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NEW YORK STATE MUSEUM
Charles C. Adams, Director

GEOLOGY OF THE CLYDE AND SODUS BAY QUADRANGLES, NEW YORK

By Tracy Gillette Ph.D.

WITH A CHAPTER ON THE WATER RESOURCES

By Bernard H. Dollen

CONDUCTED IN COOPERATION WITH THE DEPARTMENT OF GEOLOGY, UNIVERSITY OF ROCHESTER

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In the preparation of this report extensive use has been made of the early state reports of Hall and Vanuxem. Later state bulletins from which valuable information has been obtained include: Bulletin 114. Geologic Map of the Rochester and Ontario Beach Quadrangles, by C. A. Hartnagel; and Bulletin 123. Iron Ores of the Clinton Formation in New York State, by D. H. Newland and C. A. Hartnagel. Other articles which have proved of great value are: Stratigraphy of the New York Clinton, by G. H. Chadwick, appearing in the Bulletin of the Geological Society of America, volume 29, and reports by C. K. Swartz, E. O. Ulrich and R. S. Bassler in the Silurian volume of the Maryland Geological Survey.

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For the preparation of the chapter of Water Resources, which adds much to the value of this report, the writer is indebted to Bernard Dollen of Rochester, New York.
INTRODUCTION

LOCATION, SOILS AND TRANSPORTATION FACILITIES

The Clyde and Sodus Bay quadrangles are located in west central New York, lying between parallels 43° and 43° 30' north latitude and the meridians 76° 45' and 77° west longitude. The quadrangles, mainly in Wayne county, are about 35 miles east of Rochester and about the same distance from Syracuse. Their northern boundary is Lake Ontario and their southern limit is approximately one mile south of the Wayne county line. The largest villages within their limits are Lyons, Clyde and Wolcott.

The total land area of the two quadrangles is slightly less than 260 square miles. This is largely because four-fifths of the Sodus Bay quadrangle is covered by the waters of Lake Ontario and a good share of the remaining fifth is made up of bays. The land mass of both the Clyde and Sodus Bay quadrangles is low and characterized by many inland swamps, of which the Montezuma marsh in the southeastern part is the largest. The highest altitude is found in the extreme southern part of the Clyde sheet, where a few hills rise slightly over 560 feet above sea level. The lowest, or the elevation of Lake Ontario, is 246 feet. The approximate average is 350 feet.

Because of its character and richness the land lends itself favorably to agriculture, which is by far the leading occupation. In the northern part of the area, where the lake tends to moderate the climate, fruit growing flourishes. In the southern part grain and vegetables are the principal commodities. Poultry raising is not only an important side line for many farmers but is occasionally the principal occupation. On a few farms dairying is of major importance, and most farmers keep a few cows. The raising of sheep and hogs plays a small rôle in the economic life of the area.

In the past peppermint was one of the leading agricultural commodities, and was raised on poorly drained land. The ruins of the peppermint stills can be found in many places. The oil from these crude stills was hauled to Lyons, and when the industry was at its peak of development, Lyons was the center of the peppermint oil industry in the United States.

Other industries, with the exception of numerous canning factories, creameries etc., which have grown up because of the needs of the fruit, vegetable and dairy farmers, are more or less local of character. The villages are principally trading centers for the farmers,
but particularly in Lyons and Clyde small factories have become established, and furnish work to many local inhabitants. At Sodus Point fishing employs a few. The work on highways, railroads and canal is a source of revenue to other families.

The excellent transportation facilities are a great aid to the fruit and vegetable growers. The even surface of the land compared with that to the south, together with the fact that this lowland is along the level route between the Hudson valley and the Great Lakes, determined the location in the Clyde quadrangle area of the Erie canal completed in 1825. This canal has been enlarged several times and the route changed in some sections. At present it is designated as the State Barge canal. The area is well supplied with railroads. The New York Central and its parallel line the West Shore railroad pass through Lyons and Clyde in the southern part of the Clyde quadrangle, while the R. W. and O. branch of the New York Central passes through Wolcott in the northern
part. Railroad transportation from the coal fields of Pennsylvania is provided by the Pennsylvania branch of the New York Central with its northern terminus at Lyons and by the Sodus Bay branch (Northern Central) of the Pennsylvania railroad with its northern terminus at Sodus Point. Formerly a trolley line extending from Rochester to Syracuse passed through Lyons and Clyde. This trolley line together with the one extending from Rochester to Sodus Point has been abandoned.

GENERAL PHYSIOGRAPHY

The Clyde and Sodus Bay quadrangles are located in the "Eastern Lake Section" of the physiographic province, (Fenneman, '31) known as the "Central Lowland." This section, which surrounds Lakes Ontario, Erie and Michigan, and lies to the south and east of Lake Huron, is characterized by "maturely dissected and glaciated cuestas and lowlands." In the Clyde and Sodus Bay area, as in some other parts of the Eastern Lake Section of New York, the low glaciated surface features are modified by numerous drumlins.

The drumlins constitute one of the main topographic features of the quadrangles. They give the land a rolling appearance which is pleasing to the eye. West of Sodus bay they are confined to the area south of the Ridge road, but east of the bay they extend to the lake shore. A few are cut by the lake itself and form interesting and picturesque bluffs, which are used in many instances as sites for summer resorts. Drumlins will be discussed later in more detail.

Lake Ontario is not only interesting as a topographic feature in itself, but it has in the past, and is continuing to have, great influence on the topography of the land near its shores. In places it is cutting its way backward into the banks. In others it is depositing huge sand bars and great piles of boulders. It is aiding stream work in filling in the bays along its margin. With all these activities, it is gradually straightening its shore line.

Along the shore of Lake Ontario are many bays, and the Sodus Bay quadrangle has many of these inland bodies of water. Sodus bay is the largest and by far the most important economically. Many tourists are attracted there yearly by bathing, boating and fishing. Sodus Point, situated on a peninsula between Sodus bay and Lake Ontario, has one of the best natural harbors found anywhere along the lake shore. Since Sodus Point is located on a direct route between the Pennsylvania coal fields and Canada, large quantities of coal are shipped from its harbor each year. Although the bay remains
Figure 2 Sandbar at Lake Bluff
Figure 4 Swamp deposit on Red creek
Figure 5 Swamp deposit on Red creek
an important shipping center, it has declined greatly during the past few decades. This is due to the passing of the lumber business and to the fact that various goods once carried by lake vessels are now largely transported by railroads.

The small but beautiful Port bay is the next largest bay of the quadrangles. Its channel is clear, deep and free from weeds. There are a few good bathing beaches, and fishing is excellent. In general, it makes a popular summer resort for people of moderate means.

The other bays, namely, East bay, Red Creek bay, and Black Creek bay are too small and shallow to be of importance as lake ports. They are cut off from the lake by sandbars, except in the early spring when the freshets raise the water level in the bays and cause them to break through their sandbars. Shut off from the lake during the summer months, the bays become ponds of stagnant water, which are filled with rank growths of aquatic plants, and which furnish breeding places for mosquitoes. During certain seasons of the year, the fishing being exceptionally good, many fishermen are attracted to their shores.

All of these bays were once much larger than they are at present, as can be seen from the map. The process of filling can be readily observed at the heads of these bays. Each year a little more land emerges. This process is by no means slow. Seventy-five years ago large lake steamers came two miles and a half up Sodus bay and were loaded with lumber. They could dock within 200 feet of the shore. At the same place now, the shore line has advanced a hundred feet, and it would be difficult to land a good-sized launch at the end of the old pier.

Another interesting bit of evidence which proves the recession of these bays is found on Red creek, two and a half miles from the bay where the old stage coach line crosses the stream. At this point the creek is cutting into the right bank, exposing four feet and four inches of black soil, filled with pieces of wood and leaves, a typical swamp deposit. On top of this black soil are two feet of clay loam. Without a doubt, at the time this black soil was deposited, the swamp land of the bay reached that point and probably farther (see figure 4). The unaltered condition of the wood and leaves seems to indicate that only a short time has elapsed since it was deposited.

More than one-half of the area of the Clyde and Sodus Bay quadrangles is drained by northward flowing streams. These find their outlet into the bays or directly into the lake. For the most part they are small and insignificant, and many of them are dry during the summer months. Sodus creek, the largest northward
flowing stream, is the main feeder of Sodus bay. Wolcott creek, which finds its outlet into Port bay, is the only other large northward flowing stream. These streams, with the possible exception of the Wolcott creek, whose falls furnish power for the Wolcott flour mill, are at the present time of little economic importance. In the past even the small ones, however, were literally crowded by dams and mill ponds, which furnished power for sawmills. Traces of these old mill dams can be seen on all the creeks whose water supply continues throughout the year. Between Rice's Mills and North Huron on Mudge creek, a distance of one and a half miles, the remains of ten dams were counted.

The remaining or southern part of the quadrangles is drained by the eastward flowing Clyde river, a slow, winding, sluggish stream, whose course is marked by swampy land. Not only does the river fail to drain the swamps, but it tends during certain parts of the year to empty water into them. The Clyde river is of little economic importance, except that its valley is used as the course of the Barge canal. The fertile lands of its flood plain are, for the most part, too wet to cultivate.

**GENERAL GEOLOGIC RELATIONS**

The surface of the quadrangles is covered by a mantle of glacial material. This mantle is not so thick as it is in the Finger Lakes region, where in many places it is found to be 500 and 600 feet in thickness, for of all the well records examined, the till never exceeded more than 80 feet in depth. Although the glacial material is comparatively thin in this area, it is exceptionally even in its distribution. Only here and there, where the larger postglacial streams have carried away the surface material, does the underlying rock come to the surface. This feature is a great hindrance in areal mapping.

With the exception of the unconsolidated glacial deposits, the rocks found within the limits of the Clyde and Sodus Bay quadrangles are Silurian in age. The Silurian rocks may be divided into three series:

- Cayugan, highest and youngest
- Niagaran
- Medinan, lowest and oldest

All three of these Silurian series are represented in the Clyde and Sodus Bay quadrangles. Of the Medinan series only the upper portion is exposed at the surface. Rocks of Medinan age are found
in the extreme northern part of the Sodus Bay quadrangle. The Niagaran series constitute the rocks of the central portion of the area. The Cayugan rocks are found in the southern part of the Clyde quadrangle and are represented only by the lower members of the series. The youngest Cayugan rocks outcrop south of the southern limits of the Clyde and Sodus Bay quadrangles.

These series are divided into groups, which in turn are further subdivided into formations. In table 1, page 16, the series, groups and formations which constitute the surface rocks in the quadrangles are listed, and their characteristic lithology and approximate thickness given.

The rocks dip to the south at the average rate of 43 feet a mile, or slightly more than the dip of the Silurian in the Rochester section. Although this dip is very slight, it accounts for the progressive outcropping of younger layers from the north to the south. In general, the gently dipping beds have been leveled to the horizontal level, so that the contact of the various formations are often at the same or nearly the same altitude. For example, the contact between the Lockport dolomite and Rochester shale in the Clyde quadrangle has exactly the same altitude as the contact between the Medina and the Thorold six miles to the north in the Sodus Bay quadrangle.

**DETAILED STRATIGRAPHIC RELATIONSHIP**

**MEDIAN SERIES**

The name Medina was first used by Vanuxem (p. 374) in 1840 to designate those rocks which had been previously described by Eaton (1829, p. 1-163) as the Saliferous rocks and in the earlier annual reports as the red sandstone of Oswego and the Niagara sandstone. He proposed to include in the Medina all the strata between the Oswego and the Oneida conglomerate. A few years later Hall ('43, p. 34-57) proposed that the Medina be used as a name for the beds occupying the interval between the Clinton and the Oneida in the stratigraphic column. Both Vanuxem ('42, p. 71-74) and Hall made the Medina a part of their Ontario division of the New York system.

Hall considered the Oneida conglomerate as the eastern equivalent of the Oswego sandstone. For this reason his definition of the Medina is not usable. Hartnagel ('07, p. 27-38) established the fact that the Oneida conglomerate is many feet above the Oswego sandstone in the stratigraphic column at Oswego, and that the two are separated by several hundred feet of red sandstone.
### Table 1 - Classification of the Rocks of the Clyde and Sodus Bay Area

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<tr>
<td></td>
<td></td>
<td>Wolcott</td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Lower Sodus</td>
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<tr>
<td></td>
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<table>
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Table 1 Classification of the rocks of the Clyde and Sodus Bay area
In 1908 Grabau (p. 622–23) and Chadwick (p. 346–48) divided the Medina into two parts, the Queenston or Lewiston, which they placed in the Ordovician, and the Medina, which they included in the Niagara series. (See Historical Table, pages 18–19.)

Hartnagel ('12, p. 45–46) used the term Medina beds, which he included in the Oswegan group, and which he suggested included the rocks from the Oswego sandstone to the base of the Clinton.

A year later the following nomenclature was used by Kindle and Taylor ('13, p. 6):

<table>
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</tr>
<tr>
<td>Albion</td>
<td>Red sandstone and shale</td>
</tr>
<tr>
<td>Medina</td>
<td>Whirlpool sandstone</td>
</tr>
</tbody>
</table>

Queenston

Kindle ('14, p. 915–18) abandoned this classification in 1914, however, when he adopted the restricted definition of the Medina which had been proposed earlier by Grabau. At that time he recognized the following divisions:

<table>
<thead>
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</tr>
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<td>Grimsby shale and sandstone</td>
</tr>
<tr>
<td>Queenston</td>
<td>Cabot Head shale</td>
</tr>
<tr>
<td></td>
<td>Manitoulin beds</td>
</tr>
<tr>
<td></td>
<td>Whirlpool sandstone</td>
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</table>

Chadwick (p. 327–68) in 1918 used the Medina to include the rocks between the Queenston and the Thorold. It will be noted that he was the first since the time of Vanuxem to exclude the Thorold from the Medina.

Ulrich and Bassler ('23, p. 260–66) used the Medina as the name of a series, the Medinan, in which they included all the strata between the Oswego and the Thorold. The Medinan, itself, was divided into the Richmond and Alexandria groups. The Richmond contained the Queenston and the Alexandria, the Whirlpool, Cataract and Grimsby.

The latest attempt to revise the classification of the New York Silurian formation is by Goldring ('31, p. 317–20). In her classification she recognizes the Medinan series as defined by Ulrich and Bassler. She divides the series into the Queenston shale at the base, and the upper Medina beds or Albion, which consists of the Grimsby, Cataract and Whirlpool formations.
Table 2 Medinan nomenclature
### Table 2 Medinan nomenclature

<table>
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<th>New York System</th>
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<th>Ontario Division</th>
<th>Hall - 1843</th>
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<tbody>
<tr>
<td>2 Gray Quartzites</td>
<td>Sandstone and 3 Red Shales</td>
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<thead>
<tr>
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<th>Oswegan</th>
<th>Niagara</th>
<th>Clarke &amp; Schuchert - 1899</th>
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</thead>
<tbody>
<tr>
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<td>Croghan</td>
<td>Medina</td>
<td>Table 2</td>
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<table>
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<tr>
<th>Ontario or Siluric</th>
<th>Silurian</th>
<th>Ontario or Siluric</th>
<th>Silurian</th>
<th>Carver &amp; Schuchert - 1908-09</th>
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<tbody>
<tr>
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<td>Medina Sandstone (including Medina conglomerate)</td>
<td>Niagara</td>
<td>Ricketts Formation</td>
<td>Clinton</td>
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</table>

<table>
<thead>
<tr>
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<th>Medina Group</th>
<th>Silurian</th>
<th>Kindle - 1913</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medina</td>
<td>Medina Sandstone and Shales</td>
<td>Niagara</td>
<td>Limestones and Shales</td>
</tr>
<tr>
<td>Queenston</td>
<td>Queenston Sandstone</td>
<td>Medina</td>
<td>Gray Sand</td>
</tr>
<tr>
<td>Whirlpool S. S.</td>
<td>Red Shales</td>
<td>Medina</td>
<td>RED Beds</td>
</tr>
<tr>
<td>RED Beds</td>
<td>Gray Band</td>
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<table>
<thead>
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<th>Silurian</th>
<th>Niagara Group</th>
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<tbody>
<tr>
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<td>Queenston Sandstone and Shales</td>
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</tr>
<tr>
<td>Whirlpool S. S.</td>
<td>RED Sandstones and Shales</td>
<td>Medina</td>
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Table 2 Medinan nomenclature
Table 2, pages 18–19, gives the summary of the nomenclature of the Medina. In the last column is set forth the classification which will be used in describing the rocks of the Clyde and Sodus Bay quadrangles. The Queenston is omitted from any further consideration because it does not outcrop within the limits of the two quadrangles. The upper division of the Medinan series will be discussed in some detail under the heading "Albion Group."

**Albion Group**

The term Albion was suggested by J. M. Clarke and first introduced by E. O. Ulrich in 1913. In 1916 the Albion again found its way into the literature when Ulrich (p. 451–90) divided the Medinan series in the Albion and Richmond groups. Ulrich and Bassler, (p. 264–66) in 1923 proposed "to adopt the term... Alexandria Group for the upper group of the Medinan Series. It supplants the previously used term Albion Group or stage in the time scale, the discarded name being retained only for the sandy facies that prevail in New York and rather generally in the Appalachian Valley."

The term Albion is used in this report in preference to the Alexandria for the following reasons: Like the strata occurring at the type locality of the Albion group, the rocks of this group in the Clyde and Sodus Bay area are conglomerates, sandstones and sandy shales, definitely a sandy facies of sedimentation. On the other hand, the rocks at the type locality of Ulrich and Bassler's Alexandria group or Savage's ('17, p. 67–160) Alexandria series are limestones, shales etc., definitely a marine facies of sedimentation. The Albion rocks in the Clyde and Sodus Bay quadrangles contain very few fossils, none of which are of any value in correlating these rocks directly with the limestones and shales of southern Illinois and eastern Missouri. On the other hand, the strata of this group in the local area can be traced from outcrop to outcrop to the type section of the Albion. The previous works of different investigators (Schuchert, '14, p. 277–320), (Williams, '19, p. 23–46), (Savage, '17, p. 67–160) have shown rather conclusively that the Albion rocks, as defined in this report, are equivalent to the marine Cataract of Ontario. Furthermore, they have shown that the Cataract has much in common with the Alexandrian of Illinois and Missouri. The scarcity of outcrops in the intervening area between Ontario and southern Illinois has prevented any rigid correlation. Because of this lack of definite proof of the con-
temporary age of the Albion and Alexandria and because the former is a readily measurable and easily definable unit in New York State, and because the name Albion has been already accepted in publications dealing with the stratigraphy of New York, Albion is retained and given the rating of group. This conclusion does not alter the fact that there is probably an equivalent age relationship between the Albion and Alexandria.

The name Albion is taken from the town of Albion in Orleans county, where the Albion rocks form a conspicuous part of the local stratigraphy. The type locality of the group is considered the Niagara gorge, since at that place the various divisions can be seen and studied to advantage. The following is the section in the Niagara gorge (The measurements are taken in part from U. S. Geol. Sur., Geol. Atlas of U. S., Niagara Folio No. 190, 1913; by E. M. Kindle and F. B. Taylor):

<table>
<thead>
<tr>
<th>Group</th>
<th>Member</th>
<th>Description</th>
<th>Feet</th>
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</thead>
<tbody>
<tr>
<td>Clinton Group</td>
<td>Thorold sandstone</td>
<td>Red and green mottled sandstone in part cross bedded...</td>
<td>6</td>
</tr>
<tr>
<td>Albion Group</td>
<td>Grimsby sandstone</td>
<td>Red sandstones and shales. Thin bedded</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gray and red sandstone. Thick bedded with concretions...</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Red sandstone and shale. Thin bedded</td>
<td>18</td>
</tr>
<tr>
<td>Cabot Head shale</td>
<td></td>
<td>Gray calcareous shale and sandstone. Thin bedded with brachiopoda and bryozoa...</td>
<td>5</td>
</tr>
<tr>
<td>Manitoulin shale</td>
<td></td>
<td>Shale and sandstone layers, gray, red, and blue. Shale layers sandy...</td>
<td>25</td>
</tr>
<tr>
<td>Whirlpool sandstone</td>
<td></td>
<td>White sandstone often cross bedded</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>119</td>
</tr>
<tr>
<td>Richmond Group</td>
<td>Queenston shale</td>
<td>Red shale</td>
<td></td>
</tr>
</tbody>
</table>

In figure 6, page 22, is set forth graphically the writer’s conclusions concerning the stratigraphic relations of the various units comprising the Albion. It is believed that the Grimsby sandstones and shales represent a semicontinental beach deposit, and that while the Whirlpool, Manitoulin and Cabot Head shale were forming in the Niagara area, under what appears to be marine conditions, the beach and semicontinental deposits of the Grimsby were forming in the Clyde and Sodus Bay area. Evidence pointing to a beach origin
of the Grimsby will be cited under the heading "Grimsby Sandstone." Long before the deposition of the Albion ceased in New York the marine conditions responsible for depositing the lower units of the group represented in the Niagara gorge had receded from the State, and the Grimsby is found overlying the marine beds in the western area. Thus the Grimsby represents a type of deposit which formed under similar conditions over a considerable period of time in various parts of western New York.

Evidence in support of the above conclusions may be summarized as follows: No typical Whirlpool, or White Medina as it has often been called, is found in outcrops east of the village of Medina. No Whirlpool is known east of Canandaigua lake from well records. No typically or undeniably marine fossils are found east of the eastern boundary of Orleans county. Whereas the several units described in a preceding paragraph can be distinguished in the Niagara gorge, the whole stratigraphic interval is represented at Rochester and to the east of Rochester by a single unit composed of red sandstones and shales.

Since Grabau (’08, p. 622–23) and Chadwick (’08, p. 346–48) divided the Medinan series into two parts and placed the Queenston in the Ordovician, there has been a consistent practice to make some sort of separation at this point. Some writers following the aforementioned authors have placed the Queenston in the Ordovician. In other publications the Queenston has been retained in the Silurian and made to form the lower part of the Medinan series. Since the Queenston does not outcrop in the area covered in this report, the problem of the Ordovician-Silurian boundary will not be discussed. However the consistency with which a line of separation has been made at the contact of the Queenstown and Albion, is of interest and tends to make the lower limit of the Albion group a well established stratigraphic boundary.

The upper limit of the Albion group is not drawn at such a fortunate horizon. The argument concerning the exact place that the Oneida conglomerate and the Thorold sandstone should occupy in the stratigraphic column has been the subject of controversy since the days of the first geological survey. Vanuxem (’43, p. 75–78) who introduced the term Oneida conglomerate, held that the conglomerate was a part of the Clinton group. Furthermore, he considered the gray band at Rochester the western equivalent of the Oneida conglomerate. In spite of his conviction that the Oneida should “form a part of the Clinton,” he discussed it under a separate heading “Oneida conglomerate.”
As already pointed out (p. 15) Hall confused the Oneida with the Oswego, an error which Hartnagel (’07, p. 27–28) rectified. Hall (’43, p. 34–57) made the Thorold a part of his Medina. Hartnagel (’07a, p. 27–38), after pointing out the true relationship of the Oneida and the Oswego concludes that the Oneida conglomerate is of upper Medinan age. Kindle (’14, p. 915–18) and Williams (’19, p. 23–46) placed the gray band or Thorold in the Medina. Chadwick (’19, p. 327–29), Ulrich (’23, p. 327–29, footnote, p. 327–29), and Goldring (’31, p. 317–20) have more recently taken the Thorold from the Medinan series.

The generalized chart (figure 6, p. 22) gives the author’s views concerning the Thorold-Oneida relationship. The Oneida conglomerate can be seen actually grading into the Thorold sandstone in the vicinity of Fulton. Both the Oneida conglomerate, to the east of Fulton, and the Thorold, to the west of Fulton, are immediately overlain by rock of the *Zygobolba excavata* zone of lower Clinton age. To the east of Fulton the thin shale layers which are found interbedded with the conglomerate layers contain ostracoda and other marine fossils which prove beyond all reasonable doubt that the Oneida must have formed during Clinton time. If a Clinton age is assigned to the Oneida conglomerate, and the Thorold is shown to grade into the Oneida, then, in the opinion of the writer, the Thorold should also be made a part of the Clinton group.

It should be added that from a paleontologic point of view, there is no evidence of Clinton age for the Thorold. It contains only *Arthophycus alleghaniensis* and a few other nondescript forms which are found both in the Grimsby and the Oneida. On the basis of lithology the red Grimsby and gray Thorold have much in common, but as a whole the Thorold is separated from the Grimsby by a definite line of demarcation. The Thorold is a persistent unit which has been recognized since Eaton’s (1829, p. 1–163) early survey. It is evident that the arguments presented by the Thorold itself for either an Albion or Clinton age are weak.

In spite of the foregoing paragraph the continuity of the Thorold sandstone with the Oneida conglomerate and the interfingering of the latter with the Clinton shales tend to show the Clinton age of the Thorold sandstone. It thus seems desirable to remove the Thorold from the Albion and refer it to the Clinton. The Grimsby sandstone thence becomes the top of the Albion.

**Grimsby sandstone.** The oldest rock outcropping in the Clyde and Sodus Bay quadrangles is the Grimsby sandstone. This for-
mation is found to be the surface rock in the extreme northern part of the quadrangles. The outcrops are confined to the northeast part of the Sodus Bay quadrangle, and are principally found along the course of Little Red creek (see inclosed geologic and outcrop map). The Grimsby is well exposed along Salmon creek near Lake Ontario, in the Pultneyville quadrangle, which lies immediately west of the Sodus Bay quadrangle.

Because the Grimsby gives rise to an abundance of saline springs its position can sometimes be inferred even where it is covered by a considerable thickness of glacial material. Examples of such springs are found along Port bay and East bay. This phenomenon together with the records of the water wells has been utilized in drawing the contact line shown on the map.

The Grimsby consists dominantly of massive sandstone layers, but occasionally thin-bedded sandy shales occur. A few conglomeratic strata are found especially near the top of the formation.

The sand grains and pebbles which compose the major part of the rock composition show a variety of shapes. The constituents in some layers are rounded into almost perfect spheres. In others the material is angular, the edges being sharp and irregular. In still others there is a mingling of the two types.

The Grimsby is dominantly red in color, but spots and blotches and even thin layers of a peculiar light green are found scattered, apparently without reason, through the upper 20 feet. In some places these green blotches seem to follow the bedding very closely, but in the majority of cases they are irregular, crossing bedding planes, and passing from one layer into another. As a whole the green blotches seem to be confined to the more sandy layers.

The cause of these green spots is not known. It is supposed that the ferric iron in the red Grimsby has been reduced to a ferrous state. Hall ('43, p. 38) thought that this may have resulted from the decaying of vegetable matter, and considered that the reduction took place immediately after deposition and burial. C. K. Swartz ('23) reports similar green blotches in the Bloomsburg red beds of Maryland. He believes that they are caused by ground water, which contains reducing (perhaps organic) substances.

Fossils are very scarce in that part of the Grimsby which outcrops in the Clyde and Sodus Bay quadrangles. With the exception of *Fucoides auriformis*, which Hall ('43, p. 4–7) identified as a plant remain, but whose origin is still in doubt, the fossils *Arthrophycus alleghaniensis* and *Daedalus archimedes*, which Sarle ('06, p. 303) believed were worm burrows, are the only evidence of past life.
Since the days of Hall some parts of the Grimsby have been considered to be of shallow water origin. Fairchild (’01, p. 9–14) has offered substantial evidence to show that the Grimsby is of beach origin. This suggestion seems a very plausible explanation for that part of the Grimsby which outcrops in the quadrangles under discussion. Such evidence as ripple marks and mud cracks are plentiful. Cross bedding is often seen, which either might show the work of wind, when the waves had washed the sand above the level of the water, or it might record action of cross currents near the shore, such as the current of a river coming in contact with a current in the ocean. Furthermore, the sediments composing the Grimsby are not uniform in size or weight. Small pieces of shale are found even in the conglomeratic layers. The sand grains in a single layer range from a centimeter in diameter to microscopic size. This lack of uniform size and weight would tend to show that the water did not have the opportunity of sorting. This condition could easily take place at the shore of any large body of water. Such fossils as *Arthophycus alleghaniensis* and *Daedalus archimedes*, if they are worm burrows, do not disagree with, but rather substantiate, this conclusion, since beach habitat would furnish living conditions for such organisms.

**NIAGARAN SERIES**

From the time of the earliest state report the term Niagaran has been in every classification of the New York Silurian, but its meaning has not been constant. At times it has been limited to a single formation such as the Niagara limestone or Niagara shale. In other instances it has been enlarged to include the whole Silurian section from the base of the Queenston to the lowest layers of the Salina.

According to the classification of the Silurian offered by James Hall (p. 18, 80–117) in 1843, the name Niagara should be used as a group term covering the formation from the top of the Clinton to the base of the Onondaga salt group. As will be shown later, he excluded the Rochester from the Clinton and thus his Niagaran group included what is now known as the Rochester shale and Lockport dolomite. The Niagaran group was considered a part of the Ontario division of the New York system.

In 1863 Dana (p. 128–32, 237–46) defined his Niagara period to apply to all those rocks between the Oneida conglomerate, which he, as Hall before him, thought lay beneath the Queenston, and the Onondaga salt group. The upper limestone of the period was to
be called the Niagara limestone and the shale beneath that limestone the Niagara shale.

From 1863 to 1899 the classification of Dana was in general use, but because of the multitudinous meanings of the word Niagara, the literature became confused. Especially, was this true when attempts were made to compare the Silurian sections of Ohio, Indiana, Wisconsin etc., with those of New York. In 1899 Clarke and Schuchert (p. 874–78) proposed a classification which they hoped would remedy this confusion. They abandoned the terms Niagara limestone and shale, and in their place substituted the old Lockport limestone and the Rochester shale, originally introduced by Hall (p. 287–90) in 1839. Furthermore they divided the all-inclusive Niagara group into the Niagaran and the Oswegan. As they defined the term the Niagaran was to start with the Clinton beds and include all the formations to the base of the Salina.

This classification of Clarke and Schuchert, although vastly superior to the one it succeeded, was not generally accepted. Grabau ('08, p. 622–23) and Chadwick ('08, p. 346–48) attempted to offer a more acceptable arrangement in 1908. They retained the formal names Rochester and Lockport, but used the term Niagaran with essentially the same meaning as Dana employed it except that the Queenston (Grabau) or the Lewiston (Chadwick) was removed from the Silurian and placed in the underlying Ordovician.

In 1910 Schuchert (p. 427–606) submitted another classification. He suggested confining the Niagaran to those beds of rock which lie between the base of the Irondequoit and the top of the Lockport.

