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HYPOTHESIS OF ORIGIN OF THE FINGER LAKES, NEW YORK

F. T. Thwaites, 1935

<u>Introduction</u>.- For many years the attention of the writer has been drawn to the question of the origin of the Finger Lakes in western New York because it bears upon the broader problems of first, the origin of the basins of the Great Lakes and, second, large scale erosion by continental glaciers. While working at the Allegany School of Natural History in 1932 he had the opportunity to spend two days in the Finger Lake district and an equal time in the Cattaraugus quadrangle farther west. On both these trips he was guided by Prof. L. W. Ploger of Syracuse University and Prof. C. D. Holmes, also of Syracuse participated in the first named trip. The writer is greatly indebted to both.

<u>The problem</u>.- The district under considerationis the northern edge of the Appalachian plateau. For the greater part of the district the plateau slopes rather gradually down to the north as the escarpment due to the Onondaga limestone is buried beneath glacial drift and the strong sandstones of the Pennsylvanian have been eroded from even the highest hills (See fig. 1). All of the region was glaciated by the Wisconsin ice whose deposits consist mainly of rather thin ground moraine with a few prominent terminal moraines in the valleys. Almost all the larger valleys are floored with outwash and their sides are terraced with gravel benches, many of which doubtless accumulated while stagnant ice masses separated from the main body of the glacier still survived in them. The famous drumlin district of western New York lies for the most part north of the Onondaga outcrop line.

Within the plateau margin there are three distinct types of rock topography : (a) old, smooth, mature valleys between rolling hills, all clearly much older than the last glaciation, (b) narrow, youthful gorges, all obviously younger than the last ice invasion, and (c) steep-sided, fairly straight "through valleys" which cut across the divides of the topography of the first type and have themselves been glaciated. Our problem is the origin and age of the third type of valleys.

Previous hypotheses.- In the past attention seems to have been directed mainly to these valleys of the third type which contain the remarkably long, narrow, and deep Finger Lakes. The fact that some special explanation must be sought for this kind of topography seems to have impressed the majority of geologists who studied the region. As far back as 1877 Simmons (1) ascribed the basins of the lakes to glacial erosion, a view also followed by Johnson (2) in 1882. It was not until 1892, however, that Lincoln (3) announced this theory in the American Journal of Science and thus brought it to the attention of the geological profession. This author was most impressed by the hanging valleys of Cayuga and Seneca lakes (fig. 1). In the following year Brigham (4) endorsed the theory of glacial erosion explaining the fact that the lakes are deepest at the south by the fact that glacial flow was most concentrated there. In 1894 Lincoln (5) restated and amplified his theory. In the same year Tarr (6) laid stress on the hanging valleys and the fact that the lakes are deepest in the shale and not in the Onondaga limestone. Spencer (7) doubted that Lake Cayuga lies in a rock basin. Nevius (8) in 1897 repeated Tarr's ideas. In 1902 Tarr (9) also reiterated his opinion. In 1904 Matson (10) reported upon the interglacial gorges in the bottoms of the hanging valleys, first recognizing the existence of stream erosion in interglacial time. In the same year Tarr (11) described the hanging valleys of the Finger Lake region noting their discordance in level. He also cited a number of facts which are opposed to the glacial erosion hypothesis. These included (a) angular cliffs within the valleys which showed no evidence of glacial abrasion, (b) residual soil not far above lake level, (c) the rock island in Lake Cayuga, (d) lack of close parallelism of direction of lakes and of glacial movement, and (e) an apparent lack of enough drift to the south to fill the basins. In the same year Dryer (12) described the western Finger Lakes favoring the ice erosion hypothesis to explain their unique topography. In the following year Tarr published three papers on the district (13)(14)(15). In that entitled "Drainage features of central New York" he recognized the hanging valleys and through valleys as features whose formation antedated the last glaciation. Three theories of origin were considered: (a) ice erosion, (b) erosion by glacial meltwater, and (c) headwater erosion of northward flowing (obsequent) streams. The first was rejected because of the presence of decayed rock in one of the valleys and the divergent direction of valleys and ice movement, although it was suggested that the erosion might have been the result of an older ice invasion. Erosion by glacial waters was rejected because the glacial streams seemed to have deposited more than they eroded. In the same year Fairchild (16) protested strongly against the entire idea of glacial erosion both by continental and mountain glaciers, This was obviously an extreme position, for the unique topographic features of glaciated mountains have long been recognized. In 1906 Tarr (17)(18) definitely stated that most of the glacial erosion must have taken place during a pre-Wisconsin glaciation and stressed the similarity of the Finger Lakes to fiords. The same conclusions were also set forth in a United States Geological

Survey folio published in 1909 (19). Spencer (20) in 1912 denied that there are any true hanging valleys in the district urging that there are drift-filled outlets. In 1915 Rich and Filmer (21) gave the results of a detailed study of the interglacial gorges in the bottom of one of the hanging valleys at Ithaca. They concluded that there had been two interglacial intervals between successive stages of glacial erosion of the main valley. In 1925 and 1928 Fairchild (22)(23) restated his position that the Finger Lake valleys are due to the development of obsequent streams flowing north down the cuesta at the border of the plateau plus the effect of northward depression of the land. In 1931 Von Engeln (24) published an account of another interglacial gorge and in 1932 the same author (25) stated "The phenomenon of the ice of a continental glacier advancing against drainage slopes into and across a major divide in a region of marked relief does not seem to have been duplicated elsewhere. The mass of the glacial ice that followed the northward sloping valleys was thrust into channels that narrowed progressively southward. In accordance with the law of adjusted cross sections, as formulated by Penck, the effect was to accommodate excess of volume by increase in the rate of flow, until the effects of erosion magnified by the faster motion had deepened the passageways enough to provide the enlarged cross section necessary for an unimpeded, uniform forward motion of the glacier." Von Engeln stressed the fact that the erosive effects were small in comparison with the thickness of the ice. These views appear to represent the present-day argument in favor of glacial deepening of north-south valleys forming "through valleys" across divides and leaving hanging tributaries. The major portion of the erosion is ascribed to the first major ice advance into the region, for once enlarged, the valleys could accommodate later invasions. In 1934 Fairchild (26)(27)(28) restated his former views.

Holmes
Von Engeln 1938

Objections to the glacial erosion hypothesis.- To the writer an important objection to the hypothesis of glacial erosion is the fact that "through valleys" and other abnormal topographic features occur throughout a wide area extending far to the south and west of the Finger Lake region. Some occur in the area of pre-Wisconsin dirft southeast of Jamestown where several low passes join the valleys of the Connewango and the Allegheny (see Jamestown and Randolph quadrangles). The through valleys, most of which cut across the ends of spurs, run in such a variety of directions,even at right angles within a short distance, that it seems impossible to conceive of their glacial excavation. Examples of this may be found in the Cattaraugus quandrangle and in the vicinity of Texas Hollow, east of Watkins Glen. A still more important difficulty which has not been met by the advocates of glacial erosion lies in the form of the valleys. Figure 1 shows the gorge-like cross section which is characteristic of most of the smaller valleys. It is clear to the writer that the superficial resemblance of the valleys to fiords plus the fact that most observations have been made on the two largest valleys has led to a misunderstanding of the problem. In the case of the valleys of Lakes Cayuga and Seneca the narrow, steep-sided gorge did not obliterate an older high level mature valleys, which, judging from the distribution of the tributaries, must have in large part once drained south (fig. 2). Matthes' work on the Yosemite Valley has proved that glacial excavation of fiords is due to plucking of jointed rock and not to any extent to abrasion. It must also be realized that most, if not all, fiords were excavated by ice tongues which were confined to them. To the writer, it is impossible to

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conceive that these gorges in New York were made in the same way as were fiords. Surely in thin bedded shale and siltstone erosion by a continental glacier would have produced flaring valley sides merging imperceptibly into the less affected uplands. It is obvious that although Hobbs found some evidence of joint control, the abnormal valleys are not related to shear zones as are fiords on mountainous coasts. It must also be recalled that hanging valleys are not abundant and occur mainly on the sides of the two largest valleys. They are not similar to those in mountains but most owe their origin to stream diversions rather than to glacial "overdeepening" of the main valleys. Moreover crediting the erosion to a previous glaciation seems strange, for no earlier ice advanced farther or remained longer than did the last. In the opinion of the writer the major points in favor of glacial excavation are only two: (a) the straightness of some of the valley walls, and (b) the great depth (below sea level) of the rock floors of the two largest valleys.

<u>Objections to the obsequent preglacial stream hypothesis</u>.- Up to date the only serious rival to the glacial erosion hypothesis has been the suggestion mainly urged by Fairchild of stream diversions due to capture of south-flowing consequent streams by north-flowing obsequent tributaries of the preglacial Ontarian River. On hypothetical maps (Fairchild 1925, 1934) the Susquehanna River is shown flowing north through Horseheads into the valley now occupied by Seneca Lake. This explanation does not account for the facts (a) that the abnormal valleys are youthful and not mature as are all proved preglacial valleys both north-and south-flowing, (b) that abnormal valleys are by no means confined to the escarpment of the cuesta but extend far to the south, and (c) that along some of these valleys there are hanging tributaries as south of Cortland, and (d) that there are two especially large valleys occupied by the two largest lakes whereas this hypothesis would

account only for one. These objections seem to the writer to be insuperable.

Interglacial stream erosion hypothesis.- The writer suggests a third hypothesis, namely the erosive work of interglacial streams whose courses had been deranged by an earlier glaciation (fig. 3). Even a cursory examination of the present stream pattern of the region (fig. 4) shows that it was changed by glaciation. Many streams now cross the rock divides of a former cycle and their erosion is making rapids and falls. Furthermore, when parts of the region were covered by ice, the drainage was temporarily diverted. The huge abandoned plunge-pools of late-glacial falls near Syracuse are excellent testimony to the efficacy of erosion by glacial meltwater although the length of time glacial drainage remained in any one location must of necessity have been relatively brief, much shorter than the duration of an interglacial interval. As each ice sheet advanced against the north edge of the plateau, its drainage was ponded in the heads of the north-flowing preglacial valleys. The outlets of these ancestors of the Finger Lakes must have eroded the cols of the preglacial divide. It is admitted that during the maximum of each invasion glacial erosion straightened and probably somewhat broadened the valleys which offered favorable avenues of approach. The drumlins to the north prove that the glacier was active for some considerable time. During the dissipation of each glacier, melting was probably relatively slow, for the ice was early divided into separate stagnant masses in the numerous valleys and these soon were mantled with melted-out drift. The meltwaters of these times aggraded the south-flowing valleys and deposited ice contact terraces along the margins of the ice blocks. Some open-water lakes must have existed, but these were probably not as large as those of the time of ice advance. When each glacier left the district and its isolated remnants wasted away, the drainage could not resume its former position because of glacial deposits. Although the general tendency must have been to divert streams toward the south following the glacial wash plains, the writer ventures to suggest that two large streams, the Susquehanna and the Chemung, were diverted to the north as shown in figure 3, but both may not have occupied this course in the same interglacial interval. Thus it would come about that for a long period of time the amount of water in certain valleys was greatly increased over that of preglacial time. This would result in the erosion of deep valleys in the bottoms of older valleys leaving many of their tributaries hanging. The relation of the two hanging valleys at Ithaca to the very deep valley of Lake Cayuga is much more readily explained by this theory that it is by glacial erosion, for it is extremely difficult to see how glacial excavation avoided the valley straight ahead and instead turned to one side at this place (fig. 2). The interglacial theory also explains the hanging valleys south of Cortland as well as the youthful valleys of the district including oversteepened bluffs. Similar interglacial valleys have been discovered in Iowa (Kay and Apfel). Although it has been demonstrated (Kay) that there were three interglacial intervals during the Pleistocene each of which was several times as long as the time since the last glaciation, stream erosion did not pass the stage of youth in any of them. In a region such as the Appalachian Plateau the stream diversions due to early glaciations must assuredly have left their mark in just such youthful valleys as have perplexed so many geologists. In the plateau they are visible, for the drift is relatively thin whereas in Iowa later glaciations have buried most of these relics of previously deranged drainage. Possibly the main objection which could be raised is the extreme depth of the two big valleys. It is well to recall that there are no authentic well records supported by samples to show either the true depth of drift in these or their probable northward extension to Lake Ontario. The great depth of that lake is explicable by either (a) high elevation of the continent in interglacial time, (b) regional down-warping during glacial times, or (c) glacial excavation.

