THE SEDIMENTS OF FOUR WOODLAND LAKES, VILAS COUNTY, WISCONSIN.

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PART II.

MUSKELLUNGE LAKE AND ITS SEDIMENTS.

Muskellunge Lake has an area slightly exceeding 900 acres (919 acres) (Fig. 6). It has no definite outlet and only a few small inlets. The lake occupies a pit, or probably several connected pits, in a glacial outwash deposit. There are three small islands in the southwestern part of the lake and a long peninsula which is almost an island on the east end. The general shape is that of a crescent open to the southeast. The maximum depth is 20.7 meters. This is found in a hole in the central part of the basin. The shore line has an approximate length of eight miles. The lake is almost entirely surrounded by second growth forest. Its relation to other lakes considered in this paper are shown in Fig. 1.

The waters in Muskellunge Lake are soft and probably generally oligotrophic. The pH has the approximate value of 7.3 in the surface waters. It is somewhat less with depth. The bound carbon dioxide is 10 parts per million, the bound calcium 6.3 parts per million, and the bound magnesium 2 parts per million. There is a small increase of calcium with depth. The content of silica on August 25, 1932, ranged from 0.6 parts per million in the surface waters to 1.0 part per million at the depth of 19 meters; oxygen ranged from 8.0 parts per million in the surface waters to 0.2 part per million at the depth of 19 meters and carbon dioxide from 1.0 part per million in the surface waters to 21.5 parts per million at the depth of 19 meters. Ferrous and ferric iron ranged respectively from nothing in the surface waters to 0.8 and 0.0 at the depth of 19 meters (Juday, Birge, and Meloche, 1938).

Ekman samples were collected in Muskellunge Lake from 129 stations in 13 ranges (Fig. 6). Depending on position, the samples consist of sands and gyttja. The area enclosed by the dashed line of figure indicates the parts of the bottom over which the sediments consist of black to greenish or brownish gray gyttja. No chemical analyses were made of the samples of gyttja as they seem to be similar to other gyttja sediments of the lakes of the region. There sediments are known to consist of more than 90 per cent water, and to have 50 or more

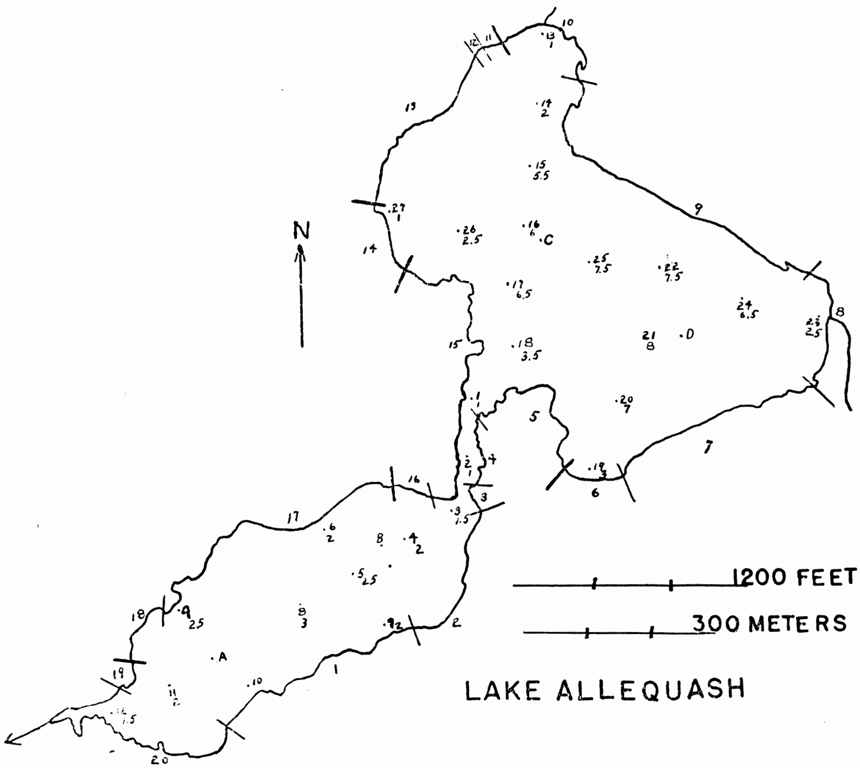

Fig. 6. Muskellunge Lake. The upper figure of the pairs represent the numbers of the station. The lower figure of the pairs, the depth at the station. A topographic map has been made of the depths in the lake, but the contours of this map do not correspond to the depths found by Mr. McKelvey. The line marked x,x, is the approximate boundary between the sandy sediments and gyttja. It should be noticed that it ranges in depth from less than 3 to 20 meters.

per cent organic matter. The solid materials in the gyttja consist of particles of plants, sponge spicules, diatom tests and clay- to small sand-size inorganic detrital particles. The gyttja dries to a hard and tough, black or dark gray substance which breaks and is crushed with difficulty. It absorbs water very slowly and in many cases the dried gyttja will float on water. The sediments between the line indicated by x, x, and the shores consist dominantly of sands and larger particles although in some places there are accumulations of plant matter. There is a narrow zone of graduation from sands to gyttja.

