The Chemical Composition of Lake Waters in Halifax County, Nova Scotia[1]

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ABSTRACT

Analyses for concentrations of total ions, Na, K, Ca, Mg, HCO_3, Cl, SO_4, and dissolved organic carbon, as well as optical density, pH, and specific conductivity, are presented for twenty-three surface lake waters collected from heathy spruce forest in Halifax County, Nova Scotia, during December 1955. As compared with the average fresh water of the world, these waters are very dilute, and proportionally low in calcium bicarbonate while high in sodium chloride. The three main factors governing chemical composition are shown to be (1) the nature of the geological substratum, (2) the influence of topography as expressed in the accumulation of mineral sediments and peat in and around the lake basins, and (3) proximity to the sea.

INTRODUCTION

Analysis of the ionic composition of dilute lake waters has until recently been a matter of some difficulty, so that the supply of the major dissolved constituents to such waters has received relatively scanty attention from limnologists. This paper records concentrations of total ions, Na, K, Ca, Mg, HCO_3, Cl, SO_4, and dissolved organic carbon, as well as optical density, pH, and specific conductivity, in a series of rather dilute surface lake waters collected from heathy spruce forest in Halifax County, Nova Scotia, during the cold dry weather of December 1955, when the lakes were under thick snow and ice cover.

The samples include both clear and peaty waters, from lakes on three main geological substrata—an intrusive granite batholith, the metamorphic Meguma gold-bearing series of slate overlying quartzite, and carboniferous strata of the late Mississippian period. The general physiography of the area, in relation to the underlying geology, is discussed by Goldthwait (1924). The lakes fall into four main size ranges: very small ponds (nos. 3, 5, 18 and 19 in Table 1), small lakes of from 1 to 10 hectares (nos. 2, 6, 7, 8, 9, 10, 11, 20, 21, 23), medium-sized lakes of about 20 to 30 hectares (nos. 13, 14, 15, 22), and larger lakes of more than about 50 hectares (nos. 1, 4, 12, 16). However, none of the chemical properties examined shows any obvious relation to lake area.

While surveys of macro-vegetation have only been carried out on four of the granite lakes, it may be of interest to point out the following species as among those most frequently encountered during a brief survey of these and other similar lakes in 1946 and subsequent years:

Eriocaulon septangulare
Lobelia dormanna
Dulichium arundinaceum
Pontederia cordata
Nymphoides cordatum
Nuphar variegatum
Nymphaea odorata
Sparganium fluctuans
Potamogeton spp. (most commonly *P. epihydrus* var. *nuttallii*)
Scirpus subterminalis
Chamaedaphne calyculata
Sphagnum spp.

Of these, the first two are perhaps more characteristic of the less organic substrata, while the last two indicate peaty conditions,

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and often the presence of a floating bog mat around the lake margins.

The zooplankton organisms most frequently met with in these surveys were as follows:

Diaptomus minutus
Diaptomus spatulocrenatus
Mesocyclops leuckarti
Bosmina longispina
Diaphanosoma brachyurum
Daphnia pulex
Holopedium gibberum
Polyphemus pediculus

By far the most common fishes were *Fundulus diaphanus* and *Salvelinus fontinalis*.

METHODS

The waters were collected through the ice in polyethylene bottles, filtered through Whatman 54 filter papers (washed with three volumes of distilled water and one volume of sample) on return to the laboratory, and stored in the original bottles until analyzed. Specific conductivity was measured with bright platinum electrodes, and pH by glass electrode, both before and after aeration with compressed air until drift ceased. Na and K were estimated without concentration by EEL flame photometer using Calor-gas fuel. Ca and Mg were determined by versenate titration according to the method of Heron and Mackereth (1955). The anions were measured conductimetrically following the ion-exchange procedures developed by Mackereth (1955), HCO_3 being estimated as the difference between total metal cations and strong acid anions. The slight differences observed in samples below pH 5.7 (the pH of distilled water in equilibrium with atmospheric CO_2 at 25° C) were attributed to experimental error, since there was no clear relation between the amount of difference and pH. Total metal cations as estimated by this procedure corresponded very closely to the sum of the four metal cations analyzed individually. SO_4 values by this method include small amounts of NO_3, which are most unlikely to be of any significance in this type of lake water, according to experience in this laboratory. Dissolved organic carbon was determined by a new wet oxidation method devised by Mackereth in this laboratory and as yet unpublished. While the samples were filtered through a no. 3 sintered glass plate (average pore size 20–30 μ), some filter-passing substances will no doubt be included with the dissolved organic materials. Optical densities were measured at 320 mμ in the above waters, by means of a Unicam SP 500 spectrophotometer with 10 cm glass tubes and slit widths of about 0.5 mm. In addition, absorption spectra were determined between 320 and 700 mμ by the same instrument, on both the clearest and the most highly colored of the lake waters, again using glass tubes, and slit widths varying from about 0.5 mm at 320 down to 0.025 mm at 700 mμ. Lastly, it was noticed that on standing the bottoms of some of the sample bottles became spotted with orange-brown colonies of iron bacteria, resembling the agar plates used for bacterial counts. The density of such iron precipitates was recorded visually in three grades.