As applied to the rocks of New York State Hartnagel ('11, table 2) was the first to define the Niagaran series as it is now generally accepted. He included in this series, which he called the Niagaran group, the rocks between the Medina and the Salina.

In the years following 1912, several attempts have been made to change the classification of this part of the Silurian, but with the exception of Chadwick's paper in 1918, these have little direct bearing on the New York classification, and need not be considered here. Chadwick ('18, p. 327–68) proposed to restrict the Niagaran series to the Rochester, Lockport and Guelph.

In the latest reports dealing with the New York Silurian Ulrich and Bassler ('23, p. 249–60) and Goldring ('31, p. 301–8, 317–18) have used the designation Niagaran series to cover the same rocks that Hartnagel included in his Niagara group. Thus the only essential difference is in the use of the terms, group and series. For a more complete historical review the reader is referred to table 3, pages 28 and 29.
<table>
<thead>
<tr>
<th>Oswegan</th>
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<th>Cayugan</th>
</tr>
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<tbody>
<tr>
<td>Medina Beds</td>
<td>Clinton Beds</td>
<td>Lockport Limestone</td>
</tr>
<tr>
<td>Red Shales</td>
<td>Clinton Beds</td>
<td></td>
</tr>
<tr>
<td>Gray Band</td>
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</table>

Table 3 Niagaran nomenclature
Table 3 Niagara nomenclature
In this report the term Niagaran series is used to include the Lockport dolomite and the Clinton group. As thus defined it becomes very useful for descriptive purposes. The formations constituting the Niagaran series are a well-marked lithologic unit of limestones and shales, which are distinct from the Medinan sandstones and sandy shales beneath and the Cayugan salt and gypsum-bearing shales, which lie above. The Medinan in these quadrangles is represented only by the Grimsby, which is a beach or semicontinental sandstone with only an occasional worm burrow etc. The Niagaran is represented by the fossiliferous shales and limestones of a normal marine period. Perhaps toward the close of the Niagaran the conditions were not so favorable to life, but as a whole this division of the Silurian in the Clyde and Sodus Bay areas was favorable to a varied and abundant sea life. The Cayugan represents an age in which the sea had become restricted with little or no direct connection with any of the oceans, and a time in which the waters became so saline that most organisms could not exist. Thus the Niagaran series is a lithologic, a stratigraphic and a faunal unit. It is devisable into the Clinton group and the Lockport dolomite.

**Clinton Group**

In his report on the Geology of the Third District, Vanuxem ('43, p. 80) defined the Clinton as follows:

The Clinton group consists of many different kinds of rocks and masses, from which circumstance, the name Protean group was given to it the first year it was examined. It then embraced the Niagara or Lockport limestone and shale, which formed the upper part, but they were separated on account of their importance in the west, and their disappearance in Herkimer County. The name Clinton was given to the lower part, the characteristic masses being found around the village of Clinton in Oneida County, and as a tribute to one who spared no effort to extend a knowledge of science, and to add to its acquisitions. The group consists of green and black-blue shale, greenish and gray sandstones, red sandstone often laminated, calcareous sandstones, encrinal sandstones, and red fossiliferous iron ore beds.

Since the appearance of Vanuxem's report the term Clinton has been generally accepted as a designation for the highly fossiliferous strata above the Grimsby and below the Lockport (see Historical tables, p. 28, 29). The exact limits of the group, however, have been the source of great controversy. As already pointed out in the preceding chapter on the Albion group, many have contended, and some
still hold, not without a certain amount of scientific backing, that the Thorold should be placed in the Albion. In this report the Thorold is included in the Clinton group for reasons already given.

If the lower limit of the Clinton is considered a difficult problem the upper limit is even more so. There are at present three views concerning the position at which this upper limit should be drawn. One group would draw the upper boundary at the top of the Rochester shale; another would exclude the Rochester; still another wishes to remove both the Rochester and the underlying Irondequoit limestone from the Clinton group.

In the earliest writings upon the subject the boundary was drawn beneath the Rochester shale. Vanuxem ('42, p. 75-90) placed the upper limits of the Clinton beneath the concretionary limestone in the vicinity of Clinton, thus including the Red Flux limestone and the sandstones lying above it in the Clinton. He correctly considered the concretionary limestone as the eastern equivalent of the Niagara limestone (Lockport), but he failed to recognize that the Red Flux and the sandstones above were the eastern equivalent of the Rochester shale. Because of this mistake he believed that the Niagara shale (Rochester) pinched out west of Clinton.

Hall ('43, p. 59-781), ('52, p. 2-4, 12-17, 106-109) very definitely terminated the Clinton in western New York with the upper Clinton limestone, the Irondequoit. He considered that the Niagara shale (Rochester) did not extend to Clinton, however, and that all the rocks below the concretionary limestone at Clinton belonged to the Clinton group.

Hartnagel ('07, p. 13-17) followed Hall in his earlier writings. Chadwick ('18, p. 353-58) was the latest advocate of this division. He held that the Rochester did not reach so far east as the type locality and should be ruled out on that evidence.

In the past 25 years there has been a tendency to include the Rochester in the Clinton group. In 1911 Ulrich (p. 580) claimed that the Clinton group by priority of Vanuxem's definition should include the Rochester. Hartnagel ('12, p. 49-50), reversing his early opinion, stated "as the fauna of the Upper Clinton at its type locality is of Rochester age, the Rochester is now included under the Clinton formations as its upper member." Ulrich and Bassler ('23, p. 355-62, 386-89) argued likewise that the typical Rochester is present at the type locality at Clinton and that it was therefore included by Vanuxem in his typical Clinton by definition. They stated "anyone who would deny the Rochester age of the Red Flux
ore bed must either disprove the identification of the bryozoa or ignore their testimony entirely." Goldring ('31, p. 321-23, 331-33), in the latest state publication on the subject, placed the Rochester in the Clinton, and gave the same arguments which Ulrich and Bassler had advanced.

Three years prior to the appearance of Ulrich's paper urging the inclusion of the Rochester in the Clinton, Chadwick ('08, p. 346-48) advanced the idea that the Irondequoit should be excluded from the Clinton group. As already seen, he later reversed his opinion and made the Irondequoit the upper member of his group (see Historical Table, p. 34-35). Schuchert (p. 427-606) in 1910 also expressed the opinion that the Irondequoit, because of faunal similarities, should not be separated from the Rochester, and that both should be taken from the Clinton and be made a part of the underlying Niagara group. Sanford ('36, p. 810-12) is the latest exponent of this view. Speaking of the Lower and Middle Silurian he says:

When genetic relationships are considered it is possible to form groups not greatly at variance with the intentions of Hall and Vanuxem. The formations fall into three divisions: the first, in which a terrestrial influence is strongly felt, includes the Queenston, Cataract and Albion; the second, which is marked by variability, is composed of formations lying between the top of the Thorold and the top of the Williamson; and the third, which is made up of the Irondequoit, Rochester and Lockport, is dominated by a marine influence. The three groups taken together form a normal sequence of uplift followed by transgression and regression with what is probably a wedge of terrestrial influence (the Otsquago), thickening shoreward.

Of these three opinions concerning the position of the upper limits of the Clinton group, the one which would exclude the Irondequoit is the least feasible. Historically, it has no justification. Both Hall and Vanuxem included the Irondequoit in the Clinton (see pages 30, 31). Paleontologically such a division appears impossible. The Irondequoit and the Williamson constitute the rocks of a single ostracod zone, the Mastigobolbina typus (page 36). To make a separation in the midst of such a zone seems unwarranted. A glance at the Faunal Range Chart, page 40, will show that no marked faunal break occurs at the base of the Irondequoit. As regards the contention that the Irondequoit and Rochester are dominated by a more marine influence than the underlying Williamson, Wolcott etc., this is not at all evident. In the Clyde and Sodus Bay quadrangles, as well as in other parts of western New York, the Rochester consists of interbedded shales and limestones. Similarly the William-
son contains both shale and limestone. Certainly both are equally variable. The Irondequoit consists of limestone with separating shale layers. The Wolcott likewise consists dominantly of limestone but it also has thin shale layers.

The two other opinions, specifically that the Clinton should terminate with the Irondequoit or Rochester, appear more in harmony with the facts as now understood. As shown in the quotation, page 30, Vanuxem defined the Clinton as those rocks outcropping in the vicinity of Clinton. It is equally noticeable that he intended to exclude the Niagara limestone (Lockport) and the Niagara shale (Rochester). In a later part of his work Vanuxem ('42, p. 94) states even more definitely “The calciferous slate of Prof. Eaton, which underlies the limestone of Niagara, Lockport, Rochester, etc., which is quite a thick mass at Wolcott village, is seen but a short distance in the third district.” In other words, he failed to recognize that the Rochester changed from a shale to a sandstone in passing from west to east, and considered that the shale pinched out (see page 31). Hall made the same mistake (see page 31). He accepted Vanuxem’s definition and limitation of the Clinton at Clinton and at the same time separated the Rochester (Niagara shale) from the Clinton in western New York. The fact remains, however, that the Clinton group was definitely established, a type locality given, and the strata were described in some detail by Vanuxem, and since there can be no doubt as to what rocks he intended to place in the Clinton group, and since the Rochester can be shown to be the western equivalent of certain beds which he included in the Clinton (page 31), then the Rochester becomes a part of the Clinton group in the strictest sense of the definition. That Vanuxem did not recognize the true relationship of the Rochester and the Herkimer does not make the conclusion any the less valid.

Paleontologically, there is a definite break in the microfauna between the Rochester and the Irondequoit (see Faunal Range Chart). A division could be made at this point without any conflicting evidence from that source. The megascopic forms do not show such a marked change at or near the contact. A more extensive study of the megascopic forms of the Rochester and the Lockport, however, might show a similar mingling of forms at that contact. Taken as a whole, it must be admitted that the corals and heavy shelled cephalopods of the Lockport make a striking contrast with the brachiopods, bryozoans and crinoids, which dominate the Rochester and Irondequoit. This argument alone has little weight since a
slight change in ecologic conditions in the same sea might easily bring about these variations.

Lithologically, the Lockport, being a dolomite or a dolomitic limestone, is distinctly different from the underlying Rochester shale and Herkimer sandstone. The Irondequoit in the area between Rochester and Buffalo is a limestone and also differs markedly from the overlying Rochester shale. To the east, however, it becomes a shaly limestone and in the Clyde and Sodus Bay area the shale breaks separating the limestone layers have a lithology very similar to the Rochester. As a whole the Rochester and Irondequoit appear to be bound closer together on the base of lithology than the Rochester and Lockport.

No reliable evidence was found that even suggested that the sea ever entirely withdrew from the State from the time of the forming of the lowest layers of the Williamson until long after the Lockport sedimentation was complete. In the region west of Rochester the Irondequoit limestone is often seen changing abruptly to the typical Rochester shale, but even in this area there is nothing which indicates a time break. To the east of Rochester, for instance in the Clyde and Sodus Bay area, the Rochester and Irondequoit are found grading into one another. In the same way the Lockport in the region around Clinton is sharply set off from the underlying Herkimer sandstone and in some places, for instance, College Hill creek, the contact between the two formations is wavy, and it seems quite possible that the sea withdrew from Oneida county between the deposition of the Herkimer and Lockport. On the other hand, to the west of Oneida county, for example, in the Clyde and Sodus Bay area, Rochester shale and Lockport dolomite are found grading into each other.

To the writer's mind one of the strongest arguments for placing the Rochester in the Clinton group has been in the past little heeded, and that is that the Clinton in general represented a time in which iron ores were forming in the eastern United States. The deposition of these ores must have required a peculiar type of sedimentary condition. The deposition of the iron ores did not cease until long after the microorganisms common to the Rochester strata came into existence in New York State. A thin but characteristic Clinton iron ore is found in the Rochester at North Victory. The Red Flux at Clinton is in the Herkimer, the eastern equivalent of the Rochester at Clinton. It would seem that if anything is Clinton it should be the Clinton iron ores.
In view of the arguments given in the preceding paragraphs, and recognizing that any arrangement of rocks into groups must necessarily be artificial, the Clinton group will be considered as including those strata which lie between the top of the Grimsby or base of the Thorold, and the top of the Rochester or base of the Lockport in the Clyde and Sodus Bay quadrangles. In the section east of Cayuga county the group will include the rock between the base of the Oneida conglomerate and the top of the Herkimer sandstone.

In general terms the Clinton group can be divided into the Lower, Middle and Upper Clinton. The Middle Clinton is not represented in the Clyde and Sodus Bay areas. The Lower and Upper Clinton can be divided into formations on the basis of lithology, and into various zones on the ostracods which are common to the formations (see table 4, page 36).

Thorold sandstone (Grabau). The basal formation of the Lower Clinton in the Clyde and Sodus Bay quadrangles is a light gray, shaly, slightly friable sandstone, the Thorold. Its only exposure within the limits of the two quadrangles is at North Wolcott, where it outcrops on Little Red creek between the sites of the upper and lower dams, which are shown to exist on the topographic map of the Sodus Bay quadrangle but which have, since the publication of the map, been removed. At that point the total thickness of the Thorold is only four feet three inches. Fourteen and one-half miles directly west of this outcrop it is uncovered on Salmon creek in the Pultneyville quadrangle, three-quarters of a mile due south of Lake Ontario. Here the measured thickness is three feet nine inches.

The Thorold is made up of layers which vary in thickness from less than an inch to more than 14 inches. With very few exceptions the composition of these various layers appear megascopically to be uniform, but it is found that some layers have a calcareous cement, whereas others show no calcium carbonate content. As compared with the Grimsby the sand grains are much finer and not so strongly cemented. The clay material which forms an appreciable part of the rock, is present in two forms, first, the very fine-grained kaolin-like material found mingled with the sand grains, and second, pieces of shale scattered through the rock. These clay or shale pellets, which are green in color and often fissile, vary in size from fine particles just visible to the eye, to pieces two or three centimeters in thickness. The largest pellets are usually found to lie either parallel or nearly parallel to the bedding planes, and are more abundant near the top of the formation. They appear more plentiful at North Wolcott than at Salmon creek.
Table 4  Subdivision of the Clinton, Clyde and Sodus Bay quadrangles

<table>
<thead>
<tr>
<th>Lithology</th>
<th>Formation</th>
<th>Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PARAECMINA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ROCHESTER</td>
<td>SPINOSA</td>
</tr>
<tr>
<td></td>
<td>ZONE</td>
<td></td>
</tr>
<tr>
<td>Irondequoit LS</td>
<td>MASTIGOBOLBINA</td>
<td>TYPUS</td>
</tr>
<tr>
<td>Williamson SH</td>
<td></td>
<td>ZONE</td>
</tr>
<tr>
<td>Wolcott Furnace O</td>
<td>ZYGOBOLBA</td>
<td></td>
</tr>
<tr>
<td>Wolcott LS</td>
<td>DECORA</td>
<td></td>
</tr>
<tr>
<td>Upper Sodus</td>
<td>ZONE</td>
<td></td>
</tr>
<tr>
<td>Lower Sodus</td>
<td>ZYGOBOLBA</td>
<td></td>
</tr>
<tr>
<td>Reynales</td>
<td>EXCAVATA</td>
<td></td>
</tr>
<tr>
<td>Furnaceville</td>
<td></td>
<td>ZONE</td>
</tr>
<tr>
<td>Thorold</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 7 Sketch map of the quadrangles and vicinity.
CORRELATION OF CLINTON OF THE ROCHESTER & SODUS BAY AREAS
FIGURE 8

Figure 8 Correlation of the Clinton in the Rochester and Sodus Bay areas
Figure 9. Correlation of the Clinton in the Wolcott, Clyde, Junius and Geneva areas.
The thickness of this formation of the Lower Clinton is comparatively uniform throughout the quadrangles, losing only six inches in crossing the quadrangles from Salmon creek to North Wolcott. The recent gas wells at Clyde show its presence and also show its thickness to be between two and five feet. Although the thickness could not be determined, the gas well drilled at Junius on the Bump property, three and a half miles south of the southern boundary of the Clyde quadrangle, proved the presence of the Thorold to the south.

Although the thickness has not changed greatly between Rochester and the Clyde and Sodus Bay area, the rock is quite different in these two places. At Rochester it is a hard firmly cemented sandstone, which forms the cap rock at the lower falls of the Genesee river. In the Sodus Bay quadrangle it is never a hard resistant formation and where exposed to the atmosphere, it crumbles. This increase in friability is due in part to the fact that some of the layers have changed from a silica to a calcium carbonate cement, and in part to the increase in shaly material. The writer believes that he can see an increase even in the shale content between Salmon creek and North Wolcott. Certainly the pieces of shale included in the sandstone are greater in number.

Like the underlying Grimsby the Thorold has very few fossils. *Arthophycus alleghaniensis* is occasionally found, but it is not so plentiful as in the Grimsby of the Sodus Bay quadrangle. In addition to the *Arthophycus* there are certain cylindrical tubelike bodies, which appear to be filled by the same green clay which is present in the pieces of the included shale described in the foregoing paragraph. These tubes, which in many ways resemble the *Paleophycus* found in the Queenston of western New York, almost always cut through the rock at right angles or nearly at right angles to the bedding planes. Although it is possible that these tubes represent the burrows of some boring organism, the fact that they possess the same color and that many of them seem to extend downward from pieces of green shale would make it appear more logical that, like pieces of shale, they had some inorganic origin.

As to the origin of the Thorold, it appears to represent the initial deposit of the Clinton sea, and to have been laid down as that sea advanced eastward across a low lying land surface. That high elevations were not present anywhere in the immediate vicinity of the Clyde and Sodus Bay quadrangles is shown by the fine-grained character of the Thorold. The sediment itself which entered into the composition of the Thorold may have been derived from the underlying Grimsby.
Figure 10  Faunal range chart
An interesting feature which may have some bearing on the condition under which the Thorold formed was noted at North Wolcott. The rock upon being pried from the creek bed broke up into polygonal pieces. Upon examination it was found that these polygonal pieces were sometimes separated by thin green shale dividers, never more than a millimeter or two in thickness. The thin vertical shales seem to be composed of the same material which constitutes the shale pellets already described. The general polygonal structure of the sandstones suggests that the Thorold may have formed in shallow water and that at times the sea withdrew leaving huge mud flats. The sediment gradually dried, baked and broke into the polygonal blocks. When the sea again covered these sun-baked areas, the fine clay particles may have settled into the cracks, thus forming the thin clay divisions. The shale pellets may also have resulted from these mud flat conditions. They may have been thin continuous layers, which upon drying cracked into small pieces and which were worked into the coarser sandy material as the sea again advanced. On the other hand, the pellets may have originally been round clay balls formed from the clayey material by wave action, and pressed flat by the normal processes of compaction. This fissile nature would seem to favor the former explanation, however, rather than the latter.

Maplewood shale (Chadwick). In the Genesee gorge at Rochester 21 feet of platy green sparingly fossiliferous shale lies directly above the Thorold gray band. In the early papers this green shale was correlated with the green Sodus shale. Chadwick (’18, p. 341) showed that it was older than the true Sodus shale, and gave it the name Maplewood. He believed that it pinched out before reaching Sodus. Ulrich and Bassler (’32, p. 328, 347) considered the Maplewood to be present at Wolcott and according to their correlation chart to have a thickness of approximately ten feet. Sanford (’35, p. 169–80) has given certain field evidence to show that the Maplewood pinches out before reaching Union Hill.

The horizon at which the Maplewood should occur does not outcrop in the Clyde and Sodus Bay quadrangles, but the section uncovered on Salmon creek offered a very good opportunity for studying the interval between the Sodus and Grimsby. Here the first typical Furnaceville iron ore layer (one-half inch thick) is separated from the Thorold by only three or four inches of strata. The lower inch or so consists of green platy shale with an occasional Stropheodonta corrugata. Above this layer is another thin shale layer green in color.
which contains oolites of hematite and phosphatic nodules. A great stretch of the imagination is required to correlate this shale with the Maplewood of the Genesee gorge, especially so since the Furnaceville is frozen directly to the Thorold at Fruitland. Because of this fact and because all except the lower inch contains hematite, these thin shales are referred to the Furnaceville.

From the outcrops to the east and to the west of the Sodus Bay area, it is logical to suppose that no shale intervenes between the Furnaceville and the Thorold in the northern part of the Clyde and Sodus Bay quadrangles. In the southern part of these quadrangles near Clyde, where gas wells were recently drilled, the writer believes that he found traces of a green platy shale directly underlying the iron ore. This shale could not have exceeded two feet in thickness. At the McGuane gas well, seven miles south of the southern boundary of the Clyde quadrangle, in the township of Waterloo, a thickness of ten feet of green shale directly underlies the Lower Clinton limestone (Reynales). From this evidence it is deduced that the southern part of the area covered by this report is underlain by a green shale which has a stratigraphic position comparable to the Maplewood. Whether this shale extends to the Genesee gorge in an unbroken band south of the line of outcrop must remain a matter of speculation.

**Furnaceville iron ore (Hartnagel).** The Furnaceville iron ore is, stratigraphically, the lowest and oldest of the thin hematite beds so common in the Clinton. The formation was once mined rather extensively to the north of the Ridge road between Ontario and Fruitland. Today only small amounts of the ore are mined and used in the paint industry. This formation was being worked as an ore of iron rather extensively near Fruitland at the time Hartnagel (’07, p. 35) published his work on the Rochester and Ontario Beach quadrangle. For this reason he called it the Furnaceville iron ore, a name which has had general acceptance and is retained.

The Furnaceville does not outcrop in the Clyde and Sodus Bay quadrangles, but to the west on Salmon creek in the extreme eastern part of the Pultneyville quadrangle it comes to the surface. At that place it is about a foot in thickness. The upper six inches is comparatively rich in hematite. The lower six inches bears less iron and is much more shaly. Overlying this thin iron bearing formation is about two and one-half feet of rock dominantly a limestone. Although it possesses an occasional stringer of hematite, it is considered best to include it in the overlying Reynales limestone.
Figure 11 Salmon creek. Looking downstream from the contact of the Thorold, Furnaceville, and Reynales. Thorold in the foreground, Grimsby in background.
Figure 12 Reynales, Furnaceville, and Thorold on Salmon creek
Although the Furnaceville does not outcrop in the Clyde and Sodus Bay quadrangles, the following evidence tends to show that it is present. The diamond drill cores which were put down by the State under the direction of Newland and Hartnagel ('08, p. 72) proved the presence of hematite at the Furnaceville horizon in the three wells, which were located in or near the Clyde and Sodus Bay quadrangles. These three wells were drilled at Wallington in the Pultneyville quadrangle, at Wolcott and at Red Creek in the Oswego quadrangle (see figure 3). In addition to these cores several other test wells have been drilled in search of iron ore by various commercial interests. At least four were put down at North Wolcott, and showed the Furnaceville present at that place. Gas wells which have been drilled recently near the village of Clyde show that this formation extends into the southern part of the area.

In brief, the Furnaceville appears to be represented in all parts of the quadrangles. The concentration of iron varies greatly from place to place, but everywhere the limestone or shaly limestone contains a sufficient amount of hematite to place the rock definitely in the Furnaceville formation.

This variation in iron content is not confined to the local Furnaceville, but is characteristic of all Clinton iron ores in eastern United States. An excellent example of the variable nature of Clinton iron ores can be obtained by tracing the Furnaceville from the Genesee gorge eastward, through the Sodus Bay area, to Fulton. In the Genesee gorge the Furnaceville is represented by 14 inches of hematite-bearing rock. Not only is the iron content above the average, but it is fairly even in its distribution. No portion of the rock shows an extremely low concentration of hematite. On Densmore creek, only about two and one-half miles east, the Furnaceville is approximately 16 inches thick. At this place it contains thin layers which have little or no hematitic content. At Glen Edyth, four and one-half miles farther to the east, no trace of any hematite-bearing rock is to be found. Six miles east of Glen Edyth at Fruitland and Ontario the Furnaceville again appears and reaches a thickness of 18 inches. Here the ore has been mined for many years although at the present the output consists mainly of ore used for paint manufacture. Between Ontario and the Sodus Bay area the formation is consistently present, but the iron content is low. As already pointed out, the Furnaceville apparently reaches across the quadrangles in a thin unbroken sheet, but it shows a low concentration of hematite. To the east of the area under consideration the formation persists and is found at every outcrop of that horizon as far
east as Fulton. At the Devoe ore pit on Black creek, five miles from the quadrangles, the formation is 16 inches thick and was once utilized as an iron ore. Three miles farther to the east at Sterling Station the formation reaches its maximum thickness of 20 inches with a comparatively high iron content. From Sterling Station eastward it can be recognized but it is usually interbedded with masses of nonhematite-bearing rock.

The Furnaceville is the oldest formation of the *Zygobolba excavata* zone. All of the ostracods, namely *Zygobolba excavata*, *Z. prolixa*, *Z. curta*, and *Z. inflata*, characteristic of this zone have been found in the formation at one locality or another. On Salmon creek the forms present are the *Zygobolba excavata* and *Z. prolixa*. The best locality for collecting ostracods in the Furnaceville is at the iron ore workings at Ontario and Fruitland.

The *Zygobolba excavata* zone, which is probably comparable to the *Z. anticoesiensis* of the island of Anticosti (Ulrich and Bassler, '23, p. 368-69) includes besides the Furnaceville, the overlying Reynales limestone and Lower Sodus shale. The extent of this zone is determined by the rocks which bear the *Z. excavata* and allied forms. For practical purposes it can be considered a unit of time, equal to the period during which those forms lived.

Ostracods, as shown by the fact that they are found in all types of rocks, were not so responsive to change in environmental conditions as the larger forms. For this reason they make better organisms upon which to base time zones. One is never sure when dealing with the larger forms whether their presence in the rock is due to the result of a particular geologic age, or whether it is due to a particular type of environment which was especially favorable to the growth of those organisms. Of course it must be understood that none of the common or uncommon forms of the Clinton is still alive, and that all forms do have a more or less restricted range, but for the purpose of making small time divisions in any group of rocks, the forms must have a very restricted vertical range, must be found in all types of rocks comprising the group and must be sufficiently plentiful to make their absence at once noticeable. Of course if the range has once been definitely determined in an area, then the fossils can be used regardless of their numbers for determining the age of the rocks in other regions. The ostracods have all the characteristics necessary to make them good time indicators. For example, *Zygobolba excavata* and its allied forms have a very limited vertical range. They are found in the Furnaceville iron ore, in the Reynales limestone,
some portions of which are magnesium-bearing, other parts of which contain chert, and in the Lower Sodus shale. As is at once apparent, these rocks represent a great range of sedimentary conditions, and still the ostracods were able to thrive and be preserved in all these types.

If these conclusions are true then the Furnaceville is a lithologic designation and carries no time connotation. It simply represents a condition during the range of *Zygobolba excavata* under which "iron ore" was forming. It is highly probable that all the ore did not form contemporaneously. For example, if it is allowed that the Clinton sea advanced eastward during *Zygobolba excavata* time, then the conditions under which hematite formed may also have migrated eastward. Thus the Furnaceville at Sterling Station may be younger than that at Fruitland.

In addition to the ostracods the Furnaceville contains many other fossils. These forms are often broken and otherwise poorly preserved. Many are dwarf specimens of species found in the overlying rocks. It seems probable that the conditions under which the ore formed were not favorable to the growth of vigorous fully developed specimens. The fragments of larger fossils may have grown under more favorable conditions and have been broken and the shell fragments replaced by hematite with the advent of hematite depositing conditions. All shells whether fragmentary or dwarf are replaced by hematite. A complete list of fossils personally collected and identified from the Furnaceville is given below:

<table>
<thead>
<tr>
<th>Chaetetes lycoperdon Hall</th>
<th>Zygobolba excavata Ulrich and Bassler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helopora fragilis Hall</td>
<td>Z. prolisa Ulrich and Bassler</td>
</tr>
<tr>
<td>Phaenopora ensiformis Hall</td>
<td>Z. curta Ulrich and Bassler</td>
</tr>
<tr>
<td>P. explanata Hall</td>
<td>Z. inflata Ulrich and Bassler</td>
</tr>
<tr>
<td>Stropheodonta corrugata Hall</td>
<td>Abundance of crinoid stems</td>
</tr>
<tr>
<td>Coelospira hemispherica (Sowerby)</td>
<td></td>
</tr>
<tr>
<td>Tentaculites minutus (Hall)</td>
<td></td>
</tr>
</tbody>
</table>

**Reynales limestone (Chadwick).** Overlying the Furnaceville iron ore is a *Pentamerus*-bearing limestone which is called the Reynales. Hartnagel ('07, p. 14–15) originally named this formation the Wolcott. When the term Wolcott was introduced as a substitute for the *Pentamerus* in the Rochester area, it was not known that there were two *Pentamerus*-bearing formations in Wayne county. In 1908 Newland and Hartnagel (p. 21–23) pointed out that there were two formations in which these fossils occurred and that they were separated by some sixty feet of shale in the Clyde and Sodus Bay quadrangles. In 1918 Chadwick (p. 344–45) restricted the term Wolcott to the younger and higher strata, and introduced the term
Reynales for the lower formation to which the *Pentamerus* limestone of the Rochester region belongs.

Like the Furnaceville, this formation is well exposed on Salmon creek, but does not come to the surface anywhere within the Clyde and Sodus Bay quadrangles. On Salmon creek the Reynales consists of a dolomitic limestone with a total thickness of approximately 15 feet. The upper three feet is thin bedded and contains an abundance of chert. The central portion of the formation is much more massive. The lower part is again thin bedded and contains many thin shale layers. In the lowest three feet little stringers of hematite are very common, sometimes reaching a total thickness of two or three inches.

The Reynales, like the Furnaceville, can be shown to be present by the various well records. Furthermore, a careful study of the well cores reveals an interesting change in lithology in this formation. In the state cores already referred to, the Reynales has an apparent thickness of 12 feet six inches at Wallington. At Wolcott the same thickness is ascribed to the formation, but whereas the shale layers were confined to the lower part of the formation on Salmon creek and in the Wallington well, and formed only a small part of the whole section, the shale layers at Wolcott are found throughout the formation and have become an important constituent of the rock. At Red Creek about 11 feet is placed in the Reynales, and here the formation consists of alternating shale and limestone layers. At this place shale for the first time is seen dominating the formation.

Although the churn drill offers many difficulties in detailed stratigraphic studies, a good general idea can be obtained from wells drilled by such methods. In the gas wells at Clyde the thickness of the Reynales remains about the same as at the outcrop on Salmon creek (figure 9). The drill cuttings showed very little shale. The upper part of the formation was extremely hard, and filled with chert. At the McGuane well (page 44), south of the limits of the Clyde quadrangle, the Reynales appeared to be slightly thinner, about ten feet thick. Here the chert seemed to persist throughout the whole thickness of the formation. No pieces of shale could be found in any of the cuttings recovered.