<u>Proof of several glaciations</u>.- That no one has suggested interglacial stream erosion as the cause of the anomalous topographic features of western New York is to be explained by the fact that most geologists in that region have not been familiar with the evidences of multiplicity of glaciation which are found in the West (Thwaites, 1927, 1934, pp.59-71). The interglacial deposits at Toronto, Canada north of the area under discussion alone prove one deglaciation of considerable length (Thwaites, 1927, pp. 144-152, 1934, p. 50). Many geologists who have worked in Pennsylvania (Thwaites, 1927, pp. 124-143, 1934, p.75) have had no difficulty in distinguishing and mapping several glacial drifts of widely different ages (Leverett, 1931, 1934).

<u>Conclusion</u>.- It must be emphasized again that the hypothesis of interglacial stream erosion as the cause of the youthful glaciated features of western New York is merely a suggestion which must be proved or disproved by further field work. Even if local glacial erosion be admitted, this hypothesis does explain the origin of <u>some</u> of the valleys.

May 31, 1934

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add Holmes paper

von Engeln later papers

Figure 2. Looking south across Otisco Lake. Note sharp contact between steep side of valley and the rolling upland which appears inconsistent with erosion by a continental glacier.

Figure 3. West side of Skaneateles Lake west of Spafford showing the sharp contact between steep side of valley and rolling upland.

Thwaites 49 (N. Y. S. M.)

Figure 4. Skinner Hollow, Cattaraugus quadrangle, showing steep sides in contrast with mature slopes in distance. Looking south.

Thwaites 51 (N.Y.S.M.)

Figure 5. Alderbottom Hollow, Cattaraugus quadrangle. This is a steep-sided youthful valley which connects two ~~two~~ other valleys, Mosher Hollow and Mud Creek Valley. Mosher Hollow also has steep sides near its south end but runs nearly at right angles to this valley. This appears to be clearly a case of drainage diversion by an earlier glacier.

add Horseheads

Figure 1. Finger Lake region, New York showing present topography. Drawn by F. T. Thwaites, 1933 The northern part of the region is deeply covered with drift which shows many drumlins. The Onondaga escarpment is visible above the drift only near Syracuse (S). South of that latitude youthful valleys, some of which contain lakes, are abundant. W = Watkins, I = Ithaca, C = Cortland. Note that there are many "through valleys" which connect the Lake Ontario drainage in the north with the valley of Susquehanna River in the south part of the region.

Figure 6. Finger Lake Region, New York showing an interpretation of preglacial drainage. Drawn by F. T. Thwaites, 1933. Note that only a few short valleys of north-flowing streams are shown indenting the Onondaga escarpment.

Figure 7. Finger Lake Region, New York showing an interpretation of drainage during an interglacial interval. Drawn by F. T. Thwaites, 1933. Both the Chemung and Susquehanna rivers are shown diverted to the north by morainal deposits. Owing to the great depth of the Ontario Valley farther north, possibly due to glacial erosion, these streams are shown cutting deep youthful valleys across the northern part of the region. Other stream diversions are shown causing the erosion of youthful valleys with local hanging tributaries.

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Objections to the obsequent preglacial stream hypothesis.- Up to date the only serious rival to the glacial erosion hypothesis has been the suggestion mainly urged by Fairchild of stream diversions due to capture of south-flowing consequent streams by north-flowing obsequent tributaries of the preglacial Ontarian River. On hypothetical maps (Fairchild 1925, 1934) the Susquehanna River is shown flowing north through Horseheads into the valley now occupied by Seneca Lake. This explanation does not account for the facts (a) that the abnormal valleys are youthful and not mature as are all proved preglacial valleys both north-and south-flowing, (b) that abnormal valleys are by no means confined to the escarpment of the cuesta but extend far to the south, and (c) that along some of these valleys there are hanging tributaries as south of Cortland, and (d) that there are two especially large valleys occupied by the two largest lakes whereas this hypothesis would account only for one. These objections seem to the writer to be insuperable.

Interglacial stream erosion hypothesis.- The writer suggests a third hypothesis, namely the erosive work of interglacial streams whose courses had been deranged by an earlier glaciation (fig. 3). Even a cursory examination of the present stream pattern of the region (fig. 4) shows that it was changed by glaciation. Many streams now cross the rock divides of a former cycle and their erosion is making rapids and falls. Furthermore, when parts of the region were covered by ice, the drainage was temporarily diverted. The huge abandoned plunge-pools of late-glacial falls near Syracuse are excellent testimony to the efficacy of erosion by glacial meltwater although the length of time glacial drainage remained in any one location must of necessity have been relatively brief, much shorter than the duration of an interglacial interval. As each ice sheet advanced against the north edge of the plateau, its drainage was ponded in the heads of the north-flowing preglacial valleys. The outlets of these ancestors of the Finger Lakes must have eroded the cols of the preglacial divide. It is admitted that during the maximum of each invasion glacial erosion straightened and probably somewhat broadened the valleys which offered favorable avenues of approach. The drumlins to the north prove that the glacier was active for some considerable time. During the dissipation of each glacier, melting was probably relatively slow, for the ice was early divided into separate stagnant masses in the numerous valleys and these soon were mantled with melted-out drift. The meltwaters of these times aggraded the south-flowing valleys and deposited ice contact terraces along the margins of the ice blocks. Some open-water lakes must have existed, but these were probably not as large as those of the time of ice advance. When each glacier left the district and its isolated remnants wasted away, the drainage could not resume its former position because of glacial deposits. Although the general tendency must have been to divert streams toward the south following the glacial wash plains, the writer ventures to suggest that two large streams, the Susquehanna and the Chemung, were diverted to the north as shown in figure 5, but both may not have occupied this course in the same interglacial interval. Thus it would come about that for a long period of time the amount of water in certain valleys was greatly increased over that of preglacial time. This would result in the erosion of deep valleys in the bottoms of older valleys leaving many of their tributaries hanging. The relation of the two hanging valleys at Ithaca to the very deep valley of Lake Cayuga is much more readily explained by this theory that it is by glacial erosion, for it is extremely difficult to see how glacial excavation avoided the valley straight ahead and instead turned to one side at this place (fig. 2). The interglacial theory also explains the hanging valleys south of Cortland as well as the youthful valleys of the district including oversteepened bluffs. Similar interglacial valleys have been discovered in Iowa (Kay and Apfel). Although it has been demonstrated (Kay) that there were three interglacial intervals during the Pleistocene each of which was several times as long as the time since the last glaciation, stream erosion did not pass the stage of youth in any of them. In a region such as the Appalachian Plateau the stream diversions due to early glaciations must assuredly have left their mark in just such youthful valleys as have perplexed so many geologists. In the plateau they are visible, for the drift is relatively thin whereas in Iowa later glaciations have buried most of these relics of previously deranged drainage. Possibly the main objection which could be raised is the extreme depth of the two big valleys. It is well to recall that there are no authentic well records supported by samples to show either the true depth of drift in these or their probable northward extension to Lake Ontario. The great depth of that lake is explicable by either (a) high elevation of the continent in interglacial time, (b) regional down-warping during glacial times, or (c) glacial excavation.

Proof of several glaciations.- That no one has suggested interglacial stream erosion as the cause of the anomalous topographic features of western New York is to be explained by the fact that most geologists in that region have not been familiar with the evidences of multiplicity of glaciation which are found in the West (Thwaites, 1927, 1934, pp.59-71). The interglacial deposits at Toronto, Canada north of the area under discussion alone prove one deglaciation of considerable length (Thwaites, 1927, pp. 144-152, 1934, p. 50). Many geologists who have worked in Pennsylvania (Thwaites, 1927, pp. 124-143, 1934, p.73) have had no difficulty in distinguishing and mapping several glacial drifts of widely different ages (Leverett, 1931, 1934).

Conclusion.- It must be emphasized again that the hypothesis of interglacial stream erosion as the cause of the youthful glaciated features of western New York is merely a suggestion which must be proved or disproved by further field work. Even if local glacial erosion be admitted, this hypothesis does explain the origin of *some* of the valleys.

May 31, 1934

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Figure 2. Looking south across Otisco Lake. Note sharp contact between steep side of valley and the rolling upland which appears inconsistent with erosion by a continental glacier.

Figure 3. West side of Skaneateles Lake west of Spafford showing the sharp contact between steep side of valley and rolling upland.

Thwaites 49 (N. Y. S. M.)

Figure 4. Skinner Hollow, Cattaraugus quadrangle, showing steep sides in contrast with mature slopes in distance. Looking south.

Thwaites 51, NYSM

Figure 5. Alderbottom Hollow, Cattaraugus quadrangle. This is a steep-sided youthful valley which connects two ~~two~~ other valleys, Mosher Hollow and Mud Creek Valley. Mosher Hollow also has steep sides near its south end but runs nearly at right angles to this valley. This appears to be clearly a case of drainage diversion by an earlier glacier.

Figure 1. Finger Lake region, New York showing present topography. Drawn by F. T. Thwaites, 1933 The northern part of the region is deeply covered with drift which shows many drumlins. The Onondaga escarpment is visible above the drift only near Syracuse (S). South of that latitude youthful valleys, some of which contain lakes, are abundant. W = Watkins, I = Ithaca, C = Cortland. Note that there are many "through valleys" which connect the Lake Ontario drainage in the north with the valley of Susquehanna River in the south part of the region.