RESULTS

The analytical data are presented in Table 1, the waters being arranged in order of increasing total ion concentration within three main groups separated according to the nature of the underlying rocks. Since the Meguma quartzite and slate lake waters show no clear chemical differences, they have been grouped together. All lakes receiving drainage from carboniferous rocks have also been grouped together, although Fraser Lake, wholly on quartzite, is transitional in its chemical properties. Results are expressed in parts per million (ppm), with the exception of pH, specific conductivity (as reciprocal megohms at 20° C), total ions (as milli-equivalents per litre), and optical density $\left(\text{as } \log \frac{I_0}{I}\right)$. The positions of the lakes on the map are also given in Table 1, and their locations are shown in Figure 2. Where "normal" lakes are referred to, the two quarry ponds and the two senescent lakes almost filled in by sediments are excluded.

TABLE 1. *Chemical composition of some lake waters from Halifax County, Nova Scotia*

Number	Name	Map position W	Map position N	Specific conductivity $\kappa_{20} \cdot 10^6$ 20°C	Total ions m.equiv. per L	pH Before aeration	pH After aeration	Na	K	Ca	Mg	HCO_3	Cl	SO_4	Dissolved organic carbon	Optical density $\log \frac{I_0}{I}$	Bacterial iron precipitates
								parts per million									
						On Granite											
1	Hubley's Big Lake (peaty arm)	63°50′	44°39′	31	0.24	4.84	4.84	3.4	0.4	1.0	0.2	nil	4.9	4.2	7.2	not done	–
2	Railway Pond	63°52′	44°41′	28	0.25	5.22	5.36	3.4	0.4	1.1	0.4	nil	4.8	4.6	5.2	0.49	++
3	Punchbowl	63°48′	44°41′	35	0.29	4.79	4.82	4.2	0.4	1.1	0.3	nil	5.5	5.6	9.8	1.87	–
4	Long Lake	63°38′	44°37′	38	0.30	4.82	4.84	4.0	0.5	1.1	0.6	nil	6.0	5.4	4.2	0.53	–
5	Purcell's Cove Granite Quarry	63°35′	44°36′	41	0.32	4.85	4.89	3.4	0.5	1.8	0.6	nil	5.6	8.5	1.2	0.21	–
6	Bluff Lake	63°39′	44°33′	39	0.32	5.12	5.28	4.9	0.3	0.9	0.6	nil	8.1	4.5	2.5	0.18	–
7	Silver Lake	63°39′	44°33′	51	0.40	4.46	4.47	5.7	0.4	1.1	0.6	nil	7.9	7.5	11.6	1.76	–
8	Purcell's Pond	63°35′	44°36′	74	0.41	3.95	3.95	5.0	0.3	0.8	0.4	nil	7.2	9.5	11.1	1.74	–
9	Black Lake	63°39′	44°31′	53	0.41	4.50	4.55	6.4	0.4	1.0	0.6	nil	9.9	5.6	7.9	1.27	–
10	Duncan Lake	63°32′	44°30′	70	0.57	4.58	4.63	9.5	0.6	0.8	1.0	nil	15.2	6.4	7.5	1.17	–
						On Gold-Bearing Series[1]											
