Appalachian revolution, when it may for a time have had an altitude of many hundreds of feet above sea level. But the St Lawrence valley has always had a tendency to sag, as compared with the territory to the north and south. How much this inherent tendency may have counteracted that uplift, it is impossible to say.

MESOZOIC HISTORY

In common with all the eastern portion of North America, with the exception of a narrow, marginal strip along the Atlantic and Gulf coasts, the Ogdensburg region was a land area and undergoing wear. In this long interval the erosion was so great that the entire area was apparently worn down to a comparative plain, or peneplain. No trace of this peneplain remains in the Ogdensburg region, as subsequent wear has entirely obliterated it; but there is strong probability that it was produced here.

TERTIARY HISTORY

Uplift of the region followed after its peneplanation, and erosion began the development of another peneplain. During the Tertiary there was more than one such oscillation, during which the district underwent partial peneplanation. A great peneplain level is today discernible in the even levels of the hilltops of the western Adirondacks, of the Oswego sandstone plateau, and of the plateau region of southern New York. This may represent the Cretaceous pene-

plain; or it may represent one of the later ones. Much work remains to be done before more definite statements regarding the history of the region during this long lapse of time will be warranted.

QUATERNARY HISTORY

Another upward movement of the region occurred toward the close of the Tertiary and the present low grounds of the region have been worn down below the level of the previous peneplain, since that occurred. Glaciation of the region followed, a series of ice sheets invading it, advancing, reaching a maximum, waning and disappearing, and separated from one another by long, interglacial intervals. There were certainly three such ice sheets, and very probably five or even six, which followed one another over the district. The later ones largely obliterated the traces of the earlier. The glacial deposits of the region consist chiefly of those left by the last retreating ice sheet, and the polish and striation of the underlying rock are chiefly also of that date, though in some places the rocks bear two sets of striae, the one superimposed on the other.[1]

The last ice sheet retreated from the district toward the northeast. It vanished from the Ogdensburg vicinity while it still remained blocking the St Lawrence valley lower down. The district also had sagged in level during the Glacial Period and was at a level some 400 feet or more below its present-day altitude. The lake waters which collected behind the retreating ice front could not pass down the St Lawrence valley because of the ice blockade lower down, and they rose until they found an outlet down the Mohawk valley to the Hudson. This lake, known as Lake Iroquois, occupied the Ontario basin, extended east to Rome, N. Y., where its outlet began, and extended itself down the St Lawrence valley behind the retreating ice wall. It has left a well-defined shore line all around Lake Ontario, distinctly recognizable as a continuous beach to a point some 5 miles east of Watertown, Cape Rutland, where its altitude, a terrace and cliff on the limestone nose of the promontory, is at 733 feet above sea level. This old shore line has

[1] The glacial striae which have been observed in the region are indicated upon the geologic maps. The usual direction shown is south, from S. 10° W. to S. 10° E. showing that to be the general direction of the latest ice motion. The older striae, however, trend from S. 40° W. to S. 30° W. Whether these were produced by an earlier ice sheet, or during an earlier stage of the last ice sheet, is not yet definitely established, though quite probably it was the former. There is considerable evidence to the effect that the action of the last ice advance in the region was very feeble, erosively.

been tilted since its formation, rises in elevation toward the north, and Fairchild estimates its altitude at some 900 feet at the south edge of the Brier Hill sheet. East of Cape Rutland, owing to the broken and uneven character of the country along the north side of the Adirondacks, this shore line is much broken and difficult to trace. But even the altitude at Cape Rutland is far above any elevation on the Brier Hill and Ogdensburg quadrangles, which were therefore covered for a time with the fresh waters of this lake, waters over 500 feet deep on these quadrangles. The moraines left by the retreating ice were deposited underneath these waters.

As the ice retreated down the valley and neared the Champlain region, the lake waters began to find outlets to that valley between the ice front on the north and the valley walls on the south, and the level of the lake began to fall. Successive stages were passed through until finally the ice entirely unblocked the valley, and the waters fell to an altitude estimated at some 450 feet, using Fairchild's figures.[1] Even this altitude would carry the water to the very top of Mount Lona, the highest point on the Ogdensburg quadrangle. And at this level, and the lower ones which succeeded it, the whole surface of the district would have been subjected to the leveling effect of wave action, laying bare surfaces of hard rocks, and filling hollows with water-laid clays.

At this stage the fresh waters of Lake Iroquois were succeeded by the brackish waters of a marine estuary, the lower altitude of the region permitting the marine waters of the Gulf of St Lawrence to extend up the valley to Lake Ontario, involving the lake itself in this marine extension. The marine fossil shells buried in the deposits of these waters have been found as far west as Ogdensburg, and farther east are abundant. Those found near Ogdensburg have all been on low grounds, only 30 to 40 feet above the river, but at Norwood, Woodworth reports them at elevations of from 335 to 360 feet.[2] The clays and sands containing these shales were obviously laid down below the marine level. The lack of these fossils west of Ogdensburg is likely due to the water not being sufficiently salty there.

In the few thousand years that have elapsed since the marine waters were in the region at their highest stage, a slow uplift has been in progress, an uplift most prominent at some point well to the northeast of Ogdensburg. This uplift not only slowly brought this

[1] N. Y. State Mus. Bul. 145, p. 139.
[2] N. Y. State Mus. Bul. 84, p. 208–9.

district above sea level, and carried the end of the St Lawrence estuary eastward to its present position, but also tipped the old shore lines of the vanished bodies of water, so that today they are no longer horizontal, but have a slowly increasing altitude as followed northeast. The entire Ogdensburg quadrangle is too low to exhibit any of these main shore lines.