Figure 6. Finger Lake Region, New York showing an interpretation of preglacial drainage. Drawn by F. T. Thwaites, 1933. Note that only a few short valleys of north-flowing streams are shown indenting the Onondaga escarpment.

Figure 7. Finger Lake Region, New York showing an interpretation of drainage during an interglacial interval. Drawn by F. T. Thwaites, 1933. Both the Chemung and Susquehanna rivers are shown diverted to the north by morainal deposits. Owing to the great depth of the Ontario Valley farther north, possibly due to glacial erosion, these streams are shown cutting deep youthful valleys across the northern part of the region. Other stream diversions are shown causing the erosion of youthful valleys with local hanging tributaries.

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HYPOTHESIS OF ORIGIN OF THE FINGER LAKES, NEW YORK

Introduction
The problem
Previous hypotheses objections to glacial erosion hypothesis
" " obsequent stream preglacial stream hypothesis
~~Hypothesis of I~~ Interglacial stream erosion hypothesis
Proof of several glaciations
Conclusion

Illustrations
Fig 2 Photo 680 Fig 3 Photo 665 Fig 4 T49, Fig 5 T51
Fig 6 preglacial Fig 7 interglacial Fig 1 postglacial

Introduction. The attention of the writer has been drawn to the ~~problem~~ question of the origin of the Finger Lakes in western New York for many years because it bears upon the broader problems of first, the origin of the basins of the Great Lakes and second, of large scale erosion by continental glaciers ~~in general~~. In 1932 while working at the Allegany School of Natural History he had the opportunity to spend two days in the Finger Lake district and ~~the same~~ an equal time in the Cattaraugus quadrangle farther west. On both these trips he was a~~ccompanied and~~ guided by Prof. L. W. Ploger of Syracuse University and ~~whose aid was invaluable~~ Prof. Holmes, also of Syracuse, ~~also~~ participated in the first-named trip. The writer is greatly indebted to both.

The problem. The district under consideration is the northern edge of the Appalachian plateau. For the greater part of the district the plateau slopes rather gradually down to the north ~~for~~ as the escarpment due to the ~~resistant~~ Onondaga limestone is buried beneath glacial drift and the strong sandstones of the basal Pennsylvanian have been eroded from even the highest hills. (See fig. 1). All of the region ~~is~~ was glaciated by the Wisconsin ice whose deposits consist mainly of rather thin ground moraine with a few prominent terminal moraines in the valleys. Almost all the larger valleys are floored with outwash and their sides are terraced with gravel benches, many of which doubtless accumulated while stagnant ice masses separated from the main body of the glacier still ~~lay in them~~ survived in them. The famous drumlin district of western New York lies for the most part north of the Onondaga outcrop line. Within th~~is~~e plateau margin there are three distinct types of rock topography: (a) old, smooth, mature valleys ~~and~~ between rolling hills, all clearly much older than the last glaciation, (b) narrow, youthful gorges, all obviously younger than the last ice invasion, and (c) steep-sided, fairly straight "through" valleys which cut across the divides ~~in~~ of the topography of the first type and have themselves been glaciated. Figs 3, 4, 5 Our problem is the origin and age of the third type of valleys. ~~It is in these valleys that the Finger Lakes lie although not all the valleys of these valleys contain lakes.~~

Previous hypotheses. In the past attention seems to have been directed mainly to these valleys of the third type which contain the remarkably long, narrow, and deep Finger Lakes. The fact that some special explanation must be sought for this ~~type~~ kind of topography seems to have impressed the majority of geologists who studied the region. As far back as 1877 Simmons (1) ascribed the basins of the lakes to glacial erosion, a view also followed by Johnson (2) in 1882. However, it was not until 1892 that Lincoln (3) announced this theory and thus in the ~~American Geologist~~ Journal of Science ~~thus bringing~~ it to the attention of the geological profession. This author was most impressed by the hanging valleys of Cayuga and Seneca Lakes (Fig. 1). In the following year Brigham (4) endorsed the theory of glacial erosion explaining the fact that the lakes are deepest at the south by the fact that glacial flow was most concentrated there.. In 1894 Lincoln (5) restated and amplified his theory. In the same year Tarr (6) laid stress on the hanging valleys and the fact that the lakes are deepest in the shale and not in the Onondaga limestone. Spencer (7) doubted that Lake Cayuga lies in a rock basin. Nevius (8) in 1897 repeated Tarr's ideas. In 1902 Tarr (9) also reinterated his opinion. In 1904 Matson (10) reported upon the interglacial gorges in the bottoms of the hanging valleys, first recognizing the existence of stream erosion in interglacial time. In the same year Tarr (11) described the hanging valleys of the Finger Lake region noting their discordance in level. He also cited a number of facts which ~~were~~ are opposed to the glacial erosion hypothesis. These included (a) angular cliffs within the valleys which showed no evidence of glacial abrasion, (b) ~~the presence of~~ residual soil not far above lake level, (c) ~~a~~ the rock island in Lake Cayuga, (d) ~~the~~ lack of close parallelism of direction of lakes and of glacial movement, and (e) an apparent lack of enough drift to the south to fill the basins.

In the same year Dryer[12] described the western Finger Lakes favoring the ice erosion hypothesis to explain their unique topography. In the following year Tarr published three papers on the district.[13,14,15] In that entitled "Drainage features of central New York" he recognized the hanging valleys and through valleys as ~~unique~~ features~~xxxThree~~ whose formation antedated the last glaciation. Three theories of origin were considered: (a) ice erosion, (b) erosion by glacial meltwater, and (c) headwater erosion of northward flowing (obsequent) streams. The first was rejected because of the presence of decayed rock in one of the valleys, and the divergent direction of valleys and ice movement, although it was suggested that the erosion might have been ~~be~~ the result of an older ice invasion. Erosion by glacial waters was rejected because the glacial streams seemed to have deposited more than they eroded. In the same year Fairchild[16] protested stongly against the entire idea of glacial erosion both by continental and mountain glaciers, obviously an extreme position because the unique topographic features of glaciated mountains have long been recognized. In 1906 Tarr[17,18] definitely ~~abandoned~~ stated that most of the glacial erosion must have taken place during a pre-Wisconsin glaciation and stressed the similarity of the Finger Lakes to fiords. The same conclusions were also set forth in a U. S. Geological Survey folio published in 1909.[19] Spencer[20] in 1912 denied that there are any true hanging valleys in the district uriging that there are drift-filled outlets. In 1915 Rich and Filmer[21] gave the results of a detailed study of the interglacial gorges in the bottom of one of the hanging valleys at Ithaca. They concluded that there had been two interglacial intervals between successive stages of glacial erosion of the ~~main~~ valley. In 1925 and 1928 Fairchild[22,23] restated his position that ~~the history of~~ the Finger Lake valleys are ~~is~~ due to the development of obsequent streams flowing north down the cuesta at the border of the plateau, plus the effect of northward depression of the land. In 1931 Von Engeln[24] published an account fo another interglacial gorge and in 1932[25] the same author stated "The phenomenon of the ice of a continental glacier advancing against drainage sl(o)pes into and across a major divide in a region of marked relief does not seem to have been duplicated elsewhere. The mass of the glacial ice that followed the northward sloping valleys was thrust into channels that narrowed progressively southward. In accordance with the law of adjusted cross sections, as formulated by Penck, the effect was to accom(m)odate excess of volume by increase in the rate of flow, until the effects of erosion magnified by the faster motion had deepened the passageways enough to provide the enlarged cross section necessary for an unimpeded, uniform fo(r)ward motion of the glacier." ~~The fact~~ It was stressed that the erosive effects were small in comparison with the thickness of the ice. These views appear to represent the present-day argument in favor of glacial deepening of north-south valleys forming "through valleys" across divides and leaving hanging tributaries. The major portion of the erosion is ascribed to the first major ice advance into the region, for once enlarged the valleys could accom(m)odate later invasions. In 1934 Fairchild restated his former views (26), 27, 28)

Fig 2 (680)

Objections to the glacial erosion hypothesis. To the writer ~~themaxim~~ an important objection to the hypot(h)esis of glacial erosion is the fact that "through valleys" and other abnormal topographic features occur throughout a wide area extending far to ~~both~~ the south and ~~the~~ west of the Finger Lake region. Some occur in the area of pre-Wisconsin drift southeast of Jamestown where several low passes join the valleys of the Connewango and the Allegheny (see Jamestown and Randolph quadrangles), most of which cut across the ends of spurs. The through valleys run in such a variety of directions, ~~differening by close to~~ even at right angles ~~in~~ within a short distance, that it seems impossible to conceive of their glacial excavation. Examples of this may be found in the Cattaraugus quadrangle and in the vicinity of Texas Hollow, east of Watkins Glen. A still more important difficulty which has not been met by the advocates of glacial erosion ~~is~~ lies in the form of the valleys. Figs. 2, 3, 4, 5 shows the gorge-like cross section which is characteristic of most of the smaller valleys — which extend clear to top. It is clear to the writer that the superficial resemblence of the valleys to fiords plus the fact that most observations have been made on the two largest valleys ~~, those which contain~~

~~Lakes Cayuga and Seneca,~~ has led to a misunderstanding of the problem. In the case of the valleys of Lakes Cayuga and Seneca the narrow, steep-sided gorge ~~has~~ did not obliterate~~d~~ an older high level mature valley, which, judging from the distribution of the tributaries, must have in large part once drained south. (Fig. ~~X~~ 6). Matthes work on the Yosemite Valley has proved that glacial excavation of fiords is ~~primarily~~ due to plucking of jointed rock and not to any extent ~~xf~~ to ~~gx~~ abrasion. It must also be realized that most, if not all, fiords were excavated by ice tongues which were confined to the ~~valleys.~~ m' To the writer, it is ~~xxxx~~ impossible to conceive that these gorges in thin bedded shale and siltstone ~~of~~ in N New York were made in the same way as were fiords. Surely ~~glacial~~ erosion by a continental glacier would have produced flaring valley sides ~~which merged~~ merging impreceptibley into the less ~~unaffected~~ affected uplands. ~~No joint control is evident although years ago~~ It is obvious that, although Hobbs found some evidence of joint control, ~~that~~ the abnormal valleys are not related to ~~structural features~~ shear zones as are fiords on mountainous coasts. It must also be recalled that hanging valleys are not ~~very common~~ abundant and occur mainly on the sides of the two largest valleys. They are not similar to those in mountains but must owe their origin to stream diversions rather than to "overdeepening" of the main valleys. Moreover ~~the~~ "passing the buck" on the matter of erosion to a previous glaciation seems strange for no earlier ice ~~advance~~ ~~seems~~ to have advanced farther or remained longer than did the last. The major points in favor of glacial excavation are, in the opinion of the writer, only two: (a) the straightness of some of the valley walls, and (b) the great depth (below sea level) of the rock floors of the two largest valleys. In the opinion of the writer these do not offset the objections enumerated above.