11	Mt. Uniacke Gold Mines Lake	63°49′	44°55′	28	0.25	5.94	6.66	2.4	0.6	2.1	0.3	3.2	3.8	4.1	6.7	0.68	++
12	Webber Lake	63°43′	44°46′	30	0.27	5.38	5.50	3.0	0.5	1.8	0.4	nil	4.5	5.2	9.5	1.23	+
13	Lewis Lake	63°46′	44°49′	33	0.28	4.96	5.00	2.9	0.4	1.9	0.4	nil	4.8	5.6	10.3	1.32	++
14	Tucker Lake	63°41′	44°51′	32	0.30	6.45	6.93	2.7	0.6	2.4	0.5	4.0	4.7	4.5	3.9	0.43	–
15	Baptizing Lake	63°46′	44°44′	34	0.30	5.76	6.04	3.4	0.7	1.7	0.5	1.8	5.6	5.2	5.3	0.56	+
16	Fish Lake	63°37′	44°46′	33	0.31	6.17	6.92	3.0	0.4	2.7	0.4	3.8	4.9	5.2	2.8	0.29	–
17	Sandy Lake	63°42′	44°44′	40	0.33	5.02	5.18	3.8	0.7	1.8	0.6	nil	6.3	6.8	7.1	0.73	–
18	Purcell's Cove Slate Quarry	63°34′	44°37′	45	0.38	4.89	4.92	4.6	0.7	1.4	1.1	nil	7.3	7.9	<0.5	not done	–
19	Mt. Uniacke Gold Mines Pond	63°49′	44°56′	44	0.42	6.60	7.24	2.8	0.4	4.9	0.5	11.6	4.8	4.5	3.8	0.41	+++
						On or Receiving Drainage from Carboniferous Strata[2]											
20	Fraser Lake	63°00′	45°05′	31	0.30	6.44	6.90	2.8	0.3	2.6	0.5	4.6	4.1	4.8	9.3	1.15	–
21	Crossgill Lake	63°11′	45°08′	36	0.36	6.60	7.10	2.8	0.6	3.2	0.7	7.6	4.3	5.5	8.7	1.04	+
22	Brine Lake	63°55′	44°37′	48	0.44	6.38	7.09	5.3	0.6	3.1	0.7	6.1	7.8	5.6	4.7	0.45	–
23	Nelson Lake	63°03′	45°05′	52	0.51	6.70	7.50	2.5	0.6	5.6	1.2	16.3	3.8	7.4	4.8	0.64	+

[1] Lakes no. 11, 13, 16 and 19 on quartzite; nos. 15 and 17 on quartzite with some drainage off slate; nos. 14 and 18 on slate; and no. 12 on slate with some drainage off quartzite.

[2] Lake no. 20 on quartzite, receiving some drainage from carboniferous rocks; no. 22 partly on granite and partly on carboniferous strata.

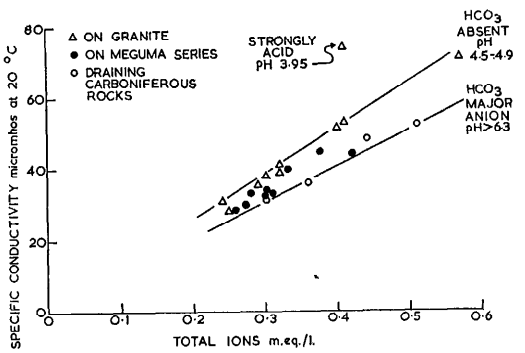

FIG. 1. The relation between specific conductivity and total ionic concentration in waters from Halifax County, Nova Scotia.

Total ions and specific conductivity

The ranges of specific conductivity and total ions are in general rather similar for the three geological groups of lakes, the median values for all lakes lying at 38 and 0.32 m. equiv./L, respectively. In the granite series the water richest in salts came from Duncan Lake, situated on an exposed headland very near the sea, and hence high in NaCl. In the other two geological groups the richest waters came from shallow lakes nearly filled in with mineral and organic sediments. These waters yielded high concentrations of $Ca(HCO_3)_2$, probably released from the bottom materials by weathering.

