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## KAME AREAS IN WESTERN NEW YORK SOUTH OF IRONDEQUOIT AND SODUS BAYS.

CONTENTS



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## INTRODUCTION.

*Scope of the paper.*—The bays of Sodus and Irondequoit are the extreme points in the great bight or landward curve in the south shore of Lake Ontario. They occupy the lowest points of two north and south depressions in the land surface, the effect, probably, of northward preglacial drainage, and locate the embouchure of the buried ancient channels.

During the recession of the great ice-sheet, the drainage of the comparatively stagnant Ontario lobe seems to have been largely determined, in this region, by these depressions, which evidently received a large share of the glacial drift. The Warren waters which continuously laved the receding ice front assisted in distributing and leveling the detritus, while its successor, Lake Iroquois, completed the work at a lower level. The extensive silt plains between Sodus Bay and lakes Seneca and Cayuga, and the Irondequoit terraces, are examples of such lake action.

The purpose of this paper is not to discuss the complicated and interesting sequence of geologic events in the region under consideration, but to describe certain massive deposits of sand and gravel apparently formed by the glacial drainage.

The term "kame" is here used in the sense which has become generally accepted, as designating deposits, chiefly sand and gravel, having a knob-and-basin topography, and formed at the margin or periphery of the ice-sheet. The term "esker" (osar, serpent-kame) is employed to denote distinct ridges, chiefly gravel, believed to have been deposited in the beds of subglacial streams, being phenomena of the radial drainage.

Three of the kame areas here described have been mentioned in former writings,[1] but a new explanation of their character and relations is here given. The Junius area is thought to be here

[1] The Glacial Geology of the Irondequoit Region, Charles R. Dryer. Am. Geol. Vol. V., p. 202, April, 1890.

Eskers near Rochester, N. Y. Warren Upham, Proc. Roch. Acad. Science. Vol. II., p. 181, January, 1893.

The Kame-Moraine at Rochester, N. Y., H. L. Fairchild. Am. Geol., Vol. XVI., p. 39, July, 1895.

mentioned for the first time in print. The Rochester kame-moraine need not be redescribed.

A comparison of the deposits will be made, and an attempt to show the relation of the areas to the glacial drainage and the larger topography, with a brief discussion of the problems involved. (See map, Fig. 1.)

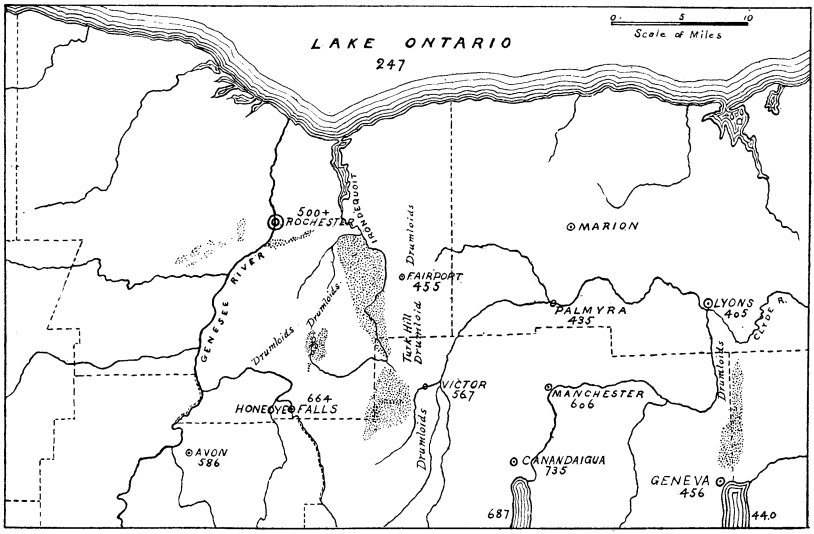


Fig. 1. General Map of Irondequoit-Sodus District.
Showing location of the four great kame areas. Figures indicate altitude above mean tide.

*Distribution of water-laid drift.*—Glacial sands and gravels are very generally distributed over western New York. Limited deposits of water-laid drift occur upon even the highest plateaus. It is a very common thing to find such deposits upon the summits or slopes of the drumloids, and some of the largest excavations of gravel for railroad ballast and other uses are superficial deposits associated with the drumloid or subglacial till. On low ground they are very abundant, but at altitudes under 875 feet above tide they are frequently leveled or distributed by the static waters or buried under lacustrine silts.

Very extensive deposits of water-worn drift occur in some of the larger stream valleys. In the upper Genesee valley immense deposits of stratified drift are mingled with the till, and much of it inextricably confused with the local lake sediments and subsequent stream detritus. South of the divide between the south-flowing and north-flowing waters the valleys are choked with the glacial wreckage converted into stream drift. Upon the north or Ontario side of the divide the glacial drift of all kinds has been retained and used, by the combined action of streams and glacial lakes, to fill depressions and thus give the smooth surface and arable soil of all the region between Syracuse and Buffalo.

*Lesser kame areas.*—To enumerate the smaller deposits of gravel or sand left in billowy or mound-and-basin topography would be tedious, even if it were possible. Those immediately about Rochester have already been described by the writer.[1] Other limited deposits occur in many places. Sometimes they are barely distinguished from the general drift sheet. Sometimes they are indicated by a few low mounds projecting from the sheet of lake or stream drift which has almost buried them. The limitation of such lesser areas is indefinite, as they blend into the prevailing sand or silt plains. At low levels, without close examination, dune sands may be mistaken for kame deposits.

One area, which merits fuller description than can now be given, is found north and south of Palmyra, Wayne county. This deposit is not large in amount of material or extensive in area but is interesting on account of the development of typical eskers. It consists of an irregular, broken series of kame mounds and esker ridges lying in the north and south valleys between heavy drumloids, and extending northward from near Manchester, Ontario county, past Palmyra to beyond Marion, a distance of about twelve miles. North of Palmyra and north of Marion are well-developed, typical eskers. At the southern end of the system, near Manchester, the sand deposit is more extensive.

[1] The Kame-Moraine at Rochester, N. Y., H. L. FAIRCHILD. Am. Geol., Vol. XVI., p. 39, July, 1895.

This drainage system does not seem to have been determined by any large north and south depression or other controlling topographic features, and it is likely that other slender series of kames and eskers may be found in neighboring drumloidal valleys.