From the above records it is quite evident that the Reynales in passing from west to east across the quadrangles, becomes more shaly, but passing from north to south the formation retains much of the same characteristics with a possible increase in the amount of chert.
The Reynales, like the underlying Furnaceville and the overlying Lower Sodus shale, falls within the range of the *Zygobolba excavata* zone of the Lower Clinton age. All of the ostracods which are characteristic of this zone, namely *Zygobolba excavata*, *Z. prolixia*, *Z. curta*, and *Z. inflata*, are found in the Reynales formation. On Salmon creek all forms except *Z. prolixia* were collected from this horizon.

Although the microfauna is the same as in the three formations of the Lower Clinton age, the megascopic forms of the Reynales show interesting differences. In addition to the brachiopods, *Coelospira hemispherica* and *Stropheodonta corrugata*, which are so abundant in the Lower Clinton of western New York, *Pentamerus oblongus* and *Camarotoechia robusta* assume by their abundance, major importance. Likewise corals, which are relatively of no consequence in the other divisions, make up a significant part of the fauna of this formation.

A plausible explanation of this variation would seem to lie in ecology. Some organisms such as the ostracods, of the *Zygobolba excavata* zone, and brachiopods, the *Coelospira* and *Stropheodonta*, could exist under diverse living conditions. On the other hand, *Pentamerus* and the corals required a special type of ecology, and only when conditions were favorable could they live. If the Reynales is scrutinized closely this theory appears even more valid. The *Pentamerus* are not found in all parts of the formation, but are confined to definite layers. These layers are separated by others which contain no *Pentamerus*. In the same manner corals are restricted to certain horizons in the Reynales. From this it may be inferred that even during the deposition of the Reynales certain periods were favorable to the growth of these forms, and other periods unfavorable.

Careful determination of the various levels at which the *Pentamerus* occur at different outcrops, further shows that the *Pentamerus* layers are not located at the same horizon at the different outcrops. For example, in the Genesee gorge there are six layers which contain *Pentamerus*. On Salmon creek there are only two. On Salmon creek the lowest layer is located two feet six inches above the Furnaceville, and 12 feet six inches from the top of the Reynales. In the Genesee gorge the lowest *Pentamerus* is only four inches above the ore, or 13 feet below the top. The second layer in the gorge is four feet seven inches above the ore and eight feet nine inches from the top. Neither of the *Pentamerus* layers corresponds to the lower layer on Salmon creek. These determinations might be of little value if this were the only record of such a variation. The
outcrops are 35 miles apart, and many factors might enter which would discount these fine line determinations, but since there are seven outcrops of the Reynales between the gorge and Salmon creek, and since the outcrops all show some variation as to the levels occupied by the *Pentamerus* layers, it does seem that these are lens-like and from this that only in certain areas and at certain times was the genus able to live. Still one other point can be cited as evidence for the effect of ecology upon the fauna of the Reynales. *Coelospira hemispherica* is a common form in all parts of the Lower Clinton, but in the Reynales they are usually not found in the *Pentamerus* layers, and particularly when the *Pentamerus* are so plentiful that they make up the major part of the rock mass. This may possibly be interpreted as showing that the *Coelospira* were not adapted to living in the environment which was particularly favorable to *Pentamerus*.

In brief, the writer holds that the three lithologic divisions of the *Zygobolba excavata* zone were deposited in essentially the same body of water and that this sea invaded the area and retained its same connection throughout the deposition of the rock units comprising this zone. The various changes in lithology were due to the relative change in level of the seas, the source and quantity of sediment, and other factors not apparent today. The fauna of the rock units vary in response to the change of ecology, but the same ostracods are found in varying abundance throughout the zone.

This explanation is admittedly at variance with the writings of earlier workers. Ulrich and Bassler ('23, p. 333–34) contended that the Reynales represented deposits laid down in a sea of southern origin. This sea brought in a distinct assemblage of forms of which *Pentamerus* and bryozoans were most indicative of a southern invasion. They also held that the shale overlying the Reynales, Lower Sodus of this report, contained fossils, such as *Coelospira hemispherica* and ostracods, which bore evidence of an eastern origin. Both *Coelospira* and ostracods have been found in great numbers in the Reynales. This fact alone apparently disproves their contentions that the two formations were deposited by seas which had different sources.

Without going into detail in this report the Reynales can actually be traced eastward into a shale which resembles the Lower Sodus in lithology and fauna. This would seem to show that the two are sedimentary facies of a single sea. In the near future a report will be published covering this and many other Clinton problems in detail.
Sanford ('35, p. 177–80) gives a different explanation for the variation in the Reynales. He considered that the rock of this formation was laid down in a sea which advanced slowly across New York State from west to east, and that the fauna of the Reynales is different at different places because of the time factor. The oldest fauna of the Reynales was the *Hyattidina congesta*, which dominates the section at Reynales basin, Niagara county. At Rochester this fauna is confined to the basal part of the formation, and the upper portion is occupied by a newer and younger fauna, the *Pentamerus*. In a similar manner the Salmon Creek section shows the *Pentamerus* occupying the lower part of the section, the upper portion having a younger fauna characterized by *Coelospira*.

Unfortunately Sanford does not define what is meant by his various faunas. If the *Coelospira* fauna consists of *Coelospira hemispherica*, it means but little, since that form definitely ranges from the lowermost Lower Clinton to the top of the Middle Clinton (See Faunal Range Chart). If the *Pentamerus* fauna consists of *Pentamerus oblongus*, it can not be said to be older than the *Coelospira* fauna, since *Coelospira* are found not only associated with *Pentamerus* in the Reynales but also are plentiful in the underlying Furnaceville. Furthermore, *Pentamerus oblongus* reoccurs in the Wolcott limestone, where it is again associated with *Coelospira*. In other words, *Pentamerus oblongus* and *Coelospira hemispherica* were contemporaneous forms.

As will be shown in a later report, the writer believes that the conditions of sedimentation did migrate eastward during the Lower Clinton, and it is probable that some layers of the Reynales exposed in the Niagara gorge are older than some parts of the Reynales in the Clyde and Sodus Bay area. There appears to be little or no evidence available, however, in support of this conclusion in the Reynales itself, and only when the larger divisions of the Clinton are viewed, are there substantial faunal proofs for an eastward advancing shore line.

The fossils collected and identified from the Reynales of Wayne County are listed below:

| Zaphrentis bilateralis (Hall) | Stropheodonta corrugata Hall |
| Chaetetes lycoferdon Hall | Pentamerus oblongus Sowerby |
| Favorites favosideus (Hall) | Camaroteochia robusta (Hall) |
| Cannopora junctiformis Hall | Coelospira hemispherica (Sowerby) |
| Stromatopora concentrica Hall | Piterinea emacerata (Conrad) |
| Dimerocrinus brachiata (Hall) | Strophostylus cancellatus Hall |
| Helopora fragilis Hall | Zygobolba excavata Ulrich and Bassler |
| Rhinopora tuberculosa Hall | Z. prolixa Ulrich and Bassler |
| Retepora angulata Hall | Z. curta Ulrich and Bassler |
| Lingula preovata Hall | Z. inflata Ulrich and Bassler |
| Leptaena rhomboidalis (Wilkens) | |
Lower Sodus shale. Hartnagel (‘07, p. 13-14) gave the name Sodus shale to the lower green shale of Hall (‘43, p. 59-60). Both Hall and Hartnagel thought that the Maplewood of the Genesee gorge was the western equivalent of the Coelospira-bearing green shale of the Sodus Bay region. Chadwick (‘18, p. 345-46) showed that the Sodus outcropping in the town of Sodus was younger than the Maplewood of the Genesee gorge.

This Sodus shale was divided into two parts by Ulrich and Bassler (‘23, p. 369-72). The lower part was called the Bear Creek and the upper part was to retain the name Sodus. This division was based largely upon the ostracods occurring in the rocks. The Bear Creek contained the ostracods belonging to their Zygobolba antioostiensis zone, the Zygobolba excavata zone of this report. The Sodus was found to have the forms common to the Zygobolba decora zone. Thorough field work appears to substantiate their conclusions. The choice of the name Bear Creek seems unfortunate, however. In the first place, it was used by Chadwick (‘18, p. 327-68) for the three feet of shaly limestone which underlies the Furnaceville in the Genesee gorge. In the second place the stream which Chadwick and Ulrich and Bassler had in mind as a type locality for their Bear creek is not Bear creek but a small unnamed tributary of Black creek. To avoid confusion and to keep from adding another name to the already overcrowded terminology of the Clinton, the writer sees no reason why the two parts of the Sodus shale can not be designated simply as the Lower and Upper Sodus shales. Certainly the two shales can not be distinguished on the basis of general lithology. Both have purple and green shale layers. Both have layers composed entirely of Coelospira hemispherica, which have been designated as pearly layers in the past. Furthermore, they have practically the same magascopic fossils (see Faunal Range Chart, page 41). It is only by studying the ostracods occurring in the two shales that a definite division can be made. Last but not least, the two shales outcrop in the township of Sodus.

The type locality of the Lower Sodus shale is on Salmon creek, which has already been referred to several times. The shale is found directly overlying the Reynales limestone. The lowest outcrop is approximately 700 feet south of the southernmost extent of the lower mill pond on Salmon creek. From this point it outcrops in the creek bed and in the banks along the creek bed for a distance of about a half mile. The southernmost outcrop of this shale is 385 feet north of the first bridge over Salmon creek south of the
Figure 13 Salmon creek. Upper limit of the Lower Sodus
Figure 14. Salmon creek. Erosional surface of Lower Sodus
Lake road. The highest layers of this shale are found outcropping under a seven-inch "pearly layer."

The total thickness of the Lower Sodus shale on Salmon creek is 19 feet six inches. It is a green and purple shale with thin limestone layers, some of which are composed entirely of Coelospira hemispherica. The lower six feet of the shale is predominantly purple in color, and contains a profuse pelecypod fauna. The thin limy layers in this part of the section are not typical "pearly layers," since they are not composed of Coelospira hemispherica. The rest of the shale consists of green and purple layers interstratified, and contains thin "pearly layers." Most of the latter are less than two inches in thickness, but the topmost layer of the Lower Sodus is a seven-inch "pearly layer."

The Lower Sodus shale is the upper formation in which the ostracods of the Zygobolba excavata zone are found. All the forms, namely, Zygobolba excavata, Z. prolisa, Z. curta and Z. inflata, are plentiful. The ostracods occur most often as internal molds, but in a few layers on Salmon creek the actual shells are beautifully preserved.

The contact of the Lower and Upper Sodus can be observed on Salmon creek. The Lower Sodus is terminated by a wavy surface, which is believed to represent an erosional unconformity. The layers of the Upper Sodus shale are not conformable with the underlying Lower Sodus layers. Parallel thin layers are often seen filling in the minor depressions of the irregular wavy upper surface of the Lower Sodus shale. The erosional unconformity, so well exposed on Salmon creek, has long escaped notice, and this is apparently due to the fact that the two Sodus shales are so similar in lithology. In fact, it is absolutely impossible to tell the two shales apart on either the basis of lithology or megascopic forms. The writer recognized the wavy surface the first time the locality was visited, but it was not until the ostracods were carefully examined that its importance was realized, and then several additional days were spent to make sure that the abrupt change in ostracod fauna was not due to the hazards in collecting. This work resulted in the conclusion that there was no mingling of ostracod forms in the two shales. Ostracods of the Zygobolba excavata zone were found extending to the contact, and the forms of the overlying Zygobolba decora zone were plentiful in the rocks overlying and in direct contact with the wavy surface. So far as known, this is the only contact of the two zones exposed in New York State.

Like the underlying formations, the Lower Sodus shale is not exposed anywhere within the limits of the quadrangles. The dia-
mond drill cores, which were made available through the courtesy of the New York State Museum, and particularly C. A. Hartnagel, show that the formation increases about two feet in thickness in crossing the quadrangles (see figure 8, page 38). Little can be said as to what happens to the formation from the outcrop southward. The cable tool samples obtained from the gas wells revealed only that the formation is present in that area.

West of Salmon creek the Lower Sodus continues to Rochester with little change in thickness. In the Genesee gorge the Lower Sodus is directly overlain by the Williamson shale of the Mastigobolbina typus zone of Upper Clinton age. The unconformity at the top of the Lower Sodus in the Genesee gorge was recognized by Chadwick ('18, p. 345–46). Chadwick failed to recognize, however, that there was any division of the Sodus shales in the Sodus Bay area. As already pointed out, this fact was first recognized by Ulrich and Bassler ('23, p. 331–33). Sanford ('35, p. 180–83) did not accept the conclusions of Ulrich and Bassler and argued that the part of the Lower Sodus, as defined in this report, bore the same fauna as the Upper Sodus. In this belief he is apparently in error since the Upper Sodus does unquestionably bear a younger ostracod fauna, the Zygobolba decora.

Although limited in the number of individual species, the Lower Sodus is very fossiliferous, and those forms, which are present, are found in great quantities. In the following list are recorded the fossils which were collected and identified by the writer from the Lower Sodus in Wayne county:

| Buthotriphs palmata Hall                           | Clidophorus suboblongatus Hall                  |
| Zaphrenis bilateralis (Hall)                      | Cyrtodonta alata (Hall)                        |
| Helopora fragilis Hall                           | Pterinea emacerta (Hall)                       |
| Phaenopora insiformis Hall                       | Modiolopsis subalatus Hall                     |
| Lingula perovata (Hall)                          | Orthodesma curtum (Hall)                      |
| L. oblongus Conrad                               | Tentaculites minutus (Hall)                    |
| L. oblata Hall                                   | Zygobolba curta Ulrich and Bassler            |
| Stropheodonta corrugata (Conrad)                 | Z. excavata Ulrich and Bassler                |
| Coelospira hemispherica (Sowerby)                | Z. inflata Ulrich and Bassler                  |
| Ctenodonta machaeriformis (Hall)                 | Z. proliza Ulrich and Bassler                  |
| C. mactraiformis (Hall)                          | Z. rectangularis Ulrich and Bassler           |
| Pyrenomeous cuneatus Hall                        |                                                |

**Upper Sodus shale.** As stated under the preceding topic, the upper division of the Sodus shale of previous writers is designated as the Upper Sodus shale in this report. Unfortunately the whole thickness of this shale does not outcrop on any one creek in the Sodus Bay area. For this reason two streams must be considered as type localities. The lowest part of the Upper Sodus outcrops on Salmon creek. Here about ten feet is exposed above the Lower
Sodus. The outcrop extends from 385 feet north of the bridge already referred to (page 54), to 635 feet south of the same bridge. The type locality for the uppermost part of the Upper Sodus is on Second creek. Here the shale is at the surface just north of the first bridge crossing Second creek north of the village of Alton. Northward the formation continues to form the bed and banks of the stream for 990 feet. The total thickness of the Upper Sodus exposed on Second creek is 17 feet five inches. By comparing the total amount of rock exposed on Salmon and Second creeks with that placed in the Upper Sodus in the diamond drill core at Wallington, it was determined that about seven feet of this shale remains unexposed on the two creeks. This seven feet occurs near the center of the formation and therefore is not too significant, especially since, as is shown by the diamond drill cores, the fossils and lithology remain constant.

The lithology of the Upper Sodus is substantially the same as that of the Lower Sodus. Green and purple shales interbedded with thin limestones, which are often typical “pearly layers” constitute the rock mass. It is true that the dark purple layers are not quite so common in this Upper Sodus shale, and that the pelecypods, which are so abundant in the darker layers of the Lower Sodus, are less frequent. In the upper six feet, as exposed on Second creek, the thin limestone layers are sometimes composed of fossils other than Coelospira hemispherica. In some crinoid stems appear to the exclusion of all other forms. In one thin layer near the top of the formation the gastropod, Holopea obsoleta, is the only constituent of the layer. In some layers Coelospira hemispherica are found mingled with Stropheodonta corrugata. In a few thin limestone layers of this upper part of the formation no fossils are found and the rock is crystalline in appearance.

The Upper Sodus outcrops in a number of places in the Clyde and Sodus Bay quadrangles. The best exposures are on Second and Mudge creeks. The location of these outcrops is given on the geologic map.

A study of the diamond drill cores in and near the Sodus Bay quadrangles (see figure 8, page 38) reveals that the Upper Sodus, unlike the Lower Sodus, increases greatly in thickness in passing from west to east. At Wallington the thickness is 34 feet nine inches, at Wolcott 44 feet five inches, and at Red Creek 49 feet one inch. A discrepancy of a few feet might be present in any of these figures, but that the formation thickens from west to east is a demonstrable fact. The lithology of the formation, as shown by
these cores and the outcrops, does not change noticeably in passing from west to east across the quadrangles.

In the gas wells near Clyde it was impossible to separate the Upper and Lower Sodus shales, due largely to the lack of good samples from that part of the section. It was determined, however, that the average thickness of both Upper and Lower Sodus was 58 feet. This does not show any great change in going south from the Wolcott core to Clyde (see figure 9, page 39). In the McGuane well the thickness was approximately 50 feet. Of course, it is impossible to say whether this slight decrease in thickness is caused by the decrease in the Upper or the Lower Sodus formations.

The Upper Sodus shale is the lowest formation which falls within the range of the *Zygobolba decor*a zone. This formation contains all the ostracods common to that zone in New York state, namely, *Zygobolba decor*a, *Z. robust*a, *Z. intermedia*, *Z. inflata*, *Mastigobolbin*a *incipiens* and *M. retifera*. The last two forms do not occur in the lower half of the formation. As a whole the Upper Sodus is very rich in ostracods, which are usually preserved as interior molds.

In a preceding paragraph the similarity in the lithology of the Upper and Lower Sodus was discussed. The reason for the similarity of these two shales, which are separated by an unconformity, must necessarily be a matter of conjecture. One possible explanation is that the seas which were responsible for the deposition of the two shales existed under similar sedimentary conditions. That is to say, the origin of the two inland seas was the same; the source of the sediment may have remained the same; the relative level of land and sea may also have been the same; and finally climatic conditions may have been similar.

There seems to be no way of determining how long the sea was removed from the Clyde and Sodus Bay area between the deposition of the two Sodus shales. Since, however, the ostracods can actually be demonstrated as having a shorter vertical range than any other class of organisms common to the Clinton (see Faunal Range Chart, p. 41), and since it must follow from this that the process of evolution was working more rapidly in this group than any other, the period of time represented by the unconformity was not necessarily of long geologic duration. Further evidence in support of this conclusion is found in other Clinton areas. For example (Ulrich and Bassler, '23, p. 372), on the island of Anticosti the *Z. decor*a zone is found directly and conformably overlying the *Z. anticostiensis* zone. Since the *Z. excavata* zone contains the forms common to the *Z. anticostiensis* zone, with the exception of *Z. anticostiensis* itself,
Figure 15  Second creek. Upper Sodus shale
they are probably equivalent, and if they are equivalent, the break represented by the unconformity on Salmon creek must be of minor importance.

Like the Lower Sodus, the Upper Sodus is extremely fossiliferous, but also has a limited number of individual species. The following list of fossils was collected, and identified from Salmon creek and the outcrops within the Clyde and Sodus Bay quadrangles:

- Rusophycus pudiens Hall
- Chaetetes lycopodion Hall
- Fenestella tenuis Hall
- Helopora fragilis Hall
- Nematosoma raripora (Hall)
- Phaenopora constellata Hall
- P. ensiformis Hall
- Stropheodonta corrugata (Conrad)
- Camarotoechia pisa (Hall and Whitfield)
- C. subhomboides Hall
- Coelospira hemispherica (Sowerby)
- Pterinea emacerata (Conrad)
- Holopeda obsoleta (Hall)
- Cornulites distans Hall
- C. flexuosus (Hall)
- Tentaculites minutus (Hall)
- Calymene senaria Conrad
- C. niagaraensis Hall
- Phacops trisulcatus Hall
- Zygodolba decora Ulrich and Bassler
- Z. inflata Ulrich and Bassler
- Z. intermedia Ulrich and Bassler
- Z. robusta Ulrich and Bassler
- Mastigobolbina incepta Ulrich and Bassler
- M. retifera Ulrich and Bassler

Wolcott limestone (Hartnagel). The upper Pentamerus limestone of the Clinton directly overlies the Upper Sodus shale in the Clyde and Sodus Bay quadrangles. Hartnagel ('07, p. 35) proposed the name Wolcott limestone for it, but he confused it with the underlying Pentamerus-bearing limestone, the Reynales. In the following year, however, Newland and Hartnagel ('08, p. 21-23) pointed out that there were two such limestones, and Chadwick ('18, p. 347-48) later restricted the term to the upper bed.

The outcrops of the Wolcott formation are plentiful in the Clyde and Sodus Bay area. The best exposures occur on Second creek, Mudge creek, Wolcott creek and the little creek which runs east of and parallel to Wolcott creek. For the exact location of these exposures see outcrops marked on the geologic map.

The Wolcott formation consists of limestones and interbedded shales. The individual layers never exceed more than 1.4 inches in thickness. In color and texture it ranges from a light coarsely crystalline limestone to a dark bluish gray dense shale. The shale layers differ from the underlying Sodus and the overlying Williamson in the manner in which the rock weathers and breaks. The Williamson and the Sodus may be split into thin plates parallel to the bedding plane, whereas the Wolcott tends to crumble rather than split. The Sodus and especially the Williamson on exposure break up into tiny flakelike pieces. The Wolcott shale layer upon weathering turns to a sticky clay.
The contact of the Wolcott with the underlying Sodus is not easily established because of the apparent mingling of lithology and fauna. An excellent opportunity for studying this part of the section is offered at Mudge creek. Here the shale of the Upper Sodus with the typical “pearly layer” is seen first to include a few thin light crystalline limestone layers of Wolcott lithology. Gradually the number of such limestone strata increases until the whole formation assumes the Wolcott type of lithology throughout. The transition occupies four and one-half feet on Mudge creek. As already stated, the shale layers of the Wolcott have a type of lithology different from the underlying Upper Sodus but to the very top of the formation these layers continue to carry the fossils characteristic of the shale layers in the Upper Sodus. A thin limestone strata five feet above the lowest Pentamerus-bearing layer is interesting and adds even more evidence to the close relationship of the Wolcott and Upper Sodus. This layer, although well within the Wolcott formation, is a typical “pearly layer” composed entirely of Coelospira.

If the base of the formation is taken at the lowest prominent Pentamerus-bearing layer, the thickness of the Wolcott according to measurement with the surveying level is 14 feet one inch on Second creek. To this thickness five feet one inch of transition rock may be added, thus making the total thickness 19 feet 10 inches. At Wallington in the diamond drill core the apparent thickness, counting transition beds, is about 20 feet. At Wolcott the drill core showed 23 feet seven inches of this limestone with its transition beds. At Red creek the limestone is reduced to 16 feet 10 inches.

In general the Wolcott limestone can best be described as a lenticular mass of rock which reaches its maximum thickness at or near the village of Wolcott. As already shown, the limestone decreases to the west even within the limits of the quadrangles. Beyond the Sodus Bay area the process continues. At Fish creek near Fruitland it is represented by approximately five feet of limestone. Between Fruitland and the Genesee gorge the Wolcott, like the underlying Upper Sodus, disappears completely (see figure 8, p. 38). To the east of Wolcott the formation becomes thinner and loses seven feet between Wolcott and Red Creek, the distance between the two test holes being about seven miles.

The westward thinning of the Wolcott from the type locality is due to one of two causes. Either the formation never attained so great a thickness as it did to the east, or having been deposited it was removed by subsequent erosion. From the facts available it seems at least possible that both processes played a part. As far west as
Figure 16  Little Wolcott creek, Wolcott limestone
Second creek the Wolcott is overlain by the Wolcott furnace iron ore, and there seems no ground for supposing that erosion has greatly affected the formation in the area covered by the quadrangles. To the west of Second creek, even as close as Wallington, the ore has disappeared and everything appears to point to the conclusion that erosion played an important part in reducing the thickness of this formation in the region to the west. One of the most striking evidences of erosion is the shell rubble between the Lower Sodus and the Williamson in the Genesee gorge. Of course, no positive evidence exists that the Wolcott limestone ever extended as far west as Rochester.

The eastward thinning of the Wolcott may also be the result of erosion after deposition. The Wolcott furnace iron ore is not present in the core at Red Creek and it may have been eroded together with some of the underlying Wolcott. Since little or no Middle Clinton was ever deposited in the area under consideration, plenty of time elapsed between the deposition of the Lower and Upper Clinton to allow the removal of considerable rock. Although erosion may have been an important cause of the thinning of the Wolcott east of the Sodus Bay area, evidence exists which also shows that the lower layers of the Wolcott become increasingly shaly in that direction. This may also be a very important factor in the apparent thinning of the Wolcott to the east. This subject will be discussed fully in a later report on the Clinton of New York.

According to well records recently acquired, the Wolcott does not change greatly in thickness to the south of Wolcott village within the limits of the Clyde and Sodus Bay quadrangles. At Clyde the thickness is about 22 feet, and at the McGuane well (p. 44) it is about 20 feet in thickness (see figure 9, page 39).

The ostracods found in the Wolcott limestone, namely, *Zygobolba decora*, *Z. robusta*, *Mastigobolbina incipiens* and *M. retifera*, show that this formation belongs with the underlying Upper Sodus within the range of the *Zygobolba decora* zone. The Wolcott does not contain so many ostracods as the Upper Sodus. For the most part the ostracods are found in the shale layers although a few have been found in the limestone part of this formation.

In describing the lithology, the gradual change of the Upper Sodus into the Wolcott, has been cited. The fact that the shale layers in the Wolcott contain many of the Upper Sodus megascopic fossils has also been pointed out. The changing of the lower limestone layers of the Wolcott into a shale, which can not be told from the Upper Sodus, has been mentioned. To these can now be added the
fact that the Wolcott and Upper Sodus have an identical microfauna. The conclusion that the two are very closely related is inescapable. The writer holds that both the Upper Sodus and the Wolcott were deposits of a single sea, and that the differences which do exist are the result of changes in the condition of sedimentation.

Ulrich and Bassler (’23, p. 333–34) have suggested that the Wolcott represents the invasion of a sea with a southern origin as contrasted with the Upper Sodus which, they believe, had an eastern source. As in the case of the Reynales, they hold that the Pentamerus and lacy bryozoans show such a connection, and that the Coelospira, ostracods, and related forms, which had an eastern origin, are not represented in this formation. The same objections are offered for this explanation of the Wolcott that were set forth in connection with the similar condition for the Reynales. Ostracods are found throughout the Wolcott. The shale layers bear Coelospira and other forms common to the Upper Sodus. Only in the crystalline limestone layers does the fauna differ markedly from the underlying Upper Sodus, and this seems more plausibly explained on the basis of ecology, than on the strength of any separate or distinct center of origin.

The following list of fossils represents those species found in the Wolcott limestone of the Clyde and Sodus Bay area, which were personally collected and identified by the writer:

<table>
<thead>
<tr>
<th>Zaphrentis bilateralis (Hall)</th>
<th>Strophodonta corrugata (Conrad)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chactetes lycoperdon Hall</td>
<td>Pentamerus oblongus Sowerby</td>
</tr>
<tr>
<td>Favorites favosides (Hall)</td>
<td>Camarotoechia pisa (Hall and Whitfield)</td>
</tr>
<tr>
<td>Chasmatopora angulata (Hall)</td>
<td>C. robusta (Hall)</td>
</tr>
<tr>
<td>Fenestella prissa Hall</td>
<td>Atrypa reticularis (Linnaeus)</td>
</tr>
<tr>
<td>F. tenuis Hall</td>
<td>Spirifer biforatus Hall</td>
</tr>
<tr>
<td>Helopora fragilis Hall</td>
<td>S. radiatus Sowerby</td>
</tr>
<tr>
<td>Nematozozara raripora (Hall)</td>
<td>Coelospira hemispherica (Sowerby)</td>
</tr>
<tr>
<td>Phacnopora constellata Hall</td>
<td>Cornulites distans Hall</td>
</tr>
<tr>
<td>P. ensiformis Hall</td>
<td>Calymene niagarensis Hall</td>
</tr>
<tr>
<td>Striatopora flexosa Hall</td>
<td>Zygobolba decora Ulrich and Bassler</td>
</tr>
<tr>
<td>Pachydictya crassa Hall</td>
<td>Z. robusta Ulrich and Bassler</td>
</tr>
<tr>
<td>Retepora angulata Hall</td>
<td>Mostigobolbina incipiens Ulrich and Bassler</td>
</tr>
<tr>
<td>Rhipidomella circulus Hall</td>
<td>M. retifera Ulrich and Bassler</td>
</tr>
<tr>
<td>Leptaena rhomboidalis (Wilckens)</td>
<td></td>
</tr>
</tbody>
</table>

Wolcott Furnace iron ore (Chadwick). The Wolcott Furnace iron ore was named by Chadwick (’18, p. 327–68). It was recognized by Newland and Hartnagel (p. 18–33) in 1908, but was not named. This formation constitutes the upper hematitic-bearing limestone of eastern Wayne county. It is the formation which was worked for a short time for iron ore at Wolcott Furnace.
The Wolcott Furnace iron ore overlies the Wolcott limestone and is always intimately related with that limestone. It contains many of the same fossils, and the layers of the Wolcott limestone are often found grading upward into the iron ore. At Wolcott Furnace, where the iron ore outcrops in the bed of Wolcott creek, the formation itself consists of 16 inches of hematitic limestone, but the limestone underlying this iron ore contains oolites of hematite for more than a foot below the base of the formation.

On Second creek the Wolcott Furnace iron ore is represented by approximately 18 inches of hematitic limestone and shale. This section is much leaner in iron content than the section described in the preceding paragraph, and with the exception of a thin two and one-half inch calcareous layer near the center of the Wolcott Furnace horizon, the hematite is confined to scattered oolites in the calcareous shale. In some parts the oolites form thin sheetlike partings between the minute shale layers, in other the oolites are scattered through the shale. From the preceding it is apparent that the Wolcott Furnace iron ore, like other Clinton iron ores, varies both in thickness and iron content from place to place. In the drill core at Wallington no trace of this "ore" is found, and apparently the formation makes its appearance in the section between Wallington and Second creek. It reaches its maximum development near Wolcott Furnace, and as shown by the drill core at Red Creek, it pinches out or is represented only by a three-inch layer of phosphatic nodules a short distance east of Wolcott. An iron ore makes its appearance at the same horizon farther to the east in the vicinity of Verona. To the south of Wolcott traces of this ore were found in the Clyde gas wells. Its thickness could not be determined. At the McGuane well (p. 44) no trace of an iron ore at that horizon could be found.

