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DEPARTMENT OF MINES
HON. MARTIN BURRELL, MINISTER; R. G. McCONNELL, DEPUTY MINISTER.

MINES BRANCH
EUGENE HAANEL, PH.D., DIRECTOR.

BULLETIN No. 20

Mineral Springs of Canada.

IN TWO PARTS

PART II.

The Chemical Character of some Canadian Mineral Springs.

BY

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LETTER OF TRANSMITTAL.

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Department of Mines,
Ottawa.

Sir,—

I beg to submit the results of an investigation of the chemical character of some Canadian mineral springs, constituting Part II of the report on "Mineral Springs of Canada". Part I, entitled "The Radioactivity of some Canadian Mineral Springs", is now in the press.

These two reports contain the complete results of the work that has thus far been undertaken.

(*Signed*) **R. T. Elworthy.**

Ottawa, October 4, 1917.

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MINERAL SPRINGS OF CANADA.

PART II.

CHEMICAL CHARACTER OF THE WATERS.

INTRODUCTORY.

The Mines Branch, Department of Mines, commenced in the summer of 1914 an investigation of Canadian mineral springs. The investigation of the waters as to their radiocative properties, was made a prominent feature of the work, and a report on this subject has already been published as Bulletin No. 16, entitled "The Radioactivity of some Canadian Mineral Springs." The major part of the investigation, however, has been the detailed chemical examination of the waters and the results that have been obtained during the last three years form the substance of this report.

Some explanation is necessary beyond the bare statement of the analyses of mineral waters in order to render the results intelligible to the non-technical reader, and especially to the owners of the springs and to mineral water dealers. Therefore, an attempt is made to explain the several ways in which the results of a water analysis are expressed; to state as far as is possible the particular therapeutic value of each water; and to compare Canadian mineral waters with some well-known European and American waters, especially those which have been imported, and sold in Canada.

The scope of the work has been outlined in Part I of this report. In brief, the principal springs in eastern Ontario and western Quebec were examined, more especially in the neighbourhood of Ottawa and of Montreal. Particulars of the celebrated hot springs at Banff, Alberta, are also included, as well as analyses of several mineral springs from the Peace River district in Alberta.

In conducting this investigation of the mineral waters of the Dominion, it was found that many of the springs were in a neglected condition, and unused, hence, no attempt was made to examine every spring in the districts surveyed; but those investigated include almost everyone of any economic importance: such as the Caledonia; Russell Lithia; Radnor; Viauville; St. Leon; Sanitaris; and Carlsbad. Most of the waters—after being carbonated—are used as medicinal, or table waters, and owe their value to constituents of medicinal importance. Some of the springs are more especially used for bathing purposes, as, for example, the sulphur waters at Carlsbad and Caledonia, Ont.; and at Banff, Alberta. Each spring was personally inspected, and, usually, samples were collected during the visit; although in a few instances, samples were forwarded by the owners themselves. All necessary tests and observations, such as measurement of flow, temperature and reaction, were made at the same time. Sanitary analyses of the waters have not been made, as the investigation has been conducted solely as a mineral analysis survey. The distinction between a "sanitary" and a "mineral" analysis, is explained in a subsequent part of the report.

SOME DEFINITIONS IN REGARD TO MINERAL WATERS.

WHAT IS MEANT BY MINERAL WATERS.

In its original signification the term "mineral water" was restricted to those natural spring waters which were supposed to possess medicinal properties, either by reason of certain salts or mineral constituents which they contained in solution, or on account of gases with which they were saturated. Yet some springs, having considerable economic importance, yield waters of lower mineral content than water supplies of many cities, and, in fact, owe their value to their great purity. The term mineral water has a wider interpretation to-day, and is commonly accepted as including almost all waters which are bottled and sold as drinking waters, even though they have a low mineral content. The International Food Congress, held in Paris in 1909, adopted as a definition: "A mineral water is a natural water proposed for consumption on account of its special therapeutic or hygienic properties." This definition has been adopted by the United States Bureau of Chemistry, in the various reports they have published on American Mineral Waters, and is also used in the U.S. Mineral Resources Reports, dealing with mineral water statistics.

Since it is a well established fact that almost all fresh water springs are radioactive, such waters might easily be classed as mineral waters under the old definition that mineral waters possess some property of therapeutic importance. Fresh water springs, however, seldom contain any permanent radioactive properties, and the definition would be no longer satisfactory after the water had been bottled for a little time, when the radium emanation would have almost completely died away.

Several other points of interest in regard to the definition of mineral waters and of natural waters were also discussed by the International Food Congress already mentioned. A brief summary of them is given in a bulletin[1] published by the U. S. Department of Agriculture. They refer, chiefly, to regulations fixing the names of mineral waters; preventing confusion between natural and artificial waters; and dealing with the natural salts obtained from the springs by evaporation.

DISTINCTION BETWEEN SPRING AND WELL WATER.

A spring is usually defined as a water rising naturally to the earth's surface, with sufficient volume to cause a distinct current and overflow. A boring in the ground, sometimes only a few feet in depth, sometimes hundreds of feet, which taps the underground water circulation, constitutes a well. An artesian well is one in which the water flows naturally to the surface, and is therefore an artificial spring. Often a spring and a well, situated in close proximity, may yield waters of similar composition. Yet

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[1] U. S. Dept. of Agr., Bur. of Chem., Bul. 139, American Mineral Waters. The New England States, p. 9, 1911.

it is an undoubted fact that a water advertised as a spring water has greater popularity than if its source is known to be a well; and many waters obtained from wells are for this reason, sold as spring waters. It is unlikely, however, that any difference will exist between the therapeutic properties possessed by two similar waters, one issuing from a spring and the other from a well, provided that both sources are satisfactory from a sanitary standpoint.

THE DISTINCTION BETWEEN A MINERAL AND A SANITARY ANALYSIS.

It was stated in the introductory that all the analyses have been carried out as mineral analyses. In a sanitary analysis attention is paid to the fitness of the water for domestic use. Determinations of those constituents which would indicate pollution by sewage are particularly made, and a bacteriological examination is of especial importance. A careful investigation of the source of the water, and of the possibility of pollution must be made. Such an examination is absolutely necessary before a mineral water is put on the market, and it should be carried out at frequent intervals afterwards. Insufficient attention has been paid to this point.

To make a mineral analysis of a water, is to determine the proportions of the various mineral constituents the water holds in solution. A mineral analysis is important, from both the therapeutic and from the geologic standpoint. Therefore, a complete study[1] of a mineral water comprises three main lines of work:—

(1), The measurements of physical properties, such as temperature, depth, flow, colour, turbidity, specific gravity, radioactivity, and electric conductivity;

(2), A complete mineral analysis; including quantitative determinations of the constituents tabulated in the next pages, and the calculation of the results to show the geologic antecedents of the water; and

(3), A bacteriological examination, and sanitary survey, indicating the potability of the water.

With the exception of the bacteriological examination, the investigation of Canadian mineral springs has been complete. Almost every determination, just enumerated, has been carried out.

THE CONSTITUENTS OF A MINERAL WATER.

It is commonly agreed to-day that the source of all springs, with few exceptions, is water which falls on the earth's surface as rain or snow. Such water—which contains small quantities of ammonia, nitric acid, and especially of carbon dioxide—has a very considerable solvent action on the substances composing the soil and rocks through which it percolates, and when the water eventually flows at the surface as a spring or is pumped from a well, it will hold in solution a far larger quantity of mineral constituents than

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[1] Gautier, A., Compt. Rend., 1911, 1–546.

when it fell as rain. The nature and amount of the various constituents will depend on the nature of the geological formations the water has traversed.[1] If its path has lain over primary rocks such as granites and gneisses, the chief constituents will be sodium and potassium carbonates, and bicarbonates; but if sedimentary formations have been traversed, calcium and magnesium salts will be predominant. Much sodium chloride or common salt in a water will indicate that its circulation has been in the neighbourhood of marine deposits containing beds of salt. The history of the underground course of a water, however, is very complex, since many chemical reactions may take place between the constituents of the water and those of rocks over which it flows. Several of the springs in Quebec and Ontario were the subject of study by Dr. Sterry Hunt,[2] many years ago, and the probable origin of the constituents and the changes in composition that the waters undergo were considered. Comparison between the analyses made by Sterry Hunt and those tabulated in the report show that little change has taken place during the last thirty years, and that the constituents, in the waters, owe their presence to the same processes as described by him.

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[1] For information on underground water circulation, the reader is referred to:—

King, Franklin Hiram, "Principles and conditions of the movements of ground water", U. S. Geol. Surv. 19th Ann. Rep., Pt. II, pp. 61–384, 1898.

Geikie. A., "Textbook of Geology," 4th edition, vol. I, pp. 465–8.

Mager, Henri, "Les Eaux Souterraines et les moyens de les découvrir," chapters 1, 2, and 3, Paris, 1912.

Von Heimhalt, Hans Hofer, Grundwässer und Quellen, Braunschweig, 1912.

Also many of the papers on water supply, published by the United States Geological Survey.

[2] Sterry Hunt, Chemical and Geological Essays, chapters 4, 5, and 6, 1878.

The following substances, either chemical elements or "individuals," or associations of elements called radicles, have been sought for in the waters, and in most cases the proportions in which they are present have been determined:—

Element or radicle.	Symbol.	Atomic or molecular weight. (1917).	Valence.	Reacting coefficient.
Alkalies.				
Sodium	Na	23·00	1	0·0435
Potassium	K	39·10	1	0·0256
Lithium	Li	6·94	1	0·1441
Ammonium	NH_4	18·01	1	0·0554
Alkaline earths.				
Calcium	Ca	40·07	2	0·0499
Strontium	Sr	87·63	2	0·0228
Barium	Ba	137·37	2	0·0146
Magnesium	Mg	24·32	2	0·0822
Hydrogen and metals.				
Hydrogen	H	1·008	1	0·9921
Iron (ferrous)	Fe	55·84	2	0·0358
Aluminium	Al	27·1	3	0·1107
Manganese	Mn	54·93	2	0·0364
Strong acid radicles.				
Chlorine	Cl	35·46	1	0·0282
Bromine	Br	79·92	1	0·0128
Iodine	I	126·92	1	0·0079
Sulphuric acid	SO_4	98·06	2	0·0208
Nitric acid	NO_3	52·01	1	0·0161
Weak acid radicles.				
Bicarbonic acid	HCO_3	61·013	1	0·0164
Carbonic acid	CO_3	60·005	2	0·0333
Sulphide	S	32·06	2	0·0624
Phosphoric acid	PO_4	95·04	3	0·316
Metaboric acid	BO_2	43·0	1	0·0232
Considered as present in the colloidal state:—				
Silica	SiO_2			
Alumina	Al_2O_3			
Ferric oxide	Fe_2O_3			
Gases in solution.				
Carbon dioxide	CO_2			
Hydrogen sulphide	H_2S			

Other elements undoubtedly occur in minute amount, and could be detected if sufficiently large quantities of water were put through the requisite procedure to test for the presence of such elements. Fresenius[1] mentions the following substances as possible constituents of mineral waters, besides those just enumerated: ceasium, rubidium, zinc, nickel, cobalt,

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[1] Fresenius. "Quantitative Chemical Analysis." Vol. II, p. 221, 6th Edition, 1904.

lead, copper, thallium, titanium, and several complex organic acids. Arsenic is occasionally present in waters, even in medicinal doses: as for example in La Bourbonle spring in the south of France, in which it occurs to the extent of seven parts per million parts of water, or, as in the water of Owens Lake in California, which contains 83·8 parts per million.[1]

Fluorine is present in most mineral waters, though it is seldom estimated. Gautier and Clausman[2] detected it in amounts up to 6 parts per million in a number of French springs.

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[1] Stone, C. H. and Eaton, F. M., A New Analysis of the Water of Owens Lake, California. Jour. Am. Chem. Soc. 28, 1,164, 1906.

[2] Gautier and Clausman, Compt. Rend., 158–1,634, 1914; also Gil, J.C.S., Abs. ii, 80, 1906.

STATEMENT OF THE RESULTS OF A CHEMICAL ANALYSIS.

IONIC FORM SUPERIOR TO HYPOTHETICAL COMBINATIONS.

In carrying out a chemical analysis of a mineral water, the quantities of the various elements or groups of elements, such as sodium, calcium, or iron, the carbonate, the sulphate, or the nitrate radicle, are found by actual experiment. The total amount of mineral matter in solution is also directly determined, but beyond these data, ordinary chemical manipulations do not give any knowledge regarding the exact amount of salts, such as sodium chloride, magnesium, sulphate, or calcium bicarbonate, that are assumed to be present in solution in the water. In fact, regarded from the standpoint of the modern theory of solution, it is probable that the substances do not exist in the form of compounds in the water, but are entirely dissociated into electrically charged particles or ions. Thus, a pinch of common salt (sodium chloride) dissolved in a gallon of water, immediately dissociates into sodium ion: which is sodium metal bound up with a positive charge of electricity and chlorine ion, that is chlorine carrying a negative charge, both entirely different, however, to the elements sodium and chlorine as we know them in the free state; the first, being a silver-like metal which readily decomposes water, the second, a greenish-yellow gas, with a choking, disagreeable odour.

In a water supposed to contain six or seven compounds such as sodium and potassium chlorides, magnesium and sodium sulphates, and calcium and magnesium bicarbonates, each substance will be dissociated, at any rate to some extent, and seven different ions can be estimated; but there is no way of telling what is the exact distribution of the ions. The only rational way is to report the amount of each ion present; a statement which is the result of actual experiments, and cannot be disputed. Thus the water considered above will contain the basic ions sodium, potassium, magnesium, and calcium, and the negative ions chlorine and bicarbonic acid.

Again, the therapeutic properties of a mineral water are due chiefly to the individual properties of the ions: for example lithium will have the same effect whether it is administered as a solution of lithium chloride, lithium sulphate, or lithium carbonate. For this reason it is more satisfactory to know the ionic composition of a water.

With a view to enabling those who are not accustomed to this form of representation to obtain some idea of the composition of a water from the analysis, hypothetical combinations have been calculated. Rules for such calculations are based on the respective solubilities of the component salts. Over forty sets of such rules exist: accounting for the confusion that has often existed between analyses of one spring by different analysts, using different rules. The following, adopted by the Bureau of Chemistry of the U.S. Department of Agriculture, have been used throughout. Sodium is first combined with nitrous, nitric, and metaboric acids. Potassium is combined with iodine, and bromine; and calcium, with phosphoric acid. Ammonium, lithium, and potassium are assigned to chlorine. Sodium, magnesium, calcium, strontium are then calculated to combine with chlorine, sulphate, bicarbonate, and carbonate ions, respectively. If there is an excess of bicarbonate ion, the iron (together with aluminium if it has been estimated with the iron) is calculated to form ferrous bicarbonate. Otherwise, ferric oxide and alumina are considered to be present, probably in the colloidal form as silica is usually considered to be. Sometimes, silica occurs in the form of a salt as calcium silicate, but it has never been found as such in any water included here.

But these rules are based on false assumptions, because the solubility of each salt when alone in solution is different from its solubility in a solution of other salts.[1] Such solubilities can only be found by individual consideration of the system under examination. The combinations should represent the solids that precipitate out when such a solution is evaporated.

The amount of both ions and hypothetical combinations are given in parts per million by weight.

Thus, if a water contains 400 parts per million of calcium ion, a million pounds of the water holds 400 pounds of calcium ion in solution; a million milligrams—practically equal to one litre if the water under consideration is of low specific gravity—contains 400 milligrams of calcium ion. Seeing that most mineral waters have a specific gravity of 1·005 to 1·001, the amount of a constituent in parts per million may be considered without serious error as equivalent to the amount expressed in milligrams per litre. The expression of water analyses in parts per million is universally adopted by sanitary and technical chemists to-day, and the exclusive employment of this unit industrially is, as R. B. Dole states,[2] delayed only by more or less objectionable precedent. Certainly, to the average person, results stated in grains per gallon are no more intelligible than when expressed in parts per million. To transform parts per million into grains per imperial gallon for an approximate result, the quantity of a constituent expressed in parts per million must be multiplied by 0·07, since there are 70,000 grains in an imperial gallon.

The amount of each constituent calculated as a percentage of the total inorganic material in solution will also be stated. In another column, the reacting values of each substance present is given: calculated to a percentage basis by means of the concentration value—which is simply the sum of the actual reacting values.

As far as possible, previous analyses have been included for the sake of comparison. Most of these have been recalculated to the ionic form, from

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[1] Turrentine. The Composition of U. S. Salines, Jour. Ind. Eng. Chem. 7, p. 689, 1915.
R. B. Dole, Hypothetical Combinations in Water Analysis, Jour. Ind. Eng. Chem. 6, p. 710, 1914.

[2] U. S. Geol. Surv., The Underground Waters of North Central Indiana, Water Supply Paper 254, p. 232.

statements of the compounds assumed to be present, often only given in grains per gallon.

REACTING VALUES.

The statement of the analytical results, as the quantity of ions or radicles present, in parts per million, does not adequately express all the information that can be obtained from the analysis of a water. Such results only show the physical weight of the various constituents, and thus give no indication of their chemical value. Therefore, the proportional reaction capacities or reacting values of the radicles are tabulated with the ionic results. Such reaction capacities or reacting values are calculated by dividing the weight of each radicle found by analysis, by its equivalent combining weight. Eight parts of oxygen unite with 23 parts of sodium, 39 parts of potassium, 20 parts of calcium, and 12·16 parts of magnesium. These are the equivalent combining weights of the abovementioned elements, and the reacting values are obtained by dividing the quantity of each radicle or element present in the water by its combining weight. The reciprocals of the equivalent combining weights are more often employed, as suggested by Herman Stabler,[1] and are termed by him reacting coefficients. The reacting coefficient of a radicle may, therefore, be defined as the ratio of the reaction capacity of 1 part of that radicle to the reaction capacity of eight parts of oxygen.

A list of the reacting coefficients of the various elements or radicles commonly estimated in the mineral analysis of a water is given on page 6. This form of expression is convenient in several ways:[2] it affords a scheme of classification which will be explained later, and allows the potency of the water as a geologic agent to be studied as well as giving information of its past history; it serves, moreover, as a check on the accuracy of the analysis, since the sums of the acidic and of the basic radicles must necessarily be equal, at least within the range of experimental error, with the exception of one or two cases, such as waters in which free, strong acids are present.

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[1] Stabler, Herman, The mineral analysis of water for industrial purposes and its interpretation by the engineer. Eng. News Vol. 60, p. 356, 1908.

Also Chapter on the industrial application of water analyses, in U. S. Geol. Surv., Water Supply Paper No. 274, p. 165, 1911.

[2] For a complete discussion of this mode of interpretation of water analyses see:—

Chase Palmer, The Geochemical Interpretation of Water Analyses, U. S. Geol. Surv., Bul. 479, 1911.

Rogers, G. Sherburne, The Interpretation of Water Analyses by the Geologist, Economic Geology, Vol. 12, pp. 56–88, 1917.

Cumming, C. L., Artesian Wells of Montreal, Geol. Surv. Can., Dept. of Mines, Memoir 72, pp. 36–44, 1915.

THE CLASSIFICATION OF THE WATERS.

Almost every book or bulletin on mineral springs advocates its own method of classification: demonstrating the difficulty of finding a satisfactory classification for subjects of such complex character as natural waters. It is not proposed to discuss the various methods here, although a list of the chief attempts is included in the appendix. Two methods have been adopted in this report: one suggested by Chase Palmer based on the reacting value of the constituents of the water, and most useful from a geological standpoint; and the other a scheme proposed by J. K. Haywood.[1]

The first method is of the most value, seeing that it gives evidence of the nature of the strata through which the water has passed, and of the solvent of the water on the rocks composing the strata. It shows the nature and amount of the predominant constituents also. The second method more readily indicates the actual elements present, and gives information concerning the therapeutic value of the water.

CHASE PALMER'S CLASSIFICATION.

The radicles are divided, according to their chemical nature, into certain groups. Thus, sodium, potassium, and lithium—called the alkalies or primary bases—are associated. They occur together in nature; are mutually interchangeable in minerals; have the similar chemical characters; and are members of the same chemical family. All these metals decompose water, and form similar salts with acids. Similarly calcium, strontium, and magnesium—the alkaline earths or secondary bases—are comparatively similar in their chemical behaviour and are geologically associated. Hydrogen and the metals form a third class of positive bases. The acid radicles fall into two groups: strong acid radicles, such as hydrochloric or muriatic (Cl'); sulphuric (SO_4''); and weak acid radicles (e.g. bicarbonic acid HCO_3'); carbonic (CO_3''); and metaboric (BO_2') acids.

According to the relative values of the several groups just referred to, all natural waters fall into one of the following classes:—

Class 1. Value of strong acids (e.g. SO_4, Cl), less than value of alkalies (e.g. Na, K).

„ 2. Value of strong acids equal to value of alkalies.

„ 3. Value of strong acids greater than value of alkalies but less than alkalies plus alkaline earths.

„ 4. Value of strong acids equal to value of alkalies plus alkaline earths.

„ 5. Value of strong acids exceeds value of alkalies plus alkaline earths.

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[1] Haywood, J. K., and Smith, B. H., Mineral Waters of the United States, U.S. Dept. Agr., Bur. Chem . Bul. 91, pp. 8–11, 1907. Also, American Mineral Waters; The New England States, U.S. Dept. Agr. ,Bur. Chem. Bul. 139, pp. 18–20, 1911.

Classes 2 and 4 seldom occur, and are included chiefly for the sake of completeness.

These main classes can be again subdivided by considering the nature of the salts formed by balancing up the various groups. The bases and strong acids combine to form salts which, dissolved in water, give it the property of salinity. Primary salinity is the salinity caused by the solution of strong acid salts of the alkalies, such as sodium and potassium chlorides or sulphates; secondary salinity, by the solution of strong acid salts of the alkaline earths chiefly calcium and magnesium chlorides and sulphates; and tertiary salinity, by the solution of strong acid salts of hydrogen (e.g., strong acids), or of metals such as iron and aluminium chlorides or sulphates. Solutions of weak acid salts, such as sodium carbonate, possess the property of alkalinity, e.g., they turn red litmus, blue; or methyl-orange, yellow: to mention two of the chief indicators which are used in determining the reaction of a solution.

Primary alkalinity, is caused by the solution of weak acid salts of the alkalies, chiefly sodium and potassium carbonates or bicarbonates; secondary alkalinity, by the solution of weak acid salts of the alkaline earths such as calcium bicarbonate; and tertiary alkalinity, by the solution of weak acid salts of the miscellaneous group of positive radicles such as hydrogen and the metals.

The following table expresses these statements more graphically:—

BASES.	ACIDS.	
	Strong acids. (e.g. Cl, SO_4, NO_3)	Weak acids. (e.g. CO_3, HCO_3)
Alkalies (e.g. Na, K, Li,).............	Primary salinity,	Primary alkalinity.
Alkaline earths (e.g. Ca, Mg, Sr.)........	Secondary „	Secondary „
Metals (e.g. H, Fe.)..................	Tertiary „	Tertiary „

When a water needs much soap to produce a lather, it is said to be 'hard'. It may be either temporarily hard, when the hardness can be dissipated by boiling; or it may be permanently hard—a property not removed by boiling, only by chemical treatment.

Temporary hardness is due to the property of secondary alkalinity, e.g., calcium or magnesium bicarbonate present in water; while permanent hardness results from the property of secondary salinity, e.g., calcium or magnesium sulphate in solution.

To obtain the amounts of these various properties from the analytical results, the reacting values are considered, calculated on a percentage basis. The sum of the reacting values of the members of each group gives the value for the alkalies, alkaline earths, strong acids, and weak acids, respectively.

Then the value for the strong group is balanced against the figure for the primary bases or alkalies, the sum of them giving primary salinity; any excess of the value of strong acids remaining over the value of the alkalies is balanced against the alkaline earth group, the sum giving the secondary salinity; and any excess then remaining against the metals or hydrogen, giving tertiary salinity—rarely found in any other but mine waters.

After the strong acids have been balanced, the weak acids are worked out against the basic radicles in the same manner. On the other hand, the value for the alkali group may be greater than that of the strong acids. Twice the value of the strong acid group gives primary salinity, and the excess alkali value is combined with weak acids to produce a primary alkalinity. The balance of the weak acid value will almost always be found to be equal to the value of the alkaline earth group, giving secondary alkalinity.

The following example illustrates the procedure:—

Lithia Spring. Carlsbad Springs. No. 20.

		Parts per million.	Reacting values.	Reacting values. Per cent.
Sulphuric acid	(SO_4)	2·4	0·05	0·03
Bicarbonic acid	(HCO_3)	750	12·30	7·84
Carbonic acid	(CO_3)	——	——	——
Nitric acid	(NO_3)	——	——	——
Nitrous acid	(NO_2)	trace	——	——
Phosphoric acid	(PO_4)	——	——	——
Metaboric acid	(BO_2)	trace	——	——
Chlorine	(Cl)	2,340·	65·90	42·03
Bromine	(Br)	12·5	0·15	0·10
Iodine	(I)	0·5	——	——
			78·40	50·00
Silica	(SiO_2)	12·7	——	——
Iron	(Fe)	2·1	0·08	0·05
Aluminium	(Al)			
Manganese	(Mn)	trace	——	——
Calcium	(Ca)	57·0	2·85	1·82
Strontium	(Sr)	trace	——	——
Magnesium	(Mg)	47·	3·86	2·46
Lithium	(Li)	1·5	0·21	0·13
Potassium	(K)	50·1	1·28	0·82
Sodium	(Na)	1,608·	70·00	44·63
Ammonium	(NH_4)	2·6	0·14	0·09
Total		4,886·4	78·42	50·00

Groups—
Strong acids.................... 42·03 + 0·10 + 0·03 = 42·16
Weak acids...................... = 7·84
Alkalies........................ 44·63 + 0·82 + 0·13 + 0·09 = 45·67
Alkaline earths................. 1·82 + 2·46 + 0·05 = 4·33

Properties—

Primary salinity,
Value of strong acids + equal amount of alkalies,
$42 \cdot 16 + 42 \cdot 16 = 84 \cdot 32$

Primary alkalinity—
Remainder of alkali value + equal amount of weak acids,
$(45 \cdot 67 - 42 \cdot 16) = 3 \cdot 51 + 3 \cdot 51 = 7 \cdot 02$

Secondary alkalinity—
Remainder of weak acid value + equal amount of alkaline earths,
$(7 \cdot 84 - 3 \cdot 51) = 4 \cdot 33 + 4 \cdot 33 = 8 \cdot 66$

These statements give the following information: sodium salts of strong acids form 84 per cent of the total solids; sodium carbonate or bicarbonate constitute 7 per cent; while calcium and magnesium bicarbonates make up the remainder. These quantities agree fairly well with the hypothetical combinations.

HAYWOOD'S CLASSIFICATION.

The second form of classification suggested by Haywood possesses more value from a therapeutic standpoint, in that it readily indicates the chief constituents of the water.

Four main classes: alkaline, alkaline-saline, saline, and acid waters, are each divided into several sub-classes. These sub-classes are again qualified by the names of the medicinally important radicles. The classification is as follows:—

Thermal or Nonthermal		Carbonated or bicarbonated		
	I. Alkaline	Borated	Sodic	
		Silicated	Lithic	
			Potassic	
		Sulphated	Calcic	Non-gaseous
	II. Alkaline-saline	Muriated	Magnesic	Carbondioxated
		Nitrated	Ferruginous	Sulphuretted
			Aluminic	Azotised
		Sulphated	Arsenic	Carburetted
	III. Saline	Muriated	Bromic	Oxygenated
		Nitrated	Iodic	
			Siliceous	
		Sulphated	Boric	
	IV. Acid	Nitrated		

Thermal waters are defined as those which issue from the ground at a temperature of 70°F., and higher. Of such waters those from 70° to 90°F., are considered warm or tepid, while those with a temperature above 90°F., are termed hot springs.

Alkaline waters are those which turn methyl-orange, yellow, and red litmus, blue, and therefore have an alkaline reaction. The alkalinity is usually due to the presence of sodium carbonate or bicarbonate.

Alkaline-saline waters are those which contain both strong acid radicles (sulphuric, hydrochloric or nitric ions), and carbonic or bicarbonic acid ions, or more rarely boric or silicic acid ions; both strong and weak acids being present as predominating constituents. Thus, such waters have both alkaline and saline properties, and contain salts of carbonic or bicarbonic acid, together with salts of the strong acids. Primary alkalinity is usually present in small amount, while in alkaline waters it is considerably greater—ranging from 40 to 100 per cent. Many of the springs, the subject of this report, belong to the alkaline-saline class of waters. Saline waters are those which have an alkaline or neutral reaction, and contain sulphuric, muriatic, or nitric acid ions in predominating quantities.

Acid waters have an acid reaction, and contain sulphuric or muriatic acid. They are seldom met with, except in the neighbourhood of iron-pyrites deposits, where they contain iron sulphate; or in regions where volcanic agencies are active. No springs belonging to this class are included in this report, though several exist in Canada:[1] for example at Tuscarora, near Brantford, and at Chippewa, in the Niagara peninsula.

Haywood's classification enables one to name any mineral water with great accuracy. If any basic or acidic element is prominent, this fact is indicated by prefixing the name of the base or acid to the regular class name—as sodic, calcic, etc.; carbonated alkaline, sulphated alkaline-saline, etc. If any basic or acid ion is prominent therapeutically, but not chemically, this fact may be indicated by affixing the name of the basic or acid ion to the regular name—as carbonated, alkaline, (arsenic, bromic, iodic, etc.).