### IRONDEQUOIT KAME AREA.

*Location and extent.*—One of the most extensive kame areas in western New York occupies the valley of Irondequoit creek, stretching from the deep depression of the bay or gorge past Pittsford to Fishers in the northwest corner of Ontario county. The extreme northern point of the deposit lies in a bend south of Allen creek, west of the Irondequoit gorge, where the main line of the New York Central Railroad has a large cut and excavation in the sand, which at that point makes a broad, high mass. This portion of the sand area and the western edge as far south as Pittsford are shown on the Rochester sheet of the New York topographic map. From the sand cut to within two miles of Fairport the railroad traverses the northern part of the kame area, as it swings southeast and east around the Irondequoit gorge past Penfield station and across the creek, a distance in curvature of four and one-half miles. The Auburn division of the same railroad passes along the western edge of the area, while the Erie canal crosses the area and the Irondequoit creek on a high embankment in line with an esker, as described by Dr. Dryer.[1]

The entire length of the area from Allen creek to Fishers is about nine miles. At the head of the Irondequoit gorge the breadth is about three miles, the area being almost entirely upon the west of Irondequoit creek, or between that creek and its tributary, Allen creek. We have no means of determining how much of the northern end of the area has been removed by the excavation of the Irondequoit gorge. South to Pittsford the remnant of the kame area rapidly narrows, and is restricted to the western edge near Pittsford, as the greater breadth on the eastern side has been leveled by the waters of lake Iroquois

[1] Am. Geol., Vol. V., p. 203.

and subsequent stream action. From Pittsford southeast to Fishers the kame deposits fill the valley to a width of about two and one-half miles.

South of Fishers is the extensive mass of kame drift described below as the Victor kame area. It might be regarded as a part of the Irondequoit area, and certainly it belongs to the same drainage system. Being separated, however, by an interval of low ground and drumloid till at Fishers and being so different in topography, with so great mass, it is found appropriate and convenient to describe it separately.

*Topography, altitude, and drainage.*—The base of the kame area rises toward the south, about 100 feet between Penfield station and Fishers. The northern and lower portion lies near the level of the ancient lake Iroquois (435 to 440 feet in this region) and a considerable portion was beneath the waters. At Cartersville, one and one-half miles southeast of Pittsford, the highest detrital plain cut out of the kame deposit has an altitude of 435 feet, but a discrimination has not yet been made positively between the lake terraces and the subsequent stream plains. The altitudes upon the main line of the New York Central Railroad across the sand area near the head of the Irondequoit gorge are as follows: Crossing of Allen creek, 420 feet; in the deep sand cut, 423; Penfield station, 417; crossing of Irondequoit creek, 407; Fairport, 455. The top of the broad sand hill near Allen creek, cut by the railroad, has an altitude of about 470 feet. The canal has but one "level" across the Irondequoit valley, of 461 feet. At Fishers the Auburn branch of the New York Central Railroad has an altitude of 510 feet, which is, however, within fifteen or twenty feet of the creek level, in the eroded channel. The Lehigh Valley Railroad crosses the valley and the western plain, being at Victor 567 feet, Fishers 557 feet, Mendon, 572 feet.

The surface configuration of the kame area is varied and difficult to describe briefly. Most of the surface north of Pittsford is billowy, low mounds of fine sand, perhaps largely the result of wind action. At the canal crossing the sand hills are lofty, of strong knob and basin topography and surround two

lakelets. From here south the drift forms massive hills, which culminate two miles north of Fishers, opposite Railroad Mills flag station. The creek at this point is crowded to the extreme western edge of the valley by the drift hills, which stretch eastward two miles to the Turk hill drumloid mass. The higher hill on the western side, known as Woolston hill, has been truncated or leveled by lake waters somewhat under 700 feet altitude. The same level is conspicuously shown upon other hills, east and south. The surface configuration is very striking, being partly morainic and partly erosional.

The drainage of the whole area is northward by Irondequoit creek.

*Eskers.*—Lying in the midst of the kame sands, nearly opposite Cartersville and north of Bushnells Basin, is a conspicuous esker which has been briefly described by Dr. Dryer. This esker first appears in a field of Mr. D. L. Guernsey (lot 21 of Pittsford town map), which is a fine adhesive or silty sand with rare stones and broad basins and kettles. In the southward sloping field the esker emerges from beneath the clayey sand at its full altitude as a ridge of gravel. For a distance of about one-fourth of a mile it extends nearly southeast, parallel with the Palmyra road; then turning more to the south it suddenly ends at the crossing of two highways. This break is perhaps the result of erosion. Some sixty or eighty rods southeastward the ridge is abruptly resumed at a gravel pit. At the top the gravel is dirty and unassorted; in the middle section is a heavy bed of clear cobble; while the bottom is finer gravel but without much stratification. Two-thirds of the cobble up to six inches in diameter is Medina sandstone.

From here southward the esker ridge is very distinct, somewhat curving, with irregular crest line. It is mostly 30 to 40 feet high, with steep slopes, 26° to 30°, and the crest in some places is clear sand. The highest section is 80 feet above the basin at its foot, with an eastern slope of 34°, in coarse gravel. From the high section it curves southeast and is lost in the artificial high embankment of the canal at the creek crossing,

beyond which it is probably buried under the lofty sand hills south of the creek. However, it can probably be identified south of the canal, at the south end of the canal embankment, in a mass of cemented, dark red Medina gravel which is similar in appearance to an exposure in the esker at the north end of the embankment. About 30 feet in thickness is shown of this cemented gravel, of which, by estimate, from one-half to three-fourths is red Medina. This occurs at the canal level, 461 feet. Similar dark red, cemented gravels occur at other localities; one and one-half miles south near the Rand powder mill; at Fishers station; in the sand cut near Allen creek at the extreme northwest point of the preserved kame area; also near the bottom of the Irondequoit gorge. It is suggested that these masses of cemented Medina gravels found in the distinct esker ridge and at different points in excavations northward and southward indicate the deposit of subglacial streams deriving their burden chiefly from the Ontario excavation in the Medina, which esker deposits have been mostly buried under the later sands deposited in front of the retreating ice.

*Lakes.*—South of Bushnells basin two lakelets exist, locally called "Bullhead pond" and "Lily pond." They are about one-fourth of a mile apart. The "Lily pond" is said to be shallow, the other deeper and more surrounded by sand hills. These are somewhat below the canal altitude 461 feet.

Another lakelet called "Crossman pond," or "Cedar pond," lies one-fourth mile north of Woolston hill, by the side of the Ketchum road. It has an area of about two acres, with a reported depth of 60 feet. The altitude is about 520 feet (aneroid).

Between Pittsford and Penfield are at least five pools and one swamp, lying in depressions in the billowy sand.

*Composition and structure.*—The surface of the northern portion of the area is chiefly a fine yellow sand. Below the Iroquois level this sand is much affected by the winds, and the billowy surface may be wholly due to æolian action.

The cutting by the railroad near Allen creek exposes about 70 feet of sand, inclosing a few lenses of gravel, and some angu-

lar material. A few bowlders occur, mainly Niagara. On the north side of the cut, twenty feet from the top, are heavy masses of cemented Medina gravel, about ten feet thick. These do not seem continuous. Another mass of similar gravel appears at the bottom of the excavation.

The top of the high mass is mostly fine sand but containing angular stones and a few bowlders. The surface from here south to Pittsford, two miles, and east to Penfield, one and one-half miles, is thrown into domes and basins. No gravels appear upon the surface north of the esker described above, although gravel is said to underlie the sand.

At Bushnells Basin and the canal crossing of Irondequoit creek the high hills are mainly the fine yellow sand, but heavy beds of gravel are worked near the canal, and cemented Medina gravels occur as described above.