In a crude way the present extent of this so-called iron ore in the vicinity of the Clyde and Sodus Bay area can be outlined. In an east-west direction the limits of the lenses correspond roughly with the limits of the quadrangle. The southern limit is somewhere between Clyde and Junius, which is located three miles south of the southern limits of the Clyde quadrangle. This lenticular shape is characteristic of all the New York Clinton formations, but the other formations involve a greater thickness of rock and naturally extend over a much greater area. Because of their broad extent their lenticular character can not be brought out in discussing the geology of a single quadrangle. The Wolcott Furnace iron ore gives an excellent example of this lenticular nature on such a scale that it can be appreciated in studying a small area.
The lenticular shape of the Wolcott Furnace ore is probably the result of more than a single factor. In the first place it is located at the top of the Lower Clinton in the Wolcott area. Although some Middle Clinton may have been deposited, it was, if such were the case, entirely removed before the advent of the seas, in which were to form the Upper Clinton formations. Thus there is little reason to doubt that the Wolcott Furnace ore was itself subject to modification by erosion before it became buried beneath the Upper Clinton formations. It may have once extended much farther to the west than it does today, and there is also a possibility that it may have formed east of Red creek, and that the present outline of the formation resulted from some physical feature which prevented erosion from stripping the Wolcott Furnace from the Clyde and Sodus Bay region.

Another possible explanation for the lenticular shape of the Wolcott Furnace iron ore is that the present outline may roughly coincide with the basin in which this formation was deposited. At the time of deposition the small basin may have been under the influence of particularly favorable conditions for the deposition of hematite.

Which of these explanations is correct does not appear answerable with the information now available. It is known that the Lower Clinton at Fruitland and to the west of Fruitland was subject to erosion in the interval between the Upper and Lower Clinton. It is also known that at the Wolcott Furnace horizon in the Red Creek core there is about three inches of rock strata containing an abundance of phosphatic nodules. Phosphatic nodules are almost always associated with the Clinton iron ores of western New York. These three inches of phosphatic nodules may be the extreme eastern representative of the Wolcott Furnace iron ore in this locality, and may indicate that the formation was never laid down in the area east of Wolcott.

The Wolcott Furnace iron ore brings out forcibly another general feature of Clinton sedimentation which deserves a passing note. As is shown by the fact that the Wolcott Furnace iron ore is unconformably overlain by formations much younger in age, it must have been deposited in a sea which was gradually drying up, or at least receding from the area. All of the Clinton iron ores of New York State are directly connected with some major movement of the strand line. Not all of them like the Wolcott Furnace are directly connected with the recession, but some, as with the Furnaceville, are associated with the positive movements of the strand line. It is easy to surmise that areas could be partly shut off either during an advance or retreat
of the sea, since both an advance and a recession would be associated with an oscillatory movement. In these isolated shallow basins iron ores apparently formed.

The gradation between the Wolcott Furnace iron ore and the Wolcott limestone has already been noted. The fauna likewise shows that the two are closely related. Nevertheless, no ostracods have been found in this thin formation, although they may be present. The fossils in the Wolcott Furnace iron ore are in a poorer state of preservation than those of the Furnaceville. The formation also contains much of its hematite in the oolitic form, rather than in the pure fossil ore of the Furnaceville type. At Wolcott Furnace, where the formation is represented largely by a hematitic limestone, the fossils, Phaenopora ensiformis and Helopora fragilis, were comparatively common. At second creek, where only the central two and one-half inches of the formation can be called a hematitic limestone, and the rest of the formation is a typical bluish gray Wolcott shale type of lithology, the lacy bryozoans, Fenestella tenuis and F. prisca, were the dominant forms. A few Phaenopora ensiformis and Helopora fragilis, however, were identified in the central thin limestone layer. These bryozoans are all well represented in the Wolcott shale, and although they do have a long range (see Faunal Range Chart, p. 41), they help, together with the lithologic and stratigraphic relations, to show that this formation should be considered with the Wolcott to fall within the Zygobolba decorata zone.

The following is the list of the fossils from the Wolcott Furnace iron ore in the Clyde and Sodus Bay quadrangles, personally collected and identified:

| Chaetetes | Phaenopora ensiformis |
| lycoperdon Hall | Hall |
| Fenestella prisca Hall | Lepiasten rhomboidalis (Wickens) |
| F. tenuis Hall | Strophoedonta corrugata (Conrad) |
| Helopora fragilis Hall | Atrypa reticularis (Linnaeus) |
| | Coelospora hemispherica Sowerby |

**Williamson shale (Hartnagel).** The lowest member of the Upper Clinton in the Clyde and Sodus Bay quadrangles is the Williamson shale which directly overlies the Wolcott Furnace iron ore. Hartnagel (’07, p. 15–16), (’12, p. 46–49) gave this shale its name from an outcrop near the village of Williamson in Wayne county. In the Genesee gorge, however, he used the term to include both the Williamson and the Lower Sodus as used in this report. The Lower Sodus and the Williamson are in contact at Rochester, but in the Clyde and Sodus Bay area the two are separated by the Upper Sodus shale, the Wolcott limestone and the Wolcott Furnace iron ore.
Chadwick ('18, p. 348–49) restricted the Williamson to apply to that part of Hartnagel's Williamson which lies above the Wolcott limestone. This definition has been accepted by Ulrich and Bassler ('23, p. 344–48) and Goldring ('31, p. 330–31).

The best exposure of the Williamson in the Clyde and Sodus Bay area is on Second creek, but good outcrops are present on Mudge creek, Wolcott creek and on the little creek which runs parallel with and east of Wolcott creek. The exact locations are given on the geologic map. Because the shale disintegrates rapidly upon being exposed to the weather, it seldom occurs on the banks of the streams, and must be studied in the stream beds, where active erosion is taking place.

The Williamson is a fine-grained shale, ranging in color from an olive-green to jet black. It is thin bedded and cleaves readily along the bedding planes. Upon being exposed to the atmosphere the shale breaks up into thin waferlike pieces. Occasionally secondary calcite is found forming a thin coating over the fissile layers. A few limestone layers, which resemble the "pearly layers" of the Sodus except that the fossils are *Plectambonites transversalis* and not *Coelospira hemispherica*, are interbedded with the shale. The formation contains an abundance of pyrite. In addition to the scattered crystals occurring in the fresh rock, there are two other modes of occurrence. Circular, radiating structures, ranging from microscopic to two centimeters in diameter, are common, and are found on the bedding planes of the waferlike layers. This type of occurrence appears to be secondary. Less frequently pyrite forms thin layers. Two of these layers on Second creek were a half-inch thick, but usually they are less than a quarter of an inch in thickness. These pyrite layers, which are made up of small but almost perfect crystals, are conformable with overlying and underlying layers, and give every evidence of being primary in origin.

The contact of the Williamson and the Wolcott Furnace iron ore is sharp and well-defined. On Second creek, where the best opportunity is offered for studying this contact, the lowest thin bedded platy typical Williamson shale layer, four inches and a half in thickness, is found six inches above the hematitic band. Following this typical Williamson layer is two inches of light blue crystalline limestone, bearing a few very poorly preserved *Plectambonites transversalis*. The limestone is followed by an inch of thin-bedded shale from which *Monograptus clintonensis* was extracted. This, in turn, is followed by one and one-half inches of sandstone, which overlies a thin conglomerate layer an inch to an inch and a half in thickness. The
Figure 18 Second creek. Williamson shale
Figure 19 Second creek. Irondequoit limestone and Williamson shale contact
pebbles, comprising the conglomerate layer, are quartz coated with a black substance, probably phosphate. The exact location of this contact is 410 feet south of the first bridge over Second creek north of Alton. The stream bed shifts slightly from time to time, and it is usually necessary to uncover the contact with a shovel.

In determining the thickness of the Williamson in the various parts of the Clyde and Sodus Bay quadrangles, one must first determine which rocks are to be included in this formation. The lower part of the Irondequoit is very shaly in this area, and it grades down into a crumbly calcareous shale, which does not have the fissile character of the Williamson. Most of the workers in the past have considered that the Irondequoit included only the limestone, but since the change from the limestone to this calcareous crumbly blue-gray shale is so very gradual, it would seem best to include only in the Williamson the fissile green and black shales. This division is substantiated by fossils. The Williamson has become known as a graptolite-bearing shale. The gray crumbly shale contains no graptolites and in this way resembles the typical Irondequoit. Any line of separation between the Williamson and Irondequoit must necessarily be arbitrary since both of these formations belong to the same ostracod zone or time unit, and that the only differences between the two were the result of changing conditions of sedimentation. Considering this, it is not to be expected that this change would be abrupt.

Placing in the Williamson only the fissile green and black shale, the thickness of the Williamson of Second creek is 18 feet three inches. In no other place in the quadrangle is the whole thickness of the Williamson measurable at the surface. The diamond drill cores give the following thicknesses: at Wallington 18 feet and six inches, at Wolcott 22 feet and nine inches, and at Red Creek 32 feet and six inches. At first thought it might seem impossible to separate the Williamson shale from the lower calcareous shale of the Irondequoit, but this is a comparatively easy task since the fissile nature of these shales shows up very well in the cores. As a whole it can be said that the Williamson with its platy cleavage increases in thickness from west to east.

In the chips from the gas wells at Clyde and from the McGuane well, a separation of the shaly Irondequoit and the Williamson could not be made. Taking into consideration, however, all the shale from the base of the true limestone part of the Irondequoit to the top of the Wolcott, no great change in thickness could be detected (see figure 9, p. 39).
The ostracods are present in great numbers in the Williamson. *Dibolbina clintoni* and *Beyrichia lakemontensis var. borsti* are plentiful from the base to the very top of the formation. *Mastigobolbina trilobata* and *M. punctata* enter the section a few feet above the base. *Mastigobolbina typus* makes its appearance near the top of the formation. All of these forms continue into the overlying Irondequoit limestone. On the basis of this assemblage of ostracods the Irondequoit and Williamson are considered to form a single ostracod zone, the *Mastigobolbina typus*, which zone is the lowest time division of the Upper Clinton. The difference in the type of sedimentation in the Williamson and Irondequoit is considered the result of ecology.

The megascopic fauna of the Williamson consists largely of graptolites and brachiopods. *Monograptus clintonensis* is the dominant species of graptolite, but a few *Retiolites venosus* are present. A careful search seldom fails to locate *Monograptus* in any part of the Williamson, but they are more plentiful near the base of the formation. Particularly in this lower part of the formation graptolites are often found covering the bedding planes of thin black shales which are interbedded with fissile green layers. The graptolites confined to these bedding planes often occur as tangled broken masses. Ruedemann (’25, p. 81) has described a similar occurrence in the Norman-skull shales of Ordovician age. He believes that the tangled broken masses are the result of periods of stormy weather. This would appear a plausible explanation for these Williamson graptolites, not only because of their fragmentary condition, but also because of their great abundance in certain very restricted parts of the section, such as bedding planes. A still further argument for this explanation is that the graptolites are found in the green layers also, but less frequently. When they do occur in these strata, the individual stocks are usually much larger, appear to be less broken, and are, in general, much better preserved.

The most common brachiopod in the Williamson is *Plectambonites transversalis*, which became so plentiful at intervals during Williamson time that their shells formed limestone layers as much as three or four inches in thickness. Other brachiopods which appear in great numbers are *Atrypa reticularis, Strophocelina corrugata, Spirifer radiatus, Cyrtia meta, Scenidium pyramidalis, Bilobites bilobus* and *Chonetes cornutus*. The brachiopods are poorly preserved and usually are represented only by casts and molds. In some cases the fossils are replaced by pyrite. A large number of these pyrite
replacements were found on the little creek which runs east of and parallel to Wolcott creek.

A complete list of the fossils, collected and identified by the writer from the Williamson shale outcrops of the Clyde and Sodus Bay quadrangles, is here recorded:

- **Zaphrentis bilateralis** (Hall)
- **Monograptus clintonensis** (Hall)
- **Reticolites venosus** Hall
- **Dalmanella elegans** (Dalman)
- **Orthis flabellites** Foerst
- **O. punctostriata** Hall
- **O. tenuidens** Hall
- **Bilobites bilobus** (Linnaeus)
- **Leptaena rhomboidalis** (Wilckens)
- **Plectambonites transversalis** (Wahlenberg)
- **Straphycodon corrugata** (Conrad)
- **Chonetes cornutus** (Hall)
- **Scoliophyllum pyramidale** Hall
- **Atrypa reticularis** (Linnaeus)
- **Spirifer eudora** (Hall)
- **S. radiatus** Sowerby
- **Coelaspis sulcata** Prouty
- **Hormotoma subulata** (Conrad)
- **Conularia niagarensis** Hall
- **Liocalymene clintoni** Vanuxem
- **Phacops trisulcata** (Hall)
- **Mastigobolbina punctata** Ulrich and Bassler
- **M. trilobatus** Ulrich and Bassler
- **M. typus** Ulrich and Bassler
- **Beyrichia lakemontensis var. borsti** N. Var.
- **Dibolbina clintoni** N. S.

**Irondequoit limestone** (Hartnagel). Overlying the Williamson shale is the Irondequoit limestone, which Hartnagel (’07, p. 16-17) named for the town of Irondequoit in Monroe county. The exposures of the Irondequoit are plentiful in the Clyde and Sodus Bay quadrangles. The best of these outcrops are those on Second creek, Beaver creek, Wolcott creek, and on the little creek which runs east of and parallel to Wolcott creek. The exact locations of these are given on the geologic map.

The Irondequoit can be divided into two parts; the upper part, which consists largely of limestone layers with shale partings, and the lower part, which is made up of dark gray calcareous shale. In the upper or true limestone part of the Irondequoit the layers toward the top of that division are coarsely crystalline, and colorless when fresh but upon being exposed to the atmosphere turns to a dirty yellowish brown. Hartnagel (’07, p. 16) claims that this color is due to stain caused by the oxidation of iron pyrite. Cubes of pyrite are common in this part of the Irondequoit, and the explanation seems plausible.

In addition to pyrite the coarsely crystalline layers often contain some galena. A five-inch layer of this crystalline Irondequoit outcropping on Wolcott creek just north of the railroad culvert exhibits an unusually large amount of galena. Although of no commercial value at the present time, it may have been the source of lead which the Indians are rumored to have collected from somewhere in this area and to have sold to the first white settlers.
As already stated, the crystalline layers are confined to the uppermost part of this upper division. Toward the middle the limestone layers lose their crystallinity. The lowest layers of limestone, which are relatively thin compared with those higher up, are dark gray in color and are shaly. The layers of limestone in this upper part of the Irondequoit are separated by shale breaks. In the upper part of this division the shales are very thin, but in the lower part they are much thicker, equaling and even surpassing the limestone layers in thickness. In other words, there is a gradual transition from a pure limestone to a pure calcareous shale.

The lower or shale division of the Irondequoit is decidedly different from the upper portion of the same formation. It is hard to conceive that this crumbly dark gray calcareous shale belongs to the same formation as the upper crystalline layers. The transition is so gradual, however, that there can be no doubt that the two formations are very closely related. Theoretically this shale could be placed in the underlying Williamson, but it differs even more from this fissile shale than it does from the limestone part of the Irondequoit. Particularly is this true when the shale is compared with the shale breaks, and even the shaly limestones themselves, in the lower part of the shaly limestone division. Although it is difficult to assign this shale to either the Irondequoit or the Williamson, its origin can easily be explained. The sea in which the Irondequoit was being deposited in the Clyde and Sodus Bay quadrangles was receiving during the deposition of the lower part of this formation a considerable amount of clastic material. As time went on the sea received less and less clastic material until it was receiving practically no sediment, and the upper crystalline layers were formed.

In studying the formation by means of drill cores and well samples it must be remembered that the division between the upper and lower parts of this formation is only arbitrary, being placed at the point where the lowest thick layer of limestone enters the section. With this in mind the following thicknesses have been accorded to the two divisions in the state cores. At Wallington the limestone part is eight feet and two inches, the shale is 19 feet and one inch; at Wolcott the limestone part is six feet and two inches, the shale is 22 feet and six inches; and at Red Creek the limestone is six feet, the shale is 29 feet and four inches. Thus the limestone is apparently decreasing in thickness from west to east, whereas the shale is increasing in that direction. The entire thickness of the Irondequoit is increasing in the same direction. These conditions continue east of the Clyde and Sodus Bay quadrangles.
Figure 20. Second creek. Irondequoit limestone, lowest exposure of the upper or true limestone part of the formation.
Figure 21  Second creek. Irondequoit limestone, typical exposure of true limestone part of the formation
Figure 22 Second creek. Irondequoit limestone. Shale parting between limestone layers in the upper or limestone part of the formation.
As previously mentioned, it is impossible in churn drill samples to separate the Williamson and the shaly part of the Irondequoit, but some interesting data have been collected on the upper part of the Irondequoit. At Clyde the limestone portion of the Irondequoit is about ten feet thick, that is, it is slightly thicker than in the Wolcott section. At the McGuane well (p. 44) there is apparently between 15 and 18 feet of limestone at this horizon. Thus the limestone portion of the formation appears to be increasing slightly to the south. That this increase does not continue far beyond the southern limits of the quadrangles is shown by the gas wells in the Geneva area, where the thickness is only 15 feet, and in the Bristol area, still farther to the south, the thickness is only twelve feet.

The fauna of the upper part of the Irondequoit is extremely interesting. Some of the limestone layers are composed entirely of crinoid stems, others contain corals and a few brachiopods, such as Leptaena rhomboidalis, Atrypa reticularis, Whitfieldella cylindrica and intermedia. The shale layers between the limestone bear quite a different fauna. In these layers the following megascopic forms are found in great numbers: the bryozoans, Eridotrypa striata, Rhinopora verrucosa, Semicoscinium tenuiceps and Phyllopora asperato-striata; the brachiopods, Bilobites bilobus, Orthis tenuidens, Stropheodonta profunda, Schuchertella subplana, Plectambonites transversalis, Dalmanella elegantulas, Spirifer radiatus, S. niagarensis, S. sulcata, Atrypa reticularis, A. rugosa and Whitfieldella nitida; the pelecypod, Pterinea emacerata; the cephalopod, Dawsonoceras annulatum; and the trilobite, Dalmanites limulus. These fossils are practically all the forms which have been formerly considered to be Rochester shale species. In lithology the highest shale layers resemble the Rochester.

The microscopic forms, which show that the upper or limestone part of the Irondequoit belongs within the range of the Mastigobolbina typus zone, were not found in the limestone layers themselves, but in the shale breaks they are common. They consist principally of Mastigobolbina typus, Plethobolbina typicalis, Mastigobolbina trilobata and M. punctata. In contrast with the megascopic forms these microscopic forms are closely related to the underlying Williamson forms, and have nothing in common with the overlying Rochester species. The only differences between the Williamson and the Irondequoit forms are that Plethobolbina typicalis has made its appearance, and Dibolbina clintoni and Beyrichia lakemontensis var. horsti have disappeared.
One other characteristic of the upper or true limestone part of the Irondequoit deserves some consideration. In this part of the formation are certain reeflike bodies. Sarle (’01, p. 281–82) has described similar structures in the Rochester section. The strata overlying these reefs are arched up, and give a folded appearance to these beds. When this part of the Irondequoit forms the bed of a stream, the reef structures being more resistant stand out as knobs, the rock around them having been worn away by stream erosion.

As Sarle pointed out, these reefs are composed almost completely of bryozoans of which the most common species are Fistulipora tuberculosa and F. crustula. The bryozoans are not easily recognized unless the rock is deeply weathered. The aforementioned species are not confined to the reefs but often occur as individuals in the thin shale layers or breaks between the limestone. A possible explanation of this dual occurrence is that the individuals in the shaldepositing areas of the sea, although able to exist, did not find conditions so favorable as those which thrived and produced the large lenticular reefs.

The fossils of the lower and shaly part of the formation deserve special consideration. They are poorly preserved, often fragmentary, and exceedingly hard to identify. Their great numbers, however, make it possible by careful collecting to determine most of the organisms living at the time the lower Irondequoit was being deposited.

The most abundant megascopic forms in the lower part of the Irondequoit are: the brachiopods, Whitfieldella intermedia, W. cylindrica, Chlorinda fornicata, Orthis tenuidens, Scenidium pyramidalis, Spirifer radiatus, Cyrtia meta, Plectambonites transversalis and Stropheodonta corrugata; the trilobites, Liocalymene clintoni, Encrinurus ornatus and Phacops trisulcata. The microscopic forms consist of the following ostracods: Mastigobolbina typus, M. trilobata, M. punctata, Plethobolbina typicalis, Beyrichia lakemontensis var. borsti and Dibolbina clintoni.

Unlike the limestone part of the formation, the list of megascopic forms in this lower portion of the Irondequoit contains few Rochester species. In fact, with the exception of Whitfieldella, the fossils are much more like those of the underlying Williamson.

The ostracods of this lower part of the Irondequoit are particularly important. The two Williamson forms, Beyrichia lakemontensis var. borsti and Dibolbina clintoni, which do not extend into the true
limestone division of the Irondequoit, are still present in great numbers. Equally important is the occurrence of *Plethobolbina typalis*. This ostracod is not found in the underlying Williamson. In brief, the *Mastigobolbina typus* zone may be summarized as follows: the ostracods show that the lithologic divisions of this zone, the Williamson and the Irondequoit, are closely related. In the early deposits of this zone is found an assemblage of megascopic organisms, which has become known as the Williamson fauna. Later in the same zone, and during the deposition of the Irondequoit, these organisms began vanishing from the sea, and in their place began appearing many of the Rochester shale species. Thus long before the close of *Mastigobolbina typus* time, most of the forms usually considered as typical Rochester shale species had already made their appearance. The larger fossils of the Irondequoit can be considered as representing a transition between the Williamson and Rochester assemblage.

Time is probably not the only factor which has brought about this gradual change in fauna. In preceding parts of this report the writer has often called attention to the fact that the larger forms appear to have been affected by ecology more than the ostracods. The similarity in lithology of the shale layers occurring in the upper part of the Irondequoit and the Rochester has also been mentioned. In view of this it seems plausible that the conditions under which these shales were laid down were similar. On the other hand, the conditions under which the black graptolite shale of the Williamson formed must have been decidedly different. This difference in sedimentary and ecologic conditions would seem to be sufficient to require an entirely different fauna even if the dark gray calcareous shales of the upper Irondequoit and Rochester had formed contemporaneously with the Williamson.

The following list of fossils represent all the species, collected and identified by the writer, from the Clyde and Sodus Bay quadrangles:

- *Enterolasma calicum* (Hall)
- *Favosites hisingeri* Edwards and Haime
- *Spatiopora maculata* (Hall)
- *Chilotrypa ostiolata* (Hall)
- *Pistulopora crustula* Bassler
- *P. tuberculosa* Hall
- *Mesotrypa nummiformis* (Hall)
- *Eridotrypa striata* (Hall)
- *Phyllopornia asperato-striata* (Hall)
- *Polypora incepta* Hall
- *Semicosismium tenueceps* (Hall)
- *Rhinopora verrucosa* Hall
- *Pseudohornera diffusa* (Hall)
- *Pholidops squamiformis* (Hall)

Other important fossils are:

- *Dalmanella elegans* (Dalman)
- *Orthis flabellites* Foerste
- *O. tenuidens* Hall
- *Bilobites bilobus* (Linnaeus)
- *Rhipidomella hybrida* (Sowerby)
- *Leptaena rhomboidalis* (Wilckens)
- *Plectambonites transversalis* (Wahlenberg)
- *Schuchertella subplana* (Conrad)
- *S. tenuis* (Hall)
- *Stropheodonta convexa* Hall
- *S. deflecta* Hall
- *S. profunda* (Hall)
- *Scenidium pyramidale* Hall
Chlorinda fornicata Hall
Dictyonella corallifera (Hall)
Camarotoechia neglecta (Hall)
C. obtusiplicata (Hall)
Atrypa nodistratiata Hall
A. reticularis (Linnaeus)
A. rugosa Hall
Cyrtia exporrecta myrtia (Billings)
C. meta (Hall)
Reticularia bicostata (Vanuxem)
Spirifer eudora (Hall)
S. niagarensis (Conrad)
S. radiatus (Sowerby)
S. repertus (Foerste)
S. sulcata Hisingeri
Cyrtina pyramidalis (Hall)
Trematospira camura Hall
Nucleospira pisiformis Hall
Whitfieldella cylindrica Hall
\[ \text{NEW YORK STATE MUSEUM} \]

**Rochester shale** (Hall). The Rochester shale is considered the highest member of the Clinton group in this report. It directly overlies the Irondequoit limestone and underlies the Lockport dolomite. The Rochester was named by James Hall ('39, p. 290) from the outcrops near Rochester in Monroe county. The exposures of this member of the Clinton are numerous in the Clyde and Sodus Bay area. The best outcrops are found on Second creek, Sodus creek, on the tributaries flowing into Sodus creek, on Beaver creek, Wolcott creek and on the little creek which runs east of and parallel to Wolcott creek.

The Rochester is a bluish gray calcareous shale, which contains, especially near its center, a few pure limestone layers. The lower 40 feet of this shale is exceedingly fossiliferous. A portion near the center, which measures approximately 30 feet, is almost barren of any evidence of past life. Again at the top of the Rochester the layers become more fossiliferous (see figure 23, p. 89). The top of the middle or comparatively barren Rochester forms the cap rock for a number of small falls in the Clyde and Sodus Bay area. The best examples of such falls are found at Wolcott on Wolcott creek and at the little settlement, locally known as Glenmark, on Sodus creek.

The upper part of the Rochester grades upward into the overlying Lockport dolomite. This gradation may best be seen on Sodus creek north of the railroad culvert. Here the typical thin-bedded siliceous dolomite of the Lockport lies slightly over two feet six inches above the highest outcrop of typical lithologic Rochester. The intervening two feet six inches is composed of three types of material, shaly layers which bear a Rochester fauna, light blue crystalline limestone layers, which also contain a Rochester fauna, and thin siliceous dolo-
Figure 23 Sections of the Rochester exposed at Wolcott and Sodus creeks

**Lockport**
- Dark blue calcareous shale, very fossiliferous. Contains all the fossils found in the lower position. Great abundance of Dalmanites limulurus.

**Rochester exposed on Sodus creek**
- Dark gray shaly limestone, very hard, especially at the top. A few fossils are found but almost barren.

**Rochester 122'**
- Bluish gray calcareous shale. Less fossiliferous than the rock below. Contains same fossils.

**Rochester exposed at Wolcott**
- Bluish gray calcareous shale with a few limestone lenses some of which are crystalline. Contains Dalmanella elegantula, Plectambonites transversalis, Spirifer radiatus, S. Niagaresis, many Bryozoa. Dalmanites limulurus, Dawsonoceras annulatum.

**Irondequoit**
mitic barren layers which resemble the Lockport in lithology. These three types are interbedded. The two types with the Rochester fauna predominate at the base. The siliceous dolomitic layers of Lockport lithology are frequent only in the upper part of this transition zone.

Since the Rochester is not completely exposed within the limits of the area, difficulties are encountered in arriving at the thickness. From the drill cores the combined thickness of the various members of the Clinton below the Rochester shale was determined and given in the report of Newland and Hartnagel (p. 21-40) in 1908. Since the appearance of this report, the thickness of the pre-Rochester Clinton has been given correctly in all subsequent papers dealing with those rocks, but the Rochester was not completely penetrated anywhere in this region by the drill cores, and various thicknesses have been assigned to this formation from time to time. Chadwick ('18, p. 353) for instance, states that the Rochester is at least 75 feet thick at Wolcott. Ulrich and Bassler ('23, p. 347) report 70 feet present at Wolcott. Actually the thickness is much greater than these men have reported it. Their misconception possibly came from supposing that the Rochester shale at the top of the Wolcott falls represented the uppermost part of the Rochester.

According to the log of the Wolcott well by Newland and Hartnagel ('07, p. 32), the drill passed through 39 feet of Rochester shale. Forty-six feet by tape and plane table measurements of this formation outcrop in the Wolcott gorge above the point where the drill entered the shale. This makes a total of 85 feet at Wolcott. By making a very careful study of the fossils, found in the various layers, the lithology and the succession of layers themselves, the author of this report believes that the highest layers of the Rochester at Wolcott can be fitted into the section on Sodus creek 37 feet below the contact with the Lockport. The task of correlation was comparatively simple because the highest layers of the Wolcott gorge were the highest layers in the barren part of the Rochester (see figure 23). This same barren zone outcrops on Sodus creek and also the layers which directly underlie as well as the layers which overlie it. Since the distance between the Wolcott gorge and Sodus creek is so short, the correlation ought to be fairly accurate. Adding the 37 feet, which represents the highest portion of the Rochester, to 85 feet, present at Wolcott, the total thickness of the Rochester in this section of the Clyde and Sodus Bay quadrangles would appear to be 122 feet. This thickness is a minimum.
Figure 24  Sodus creek. Glenmark falls. Outcrop of Rochester shale
In the wells which have recently been drilled at Clyde the thickness of the Rochester is between 136 and 138 feet. This may be the true thickness of the Rochester farther to the north. The wells to the south of Clyde, however, show that the Rochester is thickening in that direction. At the Bump well, which is near Junius and south of the southern limits of the Clyde quadrangle, the thickness of the Rochester is approximately 142 feet. The average thickness of the Rochester shale in the wells near Geneva, which have been drilled deep enough to penetrate this shale, is 147 feet.

From the data presented the Rochester shale appears to increase from 85 feet to at least 122 feet in passing from Rochester eastward to the Clyde and Sodus Bay area. It also becomes thicker toward the south in the direction of Geneva.

Many ostracods were found in the Rochester of the Clyde and Sodus Bay quadrangles, but only four of these appear to be of stratigraphic importance; that is, only four were found at a sufficient number of outcrops in western New York to be considered as an aid in correlating rocks. They are Paraechmina spinosa, P. postica, Dizygopleura proutyi and Beyrichia veronica. The above forms constitute the ostracods of the Paraechmina spinosa zone. All the forms characteristic of this zone are found from the base to the very top of the Rochester formation. The microfauna of the Rochester does not resemble in any way the fauna of any of the underlying Clinton formations.