The following statements in reference to the gases often present in mineral waters define the terms:—

Non-gaseous	water	contains	no gas.
Carbondioxated	„	„	carbon dioxide.
Sulphuretted	„	„	hydrogen sulphide.
Azotised	„	„	nitrogen.
Carburetted	„	„	methane.
Oxygenated	„	„	oxygen.

A few examples of the application of this classification to waters in the report will illustrate its use. The Sanitaris Mineral Water (page 28) is a sodic, magnesic, calcic, muriated alkaline-saline water.

"Magi" Caledonia, Caledonia Saline Spring, (page 45) is a sodic, muriated alkaline-saline carbondioxated water. Viauville Mineral Water is a sodic, muriated sulphated saline (bromic, sulphuretted) water.

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[1] Sterry Hunt, Geology of Canada, p. 545, 1863.

ON THE COLLECTION OF SAMPLES, AND METHODS OF ANALYSIS.

PROCEDURE IN THE FIELD.

It has been already stated that the examination of the springs for radioactive properties formed one of the main features of the investigation, and on that account centres were selected within easy access of the principal groups of springs, to which water samples were quickly taken after collection to ensure the radioactive examination being made with as little delay as possible. At the same time, as samples for the radioactive tests were obtained, water for chemical analysis was also collected. To contain the samples, new five-gallon glass demijohns were employed. Two bottles were usually filled: one for the radioactivity determinations, and the other for chemical tests. The greater number of the springs were flowing springs, hence a sample was easily taken at once, either from the overflow, or from the actual pool or well itself. Most springs were enclosed in earthenware pipes or wooden casings, and proved readily accessible. Sources that required pumping were always pumped for ten or fifteen minutes previously to the collection of a water, in order that a perfectly fresh sample might be obtained.

The bottles were rinsed out three times with the water to be examined, and then filled up almost to the cork; the space left depending on the temperature of the air, and quantity of gas evolved from the water. A new cork was inserted, and the bottle sealed. A bacteriological examination was not included, and, therefore, no specially collected and ice-packed samples were required, although observation was made of the sanitary condition of the surroundings.

FIELD OBSERVATIONS AND MEASUREMENTS.

Several observations and tests were carried out at the spring. The temperature of the water was measured by means of standardized thermometers. In the case of wells or deep pools, a maximum and minimum thermometer was used to obtain the temperature at the source of the water. The depth was approximately ascertained by lowering weighted measuring tapes. In the frequent instances where the overflow ran off by a pipe, the flow was calculated by noting the time required to fill a container of known volume. The taste, odour, and appearance of the water were recorded. The surroundings of the spring were observed, and particulars of its history and utilization obtained, as far as possible.

The quantity of carbon dioxide gas in the water was determined by either of two methods:—

(i). As described in Bulletin 91, U.S. Dept. of Agr., Bureau of Chemistry, The Mineral Waters of the United States, pp. 18-19.

In brief, the method is to determine, by Pettenkoffers' method,[1] the amount of carbon dioxide in excess of that necessary to form normal carbonates, and the amount of carbon dioxide given off from the bicarbonates when the water is evaporated to dryness. Subtracting the former result from the latter, gives the amount of carbon dioxide existing in solution in the free state.

(ii). By the titration of a measured volume of the water with sodium carbonate solution of known strength—according to Winkler's method.[2]

Neither of these methods proved entirely satisfactory.[3]

Hydrogen sulphide was estimated by the titration of a known volume of water with N/100 iodine solution, using starch solution as an indicator—according to the method described by Sutton.[4]

A solution of sodium nitroprusside was used to test for the presence of metallic sulphides; but only two or three waters gave any indication of the presence of such compounds. The reaction of the waters was tested by adding a few drops of methyl-orange solution to a sample, and observing the colour change.

If gases were evolved from the springs, two samples were collected in Winchester quart bottles, or in glass gas-sample tubes. In the former case, a large metal funnel was inserted in the neck of the bottle, and the whole carefully filled with water, taking especial care to expel all air bubbles. Then, with the neck and funnel under the surface, the bottle was inverted over the stream of gas bubbles which ascended and displaced the water. The stopper was carefully replaced, leaving a little water covering the stopper to act as a seal, the bottle being transported in an inverted position. The gas sample tubes were attached to the funnel by rubber tubing, and the whole system filled with water. When the lower tap of the sample tube is opened, water will only run out as fast as gas enters from the funnel at the other end—provided everything is air tight.

Measurements of the radioactive content of one sample were carried out by the usual methods.[5] The second sample was analysed for its main constituents, oxygen, nitrogen, carbon dioxide, methane, and hydrogen. No determinations were made of the rare gases of the atmosphere, which exist at least in traces in all radioactive natural gases, except in one case—that of the gas evolved from the Basin Spring at Banff, Alberta (page 142).

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[1] Sutton, F., Handbook of Volumetric Analysis, Ninth Edition, 1907, p. 98.

[2] Winkler, L. W., Z. angew Chem., Vol. 29, p. 335, 1916.

[3] For a discussion of the various methods of determining carbon dioxide in natural waters see:

Ellms, J. W., and Beneker, J. C., The estimation of carbon dioxide in water; Jour. Am. Chem. Soc., 23-405, 1901.

Forbes, F. B., and Pratt, G. H., The determination of carbonic acid in drinking water; Jour. Am. Chem. Soc., 25-742, 1903.

Johnson, J., The determination of carbonic acid, combined and free, in solution, particularly in natural waters; Jour. Am. Chem. Soc., 38-947, 1916.

[4] Volumetric Analysis, p. 336, 1907.

[5] The Radioactivity of some Canadian Mineral Springs. Mines Branch, Bul. 16, pp., 9-17, 1917.

THE METHODS OF ANALYSIS.

It is not intended to give a detailed description of the methods of analysis that have been employed. They are, for the most part, those described in U.S. Department of Agriculture, Bureau of Chemistry, Bulletin 91; and in the Standard Methods of Water Analysis, published by the American Public Health Association (2nd. edition, 1913). In the few cases where modifications of these methods have been used, fuller details will be outlined.

Usually, a demijohn of water was at hand for analysis (containing about 4½ Imperial gallons or 20 litres). Sufficient amounts of water were used in the examination for each constituent to ensure its detection, if present, to the extent of one part in ten million.

Sulphuric acid, bicarbonic acid, carbonic acid, chlorine, iron, aluminium, calcium, magnesium, sodium, potassium, and ammonium, were determined by the standard methods described in the publications referred to.

Nitric acid was usually estimated by the reduction method with aluminium foil in alkaline solution as described on page 25 of the Standard Methods of Water Analysis. The α naphthylamine sulphanilic acid colorimetric method was employed for the estimation of nitrous acid (page 22. S.M.W.A.).

The detection of boric acid was carried out as described on page 27 of Bulletin 91. No quantitative measurements of this radicle were made. For bromine and iodine the colorimetric method developed by J. K. Haywood (pages 23-26, Bulletin 91,) was used with excellent results. Considerable experimental work was done on an oxidation method for bromine and iodine. Iodine was liberated from a neutral solution of iodides and bromides by the action of potassium bicarbonate; the bromide being decomposed when sulphuric acid was added to the mixture; sodium chloride was not affected. The iodine and the bromine were absorbed in potassium iodide solutions, afterwards titrated with standard sodium thiosulphate. The method proved fairly satisfactory, and checked with the results obtained by the colorimetric method when tried on the Caledonia group of waters. But it is not as sensitive as the colorimetric method, and therefore not as convenient for the small amounts of bromine and iodine usually present in most mineral waters.

Manganese was found in most samples by using the colorimetric method described by Hillebrand,[1] in which the manganese is oxidized to permanganic acid by ammonium persulphate in the presence of silver nitrate and nitric acid.

Strontium, when present, was separated from calcium, using the ether-alcohol method recently adopted as the standard method[2] by the Association of Official Agricultural Chemists.

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[1] Hillebrand, W. F., The Analysis of Silicate and Carbonate Rocks; U. S. Geol. Surv., Bul. 422, 1916, p. 117.

[2] Skinner, W. W., The Separation and Determination of Calcium and Strontium. Jour. Assoc. Offic, Agr. Chem., Vol. II, 1916, p. 113.

Barium was seldom detected, even spectroscopically. When it was present in sufficient amount it was separated from strontium and calcium by the ammonium bichromate method.

Lithium was estimated by the well known amyl alcohol method of Gooch.[1] In a few instances lithium was determined using one or other of the spectroscopic methods outlined in a bulletin[2] on the spectroscopic determination of lithium by W. W. Skinner and W. D. Collins.

A colorimetric method recently proposed by Winkler[3] was found to be the most convenient for the estimation of phosphoric acid. One c.c. of a 10% ferric chloride solution, and 2 c.c. of a 10% alum solution are added to 1 to 5 litres of the water to be tested, and the whole boiled for an hour. Any phosphoric acid is carried down in the iron hydroxide precipitate, which is filtered off and dissolved in nitric acid. The solution is evaporated to dryness, the residue dissolved in water with a drop of nitric acid added, filtered, and ammonium molybdate solution poured in. On standing, any phosphoric acid will be precipitated as ammonium phospho-molybdate; this is filtered off, dissolved in ammonia, more ammonium molybdate solution added, and the yellow colour of the solution compared with a potassium chromate solution corresponding to a definite concentration of phosphorous pentoxide.

No tests, save in a few instances, were carried out for the presence of arsenic, copper, lead, fluorine, or selenium. Spectroscopic tests were made on all residues and precipitates, checking the presence of the several elements, which give flame spectra, and affording some indication of the completeness of the separations.

Many of the springs, especially those rising in the vicinity of peat bogs (such as the groups of springs at Caledonia and Carlsbad), contain organic compounds, which is the cause of the yellow colour of the waters. On the continent of Europe such organic substances are often determined, but in America little attention has been paid to them. They are present in small amount, possess a complex composition, and have no importance from a therapeutic standpoint. Therefore, no attempt was made to estimate them or determine their nature, interesting as such work would be.

The results of the radioactive determinations are rightly included in the statement of analyses. Details of the methods adopted for these determinations are given in full in Part I[4] of this report.

The total solid matter in solution was obtained by evaporating 100 c.c., of the water in a platinum dish, and drying at 100°C., to a constant weight. The dish was then gently ignited, and the residue on ignition determined. Sulphuric acid was added, and the solution evaporated, and finally heated

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[1] Treadwell. Analytical Chemistry, Vol. II, 4th edition, 1915, p. 53.

[2] Skinner, W. W., and Collins, W. D., Determination of Lithium, U. S. Dept. Agr., Bur. Chem., Bul. 153, 1912.

[3] Winkler, L. W., Z. angew, Chem., Vol. 22, p. 288, 1915. Abstract in Jour., Soc. Chem. Ind., p. 243, 1915.

[4] Satterly, J., and Elworthy, R. T., Mineral Springs of Canada, Part I, Radioactivity of Some Canadian Mineral Springs.' Mines Branch, Bul. 16, pp. 26, 42–46, 1917.

to a dull red heat, until all the bases were converted to sulphates. A little ammonium carbonate was added to ensure the complete conversion of acid alkali sulphates to normal sulphates. The dishes were cooled and weighed and reignited till constant weight was obtained. The residue must be heated to a sufficient temperature to convert the iron sulphate present to ferric oxide.

ACCURACY OF THE ANALYSES.

The determination just described affords a check on the accuracy of the various estimations, as the weight of the bases as sulphates present in a million parts of water should agree with the calculated value of the bases as sulphates stated in parts per million. An agreement to within 0·5% can commonly be obtained. Using a larger volume of water than 100 c.c., and taking great precautions during evaporation and ignition, no doubt a greater degree of accuracy might be attained. The following example is an illustration of the use of this procedure in checking the accuracy of an analysis.

Water from Saline Spring, Caledonia Springs, Ontario, bottled as "Magi" water:—

Parts per million.

Bases.	(From analysis page 47).		Calculated as sulphates.		
Silica...............	SiO_2	15·0	Silica...............	SiO_2	15·0
Iron...............	Fe	1·2	Iron oxide...........	Fe_2O_3	1·7
Aluminium..........	Al	0·21	Alumina............	Al_2O_3	0·4
Calcium............	Ca	41·0	Calcium sulphate.....	$CaSO_4$	139·4
Strontium...........	Sr	2·9	Strontium „	$SrSO_4$	6·0
Magnesium..........	Mg	143·0	Magnesium „	$MgSO_4$	706·4
Lithium............	Li	2·4	Lithium „	Li_2SO_4	18·8
Potassium...........	K	78·4	Potassium „	K_2SO_4	175·9
Sodium.............	Na	2691·4	Sodium „	Na_2SO_4	8308·
Ammonium..........	NH_4	4·89	Ammonium „	NH_4SO_4	volatile
					9371·6

Calculated.........................	9371·6	
Found by experiment...............	9334	
Difference.....................	37	= 0·4%

There is yet another check on the accuracy of an analysis. It has already been stated that a mineral water may be considered as a balanced chemical system, a solution of several compounds dissociated into their constituent ions, which are in a state of equilibrium with each other, neither acidic or basic ions being in excess. The only exceptions occur in the case of some mine waters and springs arising from pyrites deposits, which have been found to contain free acid. A water may have an alkaline reaction, but it will be due to the presence of hydrolysed alkali carbonate. Nevertheless, the equivalent amounts of alkali and of carbonic acid radicle will be present. Therefore, in such a state of equilibrium, the sum of the acidic ions reduced to their proportional chemical values must be equal to the sum of the basic ions similarly reduced. Practically, no analyses will show perfect equivalence, but there should be comparatively little disagreement, the actual amount depending largely on the concentration of the water. For a water containing about 1,000 parts per million mineral matter in solution, the summations of basic and of the acidic ions should not differ by more than 2 or 3%. Greater discrepancy indicates a faulty determination, or some error in calculation. It is necessary that the summations be balanced for the purposes of calculation of the various classifications and hypothetical combinations, and four courses are possible.[1]

(i) The error may be proportionately shared by all the constituents.
(ii) It may be assumed to lie in the determination of one basic and one acidic radicle, and divided equally between them.
(iii) It may depend on the determination of one radicle, such as bicarbonate or sodium.
(iv) No alteration need be made, in which case one property of the water cannot be deduced.

In the following analyses any discrepancy has usually been attributed to inaccuracies in the determination of the bicarbonate radicle, especially in waters in which it occurs in considerable quantity.

These two checks on the accuracy of the various determinations are of course not entirely independent of each other, as an error in the estimation of one of the bases—magnesium, for example, will affect both calculations. If the sum of the bases calculated as sulphates agrees with the value found by experiment, and yet the sum of reacting values of the basic ions differs from the sum of the reacting values of the acidic ions, it is probable that an error exists in the amount of one of the acidic ions. On the other hand, agreement between the bases as sulphates, calculated and found, an equilibrium between acidic and basic ions, forms a satisfactory verification of the accuracy of analytical processes.

Comparison between the sum of the constituents found by analysis and the amount of solid matter, dried at 100°C., affords no check whatever. Bicarbonates give off carbon dioxide, ammonium chloride and calcium carbonates decompose each other, and other salts become basic. All these causes tend to make the total solids found by experiment lower than the sum of the severally determined constituents.

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[1] For the complete treatment of this subject see Rogers, G. Sherbourne, The Interpretation of Water Analyses by the Geologist. Economic Geology, Vol. XII, p. 67, 1917.

DESCRIPTION OF SPRINGS AND TABULATED ANALYSES.

In the following pages the analyses of fifty spring waters are tabulated, preceded by brief descriptions of the spring surroundings and of the character of the waters.

In preceding pages, the more recent methods of expression of water analyses have been discussed, and some explanation given of the derivation of the various properties of the waters. It has been shown that the properties of reaction concisely state the character and principal constituents of a water. Primary salinity indicates the presence of alkali salts of strong acids, e.g., sodium chloride or sodium sulphate; secondary salinity, alkaline earth salts of strong acids, e.g., calcium and magnesium chlorides or sulphates. Similarly, primary alkalinity and secondary alkalinity denote alkali salts or alkaline earth salts of weak acids respectively, e.g., sodium carbonate or bicarbonate or calcium or magnesium bicarbonates.

The amounts of the constituents as ions or radicles are given in parts per million, also in percentages of the total inorganic matter in solution. Previous analyses, when they exist, are presented for comparison. The reacting value of the constituents, worked out to a percentage basis, occupies the fourth column at the foot of which the concentration value is placed. This number is the sum of actual reacting values of the constituents of the water, and from it the percentage reacting values may easily be calculated to their true values.

After the statement of the quantity of the total solids and gases in solution in the waters the hypothetical combinations worked out from the results of analysis by means of the rules given on page 20, are appended in parts per million, and as percentages of the total inorganic matter in solution.

Temperatures are stated on both Centigrade and Fahrenheit degrees.

Radioactivity, due to emanation in the water or in the gases evolved from some springs, is expressed in terms of a unit,[1] which is 1×10^{-12} curie per litre, or that amount of radium emanation in equilibrium with 1×10^{-12} gram radium metal. Dissolved radium is expressed in terms of a unit equal to 1×10^{-12} gram radium per litre.

In the tabulated analyses dashes (–) signify that the constituent has been looked for, but is not present—at least in sufficient quantity to be detected. A blank space indicates that the substance is absent or that no test for it has been carried out.

EASTERN ONTARIO

BORTHWICK MINERAL SPRING, NEAR OTTAWA, ONT.

(6)

This spring, rising in low lying marshy ground between two parallel ridges half a mile apart, is situated in the south half of lot 20, concession IV,

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[1] Part I, p. 16.

Ottawa Front, Gloucester township, Carleton county, and is about seven miles away from Ottawa. The water is collected in a bricked well of 3,000 gallons capacity, which when pumped dry, refills in about twelve hours.

According to Sterry Hunt[1] the spring rises from the lower Silurian limestone and probably obtains its large proportion of sodium chloride from rock salt imbedded in the limestone formation. Mr. William Borthwick of Ottawa is the owner of the spring. Some water is shipped and sold in the neighbourhood.

The spring was visited on two occasions, when tests were made and samples collected, and a further sample was sent in for analysis.

The following particulars were obtained upon examination. The analysis shows the spring to be sodic, magnesic, muriated saline water. The hypothetical combinations show that sodium chloride may be considered to form 87 per cent of the solids in solution, while magnesium bicarbonate forms 9 per cent.

BORTHWICK MINERAL SPRING.

Laboratory No. 6.

Sample collected	June, 1917	
Temperature	10·5°C. (50·9°F.)	
Flow	Small	
Taste	Salt and pleasant	
Reaction	Alkaline	
Specific gravity at 15°C.	1·007	
Radioactivity	Emanation	140 units
	Dissolved radium	8·4 „
	Emanation in gas evolved.	
Properties of reaction in per cent.		
	Primary salinity	90·36
	Secondary salinity	1·06
	Primary alkalinity	
	Secondary alkalinity	8·58

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[1] Sterry Hunt, Geology of Canada, 1886, p. 537.

Analysis.

Constituents:—			Previous analysis.*	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4)	7·4	399·5	0·07	0·07
Bicarbonic acid	(HCO_3)	954·	—	4·29	8·71
Carbonic acid	(CO_3)	—	—	—	—
Nitric acid	(NO_3)	—	—	—	—
Nitrous acid	(NO_2)	trace	—	—	—
Phosphoric acid	(PO_4)	0·01	—	—	—
Metaboric acid	(BO_2)	heavy trace	—	—	—
Chlorine	(Cl)	5,910·	7,257·	53·96	45·63
Bromine	(Br)	12·5	—	0·12	0·04
Iodine	(I)	0·6	36·6	0·01	—
Silica	(SiO_2)	17·2	70·0	0·15	—
Iron Aluminium	(Fe) (Al)	5·2	—	0·05	0·05
Manganese	(Mn)	0·05	—	—	—
Calcium	(Ca)	39·0	140·3	0·36	0·53
Strontium	(Sr)	2·4	29·7	0·02	—
Magnesium	(Mg)	188·	138·4	1·72	4·24
Lithium	(Li)	1·5	—	0·01	0·06
Potassium	(K)	70·8	78·5	0·65	0·50
Sodium	(Na)	3,740·	4,400·	34·15	44·57
Ammonium	(NH_4)	3·6	—	0·03	0·20
Total		10,952·2	12,550·0	100·00	100·00
Total solids in solution, residue dried at 110° C		1,058			Concentration value. 364·92

Gases:		c.c. per litre.	Parts per million.
	Carbon Dioxide CO_2	11·3	22·2
	Hydrogen Sulphide H_2S	—	—

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* Analysis by J. Baker Edwards, Ph.D., F.C.S., Montreal, 1885.

HYPOTHETICAL COMBINATIONS.

No. 6.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)..............	trace	——	
Sodium nitrate	($NaNO_3$)..............			
Ammonium chloride	(NH_4Cl)..............	10·70	0·10	
Potassium iodide	(KI)..................	0·83	0·01	
Potassium bromide	(KBr)................	17·85	0·17	
Lithium chloride	($LiCl$)................	8·92	0·08	
Potassium chloride	(KCl)................	122·93	1·12	150·
Sodium chloride	($NaCl$)...............	9,513·0	86·88	11,210·
Magnesium chloride	($MgCl_2$)..............	87·69	0·80	310·
Calcium chloride	($CaCl_2$)..............			210·0
Strontium sulphate	($SrSO_4$)..............			40·
Magnesium sulphate	($MgSO_4$)..............	9·63	0·09	280·
Calcium sulphate	($CaSO_4$)..............			220
Sodium bicarbonate	($NaHCO_3$)............			
Magnesium bicarbonate	($Mg(HCO_3)_2$)..........	984·73	9·00	
Calcium bicarbonate	($Ca(HCO_3)_2$)..........	157·95	1·44	
Strontium bicarbonate	($Sr(HCO_3)_2$)..........	3·14	0·03	
Strontium chloride	($SrCl_2$)..............	——	——	20·0
Ferrous bicarbonate	($Fe(HCO_3)_2$)..........	17·80	0·16	
Calcium phosphate	($Ca_3(PO_4)_2$)...........	trace	——	
Ferric oxide..	(Fe_2O_3)..............			70·
Alumina	(Al_2O_3)..............			
Silica	(SiO_2)................	17·20	0·16	
Magnesium iodide and bromide..............				40·
		10,952·37	100·00	

DOMINION SPRING, PAKENHAM, ONT.

(13)

This spring, situated on the farm of W. Gillan, Fitzroy township, Carleton county, Ont., has been known for many years, and was first analysed by Sterry Hunt in 1851, who stated that the water rises from the Chazy or Calciferous formation. At one time the spring was used for medicinal purposes and a hotel flourished at Pakenham, two miles away. To-day little use is made of it. The water is pumped from a well, 14 feet deep, and there is a small natural flow. A considerable quantity of hydrogen sulphide gas is present in the water, and a turbidity due to precipitated sulphur soon arises when the water stands for a short time exposed to the air.

The chief constituents may be considered to be sodium chloride which forms 78 per cent of the total inorganic matter in solution and magnesium bicarbonate (13 per cent). The water may be classified as a sodic, magnesic, muriated saline water, and is very similar in composition to the Borthwick Spring Water.

The following results were obtained as a result of analysis:—

DOMINION SPRING.

Laboratory No. 13.

Samples collected	July, 1914.	
Temperature	10°C. (50·0°F.)	
Flow	Small	
Taste	Slightly salt	
Reaction		
Specific gravity at 15°C	1·0065	
Radioactivity	Emanation	22 units
	Dissolved radium	0·8 „
	Emanation in gas evolved	
Properties of reaction in per cent.		
	Primary salinity	84·3
	Secondary salinity	1·3
	Primary alkalinity	
	Secondary alkalinity	14·4

Analysis.

Constituents:—		Previous analysis.*	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO_4).........	3·7	—	0·04	0·03
Bicarbonic acid (HCO_3)........	1,410·	—	14·26	7·19
Carbonic acid (CO_3).........	—	98·4	—	—
Nitric acid (NO_3).........	17·0	—	0·18	0·08
Nitrous acid (NO_2).........	—	—	—	—
Phosphoric acid (PO_4).........	0·04	7·2	—	—
Metaboric acid (BO_2).........	—	—	—	—
Chlorine (Cl)...........	4,870·	4,019·3	49·26	42·68
Bromine (Br)...........	6·0	16·9	0·06	0·02
Iodine (I).............	0·6	2·7	—	
Oxygen to form (Al_2O_3)........	7·7	1·9	0·08	
Silica (SiO_2).........	47·20	133·0	0·48	—
Iron (Fe)...........	1·6	trace	0·01	0·02
Aluminium (Al)...........	8·67	2·1	0·08	—
Manganese (Mn)..........	—	—	—	—
Calcium (Ca)..........	102·	60·0	1·03	1·59
Strontium (Sr)...........	—	trace	—	—
Magnesium (Mg)..........	243·	225·	2·46	6·24
Lithium (Li)..........	0·03	—	—	—
Potassium (K)...........	126·	60·7	1·27	1·00
Sodium (Na)..........	3,044·32	2,834·5	30·79	41·15
Ammonium (NH_4)........	0·07	—	—	—
Total.....................	9,887·93	8,347·3	100·00	100·00
Total solids in solution, residue dried at 110° C..............	9,272	—	—	Concentration value 321·46

	c.c. per litre.	Parts per million.
Gases: Carbon Dioxide CO_2......		
Hydrogen Sulphide H_2S...	0·5	0·8

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*By Dr. Sterry Hunt. Geology of Canada, p. 549, 1863.

HYPOTHETICAL COMBINATIONS.

No. 13.

Constituent:—		Parts per million.	Total inorganic matter in solution. Per cent.	Previous analysis.
Sodium nitrite	($NaNO_2$)	trace	——	
Sodium nitrate	($NaNO_3$)	23·29	0·24	
Ammonium chloride	(NH_4Cl)	0·21	——	
Potassium iodide	(KI)	0·83	0·01	
Potassium bromide	(KBr)	8·93	0·09	
Lithium chloride	($LiCl$)	0·17	——	
Potassium chloride	(KCl)	233·93	2·37	
Sodium chloride	($NaCl$)	7,727·15	78·14	
Magnesium chloride	($MgCl_2$)	92·80	0·94	
Calcium chloride	($CaCl_2$)			
Sodium sulphate	(Na_2SO_4)			
Magnesium sulphate	($MgSO_4$)	4·63	0·04	
Calcium sulphate	($CaSO_4$)			
Sodium bicarbonate	($NaHCO_3$)			
Magnesium bicarbonate	($Mg(HCO_3)_2$)	1,313·88	13·29	
Calcium bicarbonate	($Ca(HCO_3)_2$)	413·02	4·18	
Strontium bicarbonate	($Sr(HCO_3)_2$)			
Ferrous bicarbonate	($Fe(HCO_3)_2$)	5·07	0·05	
Calcium phosphate	($Ca_3(PO_4)_2$)	0·05	——	
Ferric oxide	(Fe_2O_3)			
Alumina	(Al_2O_3)	16·37	0·17	
Silica	(SiO_2)	47·20	0·48	
		9,887·93	100·00	

DIAMOND PARK SPRING, ARNPRIOR, SANITARIS WATER.

(14)

This spring lies at the foot of a hill about 50 yards from the Madawaska river on lot 26, concession XII, Pakenham township, Lanark county, Ontario.

It rises in a cemented and covered well, and flows at a rate of about 250 gallons per hour into the river, nearby. The water has a pleasant saline taste, and is carbonated and sold as "Sanitaris" mineral water by the Sanitaris Mineral Water Co., of Arnprior and Ottawa. This is one of the most radioactive springs of those examined in eastern Canada, but on account of the small content of dissolved radium the water, when bottled, will soon lose its activity.

The water is not as strongly mineralized as that from the Borthwick or from the Dominion Spring, although 80 per cent of the total inorganic matter in solution is sodium chloride. Calcium and magnesium bicarbonates may be considered to be the other predominant constituents.

Comparison of the two analyses, one in 1911 and the other in 1916, shows that no change in composition has taken place in the last five years. The water may be classified as a sodic, muriated alkaline-saline (bromic) water.

The following particulars were obtained as a result of analysis:—

DIAMOND PARK SPRING.

Laboratory No. 14.

Sample collected..............July, 1914.
Temperature.................9°C. (48°F.)
Flow........................5 gallons per minute.
Taste.......................Slightly salt
Reaction....................Alkaline
Specific gravity at 15°C.......1·002
Radioactivity................Emanation...........226 units
Dissolved radium..... 1·7 „
Emanation in gas evolved.

Properties of reaction in per cent.

Primary salinity......86·26
Secondary salinity....
Primary alkalinity.... 0·04
Secondary alkalinity..13·70

Analysis.

Constituents:—			Previous analysis.*	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4)	24·2	trace	0·47	0·30
Bicarbonic acid	(HCO_3)	700·	719·2	13·64	6·87
Carbonic acid	(CO_3)	——	——	——	——
Nitric acid	(NO_3)	2·4	——	0·05	0·02
Nitrous acid	(NO_2)	trace	——	——	——
Phosphoric acid	(PO_4)	0·04	——	——	——
Metaboric acid	(BO_2)	trace	——	——	——
Chlorine	(Cl)	2537	2488·45	49·37	42·77
Bromine	(Br)	6·0	1·24	0·12	0·04
Iodine	(I)	0·45	trace	0·01	——
Oxygen to form	(Al_2O_3)	0·44	——	0·01	——
Silica	(SiO_2)	25·0	18·73	0·49	——
Iron	(Fe)	0·84	0·54	0·01	——
Aluminium	(Al)	0·09			——
Manganese	(Mn)	——	——	——	——
Calcium	(Ca)	73·0	54·90	1·42	2·18
Strontium	(Sr)	——	——	——	——
Magnesium	(Mg)	95·0	81·50	1·85	4·67
Lithium	(Li)	0·2	——	——	0·02
Potassium	(K)	33·1	22·43	0·64	0·51
Sodium	(Na)	1640·	1650·35	31·92	42·62
Ammonium	(NH_4)	0·01	0·39	——	——
Total......................		5137·77	5037·73	100·00	100·00
Total solids in solution, residue dried at 110°C.............		4814	——	——	Concentration value 167·28

Gases : Carbon Dioxide CO_2 c.c. per litre. Parts per million.
Hydrogen Sulphide H_2S

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* Analysis by Prof. R. F. Ruttan, McGill University, 1911.