<u>Objections to the obsequent preglacial stream hypothesis.</u> Up to date the only serious rival to the glacial erosion hypotheses has been the suggestion mainly ~~put forward~~ urged by Fairchild, ~~that~~ of stream diversions due to capture of south-flowing consequent streams by north-flowing obsequent tributaries of ~~a~~ The preglacal ~~E~~ Ontarian River. On ~~a~~ hypothetical maps (~~Fa~~ Fairchild, ~~1925~~ 1934) the Susquehanna River ~~was~~ is shown flowing north through Horseheads ~~and~~ into the valley now occupied by Seneca Lake. ~~The weakness of~~ This explanation ~~are several:~~ (a) ~~(a) it~~ does not account for the fact that the abnormal valleys are youthful and not mature as are ~~the~~ all proved preglacial valleys both north- and south-flowing, (b) that abnormal valleys are by no means confined to the escarpment of the cuesta but extend far to the south, ~~and~~ (c) that along some of these valleys there ~~there~~ are hanging (tributaries as south of Cortland) valleys,

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Fig 3 6
Fig 4 7

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~~strata~~ rhyolite and depositing it at the surface as geyserite or siliceous sinter. In the paint pots the feldspar has been disintegrated with the resulting pure kaolin. The hot water and steam bubbles up through this mass of kaolin. (fig ___).

Insert p. 24

The deposition of this sinter is due in part to the cooling of the waters and in part to algae. The beautiful colorings in the overflow basins of the geysers and the hot springs, ~~and~~ is due to algae. ~~Different algae with different colorings flourish in waters of different~~ (due perhaps to the deposition of a certain mineral) Each group of algae with its coloring seems to be adjusted to water of a certain temperature.

At Silver Gate ~~ax~~ and the Hoodoos typical landslide topography has developed. This may be due to the collapse of the roofs of extensive caverns which had been dissolved in the underlying limestones and the subsequent tumbling of the overlying limestones into a heterogeneous mass or simply to adjustment along a zone of instability or faulting. As their latter explanation is the more simple and is in accord with the extensive faulting of this region, it is favored.

At this point it may be well to state the present theory of geyser action. Surface waters percolate down to the zone of heated rocks and become heated. They then slowly rise to the surface. If they encounter a long narrow tube in the rocks just before they reach the surface, geyser action results in the following manner. As pressure increases the boiling point, the water in the bottom of this tube boils at a higher tempeurature than the water at the top. When the water at the bottom of the ~~bux~~ tube is finally raised to its boiling point, steam developes. and begins to rise. A slight amount of water then overflows at the surface and the pressure on each layer of water is lowered to that extent. Thus each layer is raised. to the boiling point and the geyser erupts.

is a geosyncline which ~~is more sharply~~ bent more sharply upward on the west than on the east. ~~Except along its eas borders this province~~

the Susquehanna and the Chemung, were ~~at one time or another~~ diverted to the north as shown in fig. 3 but both may not have occupied this course ~~This event may n not have occured~~ in the same interglacial interval. Thus it would come about that for a long period of time the amount of water in certain valleys was greatly increased over that of preglacial time. This would result in the erosion of deep valleys in the bottoms of older valleys leaving many of their tributaries hanging. The relation of the two hanging valleys at Ithaca to the very deep valley of Lake Cayuga is much more readily explained by this theory than it is by glacial erosion, for ~~I~~t is extremely difficult ~~for the writer~~ to see how glacial excavation ~~xxxdi~~ avoided the valley straight ahead and instead turned to one side at this place (Fig 2). The ~~xxxx~~ interglacial theory also explains the hanging valleys south of Cortland ~~and all of~~ as well as the youthful valleys of the district including oversteepened bluffs.

Similar interglacial valleys have been discovered in Iowa (Kay and Apfel). Although it has been demonstrated (Kay) that there were three interglacial intervals during the Pleistocene each of which was several times as long as the time since the last glaciation, stream erosion did not pass the stage of youth in any of them. In a region such as the Appalachian Plateau the stream diversions due to early glaciations must assuredly have left their mark in just such youthful valleys as have perlexed so many geologists. ~~T~~ There they are visible ~~while~~ for the drift is relatively thin whereas in Iowa later glaciations have ~~effaced~~ ~~or~~ buried most of these relics of earlier deranged drainage. Possibly the main objection which could be raised is the extreme depth of the two big valleys. It is well to recall that no authentic well and ~~well~~ records supported by samples to show either the true depth of drift in these or their probable northward extension to Lake Ontario. The great depth of that lake is ~~readily~~ explainable by ~~high~~ either (a) high elevation of the continent in interglacial times or (b) regional down warping during glacial times or (c) ~~glacial excavation of the Ontario basin~~ glacial excavation.

The Great Plains

(over)

The Great Plains ~~is a young~~ are ~~still in youth~~. Only a few streams — the Missouri, the Platte, the Arkansas, and the Canadian River — are ~~able~~ large enough to maintain their courses across this region of scant rainfall. They all flow in shallow valleys. ~~It would seem that in the future the~~ In general The portion of this region which lies north of the Missouri River has been modified by glacial erosion and deposition.

The Great Plains region is bounded on the east by the ~~Missouri~~ ~~Coteau of the Prairies,~~ Plateau of the Missouri, a line along the edge of the glacial drift in Nebraska (in general), the approximate eastern edge of the Cretaceous and Tertiary rocks in Kansas), eastern limit of the Smoky Hills, the eastern limit of the Red Hills (Gypsum Hills), and the a line extending west of the Wichita Mountains, ~~eas~~ and northeast of the Callahan Divide to the vicinity of Dallas Texas. On the west ~~it is bounded by the~~ the boundary extends along the foot of the Lewis ~~Mts~~, Big Belt, ~~and~~ Little Belt ~~Mts and~~ Crazy ~~Mts, and~~ the Bighorn ~~Mts~~, Owl Creek, ~~and~~ Wind River, Wasatch, Uintah, Park, ~~along the western~~ ~~Nebraska Buttes~~ Rattlesnake and ~~to the~~ Laramie Mountains, ~~along~~ the ~~base of these~~, the Front Range, the Wet Mountains, and the Sangre de Cristo Range, ~~along the western margin of the Ocate Plateau~~ along the ~~western~~ eastern ~~margin of Pecos Valley~~ scarp of Glorieta Mesa, the "Hills of Pedernal", and the Mesa Jumanes, thence south along the eastern border of the Jicarilla, Capitan, ~~Comanche,~~ Sacramento, Guadaloupe, Davis, Comanche, and Santiago ranges.

~~The two main subdivisions of the Great Plains are the High Plains and the Low Plains.~~

When the Great Plains were raised out of the sea at the beginning of Tertiary time, the whole region with the exception of isolated monadnocks was brought

Proof of several glaciations. That no one has suggested interglacial stream erosion as the cause of the anamolous topographic features of western New York is to be explained by the fact that most geologists in that region have not been familiar with the evidences of multiplicity of glaciation which are found in the West (Thwaites, 1927, 1934, pp. 59-71) The interglacial deposits at Toronto, Canada, north of the area under discussion, alone prove one deglaciation of considerable length (Thwaites, 1927. pp 144-152 1934, p. 50.) Many geologists who have worked in Pennsylvania (Thwaites, 1927, pp 124-143 1934, p. 73.) have had no diffuculty in distinguishing and mapping several glacial drifts of widely different ages. (Leverett, 193 1934)

Conclusion. It must be emphasized again that the hypothesis of interglacial stream erosion as the cause of the youthful glaciated features of western New York is merely a suggestion which must be proved or disproved by further field work. However, it certainly is something that must be considered as it apparently never has been in the past. It is something that must certainly explain some of the valleys. ~~If true only in part it will relegate the ~~glacial~~ eros older hypotheses to relatively minor places~~ even if local glacial erosion be admitted

May 31, 34

which are ~~[illegible]~~ subdivided into twenty districts. Wherever the latter is not a homogeneous area, it is further subdivided into sections.

I Introduction

For convenience of discussion the United States has been divided into physiographic provinces. ~~Each~~ Though each ~~prov~~ is a unit in itself it ~~conta~~ may contain sections which have few of the characteristics of the whole province. The southern part of the Columbia Plateau, for example, contains young block mountains which are not characteristic of the region as a whole. Accordingly authorities ~~differ as to what sectio~~ on this subject have not divided the country into the same number of physiographic provinces. ~~nor have they~~ Fenneman divides the country into the country into eight ~~major~~ ~~division~~ provinces — list them — ~~and whenever it is not a homogeneous area he subdivides it into sections~~ districts (own). Sobeck, on the other hand, ~~two~~

2 Fenneman, - - - - pp 30-35

divides the country into seventeen provinces. — list them — Wherever this is great diversity as in the Appalachian Plateau, the province is discussed in sections.[2] Bowman, who was interested primarily

2 Sobeck - - -

in the forests of the United States divides the country into twenty-two main divisions.[3]

3 Bowman

In this paper only the ~~region traversed in the~~ Great Plains, the Southern Rockies, and the Northern Rockies will be discussed.

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the timberline in this locality.

Echo Lake is below timberline. It ~~seems to~~ is circular in shape and seems to be in a poorly developed cirque. It may, however, be due simply to damming by glacial drift (fig —).

From Mt Goliath we could see the cirques on the opposite side of the valley. When we turned around on Mt Goliath at an altitude of 14,000 feet we saw many ~~streams flo~~ streamlets flowing from the rapidly melting snow.

~~In Bear Creek Canyon~~

Bear Creek Canyon immediately to the south has been cut in the crystallines. Its course is to a large extent determined by joint cracks.

To the north is Boulder Creek. The eastern portion is a V-shaped canyon. ~~Between 2 and 3 miles west of Rollinsville it becomes broader and has a flat bottom~~. In the vicinity of Rollinsville the creek ~~seems~~ valley has a flat floor. A little farther to the west is a ridge or terminal moraine. Above in Boulder Park the valley is flat floored and swampy and the creek meanders from side to side. As meanders have been abandoned, ox-bow lakes have been produced. Mammoth Gulch south of Boulder Park and Jenny Creek to the north are hanging valleys. The glaciers which flowed in these valleys were weaker than the (composite) one which flowed in the main valley and hence were not able to erode as rapidly. To the west the railroad passes around a number of glacial cirques, several of which now contain lakes — Johnny Lake and Yankee Doodle Lake (fig —).

(12,000 feet in altitude)

At the Corona, the crest of the Continental divide, the western slope is fairly gentle and covered with alpine

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we stopped in a glacial cirque and noted the moraine. At Bottomless Pit we looked down into another glacial cirque. 18

On Pikes Peak the timberline occurs at 11,500 feet and above is the heterogeneous mass of crumbling boulders.

Windy Point at the summit of Pikes Peak is an arête between two cirques. The slopes to the east are on the walls of cirques and are therefore very steep. The slope to the west is ~~mo~~ unglaciated and hence more gentle. It is ascended by the ~~cog~~ railway.