The summit of the leveled Woolston hill is gravel, and heavy gravel is exposed in gullies on the slope. The hills of this culminating mass are reported as largely sand.

Till occurs in the base of the Woolston group, and on a terrace corresponding nearly with the plain stretching westward toward the Mendon hills. A land slide exposes 30 feet of till on this level, which is towards 100 feet above the creek, with a great thickness of sand beneath it. Till also occurs at a higher level on the north side of the Woolston hill. A conspicuous hill south of village of Fishers and another smaller one southeast are true drumlins.

The depth of the sand upon the borders of the northern part of the area cannot be great. Toward Penfield the water pools indicate a substratum of rock or till at altitude of about the Iroquois level. Through the midst of the area there exists a buried ancient valley.

*Surrounding features.*—The kame deposit lies upon the glacial filling of the ancient valley, lapping upon the drumloid till either side. Being wholly in a north-sloping valley and at a low altitude, the lowest northern part of the deposit was at first leveled by the waters of lake Iroquois, while the whole area has been

subjected to the valley drainage. Doubtless a considerable part of the original mass has been swept into the Irondequoit bay depression. The details of this history, as connected with Irondequoit bay, will be reserved for another paper.

There are no important morainal features upon either side of the kame area. West of the southern part of the area, at a distance of five miles, is the large, isolated group of the Mendon kame hills, with a plain intervening; otherwise the east and the west boundaries are drumloid. South is the enormous deposit of gravel forming the Hopper and Fort hill groups of Victor, which are really the antecedent part of the Irondequoit kame system. At Victor is a break in the Turk hill drumloid range, through which the Lehigh Valley and the Central railroads find passage.

### VICTOR KAME AREA.

*Location and extent.*—The most massive kame hills in the region, and probably in all western New York, are in the southwestern part of the town of Victor, Ontario county, extending into the towns of East and West Bloomfield and into the southeast corner of Mendon, Monroe county. (See Fig. 2.) They cover an area of some ten square miles and attain in the "Hopper" hills the lofty altitude of over 1100 feet. The area is elongated north and south, the northern apex being at Fishers station the Auburn branch of the New York Central Railroad, and the southern end forming a narrow belt terminating two miles south of Millers Corners station, on the Batavia and Canandaigua branch of the same railroad. The total length is about seven miles. The greatest breadth is about three miles, where the group culminates in the remarkably bold ridges northeast of Millers Corners.

*Topography, altitude and drainage.*—The higher kame hills of this area have a very remarkable topographic relief. The culminating mass is locally known as the "Hopper" hills, which lie immediately north and northeast of Millers Corners, upon the north and south line between Monroe and Ontario counties. This is a lofty, ridge-like mass lifted high above the surrounding

kames and conspicuous over a wide territory. (See Fig. 3.) The mass is irregular in form, but with the longer axis north and south, or east of south, and a length of over one mile. Upon all sides

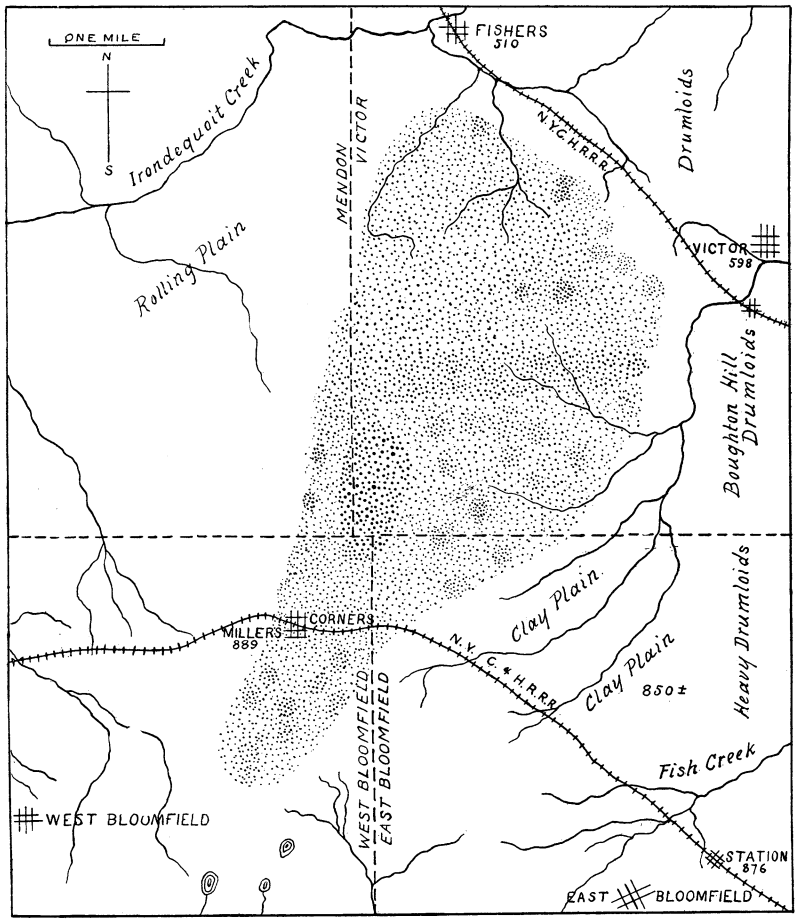


Fig. 2. Map of Victor Kame Area.
Figures indicate altitude above mean tide.

except the south it rises steeply 400 feet, attaining an altitude of 1131 feet (aneroid) above sea level, overtopping everything in western New York north of the Devonian plateau. Superficially the

mass is entirely water-laid drift, mainly gravel, and there is slight evidence of clay or till. No deep exposures have been made, and there are no land-slides, as occur upon neighboring steep kames where clay exists. The people in the vicinity report no clay or "heavy soil." The cultivated fields upon the summit show only sand and rather fine, well-rounded gravel. However it is possible that the water-laid drift is only a veneer upon a mass of till.

Southward the Hopper mass is continued in the belt of kame hills of lesser height stretching past Millers Corners. These have an altitude of 900 to 1000 feet, which height is preserved until they terminate against the rising ground to the south.

With only a fringe of comparatively low knolls, the western slope of the Hopper range falls rapidly to the rolling clay plain which declines westward toward Mendon and Honeoye Falls.

Upon the north and northeast a narrow gulf separates the mass from the western end of the Fort hill kame range. East and southeast a narrow valley intervenes between the Hopper range and the lower kames. The latter have an average altitude of 850 to 900 feet, being mostly water-leveled, and blend into a a till or clay plain of the same altitude, flanking the heavy drumloid ridges eastward. These drumloids are in line south from Victor, the northern one being known as "Boughton" hill.

North of the Hopper range and separated by a narrow valley is a broad, less elevated series which we will name the "Fort" hill range. This name is locally given to the conspicuous, abrupt plateau at the eastern end of the range, about two miles from Victor, which is historically famous as the site of a stronghold and of the defeat of the Seneca Indians by Denonville, in 1687. This range has been mostly truncated by static waters, the plateaus being 850–865 feet altitude and the highest summit 885 feet (aneroid). The breadth is about one-half mile and the length about two miles. The trend is north of west, the western end being separated from the northern end of the Hopper range by only a narrow gulf.