Many fish dwell in the lake and there are some shelled invertebrates. No remains of these organisms were found in the sediments. Erosion of the shores is active in many places and the shores are the immediate places of origin of most of the clastic sediments. Some dust probably settles from the atmosphere. The organic sediments are produced in the lake or blown or drop from the surrounding vegetation.

Colors of the sands range from light gray to greenish or brownish gray. The most important mineral in the sands is quartz and it is thought that olivine may take second place although the ratio between quartz and olivine is of the order of perhaps 20 or more to 1. There is much feldspar in some samples and most samples contain particles of a dark substance which in some cases consists of greenstone or other dark rocks. Particles larger than sand-size are present in most sand samples. These consist of rocks of many kinds among which are felsite, granite, mica schist, flint, quartzite, and greenstone. Some of the large particles are also composed of transparent and milky quartz.

Roundness of the sand and larger particles varies somewhat with the samples; most contain some well rounded grains. A few samples have most of the grains well rounded, but angular and subangular particles of the same grade size are always present. Particles of the small sand and smaller sizes are always angular. Rounded particles are usually minutely pitted or frosted (mat surface). These are always associated with angular and subangular particles which exhibit no rounding or pitting, but instead have smooth shiny surfaces. It is obvious that the sandy sediments have had variable past histories. The rounded and pitted particles have had a much longer history than the angular ones. The former were released from the parent rocks a long time ago and have undergone a long transportation. It is not known where the ice acquired the sands which its melt water deposited as outwash, but the places must have been somewhere to the north. The rounded sands probably came from a sedimentary terrane and some of the transportation which they have undergone was by wind.

TABLE 9. The three quartile dimensions and coefficients of sorting and skewness of the sands from Muskellunge Lake.

Sample Number	Depth of water	Q1	M	Q2	So	Sk
6	1 meter	.156	.200	.50	1.79	1.95
14	1.5	.217	.400	.75	1.80	1.01
15	3	.175	.25	.475	1.64	1.33
17		.1875	.55	.28	1.20	1.70
18	0.15	.175	.40	2.3	3.60	2.51
19	0.5	.19	.30	.85	2.20	1.79
20	1	.14	.225	.425	1.70	1.10
21	1.5	.18	.375	1.5	2.90	1.20
34	0.9	.09	.16	.21	1.50	.73
35	2.5	.155	.218	.375	1.50	1.80
38	1	.156	.225	.475	1.70	1.40
44		.15	.20	.30	1.40	1.10
46	7	.16	.31	.45	1.70	.75
52		.19	.35	.45	1.50	.70
53	3.5	.11	.225	.244	1.50	.53
55	1	.109	.156	.206	1.40	.95
56	10	.10	.17	.19	1.40	1.04
57	10	.10	.15	.21	1.40	.93
62	20	All pebbles, no sand				
64	5	.96	.125	.325	1.80	2.17
65	1.5	.16	.21	.30	1.36	.75
68	2.5	.16	.21	.29	1.30	1.05
69	3	.07	.20	.46	2.50	.80
72	4	.19	.375	1.70	2.97	2.30
73	3	.16	.22	.39	1.50	1.30
77	2	.08	.106	.15	4.30	1.60
78	1.5	.15	.20	.26	1.30	.94
85	1	.29	.40	.50	1.40	1.07
86	1	.175	1.00	2.80	3.99	.49
90	4	.091	.125	.19	1.40	1.20
92	6	.16	.23	.49	1.75	1.50
93 Rocky	6	.187	.275	.45	1.50	1.10
101	19	.09	.137	.21	1.50	1.00
102	18	.10	.15	.212	1.40	.94
105		.25	.85	2.60	3.40	.88
106	5.5	.21	.425	1.35	2.50	1.50
108	1	.16	.19	.26	1.20	1.10
109	5	.137	.175	.225	1.30	1.00
114		.17	.25	1.60	3.10	4.35
115	19.5	.14	.18	.24	1.30	1.03
118	7	.094	.15	.206	1.50	.905
119	3	.12	.175	.225	1.40	.88
120	3	.103	.156	.212	1.40	.85
122		.088	.106	.18	1.40	1.40
123	1	.112	.175	.212	1.40	.77
124		.24	.40	1.2	2.40	1.80
125	1	.16	.237	.535	1.80	1.50
129	11	.084	.11	.225	1.60	1.56

The larger angular particles probably have their immediate parents in igneous rocks.

The olivine particles are commonly not well rounded. They evidently have not traveled far and it is thought that they were derived from the basic igneous rocks of the upper peninsula of Michigan where Keeweenawan lavas may be the parents.

Results of the mechanical analysis of the sands are given in Table 9.