At Florrisant we were near South Park. In early Tertiary time this region must have had a more humid climate than it enjoys today, for it supported a forest of huge California redwoods. Then a period of swampy conditions prevailed, the trees died, and the bark probably rotted off. ~~The~~ This area ~~then became~~ was then covered with volcanic ash rich in silica. Percolating waters deposited silica as the root rotted and thus preserved the original structure of the grains of wood. Insects and leaves were also preserved in this manner.

This Florrisant district with its volcanic tuff ~~serves~~ ~~as a transition between the~~ is similar ~~to the~~ to the San Juan Mountains and may serve to connect ~~them~~ with the two main ranges.

~~At the Gem Mines we saw many large pe~~

~~The eastern slopes of the mountains west of Denver~~ have also ~~been greatly steepened by glacial erosion.~~

Lookout Mountain west of Denver attains an altitude of 7375 feet and represents the surface of the tertiary peneplain. This mountain is ~~too~~ also composed of

~~Buffalo Bill and his wife are buried on this mountain.~~

schist and is cut by pegmatite dikes. Some gneiss is also present. From the summit we could see the mesas at Golden, Green Mountains, and the Plains. We could also see ~~in~~ in the distance a dike along a [fault ~~plane~~ line. Genesee Pass was at an elevation of 8,110 feet and Squaw Pass] 11,000 feet-

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

STATE OF NEW YORK
REPRESENTED BY THE
DEPARTMENT OF PUBLIC WORKS

NEW YORK
CATTARAUGUS QUADRANGLE

Topography by H.H.Hodgeson, E.B.Hill, E.V.Holloway, and R.J.Belton.
Surveyed in 1921.

APPROXIMATE MEAN DECLINATION, 1921

Scale $\frac{1}{62500}$

Contour interval 20 feet.
Datum is mean sea level.

Polyconic projection. North American datum.
5000 yard grid based upon U.S. zone system, B.

CATTARAUGUS, N.Y.
Edition of 1923.
reprinted 1931

THE TOPOGRAPHIC MAPS OF THE UNITED STATES

The United States Geological Survey is making a standard topographic atlas of the United States. This work has been in progress since 1882, and its results consist of published maps of more than 42 per cent of the country, exclusive of outlying possessions.

This topographic atlas is published in the form of maps on sheets measuring about $16\frac{1}{2}$ by 20 inches. Under the general plan adopted the country is divided into quadrangles bounded by parallels of latitude and meridians of longitude. These quadrangles are mapped on different scales, the scale selected for each map being that which is best adapted to general use in the development of the country, and consequently, though the standard maps are of nearly uniform size, they represent areas of different sizes. On the lower margin of each map are printed graphic scales showing distances in feet, meters, and miles. In addition, the scale of the map is shown by a fraction expressing a fixed ratio between linear measurements on the map and corresponding distances on the ground. For example, the scale $\frac{1}{62,500}$ means that 1 unit on the map (such as 1 inch, 1 foot, or 1 meter) represents 62,500 similar units on the earth's surface.

Although some areas are surveyed and some maps are compiled and published on special scales for special purposes, the standard topographic surveys for the United States proper and the resulting maps have for many years been divided into three types, differentiated as follows:

1. Surveys of areas in which there are problems of great public importance—relating, for example, to mineral development, irrigation, or reclamation of swamp areas—are made with sufficient accuracy to be used in the publication of maps on a scale of $\frac{1}{31,680}$ (1 inch = one-half mile), with a contour interval of 1, 5, or 10 feet.

2. Surveys of areas in which there are problems of average public importance, such as most of the basin of the Mississippi and its tributaries, are made with sufficient accuracy to be used in the publication of maps on a scale of $\frac{1}{62,500}$ (1 inch = nearly 1 mile), with a contour interval of 10 to 25 feet.

3. Surveys of areas in which the problems are of minor public importance, such as much of the mountain or desert region of Arizona or New Mexico, are made with sufficient accuracy to be used in the publication of maps on a scale of $\frac{1}{125,000}$ (1 inch = nearly 2 miles), with a contour interval of 25 to 100 feet.

A topographic survey of Alaska has been in progress since 1898, and nearly 43 per cent of its area has now been mapped. About 10 per cent of the Territory has been covered by reconnaissance maps on a scale of $\frac{1}{625,000}$, or about 10 miles to an inch. Most of the remaining area surveyed in Alaska has been mapped on a scale of $\frac{1}{250,000}$, but about 4,000 square miles has been mapped on a scale of $\frac{1}{62,500}$ or larger.

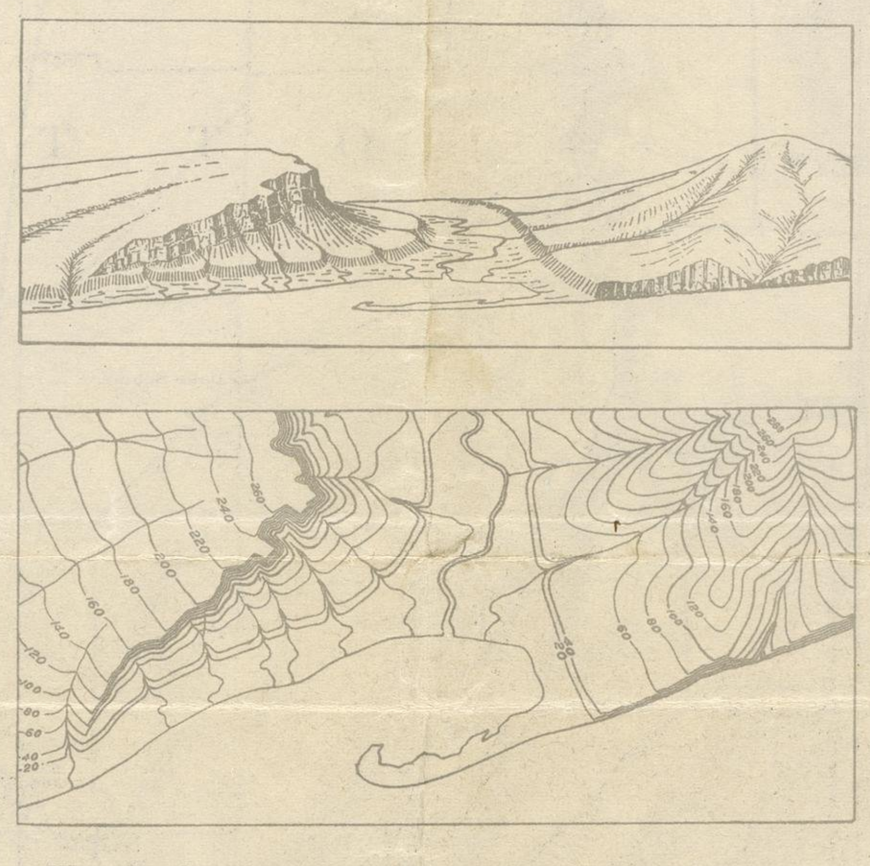
The Hawaiian Islands, with the exception of the small islands at the western end of the group, have been surveyed, and the resulting maps are published on a scale of $\frac{1}{62,500}$.

The features shown on these maps may be arranged in three groups—(1) water, including seas, lakes, rivers, canals, swamps, and other bodies of water; (2) relief, including mountains, hills, valleys, and other features of the land surface; (3) culture (works of man), such as towns, cities, roads, railroads, and boundaries. The symbols used to represent these features are shown and explained below. Variations appear on some earlier maps, and additional features are represented on some special maps.

All the water features are represented in blue, the smaller streams and canals by single blue lines and the larger streams, the lakes, and the sea by blue water lining or blue tint. Intermittent streams—those whose beds are dry for a large part of the year—are shown by lines of blue dots and dashes.

Relief is shown by contour lines in brown, which on some maps are supplemented by shading showing the effect of light thrown from the northwest across the area represented, for the purpose of giving the appearance of relief and thus aiding in the interpretation of the contour lines. A contour line represents an imaginary line on the ground (a contour) every part of which is at the same altitude above sea level. Such a line could be drawn at any altitude, but in practice only the contours at certain regular intervals of altitude are shown. The line of the seacoast itself is a contour, the datum or zero of altitude being mean sea level. The 20-foot contour would be the shore line if the sea should rise 20 feet. Contour lines show the shape of the hills, mountains, and valleys, as well as their altitude. Successive contour lines that are far apart on the map indicate a gentle slope; lines that are close together indicate a steep slope; and lines that run together indicate a cliff.

The manner in which contour lines express altitude, form, and grade is shown in the figure below.



The sketch represents a river valley that lies between two hills. In the foreground is the sea, with a bay that is partly inclosed by a hooked sand bar. On each side of the valley is a terrace into which small streams have cut narrow gullies. The hill on the right has a rounded summit and gently sloping spurs separated by ravines. The spurs are truncated at their lower ends by a sea cliff. The hill at the left terminates abruptly at the valley in a steep scarp, from which it slopes gradually away and forms an inclined table-land that is traversed by a few shallow gullies. On the map each of these features is represented, directly beneath its position in the sketch, by contour lines.

The contour interval, or the vertical distance in feet between one contour and the next, is stated at the bottom of each map. This interval differs according to the topography of the area mapped: in a flat country it may be as small as 1 foot; in a mountainous region it may be as great as 250 feet. Certain contour lines, every fourth or fifth one, are made heavier than the others and are accompanied by figures showing altitude. The heights of many points—such as road corners, summits, surfaces of lakes, and bench marks—are also given on the map in figures, which show altitudes to the nearest foot only. More exact altitudes—those of bench marks—as well as the geodetic coordinates of triangulation stations, are published in bulletins issued by the Geological Survey.

Lettering and the works of man are shown in black. Boundaries, such as those of a State, county, city, land grant, township, or reservation, are shown by continuous or broken lines of different kinds and weights. Good motor or public roads are shown by fine double lines, poor motor or private roads by dashed double lines, trails by dashed single lines.

Each quadrangle is designated by the name of a city, town, or prominent natural feature within it, and on the margins of the map are printed the names of adjoining quadrangles of which maps have been published. Over 3,300 quadrangles in the United States have been surveyed, and maps of them similar to the one on the other side of this sheet have been published.

The topographic map is the base on which the geology and mineral resources of a quadrangle are represented, and the maps showing these features are bound together with a descriptive text to form a folio of the Geologic Atlas of the United States. More than 220 folios have been published.

Index maps of each State and of Alaska and Hawaii showing the areas covered by topographic maps and geologic folios published by the United States Geological Survey may be obtained free. Copies of the standard topographic maps may be obtained for 10 cents each; some special maps are sold at different prices. A discount of 40 per cent is allowed on an order for maps amounting to $5 or more at the retail price. The geologic folios are sold for 25 cents or more each, the price depending on the size of the folio. A circular describing the folios will be sent on request.