Northward toward Fishers the hills seem small by comparison

with the Hopper and Fort hill ranges, but are really of respectable size, somewhat mound-like and billowy in contour, closely huddled together, and diminishing toward the northern end of the area.

The surface of the entire area is knob and basin topography. Broad basins and deep kettles occur even to near the top of the

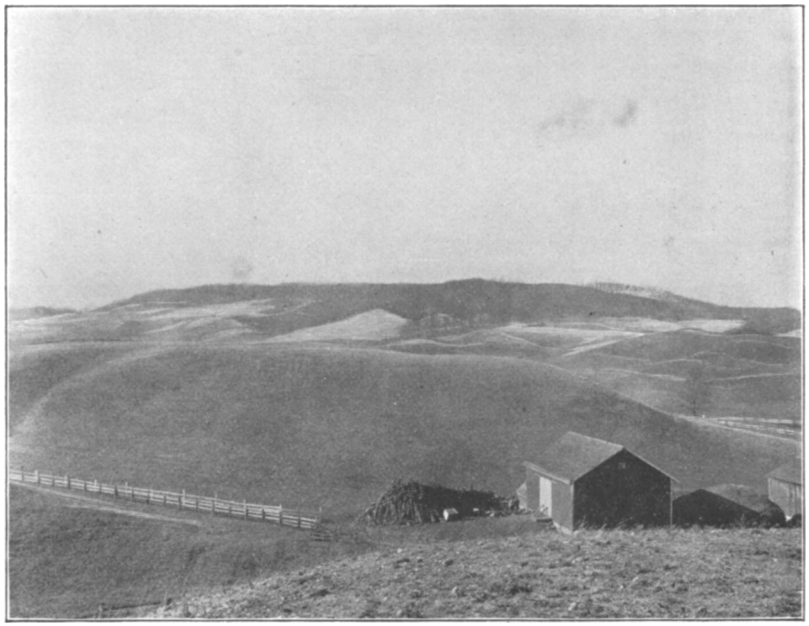

Fig. 3. VICTOR KAMES.

View from near Tobin's Corners, looking west 15° north, "Hopper" Hills in background. The point of view is upon the upper erosion plane of Warren waters, which also shows in distance upon right.

Hopper range. This topography has lost, however, some expression by the leveling effect of the Warren waters. Between 850 and 875 feet altitude the kames are strongly terraced or truncated, this plane being one of the conspicuous features of the region. A few summits in the southeastern part of the area, and one summit of the Fort hill range, have escaped the leveling action of

the static water. Another water-plane, toward 700 feet altitude, is less evident.

The drainage is west and north into Irondequoit creek and north by Great brook, the latter flowing upon the west side of the Boughton drumloid and joining Mud creek east of Victor.

Few water-pools worth mentioning occur. One pool lies in a deep basin between the western ends of the Hopper and Fort Hill ranges, back of the house of Mr. Covill. The large basins seem to be of pervious materials and far above the till or rock floor. Good kettles holding water except in dry seasons occur north of the Fort hill range.

Eskers probably do not occur in this area. If any exist they are in the northern part of the area east of the Fishers and Millers Corners road.

*Composition and structure.*—Till is found in the knolls near Millers Corners. The top of one hill, a mile northeast and with altitude of about 900 feet, seems to be wholly till, with bowlders. One-fourth mile west of the station the railroad makes a cutting in till which is probably drumloidal. Some of the slopes and summits are coarse sand, but the great bulk of the higher ranges is gravel. Fort hill is capped with sand, but the rest of the range is mostly gravel. Less sand is seen upon the summit of the Hopper range, the highest points being fine gravel. The composition of this range has been described above. The hills south of Millers Corners contain much gravel and some heavy beds of very round cobble. The bulk of the northern, constricted area toward Fishers seems to be sand, but Dr. Dryer states that there is much till in the knolls and plateau lying north of the Fort hill range.

Stones and cobbles are found in the sand at various elevations. The foundation of the southern part of the area is Corniferous limestone and the characteristic chert is found upon the summits of the Hopper range. The northern edge of the Corniferous is traced near Victor.[1] Large bowlders of crystallines, Medina and Corniferous are seen along the highway between

[1] Economic and Geologic Map of the State of New York, by F. J. H. Merrill, 1895.

Fishers and Millers Corners, especially near Millers Corners. A large proportion of the gravel, even to the Hopper summits, is Medina.

*Surrounding features.*—This kame area evidently belongs to the same glacial drainage as the Irondequoit kame area. The reasons for treating it as a separate area have been given above.

The area is bounded on the northeast by the northwest-southeast valley reaching from Fishers to Victor. Upon the east it is bounded by the Boughton hill drumloid which runs directly south from Victor village and which, notwithstanding the break at Victor, may be regarded as the southern continuation of the Turk hill mass, with which it is in line. Southeastward the kames are lost in a smooth plain of till or clay, as mentioned above, which joins a marsh north of East Bloomfield and is the level of the upper erosion plane of Warren waters. As casually seen in exposure by the roadside, this clay is of reddish color, with only small but striated stones. The streams have excavated narrow channels 40 to 60 feet deep through this plain, and are possibly on rock. Southward is high ground with a drumloidal surface, the northern spurs of the Devonian plateau.

Westward is a low silt plain, evidently deposited as a lake floor, and which may be regarded as an overwash from both the Victor and Irondequoit kames. This plain declines west toward the Honeoye creek and north toward the Irondequoit creek, with an altitude averaging about 600 feet.

It will thus be seen that the Victor kame area lies in an angle or embayment of the Warren shore line, opening toward the northwest. Northwest a few isolated mounds of sand rise out of the low silt plain, the only phenomena connecting this kame area with the Mendon kame area. Neither westward nor eastward are there any good evidences of morainal till.

In Professor Chamberlin's description of the terminal moraine in New York[1] this Victor kame group was united with the southern part of the Turk hill mass and regarded as an intermediate

[1] THOMAS C. CHAMBERLIN, Terminal Moraine of the Second Glacial Epoch. Third Ann. Rep. U. S. Geol. Surv., p. 353, and Plate XXXIII.

or interlobate moraine. The same view was subsequently held by Dr. Dryer.[1]

By referring to Professor Chamberlin's description it will be seen that he had serious doubt as to the correctness of the diagnosis. He closes the brief description with the following: "... for the glacial movements on either side of the moraine appear to have been southerly, as judged from the prevalent trend of adjacent drift ridges, and therefore essentially parallel to the moraine, instead of being at right angles to it, as in the case of a true intermediate moraine."