Although the Rochester of the Clyde and Sodus Bay area does not contain the variety of megascopic fossils which occur in the Rochester of Monroe county, it is by far the most prolific horizon in the area. Brachiopods greatly outnumber all other megascopic forms. The most common species are Dalmanella elegantula, Plectambonites transversalis, Spirifer radiatus, S. niagarensis, S. sulcata, S. crispatus, Stropheodonta profunda, Schuchertella tenuis, S. subplana, Atrypa reticularis, A. rugosa, A. nodistriata, Orthis flabellites, Leptaena rhomboidalis, Whitfieldella nitida, W. naviformis and Camarotoechia neglecta. Bryozoans, which form such an important part of the Rochester fauna of Monroe county, rank second in numbers. The three forms which outnumber all others are: Mesothyra nummiformis, Phyloporina asperato-striata and Ceramopora imbricata. In layers, appearing at various horizons, the trilobites are present to the exclusion of most other forms. Calymene niagarensis, Dalmanites limulurus and Homalonotus delphinosephalus are the outstanding species. The cephalopod, Dawsonoceras annulatum, is sometimes abundant.
Comparing the list of common fossils given in the preceding paragraph with those forms reported from the underlying Irondequoit, it is seen that all the brachiopods abundant in the Rochester are also plentiful in the shale layers of the upper Irondequoit. In fact, of all the forms mentioned only Homalonotus delphinocephalus was not found in the underlying Irondequoit. The apparent relationship of the Rochester and the Irondequoit megascopic fossils has been discussed in a previous section of this report (see p. 86).

The following is a complete list of forms collected from the Rochester of the Clyde and Sodus Bay area:

- Enterolasma caliculus (Hall)
- Zaphrentis bilateralis (Hall)
- Favosites hisingeri Edwards and Haimé
- F. pyriformis (Hall)
- Cystiphyllum niagarensis (Hall)
- Dictyonema retiformis (Hall)
- Eucalyptocrinus caelatus Conrad
- Ceramopora imbricata Hall
- Coeloclema cavernosa Bassler
- Mesotrypa nummiformis (Hall)
- Eridotrypa solida (Hall)
- E. striata (Hall)
- Phylloporina asperato-striata (Hall)
- Semicosinium tenuiceps, (Hall)
- Fenestella elegans Hall
- Rhinopora verrucosa Hall
- Pholidops squamiformis (Hall)
- Dalmanella elegantula (Dalman)
- Orthis filabellites Foerste
- O. punctostriata Hall
- O. tenuidens Hall
- Rhipidomella hybrida (Sowerby)
- R. circulus Hall
- Leptaena rhomboidalis (Wilckens)
- Plectambonites transversalis (Wahlenberg)
- Schuchertella elegans Prouty
- S. interstriata (Hall)
- S. subplana (Conrad)
- S. tenuis (Hall)
- Strophoedonta convexa Hall
- S. corrugata (Conrad)
- S. deflecta Hall
- S. profunda (Hall)
- Camarotoechia neglecta (Hall)
- C. obtusiplicata (Hall)
- Atrypa nodiatria Hall
- A. reticularis (Linnaeus)
- A. rugosa Hall
- Reticularia bicostata (Vanuxem)
- Spirifer crispatus (Hall and Clarke)
- S. niagaretensis (Conrad)
- S. radiatus (Sowerby)
- S. sulata (Hisinger)
- Whitfieldella cylindrica Hall
- W. naviformis (Hall)
- W. nitida (Hall)
- Liopteria subplana (Hall)
- Pterinea enacerta (Conrad)
- Diaphorostoma niagaretensis (Hall)
- Platyceras angulatum (Hall)
- P. niagaretensis Hall
- Dawsonoceras annullatum (Sowerby)
- Proetus stokesi Hall
- Enerinurus ornatus Hall and Whitfield
- Calymene niagaretensis Hall
- Illemaeus ioxus Hall
- Homalonotus delphinocephalus Green
- Cheirurus niagaretensis Hall
- Dalmanites limulurus (Green)
- Lichas boltoni Hall
- Paraechinites spinosa (Hall)
- P. postica Ulrich and Bassler
- Diszgopleura proutyi Ulrich and Bassler
- Beyrichia veronica Ulrich and Bassler

Lockport or Niagara Group

Ulrich ('11, p. 560 and table II) was the first to discuss the necessity of giving a name to the upper part of the Niagaran series. He believed that if the lower part of the Niagaran series must have a name, the Clinton, the upper likewise should have some designation. Therefore he proposed to call it the "Chicago group." Later he ('14, p. 666) discarded the term and used the designation "Lockport group." In 1928 Alling (p. 21) suggested that the upper part
Figure 25  Lockport dolomite. Quarry south of Wolcott
of the Niagaran series be referred to as the Niagara group. Many writers have considered it unnecessary to use a group name in referring to the rocks above the Clinton. For a complete résumé of the nomenclature of this part of the Niagaran series the reader is referred to table 3, page 28.

The practice has grown up in New York to give the lower part of the Niagaran series a group name, the Clinton, and to designate the upper part as a formation, the Lockport. There are several evident reasons for this terminology. With the exception of the extreme western part of the State, this part of the Niagaran series is poorly exposed. Wherever it does come to the surface, it is the more resistant portion of the dolomite, which has the typical Lockport lithology. Perhaps the most important single reason is the result of work by Clarke and Ruedemann ('03, p. 11-13), which showed that the Guelph, which in Ontario overlies the Lockport, is represented in New York by two lithologic members, which have Guelph fauna, but which are separated by typical Lockport rock. Because of their work the upper part of the Niagaran series including the Guelph is often referred to as the Lockport.

In the Clyde and Sodus Bay quadrangles the upper part of the Niagaran series is represented by a single formation, the Lockport dolomite. Because of this fact and because there appears to be no generally accepted name at present, the practice which has been followed in many New York State publications is adhered to, and the upper part of the Niagaran series is given no group name and is simply designated as the Lockport dolomite.

Lockport dolomite (Hall). The Lockport dolomite, which was named by Hall in 1839 from an exposure at Lockport in Niagara county, is the uppermost formation in the Niagara series of the Clyde and Sodus Bay area. Although the number of exposures, as marked on the geologic map, are numerous, no complete section is available anywhere within the boundaries of the quadrangles. The best outcrops available, with one exception which is found on Sodus creek and was referred to in the discussion of the Rochester shale, are those occurring in the old stone quarries. Unfortunately the sections exposed in these quarries are not thick and give only a few feet of rock for study.

The Lockport is composed for the most part of dolomitic limestone layers, which in places are separated by thin shale partings. In color the dolomitic layers range from a brownish gray to a very dark gray, almost a black. When freshly broken, the rock glistens
and some layers give off an odor of petroleum. Upon being exposed to the atmosphere their layers almost without exception become a dark yellowish brown. For many years the more massive dolomitic layers were used for building stones, and because of their strength and pleasing color were very satisfactory. These same rocks were burned for lime, and in some places the shale partings were mixed with the dolomitic layers and a natural cement was obtained. With the coming of Portland cement both of these industries vanished. At present only a very small amount of rock is quarried, and this is used for roads.

Besides the thick dolomitic layers there are two other types of rock present in the Lockport, the aforementioned thin shale layers, which are jet black and fine grained, and the brownish gray thin-bedded siliceous dolomitic layers found near the base. The last named outcrops on Sodus creek. At that place this part of the Lockport measured over eight feet.

Because of the recent drilling activities near Geneva, the writer has had an opportunity to study the lithology of the Lockport in that section, and although it lies considerably to the south of the Clyde and Sodus Bay area, it gives a more concise picture than is obtainable from the scattered outcrops. At its base in contact with the soft Rochester shale is 14 feet of very dark brown dolomitic limestone, which contains a small percentage of quartz. Overlying this is three feet of hard, very dark gray, fine-grained, thin-bedded dolomite. This is overlain by 27 feet of gray limestone, which contains some dolomite, but has a much lower percentage than the layer beneath. Shale is present in this part of the section and it is believed that the limestone layers are separated by shale partings. Above this part of the Lockport is two feet of hard, dark gray dolomite. The next 70 feet is composed of two parts: the lower 28 feet is a normal limestone with only a trace of dolomite and almost free of shale, the upper 42 feet is more dolomitic and is almost 20 per cent shale. This is overlain by 20 feet of dark gray hard dolomite with very little shale. Appearing above this is another two feet of very hard, dark gray, fine-grained dolomite. The highest portion of the Lockport consists of 19 feet of dark brown dolomite with very little shale. The complete section is given in figure 26, p. 99.

For the most part the gas in this formation was sealed in coral reefs. These reefs are found at various levels ranging from 30 to 114 feet from the top of the Lockport. Some gas has been found in the very basal portion where the dolomite is slightly sandy.
Figure 26  Section of the Lockport in the Geneva gas field

Vernon

DARK BROWN SILICEOUS DOLOMITE.
VERY LITTLE SHALE.

20'

HARD DARK GRAY DOLOMITE.
A LITTLE SHALE.

LOCKPORT

156'

GRAY SLIGHTLY DOLOMITIC LIMESTONE. ALSO 20% SHALE WHICH IS IN THE FORM OF SHALE PARTINGS. THE LIMESTONE LAYERS MASSIVE.

28'

GRAY LIMESTONE.
ONLY TRACE OF DOLOMITE.
A VERY LITTLE SHALE.

26'

HARD DARK GRAY SILICEOUS DOLOMITE.
GRAY LIMESTONE.
SOME DOLOMITE.
SHALE PARTINGS.
LIMESTONE LAYERS MORE MASSIVE.

14'

BROWN SILICEOUS DOLOMITE.

Rochester
Because the outcrops are so scattered and fragmentary it is impos-
sible to determine the thickness of the Lockport in the Clyde and
Sodus Bay area. Fortunately some idea may be obtained from the
drill records. At Clyde the thickness is approximately 150 feet.
Near Junius, which is about half way between Clyde and Geneva,
it is 150 to 155 feet and near Geneva 155 feet. Apparently the
Lockport is fairly consistent in thickness throughout the area under
consideration.

The Lockport, especially in western New York, contains two dis-
 tinct faunas, the normal Lockport consisting mainly of reef-building
corals and crinoids, and the Guelph with a greater and more varied
fauna, composed of cephalopods, corals, gastropods, brachiopods and
trilobites. The normal Lockport fossils, according to Hartnagel
('07, p. 19-26) and Goldring ('31, p. 334-36), represented an indige-
nous fauna which was derived from the Rochester sea. Williams
('19, p. 70) expressed a different view. He believes that the only
part of the Lockport which contains a fauna very closely related
to the Rochester is the Decew beds, which are situated at the base
of the Lockport. These Decew beds, according to the author, rep-
resented reworked Rochester shale. Thus he considers that the
Lockport seas may never have been host to many of the typical
Rochester species.

The Guelph fauna, according to Clarke and Ruedemann ('03,
p. 12-16), occupies two horizons in the Lockport at Shelby, Ontario.
The lowest, 62 feet from the base of the Lockport, is called the Lower
Shelby dolomite. The highest occurs at the very top of the Lock-
port, and is named the Upper Shelby. Hartnagel ('07, p. 19-26)
and Goldring ('23, p. 334-36) offer an explanation for this recur-
ring fauna. They believed that the increased salinity brought the
Guelph, which invaded the area from the west, and which replaced
the normal marine fauna. At first this was only temporary and the
normal marine conditions returned with its Lockport fauna, but later
the increased salinity was permanently established, and the western
Guelph forms held the dominant position until the salinity had
increased to such an extent that even those forms could no longer
live. Then followed the deposition of the rocks, which are included
in the Salina.

Williams ('19, p. 75-76) also considers the Guelph fauna to be
the result of increasing salinity. He does not consider that the
Guelph represents a fauna derived from any new source, but one
which developed in the Lockport depositing area in response to the conditions of increased salinity.

The fauna of the Lockport in the Clyde and Sodus Bay area is not abundant, and so far as the writer was able to learn consists exclusively of corals. The most common species of these are *Favosites favosus*, *Halysites catenularia* and *Cladopora fibrosa*. These corals often are found forming reefs, which as a rule are small, not exceeding three feet in diameter, but occasionally they are much larger. The largest of the reefs found by the writer is located near the site of an old stone quarry, one and three-quarters miles north of the village of Wolcott on Wolcott creek. This reef is 15 inches thick in the thickest part and ten and a quarter inches in the thinnest. It was traced for more than 11 feet up the stream, where it was concealed under the cover of the overlying layers.

All the rocks of the Clyde and Sodus Bay area appear to be of normal Lockport type. Because of the scarcity of the outcrops, however, it was impossible to study the whole section and the Guelph may be present, but covered by till. The cuttings from the wells in the area, and to the south of the area, revealed nothing which could not be considered normal Lockport, but owing to the character of the samples obtained by the cable tool method of drilling and to the lithologic similarity of the Lockport and Guelph, the Guelph could easily escape detection.

In spite of the scant amount of information available on the Lockport in the Clyde and Sodus Bay quadrangles, there is evidence that the Rochester sea did not completely withdraw from the area before the advent of the Lockport depositing conditions. The transitional contact of the Rochester and Lockport has already been described. As stated, this transition is represented by two and one-half feet of strata with Lockport and Rochester layers interbedded. Such a bed can not be interpreted in any way as representing an erosional unconformity. Hartnagel (’07, p. 22) reports a similar contact at Rochester.

**CAYUGAN SERIES**

The term Cayugan was first proposed by Clarke and Schuchert (1900, p. 117) in 1900 to include all the rocks between the top of the Guelph and the top of the Manlius. Although a great many changes have been suggested from time to time, the original definition is now generally accepted. The following table will give the development of the Cayugan series with respect to the rocks of western New York since 1900 (see table 5), (Clarke and Schuchert, 1900,
p. 17), (Chadwick, '08, p. 346-48), (Schuchert, '19, p. 505), (Hart nagel, '12, table II), (Bassler, '15, plate 3), (Ulrich and Bass ler, '23, p. 244), (Williams, '19, p. 72-95), (Alling, '28, p. 21), (Goldring, '31, p. 317).

Salina Group

The term Salina was first introduced by Dana ('64, p. 246) and took the place of the old "Saliferous Group of the Onondaga" of Hall ('39, p. 299) and Vanuxem ('39, p. 249). The latest views of the various authors concerning the Salina are given in table 5.

The Salina in this area is represented by only the Vernon and Camillus. The black Pittsford shale has either pinched out between Pittsford and the Clyde and Sodus Bay area, or it has lost its black color and is thus indistinguishable from the gray shaly limestone layers of the lower Vernon. The formations, which overlie the Camillus (see table 5) once covered the area, but have since been stripped from the surface by erosion. In fact, more than 100 feet from the upper part of the Camillus itself has been removed.

Vernon shale (Clarke) and Camillus shale (Clarke). The Vernon and Camillus shales were named by John M. Clarke ('03, p. 17-18), the Vernon from an exposure at the town of Vernon, Oneida county, and the Camillus from an outcrop near the town of Camillus, Onondaga county. Since it is impossible to find any outcrops which would give any indication of where one might draw a boundary between the Vernon and the Camillus in the Clyde and Sodus Bay area, they are treated together.

Because of the soft nature of the rocks belonging to the Vernon and Camillus there are very few outcrops. In fact, the writer was able to find only two exposures of the rock which because of their stratigraphic position should be considered Vernon. The outcrops of Camillus were found to be more plentiful but even these consisted of only a few feet of badly weathered shale. The best outcrop is on Canandaigua outlet near the small settlement of Alloway. This and all the others are marked on the geologic map.

Since the outcrops of the Vernon and Camillus are so few and poorly preserved, the writer was forced to obtain most of his information concerning their lithology from the gas wells two miles north of Geneva. In this field the two formations may be divided easily into four parts. In contact with the Lockport is 31 feet of light gray, fine-grained shaly limestone, containing some gypsum. From personal observations and from the samples collected an apparent gradation exists between the dark gray hard dolomitic Lockport
| Table 5 Cayugan of western New York |
and this light gray shaly limestone. This part is followed by 170 feet of soft shale which consists of red, gray, green and mottled layers, but which exhibits a dominance of red layers. Directly overlying this part is 410 feet of soft shale, comprised also of gray, green, red and mottled layers, but the gray and green layers are much more important than the red. Above these layers is 155 feet of fine-grained, dark gray, shaly magnesium limestone with occasional layers of gray and green shale. In this part of the section gypsum-bearing layers are plentiful. The accompanying section gives the detailed stratigraphy (see figure 28).

Water is found at many horizons in the Camillus. In the upper 155-foot limestone section sulphur water is common. In the gray shale section salt water is encountered in great abundance. So much water is found in this gray shale part that the salt may have been dissolved. At least it was impossible to locate the salt horizons. The type of drill used and the method of collecting samples, however, might easily have destroyed the evidence, if salt did exist.

No trace could be found in any well record of any Pittsford shale, which Sarle ('02, p. 1080-180), Ruedemann ('21, p. 205-15), Hartnagel ('07, p. 28-30), and Goldring ('23, p. 337-38) placed at the base of the Vernon. Alling ('28, p. 21, 32-34), however, considers that the Pittsford is a faunal phase of the Vernon and does not have a definite horizon. Chadwick and Ruedemann recognized that there are two horizons, but retained the term Pittsford as a formation.

A glance at the detailed section of the Camillus and Vernon will show that any separation of the Camillus from the Vernon by well cuttings is impossible. The red layers of the supposed Vernon are found interbedded with the gray and green layers. Alling (personal communications), having made a careful petrographical study of these rocks, has suggested that the Vernon and Camillus be used to designate the type of rock and not to have definite stratigraphic significance. The Vernon type would represent a red and green argillaceous type of rock. The Camillus would represent the gray more calcareous type. Since so little is known concerning the fauna of these two formations, and since a separation of the two would depend largely upon lithology, this suggestion appears valid. Certainly the lowest light gray shaly limestone part of the Salina is more like the Camillus than the Vernon. Furthermore, the gray layer found interbedded with the red in the lower part of the section could not be separated on the basis of lithology from the gray layer occurring in the upper half.
Figure 27  Typical outcrop of the Camillus shale in road cut, one and five-eighths miles south of Crusoe
**FIG. 28**

**VERNON-CAMILLUS SECTION FROM THE GAS FIELD AT GENEVA**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>766'</td>
<td><strong>BERTIE WATERLIME</strong></td>
</tr>
<tr>
<td>155'</td>
<td>DARK GRAY SHALY FINE-GRAINED DOLOMITIC LIMESTONE. ROCK GYPSUM PRESENT</td>
</tr>
<tr>
<td>62'</td>
<td><strong>CAMILLUS</strong></td>
</tr>
<tr>
<td>21'</td>
<td>LIMY GRAY SHALE</td>
</tr>
<tr>
<td>15'</td>
<td>GRAY SHALE</td>
</tr>
<tr>
<td>11'</td>
<td>RED SHALE</td>
</tr>
<tr>
<td>58'</td>
<td>GRAY SHALE; GYPSUM. IMPRESSION OF SALT CRYSTAL</td>
</tr>
<tr>
<td>30'</td>
<td>RED SHALE</td>
</tr>
<tr>
<td>6'</td>
<td>GRAY LIMESTONE; GYPSUM PRESENT</td>
</tr>
<tr>
<td>155'</td>
<td><strong>VERNON</strong></td>
</tr>
<tr>
<td>10'</td>
<td>GRAY FINE-GRAINED SHALY LIMESTONE</td>
</tr>
<tr>
<td>59'</td>
<td>RED SHALE</td>
</tr>
<tr>
<td>20'</td>
<td>GRAY SHALE</td>
</tr>
<tr>
<td>13'</td>
<td>RED SHALE</td>
</tr>
<tr>
<td>65'</td>
<td>RED SHALE</td>
</tr>
<tr>
<td>7'</td>
<td>VERY LIGHT RED SHALE</td>
</tr>
<tr>
<td>21'</td>
<td>DEEP RED SHALE</td>
</tr>
<tr>
<td>31'</td>
<td>FINE-GRAINED LIGHT GRAY SHALY LIMESTONE</td>
</tr>
</tbody>
</table>

Figure 28  Vernon-Camillus section from the gas field at Geneva
With the exception of the various Pittsford horizons the fossils are sparse in the Salina of western New York. Ruedemann ('21, p. 205-15), Eaton ('23, p. 111-16), and Alling ('28, p. 32-39) have reported a few species of eurypterids, pelecypods, ostracods, brachiopods, gastropods, and worm burrows. Most of these come from the lower part (Vernon) of the Salina. The only fossils found in the higher or gray part (Camillus) are pelecypods, *Ctenodonta salinen sis*, reported by Ruedemann, and graptolites, *Paleodictyo yata*, reported by Alling. The writer also found in this part of the Salina what is believed to be a new species of pelecypod, which probably belongs to the genus *Modiolopsis*. The outcrop at which this was discovered is located one and three-quarters miles south and slightly east of the settlement of Marengo (see outcrops marked on geologic map). Several fragments were discovered but only one small slab, containing six well preserved pelecypods, was unearthed. It is possible that more may be obtained at the same exposure.

**HISTORICAL GEOLOGY**

The historical geology of the Clyde and Sodus Bay quadrangles may be described under the following divisions:

The Precambrian history, which deals with the oldest rocks in the State

The pre-Silurian Paleozoic history, which includes the Cambrian, Ozarkian, Canadian and Ordovician periods

The Silurian history, which is largely revealed in the outcropping rocks, described in the preceding chapter

The post-Silurian Paleozoic, which includes the Devonian, Mississippian, Pennsylvanian and Permian periods

The Mesozoic history, which is particularly vague and which can not be divided into periods

The Tertiary history, which includes all of the Cenozoic era until the coming of the first ice sheet

The Quaternary history, which includes the Pleistocene and recent times

**PRECAMBRIAN HISTORY**

The Precambrian history, which is made to include the Archeozoic and Proterozoic, represents more geologic time than all the subsequent eras taken together. Because of the complex nature of the rocks, representing this great time interval, little is known of the events which took place. The oldest rocks which have as yet been
found are highly metamorphosed sedimentary rocks, originally representing very ancient sandstones, limestones, and shales. By their very clastic nature it is conceded that they must have formed from other preexisting rocks, but what or where these were, is not known.

In New York State the Precambrian is found outcropping in the Adirondack region and southeastern New York. The deposits consist of the highly folded, faulted and metamorphosed sedimentary Grenville series which has been shot through by many igneous intrusions. These areas have been discussed by Alling ('18), Berkey ('07, 11), Cushing ('05), Ruedemann ('22, 30) and others.

Since the Grenville series is exposed not only in the Adirondack region and in southeastern New York (the vicinity of New York City), but also to the north of Lake Ontario in the province of Ontario, Canada, it is generally supposed that the rocks of this series underlie the whole of western New York, including the area occupied by the Clyde and Sodus Bay quadrangles. The amount of strata which overlies this Precambrian series in the local area has never been definitely determined, but from the gas wells drilled to the east and west (Newland and Hartnagel, '32, p. 122, 132, 146; and '36, p. 124–25, 127–29, 136) it is supposed that the cover does not exceed 3000 feet in the Sodus Bay quadrangle and probably not more than 4000 feet in the extreme southern part of the Clyde quadrangle.

In the region north of Lake Ontario and east of Lake Huron it has been estimated that the total thickness of the Grenville is 94,000 feet (Van Hise and Leith, '09) of which 50,000 feet is crystalline limestone. If this figure is correct, then the sea in which this 18 miles of sedimentary thickness was deposited, must have existed an inconceivable length of time. To illustrate, Ulrich ('11) estimates that it requires 12,000 years to form a foot of limestone, and there are 50,000 feet of limestone to say nothing of the other sedimentary strata.

The Grenville rocks of New York and southern Ontario are more calcareous than the rocks of the same series farther to the north. The increase of clastic sediment indicates that the source of material was in that direction, and it is thought that the Hudson Bay area probably existed as a land mass at least during part of the Grenville and that much of the clastic material for the ancient sandstones and shales for that series was derived from it.

After deposition the Grenville was subjected to the intense mountain-building processes, folding, faulting and igneous rock intrusions.
In the Adirondack region the sequence, from oldest to youngest, of these intrusions is generally accepted as gneiss, anorthosite, syenite, granite, gabbro and diabase dikes, the dikes occurring near the close of the Precambrian.

The closing phase of the Precambrian was one of widespread erosion. The mountains were gradually being worn away.

**PRE-SILURIAN PALEOZOIC HISTORY**

At the beginning of the Paleozoic the whole of the United States existed as a continental mass. During the Cambrian the seas gradually began to encroach upon the land surface. Practically everywhere the initial deposits of the Cambrian are basal sandstones and conglomerates, which are thought to represent the reworking of continental debris resulting from the long periods of erosion at the close of the Precambrian.

In New York State only the extreme eastern part of the State became submerged during the Cambrian. Western New York must have existed as a land mass throughout the Cambrian and probably contributed some of the clastic material for forming the strata of eastern New York and Vermont.

In the Ozarkian period (Upper Cambrian of authors) New York State finally became completely submerged. The Adirondack region, which existed as an island during much of this period, finally became submerged near the close. In western New York the initial deposit is a basal sandstone, the Potsdam, and is thought to represent the reworked products of a long period of erosion which preceded submergence. Overlying the Potsdam is a series of limestones which appear to indicate normal marine sedimentation.

The Canadian (Lower Ordovician of authors) and Ordovician are periods of general submergence for all parts of New York State except the Adirondack region, which existed as an island mass during most of the time.

The rocks of the Ozarkian, Canadian and Ordovician do not outcrop in the Clyde and Sodus Bay area. Drilling has shown that the rocks of these periods are marine sediments and except for the Potsdam are limestones and shales. For a more complete review of the historical geology of New York State during Cambrian, Ozarkian, Canadian and Ordovician the reader is referred to the writings of Ruedemann ('25, '26, '30), Goldring ('31, '35), Grabau ('21), Schuchert ('24) and Ulrich ('11).
SILURIAN HISTORY

At the beginning of the Silurian period the typical marine conditions of the Ordovician had ceased due to a relative rise of the land surface, and the Queenston, lowest formation of the Medinan series, formed under continental or semicontinental conditions. Grabau ('09, '13) contended that the Queenston was a huge delta deposit. While this formation was being deposited in New York State there was normal marine sedimentation to the west in Ohio and Illinois. The Queenston dital condition existed for a long period of time in the local area, as shown by the presence of 860 feet of that formation. Finally the sea again began encroaching upon the land, and the Grimsby beach sandstone was formed. The advance of the sea was only temporary. During Albion time true marine conditions, which would result in the formation of shale and limestone, never reached as far east as Clyde and Sodus bay, but in the extreme western part of the State marine strata were deposited for a short period (see figure 6, p. 22). Another relative change in elevation of the sea and the land forced the beach (Grimsby ss.) westward, and long before the close of Albion sedimentation the beach condition had migrated to the west beyond the state boundary. Thus the Grimsby (beach ss.) is found overlying the marine strata of the Lower Albion in the extreme western part of the State.

During Clinton times the sea again advanced eastward over the State. The initial deposit of this advance in the local area was the Thorold sandstone. Then followed the shallow water marine condition of the Furnaceville, Reynales and Lower Sodus. Sometimes the water was comparatively free from sediments, and the limestones, such as the Reynales and the "pearly layer" of the Sodus, formed. At other times sediments were more dominant and shales were deposited. At still other the peculiar conditions, so typical of the Clinton of eastern United States, existed, and thin iron ores were laid down.

After the deposition of the Lower Sodus the Clinton sea was forced from the local area. Apparently the strandline moved eastward at this recession. Whether the withdrawal from the State was complete could not be determined.

This withdrawal was only temporary, and the sea soon returned, laying down the deposits which fall within the life range of the Zygobolba decora assemblage of ostracods. Apparently the strandline was moving westward but seemingly never reached the extreme western part of the State. This is shown by the complete absence
of the formations in which *Z. decora* is found at Rochester and to the west of Rochester. In the area under consideration the deposits of this invasion, shale, limestone and iron ore, indicate that the conditions of deposition were very much like those of the initial Clinton sea.

Following the deposition of the Wolcott Furnace iron ore the sea withdrew completely from the State and a period of erosion ensued during which time the lower part of the Middle Clinton was deposited in the states to the south.

During the Middle Clinton the only advance of the sea was into central New York. It is possible that the sea worked westward and deposited a thin veneer of sediment in the Clyde and Sodus Bay area, but if this is true, it was removed before the advent of the Upper Clinton seas.

After the forming of the Sauquoit beds of central New York the sea retreated and the whole State was again subjected to erosion. This period of erosion lasted while the closing phase of the Middle Clinton and the lowermost part of the Upper Clinton were forming in Pennsylvania and Maryland.

After this relatively short period of time the sea readvanced covering all of central and western New York. In the local area the initial deposits of this age resulted in the Williamson, a black and green fissile shale with many graptolites. Conditions gradually changed and the calcareous shaly limestone of the lower Irondequoit was laid down. Sediment became less abundant and the limestone of the upper Irondequoit formed.

Deposition continued unbroken in this part of the State, and the Rochester shale is found overlying the Irondequoit with no break in sedimentation. The Rochester fauna suggests that this uppermost formation of the Clinton was favorable to a varied sea life. The sediment and fauna show also that this like all other Clinton formations, resulted from shallow marine conditions.

In the vicinity of Clinton and to the east evidence tends to show that the strandline started migrating westward before the deposition of the Irondequoit was complete in the local area and the strata equal in age to the Rochester, as far west as Verona, are almost entirely sandstones. At Clinton the Herkimer, which is the eastern equivalent of the Rochester, contains layers which apparently originated as beach deposits.

At the close of the Clinton a slight unconformity at Clinton, N. Y., tends to show that the sea retreated entirely from that area before the advent of the Lockport sea, but in the Clyde, Sodus Bay and Roch-
ester regions the gradational contact bears evidence that the Rochester sea did not completely withdraw from the area.

During the deposition of the Lockport, conditions were more stable than in the Clinton. Dolomite or limestone formed for long periods of time. The fossils of these rocks show that ecology was vastly different and that the fauna itself may have been derived from a different source than the underlying Clinton. The distribution of rock likewise indicates that different areas received sedimentation during this period. The Lockport is found to extend much farther northward into Canada than the Clinton and does not reach so far south as the deposits of the preceding group.

At the close of the Lockport the sea does not seem to have entirely withdrawn from this part of the State. Here the Lockport is found grading upward into a gray shaly Salina limestone (see p. 102). The Lockport sea did lose its direct connection with the ocean, however. The climate became arid with the result that salt and gypsum began forming. After the period of saline deposition the sea withdrew completely and the unstratified typical red Vernon shales were laid down. In this area saline seas and desert conditions alternated throughout the rest of the formation of the Vernon and Camillus.

In the vicinity of Syracuse and to the east the sea completely withdrew after depositing a restricted amount of Lockport, and the continental Vernon sediments began collecting much earlier. Later the Vernon was covered by the more saline Camillus. The Syracuse and eastern region received a greater thickness of Vernon sediments, and the western region a greater thickness of Camillus.