The analyses show that most sands are less than 0.5 mm. in diameter. Twenty-eight samples have coefficients of sorting less than 1.6 which indicates a fair degree of sorting. Ten samples have coefficients of sorting greater than 2 and four of them have coefficients greater than 3. These are poorly sorted. Three of the four samples with coefficients greater than 3 came from shallow water, the fourth, No. 114, was derived from a depth of 14.5 meters. Coefficients of skewness range from 0.49 to 4.35 with thirty-six samples having this coefficient in the range from 0.5 to 1.5. Most curves thus seem fairly symmetrical. It may be suggested that most of the characteristics of the sands with respect to sorting and skewness are due to their having these characteristics determined by the last agent of deposition which was the melt waters of the Wisconsin glacier. The deposits exposed on the shores of the lake, however, show that the melt waters were extremely variable in competency and deposited particles in the range from clay-size to boulders so that a wide range of characteristics would be possible in sediments derived from these melt water sands. The sorting of the sands deposited in the lake seems to be due to the lake and to processes connected with the lake. The conditions have produced a bunching of characteristics which for many of the samples seem to have little relation to depth of water or distance from the shore. There are twelve samples with the coefficient of sorting of 1.40. These were derived from depths of water of one to eight meters. There are six samples with coefficients of sorting of 1.50 from depths of one to seven meters. Samples 6, 20, 38, 55, 85, 86, 108, 109, 123 and 125 were obtained from depths of one meter. These have first quartiles ranging from .109 (55) to .29 (85), mediums from .156 (55) to 1.00 (86), third quartiles from .205 (108) to 3.99 (86), and coefficients of skewness from .49 (86) to 1.95 (6). The shallowest depth from which a sample was taken is that of station 19. This has a coefficient of sorting of 2.20, a figure exceeded by the coefficients of sorting of nine other samples with depths ranging from 1 to 5.5 meters. Samples 15, 69, 73, 119, and 120 were obtained from the depths of three meters. First quartiles in the order of listing of these samples are .175, .070, .16, .12, and .103. These figures are close together. Mediums in the order of listing of these same samples are .25, .20, .22, .175, and .156. These figures are also close together. Third quartiles in the same order are .475, .46, .39, .225, and .21. These show important differences. Coefficients of sorting of the same samples in the order listed are 1.64, 2.50, 1.50, 1.40, and 1.40. Here there are also important differences which may be due to plant matter in the samples. The sample for the greatest depth listed in the table (62), 20 meters, seems to have been collected from a bottom largely covered with large particles, as it consists entirely of pebbles. Perhaps its coarseness is related to its position beyond the end of the island; No. 61 from the same depth and a short distance to the north consists of gyttja. The table also shows three other samples of sandy sediments collected from considerable depths. These are 101 (19 meters), 102 (18 meters), and 115 (19.5 meters). The first quartiles of these samples in the order listed are .09, .10, .14; mediums .137, .15, and .18, and third quartiles .21, .212, and .34. These figures are all small and very close together and yet the samples came from about the same depth as sample 62. The coefficients of sorting in the order of listing of the samples are 1.50, 1.40, and 1.30. These figures indicate very similar sorting. Samples 106 and 109 are from the same part of the lake and from about the same depths, but the former has a third quartile of 1.35 and the latter of .225. Sample 106 has a coefficient of sorting of 2.50 and 109 of .30, but sample 106 contains a number of pebbles up to about 6 mm. in diameter. If these pebbles had been considered in the analysis the coefficient of sorting of sample 106 would have been larger than shown.

It may seem difficult to explain why so many large particles should be present at considerable depths in the sediments of Muskellunge Lake. It may be due to ice rafting from the shore when the ice breaks up in spring time. Perhaps the large particles were blown from the shore when the lake was covered with ice. Either of these two agencies would give a promiscuous distribution rather than a local one. This seems to be the case. It seems obvious that the distribution can not be interpreted as simple functions of depth. Neither does it seem that the distribution is one of current transportation.

However, the figures in the analyses do not reveal the complete story. This is shown by representative samples which are described below in detail. Most samples contain plant matter in all degrees of comminution. Some samples are described from the point of view of the fractions, others as the gross samples. Depths of collection are given in table. Descriptions are as follows:

Sample 6. Mixed sands compose about 90 per cent of the sample by weight. The other ten per cent by weight consists of pieces of rock with one particle having dimension of 25 by 18 by 12 mm.

Sample 7. Mixture of pieces of stems, bark, and leaves with a little finely divided vegetable matter. There is also a little sand.

Sample 14. This sample is described after it was fractioned.

over 4 mm., 2.30 per cent. Two small pebbles of granite, rest pieces of stems, bark and leaves.

2 to 4 mm., 3.00 per cent. Fifteen angular granules composed of quartz and rock, rest pieces of stems, bark, and leaves, one seed.

1-2 mm., 5.26 per cent. About one-half of the particles consists of pieces of plant matter. The other half consists of angular and subangular particles of quartz and rock.

½ to 1 mm., 21.9 per cent. About one-half of the particles are composed of plant fragments, the other half of angular and subangular particles of quartz and a few other minerals.

¼ to ½ mm., 51.8 per cent. The fraction consists mostly of angular and subangular particles of quartz and a few other minerals. Some plant fragments are present.

⅛ to ¼ mm., 10.2 per cent. One-third to one-half is composed of angular particles of quartz and a few other light colored minerals. There is a little plant matter.

1/16 to ⅛ mm., 1.3 per cent. About one-half the particles is composed of angular particles of quartz and light colored minerals. The other half of the particles consists of organic matter.