HYPOTHETICAL COMBINATIONS.

No. 14.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)............	trace	—	
Sodium nitrate	($NaNO_3$)............	3·29	0·06	
Ammonium chloride	(NH_4Cl)............	0·03	—	
Potassium iodide	(KI)...............	0·58	0·01	trace
Potassium bromide	(KBr)..............	8·92	0·17	1·59
Lithium chloride	(LiCl)..............	1·23	0·02	
Potassium chloride	(KCl)...............	57·32	1·12	42·88
Sodium chloride	(NaCl)..............	4135·7	80·50	4066·0
Magnesium chloride	($MgCl_2$)............			
Calcium chloride	($CaCl_2$)............			
Sodium sulphate	(Na_2SO_4)...........	35·8	0·70	
Magnesium sulphate	($MgSO_4$)...........			
Calcium sulphate	($CaSO_4$)............			
Sodium bicarbonate	($NaHCO_3$)...........	1·22	0·02	189·9
Magnesium bicarbonate	($Mg(HCO_3)_2$)........	571·7	11·14	495·8
Calcium bicarbonate	($Ca(HCO_3)_2$).........	295·5	5·75	221·9
Strontium bicarbonate	($Sr(HCO_3)_2$).........			
Ferrous bicarbonate	($Fe(HCO_3)_2$).........			
Calcium phosphate	($Ca_3(PO_4)_2$)..........	0·12		
Ferric oxide	(Fe_2O_3).............	1·2	0·02	} 0·54
Alumina	(Al_2O_3).............	0·17	—	
Silica	(SiO_2)..............	25·0	0·49	18·73
		5137·78	100·00	5037·34

RUSSELL LITHIA SPRING.

(17)

Several springs are found in the neighbourhood of Bourget, Clarence township, Russell county, Ont. The Russell Lithia Mineral Water Co. own two of these on lot 20, concession II. Both were drilled and are 200 yards apart. Water from one boring is pumped by means of a windmill into tanks from which it is drawn to be bottled as Russell Lithia Water; the other flows naturally at the rate of 15 gallons per minute from a stand pipe. This water is pleasantly saline to the taste, and contains a considerable quantity of mineral matter in solution, having a specific gravity of 1·0065 at 15°C. Much gas bubbles up with the water, and also issues from pools in the swamp around the spring. Analysis showed the gas to be chiefly methane or "marsh gas" and that it was radioactive, possessing an activity of 540 units.

Two other springs of similar character were inspected on the farm of A. Martel, about two miles from the Russell Lithia Spring. Both were bored wells, with a natural flow. One was 96 feet deep while the other was drilled to a depth of 136 feet. The water from each had a pleasantly saline taste.

The following analysis shows that sodium chloride forms 82 per cent of the total inorganic matter in solution while magnesium bicarbonate amounts to almost 10 per cent. Three per cent of sodium carbonate gives the water an alkaline reaction, accounting for a primary alkalinity of 2·48 per cent. The quantity of potassium is comparatively high, forming almost 3 per cent of the alkalies.

The water may be classified as a sodic, muriated, alkaline-saline (carbon-dioxated) water.

RUSSELL LITHIA WATER.

Laboratory No. 17.

Sample collected	June, 1917.	
Temperature	10·0°C. (50°F.)	
Flow		
Taste	Pleasantly saline	
Reaction	Alkaline	
Specific gravity at 15°C	1·005	
Radioactivity	Emanation	109 units
	Dissolved radium	2·5 „
	Emanation in gas evolved.	
Properties of reaction in per cent.		
	Primary salinity	87·84
	Secondary salinity	
	Primary alkalinity	2·48
	Secondary alkalinity	9·68

Analysis.

Constituents:—			Previous analysis.*	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4)	2·7	1·9	0·03	0·02
Bicarbonic acid	(HCO_3)	960·	——	12·12	6·08
Carbonic acid	(CO_3)	——	9·6	——	——
Nitric acid	(NO_3)	trace	——	——	——
Nitrous acid	(NO_2)	Heavy trace	——	——	——
Phosphoric acid	(PO_4)	——	——	——	——
Metaboric acid	(BO_3)	Heavy trace	——	——	——
Chlorine	(Cl)	4,040·	5,426·4	51·03	43·85
Bromine	(Br)	10·0	——	0·13	0·05
Iodine	(I)	0·9	——	0·01	——
Silica	(SiO_2)	10·3	6·2	0·13	——
Iron Aluminium	(Fe) .... (Al)	3·4	——	0·04	0·12
Manganese	(Mn)	0·3	——	——	——
Calcium	(Ca)	32·3	——	0·41	0·62
Strontium	(Sr)	1·9	——	0·02	0·01
Magnesium	(Mg)	131·3	40·0	1·65	4·16
Lithium	(Li)	1·2	0·6	0·01	0·07
Potassium	(K)	90·2	231·6	1·14	0·89
Sodium	(Na)	2,630·	3,307·4	33·22	44·11
Ammonium	(NH_4)	4·2	——	0·05	0·09
Total......................		7,918·7	9,024·1	100·00	100·00
Total solids in solution, residue dried at 110°C..............		7,580	——	——	Concentration value

Gases :		c.c. per litre.	Parts per million.
	Carbon Dioxide CO_2.......	37·4	74·8
	Hydrogen Sulphide H_2S...	——	——

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*By A. R. Pyne, M.B., Toronto. 1905.

HYPOTHETICAL COMBINATIONS.

No. 17.

Constituent:—	Parts per million.	Total inorganic matter in solution. Per cent.	Previous analysis.
Sodium nitrite ($NaNO_2$)	trace	—	
Sodium nitrate ($NaNO_3$)	trace	—	
Ammonium chloride (NH_4Cl)	12·30	0·15	
Potassium iodide (KI)	1·66	0·02	
Potassium bromide (KBr)	14·28	0·18	
Lithium chloride ($LiCl$)	7·22	0·09	3·4
Potassium chloride (KCl)	162·41	2·05	440·0
Sodium chloride ($NaCl$)	6509·0	82·21	8396·6
Magnesium chloride ($MgCl_2$)			157·4
Calcium chloride ($CaCl_2$)			
Sodium sulphate (Na_2SO_4)	4·26	0·05	
Potassium sulphate (K_2SO_4)			3·5
Calcium sulphate ($CaSO_4$)			17·0
Sodium carbonate (Na_2CO_3)			
Sodium bicarbonate ($NaHCO_3$)	262·00	3·31	
Magnesium bicarbonate ($Mg(HCO_3)_2$)	789·40	9·97	
Calcium bicarbonate ($Ca(HCO_3)_2$)	130·41	1·65	
Strontium bicarbonate ($Sr(HCO_3)_2$)	4·19	0·05	
Ferrous bicarbonate ($Fe(HCO_3)_2$)	10·68	0·13	
Calcium phosphate ($Ca_3(PO_4)_2$)			
Ferric oxide (Fe_2O_3)			
Alumina (Al_2O_3)			
Silica (SiO_2)	10·30	0·13	6·2
Manganous bicarbonate ($Mn(HCO_3)_2$)	0·53	0·01	
	7,918·64	100·00	9,024·1

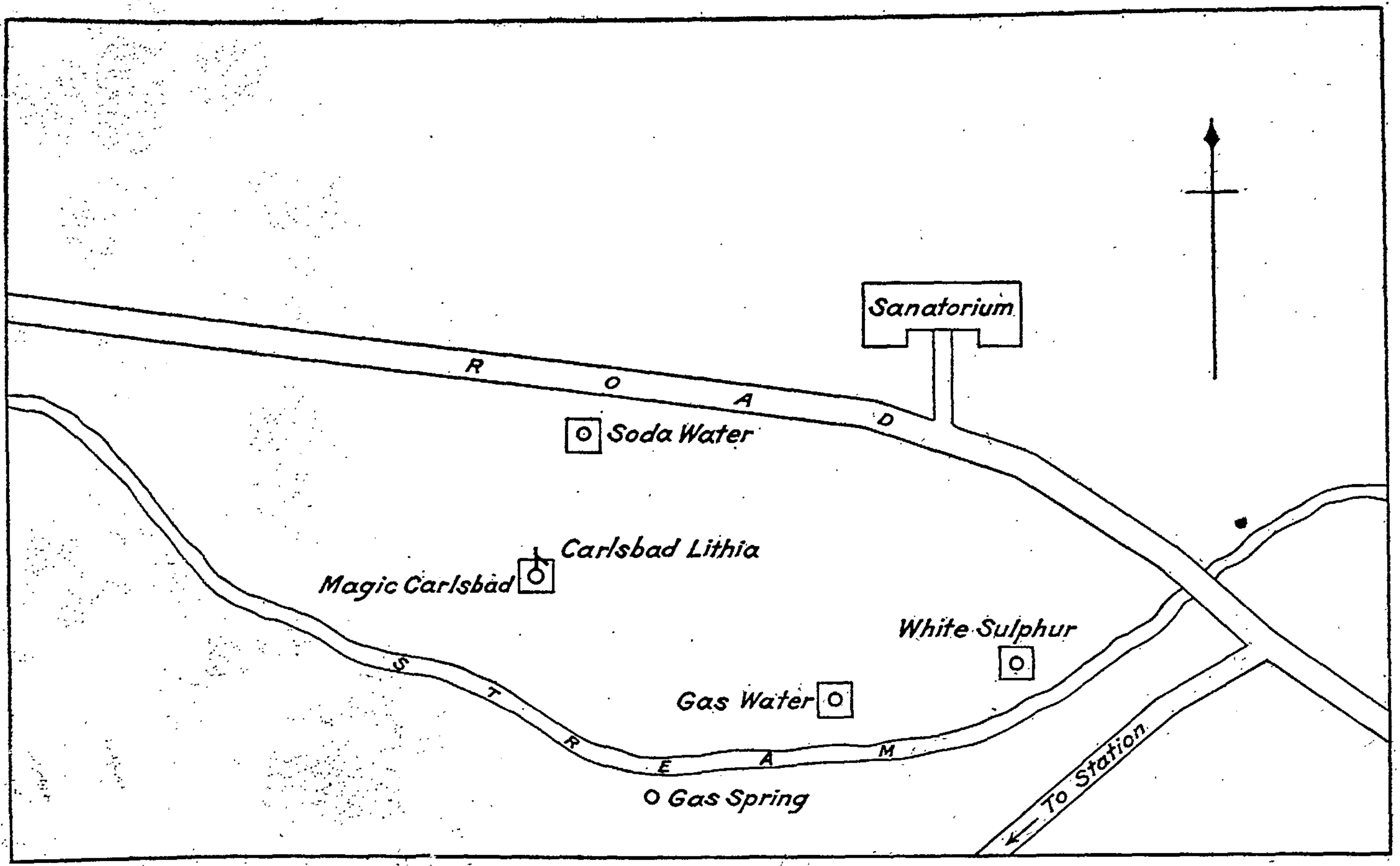
CARLSBAD SPRINGS, RUSSELL COUNTY, ONT.

A group of seven saline springs are situated at Carlsbad Springs, a station on the Grand Trunk line from Ottawa to Montreal, and eight miles by road from Ottawa.

A commodious sanitarium with accommodation for 175 guests was erected in 1909 by Mr. Thomas Boyd, who owns six of the springs. The sanitarium is open during the summer months and suitable provision is made for visitors to obtain hot sulphur baths and to drink the waters from the various sources.

The springs lie together in a small area, bounded on one side by the road and sanitarium and on the other by a creek. The principal sources are enclosed in small summer houses, and rise in earthenware wells about 2 feet in diameter and several feet deep, the overflow running into the creek nearby.

The six waters show considerable difference in concentration and in properties. In this respect as well as in possessing similar constituents, they bear a resemblance to the group of waters at Caledonia Springs.



Sketch plan of Carlsbad Springs

Fig. 1

Carlsbad Springs, Ont.

The Soda spring has a primary alkalinity of 40 per cent, that is sodium bicarbonate forms a large proportion of the mineral matter present (48 per cent) and a primary salinity of 56 per cent. (Sodium chloride 44 per cent of total solids in solution). The Sulphur water has 16 per cent primary alkalinity, and 78 per cent primary salinity; the Lithia spring 7 per cent and 84 per cent respectively, while the Magic Water has no primary alkalinity but 74 per cent primary salinity, and 25 per cent secondary salinity. The explanation of this difference in properties is to be found in the fact that the waters are mixtures of waters from different strata, the most concentrated and saline water rising from the greatest depth, and mixing with less concentrated and alkaline waters at other levels in varying proportions. Thus the Magic water comes from a well 240 feet deep; the Lithia water is a mixture of this water and a less concentrated solution, coming from a vein 60 feet deep. The Sulphur and Soda contain still larger proportions of the less concentrated water, having sodium bicarbonate as its principal constituent. The waters rise from the Trenton limestone: the same formation from which the Caledonia springs issue; and Sterry Hunt's explanation of the different properties of those waters, lying so close together, holds similarly for the Carlsbad waters.

It is of interest to note that the water from the greatest depth contains the largest amount of radium. It is to be expected that the soda would be the most temporarily radioactive but there is no evidence of this. Gas is evolved from the springs in considerable quantity, especially from the Soda and Lithia Springs. Analysis of a sample gave the following results:—

Radioactivity, 230 units.

Constituents—

Methane (CH_4) 91·7 per cent.
Carbon dioxide (CO_2) 0·6 per cent.
Oxygen (O_2) 0·8 per cent.
Nitrogen (N_2) 6·9 per cent.

The following results were obtained on analysis of the waters:—

MAGIC SPRING.

Laboratory No. 16.

Sample collected	June, 1917	
Temperature	8·5°C (47·3°F).	
Flow		
Taste	Very salt and bitter.	
Reaction	Alkaline.	
Specific gravity at 15°C	1·015.	
Radioactivity	Emanation	87 units.
	Dissolved radium	25 "
	Emanation in gas evolved.	

Properties of reaction in per cent.

Primary salinity..........73·84
Secondary salinity........25·22
Primary alkalinity........
Secondary alkalinity...... 0·94

Analysis.

Constituents:—		Previous analysis*	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO$_4$)	8·7	11·7	0·04	0·02
Bicarbonic acid (HCO$_3$)	200·00	102·3	0·97	0·47
Carbonic acid (CO$_3$)	——	——	——	——
Nitric acid (NO$_3$)	——	——	——	——
Nitrous acid (NO$_2$)	trace	——	——	——
Phosphoric acid (PO$_4$)	——		——	——
Metaboric acid (BO$_2$)	trace		——	——
Chlorine (Cl)	12,520	15,693·80	60·72	49·34
Bromine (Br)	100·00	——	0·48	0·17
Iodine (I)	2·0	——	0·01	——
Silica (SiO$_2$)	10·7	9·0	0·05	——
Iron (Fe)	15·8	24·5	0·08	0·08
Aluminium (Al)	——	1·2		
Manganese (Mn)	0·8	——	——	——
Calcium (Ca)	1,250·	1,553·	6·06	8·74
Strontium (Sr)	17·3	——	0·08	0·03
Magnesium (Mg)	368·	484·	1·78	4·23
Lithium (Li)	3·3	——	0·02	0·06
Potassium (K)	160·	82·6	0·77	0·57
Sodium (Na)	5,960·	7,465·	28·90	36·23
Ammonium (NH$_4$)	7·3	——	0·03	0·06
Total	20,618·9	25,427·1	100·00	100·00 Concentration value.
Total solids in solution, residue dried at 110°C	22,140	——	——	715·04

Gases :		c.c. per litre.	Parts per million.
	Carbon Dioxide CO$_2$	21·1	41·6
	Hydrogen Sulphide H$_2$S	0·2	0·4

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* By C. Hoffmann. Ann. Rep., Geol. Surv., 1874–75, p. 319.

HYPOTHETICAL COMBINATIONS.

No. 16.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)	trace	——	
Sodium nitrate	($NaNO_3$)			
Ammonium chloride	(NH_4Cl)	21·40	0·10	
Potassium iodide	(KI)	1·66	0·01	
Potassium bromide	(KBr)	148·75	0·72	
Lithium chloride	($LiCl$)	19·97	0·10	
Potassium chloride	(KCl)	212·33	1·03	157·7
Sodium chloride	($NaCl$)	15,152·00	73·50	18,981·2
Magnesium chloride	($MgCl_2$)	1,442·67	7·00	1,903·1
Calcium chloride	($CaCl_2$)	3,313·90	16·07	4,169·2
Sodium sulphate	(Na_2SO_4)			
Magnesium sulphate	($MgSO_4$)			
Calcium sulphate	($CaSO_4$)	12·24	0·06	19·9
Sodium bicarbonate	($NaHCO_3$)			
Magnesium bicarbonate	($Mg(HCO_3)_2$)			
Calcium bicarbonate	($Ca(HCO_3)_2$)	211·14	1·02	177·3
Strontium bicarbonate	($Sr(HCO_3)_2$)	20·96	0·10	
Ferrous bicarbonate	($Fe(HCO_3)_2$)	49·84	0·24	12·1
Calcium phosphate	($Ca_3(PO_4)_2$)			
Ferric oxide	(Fe_2O_3)			31·1
Alumina	(Al_2O_3)			2·2
Silica	(SiO_2)	10·70	0·05	9·0
Manganous bicarbonate	($Mn(HCO_3)_2$)	0·89		
		20,618·45	100·00	25,462·8

Analysis shows this to be a strongly mineralized sodic muriated saline (bromic) water. It was one of the most concentrated waters examined. The chief constituents may be considered to be sodium chloride (73 per cent of the total mineral matter in solution), magnesium chloride (7 per cent), and calcium chloride (16 per cent).

The water appears to be less concentrated than it was in 1875, when a sample was analysed by Dr. C. Hoffmann of the Geological Survey.

SULPHUR SPRING.

Laboratory No. 15.

Sample collected	June, 1917.	
Temperature	8·9°C. (48°F.)	
Flow	2 gallons per minute.	
Taste	Slight indication of hydrogen sulphide.	
Reaction	Alkaline.	
Specific gravity at 15°C.	1·002	
Radioactivity	Emanation	90 units.
	Dissolved radium	
	Emanation in gas evolved.	

Properties of reaction in per cent.

Primary salinity	78·48
Secondary salinity	
Primary alkalinity	16·42
Secondary alkalinity	5·10

Analysis.

Constituents:—		Previous analysis.*	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO$_4$)	3·6	1·5	0·11	0·07
Bicarbonic acid (HCO$_3$)	657·	680·	20·47	10·75
Carbonic acid (CO$_3$)	——	——	——	——
Nitric acid (NO$_3$)	——	——	——	——
Nitrous acid (NO$_2$)	0·6	——	0·02	0·01
Phosphoric acid (PO$_4$)	0·01	trace	——	——
Metaboric acid (BO$_2$)	heavy trace.	trace	——	——
Chlorine (Cl)	1,390·	1,328·0	43·30	39·11
Bromine (Br)	5·0	——	0·16	0·06
Iodine (I)	0·6	——	0·02	——
Oxygen to form Fe$_2$O$_3$&Al$_2$O$_3$		0·8		
Silica (SiO$_2$)	10·8	12·4	0·34	——
Iron (Fe) Aluminium (Al)	1·4	1·9	0·04	0·06
Manganese (Mn)	0·07	——	——	——
Calcium (Ca)	7·8	13·6	0·24	0·39
Strontium (Sr)	0·6	——	0·02	0·01
Magnesium (Mg)	25·4	28·2	0·79	2·09
Lithium (Li)	0·7	trace	0·02	0·10
Potassium (K)	40·0	22·5	1·25	1·02
Sodium (Na)	1,065·	1,078·	33·17	46·24
Ammonium (NH$_4$)	1·6	——	0·05	0·09
Total	3,210·18	3,166·9	100·00	100·00 Concentration value.
Total solids in solution, residue dried at 110°C	2,964			100·12

Gases:		c.c. per litre.	Parts per million.
	Carbon Dioxide CO$_2$	8·8	17·3
	Hydrogen Sulphide H$_2$S	1·3	2·2

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* Analysis by C. Hoffmann, Ann. Rep. Geol. Surv., 1874–75, p. 317

HYPOTHETICAL COMBINATIONS.

No. 15.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)............	0·69	0·02	
Sodium nitrate	($NaNO_3$)............			
Ammonium chloride	(NH_4Cl)............	4·81	0·15	
Potassium iodide	(KI)................	0·83	0·03	trace
Potassium bromide	(KBr)..............	7·14	0·22	
Lithium chloride	(LiCl)..............	4·25	0·13	
Potassium chloride	(KCl)...............	71·52	2·23	40·0
Sodium chloride	(NaCl)..............	2,225·00	69·30	2,158·4
Magnesium chloride	($MgCl_2$)............			
Calcium chloride	($CaCl_2$)............			
Sodium sulphate	(Na_2SO_4)...........	4·97	0·15	
Potassium sulphate.	(K_2SO_4)............			3·3
Calcium sulphate	($CaSO_4$)............			
Sodium bicarbonate	($NaHCO_3$)...........	690·00	21·49	836·5
Magnesium bicarbonate	($Mg(HCO_3)_2$)........	152·90	4·76	170·9
Calcium bicarbonate	($Ca(HCO_3)_2$).........	31·59	0·98	54·9
Strontium bicarbonate	($Sr(HCO_3)_2$).........	1·04	0·03	trace
Ferrous bicarbonate	($Fe(HCO_3)_2$).........	5·34	0·17	6·6
Calcium phosphate	($Ca_3(PO_4)_2$).........	trace	——	trace
Ferric oxide	(Fe_2O_3).............			
Alumina	(Al_2O_3).............			
Silica	(SiO_2)..............	10·8	0·34	12·4
		3,210·80	100·00	3,283·0

The Carlsbad Sulphur water may be classified as a sodic, muriated alkaline-saline (sulphuretted) water. The primary alkalinity is 16·4 per cent higher than any of the others, except the Soda water. Sodium bicarbonate may be considered to form 21 per cent of the total solids in solution, while the remainder is largely sodium chloride. The overflow from this spring runs into a storage tank, and the water is used for hot sulphur baths.

Very little change in composition has taken place since the analysis by Dr. Hoffmann was made in 1875, as is shown by a comparison of the analyses.

LITHIA SPRING.

Laboratory No. 20.

Sample collected..............June, 1917.
Temperature..................9·0°C. (48·2°F.)
Flow.........................6 gallons per minute.
Taste........................Saline.
Reaction.....................Alkaline.

Specific gravity at 15°C.......1·0026.
Radioactivity................Emanation...............70 units.
Dissolved radium......... 3·1 "
Emanation in gas evolved.

Properties of reaction in per cent.

Primary salinity..........84·32
Secondary salinity........
Primary alkalinity........ 7·02
Secondary alkalinity...... 8·66

Analysis.

Constituents:—			Previous analysis	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4).........	2·4		0·05	0·03
Bicarbonic acid	(HCO_3)........	750·		15·35	7·84
Carbonic acid	(CO_3).........	——		——	——
Nitric acid	(NO_3).........	——		——	——
Nitrous acid.	(NO_2).........	trace		——	——
Phosphoric acid	(PO_4).........	——		——	——
Metaboric acid	(BO_2).........	heavy trace		——	——
Chlorine	(Cl)...........	2,340·		47·89	42·03
Bromine	(Br)...........	12·5		0·26	0·10
Iodine	(I)............	0·5		0·01	——
Silica	(SiO_2).........	12·7		0·26	——
Iron	(Fe)..........	2·1		0·04	0·05
Aluminium	(Al)..........			——	——
Manganese	(Mn)..........	trace		——	——
Calcium	(Ca)..........	57·0		1·17	1·82
Strontium	(Sr)..........	trace		——	——
Magnesium	(Mg)..........	47·		0·96	2·46
Lithium	(Li)..........	1·5		0·03	0·13
Potassium	(K)...........	50·1		1·02	0·82
Sodium	(Na)..........	1,608·		32·90	44·63
Ammonium	(NH_4).........	2·6		0·05	0·09
Total......................		4,886·4		100·00	100·00
Total solids in solution, residue dried at 110° C.............		4,550			Concentration value 156·80

	c.c. per litre.	Parts per million.
Gases: Carbon Dioxide CO_2......	16·5	32·5
Hydrogen Sulphide H_2S...	0·3	0·5

HYPOTHETICAL COMBINATIONS.

No. 20.

Constituent:—		Parts per million.	Total inorganic matter in solution. Per cent.	Previous analysis.
Sodium nitrite	($NaNO_2$)............	trace	——	
Sodium nitrate	($NaNO_3$)............	trace	——	
Ammonium chloride	(NH_4Cl)............	7·49	0·15	
Potassium iodide	(KI)...............	0·66	0·01	
Potassium bromide	(KBr)..............	17·85	0·37	
Lithium chloride	($LiCl$)..............	8·92	0·18	
Potassium chloride	(KCl................	84·19	1·72	
Sodium chloride	($NaCl$).............	3,768·00	77·11	
Magnesium chloride	($MgCl_2$).............			
Calcium chloride	($CaCl_2$)..............			
Sodium sulphate	(Na_2SO_4)............	3·55	0·07	
Magnesium sulphate	($MgSO_4$)............			
Calcium sulphate	($CaSO_4$)............			
Sodium bicarbonate	($NaHCO_3$)...........	464·50	9·51	
Magnesium bicarbonate	($Mg(HCO_3)_2$).........	282·40	5·78	
Calcium bicarbonate	($Ca(HCO_3)_2$).........	230·00	4·71	
Strontium bicarbonate	($Sr(HCO_3)_2$).........	trace	——	
Ferrous bicarbonate	($Fe(HCO_3)_2$).........	6·23	0·13	
Calcium phosphate	($Ca_3(PO_4)_2$).........			
Ferric oxide	(Fe_2O_3).............			
Alumina	(Al_2O_3).............			
Silica	(SiO_2)..............	12·70	0·26	
		4,886·47	100·00	

The Lithia water can be classified as a sodic, muriated alkaline-saline water. Lithium is present in small amount, but in no greater quantity than in the other waters. The chief salts in solution may be assumed to be sodium chloride (77 per cent), sodium bicarbonate (9·5 per cent), calcium and magnesium bicarbonates (each about 5 per cent).

SODA SPRING.

Laboratory No. 19.

Sample collected..............June, 1917.
Temperature.................8·0°C. (46·5°F.)
Flow........................2 gallons per minute.
Taste.......................Slightly alkaline.
Reaction....................Alkaline.
Specific gravity at 15°C.......1·0008.
Radioactivity...............Emanation...............81 units.
Dissolved radium......... 1·1 „
Emanation in gas evolved.230 „

Properties of reaction in per cent.

Primary salinity..........56·46
Secondary salinity........
Primary alkalinity........40·52
Secondary alkalinity...... 3·02

Analysis.

Constituents:—		Previous analysis.	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO_4)..........	0·7		0·05	0·02
Bicarbonic acid (HCO_3)........	526·		37·73	21·77
Carbonic acid (CO_3).........	—		—	—
Nitric acid (NO_3).........	—		—	—
Nitrous acid (NO_2).........	—		—	—
Phosphoric acid (PO_4).........	0·02		—	—
Metaboric acid (BO_2).........	heavy trace		—	—
Chlorine (Cl)..........	394·		28·26	28·01
Bromine (Br)..........	6·1		0·44	0·20
Iodine (I)...........	trace		—	—
Silica (SiO_2).........	10·4		0·75	—
Iron (Fe).......... Aluminium (Al)..........	2·9		0·21	0·25
Manganese (Mn)..........	trace		—	—
Calcium (Ca)..........	3·8		0·27	0·48
Strontium (Sr)..........	—		—	—
Magnesium (Mg)..........	3·8		0·27	0·78
Lithium (Li)..........	1·1		0·08	0·40
Potassium (K)...........	18·8		1·35	1·21
Sodium (Na)..........	426·		30·56	46·81
Ammonium (NH_4).........	0·45		0·03	0·07
Total....................	1,394·07		100·00	100·00
Total solids in solution, residue dried at 110° C.............	1,170·			

Gases:		c.c. per litre.	Parts per million.
	Carbon Dioxide CO_2......	6·7	13·2
	Hydrogen Sulphide H_2S ..	0·3	0·5

HYPOTHETICAL COMBINATIONS.

No. 19.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)............	——		
Sodium nitrate.	($NaNO_3$)...........			
Ammonium chloride	(NH_4Cl)............	1·60	0·11	
Potassium iodide	(KI)...............	trace	——	
Potassium bromide	(KBr)..............	9·52	0·68	
Lithium chloride	($LiCl$)..............	6·80	0·49	
Potassium chloride	(KCl)..............	29·80	2·14	
Sodium chloride	($NaCl$).............	614·30	44·05	
Magnesium chloride	($MgCl_2$)............			
Calcium chloride	($CaCl_2$).............			
Sodium sulphate	(Na_2SO_4)...........	0·71	0·05	
Magnesium sulphate	($MgSO_4$)............			
Calcium sulphate	($CaSO_4$)............			
Sodium bicarbonate	($NaHCO_3$)..........	674·00	48·40	
Magnesium bicarbonate	($Mg(HCO_3)_2$).........	22·68	1·63	
Calcium bicarbonate	($Ca(HCO_3)_2$).........	15·39	1·10	
Strontium bicarbonate	($Sr(HCO_3)_2$)..........			
Ferrous bicarbonate	($Fe(HCO_3)_2$).........	8·90	0·64	
Calcium phosphate	($Ca_3(PO_4)_2$)..........	trace	——	
Ferric oxide	(Fe_2O_3).............			
Alumina	(Al_2O_3).............			
Silica	(SiO_2)..............	10·40	0·75	
		1,394·10	100·00	

Water from the Soda spring is the least mineralized of all the Carlsbad waters, and probably is the alkaline water which in the other springs mingles with a more concentrated saline water, in varying proportions.