The relation between specific conductivity and total ions is rather close, although a certain variability is evident in Figure 1. The very acid water from Purcell's Pond, along one edge of which is found a large *Sphagnum* bog, exhibits a much greater specific conductivity (74) than would be inferred from the total ion concentration of 0.4 m.equiv./L, for which the usual conductivity is about 40–50. The extremely high equivalent conductivity of the hydrogen ion is responsible for this anomaly, for which a correction can easily be made (Sjörs 1950). Again, the moderately acid lakes with no HCO_3 show higher specific conductivities than those which are only faintly acid and have HCO_3 as the main anion. Another factor involved here is the relatively low equivalent conductivity of the HCO_3 ion as compared with Cl and SO_4 ions.

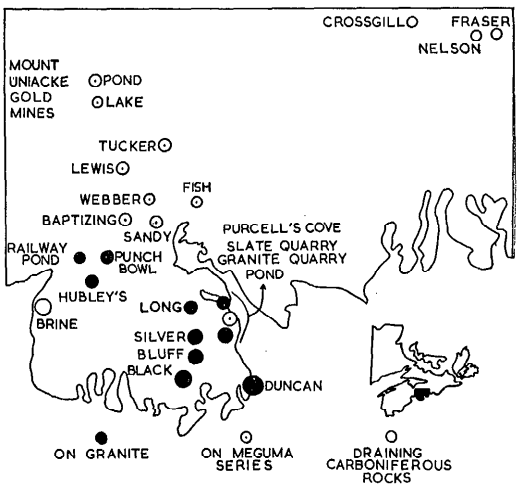

FIG. 2. The locations of the waters sampled, and the influence of proximity to the sea upon chloride concentrations. (The areas of the circles are proportional to chloride concentrations.)

Chloride, sodium and magnesium

Figure 2 shows clearly that the higher Cl concentrations occur nearest the coast. Since the granite lakes occupy the coastal belt their waters are highest in Cl. Within the other two geological groups the maximum Cl values also come from those lakes nearest the sea. The close adherence of the Na and Cl values to the line (Fig. 3) showing sea-water proportions suggests that by far the greatest part of these ions comes as sea spray in atmospheric precipitation (cf. also Conway 1942, Gorham 1955a, Eriksson 1955). The slight excess of Na may be presumed to come from rock-weathering. In this connection it may be noted that

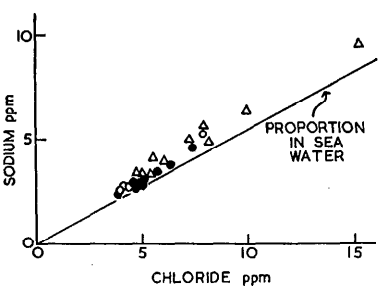

FIG. 3. The relation between sodium and chloride

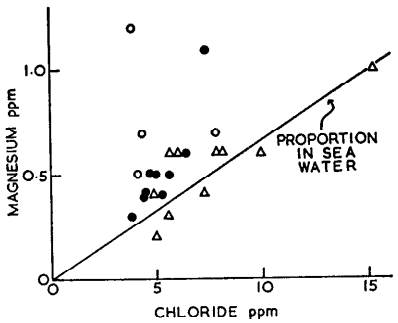

FIG. 4. The relation between magnesium and chloride.

among the "normal" lake waters those from the Meguma quartzites and slates show less excess Na than either the granite or carboniferous series, which resemble one another in this respect. The average Na/Cl ratio in sea water is 0.55, in the quartzite waters 0.61, and in both the other types 0.67.

Magnesium is also supplied to a marked extent from the sea, with the granite waters showing a Mg/Cl ratio the same as that of sea-water (0.067). However, as shown in Figure 4 the Meguma series, and especially the waters draining carboniferous strata, exhibit considerable enrichment in Mg, presumably from weathered rock and soil minerals.

Among the lakes on granite, Duncan yields the highest Mg concentration (1.0 ppm), again because of its proximity to the sea. The highest Mg/Cl ratio in this group (0.11), however, comes from the Purcell's Cove granite quarry pond, where presumably more Mg than usual is released by breakdown of the freshly exposed rocks. On the gold-bearing series the Purcell's Cove slate quarry provides an even higher Mg/Cl ratio (0.15), and the absolute concentration is also high (1.1 ppm). The greatest mineral enrichment of Mg is shown by the senescent Nelson Lake on carboniferous rocks (Mg 1.2 ppm, Mg/Cl 0.32).