1/16 mm., 0.62 per cent. More than half is composed of organic matter, the other half of angular particles of light colored minerals.

Sample 16. The sample consists of gray sands of which some are quartz and some particles of rock. Some sands rounded, others angular. The rounded particles have pitted, or mat surface. The small particles are angular. There is no plant matter.

Sample 20. This sample contains small pebbles which are angular to subangular. Sands are quartz with both round and angular grains. The sample contains fragments of stems, bark, and leaves.

Sample 21. The sample contains one well rounded pebble. There are numerous small pebbles and granules which are angular to subangular. These are composed of rock and quartz. The large sand grains are rounded. Some of these have shiny surfaces and others are minutely pitted, or frosted (mat surface.) The small sand particles are angular.

Sample 34. The sorting of the inorganic particles is excellent and much better than is indicated by the coefficient or sorting. The value of the coefficient is modified by the presence of fragments of stems, bark, and leaves.

Sample 38. This sample contains one subangular pebble with a length of 25 mm. This was removed before analysis. The mechanical analysis is as follows.

over 4 mm., 10.94 per cent of which 1.59 per cent consists of fragments of stems and bark. The rest consists of seven pebbles of which four are angular and three subangular.

2 to 4 mm., 5.39 per cent. Contains a single fragment of a small shell. About one-half of the particles consists of fragments of stems, bark, and leaves. Other half of the particles is quartz with some feldspar and rock. The particles are little rounded.

1 to 2 mm., 6.49 per cent. About one-half of the particles consists of fragments of stems, bark, and leaves. The other half is composed of quartz with some feldspar and rock. Most particles rounded and some well rounded.

½ to 1 mm., 15.97 per cent. One-half to three-fourths is composed of angular and subangular particles of quartz; the rest is mostly pink feldspar.

¼ to ½ mm., 47.56 per cent. The fraction consists largely of rounded and subangular particles of quartz.

$\frac{1}{8}$ to $\frac{1}{4}$ mm., 12.00 per cent. The fraction is largely composed of angular particles of quartz.

1/16 to $\frac{1}{8}$ mm., 1.04 per cent. The fraction is composed of angular particles of light colored minerals.

1/16 mm., 0.61 per cent. The fraction is composed of angular particles of light colored minerals.

Sample 44. This sample has its greatest percentage in the $\frac{1}{8}$ to 1 mm. grades. Rounded particles are abundant in the $\frac{1}{2}$ to 2 mm. grade. Quartz is the chief composing mineral. The 2 to 4 mm. grade contains thirty-seven angular to subangular particles of which one is quartz, two are feldspar and the others are pieces of rock.

Sample 53. The mechanical analysis of this sample with description of the fractions is as follows.

over 4 mm., 3.18 per cent. Consists of two pebbles, both subangular. The larger consists of granite, the smaller of quartz.

2 to 4 mm., 5.63 per cent. Composed of angular particles of quartz, feldspar and rocks. There are two fragments of stems.

1 to 2 mm., 6.35 per cent. About half consists of angular and subangular particles of quartz, the other half of angular pieces of rock. There are some fragments of stems.

$\frac{1}{2}$ to 1 mm., 8.43 per cent. Consists mostly of angular particles of quartz. There are some angular particles of feldspar and rock. Fragments of plants are also present.

$\frac{1}{4}$ to $\frac{1}{2}$ mm., 45.49 per cent. Consists mostly of angular particles of quartz.

$\frac{1}{8}$ to $\frac{1}{4}$ mm., 28.16 per cent. Consists mostly of angular particles of quartz.

1/16 to $\frac{1}{8}$ mm., 2.78 per cent. Composed of angular particles of light colored minerals.

Sample 52. This sample from the depth of 20 meters consists of thirteen pebbles, two granules, and some fine sand. The largest pebble is 25 mm. long and 13 mm. wide and thick.

Sample 65. The mechanical analysis of this sample is as follows.

over 4 mm., 6.26 per cent. Consists of four fragments of stems, two pebbles of quartz, one of red feldspar, and eight of rock. All are poorly rounded.

2 to 4 mm., 1.61 per cent. Consists of a few fragments

of stems and twenty-six granules of which two are quartz, one feldspar, and twenty-three rock. All are subangular.

1 to 2 mm., 2.42 per cent. Composed mostly of angular particles of rock, and about one-fifth particles of quartz.

½ to 1 mm., 18.61 per cent. More than two-thirds composed of angular to subangular particles of quartz. Much pink feldspar in angular particles.

¼ to ½ mm., 68.07 per cent. Mostly angular and subangular particles of quartz.

⅛ to ¼ mm., 2.82 per cent. Mostly angular particles of quartz.

1/16 to ⅛ mm., 1.82 per cent. Angular particles of light colored minerals.

Sample 103. The sample consists of ten pebbles with a little sand. One of the pebbles is rounded, the others are angular. The diameter range of the pebbles is from 12 to 22 mm. One is of mica schist, four are of quartzite, two of felsite and three are composed of granite.