The Turk hill body of drift is somewhat anomalous but is surely drumloidal in general character. The northern end, at Fairport, is divided into a few large ridges, which blend together southward and constitute a broad, plateau-like mass, over 900 feet in altitude. The western boundary is a fairly continuous slope, with considerable water-laid drift banked against it, and the Irondequoit kame area flanking it opposite Fishers. The eastern side is more irregular and the depressions have been largely filled with water drift. The southern declining half of the drift body is also very gravelly and of irregular surface. East of the high mass the drumloids are numerous but smaller. Much of the morainic appearance on the slopes and on the southern half of the Turk hill mass is certainly due to sub-aërial erosion. The drainage is all free. There are said to be no lakes, no swamps, and no sinks or kettles.

Upon Professor Chamberlin's map (Plate XXXIII. of the paper referred to) this supposed moraine is isolated, and with its north and south trend is quite inexplicable. It is the only isolated moraine depicted in New York north of the great east-and-west terminal moraine, and its elimination from the map simplifies the glacial phenomena of the region.

### MENDON KAME AREA.

*Location and extent.*—A remarkable accumulation of kame sands and gravel occurs in the southeastern part of Monroe

[1] See former reference.

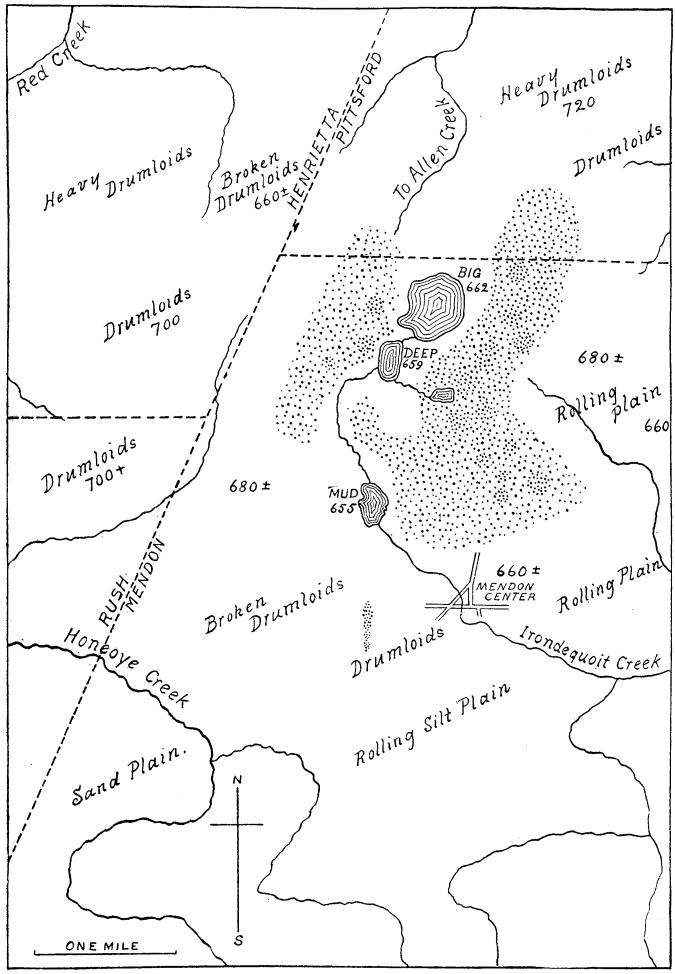


Fig. 4. Map of Mendon Kame Area.
Figures indicate altitude above mean tide.

county in the town of Mendon. The deposit has been referred to in the papers by the writer and by Dr. Dryer, but they deserve a fuller description.

The hills which constitute the heart of the kame area lie either side of the Mendon ponds. They may be said to form two

series of hills and knolls having a general direction of S. 30° W. with a low valley between holding the five ponds. (See Fig. 4.) The heavier group lies on the east side of the valley, extending between two north and south roads a distance of about two and one-half miles, with a breadth of three-fourths of a mile. The western group lies between the ponds and a north and south road and is only about one-third the area of the eastern group. The southern limits are not definite but shade into the silt-covered drumloids.

Southward, past Mendon Center, the general contour of the surface is drumloidal, but there seems to be a deposit of silt or sand over the surface and filling the hollows. This area of silt is indefinite and is intersected by the excavation of the Honeoye creek valley. Beyond this excavation a sand plain forms a conspicuous level, locally known as the "Mendon plains." This lies southwest of Rochester Junction on the Lehigh Valley Railroad and extends to Sheldon Corners.

*Eskers.*—Through the midst of the eastern high track there winds an esker ridge. This is not conspicuous, but from some points of view the knolls blend so as to form a very evident eskerine. (See Fig. 5.)

One mile south of the kame area occurs a singular group of knolls that must be regarded as an esker. This lies one-half mile south of Mud pond and three-fourths of a mile west of Mendon Center. The north end of the esker is cut by the east and west highway. This esker consists of four connected knolls, in a north and south line, making altogether a length of about one-eighth of a mile. The local name of the knolls is the "Dumpling hills." The summits and slopes of the ridge and the road cutting show only a fine, stiff or silty sand, similar to much of the surface of the region southward. A few stones were observed in the sand. The esker is thirty to fifty feet high but surmounting a ridge, probably drumloid, it is conspicuous over considerable area. Its altitude is 762 feet (aneroid). The sides of the esker are very steep and ridges of sand stretch away from it at right angles.

*Topography, altitude and drainage.*—The Rochester sheet of the New York topographic map includes the kame area, in twenty-foot contours, and to this map the writer is indebted for the altitudes. The swamp area surrounding the ponds has an altitude at the north end of 665 feet and at the south end of 655 feet. The highest peaks of the kame hills, in the eastern tract, are

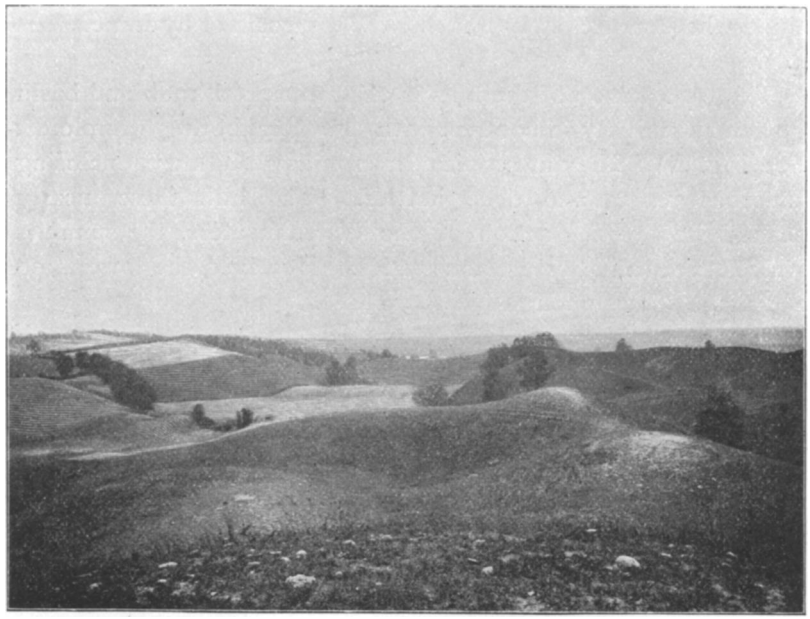

Fig. 5. MENDON KAMES.
View looking southwest over "Harris" lake. Eskerine at right.

given contours of 840 feet. These are 100 feet higher than the highest drumloids in the surrounding region. This altitude of the sand hills is a striking feature. Eight miles southeast are the Victor kame hills of much greater height. Higher ground is found in about ten miles southward on the Hamilton-Chemung plateau. North of this plateau of the "Finger lakes" region there is in all of western New York only one area, excepting the Victor hills, surpassing in height the Mendon hills; this is the drumloid mass of the Turk hill group, seven miles east,

which is about eighty feet higher. The most northern point of the high plateau is at Batavia, on nearly the same parallel as the Mud pond, where the drumloidal and morainic drift capping is something over 900 feet.