Potassium

Only a small part (on the average about 0.1 ppm) of the K in these lake waters can have been supplied from the sea (K/Cl ratio in sea-water 0.02), and the remainder (averaging 0.5 ppm) must come from the rocks and soils, much of it perhaps as atmospheric dust. Waters on the Meguma rocks are in general richest in K, and waters on granite poorest, although the differences amount to less than 0.2 ppm on the average.

Calcium and bicarbonate

Calcium is supplied to these lakes almost wholly by rock and soil weathering, the sea spray contribution calculated from Ca/Cl ratio (0.02) again averaging about 0.1 ppm. There is a distinct difference between the three geological groups in respect of Ca, the "normal" lake waters averaging about 1, 2, and 3 ppm on the granite, Meguma, and carboniferous rocks, respectively. The Ca levels in the granite lakes are not far different from those observed in the British Isles in raised and blanket bog pools completely isolated from mineral soil influence and wholly dependent upon atmospheric sources of supply such as dust fall (Gorham 1956), so that Ca release from the granite rocks may be presumed to be extremely slow. It is of interest that Silver Lake was fertilized in 1947 with about 2200 kilograms of basic slag and in 1948 with 500 kg of superphosphate, while Black Lake received 1100 kg of basic slag plus 300 kg of superphosphate in 1948. After seven years neither of these lakes differs from other similar granite lakes in respect of either Ca or pH. Also notable is the fact that Brine Lake, on the edge of a tiny enclave of carboniferous rocks surrounded by granite, manages to maintain its chemical identity with the other carboniferous lakes.

Differences are also evident in the HCO_3 concentrations of the three types of lake, this ion being absent from all the waters on granite, present in all the waters draining carboniferous strata, and present in five of the nine waters on the Meguma quartzites and slates. Only in the circumneutral waters is there a clear correlation between Ca and pH after aeration (see Fig. 5), which is paralleled by a similar relation between these two variables and HCO_3.

The two waters highest in Ca and HCO_3 are from the two senescent lakes nearly filled by sediments, from which there is almost certainly a release of $Ca(HCO_3)_2$ to

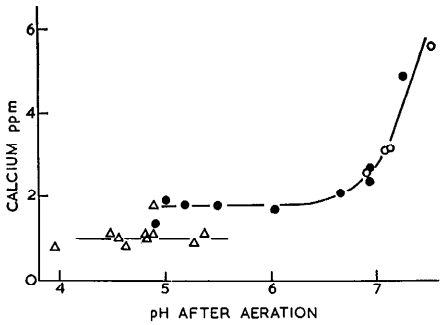

FIG. 5. Calcium and acidity in waters draining three types of geological substrata.

the water above, through the action of normal weathering processes. Of the Meguma lakes, those richest in Ca lie along the north-east border of the area sampled, nearest to the carboniferous zone, and farthest from the granites. The largest concentration of Ca in the granite waters was observed in the quarry pond at Purcell's Cove, and at 1.8 ppm was almost double the average value. The slate quarry on the other hand yielded a lower value (1.4 ppm) than the average for the Meguma waters.

Acidity

At higher pH levels an appreciable proportion of the acidity in these lake waters is due to dissolved CO_2, which can be mostly removed by bubbling with compressed air (see Table 1). However, the pH is largely governed by the amount of $Ca(HCO_3)_2$ added to the lake waters from weathering minerals, as shown above. Toward the acid end of the scale, the lowering of pH is associated with increasing concentrations of SO_4 and (with the exception of the quarry ponds) of organic matter, as illustrated in Table 2. This table also shows that at similar SO_4 levels the Meguma lakes are less acid than those on granite, which is presumably connected with the higher calcium concentrations in the former.

Using the pH of distilled water in equilibrium with the atmosphere at 25° C (pH 5.7) as a dividing point, acid waters can be separated from circumneutral waters; and in fact these two groups are quite sharply separated, since only one of the twenty-three waters falls within the pH range

TABLE 2. *The pH of waters on granite and on the Meguma Gold-Bearing Series in relation to sulfate and organic carbon concentrations*

pH values in brackets are from quarry ponds.