Sample 124. The mechanical analysis of this sample is as follows.

over 4 mm., 17.87 per cent. The fraction consists of twenty-two pebbles of which two are composed of feldspar, seven of quartz, one of quartzite, one of granite, and eleven of green or black rock. The pebbles range from little rounded to angular. There are some stem fragments.

2 to 4 mm., 9.87 per cent. The fraction largely consists of particles of rock, and a few particles of quartz. All particles are little rounded. Some fragments of stems and other parts of plants are present.

1 to 2 mm., 6.70 per cent. Mostly angular particles of rock and quartz. Some plant fragments are present.

less than ½ to 1 mm., 39.77 per cent. Mostly composed of particles of quartz of which some are well rounded and others highly angular.

¼ to ½ mm., 10.26 per cent. Mostly composed of quartz, particles angular to subangular.

⅛ to ¼ mm., 14.03 per cent. Mostly angular particles of quartz.

1/16 to ⅛ mm., 2.21 per cent. Composed of light colored minerals.

The foregoing descriptions show the wide variations in particles in individual samples. It is obvious that more than one method was involved in the transportation of the sediments to the places where the samples were collected. It does not seem possible to separate the contributions due to the different methods. In addition there are the fragments of plants which are present in most samples and which are represented in mechanical analyses and are also represented in the coefficients of sorting and skewness. With contributions from currents, from ice rafting, probably from wind blowing large particles on the ice and, in the case of the plants materials from sinking after floating on the surface until water-logged, one may wonder what significance from a sedimentary point of view may be given to the results of mechanical analyses of sands deposited under such conditions as exist in waters such as those of Muskellunge Lake.

ALLEQUASH LAKE AND ITS SEDIMENTS.

Allequash Lake really consists of two lakes connected by a short and narrow passage. The western of the two parts is the smaller and the lake is about three times as long as wide. Allequash Lake drains into Trout Lake, about a mile to the west, and the eastern part has a small indraining stream on the upper end. The entire lake has an area of about 400 acres of which about two-thirds is in the eastern and larger part. The shore line has an approximate length of about five miles. The lake owes its existence to two pits in glacial outwash and is entirely surrounded by forest, mostly second growth. The relations of this lake to others considered in the paper are shown in Fig. 1.

The waters of Allequash are believed to range from oligotrophic to dystrophic. They have been determined by work done under the auspices of Doctors E. A. Birge and Chancy Juday to contain 20.72 parts of bound carbon dioxide, 12.24 parts calcium, and 4 parts magnesium per million.

Sampling of the sediments covering the bottom of Allequash Lake was done by Mr. V. E. McKelvey during the summer of 1940 and by Mr. Henry Nelson during the summer of 1941. Mr. Nelson succeeded in obtaining a core (A) with a length of 42.5 feet (a little less than 13 meters): This core is thought to have passed through the sediments which accumulated since the departure of the ice.