While the summits of the kame hills are 100 feet above the surrounding drumloids the enclosed swamp valley is nearly 100 feet lower than the drumloid region. It has not been determined whether the swamp is floored by rock or by impervious drift.

The topography of the hills is of pronounced knob and basin type and strikingly in contrast with the neighboring drumloids. (See Fig. 6.) They are conical, mammillary, billowy, enclosing numerous basins and deep kettles. The hills have nearly escaped the leveling action of the Warren waters, the summits lying between the two erosion planes. However, the lower, 700 feet, plane shows upon the western hills.

The drainage from the ponds and enclosed valley is immediately southward, forming the head of the Irondequoit creek. After passing Mendon Center the stream swings eastward to Fishers and then northward to Irondequoit bay. From the borders of the kame area the drainage is radial in all directions.

The altitude of the southern part of the overwash sand and silt is about 600 to 610 feet (aneroid).

*Lakes.*—The location, drainage and relative size of the four lakes are shown in the accompanying sketch. The "Big pond" lying most northerly and the head of drainage, has an area of about 100 acres, and a depth of only about eight feet. The "Harris pond" lies nearly surrounded by the heavy drift on the east side of the valley. It is only a few acres in extent but is said to have a depth of twenty-four feet. "Deep pond" is mostly shallow but is said to be thirty-four feet at the deepest place. "Big pond" and "Mud pond" are shallow. The margins of the lakes are mostly swampy, but much of the valley bottom between the lakes is tilled land.

*Composition and structure.*—The kame hills are mostly pasture land or under cultivation. Very few exposures have been made

and these show mainly imperfectly assorted gravels. The tops and slopes of the hills are frequently of material so fine and adhesive as to be clayey. Till is found in the high knolls north and south of the Harris pond and probably occurs elsewhere. In the valley near the Deep pond lies one small but very distinct elongated drumlin. No exposures are seen of fine, clear sand

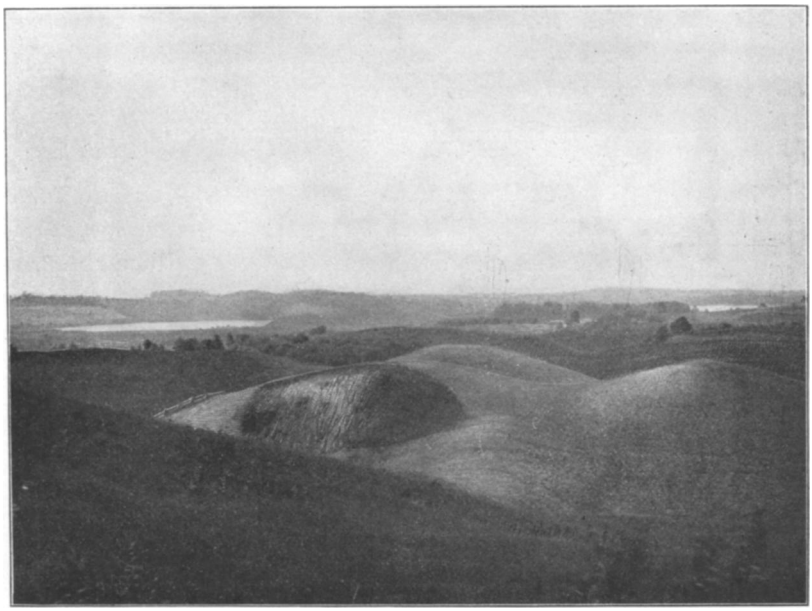

Fig. 6. MENDON KAMES.
View looking west of north over "Big" and "Deep" lakes.

blown about by the winds as in the Irondequoit and Junius areas and other sand areas near Rochester. The materials as a whole are varied, but the finer are generally rather adhesive or silty.

Some gravel pits in the borders of kame area show materials one-half Medina. Large bowlders of crystalline rock and rarer blocks of Niagara limestone occur throughout the region. In the middle valley and upon the southern borders of the area frequent cobblestone fences, one-half Medina, indicate considerable

coarse material upon the surface. Two huge Niagara blocks were seen on a gravel knoll at an altitude of 720 feet. A well upon one of the knolls in the southern part of the eastern section is said to have penetrated 130 (?) feet of clear sand.

*Relationship to surrounding features.*—An examination of the Rochester sheet of the New York topographic map will give a general view of the surface and surroundings of the kame area. It should first be noted that it lies in a drumloid area of high altitude, and a trifle west of south of the Irondequoit bay depression. The tract northward between the kame hills and Pittsford, four miles, is strongly drumloidal. Upon the west the country is distinctly but brokenly drumloidal and for two miles is not so strongly ridged. The twenty-foot contours of the topographic map do not anywhere fully indicate the drumloidal character of the surface. Southwestward the surface is drumloidal to the Corniferous escarpment, the overwash partially burying the lesser inequalities. Immediately south of the kame hills, at the village of Mendon Center, are distinct drumloids, and others apparently occur upon the southeast border. Eastward and southeastward the country is comparatively open and rolling for several miles, to the Victor kame hills. Immediately east of the middle of the kame area the ridges are quite wanting, the highest contour being 680 feet.

Concerning the rock floor or base of the region little is known. Upon the Howard farm, on the extreme western edge of the kame area, it is said that a well, starting on the 700-foot contour, was driven 130 or 140 feet without reaching bed rock. The well above referred to started at an altitude of about 680 feet and found no rock at depth considerably over 100 feet. In the southern part of the sand plains, on the farm of Mr. Judson F. Sheldon, rock is said to have been found at a depth of 69 feet. The plain at this point is near 600 feet altitude.

Eastward or westward of the kame hills there is but the slightest suggestion of a moraine. One and one-half miles northward of the Big pond a slightly morainic surface is shown among the drumloids, also two miles west, along the Lehigh Valley Railroad.

JUNIUS KAME AREA.