Its primary alkalinity is high—over 40 per cent, another way of stating that sodium bicarbonate is a predominant constituent (48 per cent of the solids in solution).

The water is not quite as pleasant to drink as the Sulphur or the Lithia water, on account of its slightly alkaline taste.

Analysis shows it to be a sodic, bicarbonated, muriated water of the alkaline-saline type.

VICTORIA SULPHUR SPRING, CARLETON COUNTY, ONT.

(22)

This is a disused spring at the side of Green's creek, two miles from Ottawa, near the Montreal Road. It is situated on the bank of the creek, rising in an old wooden well, and flows at a rate of 250 gallons per hour. A considerable quantity of hydrogen sulphide is contained in the gas given off from the water, and by the action of the air it is decomposed forming a sulphur deposit around the spring. The chief constituent of the gas is methane. The radioactivity of the gas was found to be 800 units.

Water from the spring was once in great demand and a sanitarium built near had a considerable reputation, but it is now in ruins and the spring is in a neglected condition and disused.

No complete analysis has been made but the following particulars were ascertained:—

Sample collected July 1914.
Temperature, 9·2°C.
Flow, 4 gallons per minute.
Taste, strong sulphur.
Specific gravity at 15°C., 1·004.
Radioactivity, Emanation 112 units.
Dissolved radium, trace.
Emanation in gas evolved, 800 units.
Hydrogen sulphide in water, 8·8 c.c. per litre.

PLANTAGENET MINERAL SPRING, PRESCOTT COUNTY, ONT.

(31)

This is an old spring mentioned by Sterry Hunt in Geology of Canada, p. 541, 1886. He stated that it rises from the lower Silurian formation. It is strongly saline and possesses a specific gravity of 1·0085, approximately equivalent to a sodium chloride content of 10,000 parts per million.

It rises in a wooden cased well close to Plantagenet station, but water from it is seldom used to-day, and no analysis has, as yet, been made of this water. Radioactive measurements show a temporary radioactivity of 104 units per litre.

CALEDONIA SPRINGS, PRESCOTT COUNTY, ONT.

(25, 26, and 27)

The waters at Caledonia Springs form one of the best known group of springs in Canada. They were known to the settlers in the Ottawa Valley as early as 1806 and well patronized by them. The residents of Montreal and Ottawa also visited them and had a considerably more arduous journey than their descendants to-day, who now reach the springs in an hour and a half from Montreal or Ottawa, travelling in a comfortable, well-equipped train. In those days, visitors from Montreal had to take the train to Lachine, thence by steamer through Lake St. Louis and Lake of Two Mountains, to Carillon; again by train to Grenville, where a boat was taken to l'Orignal. From this place the ten-mile journey to the springs was completed by stage. Accounts still exist of the various events of those days, horse races, walking contests, miraculous cures, and hotel fires, and many interesting stories are told. In recent years, the Canadian Pacific

Railway Co. has developed the chief springs and managed an excellent hotel, although it has been closed since the outbreak of the war.

Altogether, seven separate sources of water exist within a small area, and the eighth—the Duncan Spring—is only two miles away. Of the seven sources, three are flowing springs and four are artesian wells. The three springs: the Saline, the Sulphur, and the Gas Spring, lie quite close together, the Sulphur and Saline only a few feet apart. The springs have been the subject of several analyses, dating back from 1843, when they were examined by Dr. James Williamson. Twice Dr. Sterry Hunt made analyses of the waters, in 1847 and in 1865. In 1903-1907, Professor R. F. Ruttan of McGill University carried out a careful investigation for the Caledonia Springs Mineral Water Co. They were again analysed as detailed in this report in 1916.

The chief constituent of all the waters may be considered to be sodium chloride, and several of them show considerable similarity in composition.

The waters from the springs are of considerable therapeutic value, and many cures have been effected by the use of them. An interesting paper[1] was written on the therapeutic properties of the Caledonia Springs by Dr. E. S. Harding, B.A., M.D., sometime resident physician, and the statements given, concerning the individual waters, are taken from it.

According to Sterry Hunt, they rise from the Trenton limestone formation, though he considered that three of the waters at least were formed by the mingling of a concentrated saline water with water containing alkaline carbonate such as would be derived from argillaceous sediments, similar to those composing the Utica and Hudson River formations.

SALINE SPRING, CALEDONIA SPRINGS.

(25)

The Saline, and the Sulphur Springs, issue only a few feet apart. The sulphur water comes from a fissure in the rock, 14 feet down, while the saline water proceeds from the junction of the clay and the rock. In 1915, the outlet of these two springs was cleaned up, and white tiled partitions built, so that the two waters are entirely separated.

The saline water is carbonated and bottled, and has an extensive sale under the name of 'Magi' Caledonia water. It constitutes a very pleasant and at the same time beneficial beverage.

The water may be classified as a sodic, muriated, alkaline-saline water. (Slightly sulphuretted and carbondioxated). It contains small amounts of bromides and iodides, which have some therapeutic importance, besides the larger amounts of magnesium (10·6 per cent), and calcium bicarbonates (2 per cent), and sodium chloride (83 per cent of the total inorganic matter in solution).

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[1] Harding, E. S., The Treatment of Rheumatism at Caledonia Springs, Montreal Medical Journal, April, 1907.

The following particulars were obtained upon analysis:—

SALINE SPRING.

Laboratory No. 25.

Sample collected..............October, 1915.
Temperature.....................8·5°C. (47·3°F.)
Flow............................2 gallons per minute.
Taste...........................Pleasantly saline.
Reaction........................Alkaline.
Specific gravity at 15°C........1·0063
Radioactivity...................Emanation...........70 units.
Dissolved radium..... 5·6 „
Emanation in gas evolved.

Properties of reaction in per cent.

Primary salinity......88·60
Secondary salinity....
Primary alkalinity.... 0·94
Secondary alkalinity..10·46

Plate II.

Sulphur and Saline Springs.
Caledonia Springs, Prescott Co., Ont.

Plate III.

Gas Spring.
Caledonia Springs, Prescott Co., Ont.

Analysis.

Constituents:—		Previous analysis.*	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO_4).....	2·1	1·02	0·03	0·02
Bicarbonic acid (HCO_3)...	930·	——	11·46	5·70
Carbonic acid (CO_3).....	——	508·33	——	——
Nitric acid (NO_3).....	——	——	——	——
Nitrous acid (NO_2).....	trace	——	——	——
Phosphoric acid (PO_4).....	——	trace	——	——
Metaboric acid (BO_2).....	trace	——	——	——
Chlorine (Cl)......	4,194·	4,153·04	51·66	44·24
Bromine (Br)......	10·0	15·30	0·12	0·04
Iodine (I).......	1·6	1·26	0·02	——
Oxygen to form (Al_2O_3)....	0·18	——	——	——
Silica (SiO_2).....	15·0	28·0	0·18	——
Iron (Fe)......	1·2	0·3	0·01	0·02
Aluminium (Al)......	0·21	0·89	——	——
Manganese (Mn).....	——	trace	——	——
Calcium (Ca)......	41·0	53·98	0·51	0·77
Strontium (Sr)......	2·9	——	0·04	0·03
Magnesium (Mg).....	143·0	127·21	1·76	4·41
Lithium (Li)......	2·4	——	0·03	0·13
Potassium (K).......	78·4	15·23	0·97	0·76
Sodium (Na)......	2,691·4	2,765·43	33·15	43·78
Ammonium (NH_4)....	4·89	4·09	0·06	0·10
Total......................	8,118·28	7,674·08	100·00	100·00
				Concentration value.
Total solids in solution, residue dried at 110°C............	7,762			266·65

Gases :		c.c. per litre.	Parts per million.
	Carbon Dioxide CO_2....	20·6	40·5
	Hydrogen Sulphide H_2S.	0·5	0·7

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*By Prof. R. F. Ruttan, McGill University, 1903.

HYPOTHETICAL COMBINATIONS.

No. 25.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)	trace		
Sodium nitrate	($NaNO_3$)			
Ammonium chloride	(NH_4Cl)	14·55	0·18	
Potassium iodide	(KI)	2·00	0·02	
Potassium bromide	(KBr)	14·88	0·18	
Lithium chloride	($LiCl$)	14·58	0·18	
Potassium chloride	(KCl)	139·54	1·72	
Sodium chloride	($NaCl$)	6,766·00	83·35	
Magnesium chloride	($MgCl_2$)			
Calcium chloride	($CaCl_2$)			
Sodium sulphate	(Na_2SO_4)	3·12	0·04	
Magnesium sulphate	($MgSO_4$)			
Calcium sulphate	($CaSO_4$)			
Sodium bicarbonate	($NaHCO_3$)	110·63	1·36	
Magnesium bicarbonate	($Mg(HCO_3)_2$)	860·36	10·61	
Calcium bicarbonate	($Ca(HCO_3)_2$)	166·05	2·04	
Strontium bicarbonate	($Sr(HCO_3)_2$)	6·92	0·08	
Ferrous bicarbonate	($Fe(HCO_3)_2$)	3·83	0·05	
Calcium phosphate	($Ca_3(PO_4)_2$)			
Ferric oxide	(Fe_2O_3)			
Alumina	(Al_2O_3)	0·39	0·01	
Silica	(SiO_2)	15·0	0·18	
		8,118·15	100·00	

THE SULPHUR SPRING.

(26)

The Sulphur Spring water differs slightly from the Saline water, in holding a large amount of hydrogen sulphide gas in solution, and in containing only 4 per cent of sodium bicarbonate, giving it a higher primary alkalinity. It also contains a smaller amount of mineral matter in solution—6231 parts per million, as compared with 8118 parts per million. The analysis shows it to be a sodic, muriated, carbonated, alkaline-saline water (sulphuretted). It owes its thereapeutic properties, in part, to the presence of hydrogen sulphide, and is used largely in the treatment of rheumatism.

Analysis gave the following particulars:—

SULPHUR SPRING.

Laboratory No. 26.

Sample collected..............October, 1915.
Temperature..................8·3°C. (46·9°F.)
Flow..........................2 to 3 gallons per minute.

Taste......................Slightly saline, with indication of hydrogen sulphide.
Reaction....................Alkaline.
Specific gravity at 15°C........1·0059
Radioactivity...............Emanation...........73 units.
Dissolved radium..... 5·6 „
Emanation in gas evolved.

Properties of reaction in per cent.
Primary salinity......86·04
Secondary salinity....
Primary alkalinity.... 3·24
Secondary alkalinity..10·72

Analysis.

Constituents:—			Previous analysis.*	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4).......	3·3	6·54	0·05	0·03
Bicarbonic acid	(HCO_3).....	861·	443·84	13·82	6·98
Carbonic acid	(CO_3).......	——	——	——	——
Nitric acid	(NO_3).......	——	——	——	——
Nitrous acid	(NO_2).......	——	——	——	——
Phosphoric acid	(PO_4).......	trace	——	——	——
Metaboric acid	(BO_2).......	trace	——	——	——
Chlorine	(Cl)........	3,086·	2,836·34	49·52	42·90
Bromine	(Br)........	14·5	1·23	0·23	0·09
Iodine	(I)..........	2·5	0·48	0·04	——
Sulphur	....		0·70		
Silica	(SiO_2).......	17·9	53·95	0·28	——
Iron	(Fe).......	traces	trace	——	——
Aluminium	(Al).......		0·48		
Manganese	(Mn).......	——		——	——
Calcium	(Ca)........	39·8	124·12	0·64	0·98
Strontium	(Sr)........	0·8	——	0·01	0·01
Magnesium	(Mg).......	108·0	54·98	1·73	4·37
Lithium	(Li)........	1·8	——	0·03	0·13
Potassium	(K).........	57·2	14·65	0·92	0·72
Sodium	(Na)........	2,034·6	1,923·14	32·65	43·67
Ammonium	(NH_4)......	4·37	2·73	0·07	0·12
Total....................		6,231·77	5,463·21	100·00	100·00
Total solids in solution, residue dried at 110°C.............		5,870			Concentration value. 202·63

		c.c. per litre.	Parts per million.
Gases :	Carbon Dioxide CO_2....	30·0	61·0
	Hydrogen Sulphide H_2S.	0·6	0·94

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* By Prof. R. F. Ruttan, McGill University, 1903.

HYPOTHETICAL COMBINATIONS.

No. 26.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)..........			
Sodium nitrate	($NaNO_3$)..........			
Ammonium chloride	(NH_4Cl)..........	12·8	0·20	
Potassium iodide	(KI)..............	3·3	0·05	
Potassium bromide	(KBr)............	21·5	0·35	
Lithium chloride	(LiCl)............	10·9	0·17	
Potassium chloride	(KCl)............	94·3	1·51	
Sodium chloride	(NaCl)............	4,982·3	79·95	
Magnesium chloride	($MgCl_2$)..........			
Calcium chloride	($CaCl_2$)..........			
Sodium sulphate	(Na_2SO_4)..........	4·9	0·08	
Magnesium sulphate	($MgSO_4$)..........			
Calcium sulphate	($CaSO_4$)..........			
Sodium bicarbonate	($NaHCO_3$)........	270·9	4·35	
Magnesium bicarbonate	($Mg(HCO_3)_2$)......	649·8	10·43	
Calcium bicarbonate	($Ca(HCO_3)_2$).......	161·2	2·59	
Strontium bicarbonate	($Sr(HCO_3)_2$).......	1·9	0·03	
Ferrous bicarbonate	($Fe(HCO_3)_2$).......			
Calcium phosphate	($Ca_3(PO_4)_2$)........	trace		
Ferric oxide	(Fe_2O_3)..........	traces		
Alumina	(Al_2O_3)..........			
Silica	(SiO_2)............	17·9	0·29	
		6,231·7	100·00	

THE GAS SPRING.

(27)

The Gas Spring is also a sodic, muriated, alkaline-saline water, and closely resembles the Saline water in composition, though the flow is slightly less. Gas is evolved from the water, which rises in a circular glass capped cement well, and was found to possess a radioactivity of 306 units.

Analysis by Prof. Ruttan gave:—

Methane, CH_4.........................	63·10 per cent.
Ethane, C_2H_6.........................	0·74 „
Carbon monoxide, CO....................	1·00 „
Carbon dioxide, CO_2....................	0·80 „
Nitrogen, N_2..........................	33·60 „

The relatively high percentage of carbon monoxide may account for the alleged night-mare-giving properties of the water. The therapeutic use of the water is due mostly to the presence of carbonic acid and the bicarbonates, making it of value in gastric conditions.

The following data were obtained upon analysis:—

THE GAS SPRING.

Laboratory No. 27.

Sample collected	October, 1915.		
Temperature	7·9°C. (46·2°F.)		
Flow	2–3 gallons per minute.		
Taste	Slightly saline.		
Reaction	Alkaline.		
Specific gravity at 15°C.	1·0063		
Radioactivity	Emanation	90	units.
	Dissolved radium	8·4	„
	Emanation in gas evolved	306	„

Properties of reaction in per cent.

Primary salinity	89·12
Secondary salinity	
Primary alkalinity	0·24
Secondary alkalinity	10·64

Analysis.

Constituents:—		Previous analysis.	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO_4)	2·1	0·53	0·02	0·01
Bicarbonic acid (HCO_3)	925·	—	10·94	5·44
Carbonic acid (CO_3)	—	468·27	—	—
Nitric acid (NO_3)	—	—	—	—
Nitrous acid (NO_2)	0·14	trace	—	—
Phosphoric acid (PO_4)	1·0		0·01	0·01
Metaboric acid (BO_2)	trace		—	—
Chlorine (Cl)	4,412·	4,212·02	52·16	44·53
Bromine (Br)	2·4	13·46	0·03	0·01
Iodine (I)	0·6	0·98	—	—
Oxygen to form (Al_2O_3)	3·1	—	0·04	—
Silica (SiO_2)	17·1	30·82	0·20	—
Iron (Fe)	0·6	0·64	0·01	—
Aluminium (Al)	3·5	0·97	0·04	—
Manganese (Mn)	—	trace	—	—
Calcium (Ca)	70·8	57·74	0·84	1·27
Strontium (Sr)	2·1	—	0·02	0·01
Magnesium (Mg)	137·0	120·77	1·62	4·04
Lithium (Li)	4·7	—	0·06	0·27
Potassium (K)	60·9	13·12	0·72	0·56
Sodium (Na)	2,808·94	2,779·78	33·21	43·77
Ammonium (NH_4)	5·81	4·91	0·07	0·11
Total	8,457·79	7,704·02	100·00	100·00 Concentration value.
Total solids in solution, residue dried at 110°C	8,140			279·12

Gases :		c.c. per litre.	Parts per million.
	Carbon Dioxide CO_2	19·5	38·5
	Hydrogen Sulphide H_2S.	0·4	0·3

HYPOTHETICAL COMBINATIONS.

No. 27.

Constituent:—		Parts per million.	Total inorganic matter in solution. Per cent.	Previous analysis.
Sodium nitrite	($NaNO_2$)..........	0·21	——	
Sodium nitrate	($NaNO_3$)..........			
Ammonium chloride	(NH_4Cl)..........	17·28	0·20	
Potassium iodide	(KI).............	0·83	0·01	
Potassium bromide	(KBr)............	3·57	0·04	
Lithium chloride	($LiCl$)............	28·52	0·34	
Potassium chloride	(KCl).............	113·76	1·35	
Sodium chloride	($NaCl$)............	7,123·00	84·22	
Magnesium chloride	($MgCl_2$)...........			
Calcium chloride	($CaCl_2$)...........			
Sodium sulphate	(Na_2SO_4)..........	3·48	0·04	
Magnesium sulphate	($MgSO_4$)..........			
Calcium sulphate	($CaSO_4$)...........			
Sodium bicarbonate	($NaHCO_3$).........	26·88	0·32	
Magnesium bicarbonate	($Mg(HCO_3)_2$)......	824·00	9·74	
Calcium bicarbonate	($Ca(HCO_3)_2$).......	284·12	3·36	
Strontium bicarbonate	($Sr (HCO_3)_2$).......	5·03	0·06	
Ferrous bicarbonate	($Fe(HCO_3)_2$).......	1·87	0·02	
Calcium phosphate	($Ca_3(PO_4)_2$)........	1·60	0·02	
Ferric oxide	(Fe_2O_3)...........			
Alumina	(Al_2O_3)...........	6·60	0·08	
Silica	(SiO_2)............	17·10	0·20	
		8,457·85	100·00	

THE DUNCAN SPRING.

No. 28.

The Duncan Spring is situated two miles from the hotel, and flows with considerable force from a pipe inserted in a boring, 141 feet deep. Much gas issues in bubbles with the water, and can be lit at the mouth of the pipe. Analysis by Professor Ruttan in 1913 showed it to have the following composition:—

Methane, CH_4........................	86·00	per cent.
Ethane and heavy hydrocarbons, C_2H_6....	0·77	„
Carbon monoxide, CO..................	1·05	„
Carbon dioxide, CO_2....................	0·69	„
Nitrogen, N_2..........................	11·46	„
Argon with traces of helium.............	0·02	„

The radioactivity was found to be 224 units per litre (N.T.P.)

The water is strongly saline, and has a bitter taste, due to the large amount of magnesium and calcium salts present. The action of this water is strongly aperient, and its use is confined almost entirely to cases of constipation. The bitter taste is lost when the water is taken hot. Analysis shows it to be a sodic, magnesic, muriated water of the alkaline-saline class.

THE DUNCAN SPRING.

Laboratory No. 28.

Sample collected	October, 1915.	
Temperature	9°C. (48·2°F.)	
Flow	3 gallons per minute.	
Taste	Strongly saline and bitter.	
Reaction	Alkaline.	
Specific gravity at 15°C.	1·0073	
Radioactivity	Emanation	53 units.
	Dissolved radium	5·6 „
	Emanation in gas evolved	204 „

Properties of reaction in per cent.

Primary salinity	88·06
Secondary salinity	
Primary alkalinity	3·34
Secondary alkalinity	8·60

Analysis.

Constituents:—			Previous analysis.*	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4)	3·4	1·02	0·03	0·02
Bicarbonic acid	(HCO_3)	1,200·		12·00	5·97
Carbonic acid	(CO_3)	—	—	—	—
Nitric acid	(NO_3)	—	—	—	—
Nitrous acid	(NO_2)	—	—	—	—
Phosphoric acid	(PO_4)	1·2	trace	0·01	0·01
Metaboric acid	(BO_2)	trace	—	—	—
Chlorine	(Cl)	5,137·5	5,503·36	51·34	43·96
Bromine	(Br)	10·0	18·62	0·10	0·04
Iodine	(I)	1·5	0·65	0·01	—
Oxygen for	(Al_2O_3)	0·23	—	—	—
Silica	(SiO_2)	10·9	16·08	0·10	—
Iron	(Fe)	1·3	0·64	0·01	0·01
Aluminium	(Al)	0·26	trace	—	—
Manganese	(Mn)	0·05	trace	—	—
Calcium	(Ca)	43·5	122·68	0·44	0·66
Strontium	(Sr)	1·8	—	0·02	0·01
Magnesium	(Mg)	145·	433·61	1·45	3·62
Lithium	(Li)	17·2	—	0·17	0·75
Potassium	(K)	86·	12·51	0·86	0·67
Sodium	(Na)	3,339·3	3,208·22	33·36	44·10
Ammonium	(NH_4)	10·75	11·12	0·10	0·18
Total		10,009·89	10,151·81	100·00	100·00 Concentration value. 329·27
Total solids in solution, residue dried at 110°C		9,500·			

Gases:		c.c. per litre.	Parts per million.
	Carbon Dioxide CO_2	96·0	48·7
	Hydrogen Sulphide H_2S	—	—

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* By Prof. R. F. Ruttan, McGill University, 1903.

HYPOTHETICAL COMBINATIONS.

No. 28.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)			
Sodium nitrate	($NaNO_3$)			
Ammonium chloride	(NH_4Cl)	31·94	0·31	
Potassium iodide	(KI)	2·00	0·02	
Potassium bromide	(KBr)	14·88	0·15	
Lithium chloride	($LiCl$)	104·42	1·04	
Potassium chloride	(KCl)	154·07	1·54	
Sodium chloride	($NaCl$)	8,166·34	81·63	
Magnesium chloride	($MgCl_2$)			
Calcium chloride	($CaCl_2$)			
Sodium sulphate	(Na_2SO_4)	5·04	0·05	
Magnesium sulphate	($MgSO_4$)			
Calcium sulphate	($CaSO_4$)			
Sodium bicarbonate	($NaHCO_3$)	463·76	4·63	
Magnesium bicarbonate	($Mg(HCO_3)_2$)	872·36	8·71	
Calcium bicarbonate	($Ca(HCO_3)_2$)	173·18	1·73	
Strontium bicarbonate	($Sr(HCO_3)_2$)	4·30	0·04	
Ferrous bicarbonate	($Fe(HCO_3)_2$)	4·09	0·04	
Calcium phosphate	($Ca_3(PO_4)_2$)	1·91	0·01	
Ferric oxide	(Fe_2O_3)			
Alumina	(Al_2O_3)	0·49	——	
Silica	(SiO_2)	10·90	0·10	
Manganous bicarbonate	($Mn(HCO_3)_2$)	0·18		
		10,009·86	100·00	

THE ARTESIAN SULPHUR SPRING.

(29)

The Artesian sulphur water is obtained from an artesian well, on the other side of the track from the hotel. The well is drilled 168 feet, the first 68 feet being through clay. The water is less mineralized than the others, contains much more hydrogen sulphide gas and has high primary alkalinity (11 per cent).

It can be classified as a sodic, muriated, bicarbonated, alkaline-saline (sulphuretted) water. The water is pumped across to the hotel, where it is largely used for sulphur baths.

The following analysis, the first that has ever been made of the water, gave these particulars:—

THE ARTESIAN SULPHUR SPRING.

Laboratory No. 29.

Sample collected..............October, 1915.
Temperature.................9·4°C. (48·9°F.)
Flow.......................Small.

Taste........................Slightly saline and hydrogen sulphide.
Reaction.....................Alkaline.
Specific gravity at 15°C.......1·0024
Radioactivity..................Emanation................56 units.
Dissolved radium......... 1·7 „
Emanation in gas evolved

Properties of reaction in per cent.
Primary salinity..........79·94
Secondary salinity........
Primary alkalinity........11·30
Secondary alkalinity...... 8·76

Analysis.

Constituents:—		Previous analysis.	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO_4).........	98·6		2·91	1·95
Bicarbonic acid (HCO_3).......	645·		19·04	10·03
Carbonic acid (CO_3).........	—		—	—
Nitric acid (NO_3).........	—		—	—
Nitrous acid (NO_2).........	3·2		0·09	0·06
Phosphoric acid (PO_4).........	—		—	—
Metaboric acid (BO_2).........	trace		—	—
Chlorine (Cl)..........	1,418·5		41·88	37·90
Bromine (Br)..........	4·8		0·14	0·06
Iodine (I)...........	trace		—	—
Oxygen for (Al_2O_3)........	4·09		0·12	—
Silica (SiO_2).........	21·7		0·64	—
Iron (Fe)..........	1·0		0·03	0·03
Aluminium (Al)..........	4·6		0·13	—
Manganese (Mn)..........	0·04		—	—
Calcium (Ca)..........	27·7		0·82	1·31
Strontium (Sr)..........	2·1		0·06	0·04
Magnesium (Mg)..........	38·5		1·14	3·00
Lithium (Li)..........	1·6		0·05	0·22
Potassium (K)...........	37·5		1·11	0·91
Sodium (Na)..........	1,076·2		31·78	44·40
Ammonium (NH_4)........	1·77		0·06	0·09
Total.....................	3,386·90		100·00	100·00 Concentration value.
Total solids in solution, residue dried at 110°C.............	3,106			105·43

		c.c. per litre.	Parts per million.
Gases :	Carbon Dioxide CO_2....	15·4	30·4
	Hydrogen Sulphide H_2S.	6·8	10·9

HYPOTHETICAL COMBINATIONS.

No. 29.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)..........	4·83	0·14	
Sodium nitrate	($NaNO_3$)..........			
Ammonium chloride	(NH_4Cl)..........	5·24	0·15	
Potassium iodide	(KI).............	trace	——	
Potassium bromide	(KBr)...........	7·14	0·21	
Lithium chloride	(LiCl)...........	9·69	0·29	
Potassium chloride	(KCl)............	67·20	1·98	
Sodium chloride	(NaCl)...........	2,265·70	66·90	
Magnesium chloride	($MgCl_2$)..........			
Calcium chloride	($CaCl_2$)..........			
Sodium sulphate	(Na_2SO_4).........	145·82	4·30	
Magnesium sulphate	($MgSO_4$)..			
Calcium sulphate	($CaSO_4$)..........			
Sodium bicarbonate	($NaHCO_3$).........	498·70	14·73	
Magnesium bicarbonate	($Mg(HCO_3)_2$)......	231·60	6·84	
Calcium bicarbonate	($Ca(HCO_3)_2$).......	112·18	3·31	
Strontium bicarbonate	($Sr(HCO_3)_2$).......	5·03	0·15	
Ferrous bicarbonate	($Fe(HCO_3)_2$).......	3·20	0·10	
Calcium phosphate	($Ca_3(PO_4)_2$)........			
Ferric oxide	(Fe_2O_3)...........			
Alumina	(Al_2O_3)...........	8·69	0·26	
Silica	(SiO_2)............	21·70	0·64	
Manganous bicarbonate	($Mn(HCO_3)_2$)......	0·18		
		3,386·94	100·00	

GURD'S SALINE WATERS, CALEDONIA SPRINGS.

(33-34)

Charles Gurd and Co. of Montreal, own two artesian wells, situated some 250 yards from the main group of the chief Caledonia springs.

The two wells—20 feet apart, are both 68 feet deep, sunk through clay to the rock. Barrel loads of the less saline water are taken to Montreal each week. The more saline water contains almost twice as much mineral matter in solution as the less saline, and is nearly as concentrated as the Duncan water; but it differs from it in having sulphuric acid in noticeable quantity, and containing less bicarbonic acid. It can be classified as a sodic, muriated, sulphated saline water, and would no doubt have considerable value as a purgative water. Magnesium sulphate to the extent of 2·5 per cent and 4·2 per cent magnesium bicarbonate are present in the water, while the principal constituent is sodium chloride (84%).

The following results were obtained upon analysis:—

GURD'S SALINE.

Laboratory No. 33.

Sample collected..............October, 1915.
Temperature.................8·8°C. (44·5°F.)
Flow.......................Small.
Taste.......................Strongly saline.
Reaction.....................Alkaline.
Specific gravity at 15°C........1·0071
Radioactivity................Emanation...............50 units.
Dissolved radium......... 1·7 „
Emanation in gas evolved.

Properties of reaction in per cent.
Primary salinity..........87·52
Secondary salinity........ 6·40
Primary alkalinity........
Secondary alkalinity...... 6·08

Analysis.