The sediments over considerable parts of the bottom of Alle-

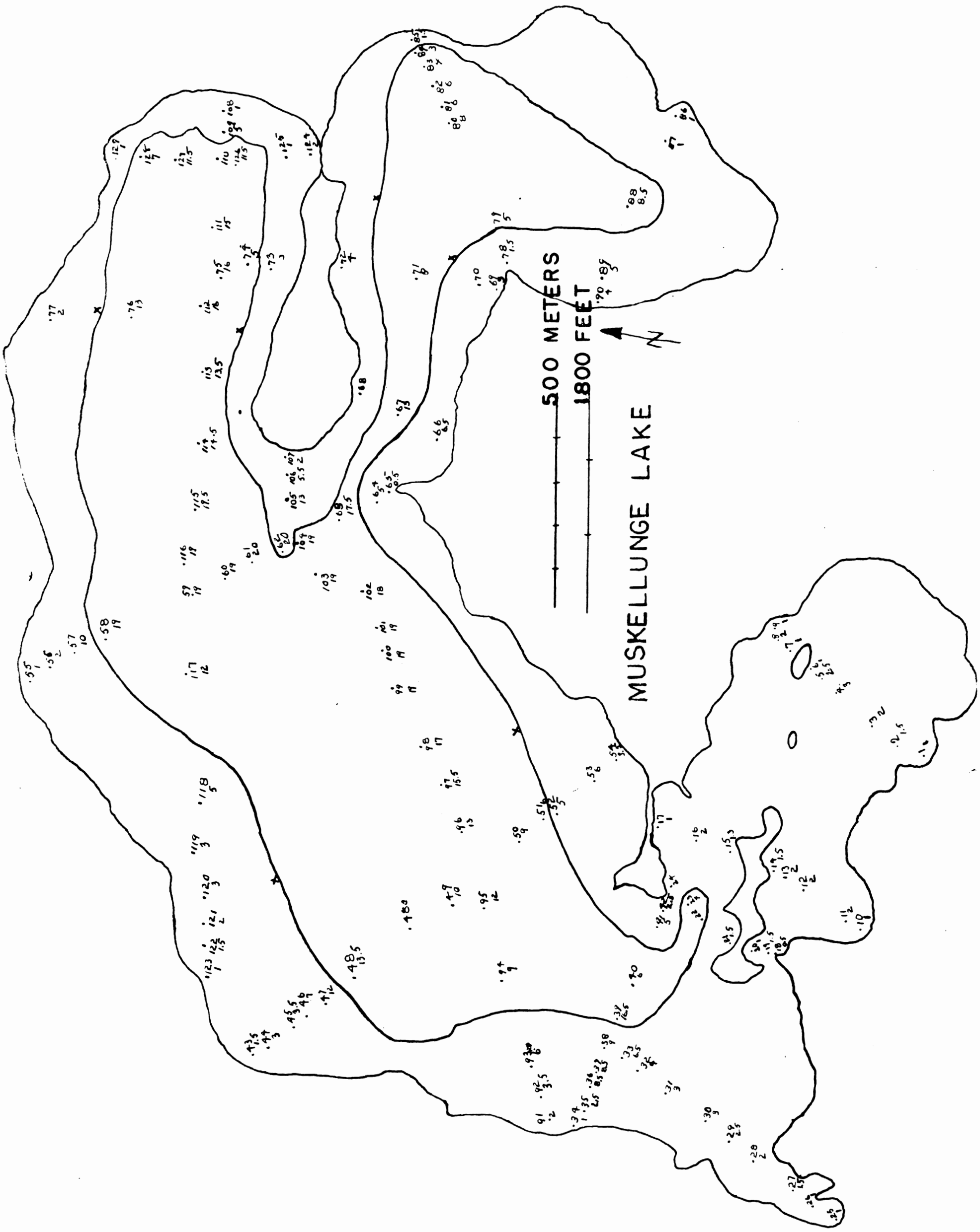

FIG. 7. Map of Allequash Lake. The upper numbers indicate the stations, the lower the depths at the stations. The shore of this lake was studied in sectors. This study established that the lake is receiving few sediments from its shores.

quash Lake contain large quantities of combustible gas during some months of the year, particularly during July and August. The gas rises in abundant bubbles as a boat is rowed over waters which are not more than two meters deep. It is a task of only a few minutes to fill a quart milk bottle with the gas.

The western and smaller of the two basins (Fig. 7) is nearly filled with organic-rich sediments and the top of the sediments is only a short distance from the surface of the water. The sediments, however, are little consolidated and an oar can readily be pushed into them with immediate large escape of gas. The eastern and larger basin is not so full of sediments and depths of water as great as eight meters (25 feet) are present.

For purpose of study of the sediments on the shore of the lake, it was divided into 20 sectors based on the character of the shore and the shore and shallow water sediments. This work was done by Mr. Nelson with the objective of determining the extent of contributions of sediments by the shores. Figure 7 shows the positions of the sectors. Their descriptions are as follows.

1. No beach, vegetation to water's edge and beyond this bottom covered with sand, pebbles, gravels, and cobbles for a short distance outward where these sediments abruptly pass into black to dark gray muddy gyttja. Much fallen timber is over the shallow bottom.

2 to 5. No beach. Boggy shore, and gyttja covers bottom.

6. Beach about one-third of a meter wide and composed of sand. Sediments consist of sand for a short distance from shore and then pass into gyttja. Vegetation extends to edge of water.

7. No beach. Pebbles, cobbles, and boulders form narrow offshore deposits and pass abruptly into gyttja.

8. Beach about one-third meter wide in some places, composed of sand. Offshore deposits of sand. Most parts of shore boggy and the shallow bottom supports a plant growth based on gyttja.

9. No beach. Steep bank, water deepens quickly. Offshore sediments sands which pass outward into coarser sediments. The shallow water sediments about the point on the north end consist of large boulders with diameters to a half meter or more. Just north of the point is a small bay of which the

shallow bottom is covered with sand. Considerable parts of the shore are being rapidly eroded.

10. No real shore, shallow bottom covered with gyttja supporting plants and gradually passing into bog.

11. No real shore, shallow bottom covered with gyttja passing into bog.

12. No beach. Sands, pebbles, cobbles form offshore deposits. No active erosion.

13. No beach. Shallow bottom covered with gyttja passing into bog.

14. No beach. Shore covered with vegetation in the form of bog which passes into gyttja on the lake bottom.

15. No beach. Sands, pebbles, and cobbles form offshore deposits, water deepens slowly. Gyttja forms deposits in small bays. Shore covered with vegetation which is bog over the southern half.

16. No beach. Shore a bog passing into gyttja.

17. No beach. Offshore deposits of sand, shore a bog.

18. No beach. Offshore deposits of gyttja, shore a bog.

19. No beach. Sand and small pebbles form offshore deposits. Shore a bog.

20. No beach. Offshore deposits of gyttja, shore a bog.

The analysis of the shores shows that only along sectors six and eight is there a beach and this is very narrow. Only along the shores of sectors seven and nine is there any erosion. It is thus obvious that the shores of Allequash Lake are now contributing very little in the form of inorganic sediments. This evidently accounts for the occurrence of gyttja in very shallow water and its nearness to the shores at most places, and the fact that gyttja covers the bottoms to the shores of sectors 2 to 5, 10, 12, 14, 16, 18, and 20. The other shallow bottoms for short distances from shore are covered with clastics in the range from sands to boulders.