*Location and extent.*—A large and interesting kame area is

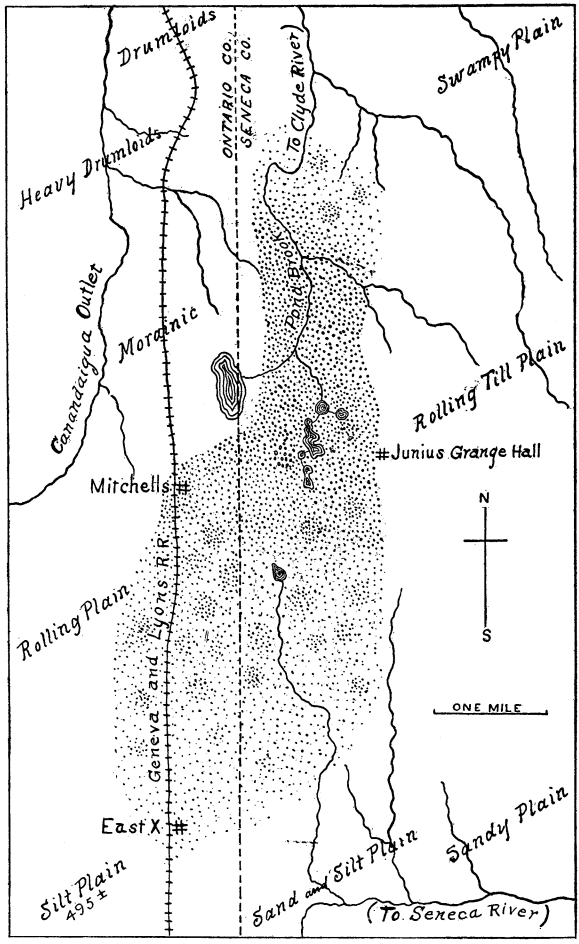


Fig. 7. MAP OF JUNIUS KAME AREA.
Figures indicate altitude above mean tide.

found north of Seneca lake in the town of Junius, in the north western edge of Seneca county and extending over the line into the town of Phelps, Ontario county. (See Fig. 7.) It lies mid-

way between Geneva and Lyons, but east of the meridian line, and constitutes the highest ground upon its meridian between lakes Ontario and Seneca. The boundaries of the sand areas are indefinite but the northern limit seems to be about one-half mile north of Bisch's sawmill or five miles in a direct line from Lyons. The heart of the area is the group of knolls surrounding the Junius ponds. Southward the knolly area broadens, east and west, and blends into the wide silt plain which extends to Seneca lake.

The width of the kame area on the "state road," which passes between the ponds and through the heart of the area, is about one and one-half miles. Junius Grange Hall is just at the eastern limit of the sand, and the western limit is beyond Mitchell's station (West Junius P. O.) on the Geneva and Lyons R. R. North from this station the railroad passes a mile west of the sand area; southward the railroad lies in the sand to beyond East X station, within three miles of Geneva. The length from Bisch's Mill to East X is about six miles.

*Topography, altitude and drainage.*—It is said that the surveys for the Geneva and Lyons Railroad made the height of the South pond 34 feet above Seneca lake. This is probably not far from correct, and would make the altitude 474 feet above tide. The South pond is about 13 feet higher than the other ponds. All the ponds in the heart of the area are drained northward by one brook into the Clyde river, with a fall of about 80 feet. The southern part of the area, including the swamp and the Lynch pond, is drained southward into Seneca river.

The topographic relief of the kame area is not remarkable. The higher knolls rise some 70 or 80 feet above the ponds, giving an extreme altitude of perhaps 550 feet above tide. The surface in the region of the ponds is decidedly hilly, but southward it would be better described as "billowy."

*Lakes.*—The lakes are notable for their reported depth as compared with their small area. The largest one, "North pond," with an area of about twenty acres, is said to be 62 feet deep. The others are reported to be of great depth. "South pond,"

the head of drainage, has a surface of about nine acres. The smallest, lying between North and South ponds, has an expanse of less than an acre. The two lakelets furthest north are called "Newton ponds." Only five lakes are here recognized, although the group is sometimes called the "Seven ponds." "Burnett's pond," which lies west of the sand area and is much larger and more shallow, is not here regarded as a member of the kame group. About one mile south is another lakelet in a large swamp.

The five kame ponds are said to retain their level in the driest seasons. Without any surface stream supply they must derive their waters from a large basin of sands enclosed in impervious drift.

*Composition and structure.*—The exposed material of the kame area is mainly fine yellow sand. A few gravel exposures are met with in the neighborhood of the ponds. East of Mr. J. C. Vandemark's residence a dark cemented gravel occurs in the crest of a knoll. The matrix is a dark, reddish, coarse sand. Of the gravel not over one-quarter is Medina, the remainder being a mixture of many hard rocks from the northern terranes. Some clay or stiff soil is said to occur on the tops of the knolls. Stones and bowlders are found at all heights in the sands. Southeast toward Waterloo and south toward Geneva the billowy yellow sands terminate in the silts of a broad plain, with occasional low, sandy knolls.

*Surrounding features.*—East and south of the kame area is the somewhat lower silt plain which extends from Geneva and Waterloo northward past Clyde to Sodus bay. The surface of the ground bordering north and west is boldly drumloidal, but northward it is slightly lower in altitude. West of the north end and heart of the kame area is a significant morainic deposit. It is best described as a morainic filling of the north and south valleys between the drumloid ridges. Part of the irregularity may be due to the east and west outcrops of harder strata of the upper Salina. This morainic surface extends along the Geneva and Lyons highway from about one mile south of Alloway to West

Junius post office (Mitchell's station). It is regarded as marking the edge of the ice-sheet during the accumulation of the larger kame hills by the concentrated drainage.

### COMPARISON OF THE KAME AREAS.

It will be instructive to briefly compare the principal features of the four large areas described above, including in this comparison the Rochester kame-moraine and some lesser areas.

The Irondequoit, Victor and Mendon areas are apparently the result of heavy drainage from the wasting ice-sheet, concentrated along the Irondequoit depression. The neighboring deposits of the Rochester kame-moraine and other lesser deposits southwest and west of Rochester have an uncertain, if any, relation to the Irondequoit drainage. The Junius area is in a separate and distinct glacial drainage system, belonging to the Sodus depression.

The Irondequoit area is singular in one respect; it rests in the lowest channel of the depression and partly below the level of Iroquois waters. The other areas are upon relatively high ground and constitute the highest points of land in their vicinities and upon their respective meridians, north of the Devonian plateau.

All the areas are alike in being located in the basin of lake Warren. Excepting the Junius area they are also alike in bearing evidence in the beautifully terraced and truncated sand hills of their accumulation beneath the Warren waters. Two strongly developed water levels are conspicuous; the higher between 850 and 900 feet, the lower about 700 feet above tide. The Junius area lies at so low an altitude that the hills have escaped the leveling action of any long pause of the Warren waters, their summits being much below 600 feet.

The areas are alike in having an overwash sand or silt plain to the southward.

The basement terranes are as follows: The Rochester kame-moraine lies upon the southern edge of the Niagara limestone. The Irondequoit stretches across the whole breadth of the Salina. The Mendon and Junius areas lie upon the Salina but near its southern limit. The Victor area lies chiefly upon the Corniferous

limestone. The composition of the three southernmost areas seems to partake somewhat of the clayey nature of the Salina strata. The Mendon, the Victor, and the Irondequoit sands, above the Iroquois level, are generally more coherent and argillaceous than the lighter sands of the Pinnacle and Chili hills near Rochester. This, however, may not be of great importance, especially since the Junius sands are also comparatively light.