Applications for maps or folios should be accompanied by cash, draft, or money order (not postage stamps) and should be addressed to

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September, 1928.

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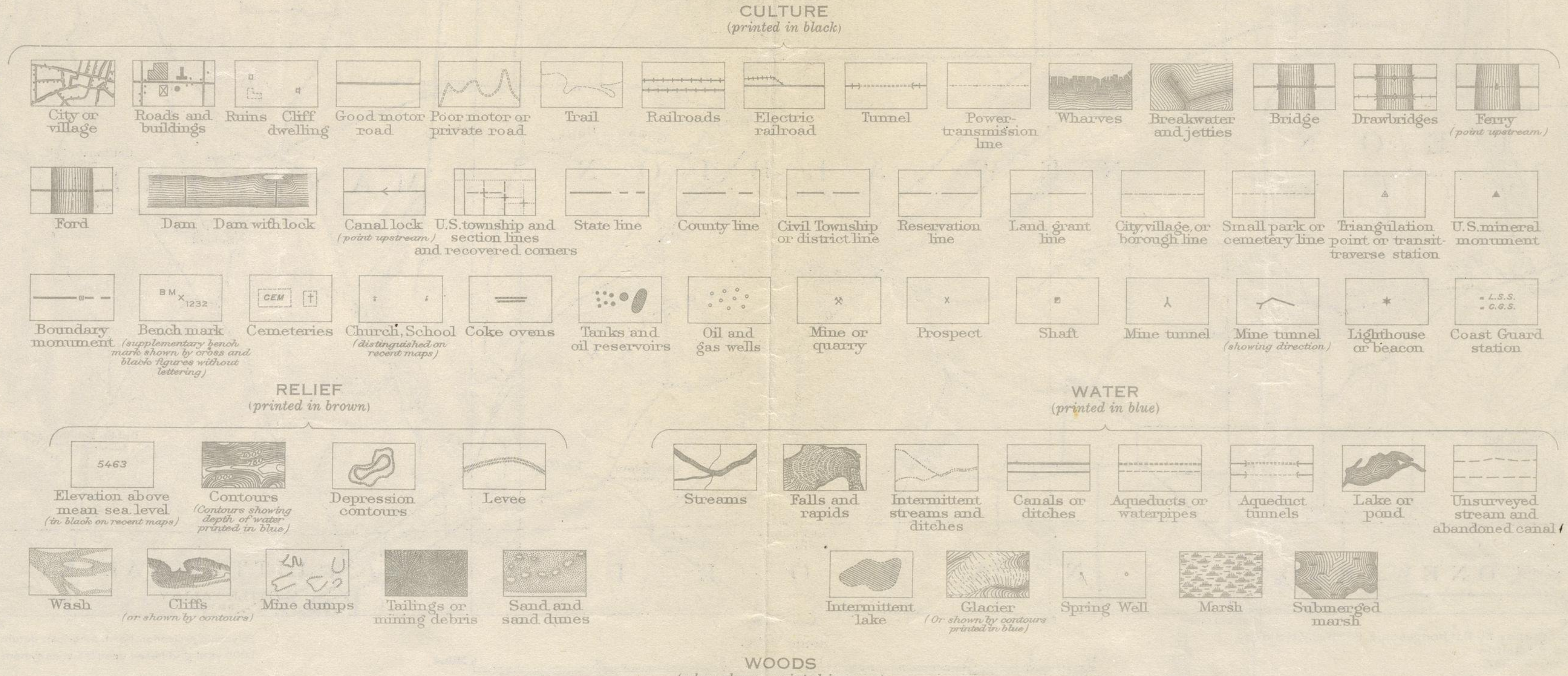

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1893

(Elev 441) (Elev 378)
Seneca 618 Cayuga 435 Skaneateles 275

Canandaigua 240

deepest to S

Flat bottomed valleys - discharged to N - open that way - general slope to N - no moraine to N.

Skan. L. Elev 86 - Depth 300 - rock 50' below outlet and 1-2 m to N

Owasco - rock near RR. sta. in outlet

Seneca - 240' drift at Geneva line 378' above lake bottom

Wages unexaggerated section -

deeper lakes to S because of concentrated flow

Fairchild H L Geologic Romance of the Finger Lakes.

1928

Smithsonian Inst. Rept 1927, 289-298, 1928

Emphasizes change to obsequent drainage. depression to N denies rock rim. Runs Susq. R through Seneca through Elmira Deepest lakes where most soft strata

Finger Lakes readings

GEOLOGY 130
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xiii + 397

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(AG 14, 1945)

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Watson T L Some higher levels in 1897

The postglacial development of the Finger lakes. lake history only

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9 170-182, 1902 (New York)

Tarr. R S 1904

(11) Hanging valleys of the Finger Lake region of central N.Y.

Am Geol 33, 271-291, 1904

Refers to Lincoln 1892, Tarr 1894

discordance of levels of hanging valleys.

opposed gorge form p 285

" angular cliffs not eroded

" residual soil + caves

" island in Cayuga

" direction of ice movement

" lack of enough drift

Favors rejuvenation by uplift

1904

(12) Dryer, C R Finger Lake region of western New York

GSA B 15, 449-460, 1904

favored glac. erosion

13 Tarr. RS Drainage features of central New York 1905

GSAB 16 229-242, 1905

hanging valleys
low divides = through valleys

2 ages of youthful valley one postglac - other glacial

Ice erosion
glacial drainage, of decayed rock - divergent direction - possibly older ice eroded
headwater erosion - depositing not eroding

1905

16 Fairchild. Ice erosion Theory a fallacy 13-74

GSA 16

p66 bottom vaguely suggests interglacial idea

14 Tarr RS. ~~Drainage features of cent~~
The gorges and waterfalls of central New York
Am geogr. Soc Bull 37, 193-212, 1905

15 Tarr, RS Some instances of moderate glacial erosion: JG
13, 160-173, 1905

1906

(17) Jan RS

glacial erosion in the Finger Lake region of central New York.

JG 14 18-21. 1906

discusses 2 stages of glacial erosion

most erosion pre-Wis. opposed only one phase of erosion between Cayuga L and Salmon Cr. Stresses similarity to other regions

(18) add Pop. Sci. Monthly papers

6 Tarr RS Lake Cayuga a rock basin 1894
GSA B 5 339-356, 1894

stresses hanging valleys bottoms decline to N
S part deepest is in shale N pt in ls.
Chamb. stressed erosion to get depth :. source of moraine in lake!

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1 Simmons F W The Geology of Ithaca, New York 1877
not read and the vicinity. Am Nat. 11, 1877, 49-51

---

2 Johnson, L. The parallel drift-hills of 1882
western New York. NYASci, Annals,
2, 1882, ~~91-95~~
249-266

Spencer, JWW Hanging valleys and their preglacial equivalents
19 in New York. GSA B 23. 477-486, 1912

---

7 Spencer JWW The rock basin of Cayuga Lake, Am. Geol. 14
134-135, 1894, brief protest urging warping up to N and
denying hanging valleys

(3) Lincoln, D F   glaciation in the F. L region of N.Y.   1892

AJS (3) 44, 290-301, 1892

mentions hanging valleys

discordance of beds means either fill with ou to S or glacial erosion to N

lake deepest to S (cites Geikie)

1893

Brigham 1893 next

~~(5).   Amt of gl. erosion in the F L region of N.Y.~~   1894

~~AJS (3) 47, 105-113, 1894~~

~~Lincoln was an MD at Geneva, NY~~

"Any long ~~[illegible]~~ stretch of horizon tends to resemble a line drawn with a ruler." p 107

wells at lake shore in Geneva 205 - 240' to rock

evidence (a) incompatible levels of valleys to N and those to S

(b) lack of stream piracy of high level rivers

(c) lack of side valleys of lanes

(10) Watson - a contribution to ~~the interglacial~~ study of the interglacial gorge problem - recognizes interglacial stream etc. JG 12: 133-151, 1904

(2) Rich JL & Filmer EA The interglacial gorges of Six mile creek also recognize same   JG 23, 59-80,   1915

preglacial - 6 m creek flowed N

1st glacial - erosion to U form - C. trough deepened more (why?)

1st interval - gorge cut

2nd glacial - more erosion

2nd interglacial - another (200') gorge to low level

Wis glac. little erosion - maybe the ice made moraine to S

cites Chamberlin 3rd AR

Post glacial erosion

considered alternatives

(2) Johnson, Lawrence, The parallel drift hills of western New York

NY Acad. Sci., Ann, 2, 249-266, 1882

progressively [illegible]. In accordance with the law of adjusted cross section, as formulated by Penck, the effect was to accomodate the excess of volume by increase in the rate of flow, until

the effects of erosion magnified by the faster motion had deepened the passageways enough to provide the enlarged cross section necessary for an unimpeded, uniform forward motion of the glacier

Ice 3000' thick - damage of advancing ice important in lowering divides

recognizes diversions before last invasion

interglacial interval proved by gorges

1909

19 Williams, H S, Tarr, R S and Kindle, E M. Watkins-Glen - Catatonk Folio

No 169, 1909

glacial erosion p 16

No Wis. erosion - diagonal rock.

angular cliffs

Erosion of valleys proved by steep wall below 900'

straight outline - hanging valleys

Refs to G S A 16, 229-242 ✓

A G 33, 271-291

J G 14, 18-21

Pop Sci. Mo 68, 387-397

Older erosion because of interglacial gorges.