Foregoing paragraphs show that Allequash Lake is now acquiring few inorganic sediments from its shores. This is evidently due to the dimensions of the lake and probably also to the shape, particularly to the shape of the western basin. It probably is also due to the protection afforded by the forest over the surrounding surface. Some inorganic sediments are dropped from the atmosphere, but these can hardly be great. The small inlet on the eastern end of the lake may also contribute a small volume of inorganic sediments. The result is that the sediments are high in organic matter. This has been derived from plants and animals dwelling in the lake and also from the surrounding vegetation. The relative quantities from the two sources do not seem possible of determination.

DESCRIPTION OF THE SEDIMENTS.

Twenty-seven samples were taken with the Ekman dredge at stations indicated on the map of figure 6 by the numbers 1 to 27. Every sample contained abundant organic matter. Narrow bands of sands and silts with occasional boulders exist along some parts of the shore as indicated in the descriptions of the shore. These sediments were not sampled. Three core samples were taken with the Jenkin and Mortimer core sampler in places indicated by letters B to D, and one core was taken with the Wilson core sampler at the place indicated by the letter A. Results of the sampling with the Ekman dredge are given in table 11.

TABLE 11. Table giving depth of water, character of sediments, moisture content, per cent of organic matter based on loss on ignition, and per cent of lignin in the organic matter.

Sample Number	Depth of Water	Character of Sediments	Moisture Content	Per Cent of Organic Matter Based on Loss on Ignition	Percentage of Lignin in Organic Matter
	Meters	Western Basin			
1	0.75	Sandy black gyttja	90.7%	20%	23%
2	1.00	Sandy black gyttja		37	45
3	1.50	Slightly brown gyttja		47	28
4	2.00	Brown gyttja	96.0	69	41
5	2.50	Greenish brown gyttja		80	20
6	2.00	Greenish brown gyttja		47	21
7	2.00	Greenish brown gyttja	97.2	71	30
8	3.00	Greenish brown gyttja		80	21
9	2.50	Greenish brown gyttja		75	32
10	2.50	Sandy black gyttja	94.5	44	18
11	1.50	Black gyttja		79	26
12	1.50	Black gyttja		79	40

Sample Number	Depth of Water	Character of Sediments	Moisture Content	Per Cent of Organic Matter Based on Loss on Ignition	Percentage of Lignin in Organic Matter
	Meters	Eastern Basin			
13	1.00	Greenish brown gyttja	95.3%	56%	34%
14	2.00	Greenish brown gyttja		31	38
15	5.50	Greenish brown gyttja		54	23
16	6.00	Greenish brown gyttja	95.4	60	44
17	6.50	Greenish brown gyttja		55	43
18	3.50	Greenish brown gyttja		54	37
19	3.00	Greenish brown gyttja		34	39
20	7.00	Black gyttja	95.2	60	39
21	8.00	Black gyttja		41	35
22	7.50	Black gyttja		55	40
23	2.50	Sandy dark gray gyttja		42	40
24	6.50	Black gyttja	94.5	44	57
25	7.50	Black gyttja		52	26
26	2.50	Greenish gyttja	93.8	50	30
27	1.00	Greenish gyttja		78	55

The average water content of the surface samples of the sediments of the eastern basin is 94.8 per cent and of the western or smaller basin 94.6 per cent. These figures are essentially the same and thus show an essential constancy in kinds of sediments deposited.

Nearly every sample is typical gyttja which has a nearly black color in gross appearance, but in thin layers under a microscope is a pale greenish-yellow gel in which are enmeshed diatom tests, sponge spicules, fragments of plant matter, pollen grains, and inorganic particles. Fish and tadpoles dwell in the lake, but no remains of these animals, or any shells were found in the sediments.

The per cent of organic matter in the sediments is shown in the fifth column of the table. This exceeds 50 per cent in 16 samples and in an additional case it is just 50 per cent. Only in ten samples is it less than 50 per cent, and in six of these it exceeds 40 per cent and in only four samples is it less than 40 per cent. The map shows the close correlation between the character of the shore and the percentage of organic matter. Samples 1, 2, 14, and 19 contain less than 40 per cent organic matter. Samples 1 and 2 were obtained in the channel between the two basins with the shore close by in each case and an occasional current from the upper to the lower basin to carry away organic matter. Sample 14 was obtained north of the point of sector 9 where the shore is being eroded and the station of sample 19 is close to a sandy beach. Samples 3, 6, 10, 21, 23, and 24 have less than 50 per cent organic matter and each, with the exception of sample 21, is from a station where it may be expected the shore supplied inorganic sediments. The map shows that, in general, the samples from the larger of the two basins contain less organic matter than those from the western and smaller basin. This is because the shores of the latter basin can contribute very little sediment which is not the case in the larger basin. The average for the larger basin is 51 per cent; for the smaller basin it is 66 per cent. There seems to be little consistency in the percentage of lignin in the organic sediments with the percentage ranging from as little as 18 to as high as 55. The results, however, are only approximate.

Core B is from a station in the western basin, core C and D are from the eastern basin. Core A is from the western part of the lower or western basin. A sample was taken with the Ekman dredge at each station.