Constituents:—			Previous analysis.	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4)	197·0		2·00	1·24
Bicarbonic acid	(HCO_3)	613·		6·23	3·04
Carbonic acid	(CO_3)	—		—	—
Nitric acid	(NO_3)	10·2		0·10	0·05
Nitrous acid	(NO_2)	—		—	—
Phosphoric acid	(PO_4)	1·6		0·01	0·01
Metaboric acid	(BO_2)	—		—	—
Chlorine	(Cl)........	5,352·		54·38	45·61
Bromine	(Br)........	13·0		0·13	0·05
Iodine	(I)..........	0·5		0·01	—
Oxygen to form	(Al_2O_3)	0·8		0·01	—
Silica	(SiO_2)	12·6		0·13	—
Iron	(Fe)........	0·9		0·01	0·01
Aluminium	(Al)........	0·9		0·01	—
Manganese	(Mn).......	0·02		—	—
Calcium	(Ca)........	82·5		0·84	1·25
Strontium	(Sr)........	10·3		0·10	0·07
Magnesium	(Mg).......	197·3		2·00	4·91
Lithium	(Li)........	1·8		0·02	0·08
Potassium	(K).........	67·1		0·68	0·52
Sodium	(Na)........	3,278·		33·31	43·12
Ammonium	(NH_4)	2·8		0·03	0·04
Total....................		9,842·32		100·00	100·00
Total solids in solution, residue dried at 110°C............		10,070			Concentration value. 330·58

Gases :	c.c. per litre.	Parts per million.
Carbon Dioxide CO_2....	20·0	39·5
Hydrogen Sulphide H_2S.	—	—

HYPOTHETICAL COMBINATIONS.

No. 33.

Constituent:—		Parts per million.	Total inorganic matter in solution. Per cent.	Previous analysis.
Sodium nitrite	($NaNO_2$)..........			
Sodium nitrate	($NaNO_3$)..........	14·03	0·14	
Ammonium chloride	(NH_4Cl)..........	8·35	0·08	
Potassium iodide	(KI)..............	0·66	0·01	
Potassium bromide	(KBr)............	19·40	0·20	
Lithium chloride	($LiCl$)...........	10·92	0·11	
Potassium chloride	(KCl)............	115·70	1·18	
Sodium chloride	($NaCl$)...........	8,328·76	84·62	
Magnesium chloride	($MgCl_2$)..........	306·12	3·11	
Calcium chloride	($CaCl_2$)..........			
Sodium sulphate	(Na_2SO_4)..........			
Magnesium sulphate	($MgSO_4$)..........	246·42	2·50	
Calcium sulphate	($CaSO_4$)..........			
Sodium bicarbonate	($NaHCO_3$).........			
Magnesium bicarbonate	($Mg(HCO_3)_2$)......	417·48	4·24	
Calcium bicarbonate	($Ca(HCO_3)_2$).......	330·08	3·35	
Strontium bicarbonate	($Sr(HCO_3)_2$).......	24·63	0·25	
Ferrous bicarbonate	($Fe(HCO_3)_2$).......	2·85	0·03	
Calcium phosphate	($Ca_3(PO_4)_2$)........	2·59	0·03	
Ferric oxide	(Fe_2O_3)...........			
Alumina	(Al_2O_3)...........	1·70	0·02	
Silica	(SiO_2)............	12·60	0·13	
Manganous bicarbonate	($Mn(HCO_3)_2$)... ..	0·08		
		9,842·34	100·00	

Gurd's less saline water, resembles the Saline and Sulphur Caledonia waters, though it contains slightly less mineral matter in solution.

It may be considered as a sodic, muriated, alkaline-saline water. The principal constituents are sodium chloride (77·8 per cent), and sodium and the alkaline earth bicarbonates.

Analysis gave the following results:—

GURD'S LESS SALINE.

Laboratory No. 34.

Sample collected..............October, 1915.
Temperature..................8·7°C. (46°F.)
Flow........................Small.
Taste.......................Saline.
Reaction....................Alkaline.
Specific gravity at 15°C.......1·0039
Radioactivity................Emanation...............50 units.
Dissolved radium......... 0·8 „
Emanation in gas evolved.

Properties of reaction in per cent.

Primary salinity..........	86·62
Secondary salinity........	
Primary alkalinity........	4·90
Secondary alkalinity......	8·48

Analysis.

Constituents:—		Previous analysis.	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO_4).......	58·7		1·09	0·70
Bicarbonic acid (HCO_3)......	708·		13·15	6·69
Carbonic acid (CO_3).......	——		——	——
Nitric acid (NO_3).......	7·2		0·13	0·07
Nitrous acid (NO_2).......	0·05		——	——
Phosphoric acid (PO_4).......	trace		——	——
Metaboric acid (BO_2).......	——		——	——
Chlorine (Cl)........	2,622·		48·70	42·50
Bromine (Br)........	6·0		0·11	0·04
Iodine (I).........	0·4		0·01	——
Oxygen to form Al_2O_3..........	0·84		0·01	——
Silica (SiO_2).......	16·7		0·31	——
Iron (Fe)........	0·6		0·01	0·01
Aluminium (Al)........	0·95		0·01	——
Manganese (Mn).......	0·10		——	——
Calcium (Ca)........	28·8		0·53	0·83
Strontium (Sr)........	7·1		0·13	0·09
Magnesium (Mg).......	70·0		1·30	3·31
Lithium (Li).........	1·5		0·03	0·12
Potassium (K).........	78·9		1·47	1·16
Sodium (Na)........	1,776·2		33·00	44·47
Ammonium (NH_4)......	0·6		0·01	0·01
Total....................	5,384·64		100·00	100·00 Concentration value. 173·76
Total solids in solution, residue dried at 110°C.............	5,017		——	

		c.c. per litre.	Parts per million.
Gases :	Carbon Dioxide CO_2....	22·0	43·5
	Hydrogen Sulphide H_2S.	——	——

HYPOTHETICAL COMBINATIONS.

No. 34.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	$(NaNO_2)$..........	0·07	—	
Sodium nitrate	$(NaNO_3)$..........	9·86	0·18	
Ammonium chloride	(NH_4Cl)..........	1·79	0·03	
Potassium iodide	(KI)..............	0·50	0·10	
Potassium bromide	(KBr)............	8·93	0·17	
Lithium chloride	$(LiCl)$............	9·10	0·17	
Potassium chloride	(KCl)............	144·90	2·69	
Sodium chloride	$(NaCl)$............	4,192·52	77·86	
Magnesium chloride	$(MgCl_2)$...........			
Calcium chloride	$(CaCl_2)$...........			
Sodium sulphate	(Na_2SO_4)..........	86·70	1·61	
Magnesium sulphate	$(MgSO_4)$..........			
Calcium sulphate	$(CaSO_4)$...........			
Sodium bicarbonate	$(NaHCO_3)$.........	354·70	6·59	
Magnesium bicarbonate	$(Mg(HCO_3)_2)$......	421·20	7·82	
Calcium bicarbonate	$(Ca(HCO_3)_2)$.......	116·65	2·17	
Strontium bicarbonate	$(Sr(HCO_3)_2)$.......	16·93	0·31	
Ferrous bicarbonate	$(Fe(HCO_3)_2)$.......	1·87	0·04	
Calcium phosphate	$(Ca_3(PO_4)_2)$........			
Ferric oxide	(Fe_2O_3)...........			
Alumina	(Al_2O_3)...........	1·79	0·03	
Silica	(SiO_2)............	16·70	0·31	
Manganous bicarbonate	$(Mn(HCO_3)_2)$......	0·35	—	
		5,384·64	100·00	

ADANAC SPRING, BOURGET, ONT.

(30).

This is a fresh water spring owned by the Caledonia Springs Mineral Water Co. It was discovered during the construction of a cutting on the Canadian Pacific railroad, and was soon utilized. The spring is enclosed in a large white tiled well, and a substantial house encloses it, so that every precaution has been taken to avoid pollution.

Most of the high land in the neighbourhood is of a sandy nature, and probably the spring is a surface water, filtered through the sandy soil. The radioactivity is comparatively high, but there is only a trace of radium salts in solution. Similar statements can be made about many surface waters.

The following particulars were obtained upon examination:—

ADANAC SPRING.

Laboratory No. 30.

Sample collected..............August, 1914.
Temperature.................11°C. (51·8° F.)
Flow.......................10 gallons per minute.

Taste.........................Fresh.
Reaction.........................Alkaline.
Specific gravity at 15°C........1·0002
Radioactivity................Emanation...............202 units.
Dissolved radium.......... 0·3 „
Emanation in gas evolved.

Properties of reaction in per cent.
Primary salinity.......... 31·6
Secondary salinity........
Primary alkalinity........ 5·8
Secondary alkalinity...... 62·6

Analysis.

Constituents:—			Previous analysis.*	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4).....		5·68	4·5	2·7
Bicarbonic acid	(HCO_3)...		—	—	—
Carbonic acid	(CO_3).....		45·48	36·0	34·2
Nitric acid	(NO_3).....		19·7	15·6	6·8
Nitrous acid	(NO_2).....				
Phosphoric acid	(PO_4).....				
Metaboric acid	(BO_2).....				
Chlorine	(Cl)......		10·0	8·0	6·3
Bromine	(Br)......				
Iodine	(I).......				
Silica	(SiO_2).....				
Iron	(Fe)......				
Aluminium	(Al)......				
Manganese	(Mn).....				
Calcium	(Ca)......		24·3	19·2	27·3
Strontium	(Sr)......				
Magnesium	(Mg).....		2·24	1·7	4·0
Lithium	(Li)......				
Potassium	(K).......				
Sodium	(Na)......		19·08	15·0	18·7
Ammonium	(NH_4)....				—
Total....................			126·48	100·0	100·00 Concentration value.
Total solids in solution, residue dried at 110°C............					4·44

	c.c. per litre.	Parts per million.
Gases : Carbon Dioxide CO_2....		
Hydrogen Sulphide H_2S.	—	—

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* By Prof. T. A. Starkey, McGill University, Montreal.

HYPOTHETICAL COMBINATIONS.

No. 30.

Constituent:—		Parts per million.	Total inorganic matter in solution. Per cent.	Previous analysis.
Calcium carbonate	($CaCO_3$)..........	60·9	48·2	——
Magnesium carbonate	($MgCO_3$)..........	7·78	6·1	——
Sodium carbonate	($NaCO_3$)..........	5·9	4·7	——
Sodium sulphate	(Na_2SO_4)..........	8·4	6·6	——
Sodium nitrate	($NaNO_3$)..........	27·0	21·3	——
Sodium chloride	($NaCl$)............	16·5	13·1	——
		126·48	100·0	——

The water is a very lightly mineralized, calcic, bicarbonated, alkaline water.

WESTERN QUEBEC.

GUARANTEED PURE MILK CO'S. WELL, MONTREAL.

(35)

This well was one of the deep wells included in the investigation of the radioactivity of waters in the neighbourhood of Montreal. The water flows naturally from a well which was drilled to a depth of 151 feet, though by pumping, 60 gallons per minute can be obtained.

Analysis shows this to be a calcic, sodic, sulphated, alkaline-saline water. Calcium bicarbonate forms 45 per cent of the total solid matter in solution, and calcium sulphate 27 per cent, while 11 per cent of sodium chloride is also present.

It belongs to a group of wells which are all high in calcium and situated in the same neighbourhood.

The following particulars were obtained upon analysis:—

GUARANTEED PURE MILK CO'S. WELL.

Laboratory No. 35.

Sample collected.............August, 1914.
Temperature.................10·5°C. (50·9° F.)
Flow........................60 gallons per minute.
Taste.......................Fresh.
Reaction....................Alkaline.
Specific gravity at 15°C.......1·0006
Radioactivity...............Emanation...............176 units.
Dissolved radium.........
Emanation in gas evolved.

Properties of reaction in per cent.

Primary salinity..........21·34
Secondary salinity.........35·90
Primary alkalinity........
Secondary alkalinity......42·76

Analysis.

Constituents:—			Previous analysis.*	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4).........	114·5	65·9	26·64	20·77
Bicarbonic acid	(HCO_3).......	149·7	——	34·83	21·38
Carbonic acid	(CO_3).........	——	162·7	——	——
Nitric acid	(NO_3).........	0·08	——	0·02	0·01
Nitrous acid	(NO_2).........	——	——	——	——
Phosphoric acid	(PO_4).........	——	——	——	——
Metaboric acid	(BO_2).........	——	——	——	——
Chlorine	(Cl)...........	32·0	37·6	7·44	7·84
Bromine	(Br)...........	——	——	——	——
Iodine	(I)............	——	——	——	——
Silica	(SiO_2)........	16·8	——	3·91	——
Iron	(Fe)..........	1·1	——	0·26	0·35
Aluminium	(Al)..........				
Manganese	(Mn)..........	——	——	——	——
Calcium	(Ca)..........	82·8	89·2	19·26	36·00
Strontium	(Sr)...........	——	——	——	——
Magnesium	(Mg)..........	4.16	11.6	0·97	2·98
Lithium	(Li)...........	0·1	——	0·02	0·12
Potassium	(K)...........	1·7	——	0·40	0·37
Sodium	(Na)..........	26·86	56·0	6·25	10·18
Ammonium	(NH_4).........	0·02	——	——	——
Total.....................		429·82	423·0	100·00	100·00
					Concentration value.
Total solids in solution, residue dried at 110°C..............		——	——	——	11·48

Gases:		c.c. per litre.	Parts per million.
	Carbon Dioxide CO_2......	27·0	53·2
	Hydrogen Sulphide H_2S...	—	—

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* By J. T. Donald, Montreal, 1909.

HYPOTHETICAL COMBINATIONS.

No. 35.

Constituent:—		Parts per million.	Total inorganic matter in solution. Per cent.	Previous analysis.
Sodium nitrite	($NaNO_2$)............			
Sodium nitrate	($NaNO_3$)............	0·08	0·02	
Ammonium chloride	(NH_4Cl)............	0·05	0·01	
Potassium iodide	(KI)...............			
Potassium bromide	(KBr)..............			
Lithium chloride	($LiCl$)..............	0·59	0·14	
Potassium chloride	(KCl)..............	3·21	0·75	
Sodium chloride	($NaCl$).............	49·25	11·46	
Magnesium chloride	($MgCl_2$)............			
Calcium chloride	($CaCl_2$).............			
Sodium sulphate	(Na_2SO_4)...........	23·09	5·37	
Magnesium sulphate	($MgSO_4$)............	20·59	4·79	
Calcium sulphate	($CaSO_4$)............	116·90	27·20	
Sodium bicarbonate	($NaHCO_3$)..........			
Magnesium bicarbonate	($Mg(HCO_3)_2$)........			
Calcium bicarbonate	($Ca(HCO_3)_2$).........	195·70	45·52	
Strontium bicarbonate	($Sr(HCO_3)_2$)..........			
Ferrous bicarbonate	($Fe(HCO_3)_2$).........	3·56	0·83	
Calcium phosphate	($Ca_3(PO_4)_2$)..........			
Ferric oxide	(Fe_2O_3).............			
Alumina	(Al_2O_3).............			
Silica	(SiO_2)..............	16·80	3·91	
		429·82	100·00	

LAURENTIAN SPRING WATER, MONTREAL.

(36)

This water is consumed very considerably in Montreal and vicinity. The well, owned by Messrs. Robert White and Company, 208 Craig Street, Montreal, is 457 feet deep. Water was struck at 250 feet, and again at 450 feet, and the combined capacity is 4,500 gallons per hour, when pumped by an air lift pump with air at a pressure of 100 pounds per square inch. The water probably rises from the Trenton limestone, though a well near by on the same property seems to obtain its water from a shale bed which occurs interstratified with the Trenton limestone. The radioactivity is low, some emanation being lost on account of the method of pumping. The air blows the gas out of the water.

Analysis shows the water to be a sodic, muriated, sulphated, carbon-dioxated water of the alkaline-saline type. The hypothetical combinations indicate that the chief salts composing the inorganic matter in solution are, sodium sulphate 32 per cent, sodium chloride 17 per cent, and sodium bicarbonate 20 per cent.

LAURENTIAN SPRING WATER.

Laboratory No. 36.

Samples collected	August, 1914, and October, 1915.	
Temperature	12°C. (54°F.)	
Flow	70 gallons per minute.	
Taste	Fresh.	
Reaction	Alkaline.	
Specific gravity at 15°C.	1·001	
Radioactivity	Emanation	5–6 units
	Dissolved radium	
	Emanation in gas evolved.	
Properties of reaction in per cent.		
	Primary salinity	50·6
	Secondary salinity	
	Primary alkalinity	25·8
	Secondary alkalinity	23·6

Analysis.

Constituents:—		Previous analysis.*	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO_4).........		240·0	22·3	15·4
Bicarbonic acid (HCO_3)........		233·6	21·7	11·8
Carbonic acid (CO_3).........		125·5	11·6	12·9
Nitric acid (NO_3).........				
Nitrous acid (NO_2).........				
Phosphoric acid (PO_4).........				
Metaboric acid (BO_2).........				
Chlorine (Cl)..........		114·4	10·6	9·9
Bromine (Br)..........				
Iodine (I)...........				
Oxygen for Fe_2O_3 & Al_2O_3.......		0·7		—
Silica (SiO_2).........		11·1	1·0	—
Iron (Fe).......... Aluminium (Al)..........		1·6	0·2	—
Manganese (Mn).........				
Calcium (Ca)..........		51·4	4·8	7·9
Strontium (Sr)..........				—
Magnesium (Mg)..........		15·3	1·4	3·9
Lithium (Li)..........				
Potassium (K)..........				
Sodium (Na)..........		285·1	26·4	38·2
Ammonium (NH_4).........				—
Total.....................		1,078·7	100·0	100·0
				Concentration value.
Total solids in solution, residue dried at 110° C.............		912·		32·47

Gases:	c.c. per litre.	Parts per million.
Carbon Dioxide CO_2......	76·6	
Hydrogen Sulphide H_2S...		

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* By J. T. Donald, Montreal, 1915.

HYPOTHETICAL COMBINATIONS.

No. 36.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)			
Sodium nitrate	($NaNO_3$)			
Ammonium chloride	(NH_4Cl)			
Potassium iodide	(KI)			
Potassium bromide	(KBr)			
Lithium chloride	($LiCl$)			
Potassium chloride	(KCl)			
Sodium chloride	($NaCl$)	188·6	17·5	
Magnesium chloride	($MgCl_2$)			
Calcium chloride	($CaCl_2$)			
Sodium sulphate	(Na_2SO_4)	354·6	32·9	
Magnesium sulphate	($MgSO_4$)			
Calcium sulphate	($CaSO_4$)			
Sodium carbonate	(Na_2CO_3)	221·8	20·6	
Magnesium bicarbonate	($Mg(HCO_3)_2$)	92·3	8·5	
Calcium bicarbonate	($Ca(HCO_3)_2$)	208·	19·3	
Strontium bicarbonate	($Sr(HCO_3)_2$)			
Ferrous bicarbonate	($Fe(HCO_3)_2$)			
Calcium phosphate	($Ca_3(PO_4)_2$)			
Ferric oxide	(Fe_2O_3)	2·3	0·2	
Alumina	(Al_2O_3)			
Silica	(SiO_2)	11·1	1·0	
		1,078·7	100·0	

SALINE WELL, 112 BEAUDRY STREET, MONTREAL.

(37)

This well is the property of Messrs. Charles Gurd and Co. Water was struck at a depth of 318 feet, and rose to within 50 feet of the surface, and when pumped flows at a rate of 8 gallons per minute.

Analysis shows the water to be a sodic, calcic, sulphated, bicarbonated, alkaline-saline water.

Sodium sulphate forms 28 per cent of the total solids present, the other chief constituents are calcium and magnesium bicarbonates, and sodium chloride. It bears a resemblance to the Laurentian Spring Water (No. 36).

SALINE WELL.

Laboratory No. 37.

Sample collected..............August, 1914.
Temperature..................10·5°C. (50·9°F.)
Flow........................Pumped.
Taste........................Fresh.
Reaction.....................Alkaline.
Specific gravity at 15°C.......1·0015.

Radioactivity................Emanation...............62 units
Dissolved radium.........—
Emanation in gas evolved.

Properties of reaction in per cent.
Primary salinity..........47·78
Secondary salinity........
Primary alkalinity........ 9·18
Secondary alkalinity......43·04

Analysis.

Constituent:—			Previous analysis.	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4).........	228·9		19·00	14·84
Bicarbonic acid	(HCO_3)........	511·2		42·50	26·11
Carbonic acid	(CO_3).........	—		—	—
Nitric acid	(NO_3).........	0·24		0·02	0·01
Nitrous acid	(NO_2).........	trace		—	—
Phosphoric acid	(PO_4).........	—		—	—
Metaboric acid	(BO_2).........	—		—	—
Chlorine	(Cl)..........	103·0		8·58	9·04
Bromine	(Br)..........	—		—	—
Iodine	(I)...........	—		—	—
Silica	(SiO_2)........	25·0		2·08	—
Iron	(Fe)..........	1·7		0·14	0·19
Aluminium	(Al)..........				
Manganese	(Mn)..........	—		—	—
Calcium	(Ca)..........	85·5		7·11	13·30
Strontium.	(Sr)..........	—		—	—
Magnesium	(Mg)..........	31·3		2·60	8·30
Lithium	(Li)..........	0·7		0·06	0·31
Potassium	(K)...........	16·9		1·42	1·35
Sodium	(Na)..........	198·2		16·49	26·82
Ammonium	(NH_4).........	0·03		—	—
Total.....................		1,202·67		100·00	100·00
Total solids in solution, residue dried at 110° C.............					Concentration value. 32·11

Gases:		c.c. per litre.	Parts per million.
	Carbon Dioxide CO_2......	6·3	12·4
	Hydrogen Sulphide H_2S...	—	—

HYPOTHETICAL COMBINATIONS.

No. 37.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)............	trace	——	
Sodium nitrate	($NaNO_3$)............	0·1	0·01	
Ammonium chloride	(NH_4Cl)............	0·1	——	
Potassium iodide	(KI)...............			
Potassium bromide	(KBr)...............			
Lithium chloride	(LiCl)...............	4·3	0·36	
Potassium chloride	(KCl)...............	32·2	2·68	
Sodium chloride	(NaCl)...............	138·6	11·53	
Magnesium chloride	($MgCl_2$)............			
Calcium chloride	($CaCl_2$)............			
Sodium sulphate	(Na_2SO_4)...........	338·7	28·17	
Magnesium sulphate	($MgSO_4$)............			
Calcium sulphate	($CaSO_4$)............			
Sodium bicarbonate	($NaHCO_3$)...........	123·8	10·30	
Magnesium bicarbonate	($Mg(HCO_3)_2$)........	188·3	15·64	
Calcium bicarbonate	($Ca(HCO_3)_2$)........	346·0	28·79	
Strontium bicarbonate	($Sr(HCO_3)_2$)........			
Ferrous bicarbonate	($Fe(HCO_3)_2$)........	5·3	0·44	
Calcium phosphate	($Ca_3(PO_4)_2$)........			
Ferric oxide	(Fe_2O_3)............			
Alumina	(Al_2O_3)............			
Silica	(SiO_2).............	25·0	2·08	
		1,202·4	100·00	

WATSON FOSTER CO'S. WELL, MAISONNEUVE, MONTREAL.

(43)

This is another of the deep wells of Montreal, examined especially for its radioactivity. It is drilled to a depth of 750 feet, and is pumped into a large storage tank. No estimate of the flow was obtainable.

The water is moderately mineralized, and can be classified as a sodic, bicarbonated, alkaline water. Sodium bicarbonate and sodium carbonate form 64 per cent of the total solids, while sodium sulphate and sodium chloride constitute the major portion of the remaining constituents.

WATSON FOSTER CO'S. WELL.

Laboratory No. 43.

Sample collected..............August, 1914.
Temperature.................13·0°C. (56°F.)
Flow.......................—
Taste.......................Fresh.
Reaction....................Alkaline.
Specific gravity at 15°C.......1·0009.

Radioactivity...............Emanation...............42 units
Dissolved radium.........—
Emanation in gas evolved.

Properties of reaction in per cent.
Primary salinity..........39·34
Secondary salinity........
Primary alkalinity........57·70
Secondary alkalinity...... 2·96

Analysis.

Constituents:—			Previous analysis.	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4).........	194·5		12·76	9·86
Bicarbonic acid	(HCO_3)........	655·1		42·96	26·12
Carbonic acid	(CO_3).........	52·0		3·41	4·21
Nitric acid	(NO_3).........	0·08		—	—
Nitrous acid	(NO_2).........	—		—	—
Phosphoric acid	(PO_4).........	—		—	—
Metaboric acid	(BO_2).........	—		—	—
Chlorine	(Cl)..........	143·0		9·38	9·81
Bromine	(Br)..........	—		—	—
Iodine	(I)...........	—		—	—
Silica	(SiO_2)........	10·5		0·69	—
Iron	(Fe)..........	2·3		0·15	0·20
Aluminium	(Al)..........				
Manganese	(Mn).........	—		—	—
Calcium	(Ca)..........	3·74		0·24	0·45
Strontium	(Sr)..........	—		—	—
Magnesium	(Mg)..........	4·17		0·27	0·83
Lithium	(Li)..........	trace		—	—
Potassium	(K)...........	4·38		0·29	0·27
Sodium	(Na)..........	455·2		29·85	48·25
Ammonium	(NH_4)........	0·02		—	—
Total.....................		1,524·99		100·00	100·00
Total solids in solution, residue dried at 110° C.............		1,204·			Concentration value. 41·12

Gases:	c.c. per litre.	Parts per million.
Carbon Dioxide CO_2......	9·1	18·0
Hydrogen Sulphide H_2S...	—	—

HYPOTHETICAL COMBINATIONS.

No. 43.

Constituent:—		Parts per million.	Total inorganic matter in solution. Per cent.	Previous analysis.
Sodium nitrite	($NaNO_2$)			
Sodium nitrate	($NaNO_3$)	0·10	0·01	
Ammonium chloride	(NH_4Cl)	0·07	——	
Potassium iodide	(KI)			
Potassium bromide	(KBr)			
Lithium chloride	($LiCl$)	trace		
Potassium chloride	(KCl)	8·48	0·55	
Sodium chloride	($NaCl$)	229·10	15·02	
Magnesium chloride	($MgCl_2$)			
Calcium chloride	($CaCl_2$)			
Sodium sulphate	(Na_2SO_4)	287·0	18·82	
Magnesium sulphate	($MgSO_4$)			
Calcium sulphate	($CaSO_4$)			
Sodium carbonate	(Na_2CO_3)	91·88	6·03	
Sodium bicarbonate	($NaHCO_3$)	850·60	57·76	
Magnesium bicarbonate	($Mg(HCO_3)_2$)	25·06	1·64	
Calcium bicarbonate	($Ca(HCO_3)_2$)	15·10	0·99	
Strontium bicarbonate	($Sr(HCO_3)_2$)			
Ferrous bicarbonate	($Fe(HCO_3)_2$)	7·40	0·49	
Calcium phosphate	($Ca_3(PO_4)_2$)			
Ferric oxide	(Fe_2O_3)			
Alumina	(Al_2O_3)			
Silica	(SiO_2)	10·5	0·69	
		1,524·99	100·00	

MOUNT BRUNO FLORAL COMPANY'S WELL, ST. BRUNO, QUE.

(46)

This well is situated at St. Bruno, Chambly county, Que., and is the property of the Mount Bruno Floral Company. It was drilled by Wallace Bell of Montreal, who gives the log of the well as follows: 28 feet to bed rock, then 384 feet in hard rock probably Hudson River or Utica Shale. The water was found to be unsuitable for watering purposes on account of its strong alkalinity.

It is moderately mineralized, sodic, muriated, water of the alkaline-saline type, and possesses a primary alkalinity of approximately 25 per cent. Sodium chloride constitutes almost 59 per cent of the total inorganic matter in solution. Bicarbonates of sodium, calcium, and magnesium are also present.

The following data were obtained upon analysis:—

MOUNT BRUNO FLORAL COMPANY'S WELL.

Laboratory No. 46.

Sample collected..............August, 1914.
Temperature..................10·0°C. (50° F.)

Flow.......................7 gallons per hour.
Taste......................Slightly flat.
Reaction...................Alkaline.
Specific gravity at 15°C.......1·002.
Radioactivity...............Emanation..............100 units
Dissolved radium.........—
Emanation in gas evolved. —

Properties of reaction in per cent.
Primary salinity..........66·16
Secondary salinity........
Primary alkalinity........24·68
Secondary alkalinity...... 9·16

Analysis.

Constituents:—			Previous analysis.*	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4).........	2·0	8·79	0·10	0·07
Bicarbonic acid	(HCO_3).......	486·	——	24·60	13·02
Carbonic acid	(CO_3).........	71·9	314·93	3·64	3·90
Nitric acid	(NO_3).........	——	——	——	——
Nitrous acid	(NO_2).........	——	——	——	——
Phosphoric acid	(PO_4).........	——	——	——	——
Metaboric acid	(BO_2).........	——	——	——	——
Chlorine	(Cl)..........	718·	9·45	36·33	33·01
Bromine	(Br)..........	——	——	——	——
Iodine	(I)...........	——	——	——	——
Silica	(SiO_2)........	9·0	32·42	0·46	——
Iron	(Fe)..........	0·6		0·03	0·03
Aluminium	(Al)..........				
Manganese	(Mn).........	——	——	——	——
Calcium	(Ca)..........	27·0	20·05	1·37	2·21
Strontium	(Sr)...........	——	——	——	——
Magnesium	(Mg)..........	17·5	14·30	0·89	2·34
Lithium	(Li)...........	0·1	——	——	0·02
Potassium	(K)...........	10·6	——	0·53	0·44
Sodium	(Na)..........	633·0	201·54	32·00	44·87
Ammonium	(NH_4).........	1·03	——	0·05	0·09
Total....................		1,976·79	601·48	100·00	100·00
Total solids in solution, residue dried at 110°C.............		1,855·	——	——	Concentration value. 61·31

Gases:		c.c. per litre.	Parts per million.
	Carbon Dioxide CO_2......	7·6	15·0
	Hydrogen Sulphide H_2S...		——

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* By J. T. Donald, Montreal, 1911.