finds old soil in valleys, angular cliffs

old gorges not eroded

∴ older glacier did erode

Physiographic record 29-31

old mature upland

rejuvenation at valleys to 900-1000 ft level

2nd rejuv may be ice erosion

1912

20 ~~19~~ Spencer J W W

1925

1928

22 23 Fairchild

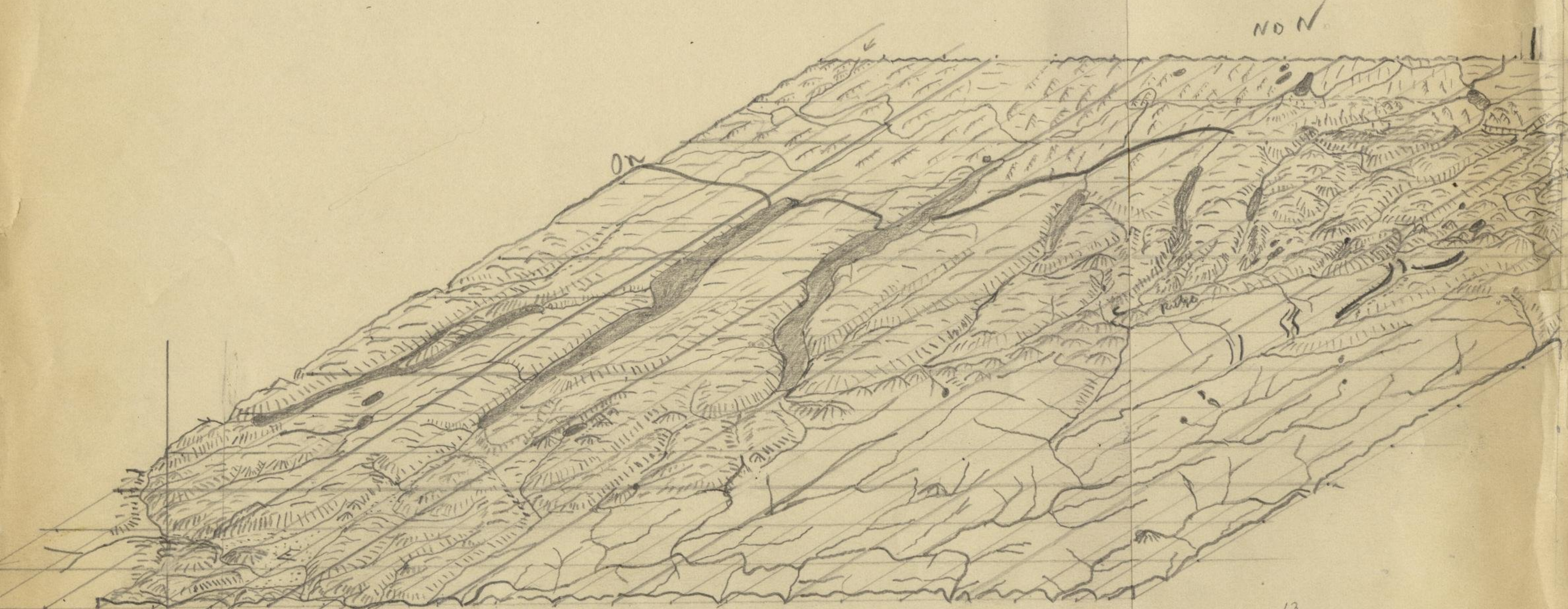
~~23 Von Engeln, O D a preglacial or interglacial gorge near Seneca Lake, New York~~ 1931

NYS M B 286, 127-133, 1931

~~24~~ Von Engeln, O D The Finger Lake region: XVI International ~~Cong.~~ Geol. ~~[illegible]~~ Congress'

~~16th Sess~~. Guidebook 4, ~~47~~ - ~~53~~ 49 - 57 1932

The phenomenon of the ice of a continental glacier advancing against drainage slopes into and across a major divide in a region of marked relief does not seem to have been duplicated elsewhere. The mass of the glacial ice that followed the northward sloping valleys was thrust into channels that narrowed



13
6
78

CO. REPORT NO.__________ LOCATION NO.______

DATE Aug 27. 32 GEOLOGIST______________

The_____ ¼ of the_____ ¼ of Sec._____ Tp._____ R._____

Photo No 2. roll # 20 O f22 5 sec -
junction of Pony Hollow & Cayuta creek
Photo looking SE showing Truncated (?)
spurs. 5 pm cloudy
No 3 - looking SW at moraine on side of
Welz hill. 7 sec.

Page__________

CO. REPORT NO. LOCATION NO.

DATE Aug 28. 32 GEOLOGIST

The ¼ of the ¼ of Sec. Tp. R.

#4 well 20 G f32 5 sec - cloudy
looking SW over Ithaca

no print #5 ortho no filter - spoiled
? 6 " G long f45 . 40 sec.
looking N over Cayuga Lake

#5 well 20 K2 f22 ½ . 25 ft.
looking NW at sand lense in
marginal outwash at Ludlowville
pit shows much x-b dipping SW
most horizontal. Sand lenses slumped
or slidden (?) . Some open work gravel.
Sorting fair to poor. Tops weathered
~~to~~ 1½ ft to several feet in pipes.
secondary calcium carbonate but no
conglomerate - some silt bands oxidized

#

Page

CO. REPORT NO. LOCATION NO.

DATE Aug 28. 32 GEOLOGIST

The ¼ of the ¼ of Sec. Tp. R.

W. side lake mandana — #9 ortho G f45 long 30 sec - gray hood. looking S on Skaneateles lake showing steep sides

? — #6 roll - G f32 5 sec looking S

W of — # 10 ortho G f45 long 60 sec - looking up S. lake

Spafford — #1 roll 21 G f22 5 sec - looking up lake (N)

2 W. across lake

3. do to S.

4 S of Scott - terrace across valley f32 G 5 sec dull W of Factory Creek

#11 ortho f45 short G 10 sec - gravely looking S up Otisco valley from near Otisco Valley

12 ortho f45 long G 45 sec gray looking S down Otisco L

Page

CO. REPORT NO. LOCATION NO.

DATE Aug 28, 32 GEOLOGIST

The ¼ of the ¼ of Sec. Tp. R.

#5 roll 21 G f22 6 sec - looking SE into cross gorge SE of Marcellus - ascribed to glacial waters - Clear of leaf 5 80

#6 G f22 - 5 sec. mesa in ~~Ot~~ marcellus - Cedarvale valley looking SE 4 20 PM

#1 roll 22 - G-f22 - 4 sec - looking N at Canoe E of Cedarvale N/S Onondaga village

#2 roll 22 G f22 - 5 sec -

Poult Res. plunge pool lk. N

#3 same 4 sec - looking E at outlet & Solvay quarry in Onondaga

#4 N of Tully G f22 30 sec -
same long
lk. S at TM in valley

CO. REPORT NO. LOCATION NO.

DATE Aug 29, 32 GEOLOGIST

The ¼ of the ¼ of Sec. Tp. R.

#5 G f22 - 5 sec - looking w at Allentown oil field ~~Bliown~~ Bolivar oil pool.

#6 same farther down valley

Page

Whitney F-I 05

Tarr 05 WSP ~~110~~

~~134-140~~

~~55-64~~

Rundle 05 a

WSP 145

~~53-57~~

JG 12, 69 -

Finger Lakes GSA 15, 449-60

Dryer 04, ~~06~~ western area

forming gl. ervin

~~Caswold 55 c~~

~~Rich 08~~

Watson 99 NYSM AR 51

r5 5-117, 1899

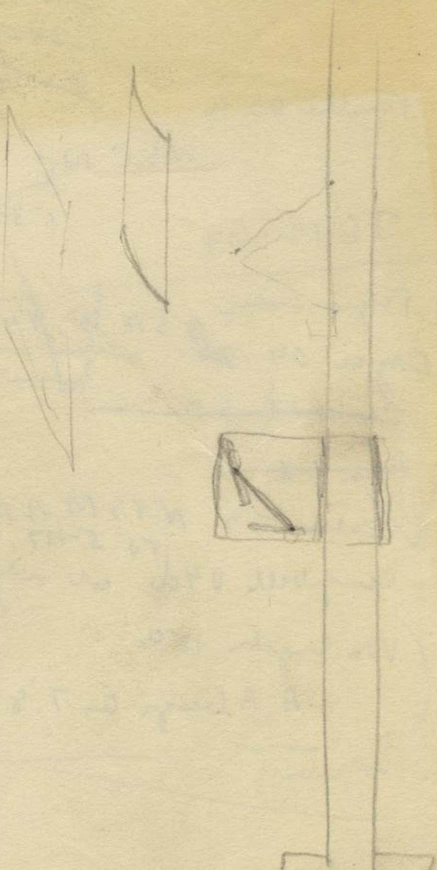
Campbell 04d ab[illegible]

(Von Engeln 18a

A A Geogr An 7, 83-85

1918

important



p 66 bottom

Fairchild on Ice

Erosion a falling

GSA 16

HERMAN L. FAIRCHILD
GEOLOGIST

OFFICE AND MAIL ADDRESS
CARNEGIE BUILDING
UNIVERSITY OF ROCHESTER

ROCHESTER, N.Y.

Sept. 17, 1934.

Dear Professor Thwaites:-

Your central New York drainage idea is "'way off". It ignores the erosion in Tertiary time, the effects of rock control, and vastly overestimates any possible interglacial work. I will be more specific.

Tertiary conditions.

In late Tertiary time this province in America stood several thousand feet higher A. T. than at present. The New York rivers carved deep canyons, graded to the master stream in the Ontario Valley. At Watkins the drill failed to reach rock at 1,200 feet; and at Ithaca at 1,250 feet. Even today the bottom of Lake Ontario is quite 500 feet below sealevel, with unknown depth of drift.

The millions of years of the Tertiary was perhaps 50 or 100 times the duration of any possible interglacial stage, yet your diagrams gives more erosional credit to the interglacial, when the land was at lower elevation than it is now.

Interglacial Stage.

No interglacial deposits have been found anywhere in New England, New York, New Jersey and Pennsylvania. And no other evidence has been discovered. The drainage features which have been cited as evidence could have been produced in a century, or centuries, of the changing positions of the oscillating ice margin. The only recognized interval of deglaciation was that in closing Wisconsin time, described in the G. S. A. Bull. Vol. 43, page 603. The Quebec ice cap may have lingered over the eastern area while it was fickle in your province. The Wisconsin reach was practically as great as the earlier and greatest invasion.

And the ice cap load had depressed the area.

Of course, it is legitimate to appeal ~~to appeal~~ to long deglaciation, but it is only assumption for New York.

Rock Control.

An effective west-east trough along the outcrop of Salina strata threw the tributary drainage in western and central New York into east and west courses in preglacial time, the same as today. (See Cayuga Valley paper, in the Bulletin, Vol. 45, pp. 233-280). The only Tertiary trenches across the Niagara ridge were the Irondequoit (Genesee River) and Sodus (Susqeseneca). And today only Niagara, Genesee and Oswego trench the barrier on the north.

Sincerely,

Fairchild

March 23, 1936

Dr. Chas C. Adams, Director,
New York State Museum,
Albany, New York

Dear Dr. Adams:

Reply to yours of Feb. 19 has been delayed until I could put in the illustrations with the manuscript. As this was not classed as a "rush job" it had to wait its turn. However, the job is now done. You will note that I have included two New York State Museum photos in blank as I have no extra prints. I have also sent only blueline prints of the drawings. If after reading by those able to judge, you decide to publish I can send either the originals or vandyke positives.

Now you will probably not get very much in the way of favorable reaction to what the late W. M. Davis would have termed an "outrageous hypothesis". Ploger was impressed but not Holmes or Fairchild. I sent copies of the block diagrams to the latter once. In fact most geologists who have been trained in the East seem not to be impressed with evidence of multiplicity of glaciation. It should be noted that the paper does not pretend to settle the problem of the Finger Lakes but simply to present another factor in the physiographic history of the Apphlachian Plateau which must certainly be reckoned with in rendering a final opinion. My work was not enough to enable me to render such an opinion.

We have all been sorry to hear of Lobeck's poor health and hope that the long trip will help him. In fact, we who are finding the Depression getting worse instead of better, may secretly envy him being able to make it!

The main point in publishing the paper is to be sure that it will not be against the wishes of Ploger for I did much of the work in the field in his area, the Cattaraugus quadrangle. Otherwise I do feel that it presents a new idea and that is what is needed to make progress in science.