The Camillus is the highest formation which now outcrops in the area, but unquestionably the later formations once existed, and have since been removed by erosion. It may be safely said that the area saw the saline seas of the Camillus gradually freshen and life again began to return. The strata of this transitional period are called the Bertie. The Bertie was followed by a return to normal marine conditions which remained until the close of the Silurian.

In western New York the Silurian closed with a complete elevation of the land surface, and erosion was active. In the region of the Helderbergs sedimentation was continuous and there is no unconformity at the close of the Silurian.

**POST-SILURIAN PALEOZOIC HISTORY**

It certainly seems plausible that a greater part of the Devonian formations were deposited in the Clyde and Sodus Bay area, and possibly marine sedimentation did not cease completely until the
close of that geologic period. All that can be said at the present time is that erosion has removed vast quantities of rock strata. Certainly with the close of the Devonian, which witnessed widespread elevation, marine conditions finally withdrew, and its direct influence was not felt again until late in the Pleistocene, when a small salt water body, an arm of the ocean, occupied the present valley of Lake Ontario for an extremely short period.

With the withdrawal of the sea at the close of the Paleozoic the drainage of the newly formed area started. At first the streams must have been short and flowed into the sea removed only a short distance. The extent of these ancient stream systems is unknown, but since the areas of deposition remained in central United States until the close of the Paleozoic, they must have been insignificant compared with those of Mesozoic time.

MESOZOIC HISTORY

Geologically, the Mesozoic history of the Clyde and Sodus Bay area was comparatively quiet. Erosion continued uninterrupted. The most important event of local interest in this area was the gradual development of the huge river system, which Fairchild ('07, p. 426-27) named the Susqueseneca. According to Fairchild, one branch of this river must have been flowing through the local area, south through the present site of Seneca lake, and thence southward following the course which roughly coincides with the present-day Susquehanna. The Finger Lakes, according to the same authority, were the approximate location of tributaries to the main Susqueseneca system.

In this connection it should be borne in mind that the present-day valleys of the Finger Lakes are not the result of this Mesozoic river system. Those rivers flowed over rocks and excavated gorges which were worn down long before the close of the Mesozoic. The only relation between the courses of those streams and the present valleys is that they flowed in approximately the same locations, and that when later the land was slowly raised they worked their way downward in place. The later rejuvenation accounts for the present depressions.

During this relatively quiet time in eastern United States nothing happened which would hinder the development of a great river system, and the planation of the land to base level with the formation of a peneplain. The local area was probably monotonous, level, relatively low, and possibly swampy at the end of the Mesozoic.
TERTIARY HISTORY

At the close of the Mesozoic the land was reelevated. This uplift gave the southward-flowing streams more impetus, and the work of erosion again began in earnest. According to Fairchild (’04), the present Finger Lakes valleys were excavated during this period. In fact, these valleys were thought by Fairchild to have been excavated to even a greater depth than their present outline suggests, and they were filled in to a considerable degree during the Pleistocene.

The rejuvenated streams during this period found their way through the overlying formation into the soft shales of the Ordovician. Once having been brought to the surface, streams began flowing along the strike of these softer beds. These subsequent streams in western New York are supposed to have united into one river system which flowed through the present Ontario basin, and to have been directly responsible for forming this valley.

This new river, flowing across the softer formations, had a decidedly easier path than the old Susqueseneca system, flowing across the dip of the formation. For this reason the new system, having captured at the very first the headwaters of the Susqueseneca, began eating its way southward by headward erosion capturing more and more streams as time progressed. The authorities do not agree as to how far this process went. Some, of which Fairchild (’04) is the leading exponent, contend that practically the whole drainage of western and central New York was turned northward in response to continuous warping in southeastern United States and as the result of headward erosion of shorter northward flowing streams.

Dollen (’31, p. 20–21), whose work on preglacial drainage is the latest contribution to the subject, concludes that the amount of uplift to the southeast of New York State has been overemphasized. He believes, however, that most of the drainage of the State was diverted northward and that the divide “of the northward and southward flowing streams was farther to the south than it is at present” (see figures 29–30).

The east or west-flowing river in the Ontario basin has received even more attention than the Susqueseneca system. The direction and outlet of this river, which has been called the Ontarian, has been a matter of dispute for many years. Grabau (’01), Upham (1896) and Johnson (’15) held that it flowed west into the Mississippi system. Spencer (1881) and Claypole (1881) held that the direction of flow was east. Dollen (’31, p. 17) (see map, figure 30)
Figure 29: Tertiary obsequent drainage after stream piracy.
Figure 30 Laurentian-Ontarian system immediately before glaciation
concludes that the "main drainage of the region was eastward with its outlet through the St Lawrence river below Ottawa. The main stream had its origin somewhere near the Straits of Mackinac and flowed through the present basin of Lake Huron across a now buried channel to the head of the present Lake Ontario."

**QUATERNARY HISTORY**

In the Pleistocene great continental ice sheets pushed southward over the Clyde and Sodus Bay area. This glaciation upset the well-established drainage system, eroded valleys of its own, and left a huge mantle of glacial debris over the surface. Since the retreat the agents of erosion have been active, but as will be shown in the following chapter their tasks are enormous, and as yet they have made little progress.

**GLACIAL GEOLOGY**

In the Clyde and Sodus Bay area the bedrock is concealed by a mantle of clay, sand, gravel and glacial till, all of which is referable to the late glacial or recent times. These deposits, with the exception of small quantities of a clayey residual soil which was formed by the weathering of exposed rocks, are the products of a moving mass of ice. It is known that several masses or sheets of ice must have pushed their way southward over the area during the Pleistocene (Bowman, '11, p. 465-69), but the evidences of the early sheets were badly mutilated if not completely destroyed by the last great ice sheet, the Wisconsin. The deposits of the Wisconsin, since their deposition, have been subjected to erosion, which in places has greatly modified but not often destroyed the original features. Any map on which all the evidences of glaciation in the Clyde and Sodus Bay area were recorded would not leave a single square mile unmarked.

**DRUMLINS**

The drumlins constitute the most prominent feature of glaciation in this region. Their oval elongated shape with a steep slope to the north and a more gradual slope to the south is evident at once. They range in size from very small hillocks to large hills covering more than two square miles and in many instances reaching the height of more than 100 feet. With few exceptions the axes of these drumlins in this region are directly north and south, indicating that the glacier which formed them was moving due south.

In several places east of Sodus bay, drumlins are cut by the waves of Lake Ontario, exposing excellent cross sections. From these
Figure 31. A small drumlin, 2 miles east of East Bay. Cut by waves of Lake Ontario.
Figure 32 Chimney bluff. Work of waves, rain and wind
Figure 33. Drumlin, Chimney bluff. Lower beds of glacial till resist weathering. Note how stones are supported by only a small part of their surface.
sections a very good idea of their internal structure can be obtained (see figure 33). They are composed of a heterogeneous mixture of boulders, pebbles and clay. The boulders and pebbles are often smoothed and polished. On their polished faces are found scratches or glacial striae. The drumlins show no stratification whatsoever and lack any evidence of water work.

Although stratification is lacking, most of the cross sections, however, show concentric bedding or onion peel structure. In many cases this bedding is amazingly distinct and can be seen for long distances, but because of the size of these drumlins which are cut by the lake and their nearness to the lake no photographs showing this phenomenon were obtained. They are usually four well-defined beds which on closer observation frequently can be subdivided. The lowest layers are always simple in form, flat with slight upward curving at the center of the drumlin. The progressively higher layers become more convex and assume the shape of the drumlin. In some cases these beds are regular in their curving. The accompanying diagramatic cross section of Cline’s bluff, one mile east of Sodus bay, shows this type very well (see figure 34, page 124). In others the beds are irregular and follow the present shape of the hill only in general outline. The drumlin found as an island between the two outlets of Red creek is a good example of the latter (see figure 35, page 125). The lowest bed is flat with the usual upward curve near the center of the drumlin. The second bed, although still following the characteristic shape, has two high points with a depression between them. The third bed has a broad flat top, and the fourth takes the usual semicircular shape. It is as if two drumlins had attempted to form side by side.

The various layers of till can often be distinguished by color alone, as can be seen at Chimney bluff, one mile west of East bay. The lowest bed is a grayish blue. Less well marked divisions can also be made by degree of compactness. In the lowest beds stones, weighing as much as 15 pounds, were held in the bank by a twelfth part of their surface. In the higher beds the rocks need more and more till to support them.

This phenomenon of concentric bedding or onion peel structure seems to be in accord with Fairchild’s (‘29, p. 29–34) latest views on the formation of drumlins. He believes that they are the product of the oscillatory movement of the ice sheet, each successive advance adding to the deposits of the preceding, the small divisions representing minor oscillations within a single major advance.
**FIG. 34**

**DIAGRAM SHOWING INTERNAL STRUCTURE OF DRUMLIN AT CLINE'S BLUFF, ONE MILE EAST OF SODUS BAY ON LAKE ONTARIO**

Figure 34 Diagram showing internal structure of drumlin at Cline's Bluff, one mile east of Sodus Bay on Lake Ontario

**FIG. 35**

**DIAGRAM SHOWING INTERNAL STRUCTURE OF DRUMLIN BETWEEN TWO OUTLETS OF RED CREEK**

Figure 35 Diagram showing internal structure of drumlin between two outlets of Red creek
ROCDRUMLINS

Resembling in many ways true drumlins, the rocdrumlins differ mainly in their length and relatively narrow width. These hills, which are found in the area marked on the glacial map (in pocket), are usually two or three times longer than the average drumlin, while their width is about equal to or less than the average drumlin. As to the material constituting the rocdrumlin, the sides and top, like the ordinary drumlin, are a heterogeneous mixture of till and boulders, but unlike the drumlins, the rocdrumlins have a core of rock.

The rocks underlying the main rocdrumlin area is the Camillus, which is a soft calcareous, gypsiferous shale. Because of the character of this shale, the writer believes that the glacier acted on it as if it were a mass of unconsolidated material. In places the soft rock was gouged out by the advancing fingers of ice. In between these fingers the rock was not subject to violent action, and the glacier tended to deposit some of its clay, boulders and till, which formed a protecting mantle over which the main body of ice could ride with little effect upon the underlying soft rock strata.

There are two main arguments in support of this supposition. First, the hills are long and parallel. Since these long parallel hills represent ridges of till with an underlying rock core, and since the valleys between the hills are also covered with glacial material, then the hills or ridges must have received greater deposition than the valleys between them. Even a casual glance at the topographic map will show that these hills are not the result of postglacial erosion.

The second argument supporting the foregoing supposition is the actual cross section of a rocdrumlin itself. One mile and a quarter northeast of Malcom (shown on the Clyde quadrangle) at the first three corners from that hamlet, the rock core of a rocdrumlin was exposed by a recent road cut. Along the east and west edges the rocks were crumpled, broken and mingled with other glacial material, showing some force must have been exerted on either side of the hill. In the center of the hill the rock strata was unbroken and apparently untouched by glacial action.

NONDRUMLIN AREAS

The distribution of drumlins and rocdrumlins is not at all uniform throughout the quadrangles. There are areas in which neither are present, and to these Fairchild ('07, p. 397) has given the name non-drumlin areas. Their location is shown on the glacial map (in pocket). As shown on this map, there is a band, crossing the quad-
rangles roughly from east to west, in which neither drumlins nor rocdrumlins occur. Another similar area reaches from the center of the Clyde quadrangle south about a half mile west of Clyde to the southern limits of the quadrangle.

There would seem to be only two possible explanations for these nondrumlin areas: either the drumlins were never formed, or having been formed, were destroyed. Fairchild ('07, p. 397–98) favors the former and states, "The lack of drumlins is certainly not due to their destruction." He believes that the drumlins east of Sodus bay along the lake are due to minor readvances of the ice sheet which for some unknown reason did not reach west of the bay. He holds that the other or inland nondrumlin tract may be due to the filling in of a large valley which was below the average level of the surrounding land. The glacier simply filled in this huge trough with debris, and did not deposit sufficient material to bring the level up to the height of the plane at which drumlins could form, and did form in the directly adjoining regions. Fairchild ('07, p. 426–27) uses his Susqueseneca system to produce the depression through the center of the Clyde and Sodus Bay area.

The nondrumlin areas are not confined to the Clyde and Sodus Bay quadrangles, and similar areas are found throughout the New York State drumlin belt. Perhaps the most striking example and one which, because of the magnitude of its scope, is important, is found north of the Ridge road, west of Wallington. In this area drumlins extend as far north as the Ridge road, and many show the cutting and notching of Lake Iroquois. North of the Ridge road or beach of Lake Iroquois only a few poorly developed drumlins exist, and all of these are near the shore of Lake Ontario.

As will be pointed out later in this section, the beach of Lake Iroquois swings southward west of Wallington in the Palmyra quadrangle and continues in a southeasterly direction into the Clyde quadrangle. The nondrumlin area which lies between this beach and the lake also swings southward following the same trend, and connects with the other or inland nondrumlin area. Thus it would seem that the two are in reality only one, and probably have a common origin.

To the writer it seems reasonable that a lake, which remained in existence for a period of sufficient duration to permit the forming of such a well-established beach as Lake Iroquois exhibits, could destroy or at least greatly modify the drumlins which happened to be submerged along its margin. At first it would seem, if this were
true, that there should be no drumlins between the beach of Lake Iroquois and the present Lake Ontario, and that the drumlins occurring east of Sodus bay along the lake shore would refute this argument (see glacial map). It is hoped that the accompanying profiles (see figures 36 and 37, page 128), which show the present elevation southward from Lake Ontario, one through the central nondrumlin area, the other east of this nondrumlin area, will help to explain the presence of these drumlins.

On the profiles (figures 36 and 37) the elevation of Lake Ontario is given as 250 feet. South from the lake the land surface is shown to rise. In the profile through the nondrumlin area, the rise is very gradual, and at Clyde, 15 miles south of the lake, the elevation is only 400 feet. The increase is more rapid in the profile which enters the drumlin area east of Wolcott, and the surface attains an elevation of 465 feet less than eight miles from the lake. The present elevation of Lake Iroquois beach (figure 36) is 465 feet. For the sake of argument Lake Iroquois may be reconstructed with a water level of 465 feet. It is recognized that Lake Iroquois at the time of its existence was not at this elevation and that the land surface has been raised by postglacial uplift. Furthermore it is accepted that this uplift (Fairchild, '16, p. 235-62) increased at the rate of one and nine-tenths feet a mile. Since this uplift is relatively small, however, it can be disregarded in the present consideration.

According to Johnson ('19, p. 55-83) and others, the maximum amount of wave erosion occurs at the margin of land masses. It becomes less important farther from shore and it also decreases with depth. By comparing (see figures 36 and 37) the elevation of the land with that of the reconstructed level of Lake Iroquois it will readily be seen that the zone of maximum wave destruction was between 400 and 465 feet. It will also be noted that the region toward the lake which is occupied by drumlins must have been covered by much deeper water. Furthermore, some of the highest of the drumlins found along the lake shore exhibit flat tops which indicate that they have been planed off by wave action. A very good example of this type of drumlin can be seen at Chimney bluff, one mile east of East bay (see figures 38 and 39, p. 129).

There are other reasons besides the height of the land for believing that the inland nondrumlin area is due to the destruction of the drumlins by water. In the first place, the margins of this area are roughly parallel with the outline of Sodus bay. The whole region bears evidence of being covered by water of which the present numerous swamps and muck lands are remnants. Another interesting
FIG. 36
CROSS PROFILE FROM RED CREEK BAY TO SOUTH BUTLER

Figure 36 Cross profile from Red Creek bay to South Butler

FIG. 37
CROSS PROFILE FROM CHIMNEY BLUFF, .5 MI. WEST OF EAST BAY, TO A POINT 2 MILES WEST OF CLYDE

Figure 37 Cross profile from Chimney bluff, .5 miles west of East bay, to a point two miles west of Clyde
Figure 38 Comparing N—S profile of normal drumlins with those which were submerged in Lake Iroquois

Figure 39 Comparing E—W profile of normal drumlins with those which were submerged in Lake Iroquois
feature which adds to the evidence that Lake Iroquois did extend south into this nondrumlin area is the two semimutilated drumlins, one-half mile north of the village of Rose. As can be seen by their notched surface these drumlins, which at one time must have been large, received the attack of the waves on their northern ends and were worn back. The material eroded from them was used to construct the off-shore bars which are found to the east and south. After their formation these bars (see glacial map) must have partly protected the drumlins inclosed by them and prevented their further destruction. The bars themselves, plentiful in this nondrumlin area, also testify to the existence of Lake Iroquois in the region. Their structure will be discussed later in this report.

GLACIAL LAKES

A series of glacial lakes, at successively lower levels, existed as the front of the waning glacier retreated northward. These lakes had outlets at different times through the Susquehanna, through the Mississippi and through the Mohawk-Hudson. Many of these lakes do not have a direct bearing on the Clyde and Sodus Bay quadrangles, since these quadrangles were still covered by ice at the time of their existence.

The earliest of these lakes which is of local interest is Lake Montezuma (Fairchild, '19, p. 12-13). This lake existed when the ice sheet was still in the northern part of the Clyde quadrangle. It filled the valley of Cayuga Lake and its northern extension, the Montezuma marsh. Through channels leading east from Fairport, past Palmyra, Newark, Lyons and Clyde it received the outflow of Lake Dawson, which was then situated in the Genesee valley near Rochester. Lake Montezuma found its outlet during this stage through the valley now occupied by the Seneca river into Lake Iroquois, which at that time was only a small lake extending from Syracuse to Rome. Lake Iroquois, then as in its later stages, poured its water into the Mohawk and thence into the Hudson (Fairchild, '19, p. 12-13, '95, p. 53-74, and '13, p. 133-62).

As the glacier retreated still farther northward, the waters of Lake Iroquois spread farther to the north and west into the present valley of Lake Ontario. Due to this spreading, Lake Dawson in the Rochester area lost its identity and became a part of Lake Iroquois. At that time Lake Montezuma found an outlet to the north directly into Lake Iroquois. Lake Montezuma, however, as will be shown later, did not lose its identity as completely as Lake Dawson.
Figure 40  South Sodus, beach of Lake Iroquois
It was a distinct lake connected to Lake Iroquois by numerous channels.

Unlike the preceding glacial lakes, Lake Iroquois existed for a long period of time, building beaches and bars which are easily recognized at the present time. West of the village of Sodus the beach of this lake parallels or coincides with the present Ridge road (U. S. Route No. 102), and is well known even to the layman. At Sodus the beach leaves the Ridge road and swings southward into the vicinity of Sodus Center, thence in a southeasterly direction to South Sodus where it enters the Clyde and Sodus Bay quadrangles. The location of this beach throughout the two quadrangles is indicated on the glacial map (in pocket). Its position, as usual, is indicated by the wave-cut land surface. Four of the best examples are found (1) south of South Sodus, (2) northwest of Wayne Center, (3) the two prominently notched hills north of Rose, and (4) west of Butler. Next in importance to the notched land surface in testifying to the existence of this former lake are the sandbars and off-shore bars. These are shown as dotted areas on the glacial map.

Like Lake Ontario, Lake Iroquois had bays and indentations along its shore. In the Clyde and Sodus Bay quadrangles the most notable indentation was one which occupied the triangular area south and west of Rose, and south and east of Wayne Center to the southern limits of the area under discussion. To this indentation the writer has given the name Clyde bay. Its exact location is shown on the glacial map. In many ways this bay resembles the present Sodus bay. It assumes roughly the same shape, and apparently was partly cut off by sandbars from Lake Iroquois, as Sodus bay is from Lake Ontario. Since the same forces which worked to form the sandbars in Sodus bay were active in Clyde bay, this is to be expected.

A much smaller but interesting indentation in the beach of Lake Iroquois is found southeast of Wolcott. This bay, like the present day East bay, was completely cut off from Lake Iroquois by a sandbar. Even today this sandbar, which incidently is used as a road-bed, is successfully holding back water, and its inside margin is marked by low swampy land.

The sandbars and off-shore bars are made up of water-laid stratified material. In some places they are being utilized as sources of gravel. The cuts made in them reveal their internal structure. One of the best places for observing this phenomenon is in the gravel pit just north of the village of Rose (see figure 43, p. 137).

While Lake Iroquois was occupying the Sodus Bay quadrangle and the northern part of the Clyde quadrangle, the Finger Lakes
valleys were filled with bodies of water. These lakes were much larger than they are at the present time, their valleys having since been filled in by stream deposits and vegetation. One of these Finger Lakes reached into the Clyde and Sodus Bay areas. This was the lake occupying the present Cayuga Lake valley. The present extent of that old lake is marked by the Montezuma marsh, and its northern extension in the Clyde and Sodus Bay quadrangles, Tam- arac swamp. To this lake, as already pointed out, Fairchild ('19, p. 39) has given the name Lake Montezuma. Lake Montezuma must have had at least two direct connections with Lake Iroquois across the Clyde and Sodus Bay area. One of these, as shown on the glacial map, was located east of West Butler, the other west and south of West Butler. If the present elevation of the land is a correct guide, these two may have been the main outlets for Lake Montezuma. Indications are that it also had a less well defined outlet in the Weedsport quadrangle.

The evidence supporting Lake Montezuma is much the same and as forceful as the evidence supporting Lake Iroquois. The drumlin and rocdrumlin area to the south of the village of Savannah is cut and notched by wave action. The level of the terrace thus produced is 438 feet. East of Wolcott (see glacial map) the level of Lake Iroquois beach is 465 feet. Postglacial uplift, according to Fairchild ('16, p. 235-62), would certainly account for this difference. Thus it would seem that the level of Lakes Montezuma and Iroquois must have been approximately the same, and a direct outlet near-by must be assumed.

By no stretch of the imagination can the present insignificant streams which flow through these swampy former outlets of Lake Montezuma be attributed with eroding such wide channels. At present no erosion is taking place, and vegetation, plus what little the stream from the surrounding hills bring down, is filling in these channels.

Lake Iroquois and its associated bodies became extinct when the ice front had receded from the present Ontario valley and when northern New York was completely uncovered. The land, because of the heavy crushing weight of the preceding ice sheet, was much lower than it is at the present time. During this stage sea level water flooded up the Hudson-Champlain valley and down the St Lawrence to the Ontario valley. The new and lower outlet caused the water level in the Ontario basin to fall. To this sea level phase Fairchild ('16a, p. 235-62) has given the name Gilbert's gulf.
West of Rose. Off-shore bar. Road runs almost along top of off-shore bar. Note how land slopes away from bar on either side.
Figure 42 West of Rose. Internal structure of off-shore bar shown in figure 41.
Figure 43  Internal structure of off-shore bar. Note the cross bedding
Because the level of Gilbert’s gulf was lower than Lake Ontario, which followed it, the beaches and bars of this body of water are concealed by the present lake. For this reason no direct evidence of its existence can be found in the local area.

The extinction of Gilbert’s gulf was due to two causes. First, the slow rising of the land after the glacial recession, called post-glacial uplift (Fairchild, '07, p. 712–18), forced the marine waters on the Champlain-Hudson region. Simultaneously the glacier finally withdrew from the lower St Lawrence valley, and the Ontario basin found a more direct outlet to the ocean. When the St Lawrence became the outlet, the present Lake Ontario came into being.

**DELTAS**

Aside from sandbars and off-shore bars there was apparently one other type of deposit forming in the glacial lakes, and this was the deltas. Four well-defined deltas were recognized in working the Clyde and Sodus Bay quadrangles. They are located (1) one and one-half miles south of the village of Wolcott on the road to West Butler, (2) two miles northeast of Angels Corners, (3) just west of the village of Clyde, and (4) two and one-quarter miles southeast of Wayne Center. The exact location of these is shown on the glacial map (in pocket). These deposits are roughly circular in outline and were formed at the outlet of former stream channels. They consist of roughly stratified material, and although not so well sorted as the sandbars, they evidently were laid down by water. A cut in the one located two and one-quarter miles southeast of Wayne Center gives an excellent opportunity for studying their internal structure.

Besides the four deltas located on the glacial map, Fairchild ('06, p. 19–23) has described three others within the limits of the Clyde quadrangle. All three of these are near Lyons, (1) to the north within the village limits, (2) on the south side of the main line of the New York Central railroad, and (3) southeast of the village near the junction of the New York Central and Pennsylvania railroads.

**MUCK LANDS**

Another type of glacial and recent deposit, and one which, because of its economic importance, is of vital interest to the inhabitants of the area, is the muck lands. These areas are the direct result of glacial lakes, and many of them represent the last remnants of Lake Iroquois and Lake Montezuma. As the lake receded, the water slowly
drained from the area. Undrainable portions of the old lake beds were gradually filled in by plant remains, until the present muck lands were produced.

So numerous are the muck lands that no attempt will be made to describe all of them. One of the larger muck areas is about a mile east of Rose. This muck land (see glacial map) formed in a body of water, whose northern outlet was blocked by an old sandbar. Of course not all the muck lands were shut off by sandbars and their normal drainage thus blocked, but another example of this type is found on the road leading southeast from Wolcott. Sometimes simply the irregularity of the bed of Lake Iroquois resulted in the formation of muck lands. This appears to explain the muck land lying one mile west of the first four corners south of North Rose.

ECONOMIC GEOLOGY

Under the conditions existing at present the mineral resources of the Clyde and Sodus Bay quadrangles, with the exception of the ground water resources, which are discussed under a separate heading, are of small economic importance. Their exploitation in the past, however, is of historic interest and thus worthy of consideration.

In discussing the economic geology of these two quadrangles the resources will be considered under three headings: (1) metalliferous deposits, of which only iron ores are of any significance, (2) the non-metalliferous deposits consisting of gravel, building stones, lime, gypsum and salt, (3) the petroliferous deposits, of which natural gas is the only important one.

METALLIFEROUS DEPOSITS

Lead Ore

As already pointed out in discussing the Irondequoit limestone, it is barely possible that this limestone furnished the lead which the Indians are reported to have sold to the first white settlers (see page 79). Whether the Indians ever obtained lead from the rocks in this vicinity is in itself questionable. Many of the oldest residents in the quadrangles have told the same story or a version of this story, but like so many other legendary tales, its accuracy is questionable. In the first place, it is doubtful if the Indians knew enough concerning metallurgy to admit of the refining of the lead sulphide, galena. In the second place, if this mineral occurred even in
restricted amounts, it would have been found and worked by the white settlers themselves, and there are no records of any such workings.

Iron Ore

Unlike the minerals of lead, the minerals of iron are very common in the rocks of the Clyde and Sodus Bay quadrangles. In order of their distribution the prevalent minerals of iron are: (1) pyrite, (2) limonite, (3) hematite, (4) siderite and (5) magnetite.

Pyrite occurs disseminated through every formation in the area. Only in the Williamson shale is pyrite found in layers, and even in that formation the individual layers are exceedingly thin. Pyrite is usually present in tiny cubes, which are bright yellow in color. It is often referred to as fool's gold. The composition of pyrite is 46.7 per cent iron and 53.3 per cent sulphur. Because it is so scattered through the rocks this mineral has never been and probably will never be of any commercial importance in the area under consideration.

Limonite is another very common mineral of iron. This mineral, which is a dirty yellowish brown or rust color, also is found in many formations, and is particularly common in the Sodus shale, the Wolcott limestone, the Williamson shale and the Irondequoit limestone. Limonite found in these rocks has no definite crystal structure, and is always a secondary product, due to the oxidizing of some earlier iron-bearing mineral. When the Wolcott or Irondequoit limestones have not been subjected to weathering the layers are often clear crystalline, but when long exposed to atmospheric conditions, the pyrite oxidizes to limonite and gives the rock a dirty, rusty appearance. Limonite in the pure state consists of 59.9 per cent iron, 25.7 per cent oxygen and 14.4 per cent water. Like pyrite, this mineral is too widely disseminated to be of any commercial importance.

Hematite, although not so widely distributed as the two preceding minerals, is present in considerable quantities in two formations, the Wolcott Furnace iron ore and the Furnaceville iron ore. It is also sparingly present in the Wolcott and Reynales limestones. Hematite is a blood red mineral occurring in two forms, either as an irregular replacement of some preexisting structure such as a fossil, or as round beadlike objects called oölites. In some instances the oölites are perfect spheres, in others they are flattened. No individual oölite was found exceeding three millimeters in diameter, and the average diameter was about one and one-half millimeters. Hematite when pure is 70 per cent iron and 30 per cent oxygen. This
mineral was the source of all the iron formerly mined in the quadrangles.

Siderite is much less common than any of the preceding minerals. It has been positively identified in the Furnaceville iron ore, the Wolcott Furnace iron ore, the Wolcott limestone, and in some of the thin limestone layers in the Williamson. In the area siderite has been recognized only in the crystalline form. The crystals are principally simple rhombohedrons. Usually these rhombohedrons are only a few millimeters on a side, but a few crystals measuring more than an inch on a face were found. Siderite of the Clyde and Sodus Bay area is light brown, often semitransparent. The pure siderite has 48.3 per cent iron, 13.8 per cent oxygen, and 37.9 per cent carbon dioxide. It is not sufficiently concentrated to be of any commercial value.

As revealed by careful microscopic examination, magnetite is sparingly present in minute grains in all the formations which outcrop in the two quadrangles, but it is only in the Albion near North Wolcott that it is present in such quantities to attract attention megascopically. Magnetite has a black color, and some layers in the Albion have the appearance of being peppered with this mineral. The individual crystals are small and often have an octohedral form. The chemical composition of magnetite is 72.4 per cent iron and 27.6 per cent oxygen. This mineral is of no economic importance in the Clyde and Sodus Bay area.

During the first half of the nineteenth century hematite was mined in two places in the Clyde and Sodus Bay area. One of these places and the best known was at the Wolcott Furnace about two miles north of the village of Wolcott on Wolcott creek. The ore was not only mined here but was also smelted in the charcoal furnace. The first ore was taken out about 1820. The chief product manufactured at the Wolcott Furnace was plough irons. These finished products were hauled to Clyde and shipped on the Erie canal. The grade of the ore was found to be very low, and the actual mining at the furnace did not last more than a few years. Local inhabitants say that the ore was mined continuously for about four years and sporadically for another five years. The furnace did not cease to operate with the shutting down of the local pit. Ore was brought in from neighboring places where the iron content was higher and more constant in composition. The Wolcott Furnace continued to turn out castings at intervals until 1869, when it was shut down permanently. The ruins of the old furnace can still be seen.
The other pit from which iron ore was taken in the Clyde and Sodus Bay areas is situated three miles west and slightly north of the Wolcott Furnace. The pit is located on the small stream which flows into Port bay. It is east of the road locally known as Dutch street. The exact position of the outcrop is shown on the geologic map. The ore taken from here was hauled to the Wolcott Furnace. Although at first the ore promised to be richer in iron than that at the furnace, its content and thickness was so variable that this pit also proved a disappointment. After about one-quarter of an acre was worked over, the pit was finally abandoned.