INDEX

Alexandria, 19
Alexandria bathylith, 17
Alexandria Bay quadrangle, 11, 17, 25, 26, 27
Algoman, 13
Amphibolite, 14, 15, 16, 17, 22
Anorthosite, 12

Beaver creek, 9
Beekmantown formation, 7, 51
Black lake, 9, 26, 27, 30
Black river, 9
Black River limestone, 23
Brainerd, E., work of, 38
Brier Hill, 30
Brier Hill sheet, 8, 9, 10, 12, 17, 22, 25, 26
Brier Hill Station, 26

Calcareous shales, 15
Cambrian (Ozarkian) series, 25, 28
  time, 55
Cameroceras (?), 48
Canton sheet, 16, 19, 22, 25, 29, 35
Chadwick, G. H., work of, 7, 29, 35; cited, 36, 37, 51
Chazy limestone, 23, 51
Chippewa bay, 17, 18
Cryptozoon sp., 48
Crystalline rocks, 12, 54

Dekalb, 13, 17, 21
Dekalb granite, 19, 23
Dekalb Junction, 9, 20
Depeyster, 25
Diabase, 17, 21
Dip, 52
Drainage, 9

Eccyliopterus planibasalis, 48
  planidorsatus, 48
Endoceras montrealense, 48

Faults, 53
Fish creek, 9
Folds, 23, 52
Foliation, 22
Fossils, 33

Gabbro, 12, 15, 16, 17
Gabbroic eruptives, 13
Garnet schists, 15, 16
Geology, descriptive, 12; general, 12; historical, 53–61
Glacial deposits, 10
Gneisses, 13, 19
Gouverneur sheet, 12, 13, 17, 21
Granite, 12, 13, 14, 15, 16, 17, 19, 20, 25, 54
Granite-gneiss, 17, 19, 20
Granitic eruptives, 13
Grass river, 9
Grenville
  amphibolite, 15
  gneiss, 19
  limestone, 14, 16, 25, 27
  quartzite, 22, 25, 26, 27
  schist, 14
  series, 12, 13, 15, 19, 21, 22, 23, 53, 54

Hall, cited, 34
Hammond, 17, 26
Hammond sheet, 12, 13, 21, 26
Heuvelton, 26
Heuvelton beds, 23, 30, 33, 34, 39, 50, 51
Hewittville, 37
Hormotoma gracilens, 48

Igneous rocks, 12, 13, 15, 17
Indian river, 9

Kindrews Corners, 21
Kings Corners, 30

Laurentian, 13, 19, 20
Laurentian granites, 54
Limestones, 13, 14, 15, 16, 17, 25, 27
Lingulella acuminata, 28, 29
Liospira (? Ophileta)
  aff. hunterensis, 47
  sp. cf. Raphistoma praevium, 47
  sp. *no.* 3, 47
Little Falls dolomite, 28, 34
Lost village, 11

Maclurea (?) cf. affinis, 47
oceana, 47
transitionis, 47
Macomb bathylith, 19
Macomb granite, 13, 17, 18, 19, 25, 26
Marble, 13
Martin, Doctor, J. C., 16, 19
Mesozoic history, 58
Mica schists, 15
Morainic belt, 10
Morristown, 26, 36, 39, 53; generalized section at, 31
Mount Lona, 11
Mud lake, 14

Oak Point, 26
Ogdensburg formation, 23, 37; summary of section, 50
Ogdensburg quadrangle, 8, 9, 10, 26, 27
"Ophileta"
compacta, 47
grandis, 47
Ordovician formations, 35
time, 56
Orthogneiss, 18, 19, 20
Oswegatchie river, 9

Paleozoic history, later, 57
Paleozoic plain of the St Lawrence valley, general breadth, 8
Paleozoic rocks, 12, 17, 23; structures of, 52
Pleurotomaria hunterensis, 33, 35
Point Comfort, 26, 53
Porphyritic granite, 15, 20
Potsdam, 51
Potsdam sandstone, 12, 14, 15, 17, 20, 23, 25, 27, 55
Precambrian rocks, 12, 19, 23, 27
Precambrian surface, character of, 24
Precambrian time, 53
Pythian Home, section at, 41

Quartz schists, 13, 14
Quartzites, 13, 14, 15, 22, 25, 26, 27
Quaternary history, 59

Raquette river, 9
Red Mills, 50
Red Mills quadrangle, 8, 10
Rockaway point, 50
Ruedemann, R., work of, 7, 35
Rusty gneiss, 14, 16

St Lawrence river, 10
St Regis river, 9
Sandstones, 13
Schists, 13, 14, 15, 16, 23, 25
Seely, H. M., work of, 38
Shales, 13, 15, 16
Syenite, 12, 13, 17, 19, 20
Syenitic eruptives, 13
Syntrophia lateralis, 48

Tertiary history, 58
Theresa, 36
Theresa formation, 23, 25, 28
Theresa quadrangle, 11
Thousand Islands region, 12, 14, 22, 25
Tilden, 50
Topography, general, 9
Trap, 13, 55
Trap dikes, 13, 21
Trenton limestone, 23
Tribes Hill formation, 23, 29, 34, 35, 51
Tryblidium cf. ovatum, 47
Turritospira cf. anna, 48

Ulrich, E. O., work of, 7, 28, 33, 34, 35; cited, 47, 48, 56
Utica beds, 23

Woodworth, J. W., cited, 60

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