HYPOTHETICAL COMBINATIONS.

No. 46.

Constituent:—		Parts per million.	Total inorganic matter in solution. Per cent.	Previous analysis.
Sodium nitrite	($NaNO_2$)............			
Sodium nitrate	($NaNO_3$)............			
Ammonium chloride	(NH_4Cl)............	3·06	0·15	
Potassium iodide.	(KI)...............			
Potassium bromide	(KBr)...............			
Lithium chloride	(LiCl)...............	0·59	0·03	
Potassium chloride	(KCl)...............	20·22	1·02	
Sodium chloride	(NaCl)...............	1,164·0	58·90	
Magnesium chloride	($MgCl_2$)............			
Calcium chloride	($CaCl_2$)............			
Sodium sulphate	(Na_2SO_4)............	3·06	0·15	
Magnesium sulphate	($MgSO_4$)............			
Calcium sulphate	($CaSO_4$)............			
Sodium carbonate	(Na_2CO_3)............	127·0	6·42	
Sodium bicarbonate	($NaHCO_3$)............	432·8	21·90	
Magnesium bicarbonate	($Mg(HCO_3)_2$)........	105·2	5·33	
Calcium bicarbonate	($Ca(HCO_3)_2$)........	109·8	5·55	
Strontium bicarbonate	($Sr(HCO_3)_2$)........			
Ferrous bicarbonate	($Fe(HCO_3)_2$)........	2·06	0·10	
Calcium phosphate	($Ca_3(PO_4)_2$)........			
Ferric oxide	(Fe_2O_3)............			
Alumina	(Al_2O_3)............			
Silica	(SiO_2)............	9·00	0·45	
		1,976·79	100·00	

MONTREAL JOCKEY CLUB WELL, BLUEBONNETS.

(50)

This water was investigated in connexion with the radioactivity examination. The well is 203 feet deep, and yields water at the rate of 132,000 gallons a day. The drilling penetrates the rock for a few feet.

Analysis shows the water to be a lightly mineralized sodic bicarbonated alkaline water. Bicarbonates and carbonates of the alkalies and alkaline earths form over 70 per cent of the total solids.

The following particulars were obtained:—

MONTREAL JOCKEY CLUB WELL.

Laboratory No. 50.

Sample collected..............August, 1914.
Temperature..................8·3°C. (47° F.)
Flow........................—
Taste.......................Fresh.
Reaction....................Alkaline.

Specific gravity at 15°C.......1·0005.
Radioactivity...............Emanation...............25 units
Dissolved radium.........—
Emanation in gas evolved.
Properties of reaction in per cent.
Primary salinity..........24·96
Secondary salinity........
Primary alkalinity........53·28
Secondary alkalinity......21·76

Analysis.

Constituents:—			Previous analysis.	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4).........	47·37		10·95	8·24
Bicarbonic acid	(HCO_3)........	183·0		42·33	25·08
Carbonic acid	(CO_3).........	45·0		10·41	12·54
Nitric acid	(NO_3).........	0·16		0·04	0·01
Nitrous acid	(NO_2).........	0·05		0·01	—
Phosphoric acid	(PO_4).........	—		—	
Metaboric acid	(BO_2).........	—		—	
Chlorine	(Cl)..........	17·5		4·05	4·13
Bromine	(Br)..........	—		—	—
Iodine	(I)...........	—		—	—
Silica	(SiO_2).........	9·6		2·22	—
Iron	(Fe).........}	0·92		0·21	0·28
Aluminium	(Al)..........}				
Manganese	(Mn).........	—		—	—
Calcium	(Ca)..........	4·5		1·05	1·88
Strontium	(Sr)...........	—		—	—
Magnesium	(Mg)..........	12·7		2·94	8·72
Lithium	(Li)...........	trace		—	—
Potassium	(K)...........	9·4		2·17	2·00
Sodium	(Na)..........	102·2		23·62	37·12
Ammonium	(NH_4).........	0·02		—	—
Total.....................		432·42		100·00	100·00
Total solids in solution, residue dried at 110°C.............		360·			Concentration value 11·97

	c.c. per litre.	Parts per million.
Gases: Carbon Dioxide CO_2......		
Hydrogen Sulphide H_2S...		

HYPOTHETICAL COMBINATIONS.

No.50.

Constituent:—		Parts per million.	Total inorganic matter in solution. Per cent.	Previous analysis.
Sodium nitrite	($NaNO_2$)	0·07	0·02	
Sodium nitrate	($NaNO_3$)	0·21	0·05	
Ammonium chloride	(NH_4Cl)	0·06	0·01	
Potassium iodide	(KI)			
Potassium bromide	(KBr)			
Lithium chloride	($LiCl$)	trace	——	
Potassium chloride	(KCl)	17·93	4·15	
Sodium chloride	($NaCl$)	14·74	3·41	
Magnesium chloride	($MgCl_2$)			
Calcium chloride	($CaCl_2$)			
Sodium sulphate	(Na_2SO_4)	70·00	16·19	
Magnesium sulphate	($MgSO_4$)			
Calcium sulphate	($CaSO_4$)			
Sodium carbonate	(Na_2CO_3)	79·50	18·38	
Sodium bicarbonate	($NaHCO_3$)	142·70	33·00	
Magnesium bicarbonate	($Mg(HCO_3)_2$)	76·50	17·68	
Calcium bicarbonate	($Ca(HCO_3)_2$)	18·19	4·21	
Strontium bicarbonate	($Sr(HCO_3)_2$)			
Ferrous bicarbonate	($Fe(HCO_3)_2$)	2·92	0·68	
Calcium phosphate	($Ca_3(PO_4)_2$)			
Ferric oxide	(Fe_2O_3)			
Alumina	(Al_2O_3)			
Silica	(SiO_2)	9·6	2·22	
		432·42	100·00	

VIAUVILLE MINERAL WATER, MAISONNEUVE, MONTREAL.

(42)

The Viauville mineral water is obtained from a deep boring, drilled in the hope of striking natural gas. Good water was met with at 450 feet, which rose to within 10 feet of the surface. At 1190 feet, a strong flow of saline water containing much hydrogen sulphide was encountered. Drilling was continued however to 1370 feet. Trenton limestone was the only formation traversed.

The water has a strong saline taste, together with the disagreeable odour and flavour of hydrogen sulphide gas, which it contains in considerable quantity. The well is owned by Mr. Daniel Bergevin, and the water is bottled under the name of "Radium" water. The radioactivity is low and no radium salts in solution could be detected, therefore, the bottled water after a few days will possess no radioactivity whatever. These results confirm those of Dr. McIntosh of McGill University, who found about as much radium emanation present as is found in St. Lawrence River water.

The following results were obtained upon analysis:—

VIAUVILLE MINERAL WATER

Laboratory No. 42.

Sample collected..............October, 1914.
Temperature.................12·5°C. (54·5°F.)
Flow.......................
Taste......................Strong sulphur.
Reaction....................Alkaline.
Specific gravity at 15°C.......1·0063.
Radioactivity................Emanation...............11·2 units
Dissolved radium......... —
Emanation in gas evolved.

Properties of reaction in per cent.

Primary salinity..........93·34
Secondary salinity........
Primary alkalinity........ 1·10
Secondary alkalinity...... 5·56

Analysis.

Constituents:—			Previous analysis.	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO)	2,347·0		23·21	15·40
Bicarbonic acid	(HCO_3)	641·0		6·34	3·30
Carbonic acid	(CO_3)	——		——	——
Nitric acid	(NO_3)	——		——	——
Nitrous acid	(NO_2)	——		——	——
Phosphoric acid	(PO_4)	——		——	——
Metaboric acid	(BO_2)	——		——	——
Chlorine	(Cl)	3,509·		34·70	31·20
Bromine	(Br)	19·0		0·19	0·07
Iodine	(I)	0·25		——	——
Silica	(SiO_2)	10·4		0·10	——
Iron	(Fe)	4·68		0·05	0·05
Aluminium	(Al)				
Manganese	(Mn)	0·01		——	——
Calcium	(Ca)	64·3		0·63	1·01
Strontium	(Sr)	2·15		0·02	——
Magnesium	(Mg)	65·6		0·65	1·72
Lithium	(Li)	4·0		0·04	0·18
Potassium	(K)	34·1		0·34	0·28
Sodium	(Na)	3,408·		33·72	46·74
Ammonium	(NH_4)	1·52		0·01	0·02
Total		10,111·01		100·00	100·00
Total solids in solution, residue dried at 110°C		9,890·		——	Concentration value. 317·06

Gases:	c.c. per litre.	Parts per million.
Carbon Dioxide CO_2	18·5	36·4
Hydrogen Sulphide H_2S	30·5	460·

HYPOTHETICAL COMBINATIONS.

No. 42.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)			
Sodium nitrate	($NaNO_3$)			
Ammonium chloride	(NH_4Cl)	4·51	0·05	
Potassium iodide	(KI)	0·32	——	
Potassium bromide	(KBr)	28·3	0·28	
Lithium chloride	(LiCl)	24·3	0·24	
Potassium chloride	(KCl)	47·6	0·47	
Sodium chloride	(NaCl)	5,710·0	56·47	
Magnesium chloride	($MgCl_2$)			
Calcium chloride	($CaCl_2$)			
Sodium sulphate	(Na_2SO_4)	3,470·0	34·32	
Magnesium sulphate	($MgSO_4$)			
Calcium sulphate	($CaSO_4$)			
Sodium bicarbonate	($NaHCO_3$)	138·0	1·36	
Magnesium bicarbonate	($Mg(HCO_3)_2$)	397·0	3·93	
Calcium bicarbonate	($Ca(HCO_3)_2$)	260·5	2·58	
Strontium bicarbonate	($Sr(HCO_3)_2$)	5·2	0·05	
Ferrous bicarbonate	($Fe(HCO_3)_2$)	14·9	0·15	
Calcium phosphate	($Ca_3(PO_4)_2$)			
Ferric oxide	(Fe_2O_3)			
Alumina	(Al_2O_3)			
Silica	(SiO_2)	10·4	0·10	
		10,111·03	100·00	

The analysis shows that the water is a sodic, muriated, sulphated (bromic, sulphuretted) water of the saline type.

The chief constituents may be considered to be sodium chloride (56 per cent of total solids), and sodium sulphate (34 per cent). Hydrogen sulphide occurs in notable amount, and it is probable that traces of alkali sulphides are present. Dr. G. H. Baril[1] of Laval University, Montreal, has pointed out the resemblance between the Viauville water and the Uriage water, a celebrated French medicinal spring. The following table enables comparison of the chief constituents of the two springs to be made:—

	Uriage.	Viauville.
	Parts per million.	
Hydrogen sulphide	110·8	460·
Sodium chloride	6,056·7	5,710·0
Potassium chloride	408·8	47·6
Lithium chloride	7·5	24·3
Calcium sulphate	1,520·5	——
Sodium sulphate	1,187·5	3,470·0
Sodium bicarbonate	555·5	138·0
Total mineral matter in solution	10,539·2	10,111·03

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[1] Baril, G. H., L'Eau Minérale de Viauville, L'Union Médicale du Canada, Vol. 45, No. 7, p. 367, 1916.

The Uriage waters are chiefly used in the treatment of scrofula, chronic skin diseases, and for syphilis, especially in association with mercurial treatment. Dr. Baril states that Viauville water has been used in similar cases with success.

ABENAKIS SPRINGS, QUE.

(44 and 45)

The Abenakis Springs are situated near St. François du Lac, Yamaska county, Que., in the valley of the St. François river, sixty-eight miles from Montreal.

A modern and well equipped hotel has been established under the management of Mr. W. E. Watt, and special attention has been paid to the development of the waters. The water rises from three borings in a flat, marshy plain a little distance from the steeply-sloping side of the higher ground running parallel to the St. François river. Two summer houses, 100 yards apart, enclose the wells.

In the west house the well is 12 feet deep, and three feet away is another boring 60 feet deep, from which water flows naturally at a rate of 60 gallons an hour. In the east house is another flowing well, 12 feet deep. The waters probably rise from the Hudson River formation, and obtain their saline constituents from beds of alkaline and alkaline-earth chlorides in the limestone. The following results were obtained:—

SPRING IN WEST HOUSE.

Laboratory No. 44.

Sample collected	August, 1914.	
Temperature	11·5°C. (48°F.)	
Flow		
Taste	Strongly saline.	
Reaction	Alkaline.	
Specific gravity at 15°C	1·0106	
Radioactivity	Emanation	62 units.
	Dissolved radium	0·5 „
	Emanation in gas evolved.	
Properties of reaction in per cent.		
	Primary salinity	79·74
	Secondary salinity	16·20
	Primary alkalinity	
	Secondary alkalinity	4·06

Analysis.

Constituents:—		Previous analysis.	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO$_4$)	754·		5·34	3·32
Bicarbonic acid (HCO$_3$)	588·		4·16	2·03
Carbonic acid (CO$_3$)	—		—	—
Nitric acid (NO$_3$)	2·5		0·02	—
Nitrous acid (NO$_2$)	0·01		—	—
Phosphoric acid (PO$_4$)	0·17		—	—
Metaboric (BO$_2$)	trace		—	—
Chlorine (Cl)	7,522·		53·30	44·62
Bromine (Br)	15·0		0·11	0·04
Iodine (I)	0·5		—	—
Oxygen for Fe$_2$O$_3$ & Al$_2$O$_3$	21·62		0·15	—
Silica (SiO$_2$)	19·22		0·14	—
Iron (Fe)	5·0		0·03	—
Aluminium (Al)	21·8		0·15	—
Manganese (Mn)	0·5		—	—
Calcium (Ca)	479·		3·40	5·04
Strontium (Sr)	5·8		0·04	0·03
Magnesium (Mg)	292·7		2·07	5·06
Lithium (Li)	1·0		0·01	0·03
Potassium (K)	95·1		0·67	0·51
Sodium (Na)	4,285·		30·36	39·23
Ammonium (NH$_4$)	7·65		0·05	0·09
Total	14,116·57		100·00	100·00
Total solids in solution, residue dried at 110°C	14,298·			Concentration value. 474·93

Gases:	c.c. per litre.	Parts per million.
Carbon Dioxide CO$_2$	1·7	3·3
Hydrogen Sulphide H$_2$S	—	—

HYPOTHETICAL COMBINATIONS.

No. 44.

Constituent:—		Parts per million.	Total inorganic matter in solution. Per cent.	Previous analysis.
Sodium nitrite	($NaNO_2$)...........	trace		
Sodium nitrate	($NaNO_3$)...........	3·40	0·02	
Ammonium chloride	(NH_4Cl)............	22·74	0·16	
Potassium iodide	(KI)...............	0·66	——	
Potassium bromide	(KBr)..............	22·37	0·16	
Lithium chloride	($LiCl$)..............	6·12	0·04	
Potassium chloride	(KCl)..............	167·32	1·19	
Sodium chloride	($NaCl$).............	10,896·33	77·19	
Magnesium chloride	($MgCl_2$)............	1,087·12	7·70	
Calcium chloride	($CaCl_2$)............			
Sodium sulphate	(Na_2SO_4)...........			
Magnesium sulphate	($MgSO_4$)...........	75·76	0·54	
Calcium sulphate	($CaSO_4$)............	983·40	6·97	
Sodium bicarbonate	($NaHCO_3$)..........			
Magnesium bicarbonate	($Mg(HCO_3)_2$)........			
Calcium bicarbonate	($Ca(HCO_3)_2$).........	769·34	5·45	
Strontium bicarbonate	($Sr(HCO_3)_2$).........	14·04	0·10	
Ferrous bicarbonate	($Fe(HCO_3)_2$).........			
Calcium phosphate	($Ca_3(PO_4)_2$).........	0·26	——	
Ferric oxide	(Fe_2O_3)............	7·16	0·05	
Alumina	(Al_2O_3)............	41·11	0·29	
Silica	(SiO_2).............	19·22	0·14	
Manganese oxide	(Mn_3O_4)............	0·21	——	
		14,116·56	100·00	

SPRING IN EAST HOUSE.

Laboratory No. 45.

Sample collected.............August, 1914.

Temperature................11·5°C. (48°F.)

Flow........................

Taste.......................Saline.

Reaction....................

Specific gravity at 15°C.......1·0108

Radioactivity...............Emanation...............62 units.

Dissolved radium......... 0·5 „

Emanation in gas evolved.

Properties of reaction in per cent.

Primary salinity..........79·08

Secondary salinity........16·98

Primary alkalinity........

Secondary alkalinity...... 3·94

Analysis.

Constituents:—		Previous analysis.*	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO_4)	722·13	772·1	5·25	3·24
Bicarbonic acid (HCO_3)	558·8	478·0	4·06	1·97
Carbonic acid (CO_3)	——	——	——	——
Nitric acid (NO_3)	1·4	——	0·01	——
Nitrous acid (NO_2)	0·48	——	——	——
Phosphoric acid (PO_4)	0·17	0·6	——	——
Metaboric acid (BO_2)	trace	——	——	——
Chlorine (Cl)	7,360	8,106	53·53	44·71
Bromine (Br)	30·0	trace	0·22	0·08
Iodine (I)	0·8	trace	0·01	——
Oxygen for Fe_2O_3 & Al_2O_3	16·08	——	0·12	——
Silica (SiO_2)	11·35	13·9	0·08	——
Iron (Fe)	3·75	trace	0·03	——
Aluminium (Al)	16·20		0·12	——
Manganese (Mn)	0·40	——	——	——
Calcium (Ca)	485·3	499·	3·53	5·21
Strontium (Sr)	7·12	——	0·05	0·04
Magnesium (Mg)	293·7	328·5	2·14	5·21
Lithium (Li)	1·3	——	0·01	0·04
Potassium (K)	68·92	40·0	0·50	0·38
Sodium (Na)	4,169·3	4,578·3	30·22	39·09
Ammonium (NH_4)	2·55	——	0·02	0·03
Total	13,749·75	14,818·0	100·00	100·00
Total solids in solution, residue dried at 110°C	14,195·			Concentration value. 463·90

Gases:		c.c. per litre.	Parts per million.
	Carbon Dioxide CO_2	10·2	20·1
	Hydrogen Sulphide H_2S	——	

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* By Milton Hersey, Montreal, 1904.

HYPOTHETICAL COMBINATIONS.

No. 45.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	$(NaNO_2)$	0·69	——	
Sodium nitrate	$(NaNO_3)$	1·96	0·02	
Ammonium chloride	(NH_4Cl)	7·60	0·06	
Potassium iodide	(KI)	1·00	0·01	
Potassium bromide	(KBr)	44·63	0·32	
Lithium chloride	$(LiCl)$	7·90	0·06	
Potassium chloride	(KCl)	103·25	0·75	
Sodium chloride	$(NaCl)$	10,602·48	77·12	
Magnesium chloride	$(MgCl_2)$	1,151·13	8·37	
Calcium chloride	$(CaCl_2)$	12·10	0·09	
Sodium sulphate	(Na_2SO_4)			
Magnesium sulphate	$(MgSO_4)$			
Calcium sulphate	$(CaSO_4)$	1,023·00	7·44	
Sodium bicarbonate	$(NaHCO_3)$			
Magnesium bicarbonate	$(Mg(HCO_3)_2)$			
Calcium bicarbonate	$(Ca(HCO_3)_2)$	728·84	5·29	
Strontium bicarbonate	$(Sr(HCO_3)_2)$	17·06	0·12	
Ferrous bicarbonate	$(Fe(HCO_3)_2)$			
Calcium phosphate	$(Ca_3(PO_4)_2)$	0·26	——	
Ferric oxide	(Fe_2O_3)	5·37	0·04	
Alumina	(Al_2O_3)	30·55	0·22	
Silica	(SiO_2)	11·35	0·08	
Manganese oxide	(Mn_3O_4)	0·51		
		13,749·70	100·00	

Both waters are strongly mineralized, sodic, muriated, saline (bromic and iodic) waters. Sodium chloride is the predominating constituent, being present to the extent of 77 per cent. Calcium sulphate, magnesium chloride, and calcium bicarbonate, are other salts in notable amount. Iodides and bromides are also present.

The analyses show good agreement with that carried out by Milton Hersey in 1904, and prove that little change in concentration has taken place in the last few years.

Waters of this character are efficacious in the treatment of gout and rheumatism, and in promoting the action of the intestines.

The Abenakis waters very closely resemble the celebrated Homburg and Kissingen waters in Germany, the predominating constituents of which are sodium chloride and smaller amounts of calcium and magnesium salts. The following analysis of the Elizabeth spring at Homburg, carried out by Liebig, enables comparison to be made:—

		Elizabeth Spring.	Abenakis West House.
		Parts per million.	
Sodium chloride	(NaCl)........	11,307·4	10,896·33
Magnesium chloride	($MgCl_2$).......	1,113·1	1,087·12
Ferrous carbonate	($FeCO_3$).......	65·1	
Calcium carbonate	($CaCO_3$)......	1,570·3	769·34
Sodium sulphate	(Na_2SO_4)......	52·7	——
Magnesium carbonate	($MgCO_3$)......	286·8	
Silica	(SiO_2).........	45·7	19·22
Calcium sulphate	($CaSO_4$).......		983·40
Other salts......................................			361·15
Total mineral matter.....................		14,441·3	14,116·56

VARENNES SPRING, VARENNES, QUE.

(48)

Two springs occur about one mile north of the village of Varennes, Varennes township, Verchères county, Que. They are at the foot of a slight slope about 500 yards from the right bank of the St. Lawrence, into which the overflow runs. They were examined in 1863 by Sterry Hunt, who considered that the water rose from the Utica or Hudson River formation, a supposition the recent analysis confirms.

They are the property of Messrs. Charles Gurd and Co. of Montreal; but water is seldom bottled, and the springs have fallen into disuse. The spring investigated rises in a well made by an earthenware pipe, 30 inches diameter, and 10 or 12 feet deep. A considerable evolution of gas, chiefly methane, occurs. The radioactivity of a sample of the gas was found to be 810 units per litre. The radioactivity of the water is high, compared with most of the results obtained, but the dissolved radium content is low, and the water would soon lose its radioactivity when bottled.

The water may be classified as a strongly mineralized, sodic, magnesic, muriated alkaline-saline water. Sodium chloride constitutes 84 per cent of the mineral matter in solution, and magnesium bicarbonate 10 per cent. The water should be valuable from a therapeutic standpoint. It bears some resemblance to the springs at Kissingen in Bavaria.

The results of the analysis are as follows:—

VARENNES SPRING.

Laboratory No. 48.

Sample collected....................	October, 1915.
Temperature.........................	8·6°C. (47·5°F.)
Flow....................................	Considerable.
Taste....................................	Saline.
Reaction................................	Alkaline.
Specific gravity at 15°C.........	1·009

Radioactivity...............	Emanation...............	224 units.
	Dissolved radium.........	9·2 „
	Emanation in gas evolved.	810 „

Properties of reaction in per cent.

Primary salinity..........	88·82
Secondary salinity........	0·22
Primary alkalinity........	
Secondary alkalinity......	10·96

Analysis.

Constituents:—		Previous analysis.	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO_4)...	1·5		0·01	0·01
Bicarbonic acid (HCO_3)..	1,285		11·05	5·48
Carbonic acid (CO_3)...	—		—	—
Nitric acid (NO_3)...	—		—	—
Nitrous acid (NO_2)...	0·05		—	—
Phosphoric acid (PO_4)...	—		—	—
Metaboric acid (BO_2)...	—		—	—
Chlorine (Cl)....	6,060·5		52·08	44·45
Bromine (Br)....	18·0		0·15	0·06
Iodine (I).....	0·7		—	—
Oxygen for Al_2O_3.............	3·28		0·03	—
Silica (SiO_2)...	15·8		0·14	—
Iron (Fe)....	0·7		—	0·01
Aluminium (Al)....	3·7		0·03	—
Manganese (Mn)...	0·06		—	—
Calcium (Ca)....	99·5		0·86	1·30
Strontium (Sr)....	1·2		0·01	—
Magnesium (Mg)...	200·1		1·72	4·28
Lithium (Li)....	4·6		0·04	0·17
Potassium (K).....	84·5		0·73	0·56
Sodium (Na)....	3,858·2		33·15	43·68
Ammonium (NH_4)..	—		—	—
Total....................	11,634·01		100·00	100·00 Concentration value.
Total solids in solution, residue dried at 110°C............	11,220			384·09

	c.c. per litre.	Parts per million.
Gases : Carbon Dioxide CO_2....		
Hydrogen Sulphide H_2S.		

HYPOTHETICAL COMBINATIONS.

No. 48

Constituent:—		Parts per million.	Total inorganic matter in solution. Per cent.	Previous analysis.
Sodium nitrite	($NaNO_2$)	0·07	——	
Sodium nitrate	($NaNO_3$)			
Ammonium chloride	(NH_4Cl)			
Potassium iodide	(KI)	1·00	0·01	
Potassium bromide	(KBr)	26·77	0·23	
Lithium chloride	($LiCl$)	27·92	0·24	
Potassium chloride	(KCl)	144·23	1·24	
Sodium chloride	($NaCl$)	9,810·00	84·33	
Magnesium chloride	($MgCl_2$)	18·06	0·15	
Calcium chloride	($CaCl_2$)			
Sodium sulphate	(Na_2SO_4)			
Magnesium sulphate	($MgSO_4$)	1·86	0·02	
Calcium sulphate	($CaSO_4$)			
Sodium bicarbonate	($NaHCO_3$)			
Magnesium bicarbonate	($Mg(HCO_3)_2$)	1,173·10	10·08	
Calcium bicarbonate	($Ca(HCO_3)_2$)	402·98	3·46	
Strontium bicarbonate	($Sr(HCO_3)_2$)	2·83	0·02	
Ferrous bicarbonate	($Fe(HCO_3)_2$)	2·23	0·02	
Calcium phosphate	($Ca_3(PO_4)_2$)			
Ferric oxide	(Fe_2O_3)			
Alumina	(Al_2O_3)	6·98	0·06	
Silica	(SiO_2)	15·80	0·14	
Manganous bicarbonate	($Mn(HCO_3)_2$)	0·18	——	
		11,634·01	100·00	

RICHELIEU SPRING, GRAND COTEAU, CHAMBLY BASIN, QUE.

This spring is situated on a plateau, in area about two acres. Below the spring the ground is marshy, and slopes gradually to the Richelieu river. The water rises in a cement pit about fifteen feet in depth, which penetrates the clay overlying the Hudson River formation. The well has a capacity of 3000 gallons, and if pumped dry, takes two days to refill. The spring was the property of Mr. George Tetreau of Montreal. It was the subject of examination by Dr. Sterry Hunt on three occasions, in 1851, 1852, and 1864, when slight changes of concentration were observed. Prof. G. H. Baril, of Laval University, Montreal, carried out an exhaustive analysis in 1913, and his results, compared with those obtained recently, show similar slight variations.

The water is a moderately mineralized, sodic, muriated, bicarbonated water of the alkaline-saline type. The chief constituents may be considered to be sodium bicarbonate (58 per cent), and sodium chloride (33 per cent).

Prof. Baril states that the water is of value in the treatment of urinary diseases and of the digestive organs—sodium chloride stimulating the secretion of the glands. It is also prescribed for diseases of the biliary or renal lithiasis, chronic rheumatism, gout, and obesity.

RICHELIEU SPRING.

Laboratory No. 49.

Sample collected..............August, 1914.
Temperature.................9·4°C. (49·0°F.)
Flow.......................Small.
Taste.......................Slightly sweet and pleasant.
Reaction....................Alkaline.
Specific gravity at 15°C.......1·0028
Radioactivity...............Emanation...............104 units.
Dissolved radium......... —
Emanation in gas evolved.

Properties of reaction in per cent.
Primary salinity..........42·20
Secondary salinity........
Primary alkalinity........51·80
Secondary alkalinity...... 6·00

Analysis.

Constituents:—		Previous analysis.*	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO_4)..........	0·89	—	0·03	0·03
Bicarbonic acid (HCO_3)........	1228·	589·00	47·80	28·90
Carbonic acid (CO_3)..........	—	—	—	—
Nitric acid (NO_3)..........	1·50	—	0·06	0·03
Nitrous acid (NO_2)..........	—	—	—	—
Phosphoric acid (PO_4)..........	0·17	1·86	—	—
Metaboric acid (BO_2)..........	—	2·66	—	—
Chlorine (Cl)...........	518·9	505·00	20·23	21·00
Bromine (Br)...........	2·5	0·74	0·10	0·04
Iodine (I)............	trace	0·58	—	
Oxygen to form Al_2O_3..........	5·14	—	0·20	
Silica (SiO_2)..........	22·30	36·88	0·87	—
Iron (Fe)...........	1·25	1·35	0·05	—
Aluminium (Al)...........	5·80	0·53	0·23	—
Manganese. (Mn)..........	trace	3·64	—	—
Calcium (Ca)..........	10·34	10·87	0·40	0·74
Strontium (Sr)...........	1·02	1·22	0·04	0·03
Magnesium (Mg)..........	18·89	22·37	0·74	2·23
Lithium (Li)...........	0·58	0·44	0·02	0·12
Potassium (K)...........	1·95	13·61	0·08	0·07
Sodium (Na)..........	748·72	712·20	29·15	46·81
Ammonium (NH_4).........	0·03		—	—
Free carbon dioxide............		532·43		
Total......................	2,567.98	2,435.08	100·00	100·00
Total solids in solution, residue dried at 110°C........	2,077			Concentration value 69·65

Gases:	c.c. per litre.	Parts per million.
Carbon Dioxide CO_2		
Hydrogen Sulphide H_2S.		