Organic Carbon ppm	Lakes on granite				Lakes on Meguma quartzites or slates			
	Sulfate ppm				Sulfate ppm			
	4–5	5–6	6–8	>8 ppm SO_4	4–5	5–6	6–8	>8 ppm SO_4
0–2				(4.9)			(4.9)	
2–4	5.3				7.2 6.9	6.9		
4–6	5.4	4.8				6.0		
6–8	4.8	4.6	4.6		6.7		5.2	
8–10		4.8				5.5		
10–12			4.5	4.0		5.0		

TABLE 3. *A comparison of acid and circumneutral waters*

	Ionic concentrations (m.equiv./L)			
	H	SO_4	Ca	HCO_3
Acid waters	0.021	0.131	0.063	nil
Neutral waters	trace	0.108	0.157	0.108
Difference	0.021	0.023	0.094	0.108

5.5–6.5. While all the waters on granite are acid, and on the carboniferous rocks circumneutral, the Meguma group is evenly divided between these two classes. It is now instructive to compare the equivalent levels of hydrogen ions, SO_4, Ca, and HCO_3 in these acid and neutral waters, as set out in Table 3. At once apparent is the even balance between the hydrogen ions of the acid group and the excess of SO_4 in this as compared with the circumneutral series (hydrogen ions 0.021 m.equiv./L, SO_4 excess 0.023 m.equiv./L). Thus it may be inferred that the acidity of these lake waters is due mainly to sulfuric acid. Moreover, about nine-tenths of the HCO_3 ions in the neutral waters are balanced by the excess of Ca in this group, which suggests that these lakes are more strongly influenced by rock and soil weathering.

It is worth noting that both the acid and circumneutral waters show rather wide ranges of organic carbon concentration, although the acid series includes more of the highly organic samples.

Sulfate

Of the average level of 5.6 ppm SO_4 in all the "normal" lake waters, only about 0.9 ppm can have come as SO_4 from sea-water (SO_4/Cl 0.14), although it has been suggested by Conway (1942) and others that H_2S may diffuse from the muds of the continental shelf into the atmosphere and be oxidized there, later to come down in atmospheric precipitation.

Sphagnum bog peats accumulate sulfur from the atmosphere, and may release it as sulfuric acid (Gorham 1956), which probably provides the source of acidity in these Nova Scotian waters, many of which drain, or are bordered by, *Sphagnum* peats. For instance, among the granite lakes Purcell's Pond has a large peat bog immediately along one side, and Silver Lake a smaller one, while the Punchbowl is entirely surrounded by a *Sphagnum* mat. And the most acid water on the Meguma gold-bearing series is that of Lewis Lake, which appears from the map to drain large areas of peaty swampland. Webber Lake, also acid, is part of the Sackville River system, which in its upper reaches appears to run through extensive stretches of swampy land. Such a mode of supply could account for the intercorrelations between pH, SO_4, and organic carbon shown in Table 2. However, since even the clearest lake waters contain more than 4 ppm of SO_4, the addition of sulfuric acid from peat cannot by any means provide the main supply of this ion. That rain is a major source of SO_4 for these lake waters is suggested by recent analyses of Herman (unpublished), who found an average of 0.96 ppm total sulfur, equivalent to 2.9 ppm SO_4, in rain collected over a two-year period at the Dominion Experimental Station, Kentville, N. S. Moreover, rain SO_4 would be concentrated somewhat before reaching the lakes, owing to evaporation, so that this value represents a minimum for the rain contribution to lake water concentrations.

Other possible sources for SO_4 in these lake waters are the often rather organic bottom deposits, where sulfur may accumulate in organic debris. Anaerobic decomposition frequently produces H_2S in these sediments, and this is free to diffuse into the overlying water and become oxidized to H_2SO_4 when oxygen is present.

Most rocks contain much less sulfur than alkali and alkaline earth metals, and have generally been thought unlikely to be a major source of supply to fresh waters. However, it may be noted that in the present case the quarry ponds, with very little organic matter in their waters, both exhibit high SO_4 concentrations, and the slate quarry pond yields the most acid water among those on the gold-bearing series. The slates round about Halifax are often rich in iron pyrites, which may be the the source of the observed acidity. It is also interesting that in the lakes draining carboniferous strata there is a clear correlation between SO_4 on the one hand and Ca and HCO_3 on the other. This may be taken to suggest that a little $CaSO_4$ as well as $CaCO_3$ is being weathered from these rocks.