Both the Wolcott Furnace and Dutch Street pits are in the Wolcott Furnace iron ore formation, but the opening, which furnished the most of the ore for operating the furnace, was in the lower iron ore formation, the Furnaceville. The pit, which is known as the Devoe ore pit, is located to the east of the Clyde and Sodus Bay area in the Oswego quadrangle. In the Devoe pit the ore bed was not only much thicker, but had a higher and more constant iron content. The ore was hauled five and one-half miles by wagon to the Wolcott Furnace. The road over which the ore was hauled is still known to the residents as the Ore road. This road cuts diagonally from the pit and joins the east-west road to the Wolcott Furnace two and one-quarter miles east of that settlement.

The earliest ore mined in the vicinity was taken from the outcrop of the Furnaceville formation on Salmon creek just west of the quadrangles. Mining started several years before the pits at Wolcott Furnace were opened. A small charcoal furnace was built on Salmon creek. The ore was very lean, and, according to Hall 1839, p. 290), the workings and the furnace were both abandoned before 1838.

As already inferred in discussing the various openings, the composition of these ores is extremely variable. The cause of this variation in iron content is largely the result of foreign matter in the ore. Thin layers of unreplaced limestone and partings of shale material serve to dilute the iron in various horizons.

Chemically the ores are similar to the Clinton ores in the Birmingham district. The worked portions run about the same in iron content. The sulphur content is a little higher in the New York State ores, as also is the phosphorus. These are objectionable features, but if the thickness were constant and sufficient, they would not be unsurmountable. The following analyses are given by Newland and Hartnagel ('08, p. 33, 48). Number 1 can be considered
a general analysis of the Clinton ores, and Number 2 is an analysis of the Wolcott Furnace ore pit.

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The only use that has been made of the Clinton iron ores of New York State in the past 20 years is in the manufacturing of paint. During the War of 1812 the practice of using these Clinton iron ores for this purpose was started (Hall, '43, p. 419). At first the ore was hauled by wagon from Ontario to Auburn, where it was crushed. At present a few carloads a year are used for this purpose. The ore now comes entirely from Fruitland in Wayne county and Clinton in Oneida county.

NONMETALLIFEROUS DEPOSITS

Sand and Gravel

Although the nonmetalics, of which sand and gravel are the principal ones in the Clyde and Sodus Bay quadrangles, are of much greater value than the metalics, the quadrangles are not so favored in this respect as are many in the immediate region. A considerable amount of sand and gravel is used for gravel roads each year, and the greater part of this is dug from local pits. Aside from this most of the sand and gravel for construction is brought in from outside areas.

As previously pointed out, a large part of the sand and gravel deposits in the quadrangles are sandbars and the off-shore bars of Lake Iroquois. With few exceptions these deposits are not well sorted and often contain a considerable amount of clay material. Because clay material shrinks and swells under atmospheric changes, it proportionally lowers the quality of the sand and gravel. The recognition of this fact has served to reduce the amount of local sand and gravel employed in construction. On the other hand, sand and gravel with some clayey material makes a better gravel road.
since the clay acts as a binding constituent. Because of this and because of its low price, townships continue to obtain their gravel locally for that type of road building.

The Vandermellon gravel pit, which is in an old Iroquois bar at Rose, has furnished more gravel than any other pit in the area for construction purposes. Although this deposit is similar in origin to many others in the region, it is freer from clayey material and more evenly sized.

The beaches and bars of Lake Ontario, although little worked at present, contain a large potential supply of both sand and gravel. The gravel is used sparingly for local masonry, and sand is utilized by near-by nurseries in preparing seedbeds for growing evergreens. In the past considerable quantities of sand have been shipped from Sodus Point for various purposes.

The excellent quality of the sand and gravel at Five Points and Oaks Corners just to the south of the quadrangles is an important reason why the local deposits are not used more extensively.

Building Stone

When labor costs were low, transportation slow, tedious and relatively costly, and before the advent of Portland cement, local stone was used in large quantities. The favorite stone for building was the ordinary field or glacial stone. The cellar walls and foundations were nearly always laid up of the larger stones or boulders. The great majority of these stones were originally not local rocks but represented the more resistant igneous rocks, such as granite, gneiss, gabbro etc., brought from the Precambrian area of Canada by the glacier and left as erratics by the retreating ice.

Particularly characteristic and picturesque in western New York are the cobblestone houses of which the Clyde and Sodus Bay area can boast of its share. The outer walls of these houses are laid up of small well-rounded glacial stones, locally called cobbles. The cobbles usually average about three inches in diameter and are often slightly elongated, being elipsoids rather than spheres. The stones, which were selected, are remarkably uniform in size and shape, and vary only in color and texture. The labor of collecting, hauling and laying these stones must have been great, but the uniqueness and beauty of these houses when kept in repair can not, according to the writer's feelings, be overemphasized. Like the stones employed in constructing cellar walls, these are also glacial in origin. They apparently were rounded by the ice while being transported, and further planed and polished by the waters of Lake Iroquois.
Glacial stone is not the only rock which has been used as building material. The Lockport dolomite has also contributed in the construction of foundations, cellar walls, stream and railroad culverts etc. This rock was not quarried so extensively in the Clyde and Sodus Bay quadrangles as in adjoining areas such as the region around Sodus Center in the Palmyra quadrangle, but the narrow band of Lockport dolomite reaching east and west across the quadrangles has no less than five outstanding quarries. The extent of the Lockport dolomite, locally called the Niagara lime, and the location of the old quarries, are shown on the geologic map.

Many of the old quarries furnished stone for building the locks in the Erie canal. Hall ('43, p. 421) mentioned three of these quarries which were operating in 1843 and which contributed rocks for the construction of the canal locks. Two of these were in the township of Butler, and one in the township of Rose. He referred particularly to the high quality of the rock from Roe's quarry, located south of the village of Wolcott on Wolcott creek, and from Utoe's or Miner's quarry, just north of the Central High School at North Rose.

The last real boom in the Lockport quarries of this district was during the period of the construction of the R. W. and O. Railroad (Ontario Division of the New York Central). The stone was used for the construction of railroad culverts.

The Albion never furnished a great amount of building stone in the area. Two quarries were worked for a short time near North Wolcott. One was located on Little Red creek at the settlement of North Wolcott, the other just to the east of the same settlement on another small creek. Both are located on the geologic map. The Albion at these two old quarries is not particularly fitted for building purposes. The rock is irregularly bedded and contains many useless thin-bedded sandstones and shale layers. The rock from these quarries was used in constructing the sides of the charcoal furnace at Wolcott Furnace. The stone was suitable for side walls but when used for the hearth where it was subjected to great heat, Hall ('43, p. 420) reports that the stone by some peculiar property contracted when heated instead of expanding. The contraction caused the temp stone (which is the same as the keystone in an arch) to drop out.

Although never extensively used, some fossiliferous layers in the Rochester shale were quarried, mainly as hearthstones, in the days when fireplaces served other than ornamental purposes. The stone
appears to have been able to withstand the changes in temperature very well. The only known quarry of this stone was located on Sodus creek (Glenmark creek) at the small settlement of Glenmark.

The Wolcott limestone furnished some stone for road culverts in the town of Huron. According to a couple of old pathmasters of Huron township, some of the stone was obtained from the Wolcott limestone outcrop on Mudge creek. Some was also taken from the outcrop on Second creek. Hall (p. 420) in 1843 mentioned the quarry on Second creek and said that some of the stone acquired from that place was employed as a marble and used for ornamental purposes. Some layers of the Wolcott are composed entirely of large shells and would unquestionably make a beautiful polished stone. Unfortunately there is only a small portion of this comparatively thin formation which could be so utilized, and the cost of quarrying is prohibitive under existing conditions.

Unlike building stone, the crushed stone industry is comparatively a modern business, and the demand has steadily increased and markedly so with the coming of cement highways. In the past crushed stone, which was used as part of the base in the construction of the gravel roads in local townships, was made from glacial stones picked from the field and gladly donated by the farmers. With the introduction of macadam and cement roads, as town highways, freshly quarried crushed stone has been increasing in favor. The fresh stone crumbles less, gives better underdrainage, and naturally lasts much longer. Although some of the stone has been quarried from the old Lockport pits, most towns find that it is cheaper to buy a better grade of stone than they can quarry and crush from the local pits. A large portion of the stone for the roads of this area is obtained from the quarries at Oaks Corners in the Phelps quadrangle. Another large contribution is the Lockport dolomite near Rochester.

Lime

The quicklime industry in western New York is another business which passed with the advent of Portland cement. Many of the old Lockport quarries were equipped for the manufacturing of lime. The two best known lime kilns within the quadrangles were located about one and one-half miles northeast of Wayne county and three miles south of Wolcott on Wolcott creek. The ruins of the old kilns can still be seen at these places. Although dark in color, the Lockport is reported to have produced a good quality of white lime.
Salt

The Camillus shale is the parent rock for all salt mined in New York State. The salt occurs in the lower part of this formation, and unfortunately this salt-producing portion of the Camillus outcrops in the southern part of the two quadrangles. The action of surface waters on this easily soluble substance has long since removed any commercial salt that may have existed. Enough salt still remains in the beds, however, to be the bane of many farmers’ existence. It is because of the salt still remaining in the Camillus that many wells in the southern part of the Clyde and Sodus Bay quadrangles produce worthless salt water and force the local inhabitants to obtain their water solely from the glacial till.

Before the salt industry became established at more favored localities some salt was manufactured in this area. A large salt water spring southwest of Savannah in lot 54 of that township was once used. The company which operated it was known as the Galen Salt Works. How long salt was produced from this spring is not known. None of the oldest inhabitants could answer that question, but several had ancestors who had told them about the operation. The works were finally abandoned about 1815.

Knowing that salt water was found in many wells in the immediate vicinity at Clyde, a group of the local citizens tried to drill a brine well there in 1837. They found salt water, but the brine was neither sufficiently concentrated nor the volume great enough to make the manufacture of salt profitable.

A futile attempt was made to utilize the salt springs of the Medina. Hall ('43, p. 417) reports that the salt springs north of Wolcott Furnace were used during the War of 1812. He further reports that the salt produced from these springs was a poor quality and red in color. Certainly the salt water in the Medina will never be used as a source of sodium chloride as long as the huge deposits in the Camillus exist, and evidence seems to support the conclusion that these deposits under existing conditions are for all practical purposes inexhaustible.

Gypsum

Like salt, commercial gypsum is confined to the Camillus shale. Gypsum has been known to exist in the southern part of the quadrangles for more than 125 years. Never has anything approaching a sufficient concentration to warrant exploitation been discovered and it is highly doubtful if any ever will be brought to light in this area. The gypsum deposits which are successfully worked in Ontario,
Monroe, Genesee and Erie counties are all in the upper third of the Camillus formation, which outcrops south of the southern limits of the area under consideration.

PETROLIFEROUS DEPOSITS

Because of the recent activity in this field the subject is of immediate interest. No oil has ever been found in sufficient quantity even to stir the imagination. Gas, on the other hand, is found in practically every well drilled to a depth of 500 feet or more. Never has it been found in commercial quantities, but the huge pockets often encountered are of such magnitude that they seem to indicate a vast wealth of this natural resource. The fact that these pockets are soon exhausted does not at first dampen the ardor of the wild-catters. They are always looking for the huge supply which they believe must exist somewhere in the close proximity.

History of Activity

Eleven wells have been drilled and have exploded any theory that gas might exist in the Clyde and Sodus Bay quadrangles in commercial quantities. The first two wells were finished more than 50 years ago. In October 1887 a well was completed in the Trenton in the Wolcott gorge within the limits of Wolcott village. It reached a total depth of 2700 feet. Two strong shows of gas were encountered in the Trenton. When these two shows were first struck, they appeared to be of commercial importance, but in both instances long before the well could be shut in the volume had dwindled so far as to discourage any utilization. Like many Trenton wells in this State, gas in insignificant amounts has continued to seep from this well ever since its completion, and even today with some care the well can be lighted. In the latter part of November of the same year a well was completed in the village of Clyde. It reached a total depth of 1792 feet. A small amount of gas was found in the Lockport dolomite. Below this formation the well proved void of any shows, and it was abandoned while still in the Queenston shale.

Eleven years elapsed before the next attempt was made. In 1899 a well was put down near Alloway. After attaining a total depth of 2365 feet, it was completed in the Oswego sandstone. The only gas encountered was a small show in the Lockport dolomite.

With the completion and failure of the Alloway well, no attempt was made to test the area for gas until December 6, 1932, when the
Welch No. 1, whose location is shown on the accompanying sketch map, was spudded. The well was completed May 23, 1933, at a total depth of 2740 feet. It is reported to have found gas at 2733 feet. The volume of this gas was variously estimated from three million to ten million cubic feet a day at the time of the strike. The flow of gas decreased rapidly and a measured flow showed the well to be making only 600,000 cubic feet a day after completion. This alone should have been considered as a bad feature. Furthermore, the action of the rock pressure showed that no great supply of gas existed. The pressure was approximately 400 pounds when the well was finished. On June 1st it was 790 pounds a square inch; on June 6th, 1100 pounds; on June 26th, 1660 pounds; and on July 11th an official test gave the pressure as 1900 pounds. This slow rise in pressure showed that in blowing open one day, the well had so depleted the gas in the vicinity of the well that it required two months to allow the gas to seep back into the depleted area.

The next well to be completed was the Harper No. 1. This well, although only a few yards from the Welch No. 1, passed through an unproductive area in the Trenton and was abandoned at 3400 feet.

The Harper No. 2, also drilled much too close to either the Welch No. 1 or Harper No. 1, was the next completion. At 2727 feet and in the Trenton a small-sized gas pocket, the open flow of which was estimated at one-half million cubic feet, was found. Within a day the flow of this well had also greatly decreased, so much so that the well was deepened to 2865 feet, but no further supply of gas was found.

The Noble well was next completed. Unlike the preceding wells, this well was not drilled too near the other three, being placed one-quarter of a mile to the south. The well was drilled to 3140 feet, and did not encounter more than the two very small shows in the Trenton.

Again returning to the close drilling which marked the procedure in drilling the first three wells, the Welch No. 2 was then drilled a few rods from the Welch No. 1. The total depth of this well was 2770 feet. Gas was encountered at 2735 feet. At the time of the strike this well made two and one-half to three million cubic feet a day, but soon decreased to an almost unmeasurable amount.

In the meantime gas was being used from the Welch No. 1 to drill some of the near-by wells and particularly the Welch No. 2. The gas that was used in these operations was lowering the pressure and volume at a very alarming rate. When the gas was encountered at
the same horizon in the Welch No. 2, the pressure and volume of the Welch No. 1 was completely destroyed, and the pressure of both wells on February 23, 1934, was only 30 pounds. In other words, the blowing of these two wells into the atmosphere for a very short time had depleted that part of the Trenton to the point where no gas could be produced commercially.

In March 1934 the Ely well, only a few hundred feet from the Welch No. 1 and No. 2, was finished at 2961 feet. No gas was encountered in the twenty-seven hundreds, but a considerable pocket was found at 2950 feet. The initial flow was placed at two million cubic feet. Before this well could be shut in, it also had dropped to such a point that it could not be gauged by ordinary methods.

The Harper No. 3 was the last well finished in the small huddle around the Welch No. 1. Completed in the latter part of March 1934, the well struck gas at 2722 feet. The initial flow of this well was estimated between four and five million cubic feet. It threw pieces of rock and mud high above the derrick. Three or four hours after the strike the well would not gauge more than three hundred thousand, and upon being left open for a day, it further decreased to only a few thousand.

The folly of any further wells in the immediate vicinity of those already completed being finally recognized, the final well in the area was drilled one and one-half miles northeast of the Welch No. 1. The final depth of this well was slightly in excess of 2670 feet. At 2670 feet the drill pierced a gas pocket and the well (Arnold) was reported to have made five million cubic feet. A short time after the strike the well became ignited and burned down the drilling rig. Because the open flow dwindled so rapidly the fire was easily put out by the use of chemicals. The well was then shut in, and the pressure was found to be 60 pounds. A new rig was built and the well drilled a few feet deeper, but without success.

Geology

The recent Clyde wells have furnished a wealth of information concerning the subsurface stratigraphy of the Clyde and Sodus Bay quadrangles. This information has been summarized in the log which immediately follows and in the table of the following page. The log is not the log of any specific well, but the information was derived from several.
### Generalized Log of the Clyde Area

#### Age
- Pleistocene and Recent

#### Formation
- Till, sand and gravel

#### Thickness
- 0–40'

#### Silurian System

<table>
<thead>
<tr>
<th>Age</th>
<th>Formation</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salinian</td>
<td>Camillus shale</td>
<td>95'-185'</td>
</tr>
<tr>
<td></td>
<td>Vernon shale and shaly limestone</td>
<td>170'</td>
</tr>
<tr>
<td>Lockport</td>
<td>Lockport dolomite</td>
<td>155'</td>
</tr>
<tr>
<td>Clinton</td>
<td>Rochester calcareous shale</td>
<td>137'</td>
</tr>
<tr>
<td></td>
<td>Irondequoit limestone and shale, and Williamson shale</td>
<td>60'</td>
</tr>
<tr>
<td></td>
<td>Wolcott Furnace iron ore</td>
<td>Trace</td>
</tr>
<tr>
<td></td>
<td>Wolcott limestone</td>
<td>22'</td>
</tr>
<tr>
<td></td>
<td>Upper Sodus shale and Lower Sodus shale</td>
<td>58'</td>
</tr>
<tr>
<td></td>
<td>Reynales limestone</td>
<td>15'</td>
</tr>
<tr>
<td></td>
<td>Furnaceville iron ore</td>
<td>Trace</td>
</tr>
<tr>
<td></td>
<td>Thorold sandstone</td>
<td>5'</td>
</tr>
<tr>
<td>Albion</td>
<td>Grimsby</td>
<td>70'</td>
</tr>
<tr>
<td>Richmond</td>
<td>Queenston</td>
<td>860'</td>
</tr>
</tbody>
</table>

#### Ordovician System

<table>
<thead>
<tr>
<th>Age</th>
<th>Formation</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oswego</td>
<td>Oswego sandstone</td>
<td>195'</td>
</tr>
<tr>
<td>Lorraine</td>
<td>Pulaski shale, Frankfort shale, and Utica shale</td>
<td>655'</td>
</tr>
<tr>
<td>Utica</td>
<td>Trenton shaly limestone</td>
<td></td>
</tr>
<tr>
<td>Trenton</td>
<td>Trenton shaly limestone</td>
<td></td>
</tr>
<tr>
<td>Black River Beds</td>
<td>Watertown limestone, Leray limestone, and Lowville limestone</td>
<td>145'-820'</td>
</tr>
</tbody>
</table>

Total ........................................................................................................... 3447'

In the preceding log no attempt was made to separate the true Trenton from the underlying limestones. The task of making such a separation would require the attention of one very familiar with that part of the stratigraphic column, and probably could not be accurately determined unless that person were present and could work with the drillers. It might possibly be accomplished by a very complete set of well samples and by the careful study of the microfauna.

As can be seen by the table on page 153, almost all of the gas is found in the upper third of the lower limestone series. Because of this and because there is no work which definitely shows otherwise, the gas-bearing strata will be referred to as the Trenton.

Gas in the Trenton is not contained in definite layers, or reservoir strata, but is apparently confined to small cavities or openings. That the openings are not large is easily proved by the fact that the drills, upon piercing the gas horizon, do not drop into any huge subterranean cavity. The very nature of the rock, as revealed at the out-
<table>
<thead>
<tr>
<th>NAME</th>
<th>PROPERTY</th>
<th>OWNER OF WELL</th>
<th>ELEVATION</th>
<th>TOP OF LOCKPORT</th>
<th>TOP OF GRIMSBY</th>
<th>TOP OF OSWEGO</th>
<th>TOP OF TRENTON</th>
<th>TOTAL DEPTH</th>
<th>GAS AT</th>
<th>INITIAL PRODUCTION</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>WELCH 1</td>
<td>J.O. WELCH FARM</td>
<td>M.C. B.G.K. ROGERS, H.S. HADLEY ET AL.</td>
<td>413'</td>
<td>325'</td>
<td>760'</td>
<td>-</td>
<td>2590'</td>
<td>2740'</td>
<td>SHOW 435' (LOCKPORT) MAIN FLOW 2733</td>
<td>3.5 M.M.</td>
<td>FLOW DECREASED RAPIDLY. 4 MM.WHEN SHUT IN. USED IN HOUSE &amp; DRILLING. COMMERCIAL A FAILURE.</td>
</tr>
<tr>
<td>HARPER 1</td>
<td>R. HARPER FARM</td>
<td>T. BOYCE ET AL.</td>
<td>405'</td>
<td>300'</td>
<td>755'</td>
<td>-</td>
<td>2582'</td>
<td>3400'</td>
<td>SHOW 415' (LOCKPORT) MAIN FLOW 2727</td>
<td>5 M.M.</td>
<td>DRY</td>
</tr>
<tr>
<td>HARPER 2</td>
<td>R. HARPER FARM</td>
<td>T. BOYCE ET AL.</td>
<td>400'</td>
<td>310'</td>
<td>755'</td>
<td>1680'</td>
<td>2579'</td>
<td>2885'</td>
<td>SHOW 440' (LOCKPORT) SHOW 2815'</td>
<td></td>
<td>FLOW DECREASED RAPIDLY. WELL NEVER TUBED. SHUT IN ON Casing. Commercially A Failure.</td>
</tr>
<tr>
<td>NOBLE</td>
<td>CHARLES NOBLE FARM</td>
<td>H.J. HADLEY ET AL.</td>
<td>410'</td>
<td>353'</td>
<td>795'</td>
<td>-</td>
<td>2630'</td>
<td>3150'</td>
<td>SHOW 440' (LOCKPORT) SHOW 2815'</td>
<td></td>
<td>WELL USED IN FARMHOUSE GAS DID NOT HOLD UP FAILURE.</td>
</tr>
<tr>
<td>WELCH 2</td>
<td>J.O. WELCH FARM</td>
<td>H.J. HADLEY ET AL.</td>
<td>410'</td>
<td>300'</td>
<td>760'</td>
<td>-</td>
<td>2592'</td>
<td>2770'</td>
<td>ST. SHOW 2732' WK. SHOW 2745' MAIN FLOW 2751'</td>
<td>1.5 M.M.</td>
<td>FLOW DECREASED RAPIDLY ONLY FEW THOUSAND WHEN FINISHED. COMMERCIALLY A FAILURE.</td>
</tr>
<tr>
<td>ELY</td>
<td>C.D. ELY ESTATE</td>
<td>T. BOYCE ET AL.</td>
<td>415'</td>
<td>770'</td>
<td>1695'</td>
<td>-</td>
<td>2590'</td>
<td>2961'</td>
<td>SHOW 1082' (GRIMSBY) MAIN FLOW 2950</td>
<td>1.5 M.M.</td>
<td>FLOW DECREASED RAPIDLY SHUT IN WITH TUBING FAILURE.</td>
</tr>
<tr>
<td>HARPER 3</td>
<td>R. HARPER FARM</td>
<td>T. BOYCE ET AL.</td>
<td>420'</td>
<td>320'</td>
<td>765'</td>
<td>-</td>
<td>2585'</td>
<td>2771'</td>
<td>GAS 2717' GAS 2722'</td>
<td>4 M.M.</td>
<td>DWINDLED TO ONLY FEW THOUSAND IN A FEW HOURS. FAILURE.</td>
</tr>
<tr>
<td>ARNOLD</td>
<td>ETHEL ARNOLD FARM</td>
<td>COYKEN-DALL ET AL.</td>
<td>461'</td>
<td>320'</td>
<td>760'</td>
<td>1688</td>
<td>2540'</td>
<td>2685'</td>
<td>SHOW 415' (LOCKPORT) SHOW 1748' (OSWEGO) MAIN FLOW 2670'</td>
<td>5 M.</td>
<td>RIG BURNED. GAS DECREASED. FIRE PUT OUT BY CHEMICALS.</td>
</tr>
</tbody>
</table>

Table 6  Records of gas wells in the Clyde area
crop, proves also that such cavities are not likely to occur. The rock contains too much interstratified insoluble constituent to form a cavernous limestone. Furthermore, if the limestone were cavernous and the gas confined to even small irregular but continuous cavities, the gas would immediately rush out and completely drain the opening in a very short time. As a matter of fact, the gas does lose much of its volume in a short time, but it also continues to produce a small amount of gas for a long time.

Careful observation of many Trenton wells during the process of drilling, not only in the Clyde and Sodus Bay areas but also in other areas in New York State, indicates that the following are apparently the conditions under which the gas occurs. Always the drill encounters a hard dense layer immediately above the horizon at which the gas is found. This layer acts as a cap. It may be only two or three feet in thickness, or it may be as much as ten. Once the drill breaks through this cap the gas which has been confined under enormous pressure to the tiny openings, such as bedding planes, joints etc., rushes out with explosive force. The openings which are directly connected with the well are quickly exhausted, but the openings which are imperfectly connected with the outlet, gradually break through and continue to supply a much restricted flow of gas over a long period of time. It is probable that many of these openings originally had no connection whatsoever, but when the well drained some of the openings, immediately the equilibrium was destroyed and the differential pressure between the drained and undrained openings became of such magnitude that the small partitions and barriers between the two could not remain unbroken. Thus the gas confined in the openings farther and more distinctly separated from the outlet continues by a slow process to work its way to the outlet.

The nature of the actual gas accumulation in these small openings must remain entirely a matter of conjecture. The fact that the gas is not found except under a dense impervious layer tends to show that these layers acted as a dam preventing the gas from migrating upward. There seem to be two possible explanations why the gas is not always found at the same horizons and under the same impervious layers even in Trenton fields as restricted as the Clyde. In the first place, the impervious layers may not have been everywhere equally effective. On the other hand, even if these impervious layers are equally effective, unless some kind of opening existed in which the gas could be stored, they would be no factor in the accumulation. Of these two conjectures the latter appears only slightly more acceptable.
Figure 44 Sketch map of the Clyde gas field
Although the Welch No. 2 was near the Welch No. 1, it was not any nearer that well than were the Harper No. 1 and No. 2. Neither of the Harper wells affected the Welch No. 1 appreciably, whereas the Welch No. 2 showed every possible indication of having a direct connection with the Welch No. 1, and probably pierced an opening which was continuous. It would seem that a barrier capable of keeping gas in the area of the Welch No. 1 would be active a few yards distant in the proximity of the Harper No. 1. It would be much easier to imagine that no openings existed at the producing horizon in the vicinity of the Harper No. 1.

The gas is not controlled by structural conditions in the Clyde field. The subsea levels on the top of the Trenton show only minor irregularities other than regional dip. The irregularities which do exist can be attributed to errors in measuring the depth to the Trenton in the various wells.

In brief, the recent drilling at Clyde aids in arriving at the following general conclusions: (1) Gas exists in the Trenton. (2) Gas is not held in a reservoir, such as sandstones or porous limestones, but is confined to small openings such as bedding planes, joints etc. (3) Gas is not localized by structure, and often occurs without any reference to structure. (4) Since no factor or factors localize this gas, although it is present in considerable quantities, it is of no commercial value.

Future Possibilities

The future possibilities of gas or oil production in the Clyde and Sodus Bay quadrangles are exceedingly poor. Of the formations which have produced gas and oil in New York State, all except one are missing or too near the surface in this area. Oil in the southern part of the State is contained in rocks of Chemung age. These rocks outcrop many miles south of the area. The Oriskany, which has been the most recent source of profitable gas, also does not reach into the area. The Lockport dolomite, which was the source of some gas in the Geneva area, but which has never produced a profitable commercial supply in New York State, outcrops within the quadrangles, and therefore loses what little value it might have. That portion of the Albion group, the Whirlpool, which has long been the source of commercial gas in western New York State, pinches out before reaching the Clyde and Sodus Bay area (see figure 6, page 22). The only other rock which has ever produced gas is the Trenton. The Trenton has been drilled for a great many years, but has never proved a
very successful producer. It is true that it has furnished a limited supply of gas for two or three communities, but a great deal more money has been lost in drilling Trenton wells than has ever been made in New York State from the sale of gas obtained from that source. The Trenton contains an enormous amount of gas, but it has neither reservoir rock nor suitable structural traps for this gas. No method is known, and it seems unlikely that any will ever be devised, for recovering the gas in a commercial way. None of the rocks underlying the Trenton has absolutely any possibility of producing gas in the Clyde and Sodus Bay quadrangles.

Many of the citizens of the Clyde and Sodus Bay area have learned by bitter experience that local gas wells are poor investments, but, if economic conditions remain the same and natural gas continues to play an important role in our social system, another generation will remember only as children the experiences of their fathers. They will be told that some large company hired the promoters to kill the wells, or that some jealous and angry driller plugged the wells with a cannon ball or some other round object. (These stories or slight variations are used throughout western and central northern New York to explain the failure of any well more than 30 years old.) They will be told of the vast riches made in the oil and gas fields, and finally they will be let in on the greatest opportunity of their lives. Then history will again repeat itself. This may sound like idle prophecy, but it has happened over and over again. In fact, it happened in a moderate way in the very area under discussion. The gas discovered in the old wells was one of the main selling points for the more recent attempts.

The arguments might be offered that none of our great oil fields would have been discovered if corporations or individuals were afraid to invest capital in purely wildcat propositions. There is of course some truth in such statements, but there is no excuse for operations in areas which not only appear geologically unfavorable, but have been proved by actual drilling to be worthless. The only companies attracted to such areas are usually only the wildest promotion and stock-selling outfits. The officials of these companies often have only a very slight acquaintance with the gas and oil industry. They have very little capital with which to operate, and can not spend the necessary capital to investigate the region before drilling. As a consequence they hire not trained geophysicists, petroleum engineers and geologists of integrity, but other promoters who can pose as technical men and whose chief aim is not the finding of favorable drilling sites.
but areas where capital is easy to raise. Their maps can be drawn equally well for any place, and at any time, and require only the ability to use the imagination and the strength to hold the pen.

