QUANTITATIVE DETERMINATIONS OF BORON IN SARATOGA MINERAL WATERS.*

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ABSTRACT. The results of quantitative determinations for the element boron in Saratoga Mineral Waters are presented for the first time. Additional precautionary measures used in the experimental procedures for determining this element are briefly discussed. The concentrations of several of the elements present in the mineral waters are tabulated and their ratios with each other and with boron are given.

THE presence of boron in the Saratoga mineral waters has been known for many years but up to the present time, no quantitative determinations have been recorded. In view of the great physiological interest in this element, quantitative determinations were made of the mineral waters as a preliminary phase to further work.

A study was made of the ratios of boron with respect to other elements present in the waters but no conclusions are given as there seems to be no simple correlation between the amounts of boron or ratios of other elements with boron. The concentrations and ratios are given here as a matter of interest.

EXPERIMENTAL.

As a result of much preliminary work, in which various methods, and variations of these methods, were used in determining boron in the mineral waters,[1-3] it was found that the method of Naftel[4] was suitable for the work here. In using this method, checks were made by running blanks and standards that were treated exactly the same as the samples. Blanks were used that simulated the mineral content of Hathorn 2 water. To these were added different amounts of boron and these were checked against standard solutions of H_3BO_3, and

* A second paper on boron is in preparation. The absorption of boron through the skin is its object. Boric acid is lipoid and water soluble. Boron possesses a remarkably strong affinity for forming cyclic complexes with OH groupings. Boron penetrates through the lipoid wall of living cells and enters through the skin into the bloodstream. O. Baudisch.

samples to which had been added the same amount of 0.1n $Ca(OH)_2$ suspension as was added to the blank. After evaporating and drying on a steam bath, the same amount of freshly made HCl-oxalic acid mixture and alcohol solution of turmeric were added to each. The drying took place in an electric oven at $55\pm3^\circ$ for the same length of time for standards, blanks and samples of each run. The extraction was made with 95 per cent alcohol, centrifuged and a comparison of colors was made in a Klett Biocolorimeter.

It was found that differences in results obtained while using standard solutions of boric acid and blanks to which boric acid had been added were very slight. Therefore, for some of the runs, standard solutions of boric acid with no salts added other than calcium hydroxide were used as standards of comparison. In order to obtain more accurate results these standards were run with each series of samples, treated the same and for the same lengths of time, and contained approximately the same amount of boron as the samples. As the red color formed is unstable, comparisons were made as soon after formation of color and extraction as was possible. Sunlight was excluded and 95 per cent alcohol was used as the color change is more rapid in sunlight and when water is present in the solvent.

The blanks, which were made to simulate Hathorn 2 water were prepared as follows: 0.06 g ammonium chloride, 8.5 g sodium chloride, 0.1 g potassium bromide, 0.4 g sodium bicarbonate, 2 g calcium carbonate, 1 g magnesium carbonate. Made up to a volume of one liter with distilled water. Samples of this solution were treated and no red color was developed. When known amounts of boric acid were added to samples of this solution and compared with standard solutions of boric acid treated the same way, the recovery was such that it was not considered necessary to run blanks containing these salts. Comparisons between blanks and samples, and standards and samples gave similar results.

In the treatment of mineral water samples it was found that it was only necessary to add enough calcium hydroxide to make the sample alkaline and then to evaporate and dry on a steam bath and follow the usual procedure.

The results shown in Table One give the upper and lower ranges and averages of from seven to twelve samples of each water. At least three samples were taken for each run and these were taken on different dates. Samples and standards

were of such size as to contain 5 to 50 gammas of boron. Better results were obtained with the smaller samples.

Checks were made on some of the waters that had been standing open to air and protected from contamination for periods

TABLE 1.

Spring	Boron-Range Mg/L	Average Mg/L
Hathorn 2	5.3 −5.8	5.5
Hathorn 3	3.1 −3.3	3.2
Orenda	1.7 −2.1	1.8
Hayes	1.9 −2.2	2.0
Coesa	3.2 −3.3	3.3
Hathorn 1	2.0 −2.3	2.1
Lincoln	2.1 −2.6	2.4
Geyser	2.2 −2.4	2.3
Red	0.37−0.50	0.46
Sea Water	4.5 −5.0	4.5−5.0

of from four days to three weeks. There was no change in the boron content of the supernatant liquid. This showed that the boron did not precipitate out and that there was no change in results even though the iron and considerable calcium and magnesium salts had precipitated out.

DISCUSSION.

No deductions have been made as to the sources of boron or of the concentration or ratio with other elements. Some interesting comparisons and ratios are given of concentrations of some of the elements in the waters. As can be seen in Table 2, there is a direct relation between total solids and chlorides. With an increase in solids there is an increase in percentage of chlorine to total solids and a decrease in per cent of bicarbonates. With few exceptions there is a direct relation between total solids and calcium, magnesium, potassium and the bicarbonate radical. (Tables 2 and 3).