Organic carbon

The lowest concentrations of dissolved organic carbon are found in the quarry ponds, while the "normal" lakes vary from 2.5 ppm in the very clear water of Bluff Lake to around 10 ppm in lakes like Lewis, Webber, Silver, Purcell's Pond, and the Punchbowl, all in peaty surroundings. Both high and low levels are encountered on all three rock types.

As might be expected, optical density in these lake waters (at 320 mμ) is closely re-

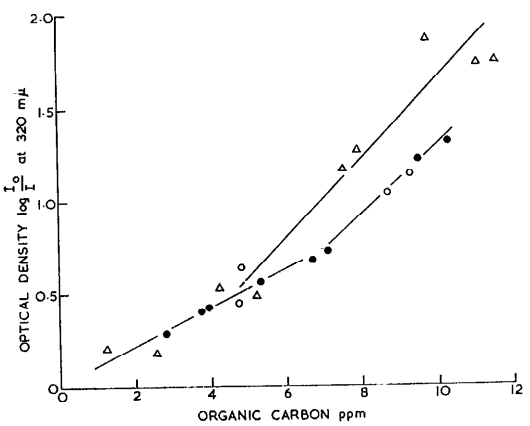

FIG. 6. The relation between optical density and organic carbon concentration.

lated to organic carbon concentration. However, the relationship is not strictly linear, and Figure 6 shows that the most organic waters exhibit proportionally greater optical densities than those with a low carbon content. Moreover, the peaty waters from granite lakes appear to be more highly absorptive than those from lakes draining Meguma or carboniferous rocks, with similar concentrations of carbon. It is reasonable to suppose that this may be connected with the type of vegetation from which the organic matter is derived, and with its mode of decomposition. The water giving the highest ratio of optical density to carbon (0.19) is that from the Punchbowl, which is wholly surrounded by a *Sphagnum* mat growing out from deep *Sphagnum* peat; and high ratios are also shown by Silver Lake (0.15) and Purcell's Pond (0.16), where *Sphagnum* peat is abundant in the vicinity. In contrast, the peaty areas draining into Webber and Lewis Lakes, which show relatively lower ratios (0.13), seem from the map more likely to be sedge swamps, being largely developed along the margins of the Sackville River system. At any rate, they seem unlikely to be as strongly dominated by *Sphagnum* as the peats beside the granite lakes mentioned, which are all characteristic of sites where there is little mineral soil influence, and fairly stagnant conditions predominate. Among the lakes draining carboniferous strata the senescent Nelson Lake yields the highest ratio of optical density to carbon (also 0.13). This lake is certainly still in the phase of marginal fen colonization, without much formation of *Sphagnum* peat.

The lowest ratio (0.07) comes from Bluff Lake, with the least organic carbon among the "normal" lake waters. It is not inconceivable that in this instance the organic material is derived more from organisms within the lake, which are certainly of different chemical composition from *Sphagnum*, sedges, or coniferous forest plants, and are quite probably susceptible to different types of breakdown.

Adjustment of an acid water from Black Lake to pH 7.0 had no significant effect upon the light absorption at 320 mμ, nor did

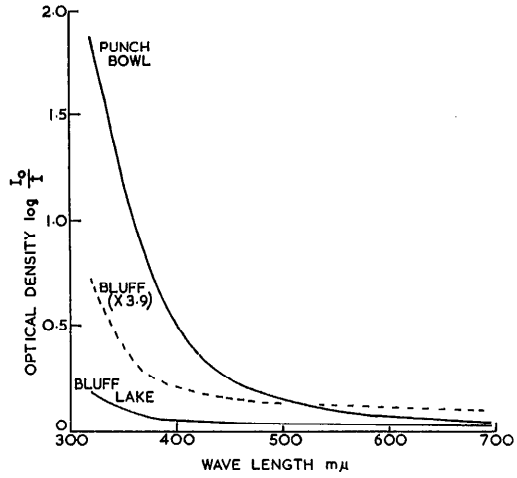

FIG. 7. Light absorption by a highly colored water with much organic carbon, from the Punchbowl, as contrasted with a very clear water low in organic carbon, from Bluff Lake.

acidification of Fraser Lake water to pH 4.8, the middle of the acidity range for the present series of lakes.