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* Analysis by G. H. Baril, Laval University, 1913.

HYPOTHETICAL COMBINATIONS.

No. 49.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis
			Per cent.	
Sodium nitrite	($NaNO_2$)			
Sodium nitrate	($NaNO_3$)	2·04	0·08	
Ammonium chloride	(NH_4Cl)	0·11	——	
Potassium iodide	(KI)	trace	——	
Potassium bromide	(KBr)	3·69	0·14	
Lithium chloride	($LiCl$)	3·53	0·14	
Potassium chloride	(KCl)	1·42	0·04	
Sodium chloride	($NaCl$)	849·0	33·10	
Magnesium chloride	($MgCl_2$)			
Calcium chloride	($CaCl_2$)			
Sodium sulphate	(Na_2SO_4)	1·28	0·04	
Magnesium sulphate	($MgSO_4$)			
Calcium sulphate	($CaSO_4$)			
Sodium bicarbonate	($NaHCO_3$)	1,511·90	58·85	
Magnesium bicarbonate	($Mg(HCO_3)_2$)	113·63	4·43	
Calcium bicarbonate	($Ca(HCO_3)_2$)	41·47	1·62	
Strontium bicarbonate	($Sr(HCO_3)_2$)	2·41	0·09	
Ferrous bicarbonate	($Fe(HCO_3)_2$)	4·00	0·16	
Calcium phosphate	($Ca_3(PO_4)_2$)	0·26	0·01	
Ferric oxide	(Fe_2O_3)			
Alumina	(Al_2O_3)	10·94	0·43	
Silica	(SiO_2)	22·30	0·87	
		2,567·98	100·00	

RADNOR FORGES SPRING, CHAMPLAIN COUNTY, QUE.

(52)

Water from this spring is bottled by the Radnor Water Co., of Montreal, as "Radnor" mineral water. It rises from a drilling 12 feet in the rock, which was put down to increase the flow of the original source; and it issues under considerable pressure with a steady flow of 1500 gallons per hour.

It was one of the most temporarily radioactive waters found, possessing 345 units of activity, but the dissolved radium content is small and on that account the bottled water will not remain charged with radium emanation for more than a few days. The water has a pleasant, slightly saline taste, and is a very satisfactory mineral water for bottling purposes. It is a moderately mineralized, sodic, muriated, saline water; sodium and magnesium chlorides are the chief salts in solution together with calcium bicarbonate. It would be useful therapeutically in the treatment of disorders of the digestive system and other diseases for which moderately saline waters are beneficial.

RADNOR FORGES SPRING.

Laboratory No. 52.

Sample collected..............September, 1914.
Temperature.................9·0°C. (48°F.)
Flow........................20 gallons per min.
Taste.......................Pleasantly saline.
Reaction....................Alkaline.
Specific gravity at 15°C.......1·0015.
Radioactivity...............Emanation...............345 units
Dissolved radium......... 0·3 „
Emanation in gas evolved.

Properties of reaction in per cent.
Primary salinity..........68·76
Secondary salinity........18·24
Primary alkalinity........
Secondary alkalinity......13·00

Analysis.

Constituents:—			Previous analysis.*	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4).........	105·	114·9	5·56	3·58
Bicarbonic acid	(HCO_3).........	224·	344·5	12·92	6·50
Carbonic acid	(CO_3).........	—	—	—	—
Nitric acid	(NO_3).........	3·9	—	0·21	0·10
Nitrous acid	(NO_2).........	—	—	—	—
Phosphoric acid	(PO_4).........	0·01	—	—	—
Metaboric acid	(BO_2).........	—	—	—	—
Chlorine	(Cl)..........	869·	880·5	46·01	39·78
Bromine	(Br)..........	1·7	6·2	0·09	0·04
Iodine	(I)...........	—	—	—	—
Oxygen to form Al_2O_3	....	2·4	—	0·13	—
Silica	(SiO_2).........	11·8	14·5	0·62	—
Iron	(Fe)..........	2·0	trace	0·11	0·11
Aluminium	(Al)..........	2·7		0·14	—
Manganese	(Mn)..........	—	—	—	—
Calcium	(Ca)..........	97·	72·7	5·14	7·89
Strontium	(Sr)..........	—	—	—	—
Magnesium	(Mg)..........	57·	25·5	3·02	7·62
Lithium	(Li)..........	—	—	—	—
Potassium	(K)...........	13·9	11·0	0·74	0·58
Sodium	(Na)..........	478·	620·1	25·31	33·80
Ammonium	(NH_4).........	0·02	—	—	—
Total.....................		1,888·43	2,089·9	100·00	100·00 Concentration value 61·50
Total solids in solution, residue dried at 110°C........		1,841			

Gases:	c.c. per litre.	Parts per million.
Carbon Dioxide CO_2	3·2	6·3
Hydrogen Sulphide H_2S	—	—

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* By J. T. Donald, Montreal, 1894.

HYPOTHETICAL COMBINATIONS.

No. 52.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.*
			Per cent.	
Sodium nitrite	($NaNO_2$)			
Sodium nitrate	($NaNO_3$)	5·35	0·29	
Ammonium chloride	(NH_4Cl)	0·05	—	
Potassium iodide	(KI)			
Potassium bromide	(KBr)	2·50	0·13	8·0
Lithium chloride	($LiCl$)			
Potassium chloride	(KCl)	24·96	1·32	21·1
Sodium chloride	($NaCl$)	1,212·22	64·20	1,435·4
Magnesium chloride	($MgCl_2$)	163·09	8·64	
Calcium chloride	($CaCl_2$)			
Sodium sulphate	(Na_2SO_4)			21·0
Magnesium sulphate	($MgSO_4$)	76·16	4·03	126·2
Calcium sulphate	($CaSO_4$)	62·63	3·32	
Sodium bicarbonate	($NaHCO_3$)			169·7
Magnesium bicarbonate	($Mg(HCO_3)_2$)			
Calcium bicarbonate	($Ca(HCO_3)_2$)	318·25	16·85	294·0
Strontium bicarbonate	($Sr(HCO_3)_2$)			
Ferrous bicarbonate	($Fe(HCO_3)_2$)	6·32	0·33	trace
Calcium phosphate	($Ca_3(PO_4)_2$)	trace	—	
Ferric oxide	(Fe_2O_3)			
Alumina	(Al_2O_3)	5·10	0·27	
Silica	(SiO_2)	11·80	0·62	14·5
		1,888·43	100·00	2,089·9

ST. LEON SPRING, ST. LEON, MASKINONGE COUNTY, QUE.

(53)

This spring was once the site of a flourishing sanitorium, which is now in ruins. Water from it was bottled by the St. Leon Mineral Water Co., of Toronto, but nothing has been done during the last few years. The spring rises in a wooden cased well, about eight feet square, 20 feet from the bank of the Rivière-du-Loup, into which the overflow of 100 gallons an hour empties.

The geologic formation of the neighbourhood is the Hudson River. Gas is evolved from the spring in considerable quantities, its chief constituent being methane. The radioactivity of a sample was not found as high as usual for gases of similar origin.

Analysis shows the water to be a strongly mineralized, sodic, muriated, saline (carburetted) water.

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*By J. T. Donald, Montreal, 1894.

ST. LEON SPRING.

Laboratory No. 53.

Sample collected..............September, 1914.
Temperature.................11·7°C. (48°F.)
Flow........................1½ gallons per minute.
Taste.......................Saline.
Reaction....................
Specific gravity at 15°C........1·0106.
Radioactivity...............Emanation...............39 units.
Dissolved radium......... 2·2 „
Emanation in gas evolved. 140 „

Properties of reaction in per cent.
Primary salinity..........82·18
Secondary salinity........ 5·94
Primary alkalinity.
Secondary alkalinity......11·88

Analysis.

Constituents:—			Previous analysis.	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4).........	2·37		0·02	0·01
Bicarbonic acid	(HCO_3).......	1,675·		12·00	5·94
Carbonic acid	(CO_3).........	—		—	—
Nitric acid	(NO_3).........	0·75		0·01	—
Nitrous acid	(NO_2).........	trace		—	—
Phosphoric acid	(PO_4).........	trace		—	—
Metaboric acid	(BO_2).........	—		—	—
Chlorine	(Cl)...........	7,215·		51·70	43·98
Bromine	(Br)...........	26·0		0·18	0·07
Iodine	(I)............	3·0		0·02	—
Oxygen for Fe_2O_3 & Al_2O_3.......		12·14		0·08	—
Silica	(SiO_2).........	31·5		0·23	—
Iron	(Fe)...........	3·0		0·02	—
Aluminium	(Al)...........	12·2		0·08	—
Manganese	(Mn)..........	0·1		—	—
Calcium	(Ca)...........	125·6		0·90	1·35
Strontium	(Sr)...........	2·75		0·02	0·02
Magnesium	(Mg)..........	423·3		3·03	7·54
Lithium	(Li)...........	0·57		0·01	0·02
Potassium	(K)............	154·9		1·11	0·86
Sodium	(Na)..........	4,250·2		30·45	39·97
Ammonium	(NH_4).........	20·0		0·14	0·24
Total......................		13,958·38		100·00	100·00
Total solids in solution, residue dried at 110°C.............		13,796·			Concentration value. 462·22

Gases:		c.c. per litre.	Parts per million.
Carbon Dioxide	CO_2...		
Hydrogen Sulphide	H_2S...	1·2	1·9

HYPOTHETICAL COMBINATIONS.

No. 53.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)............	trace		
Sodium nitrate	($NaNO_3$)............	1·02	0·01	
Ammonium chloride	(NH_4Cl)............	59·44	0·43	
Potassium iodide	(KI)...............	3·98	0·03	
Potassium bromide	(KBr)..............	38·68	0·28	
Lithium chloride	($LiCl$)..............	3·44	0·02	
Potassium chloride	(KCl)..............	269·91	1·93	
Sodium chloride	($NaCl$).............	10,809·45	77·44	
Magnesium chloride	($MgCl_2$)............	650·42	4·66	
Calcium chloride	($CaCl_2$).............			
Sodium sulphate	(Na_2SO_4)...........			
Magnesium sulphate	($MgSO_4$)............	2·95	0·02	
Calcium sulphate	($CaSO_4$)............			
Sodium bicarbonate	($NaHCO_3$)..........			
Magnesium bicarbonate	($Mg(HCO_3)_2$)........	1,544·70	11·07	
Calcium bicarbonate	($Ca(HCO_3)_2$).........	508·68	3·64	
Strontium bicarbonate	($Sr(HCO_3)_2$)..........	6·81	0·05	
Ferrous bicarbonate	($Fe(HCO_3)_2$).........			
Calcium phosphate	($Ca_3(PO_4)_2$)..........	trace	—	
Ferric oxide	(Fe_2O_3).............	4·29	0·03	
Alumina	(Al_2O_3).............	23·00	0·16	
Silica	(SiO_2)..............	31·50	0·23	
Manganese oxide	(Mn_3O_4)............	0·15	—	
		13,958·39	100·00	

POTTON SPRING, POTTON TOWNSHIP, BROME CO., QUE.

(54)

This sulphur spring flows from a crevice in the mountain side, close to Potton Springs station, on the Canadian Pacific railway branch line between Eastman and North Troy, not far from Sherbrooke, and within a few miles of Lake Memphremagog.

A sanitorium has been built by Mr. J. A. Wright, near the spring, and numerous visitors take the cure. The water is lightly mineralized, and contains only a small amount of hydrogen sulphide in spite of its taste, very little of this gas being sufficient to give a water the peculiar rotten-egg flavour.

Analysis shows it to be a calcic, sodic bicarbonated water of the alkaline type. The hypothetical combinations indicate that calcium, magnesium and sodium bicarbonates, together form 78 per cent of the total solids in solution.

POTTON SPRING.

Laboratory No. 54.

Sample collected..............September, 1914.
Temperature.................10·0°C. (50°F.)
Flow........................1 gallon per minute.
Taste.......................Slight taste of hydrogen sulphide.
Reaction....................Alkaline.
Specific gravity at 15°C.......1·0002.
Radioactivity................Emanation...............280 units.
Dissolved radium.........
Emanation in gas evolved.

Properties of reaction in per cent.

Primary salinity..........19·30
Secondary salinity........
Primary alkalinity........11·70
Secondary alkalinity......69·00

Analysis.

Constituent:—			Previous analysis.	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4).........	3·7		1·84	1·55
Bicarbonic acid	(HCO_3).......	123·		61·30	40·35
Carbonic acid	(CO_3).........	—		—	—
Nitric acid	(NO_3).........	1·3		0·65	0·41
Nitrous acid	(NO_2).........	—		—	—
Phosphoric acid	(PO_4).........	—		—	—
Metaboric acid	(BO_3).........	—		—	—
Chlorine	(Cl)..........	13·6		6·78	7·69
Bromine	(Br)..........	—		—	—
Iodine	(I)...........	—		—	—
Silica	(SiO_2)........	9·9		4·93	—
Iron.	(Fe).........	1·3		0·65	0·92
Aluminium	(Al)..........				
Manganese	(Mn).........	—		—	—
Calcium	(Ca)..........	23·6		11·75	23·53
Strontium	(Sr)..........	—		—	—
Magnesium	(Mg).........	6·1		3·04	10·05
Lithium	(Li)..........	0·01		—	—
Potassium	(K)...........	0·96		0·48	0·02
Sodium	(Na).........	17·16		8·56	0·48
Ammonium	(NH_4)........	0·05		0·02	14·94
					0·06
Total..................		200·68		100·00	100·00
Total solids in solution, residue dried at 110°C............		135·			Concentration value. 5·00

Gases:		c.c. per litre.	Parts per million.
	Carbon Dioxide CO_2......	14·4	33·0
	Hydrogen Sulphide H_2S...	0·6	1·0

HYPOTHETICAL COMBINATIONS.

No. 54.

Constituent:—		Parts per million.	Total inorganic matter in solution. Per cent.	Previous analysis.
Sodium nitrite	($NaNO_2$)			
Sodium nitrate	($NaNO_3$)	1·77	0·88	
Ammonium chloride	(NH_4Cl)	0·15	0·07	
Potassium iodide.	(KI)			
Potassium bromide	(KBr)			
Lithium chloride	($LiCl$)	0·06	0·03	
Potassium chloride	(KCl)	1·83	0·91	
Sodium chloride	($NaCl$)	20·74	10·34	
Magnesium chloride	($MgCl_2$)			
Calcium chloride	($CaCl_2$)			
Sodium sulphate	(Na_2SO_4)	5·48	2·73	
Magnesium sulphate	($MgSO_4$)			
Calcium sulphate	($CaSO_4$)			
Sodium bicarbonate	($NaHCO_3$)	24·61	12·25	
Magnesium bicarbonate	($Mg(HCO_3)_2$)	36·70	18·30	
Calcium bicarbonate.	($Ca(HCO_3)_2$)	95·35	47·53	
Strontium bicarbonate	($Sr(HCO_3)_2$)			
Ferrous bicarbonate	($Fe(HCO_3)_2$)	4·06	2·02	
Calcium phosphate	($Ca_3(PO_4)_2$)			
Ferric oxide	(Fe_2O_3)			
Alumina	(Al_2O_3)			
Silica	(SiO_2)	9·9	4·94	
		200·65	100·00	

PHILUDOR SPRING, ST. HYACINTHE, ST. HYACINTHE CO., QUE.

(55)

Several springs occur in the neighbourhood of St. Hyacinthe. Philudor spring rises, not far from a creek at the foot of a steep slope on the farm of Napoleon Solis, in the parish of St. Hyacinthe le Confesseur. It issues from a boring 28 feet deep, and flows at a rate of 35 gallons an hour, into a wooden trough. There is another spring of slightly greater flow about 50 yards away, but it is unused. The water from the former spring is bottled by the St. Hyacinthe Mineral Water Company, under the name 'Philudor' mineral water.

Analysis shows the water to be a moderately mineralized sodic, muriated bicarbonated, alkaline-saline water. Sodium chloride forms 65 per cent of the total solids in solution, magnesium and calcium bicarbonates 12 per cent, and sodium bicarbonate 18 per cent.

PHILUDOR SPRING.

Laboratory No. 55.

Sample collected..............September, 1914.
Temperature..................8·6°C. (47·5°F.)
Flow.........................A gallon per minute.
Taste........................Slightly saline with indications of hydrogen sulphide.
Reaction.....................Alkaline.
Specific gravity at 15°C........1·0046
Radioactivity................Emanation...............106 units.
Dissolved radium......... 46 „
Emanation in gas evolved.

Properties of reaction in per cent.
Primary salinity..........75·00
Secondary salinity........
Primary alkalinity........13·98
Secondary alkalinity......11·02

Analysis.

Constituents:—			Previous analysis.	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4)...	19·5		0·41	0·27
Bicarbonic acid	(HCO_3)..	1,130·		23·59	12·50
Carbonic acid	(CO_3)...	—		—	—
Nitric acid	(NO_3)...	15·8		0·33	0·17
Nitrous acid	(NO_2)...	trace		—	—
Phosphoric acid	(PO_4)...	—		—	—
Metaboric acid	(BO_2)...	—		—	—
Chlorine	(Cl)....	1,943·0		40·57	37·00
Bromine	(Br)....	7·0		0·15	0·06
Iodine	(I).....	—		—	—
Silica	(SiO_2)...	14·5		0·30	—
Iron	(Fe)...	4·68		0·10	0·11
Aluminium	(Al)...			—	—
Manganese	(Mn)...	0·6		0·01	—
Calcium	(Ca)....	54·6		1·14	1·84
Strontium	(Sr)	trace		—	—
Magnesium	(Mg)...	64·1		1·34	3·56
Lithium	(Li).....	—		—	—
Potassium	(K).....	50·5		1·05	0·87
Sodium	(Na)....	1,485·4		31·01	43·62
Ammonium	(NH_4)..	0·002		—	—
Total...................		4,789·68		100·00	100·00
Total solids in solution, residue dried at 110°C.........					Concentration value. 148·12

		c.c. per litre.	Parts per million.
Gases :	Carbon Dioxide CO_2....		
	Hydrogen Sulphide H_2S.		

HYPOTHETICAL COMBINATIONS.

No. 55.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	$(NaNO_2)$	trace	—	
Sodium nitrate	$(NaNO_3)$	21·58	0·45	
Ammonium chloride	(NH_4Cl)	0·01	—	
Potassium iodide	(KI)			
Potassium bromide	(KBr)	10·36	0·21	
Lithium chloride	$(LiCl)$			
Potassium chloride	(KCl)	89·8	1·87	
Sodium chloride	$(NaCl)$	3,132·5	65·42	
Magnesium chloride	$(MgCl_2)$			
Calcium chloride	$(CaCl_2)$			
Sodium sulphate	(Na_2SO_4)	28·82	0·60	
Magnesium sulphate	$(MgSO_4)$			
Calcium sulphate	$(CaSO_4)$			
Sodium bicarbonate	$(NaHCO_3)$	868·5	18·13	
Magnesium bicarbonate	$(Mg(HCO_3)_2)$	385·7	8·05	
Calcium bicarbonate	$(Ca(HCO_3)_2)$	221·0	4·61	
Strontium bicarbonate	$(Sr(HCO_3)_2)$	trace	—	
Ferrous bicarbonate	$(Fe(HCO_3)_2)$	14·95	0·31	
Calcium phosphate	$(Ca_3(PO_4)_2)$			
Ferric oxide	(Fe_2O_3)			
Alumina	(Al_2O_3)			
Silica	(SiO_2)	14·5	0·31	
Manganous bicarbonate	$(Mn(HCO_3)_2)$	1·94	0·04	
		4,789·66	100·00	

SPRING AT LA PROVIDENCE, ST. HYACINTHE.

(56)

The spring, on the farm of the Sisters of La Metairie, at the village of La Providence, is situated at the foot of a slope. It is enclosed in a wooden casing, and the water is 10 feet deep. Occasional bubbles of gas, chiefly methane, rise to the surface.

This water is considerably more alkaline and less mineralized than the Philudor water, though they both issue from the Hudson River formation. It can be similarly classified, however, as a sodic, muriated, bicarbonated, alkaline-saline (carburetted) water. Sodium bicarbonate may be considered to constitute 59 per cent of the total inorganic matter in solution.

SPRING AT LA PROVIDENCE.

Laboratory No. 56.

Sample collected	September, 1914.
Temperature	9·4°C. (49°F.)
Flow	Small.
Taste	Saline.

La Providence Spring, St. Hyacinthe, Que. (Typical location of many springs.)

Reaction.....................Alkaline.
Specific gravity at 15°C.......1·0025
Radioactivity...............Emanation...............112 units
Dissolved radium......... 0·5 „
Emanation in gas evolved.540 „

Properties of reaction in per cent.

Primary salinity..........44·80
Secondary salinity........
Primary alkalinity........52·06
Secondary alkalinity...... 3·14

Analysis.

Constituents:—			Previous analysis.	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4)...	2·05		0·07	0·05
Bicarbonic acid	(HCO_3)	1,369· ·		45·84	27·60
Carbonic acid	(CO_3)...	——		——	——
Nitric acid	(NO_3)...	5·4		0·18	0·09
Nitrous acid	(NO_2)...	trace		——	——
Phosphoric acid	(PO_4)...	——		——	——
Metaboric acid	(BO_2)...	trace		——	——
Chlorine	(Cl)....	643·		21·53	22·26
Bromine	(Br)....	trace		——	——
Iodine	(I).....	——		——	——
Oxygen for Fe_2O_3 & Al_2O_3.......		4·73		0·16	——
Silica	(SiO_2)...	14·6		0·49	——
Iron	(Fe)...	11·0		0·37	——
Aluminium	(Al)...				
Manganese	(Mn)...	trace		——	——
Calcium	(Ca)....	7·1		0·24	0·44
Strontium	(Sr)....	——		——	——
Magnesium	(Mg)..	11·2		0·37	1·13
Lithium	(Li)	——		——	——
Potassium	(K).....	29·4		0·98	0·93
Sodium	(Na)....	889·		29·76	47·50
Ammonium	(NH_4). .	0·04		0·01	——
Total....................		2,986·52		100·00	100·00 Concentration value.
Total solids in solution, residue dried at 110°C.............					81·37

		c.c. per litre.	Parts per million.
Gases :	Carbon Dioxide CO_2....		
	Hydrogen Sulphide H_2S.	1·2	2·0

HYPOTHETICAL COMBINATIONS.

No. 56.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)............			
Sodium nitrate	($NaNO_3$)............	7·40	0·25	
Ammonium chloride	(NH_4Cl)............	0·11	0·04	
Potassium iodide	(KI)................			
Potassium bromide	(KBr)..............	trace	——	
Lithium chloride	(LiCl)..............			
Potassium chloride	(KCl)...............	56·17	1·88	
Sodium chloride	(NaCl)..............	1,015·36	34·00	
Magnesium chloride	($MgCl_2$)..............			
Calcium chloride	($CaCl_2$).............			
Sodium sulphate	(Na_2SO_4)...........	3·05	0·10	
Magnesium sulphate	($MgSO_4$)............			
Calcium sulphate	($CaSO_4$).............			
Sodium bicarbonate	($NaHCO_3$)...........	1,778·00	59·50	
Magnesium bicarbonate	($Mg(HCO_3)_2$).........	67·38	2·26	
Calcium bicarbonate	($Ca(HCO_3)_2$).........	28·76	0·96	
Strontium bicarbonate	($Sr(HCO_3)_2$).........			
Ferrous bicarbonate	($Fe(HCO_3)_2$).........			
Calcium phosphate	($Ca_3(PO_4)_2$)..........			
Ferric oxide	(Fe_2O_3) }	15·73	0·53	
Alumina	(Al_2O_3) }			
Silica	(SiO_2)..............	14·60	0·48	
		2,986·56	100·00	

ST. LEON SPRING, (LUPIEN), MASKINONGE COUNTY, QUE.

(57)

This spring is on the farm of Mr. B. Lupien, and water from it is bottled by Mr. J. C. Rousseau, of Three Rivers, as "St. Leon" mineral water. It is one mile farther up the Rivière-du-Loup than the original St. Leon spring (No. 53), and like it rises from the Hudson River formation. There are two springs, 15 feet apart, and close to the river bank; the flow from each is small. Water is pumped from the deeper spring into barrels for shipping.

Gas is evolved from both waters and a sample collected in September 1914, possessed 148 units of radioactivity. The water is a strongly mineralized, sodic, muriated, alkaline-saline (bromic, carburetted) water. Sodium and potassium chlorides constitute 77 per cent of the total solids, the remainder is composed of calcium and magnesium bicarbonates.

Analysis gave the following particulars:—

St. Leon (Lupien) Spring, Que.

ST. LEON SPRING, (LUPIEN.)

Laboratory No. 57.

Sample collected..............September, 1914.
Temperature.................8·3°C. (47·8° F.)
Flow.......................Small.
Taste......................Strongly saline.
Reaction....................
Specific gravity at 15°C.......1·0103.
Radioactivity...............Emanation...............148 units
Dissolved radium......... 0·8 „
Emanation in gas evolved. 460 „

Properties of reaction in per cent.
Primary salinity.......... 81·12
Secondary salinity........ 0·62
Primary alkalinity........
Secondary alkalinity...... 17·26

Analysis.

Constituents:—			Previous analysis.	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4)...	0·41		—	—
Bicarbonic acid	(HCO_3)	2,332·4		16·97	8·63
Carbonic acid	(CO_3)...	—		—	—
Nitric acid	(NO_3)...	0·3		—	—
Nitrous acid	(NO_2)...	—		—	—
Phosphoric acid	(PO_4)...	trace		—	—
Metaboric acid	(BO_2)...	—		—	—
Chlorine	(Cl)....	6,495·		47·25	41·30
Bromine	(Br)....	25·0		0·18	0·07
Iodine	(I)......	2·5		0·02	—
Oxygen for Al_2O_3..............		3·17		0·02	—
Silica	(SiO_2)...	31·45		0·23	—
Iron	(Fe)....	0·91		—	0·01
Aluminium	(Al)....	3·57		0·03	—
Manganese	(Mn)...	—		—	—
Calcium	(Ca)....	285·5		2·08	3·22
Strontium	(Sr).....	2·11		0·02	0·01
Magnesium	(Mg)..	307·1		2·23	5·70
Lithium	(Li)	0·23		—	0·01
Potassium	(K).....	197·5		1·44	1·14
Sodium	(Na)....	4,029·1		29·31	39·54
Ammonium	(NH_4)...	30·0		0·22	0·37
Total....................		13,746·25		100·00	100·00
Total solids in solution, residue dried at 110°C............		12,584·			Concentration value. 443·08

Gases :		c.c. per litre.	Parts per million.
	Carbon Dioxide CO_2....		
	Hydrogen Sulphide H_2S.	1·1	1·7

HYPOTHETICAL COMBINATIONS.

No. 57.

Constituent:—		Parts per million.	Total inorganic matter in solution. Per cent.	Previous analysis.
Sodium nitrite	($NaNO_2$)......	—	—	
Sodium nitrate	($NaNO_3$)......	0·43	—	
Ammonium chloride	(NH_4Cl).......	89·13	0·65	
Potassium iodide	(KI)..........	3·15	0·02	
Potassium bromide	(KBr).........	37·13	0·27	
Lithium chloride	(LiCl).........	1·40	0·01	
Potassium chloride	(KCl).........	352·11	2·56	
Sodium chloride	(NaCl)........	10,247·74	74·55	
Magnesium chloride	($MgCl_2$)........	64·90	0·47	
Calcium chloride	($CaCl_2$)........			
Sodium sulphate	(Na_2SO_4)......			
Magnesium sulphate	($MgSO_4$)........	0·54	—	
Calcium sulphate	($CaSO_4$).......			
Sodium bicarbonate	($NaHCO_3$).....			
Magnesium bicarbonate	($Mg(HCO_3)_2$)..	1,747·28	12·71	
Calcium bicarbonate	($Ca(HCO_3)_2$)...	1,156·27	8·41	
Strontium bicarbonate	($Sr(HCO_3)_2$)...	5·03	0·04	
Ferrous bicarbonate	($Fe(HCO_3)_2$)...	2·94	0·02	
Calcium phosphate	($Ca_3(PO_4)_2$)....	trace	—	
Ferric oxide	(Fe_2O_3)........			
Alumina	(Al_2O_3)........	6·74	0·05	
Silica	(SiO_2).........	31·45	0·23	
		13,746·24	100·00	

AETNA SPRING, ST. SEVERE, ST. SEVERE TOWNSHIP, ST. MAURICE CO., QUE.

(58)

The water rises in a cement well, 4 feet diameter, and 24 feet deep, on the farm of Mr. A. Lacerte, close to the Rivière-du-Loup. The water is very saline to the taste and has but a small flow. It is bottled under the name of "Divina" mineral water by Mr. J. T. Lemyre of Three Rivers.

Sodium and potassium chlorides may be considered to form 83 per cent of the total solid matter (17,945 parts per million), a concentration approximately equivalent to four heaped teaspoonfuls of common salt in a gallon of water.

Analysis shows the water to be a strongly mineralized sodic, muriated, saline (bromic and iodic) water. The concentration of the water appears to have increased to some extent since the analysis by Prof. F. Fafard of Laval University in 1887.