If the people of the State would learn to investigate such enterprises carefully before investing, much needless waste could be saved and more capital would be available for enterprises about which more is known. The State of New York maintains an excellent geological survey at Albany and this department is always ready to advise the people of the State.
WATER RESOURCES OF THE CLYDE AND SODUS BAY QUADRANGLES

By Bernard H. Dollen

ACKNOWLEDGMENTS

The writer is indebted to the many well owners and well drillers of the area for their generous cooperation in making available information and records. Village officials, water superintendents and health officers cooperated in furnishing the material for the section on Municipal Supplies. C. A. Holmquist, director of the Division of Sanitation, and C. R. Cox, chief of the Bureau of Water Supply, New York State Department of Health, supplied 17 sanitary analyses of representative waters from the area. A. H. Gorsline, of the Rochester and Lake Ontario Water Company, supplied the report of the complete analysis of the Clyde Water Supply. Thanks are due to Professors Harold L. Alling and J. Edward Hoffmeister, of the Department of Geology, University of Rochester, for assistance in reading the manuscript, and to Dr Tracy Gillette for making the arrangements for incorporating this chapter in his report on the Geology of the Clyde and Sodus Bay Quadrangles.

GROUND WATER RESOURCES

Most of the supply of water used in the Clyde and Sodus Bay area is derived from ground water sources. The water is obtained from springs and wells of various depths.

Some of the water is derived from the various horizons in the bedrock formations, and some from the unconsolidated glacial drift overlying the bedrock.

Sources and Occurrence

For a more comprehensive treatment of the occurrence of ground water, see Meinzer (1923).

Most of the water in the outer portions of the earth comes from precipitation. In the Clyde area, where the average annual precipitation is more than 30 inches, more than 500,000,000 gallons of water fall on each square mile during an average year. Part of this water flows directly into the streams, part of it evaporates and the rest sinks into the ground.

The bedrock and the glacial drift are not entirely solid but contain openings or pores which are filled with either liquid or gas. The liquid may be water or oil, and the gaseous material may be air or
natural gas. The pores range in size from microscopic openings to large cavernous openings found in limestone regions where caves occur. In the Clyde and Sodus Bay area the openings in which ground water occurs are of two types: namely, (1) the pore spaces between the grains of sand, gravel and sandstone, and (2) the joint planes, bedding planes and the solution cracks in limestone, sandstone and shale.

The amount of water that can be stored in a rock depends on its porosity; that is, the ratio of pore space to the total volume of the rock. A rock with grains of uniform size is much more porous than a rock composed of grains of various sizes. The permeability of a rock is its capacity for transmitting water under pressure. Some rocks may be well saturated with water, but because of their very fine grained texture have low permeability and yield little or no water to wells drilled in them.

Joint planes and cracks are secondary openings in rocks, produced by stresses which have accumulated until the rocks were fractured. Joint cracks and fissures are generally more numerous near the surface, becoming smaller with depth. Calcareous rocks, such as limestone and dolomite, are soluble in water. Movement of ground water along fractures and bedding planes eventually enlarges these openings.

Joint planes and solution openings not only allow free movement of water but permit the storage of large quantities of water. The occurrence of ground water along joints and in solution cavities is probably responsible for the erroneous impression that all ground water occurs in veins or channels.

Imaginary lines connecting the water levels in a number of adjacent wells form a plane below which the rock or drift is saturated with water. The upper surface of the zone of saturation is the "water table." The water table fluctuates as water is withdrawn from storage or as replenishment from precipitation occurs. In general, the water level in a well located on a hill stands at a higher elevation than that in a well located near the adjacent valley. Figure 45 shows that the water table slopes toward the streams and as a consequence, the movement of ground water is toward the streams. The streams therefore are gaining water from the ground, and are not losing it to the ground. In dry seasons the water table is low because the water is drawn from or is draining out of the ground more quickly than it is being replenished by rainfall.

Artesian conditions exist where ground water is confined under pressure by an overlying impermeable bed. A number of wells in the Clyde and Sodus Bay area encounter water under artesian pressure,
Figure 45: Relation of water table and ground water zones to topography.
and it rises in the well. The rise of water level may be small or it may be great enough to cause the water to flow above the ground surface. In either case, the well is an artesian well. If it flows it is known as an artesian flowing well.

There are a few flowing wells in the Clyde and Sodus Bay region. Two of these flowing wells derive their waters from the Camillus shale. One well at Savannah is 46 feet into the shale; the water flows at the surface and is of good quality. One well at the Noble Vinegar Works, one mile east of Clyde, was drilled 110 feet into the Camillus shale. No water was encountered until the bottom was reached. Water rose to the surface and overflowed. At one time a two-inch stream was pumped day and night for six months, with a drawdown or lowering of water level of only three feet. The water here is not of very good quality.

There are a great number of springs in the area. Springs occur where the water table reaches the land surface. The great swamp areas in the southern and eastern part of the Clyde quadrangle indicate a condition where the water table is above the surface most of the year. All along the edges of these swamps are springs discharging various quantities of water. The headwaters of many of the northward-flowing creeks are fed by springs, and a number of springs are located at the base of drumlins in the central and southern parts of the Clyde quadrangle.

The villages of Wolcott and Savannah obtain their water supplies from springs. These are described in more detail later, pages 170-71. Among the most important springs which are not utilized as village supplies are the following: (1) on the John Mack farm, three miles east of North Rose, which in an undeveloped state yields more than 97,000 gallons daily; (2) on the Green Dairy farm, just west of Wolcott village, which yields about 50,000 gallons daily; (3) at the Carlton Gillette property, one mile north of North Rose, yielding more than 30,000 gallons daily.

**Nature of the Water-bearing Material**

The water-bearing material may be divided into two general classes, the unconsolidated deposits, and the bedrock.

The unconsolidated material in the Clyde and Sodus Bay quadrangles consists almost entirely of glacial drift, with small deposits of muckland in some of the longitudinal north-south valleys. Glacial drift over 80 feet in thickness has not as yet been reported in this area. If the buried Susqueseneca valley connecting Seneca Lake
valley with Sodus Bay valley, as advanced by Professor Fairchild (1925), is located in the western part of the Clyde and Sodus Bay quadrangles, then the valley fill should be much thicker than 80 feet. This valley with its tributaries may be a good source of ground water. The present study, however, has not revealed any data which would be helpful in locating this valley. Future work with geophysical equipment may determine the existence and location of this buried drainage channel.

The water-laid glacial material is fairly well sorted; sand, gravel and clay occur in alternate layers. Some broad delta deposits are located at Lyons, southeast of Lyons and southeast of Clyde. These delta deposits are indicated on the accompanying map. The material composing the beds of glacial Lake Iroquois in the northern part of the Clyde quadrangle and in all of the Sodus Bay quadrangle is well sorted lake sand. The stratified glacial drift is a good source of ground water in the area.

There are many drumlins in the central and southern parts of the Clyde quadrangle, and a few in the northern part and in the Sodus Bay quadrangle, including some now being cut away by the waters of Lake Ontario. The material of the drumlins is unassorted till, and while it contains some water, it is not so productive as the stratified deposits.

About 90 per cent of the wells in the Clyde and Sodus Bay quadrangles are dug and drilled into the unconsolidated glacial drift. The other 10 per cent of the wells are drilled into various layers of the bedrock. The waters of the bedrock layers differ greatly in quantity and quality. In general, in the Clyde and Sodus Bay region, the waters from the bedrock are not so satisfactory as those from the overlying glacial drift.

Sandstone is generally water-bearing although not so much so as glacial sand and gravel. The only sandstone formations in the region are the Medina and Thorold sandstones. These rocks are near the surface only at the extreme northern part of the Sodus Bay quadrangle, a region sparsely settled. Only a few wells were drilled into the Medina; two of these yielded a sufficient supply of potable water for domestic use. One was reported dry and abandoned at 95 feet from the surface (about 70 feet in the Medina). Three others produced water so high in chlorides (salt) that they were not usable. Farther west, especially in Monroe county, the Medina sandstone is known to bear a large amount of water, although the quality varies considerably. There are some brine-bearing lenses in the Medina
there, and very often the water shows a high concentration of chlorides. There were no wells reported from the Thorold sandstone.

Although shales in general are not considered good water-yielding rocks because of the unusual nature of some of the shale formations in the Clyde and Sodus Bay quadrangles a few carry water. The difference in texture and porosity of the Sodus shale due to the presence of the “pearly” limestone layers makes possible the accumulation of some water in this formation. Some wells that entered the Sodus for a short distance may be deriving their water from the contact with the glacial drift just above.

The Rochester shale also contains water-bearing limestone layers near its central part. In the area one mile south of the Ridge road a number of wells end in the Rochester shale and derive a sufficient amount of good water for domestic use. There may be some water at the contact of the Rochester shale and the Lockport dolomite above, but there were no wells reported at this horizon. Since the waters of the Lockport dolomite are of poor quality, there are no wells reported to have been drilled through the Lockport and into the Rochester. If such deep wells were to be drilled, sulphurous water of the Lockport would have to be shut off. The quality of the waters in the Rochester shale at that depth has not been ascertained.

The Vernon shale, where it is not overlain by the Camillus shale, contains some water of potable quality. Several wells in the central part of the Clyde quadrangle, about two to three miles north and northwest of the village of Clyde, struck good water in gray or blue layers 60 to 80 feet below the surface. The thickness of the glacial drift increases toward the east, and enough water is derived from this source to make drilling into the Vernon unnecessary.

There is a large amount of water in various layers of the Camillus shale, but the most of it is of rather poor quality. In the upper part a large amount of sulphurous water is available, but the taste and odor make it unfit for ordinary uses. In the middle gray shale section, very salty water is found. The so-called mineral spring in the park at the village of Clyde is a deep well in the Camillus whose waters contain high amounts of chloride. Fortunately in the region underlain by Camillus shale the glacial drift is thick enough to yield considerable supplies of water. Numerous springs from this drift augment the supplies derived from dug wells.

Limestones generally are regarded as fairly good sources of water. The limestone layers in the Sodus and Rochester shales have already been mentioned. There were no wells specifically reported as ending
in the Irondequoit limestone, although some of the deeper wells in the Rochester shale may have reached the Irondequoit. Two wells in the Wolcott limestone at the Wolcott creamery gave a small amount of water, but were abandoned because the quantity was not sufficient to supply the needs.

In a broad band across the north-central part of the Clyde sheet, the Lockport dolomite is the bedrock immediately underlying the glacial drift. This magnesian limestone contains large amounts of water, but most of it is of poor quality in this region. The glacial drift is not very thick over the Lockport dolomite, averaging about 18 feet. Most of the people have to rely on shallow wells in this drift, although some do use the sulphurous water from the Lockport. Test wells could be drilled through the Lockport dolomite casing off its water horizons, to determine the quantity and quality of water in the Rochester shale below, but this survey produced no records of such wells.

Recovering the Water

The chief means of making ground water available for use is through the development of wells and springs. If springs are close by, they can be utilized by cleaning out the opening from which the water issues and by constructing a stone curbing around the opening. A suitable reservoir may be built to store quantities of the water.

To recover the greatest amount of water of good quality from wells it is important to consider carefully the selection of a well site. Wells should not be near a possible source of contamination, and should be so located that all surface drainage flows away from the site. The casing or curbing of the well should extend a foot or so above the land surface and should be banked with earth or concrete that slopes away from the well.

A study of the topography and geology of the area, and the records of near-by wells should be made before drilling a well to get an idea as to the probable depth of the well, and the nature of the material to be penetrated. If a large amount of water is required, a number of test wells should be put down in order to determine the exact nature and location of the water-bearing beds and the quality of the water.

Most of the wells in the Clyde and Sodus Bay quadrangles are dug into the glacial drift, and are walled up with boulders. The diameter of these wells is usually three or four feet. Many of these wells were dug to or just below the water table at the time of digging, and with the general lowering of the water table over wide areas during
the past few dry summers, a number of these wells failed in the summer and autumn. Dug wells should be sunk far enough below the water table to provide a reservoir for storage and to prevent the well from going dry as a result of the seasonal fluctuation of the water table. The wells that failed may become satisfactory producers if they are dug several feet deeper. If the bedrock is close enough to the bottom of the well, it may be advisable to dig to the bedrock and to blast a few feet into the rock to maintain a storage reservoir and to take advantage of the amount of ground water usually to be obtained at the contact of the glacial drift and the bedrock.

Shallow dug wells are generally inexpensive and fairly easy to construct. Great care should be taken to insure the proper protection of these wells from possible contamination. If there is a suspicion of contamination in the water, a sample should be taken to the town health officer for sanitary chemical or bacterial analysis, and the proper remedy should be applied to the source of supply at once.

The average depth of the dug wells investigated in the area was 19 feet. All of these were in the glacial drift.

The drilled wells in the region ranged from 24 feet to 182 feet in depth with the majority ranging from 40 to 60 feet. Some of these wells were in glacial drift and some were in the various rock layers. Satisfactory quantities and quality of water were shown to be derived from the glacial drift, the Vernon shale, the Rochester shale and in a few instances from the Medina sandstone. Unsatisfactory quality of water was derived from the Lockport dolomite, the Camillus shale and from the Medina. Small amounts of water were reported from the Sodus shale, Wolcott limestone and Irondequoit limestone where these beds were close to the surface, and possibly some of the water was accumulated from the contact with the glacial drift above.

Quality of the Water

The quality of the water varies somewhat from place to place in the Clyde and Sodus Bay quadrangles. An average of 16 sanitary chemical analyses, furnished by the Bureau of Water Supply of the New York State Department of Health, shows 240.5 parts per million alkalinity. Of these 16 water samples the average of chlorides was 13.35 parts per million, the range being 0.2 up to 128 parts. The average amount of iron reported in 10 of the 16 samples was 0.59 parts per million. The Department of Health reports these results as typical of the waters of the area. One extreme case of iron was reported,
<table>
<thead>
<tr>
<th>Date</th>
<th>Owner</th>
<th>Location</th>
<th>Location</th>
<th>Ammonia Free</th>
<th>Ammonia Alumina-</th>
<th>Nitrites</th>
<th>Nitricates</th>
<th>Iron</th>
<th>Oxygen Consumed</th>
<th>Chlorides</th>
<th>Total Hardness</th>
<th>Alkinity</th>
<th>PH Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-15-37</td>
<td>Village Supply</td>
<td>Sodus Point</td>
<td></td>
<td>0.004</td>
<td>0.072</td>
<td>0.002</td>
<td>0.50</td>
<td>3.1</td>
<td>13.2</td>
<td>134.0</td>
<td>94.0</td>
<td>7.9</td>
<td></td>
</tr>
<tr>
<td>11-26-32</td>
<td>Upper Springs</td>
<td>Wolcott</td>
<td></td>
<td>0.006</td>
<td>0.014</td>
<td>0.001</td>
<td>1.80</td>
<td>0.6</td>
<td>1.6</td>
<td>175.5</td>
<td>170.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-13-38</td>
<td>Alton Diner Well</td>
<td>Alton</td>
<td></td>
<td>0.044</td>
<td>0.010</td>
<td>0.01</td>
<td>0.50</td>
<td>2.0</td>
<td>39.0</td>
<td>340.0</td>
<td>216.0</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td>12-21-36</td>
<td>School No. 12</td>
<td>Morse Hill</td>
<td></td>
<td>1.35</td>
<td>0.030</td>
<td>0.002</td>
<td>0.02</td>
<td>1.1</td>
<td>1.3</td>
<td>90.0</td>
<td>145.0</td>
<td>8.5</td>
<td></td>
</tr>
<tr>
<td>8-17-37</td>
<td>Sodus Village-Well</td>
<td>Town of Sodus</td>
<td></td>
<td>0.002</td>
<td>0.006</td>
<td>0.004</td>
<td>3.2</td>
<td>0.3</td>
<td>0.4</td>
<td>220.0</td>
<td>173.0</td>
<td>7.4</td>
<td></td>
</tr>
<tr>
<td>10-30-35</td>
<td>School No. 12</td>
<td>Town of Sodus</td>
<td></td>
<td>0.20</td>
<td>0.010</td>
<td>0.003</td>
<td>0.02</td>
<td>0.9</td>
<td>1.5</td>
<td>104.0</td>
<td>139.0</td>
<td>8.7</td>
<td></td>
</tr>
<tr>
<td>8-7-34</td>
<td>Ward Springs</td>
<td>Town of Sodus</td>
<td></td>
<td>0.010</td>
<td>0.006</td>
<td>0.005</td>
<td>1.80</td>
<td>0.03</td>
<td>1.0</td>
<td>200.0</td>
<td>188.0</td>
<td>7.6</td>
<td></td>
</tr>
<tr>
<td>10-4-34</td>
<td>School No. 21</td>
<td>Town of Sodus</td>
<td></td>
<td>0.030</td>
<td>0.092</td>
<td>0.001</td>
<td>0.08</td>
<td>2.0</td>
<td>1.6</td>
<td>360.0</td>
<td>255.0</td>
<td>7.6</td>
<td></td>
</tr>
<tr>
<td>2-26-32</td>
<td>Well &quot;A&quot;</td>
<td>Town of Sodus</td>
<td></td>
<td>0.088</td>
<td>0.032</td>
<td>0.001</td>
<td>2.50</td>
<td>1.0</td>
<td>8.8</td>
<td>162.5</td>
<td>141.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-7-32</td>
<td>&quot;Raw&quot; Water In</td>
<td>Lyons Village</td>
<td></td>
<td>0.002</td>
<td>0.176</td>
<td>0.001</td>
<td>0.12</td>
<td>7.4</td>
<td>2.6</td>
<td>364.5</td>
<td>128.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-1-33</td>
<td>Tap In Village</td>
<td>Savannah Village</td>
<td></td>
<td>0.004</td>
<td>0.110</td>
<td>0.002</td>
<td>0.60</td>
<td>6.8</td>
<td>3.2</td>
<td>250.0</td>
<td>216.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-2-33</td>
<td>C.H. Ward</td>
<td>Town of Sodus</td>
<td></td>
<td>0.002</td>
<td>0.004</td>
<td>0.002</td>
<td>1.80</td>
<td>0.01</td>
<td>1.7</td>
<td>190.0</td>
<td>178.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-11-32</td>
<td>Stream Water - A</td>
<td>Savannah</td>
<td></td>
<td>0.002</td>
<td>0.058</td>
<td>0.001</td>
<td>0.05</td>
<td>3.5</td>
<td>1.0</td>
<td>338.0</td>
<td>204.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-11-37</td>
<td>&quot;Raw&quot; Water At</td>
<td>Lyons Village</td>
<td></td>
<td>0.012</td>
<td>0.130</td>
<td>0.002</td>
<td>0.20</td>
<td>0.7</td>
<td>4.7</td>
<td>218.0</td>
<td>133.0</td>
<td>8.2</td>
<td></td>
</tr>
<tr>
<td>11-10-33</td>
<td>Houston Well</td>
<td>Wolkott Village</td>
<td></td>
<td>0.218</td>
<td>0.004</td>
<td>0.006</td>
<td>0.04</td>
<td>0.1</td>
<td>0.7</td>
<td>221.5</td>
<td>221.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-6-33</td>
<td>Wallington School</td>
<td>Wallington</td>
<td></td>
<td>0.034</td>
<td>0.024</td>
<td>0.003</td>
<td>0.40</td>
<td>18.75</td>
<td>2.5</td>
<td>128.0</td>
<td>471.5</td>
<td>33.0</td>
<td></td>
</tr>
<tr>
<td>11-7-36</td>
<td>Village Well</td>
<td>Wolkott</td>
<td></td>
<td>0.108</td>
<td>6.0</td>
<td>0.001</td>
<td>10.0</td>
<td>2.5</td>
<td>6.4</td>
<td>2900.0</td>
<td>1460.0</td>
<td>7.3</td>
<td></td>
</tr>
</tbody>
</table>

Table 7 Results of seventeen sanitary chemical analyses
18.75 parts being present. In addition to those 16 records, the Department of Health furnished a record of a well in the village of Wolcott which had chlorides 2900 parts per million, with a total hardness of 1460 parts per million. The records of these analyses are shown in table 7. It was impossible in most cases to correlate definitely these chemical results with a particular water-bearing bed. The chemical analyses of the village supplies are given in the section under the Municipal Supply of each village.

The hardness of the ground waters, averaging about 240 parts per million, is not excessive for domestic consumption. Large industry or public supply would probably have to install softening equipment to reduce the hardness. In many homes, rain water is collected in cisterns for washing purposes.

SURFACE WATERS

Lakes and Bays

The Sodus Bay quadrangle is bounded on the north by Lake Ontario. The village of Sodus Point pumps water from this lake for its water supply.

There are a number of bays adjacent to the south shore of Lake Ontario. The largest of these bays are Sodus bay, Port bay and East bay. The bays occupy the low marshy areas at the mouths of many of the small north-flowing streams. In other words, the bays represent estuaries or drowned river mouths of these streams. Waters of the bays are not used for domestic supplies.

Sodus bay is a good harbor, while the smaller bays are used only for summer resorts and fishing.

Rivers and Creeks

The Clyde river, which flows across the southern part of the Clyde quadrangle from west to east, and its tributary, the Canandaigua outlet in the southwestern part of the quadrangle, are the only large streams in the area. The Clyde river is a winding, sluggish stream flowing for the most part through marsh land. It is utilized in this area for the Barge canal.

The Niagara and Hudson Power Plant pumps water from the river for shop purposes. Its drinking water is obtained from the Lyons village supply.

A number of small streams flow northward into Lake Ontario, or into the bays. The principal streams are Sodus creek, Second creek, Wolcott creek, Mudge creek, Beaver creek and Third creek. These
creeks are spring-fed at their headwaters, and the waters are for the most part of low temperature and of good quality when filtered. A number of farmers in the region north of the Ridge road pump water from these creeks for stock.

**MUNICIPAL SUPPLIES**

There are five villages in the Clyde and Sodus Bay quadrangles having public water supplies, and a sixth, North Rose, is contemplating installing a water system.

Lyons, the largest village in the area, derives its water supply from the Junius ponds, a series of spring-fed ponds of glacial origin, seven miles south of the village, in the Geneva quadrangle. The water is brought by gravity to the plant, where it is treated by chlorine and alum. There is a clear well storage of 500,000 gallons at the water plant. A standpipe with 318,000 gallons capacity is located on a hill on the west side of the village. A smaller adjoining standpipe is no longer used. The average daily consumption is 350,000 gallons, although it fluctuates from 250,000 to 700,000 gallons.

A chemical analysis of the raw water supplied at the plant by the superintendent, Mr Welch, shows the following constituents:

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Parts per million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved oxygen</td>
<td>9.5</td>
</tr>
<tr>
<td>Free CO₂</td>
<td>18.0</td>
</tr>
<tr>
<td>pH</td>
<td>7.4</td>
</tr>
<tr>
<td>Chlorides</td>
<td>3.0</td>
</tr>
<tr>
<td>Nitrates</td>
<td>1.4</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>172.0</td>
</tr>
<tr>
<td>Bicarbonates</td>
<td>216.0</td>
</tr>
<tr>
<td>Dissolved solids</td>
<td>478.0</td>
</tr>
<tr>
<td>Loss on ignition</td>
<td>127.0</td>
</tr>
<tr>
<td>Fixed residues</td>
<td>351.0</td>
</tr>
<tr>
<td>SO₄</td>
<td>191.4</td>
</tr>
<tr>
<td>Ca</td>
<td>101.3</td>
</tr>
<tr>
<td>Mg</td>
<td>21.6</td>
</tr>
<tr>
<td>Total hardness</td>
<td>342.0</td>
</tr>
<tr>
<td>Fe</td>
<td>0.08</td>
</tr>
<tr>
<td>Fe₂O₃, Al₂O₃</td>
<td>38.8</td>
</tr>
</tbody>
</table>

The village of Clyde receives its water from an artesian well in the glacial outlet channel just west of the village. The well is 22 feet deep, nicely housed, and the water rises to within eight feet of the surface. The water is pumped to a standpipe on a hill in the east side of the village. The standpipe has a storage capacity of 200,000 gallons. The average daily consumption is 105,000 gallons.
A complete chemical analysis, furnished by the Rochester and Lake Ontario Water Company, which controls the Clyde system, shows the following constituents:

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Parts per million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total dissolved solids</td>
<td>1372.0</td>
</tr>
<tr>
<td>Chlorides as Cl&lt;sub&gt;2&lt;/sub&gt;</td>
<td>40.0</td>
</tr>
<tr>
<td>Sulphate as SO&lt;sub&gt;4&lt;/sub&gt;</td>
<td>777.0</td>
</tr>
<tr>
<td>Nitrates as NO&lt;sub&gt;3&lt;/sub&gt;</td>
<td>2.9</td>
</tr>
<tr>
<td>Bicarbonates as HCO&lt;sub&gt;3&lt;/sub&gt;</td>
<td>258.6</td>
</tr>
<tr>
<td>Free carbon dioxide as CO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>37.0</td>
</tr>
<tr>
<td>Hydrogen ion concentration (p&lt;sub&gt;H&lt;/sub&gt;)</td>
<td>7.1</td>
</tr>
<tr>
<td>Nonvolatile residue</td>
<td>1.0</td>
</tr>
<tr>
<td>Silica as SiO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>11.6</td>
</tr>
<tr>
<td>Manganese as Mn</td>
<td>0.34</td>
</tr>
<tr>
<td>Iron as Fe</td>
<td>0.30</td>
</tr>
<tr>
<td>Calcium as Ca</td>
<td>351.4</td>
</tr>
<tr>
<td>Magnesium as Mg</td>
<td>35.4</td>
</tr>
<tr>
<td>Sodium and potassium as Na</td>
<td>25.9</td>
</tr>
<tr>
<td>Alkalinity as CaCO&lt;sub&gt;3&lt;/sub&gt;</td>
<td>212.0</td>
</tr>
<tr>
<td>Hardness as CaCO&lt;sub&gt;3&lt;/sub&gt;</td>
<td>970.0</td>
</tr>
</tbody>
</table>

The village of Wolcott derives its water from a set of springs two miles southeast of the village. Two wells on the site of the pumping station at the edge of the village on Auburn street serve as an auxiliary supply. There are two reservoirs, one standpipe holding 120,000 gallons and a basin reservoir with a capacity of 300,000 gallons. The average daily consumption is 125,000 gallons, but a much larger quantity is used in the summer when the canning company is in operation.

Sanitary chemical analysis of water from the upper spring shows:

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Parts per million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia free</td>
<td>0.006</td>
</tr>
<tr>
<td>Ammonia albuminoid</td>
<td>0.014</td>
</tr>
<tr>
<td>Nitrites</td>
<td>0.001</td>
</tr>
<tr>
<td>Nitrates</td>
<td>1.80</td>
</tr>
<tr>
<td>Oxygen consumed</td>
<td>0.6</td>
</tr>
<tr>
<td>Chlorides</td>
<td>1.6</td>
</tr>
<tr>
<td>Hardness, total</td>
<td>175.5</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>170.0</td>
</tr>
</tbody>
</table>

Sanitary chemical analysis of water from the village well shows the following:

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Parts per million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia free</td>
<td>0.018</td>
</tr>
<tr>
<td>Ammonia albuminoid</td>
<td>6.0</td>
</tr>
<tr>
<td>Nitrites</td>
<td>0.001</td>
</tr>
<tr>
<td>Nitrates</td>
<td>2.0</td>
</tr>
<tr>
<td>Oxygen consumed</td>
<td>6.4</td>
</tr>
<tr>
<td>Chlorides</td>
<td>2900.0</td>
</tr>
<tr>
<td>Hardness, total</td>
<td>1460.0</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>178.0</td>
</tr>
<tr>
<td>pH value</td>
<td>7.3</td>
</tr>
</tbody>
</table>
The village of Sodus Point is located in the extreme northwest corner of the Sodus Bay quadrangle. This village is a port on Sodus bay and is also a summer resort of some note. The village derives its water supply from Lake Ontario, from which it is pumped directly into the treatment plant, a new building constructed in 1936. The pipe line extends into the lake 720 feet, at a depth of 10 feet. The water is treated by chlorine and alum and also for hardness.

There are two standpipes:

<table>
<thead>
<tr>
<th>Road</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pultneyville road</td>
<td>220,000 gallons</td>
</tr>
<tr>
<td>Alton road</td>
<td>130,000 gallons</td>
</tr>
<tr>
<td><strong>Total storage</strong></td>
<td><strong>350,000 gallons</strong></td>
</tr>
</tbody>
</table>

The daily consumption is from 20,000 gallons in the winter to 350,000 gallons in the summer. The Pennsylvania railroad, the Genesee Brewing Company malt house, and the hotels are the largest consumers.

Sanitary chemical analysis of the raw water shows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Parts per million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia free</td>
<td>0.004</td>
</tr>
<tr>
<td>Ammonia albuminoid</td>
<td>0.072</td>
</tr>
<tr>
<td>Nitrites</td>
<td>0.002</td>
</tr>
<tr>
<td>Nitrates</td>
<td>0.50</td>
</tr>
<tr>
<td>Iron</td>
<td>0.5</td>
</tr>
<tr>
<td>Oxygen consumed</td>
<td>3.1</td>
</tr>
<tr>
<td>Chlorides</td>
<td>13.2</td>
</tr>
<tr>
<td>Hardness, total</td>
<td>134.0</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>94.0</td>
</tr>
<tr>
<td>pH</td>
<td>7.9</td>
</tr>
</tbody>
</table>

The village of Savannah obtains its water from a group of springs about one mile south of the village. This supply is unsatisfactory both from the standpoint of quantity and quality.

In the summer of 1936 the springs failed and Savannah was forced to carry its supply from the village of Clyde in trucks. The bacterial examination showed 1600 bacteria per cubic centimeter, grown in 24 hours at 37° C., including Bacillus coli, the harmful bacterium. The State Laboratory recommended a change or improvement of the water supply.

The water is stored in an open reservoir on the top of a hill, with a capacity of 500,000 gallons. The average daily consumption is about 14,000 gallons.

The village of North Rose is contemplating the construction and development of a water supply, probably on the watershed of Trout brook, a small stream one and one-half miles west of the village. The village desires a maximum water supply of 60,000 gallons a day to care for its cold storage plants and canning factory.
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Glacial map of Clyde and Sodus Bay
GLACIAL MAP OF THE CLYDE AND SODUS BAY QUADRANGLES

- **CAMILLUS**
- **VERNON**
- **LOCKPORT**
- **ROCHESTER**
- **IRONDEQUOIT**
- **WILLIAMSON**
- **WOLCOTT**
- **SODUS**
- **REYNALDSON**
- **THOBOLD**
- **MEDINA**
- **DUTCHESS**

- **SAND BARS AND OFFSHORE BARS**
- **WAVE CUT TERRACES**
- **LAND MASSES**
- **DELTAS**

**LAKE ONTARIO**

**WAVE PLANE**

**DRUMLIN AREA**

**HURON**

**ALTON**

**LAKE IROQUOIS**

**NORTH ROSE**

**SOUTH SODUS ROSE**

**SODUS BAY**

**DRUMLIN**

**BUTLER AREA**