However, of the other elements, some of which are listed here, there seems to be no correlation as to concentrations or ratios although the ratio of I: B, HCO_3: B, and K: B are quite similar in some cases.[5-6]

In only one water, Hathorn 2, is the concentration of boron greater than that of the average lithosphere, (3.3 Mg/Kg).[7]

TABLE 2.

Spring	Total Solids	Chlorine as Chlorides	Br	I	Boron	Ratios				
						Total Solids: Cl	Total Solids: B	Cl: B	Br: B	I: B
Hathorn 2	14,581	5,099	30.8	2.7	5.50	2.86:1	2,651:1	927:1	5.6:1	.49:1
Hathorn 3	14,186	4,979	65.5	2.89	3.19	2.85:1	4,447:1	1,560:1	20.53:1	.90:1
Orenda	11,994	4.011	1.07	.92	1.83	2.99:1	6,554:1	2,192:1	.584:1	.50:1
Hayes	11,742	3,870	20.1	.95	2.02	3.03:1	5,812:1	1,916:1	9.95:1	.47:1
Coesa	10,130	2,967	9.4	1.04	3.29	3.41:1	3,079:1	902:1	2.86:1	.32:1
Hathorn 1	8,455	2,418	8.95	.87	2.1	3.5:1	4,026:1	1,151:1	4.26:1	.41:1
Lincoln	8,296	2,085	10.02	1.06	2.35	3.98:1	3,530:1	887:1	4.26:1	.45:1
Geyser	7,284	1,441	6.2	.84	2.33	5.05:1	3,126:1	618:1	2.66:1	.36:1
Red	2,874	574	4.0	.3	.46	5.00:1	6,194:1	1,237:1	8.62:1	.65:1
Sea	35,000	19,341	66.0	.05	4.5–5	1.81:1	7,000:1	4,298:1	14.66:1	.011:1

Concentrations in Mg per Liter

TABLE 3.

Spring	Concentration					Ratios					
	Ca	Mg	K	HCO_3	Li	Ca:B	Mg:B	K:B	Total Solids:HCO_3	HCO_3:B	Li:B
Hathorn 2 ...	799	331	468	4,602	7.2	145:1	60:1	85:1	3.17:1	837:1	1.31:1
Hathorn 3 ...	786	319	431	4,415	12.5	246:1	100:1	135:1	3.21:1	1,380:1	3.92:1
Orenda	739	273	*238	4,087	6.1	404:1	149:1	130:1	2.93:1	2,230:1	3.33:1
Hayes	705	270	*254	4,040	3.97	349:1	134:1	126:1	2.91:1	2,000:1	1.97:1
Coesa	623	197	380	3,868	7.6	190:1	60:1	115:1	2.62:1	1,175:1	2.31:1
Hathorn 1 ...	537	194	234	3,321	3.55	256:1	92:1	111:1	2.55:1	1,580:1	1.69:1
Lincoln	499	*210	201	*3,614	4.02	212:1	89:1	86:1	2.29:1	1,540:1	1.71:1
Geyser	452	122	193	3,613	3.45	194:1	52:1	83:1	2.01:1	1,550:1	1.48:1
Red	250	74	65	1,419	1.80	539:1	160:1	140:1	2.02:1	3,060:1	3.09:1

* Apparent exceptions to direct relation with Total Solids.

TABLE 4.

Spring	Ra*[5]	Ba	Fe	Ratios Ra:B[5]	Ratios Ba:B	Ratios Fe:B
Hathorn 2	5.16×10^{-7}	28.0	5.9	$.938\times10^{-7}$:1	5.09:1	1.07:1
Hathorn 3		18.83	3.92		5.90:1	1.23:1
Orenda	1.24×10^{-7}	8.89	5.88	$.68\times10^{-7}$:1	4.86:1	3.21:1
Hayes		16.34	3.4		8.09:1	1.68:1
Coesa	1.99×10^{-7}	13.24	1.84	$.603\times10^{-7}$:1	4.02:1	0.56:1
Hathorn 1	2.84×10^{-7}	19.70	5.92	1.35×10^{-7}:1	9.38:1	2.82:1
Lincoln		7.8	24.50		3.32:1	10.42:1
Geyser	$.363\times10^{-7}$	8.83	3.12	$.158\times10^{-7}$:1	3.79:1	1.34:1
Red	$.25\times10^{-7}$	2.70	8.80	$.54\times10^{-7}$:1	5.81:1	18.97:1

Enrichment with respect to Fe. 900 (in Red) to 30,350 (in Coesa),
Ratio of Fe.B in Lithosphere = 17,000:1 ([7]).
Ratio of Fe:B in Hayes water = 1.68:1 (An average water).
Enrichment with respect to Fe = 10,000.

However, in comparing the enrichment with respect to iron[6] in an average water (Hayes) the boron is enriched by a factor of 10,100 over the lithosphere.

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