To provide further information concerning light absorption in these lake waters, the spectra of Bluff Lake and the Punchbowl were measured between 320 and 700 mμ. Figure 7 illustrates the great increase of absorption in both waters with decreasing wave length. If the Bluff Lake values are multiplied by a factor of 3.9, the ratio of organic carbon contents in the two waters, it is evident that the Punchbowl has a relatively greater absorption at the lower wave lengths, and Bluff Lake at the higher wave lengths. Dilution of the Punchbowl water

TABLE 4. *A comparison of the proportions of major ions in Nova Scotian lake waters and in the average fresh water of the world*

Lake type	Ionic proportions (m.equiv. %)							
	H	Na	K	Ca	Mg	HCO_3	Cl	SO_4
On granite	8	62	3	14	12	—	64	36
On quartzite and slate	1	46	5	36	13	11	50	39
Draining carboniferous strata	—	42	3	40	14	28	42	30
Average fresh water of the world	—	16	3	64	17	74	10	16

to one-tenth concentration decreased absorption to 10.5 per cent of the original at 320 mμ, and to 7.9 per cent of the original at 500 mμ.

DISCUSSION

Examination of the equivalent composition of "normal" lake waters receiving drainage from the three geological substrata investigated here reveals striking differences from the world average composition of fresh water (Conway 1942, Rodhe 1949), as illustrated in Table 4. The Nova Scotian waters are proportionally much richer in Na and Cl, much poorer in Ca and HCO_3, and more acid than the world average, which reflects the abnormal balance in Nova Scotia between the supplies of sea spray and rock weathering products, the former being somewhat high and the latter extremely low, particularly on the granites.

From the results of the present survey, it can be seen that the main factors affecting ionic composition in these lake waters are (1) the nature of the geological substratum, (2) the influence of topography as expressed in the accumulation of both mineral sediments and peat in and around the lake basin, and (3) proximity to the sea.

In connection with geological influences, the levels of Ca and HCO_3 in the Meguma lakes present certain problems. Quartzite is generally considered to be one of the most infertile soil parent materials, slow in weathering, and usually lower in lime even than granite. Moreover, the local quartzite terrain is described by Goldthwait (1924) as closely resembling that of granite, and similarly barren. On the other hand, he remarks that slate yields a much more productive and fertile landscape. From this account one might expect the quartzite lakes to resemble the granite lakes in their calcium and acidity levels, rather than the other Meguma lakes on slate, to which they do correspond in fact.

The rather high Ca and HCO_3 status of Fish, Tucker, and Mt. Uniacke Gold Mines Lakes relative to the others on the Meguma series is also difficult to account for. Since Fish and Tucker Lakes lie close to the axis of the great Shubenacadie Grand Lake valley which runs south from the softer rocks of the Hants-Colchester Lowlands, they may have received drift richer in lime from the ice-sheets moving southward along this route during the last glacial period. And Gold Mine Lake may also have acquired such material during the southeastward advance of the ice from New Brunswick. At present, unfortunately, evidence to support these speculations is wholly lacking, and it is obvious that the factors determining the lime content of the Meguma waters require a good deal of elucidation. Studies of soil profiles, both mineralogical and chemical, would be of much interest in this connection.

The chief value of the present survey may perhaps lie in the provision of a background for further ecological studies. Primary differences are clearly evident in both calcium concentration and acidity of waters on the three types of geological substratum, and since the lime concentrations in all three groups are extremely low in comparison with most fresh waters, it would be very surprising if there were not associated differences in soil profiles and vegetation, both within the lakes and in their drainage basins. It might also be worthwhile to look for differences in organic production, with particular reference to the production of trout for angling. A comparison of peaty and clear waters might also be of interest here.

A last point to be remarked is that all these areas have probably been subjected to repeated burning and cutting, and have in consequence suffered a good deal of soil degradation and vegetational change within historical times (cf. Smith 1835, as quoted by Gorham 1955b). Such factors may well have influenced lakes in these areas.

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