With best regards,

Sincerely,

F. T. Thwaites

not
read

New York Acad Sci, Annals. vol 2
1882,

Am. Naturalist, vol. 11, 1877

Finger Lakes

Z

O

R

THE UNIVERSITY OF THE STATE OF NEW YORK
THE STATE EDUCATION DEPARTMENT
NEW YORK STATE MUSEUM
ALBANY, N. Y.

CHARLES C. ADAMS
Director
ALVIN G. WHITNEY
Assistant Director

February 19, 1936.

OFFICE OF DIRECTOR

Mr. F. T. Thwaites,

Geologist,
R.F.D. No. 4,

Madison, Wisconsin

Dear Mr. Thwaites:-

I have your letter of February 17 about your paper on the Valleys of the Finger Lakes. I believe that all the difficulty with Ploger is that he has been overloaded with teaching. So send on your manuscript and I will gladly send it to him. If you decide to publish it, it is possible that we may be able to ~~publish it~~, as it is the outcome of your work at the Allegany Park.

A few months ago I saw Lobeck in New York City and had a pleasant visit with him. He was planning for a long ocean trip, and possibly some time in the South West. He has not had good health for some time.

Very sincerely,

Chas. C. Adams

Chas. C. Adams,

Director.

Feb. 17, 1936

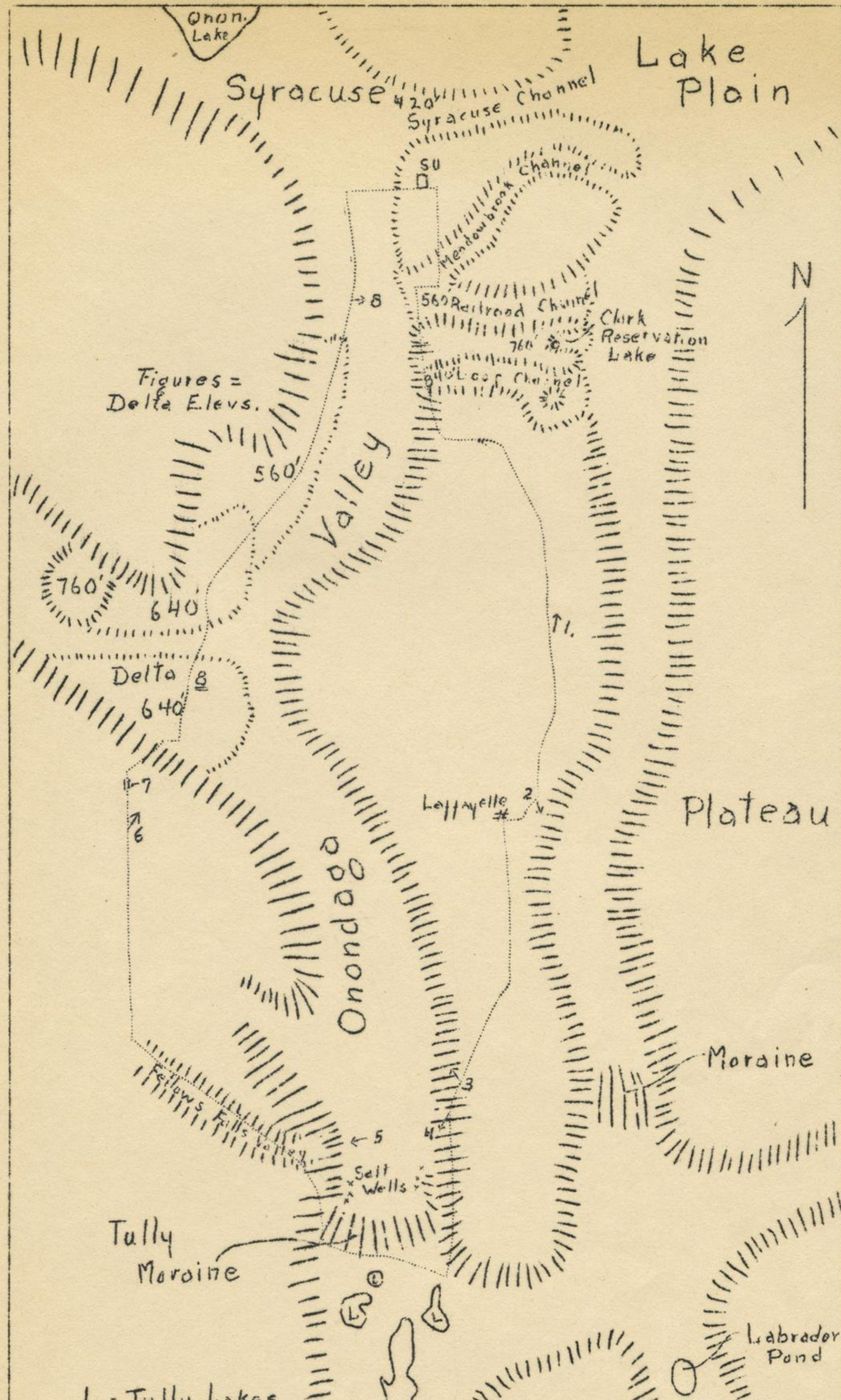
Dr. C. C. Adams, Director,
New York State Museum,
Albany, New York

Dear Dr. Adams:

After many delays due to other matters which were classed as "rush" I have completed the manuscript of a paper which presents some ideas on the origin of the valleys in which the Finger Lakes are situated. This idea of interglacial stream erosion has been published in brief in my text book, "Outline of Glacial Geology". It was first proposed to Prof. Fleger while we were going over the Cattaraugus Quadrangle in '32. Later I visited the lakes with Fleger and Holmes.

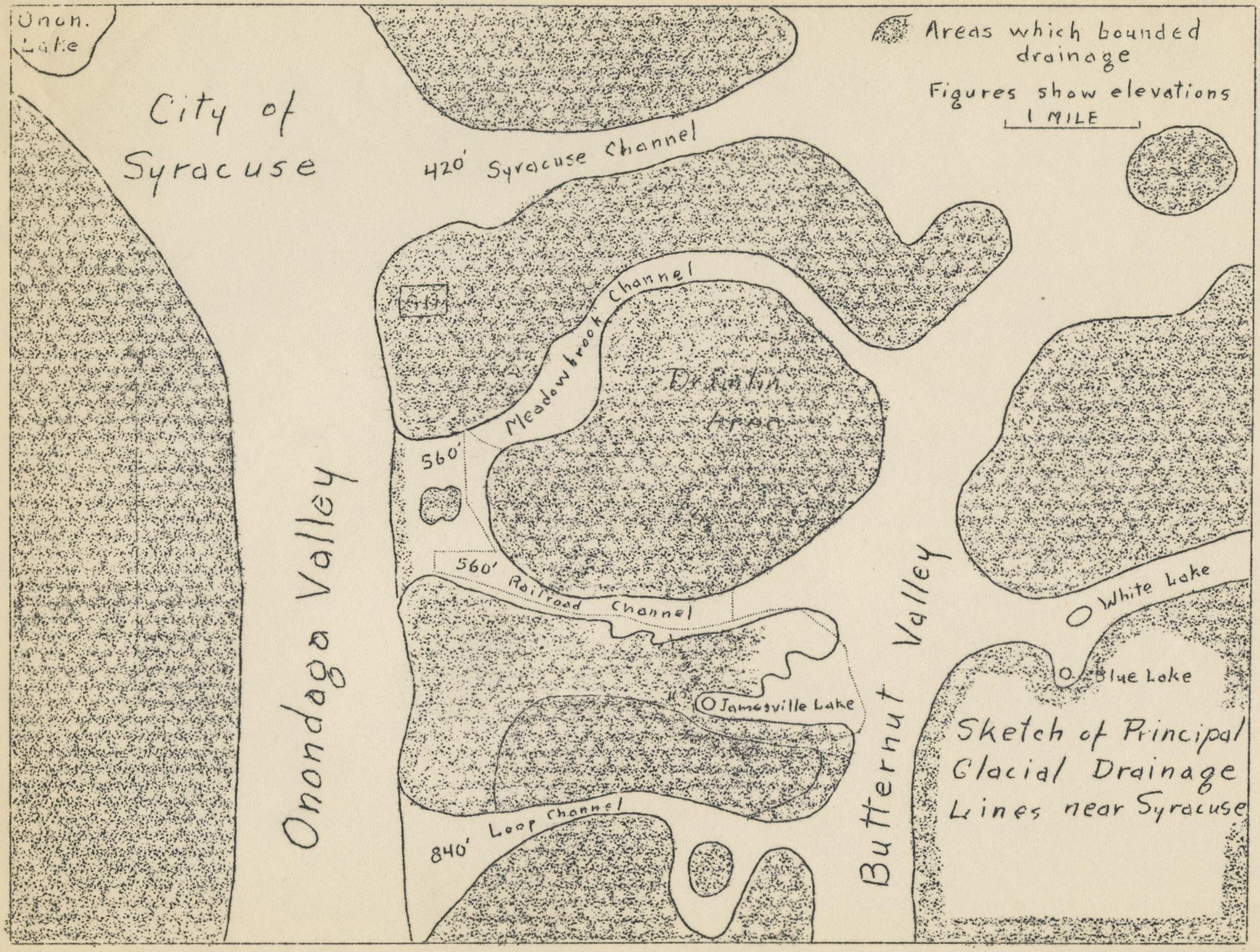
I have hesitated about what course to pursue in this matter for I do not want to do anything which might be construed as unfair to Fleger. I have not discussed the matter with him as he has failed to answer any letters. With your approval I thought of sending copies to both him or Holmes and to Leverett to see if they think it worth publication. If you desire I can send a copy to you to be forwarded to Syracuse. I have only three copies except for the rough draft.

Sincerely,



Sketch Map
of
Principal Feature
south of
Syracuse

Small arrows point in direction of features to be observed.


Onon. Lake
City of Syracuse
Areas which bounded drainage
Figures show elevations
1 MILE
420' Syracuse Channel
Meadowbrook Channel
Drumlin Area
560'
560'
Railroad Channel
Onondaga Valley
Butternut Valley
White Lake
Blue Lake
Jamesville Lake
840' Loop Channel
Sketch of Principal Glacial Drainage Lines near Syracuse

Finger Lakes

Stout, Wilber and Lamb G F

Physiographic features of southeastern Ohio.

Ohio J. Sci 38, 49-83, 1938

Foshay P Max. preglacial drainage and recent history of western Penna - A. J. Sci vol 40, 1890 complete

Rich - inner gorge Lenawee A J S 1895

Sharp H S. Geomorphic development of central Ohio.

Denison Univ Bull 32, 1932

Coffey G. N. Preglacial, interglacial and postglacial changes of drainage in southeastern Ohio with special reference to the upper Muskingum drainage basin

Ohio Jour. Sci 30, 1930