Core A shows a thickness of a little more than 13 meters (42.5 feet) of organic rich sediments and encountered gray sand at that depth. The sediments consisted of brown to brownish-black gyttja to the depth of two meters (about six feet). These sediments showed little coherence. Below two meters the color changed with depth through loss of brown. At seven feet the gyttja became fairly coherent and acquired a greenish shade to its blackness. This increased in intensity to the bottom. The organic content was fairly consistent to the bottom of the gyttja and in the range from 70 to 80 per cent. As noted above, sand was encountered at 42.5 feet (about 13 meters). This sand is thought to mark the time of the disappearance of the glacier.

Core B extended to a depth of six meters (20 feet) and consisted of brownish-black gyttja to about five meters (16 feet) and then greenish-black gyttja to about six meters (19 feet.) There was then eight inches of gray sand and silt with organic matter and then gray sand and silt for four inches. Core C was carried to the depth of 5.91 meters (19.5 feet) and consisted of greenish-black gyttja. The bottom of the gyttja was not found. Core D was carried to the depth of about five meters (16 feet.) The sampler penetrated an additional foot but no sample was obtained.

The water content of the samples from the cores was found as follows.

TABLE 12. Water contents of the sediments from cores in Allequash Lake.

Position of Sample in Core	Content of Water
Core A	
Ekman	97.5%
5 feet	96.0
15	89.6
20	94.8
23	95.0
27	95.0
32	94.0
36	93.2
39	90.5
Average including Ekman sample	94.8
Core B	
3–4 feet	95.0%
11–12	92.8
15–16	94.7
19–20	56.5
Core C	
Ekman	94.4%
5–6 feet	93.6
9–10	93.1
13–14	91.8
15–16	90.0
17	89.7
Core D	
Ekman	94.3%
5–6 feet	92.6
9–10	92.0
13–14	91.0
17–18	90.8
18–19.5	90.2

The samples show a very small decrease in water with depth and it seems obvious that organic rich sediments such as these yield water very slowly and that there has been very little expulsion of water from the bottom sediments since they were deposited following retreat of the ice some 25,000 to 50,000 years ago. The possible loss of water is of the order of one to two per cent. There also seems to be a small decrease in content of organic matter with depth which renders it obvious that elimination of organic matter by bacteria and other organisms is very small once the sediments are covered by other sediments. Lithification of these sediments would produce a carbonaceous or bituminous shale, presumably the latter. If all the water was expelled the maximum thickness of about 13 meters (42.5 feet) would be reduced to less than one meter or three feet, thus giving a rate of deposition of about one meter in 25,000 to 50,000 years.

No stratification planes of any kind were found in the sediments of any of the cores taken from Allequash Lake. This is ascribed to the similarity of the sediments from year to year and to reworking of the sediments by organisms dwelling in the sediments although it must be admitted that these do not seem to be either numerous or varied. It is known that numerous larvae dwell in the sediments at times and that the top sediments contain considerable, but not large numbers of bacteria. The number is by no means as large as was expected when the studies of the northern soft water lakes was undertaken.

The maximum thickness of sediments deposited since the departure of the glacier was found in the western basin at the position of core A where about 13 meters (42.5 feet) was found. This was reduced to nearly six meters (19 feet) at the position of core B. The sediments deposited in the eastern basin since the departure of the ice are known to have a minimum thickness of about six meters (19.5 feet) at the position of core C without the entire thickness having been penetrated. The bottom of the gyttja is thought to have been reached at about 4.8 meters (16 feet) at the position of core D.

GENERAL CONCLUSIONS.

1. The dominant and most abundant form of organic sediment in lakes of the character described in this paper is a pale greenish-yellow gel which is in the form of small globules. This is thought to have been precipitated from suspension through flocculation.

2. Recognizable organic animal remains consist of sponge spicules and a very rare occasional shell. Recognizable plant remains consist of fragments of stems, bark and leaves and tests of diatoms.

3. The organic-rich sediments of all depths penetrated contain water generally to more than 90 per cent.

4. Approximately 50 or more per cent of the dried organic-rich sediments collected below a depth of three meters are composed of organic matter.

5. Rates of deposition of the organic-rich sediments are very slow and are in the range of one meter of solid sediments in 25,000 to 100,000 years.

6. The maximum thickness of wet organic-rich sediments was found in Allequash Lake with about 13 meters (42.5 feet).

7. No stratification of any kind was found in any of the organic-rich sediments.

8. Several methods of transportation were concerned in the deposition of the sands about the shores. Most sands contain organic matter.

9. Because of the several methods of transportation and the inclusion of organic matter, mechanical analyses of the clastic sediments have little sedimentational significance.

10. Mechanical analyses of the organic-rich sediments are considered to have no sedimentational significance so far as transportational agencies are concerned. Several agencies were involved in their transportation; most were probably in a flocculated condition when deposited and there is no assurance that existing dimensions are those present when deposition took place.

11. The organic-rich sediments seem to have undergone few changes following deposition. Colors are almost the same and the content of organic matter and water content are very much the same at the bottom and the top of every core obtained.

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