The four areas lie in the midst of drumloid ridges which certainly antedate the kame deposits that partially overlie them.

Only the Rochester area has any clear connection with an extended frontal moraine. The morainic surface immediately west of the Junius hills is significant but not sufficiently clear or extensive to be important in this connection. It should be said, however, that in the drumloidal region bordering these kames an amount of morainal material even surpassing that in the moraine west of Rochester would scarcely be noticeable.

The break at Fishers may possibly be partly the scouring effects of currents during the lowering of lake Warren, but not entirely, and the cessation at this point of the process of such heavy drainage accumulation would seem to render probable the accumulation at some other point on the ice-front, east or west. For this reason the suggestion is made that the Mendon area may have been formed by the temporary westward diversion of the main Irondequoit drainage; that is, the Mendon water deposits may represent the gap between the Victor and the Irondequoit deposits. The center of the Mendon area is about five miles from Fishers, which lies in the break between the other two areas, and it has the proper position transversely to the drainage line.

## DISCUSSION OF PROBLEMS.

The precise manner of formation of the kame hills is the most obtrusive question. Two elements may be considered in this connection, the composition of the kames, and their altitude and location. In composition the red Medina waste plays the

conspicuous rôle. In the Irondequoit esker it is 50 to 75 per cent. of the whole mass. The kames contain somewhat less waste of the Medina, although the red color is usually pronounced even upon the highest summits. The Medina is the lowest terrane of the region, the top being only about 100 feet above Lake Ontario. In the Victor subaqueous kames, leaving the lofty Hopper range out of account, Medina gravel has been lifted towards 500 feet. Of this height not over 200 feet is due to the southward rise of the rock base, which leaves nearly 300 feet of actual lifting of the gravel. The distance from the Victor hills to the nearest Medina exposure, at the head of the Irondequoit gorge, is 12 miles. Another example is more striking. The Corniferous chert also occurs upon the tops of the Victor hills. The limestone is supposed to underlie the hills, but it cannot extend farther north at present than three or four miles. Within that distance the Corniferous has been lifted about 300 feet. Flotation by ice in lake waters might explain the presence of fragments of chert on these summits, but the Medina gravel which forms a constituent part of the hill summits cannot be so accounted for. The overriding of the gravel deposits by the readvancing ice will probably account for the till upon the higher kame summits, as it will for the angular blocks of Niagara limestone upon the summit of the Pinnacle, and for the till on Cobb's hill of the Rochester kame-moraine, but the areas here described give no evidence of extensive burial under glacial ice.

The summits of the Hopper ridge are about 250 feet above the upper lake terraces. It seems possible that some part of this remarkable elevation of the water drift upon this ridge may be due to a pushing by the ice in a slight readvance. The direction and form of this high ridge, however, are not entirely consonant with its being a pushed moraine. The interior structure of the hills is unknown. This explanation, a pushing by the ice, applies in part to the Rochester kame-moraine. Possibly it may partially apply in the case of the Fort hill range lying immediately north of the Hopper range, but it would

scarcely be suggested by the form of the hills in either of the other kame areas. It should be noted here that the directions of the Hopper and Fort hill ranges are nearly at right angles to each other.

There can be no doubt that the greater part of the material of all the groups has been derived from the Ontario excavation and rock degradation upon the north, and has been carried southward up hill. It has been lifted hundreds of feet by either ice or water, or both combined. Upward currents probably do not exist in the body of the ice-sheet sufficient to lift the subglacial débris to such a height in so short a distance. Indeed, the material, if taken from the ground moraine, would require to be lifted far above its present height, as the fully rounded gravel and the large proportion of sand represent the wear of a considerable journey by stream transportation.

The theory advanced by Professor Shaler [1] several years ago seems the most acceptable. In some manner the lifting of the gravel and sands may have been done by forceful upward currents of water at the ice-front, impelled by the hydraulic pressure of water in the lofty ice-sheet to the northward. The kame deposits under discussion were doubtless formed in the waters of lake Warren, along a belt where the deep static waters opposed the detritus-burdened, glacial torrents. The buoyant effort of the static water probably kept the ice-front comparatively steep or high. The heavier glacial streams would probably cause deep reëntrant angles in the ice-front, or even canon-like indentations, which would be choked by the piling of the detritus until a balance was established between the height of the detrital dam and the lifting power of the stream. The full analysis of the interaction of the three agencies, the ice-sheet, the subglacial streams, and the static water, would be exceedingly instructive in this study.

Professor Shaler supposed the Martha's Vineyard kames to

[1] On the Origin of Kames. Proc. Boston Soc. Nat. Hist. Vol. XXIII., 1884, pp. 36-44. Geology of Martha's Vineyard. Seventh Ann. Rep. U. S. Geol. Sur., 1885–6, pp. 314–322.

have been formed beneath sea-water. The static water in the cases under discussion was fresh water and would oppose less resistance to the glacial streams.

The chief and perhaps fatal objection to this explanation is the extreme height of the Hopper range, which is 250 feet over the highest water-level, but there is so much uncertainty concerning the internal composition of the Hopper mass that it is an unsafe basis in this argument.

This discussion has a direct bearing upon the matter of glacial drainage in another aspect. To deny the possibility of ice-dams, or the capacity of glacial ice to serve as a barrier to deep water, requires evidently interglacial or subglacial drainage to the sea in the case of the Ontario glacier. The topography of the land surface is such that during the melting toward the northeast of the Adirondack-Ontario ice-sheet the resulting waters must either have been ponded in front of the ice or have been suffered to escape beneath the ice to the sea by the St. Lawrence or the Mohawk depressions. The latter alternative means northward drainage. As a matter of evident fact these kame areas consist of matter derived from terranes lying upon the north, and as evidently were produced by water currents from the north. The waters flowed from the ice-sheet not into the ice-sheet.

The fact of static waters over the region is clearly shown by the two conspicuous erosion planes upon the kame hills, as already described. The suggestion of marine submergence is not entertained.

The general trend of the kame areas southwestward may have been due to the prevailing direction of the glacial movement.

The glacial débris above the ground moraine throughout this region seems to have been deposited chiefly as water-laid drift. The kame areas stand apart, without morainic connections, and terminal or frontal till moraines are no more than barely observable. The causation is probably complex. Rapid ice retreat; action of the lake waters preventing considerable local accumu-

lations of morainal till, or subsequently either dispersing or burying them; and the fact of the heavy glacial drainage, occur to mind as possible causes. Another important fact is that the bulk of the ground moraine had been left as heavy drumloid ridges.

The relation of the drumloid and the kame deposits are such as to clearly indicate the later deposition of the kames. For many reasons the writer has no doubt of the subglacial origin of the drumlins and drumloids of western New York, which are here regarded as a part of the ground moraine.

H. L. FAIRCHILD.