The following results were obtained:—

AETNA SPRING.

Laboratory No. 58.

Sample collected.............September, 1914.
Temperature.................8·0°C. (47°F.)
Flow.......................Small.
Taste......................Very saline.
Reaction...................—
Specific gravity at 15°C.......1·0132.
Radioactivity...............Emanation...............87 units
Dissolved radium......... 2·8 „
Emanation in gas evolved.

Properties of reaction in per cent.
Primary salinity..........85·64
Secondary salinity........ 3·60
Primary alkalinity........
Secondary alkalinity......10·76

Analysis.

Constituents:—		Previous analysis.*	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO_4)..........	2·8	trace	0·02	0·01
Bicarbonic acid (HCO_3)........	1,955·	1,694·8	10·90	5·38
Carbonic acid (CO_3).........	——	——	——	——
Nitric acid (NO_3).........	29·1	——	0·16	0·08
Nitrous acid (NO_2).........	0·6	——	——	——
Phosphoric acid (PO_4).........	——	8·0	——	——
Metaboric acid (BO_2).........	——	——	——	——
Chlorine (Cl)..........	9,400·	5,755·6	52·40	44·49
Bromine (Br)...........	15·0	4,420·0	0·08	0·03
Iodine (I)............	9·0	76·6	0·05	0·01
Oxygen for Fe_2O_3 & Al_2O_3.......	11·3	254·0	0·06	——
Silica (SiO_2).........	37·4	78·4	0·20	——
Iron (Fe)...........	4·2	81·0	0·02	0·03
Aluminium (Al)...........	10·0	288·0	0·06	——
Manganese (Mn)..........	0·1	1·3	——	——
Calcium (Ca)..........	71·2	38·1	0·39	0·60
Strontium (Sr)...........	4·8	——	0·03	0·02
Magnesium (Mg)..........	473·4	496·0	2·64	6·53
Lithium (Li)...........	3·8	17·0	0·02	0·09
Potassium (K)...........	166·9	288·0	0·93	0·72
Sodium (Na)..........	5,729·0	4,385·8	31·92	41·81
Ammonium (NH_4)........	22·0	——	0·12	0·20
Total....................	17,945·6	17,882·6	100·00	100·00
Total solids in solution, residue dried at 110°C..............	17,477			Concentration value. 595·87

	c.c. per litre.	Parts per million.
Gases: Carbon Dioxide CO_2.......		
Hydrogen Sulphide H_2S....	0·5	0·8

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* By F. Fafard, Laval University, 1887.

HYPOTHETICAL COMBINATIONS.

No. 58.

Constituent:—		Parts per million.	Total inorganic matter in solution. Per cent.	Previous analysis.
Sodium nitrite	($NaNO_2$).......	0·9	——	
Sodium nitrate	($NaNO_3$)......	39·9	0·22	
Ammonium chloride	(NH_4Cl)......	65·4	0·36	
Potassium iodide	(KI)..........	11·7	0·06	
Sodium iodide	(NaI).........			91·7
Potassium bromide	(KBr).........	22·3	0·12	
Lithium chloride	(LiCl).........	23·1	0·13	104·0
Potassium chloride	(KCl)..........	299·5	1·67	550·5
Sodium chloride	(NaCl)........	14,540·0	81·05	7,870·6
Magnesium chloride	($MgCl_2$).......	495·5	2·76	830·2
Calcium chloride	($CaCl_2$)........			21·3
Sodium bromide	(NaBr)........			5,690·6
Magnesium sulphate	($MgSO_4$).......	3·6	0·02	
Calcium sulphate	($CaSO_4$).......			
Sodium bicarbonate	($NaHCO_3$).....			
Magnesium bicarbonate	($Mg(HCO_3)_2$)..	2,082·0	11·60	1,707·9
Calcium bicarbonate	($Ca(HCO_3)_2$)...	287·2	1·60	122·3
Strontium bicarbonate	($Sr(HCO_3)_2$)...	11·5	0·06	——
Ferrous bicarbonate	($Fe(HCO_3)_2$)...			25·7
Sodium phosphate	($Na_3(PO_4)$).....			13·7
Ferric oxide	(Fe_2O_3).......	6·0	0·03	
Alumina	(Al_2O_3)........	19·6	0·11	
Silica	(SiO_2)........	37·4	0·21	78·4
Manganous bicarbonate	($Mn(HCO_3)_2$)..			4·1
		17,945·6	100·00	1,788·0

ST. GENEVIEVE DE BATISCAN, QUE.

(59)

Several strongly saline springs are known in the vicinity of St. Genevieve, but only one was examined. It is situated on the right bank of the Batiscan river, just above the bridge leading across to the village of St. Genevieve. It is the property of D. Veillet and Co., and is bottled under the name of "Star" mineral water. Salt is also obtained by evaporation of the water, 8 gallons yielding 1 pound of salt.

Much gas is given off from the water, and is collected in a tank over the well, from which it is led into the bottling house to run a gas engine. Analysis showed the gas to be chiefly methane.

This spring was examined by Sterry Hunt before 1863, with very similar results to those obtained in 1915. He drew attention to the high percentage of iodine (0·063 per cent of the solid matter in solution). A somewhat lower result is shown in this analysis (0·02 per cent). The water issues from the Lower Silurian limestone formation.

Analysis shows it to be a strongly mineralized, sodic, muriated, saline water.

Alkaline chlorides form over 82 per cent of the total solid material; in sodium and magnesium chloride 11·6 per cent. It closely resembles some of the strongly saline European spa waters, such as at Nauheim, Kreuznach, Pyrmont and Bourbonne les Bains.

"STAR" MINERAL WATER.

Laboratory No. 59.

Sample collected	September, 1914.		
Temperature	8·3°C. (47°F.)		
Flow	8 gallons per minute.		
Taste	Very salt and bitter.		
Reaction	Alkaline.		
Specific gravity at 15°C	1·0220.		
Radioactivity	Emanation	145	units
	Dissolved radium	0·8	„
	Emanation in gas evolved.		
Properties of reaction in per cent.			
	Primary salinity	82·08	
	Secondary salinity	14·40	
	Primary alkalinity		
	Secondary alkalinity	3·52	

Analysis.

Constituents:—		Previous analysis.*	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO_4)	2·95	—	0·01	—
Bicarbonic acid (HCO_3)	1,123·	—	3·91	1·76
Carbonic acid (CO_3)	—	464·3·	—	—
Nitric acid (NO_3)	0·6	—	—	—
Nitrous acid (NO_2)	trace	—	—	—
Phosphoric acid (PO_4)	—	—	—	—
Metaboric acid (BO_2)	trace	—	—	—
Chlorine (Cl)	16,850·	14,677·	58·77	48·20
Bromine (Br)	34·0	—	0·12	0·04
Iodine (I)	7·0	39·8	0·02	—
Oxygen for Al_2O_3	9·1	—	0·03	—
Silica (SiO_2)	11·0	26·0	0·04	—
Iron (Fe)	17·2	5·4	0·06	0·06
Aluminium (Al)	10·2	8·5	0·03	—
Manganese (Mn)	0·02	—	—	—
Calcium (Ca)	289·6	696·4	1·01	1·46
Strontium (Sr)	7·32	203·0	0·02	0·02
Magnesium (Mg)	891·0	909·5	3·11	7·42
Lithium (Li)	1·01	0·2	—	0·01
Potassium (K)	282·0	3·3	0·98	0·73
Sodium (Na)	9,090·	7,829·0	31·70	46·00
Ammonium (NH_4)	55·0	—	0·19	0·30
Barium	—	84·2		
Total	28,680·99	24,946·6	100·00	100·00
Total solids in solution, residue dried at 110°C	29,260			Concentration value. 988·28

Gases:	c.c. per litre.	Parts per million.
Carbon Dioxide CO_2	—	—
Hydrogen Sulphide H_2S	trace	trace

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*By C. P. Choquette, St. Hyacinthe, Que.

HYPOTHETICAL COMBINATIONS.

No. 59.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)	0·01	——	
Sodium nitrate	($NaNO_3$)	0·80	——	
Ammonium chloride	(NH_4Cl)	163·35	0·57	
Potassium iodide	(KI)	9·15	0·04	47·0
Potassium bromide	(KBr)	50·65	0·18	
Lithium chloride	($LiCl$)	6·12	0·03	
Potassium chloride	(KCl)	501·8	1·75	6·3
Sodium chloride	($NaCl$)	23,103·0	80·52	19,413·8
Magnesium chloride	($MgCl_2$)	3,335·5	11·63	3,594·3
Barium chloride	($BaCl_2$)			12·79
Sodium sulphate	(Na_2SO_4)			
Magnesium sulphate	($MgSO_4$)	3·71	0·01	
Calcium sulphate	($CaSO_4$)			
Sodium bicarbonate	($NaHCO_3$)			
Magnesium bicarbonate	($Mg(HCO_3)_2$)	232·7	0·81	
Calcium bicarbonate	($Ca(HCO_3)_2$)	1,171·7	4·08	1,160·7
Strontium bicarbonate	($Sr(HCO_3)_2$)	17·51	0·06	
Strontium chloride	($SrCl_2$)			36·79
Ferrous bicarbonate	($Fe(HCO_3)_2$)	54·64	0·19	
Sodium phosphate	($Na_3(PO_4)$)			45·5
Ferric oxide	(Fe_2O_3)			7·8
Alumina	(Al_2O_3)	19·3	0·08	8·5
Silica	(SiO_2)	11·0	0·05	2·6
Manganous bicarbonate	($Mn(HCO_3)_2$)	0·06		
		28,681·00	100·00	24,946·6

SPRING AT BERTHIER, BERTHIER CO., QUE.

(62)

The spring examined at Berthier rises in the middle of the Bayonne River at Fernierville. A wooden tub surrounds it, and there is a considerable evolution of gas with the water. The strange situation of the spring is the result of a landslide in 1914, when the course of the river was changed. In winter and spring the source is covered by the depth of river water, but when visited in the summer of 1914 there was a strong flow from the spring, and the water appeared entirely free from admixture with the surrounding river water.

Sterry Hunt supposed it to ascend from the Lower Silurian limestones.

It is moderately mineralized, sodic, muriated, alkaline saline (bromic, carburetted) water, having a primary alkalinity of 5·7 per cent. The chief constituents may be considered to be sodium chloride, sodium bicarbonate, and magnesium bicarbonate. The amount of bromine in the water is comparatively high, sodium bromide forming 0·58 per cent of the total solid matter.

Analysis gave the following particulars:—

SPRING AT BERTHIER.

Laboratory No. 62.

Sample collected	September, 1914.		
Temperature	8·0°C. (47°F.)		
Flow	Considerable.		
Taste	Pleasantly saline.		
Reaction	Alkaline.		
Specific gravity at 15°C	1·0048.		
Radioactivity	Emanation	112	units
	Dissolved radium	trace.	
	Emanation in gas evolved.	450	"

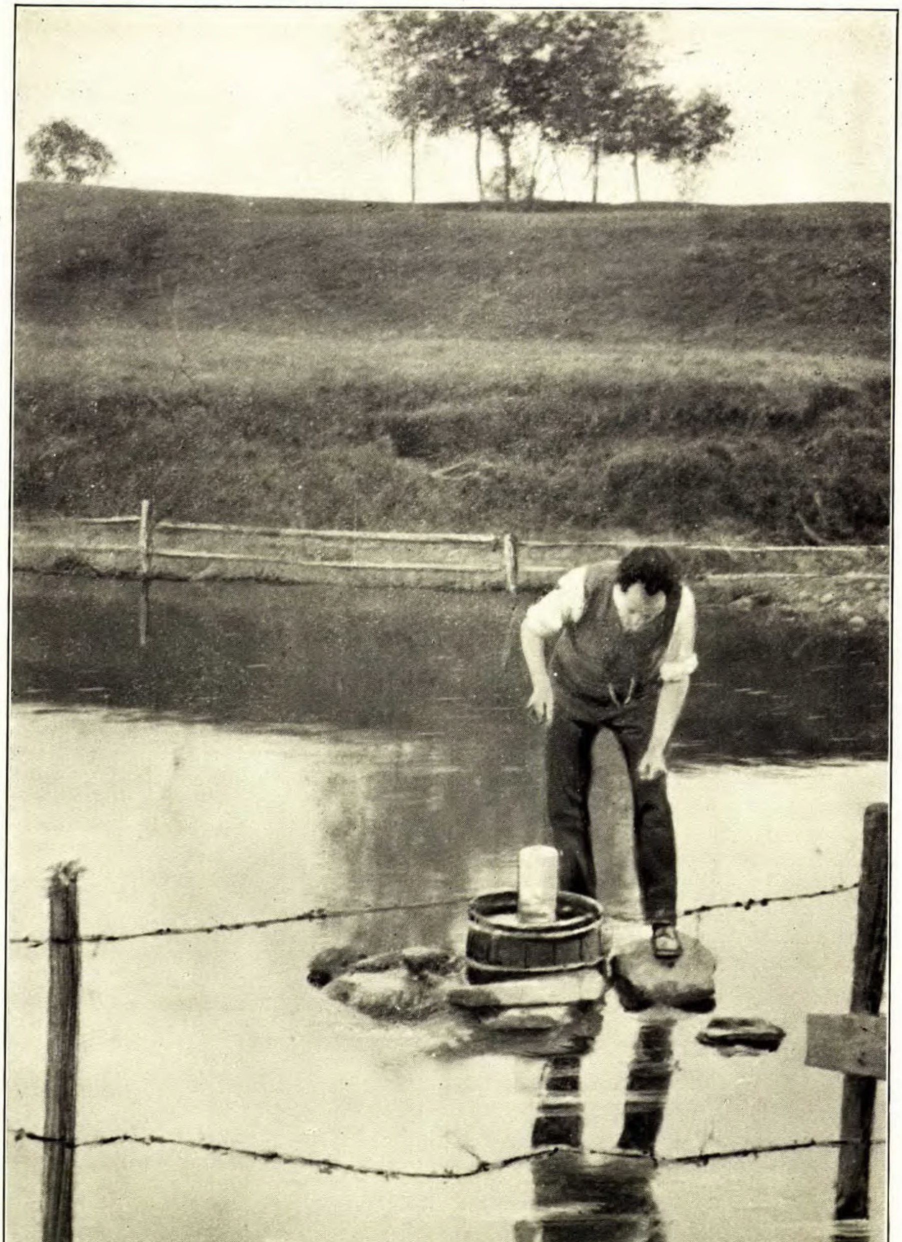
Properties of reaction in per cent.

Primary salinity	81·82
Secondary salinity	
Primary alkalinity	5·74
Secondary alkalinity	12·44

Analysis.

Constituents:—			Previous analysis.	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4)	1·2		0·02	0·01
Bicarbonic acid	(HCO_3)	1,218·		17·73	9·09
Carbonic acid	(CO_3)	——		——	——
Nitric acid	(NO_3)	0·9		0·01	——
Nitrous acid	(NO_2)	——		——	——
Phosphoric acid	(PO_4)	0·3		——	——
Metaboric acid	(BO_2)	——		——	——
Chlorine	(Cl)	3,171·		46·17	40·70
Bromine	(Br)	33·0		0·48	0·29
Iodine	(I)	6·0		0·09	——
Oxygen for	(Al_2O_3)	4·44		0·06	——
Silica	(SiO_2)	35·5		0·52	——
Iron	(Fe)	1·16		0·02	0·02
Aluminium	(Al)	5·01		0·07	——
Manganese	(Mn)	0·05		——	——
Calcium	(Ca)	30·63		0·45	0·70
Strontium	(Sr)	2·92		0·04	0·03
Magnesium	(Mg)	146·2		2·13	5·47
Lithium	(Li)	0·42		0·01	0·03
Potassium	(K)	2·85		0·04	0·03
Sodium	(Na)	2,202·2		32·06	43·56
Ammonium	(NH_4)	6·50		0·09	0·16
Total		6,868·28		100·00	100·00 Concentration value. 219·80
Total solids in solution, residue dried at 110°C		6,370			

Gases:		c.c. per litre.	Parts per million.
	Carbon Dioxide CO_2		
	Hydrogen Sulphide H_2S	1·3	2·1



Spring in Bayonne river, Berthier, Que.

HYPOTHETICAL COMBINATIONS.

No. 62.

Constituent:—		Parts per million.	Total inorganic matter in solution. Per cent.	Previous Analysis.
Sodium nitrite	($NaNO_2$)............			
Sodium nitrate	($NaNO_3$)............	1·28	0·02	
Ammonium chloride	(NH_4Cl)............	19·30	0·28	
Potassium iodide	(KI)................	7·80	0·11	
Potassium bromide	(KBr)..............	3·09	0·04	
Sodium bromide	($NaBr$).............	39·83	0·58	
Lithium chloride	($LiCl$)..............	2·59	0·04	
Potassium chloride	(KCl)...............			
Sodium chloride	($NaCl$)..............	5,203·1	75·75	
Magnesium chloride	($MgCl_2$)............			
Calcium chloride	($CaCl_2$)............			
Sodium sulphate	(Na_2SO_4)...........	1·77	0·03	
Magnesium sulphate	($MgSO_4$)...........			
Calcium sulphate	($CaSO_4$)............			
Sodium bicarbonate	($NaHCO_3$)..........	530·56	7·72	
Magnesium bicarbonate	($Mg(HCO_3)_2$)........	879·60	12·80	
Calcium bicarbonate	($Ca(HCO_3)_2$)........	123·16	1·79	
Strontium bicarbonate	($Sr(HCO_3)_2$).........	6·92	0·10	
Ferrous bicarbonate	($Fe(HCO_3)_2$)........	3·65	0·05	
Calcium phosphate	($Ca_3(PO_4)_2$).........	0·46	0·01	
Ferric oxide	(Fe_2O_3)............			
Alumina	(Al_2O_3).............	9·45	0·14	
Silica	(SiO_2)..............	35·5	0·52	
Manganous bicarbonate	($Mn(HCO_3)_2$)........	0·17		
		6,868·23	100·00	

SPRING AT MASKINONGE, MASKINONGE CO., QUE.

(63)

This spring was discovered by Mr. J. T. Lemyre of Three Rivers in 1912. It rises in a small pool at the foot of the steeply sloping bank of the River Maskinonge, about 40 yards from the water's edge. The water had a pleasant saline taste, resembling the Magi Caledonia water, or the Radnor water, when examined in September 1914.

Analysis shows it to be moderately mineralized, sodic, muriated, alkaline-saline water, very similar in composition to the Berthier water.

Sodium chloride forms 71 per cent of the total inorganic matter in solution, magnesium bicarbonate 12 per cent, and sodium bicarbonate 6 per cent.

The following results were obtained upon analysis:—

SPRING AT MASKINONGE.

Laboratory No. 63.

Sample collected..............September, 1914.
Temperature...................8·0°C. (47°F.)
Flow..........................Small.
Taste.........................Pleasantly saline.
Reaction......................Alkaline.
Specific gravity at 15°C......1·0044.
Radioactivity.................Emanation...............79 units
Dissolved radium......... 0·5 „
Emanation in gas evolved. 250 „

Properties of reaction in per cent.
Primary salinity..........82·04
Secondary salinity........
Primary alkalinity........ 5·12
Secondary alkalinity......12·84

Analysis.

Constituents:—		Previous analysis.	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO_4)...	2·7		0·04	0·03
Bicarbonic acid (HCO_3)	1,075·1		17·38	8·98
Carbonic acid (CO_3)...	——		——	——
Nitric acid (NO_3)...	49·3		0·80	0·40
Nitrous acid (NO_2)...	1·35		0·02	0·01
Phosphoric acid (PO_4)...	0·07		——	——
Metaboric acid (BO_2)...	——		——	——
Chlorine (Cl)....	2,826·		45·68	40·55
Bromine (Br)....	6·0		0·09	0·03
Iodine (I)......	0·4		——	——
Oxygen for Al_2O_3..............	4·23		0·06	
Silica (SiO_2)...	19·2		0·31	——
Iron (Fe)....	0·45		0·07	0·01
Aluminium (Al)....	4·30		0·08	——
Manganese (Mn)...	——		——	——
Calcium (Ca)....	49·6		0·80	1·26
Strontium (Sr)....	——		——	——
Magnesium (Mg) ...	122·8		1·99	5·15
Lithium (Li)	0·3		——	0·02
Potassium (K).....	145·2		2·34	1·89
Sodium (Na)....	1,872·1		30·25	41·51
Ammonium (NH_4)...	5·7		0·09	0·16
Total....................	6,184·80		100·00	100·00
Total solids in solution, residue dried at 110°C............	5,586			Concentration value. 196·20

Gases:		c.c. per litre.	Parts per million.
	Carbon Dioxide CO_2..		
	Hydrogen Sulphide H_2S .	0·4	0·6

HYPOTHETICAL COMBINATIONS.

No. 63.

Constituent:—		Parts per million.	Total inorganic matter in solution. Per cent.	Previous analysis.
Sodium nitrite	($NaNO_2$)	2·0	0·03	
Sodium nitrate	($NaNO_3$)	67·6	1·10	
Ammonium chloride	(NH_4Cl)	17·1	0·28	
Potassium iodide	(KI)	0·6	0·01	
Potassium bromide	(KBr)	9·0	0·15	
Lithium chloride	($LiCl$)	1·8	0·03	
Potassium chloride	(KCl)	271·4	4·39	
Sodium chloride	($NaCl$)	4,423·0	71·50	
Magnesium chloride	($MgCl_2$)			
Calcium chloride	($CaCl_2$)			
Sodium sulphate	(Na_2SO_4)	4·0	0·06	
Magnesium sulphate	($MgSO_4$)			
Calcium sulphate	($CaSO_4$)			
Sodium bicarbonate	($NaHCO_3$)	411·0	6.64	
Magnesium bicarbonate	($Mg(HCO_3)_2$)	747·0	12·09	
Calcium bicarbonate	($Ca(HCO_3)_2$)	201·0	3·25	
Strontium bicarbonate	($Sr(HCO_3)_2$)			
Ferrous bicarbonate	($Fe(HCO_3)_2$)	1·5	0·02	
Calcium phosphate	($Ca_3(PO_4)_2$)	0·1	—	
Ferric oxide	(Fe_2O_3)			
Alumina	(Al_2O_3)	8·5	0·14	
Silica	(SiO_2)	19·2	0·31	
		6,184·8	100·00	

ST. BENOIT SPRING, ST. BENOIT, TWO MOUNTAINS CO., QUE.

No. 64.

The spring rises in a well in a small wooden house, and the small overflow runs into a creek about 200 yards away. It is the property of Alfred Ferland, and is bottled by the Canadian Aerated Co., of Montreal. According to Sterry Hunt the origin of the water is the Potsdam formation (Geology of Canada 1863, p. 542). Analysis shows the water to be a moderately mineralized, sodic, muriated water of the saline type. The chief compounds assumed to be present are sodium chloride, 77·6 per cent, magnesium chloride, 10 per cent, calcium chloride and calcium sulphate—both about 3 per cent.

ST. BENOIT SPRING.

Laboratory No. 64.

Sample collected	September, 1914.
Temperature	10·5°C. (51°F.)
Flow	Small.
Taste	Slightly saline.
Reaction	
Specific gravity at 15°C.	1·004.

Radioactivity...............Emanation...............28 units
Dissolved radium......... —
Emanation in gas evolved.

Properties of reaction in per cent.
Primary salinity..........78·88
Secondary salinity........19·14
Primary alkalinity........
Secondary alkalinity...... 1·98

Analysis.

Constituents:—		Previous analysis.	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO$_4$)..........	115·6		2·20	1·32
Bicarbonic acid (HCO$_3$)........	109·2		2·09	0·99
Carbonic acid (CO$_3$)..........	——		——	——
Nitric acid (NO$_3$)..........	1·8		0·03	——
Nitrous acid (NO$_2$)..........	——		——	——
Phosphoric acid (PO$_4$)..........	——		——	——
Metaboric acid (BO$_2$)..........	trace		——	——
Chlorine (Cl)...........	3,062·		58·21	47·61
Bromine (Br)...........	12·0		0·23	0·08
Iodine (I)............	1·0		0·02	——
Silica (SiO$_2$)..........	7·53		0·14	——
Iron (Fe).......... Aluminium (Al)..........	5·74		0·11	0·11
Manganese (Mn)..........	0·25		0·05	——
Calcium (Ca)..........	148·1		2·82	4·08
Strontium (Sr)...........	1·64		0·03	0·02
Magnesium (Mg)..........	140·		2·68	6·35
Lithium (Li)...........	1·27		0·03	0·10
Potassium (K)...........	43·8		0·84	0·62
Sodium (Na)..........	1,606·8		30·54	38·55
Ammonium (NH$_4$)..........	0·55		0·01	0·17
Total.....................	5,263·28		100·00	100·00
Total solids in solution, residue dried at 110°C.............	5,530·			Concentration value. 181·26

		c.c. per litre.	Parts per million.
Gases:	Carbon Dioxide CO$_2$......	22·5	44·3
	Hydrogen Sulphide H$_2$S...	0·5	0·8

HYPOTHETICAL COMBINATIONS.

No. 64.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)............			
Sodium nitrate	($NaNO_3$)............	2·47	0·05	
Ammonium chloride	(NH_4Cl)............	16·32	0·31	
Potassium iodide	(KI)...............	1·33	0·03	
Potassium bromide	(KBr)...............	17·85	0·34	
Lithium chloride	($LiCl$)..............	7·69	0·15	
Potassium chloride	(KCl)...............	71·89	1·37	
Sodium chloride	($NaCl$)..............	4,085·11	77·62	
Magnesium chloride	($MgCl_2$)............	548·71	10·42	
Calcium chloride	($CaCl_2$).............	193·00	3·66	
Sodium sulphate	(Na_2SO_4)...........			
Magnesium sulphate	($MgSO_4$)............			
Calcium sulphate	($CaSO_4$).............	163·74	3·11	
Sodium bicarbonate	($NaHCO_3$)...........			
Magnesium bicarbonate	($Mg(HCO_3)_2$)........			
Calcium bicarbonate	($Ca(HCO_3)_2$).........	124·70	2·37	
Strontium bicarbonate	($Sr(HCO_3)_2$)..........	3·87	0·07	
Ferrous bicarbonate	($Fe(HCO_3)_2$).........	18·25	0·35	
Calcium phosphate	($Ca_3(PO_4)_2$)..........			
Ferric oxide	(Fe_2O_3).............			
Alumina	(Al_2O_3).............			
Silica	(SiO_2)..............	7·53	0·14	
Manganous bicarbonate	($Mn(HCO_3)_2$)........	0·80	0·01	
		5,263·26	100·00	

SPRING IN BOWMAN TOWNSHIP, LABELLE CO., QUE.

No. 152—1915.

This spring, the property of Mr. Eugene Lafleur, has not been visited by officers of the Department, and consequently no radioactive determinations have been carried out. The following analysis was made of a sample collected in August, 1915.

The water is a moderately mineralized, sodic, calcic, muriated saline water:—

SPRING IN BOWMAN TOWNSHIP.

Laboratory No. 152—1915.

Sample collected..............August, 1915.
Temperature.................
Flow.......................Small.
Taste.......................Slightly saline.
Reaction.....................Alkaline
Specific gravity at 15°C.......1·0035.

Radioactivity................Emanation.
Dissolved radium.
Emanation in gas evolved.

Properties of reaction in per cent.

Primary salinity..........	48·60
Secondary salinity.........	49·84
Primary alkalinity........	—
Secondary alkalinity......	1·56

Analysis.

Constituents:—		Previous analysis.	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO$_4$)..........	335·4		10·2	6·16
Bicarbonic acid (HCO$_3$)........	53·1		1·6	0·78
Carbonic acid (CO$_3$)..........	—		—	
Nitric acid (NO$_3$)..........	0·7		—	
Nitrous acid (NO$_2$)..........	trace		—	
Phosphoric acid (PO$_4$)..........	—		—	
Metaboric acid (BO$_2$)..........	—		—	
Chlorine (Cl)............	1,734·0		52·9	43·06
Bromine (Br)..........				
Iodine (I)............				
Oxygen for Fe$_2$O$_3$ & Al$_2$O$_3$........	0·6		—	
Silica (SiO$_2$)..........	12·1		0·4	—
Iron (Fe)......... Aluminium (Al)..........	1·2		—	
Manganese (Mn)..........	—		—	
Calcium (Ca)...........	396·5		12·1	17·50
Strontium (Sr)...........	trace		—	
Magnesium (Mg)..........	113·7		3·5	8·20
Lithium (Li)...........	—		—	
Potassium (K)...........	trace		19·3	24·30
Sodium (Na)..........	632·			
Ammonium (NH$_4$).........	0·18		—	
Total.....................	3,279·48		100·0	100·00
Total solids in solution, residue dried at 110° C.............	3,096·			Concentration value. 113·38

Gases:		c.c. per litre.	Parts per million.
	Carbon Dioxide CO$_2$....	—	—
	Hydrogen Sulphide H$_2$S	—	—

HYPOTHETICAL COMBINATIONS.

No. 152—1915.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	$(NaNO_2)$			
Sodium nitrate	$(NaNO_3)$	0·94	—	
Ammonium chloride	(NH_4Cl)	0·54	—	
Potassium iodide	(KI)			
Potassium bromide	(KBr)			
Lithium chloride	$(LiCl$			
Potassium chloride	(KCl)			
Sodium chloride	$(NaCl)$	1,608·0	49·1	
Magnesuim chloride	$(MgCl_2)$	445·5	13·6	
Calcium chloride	$(CaCl_2)$	666·0	20·3	
Sodium sulphate	(Na_2SO_4)			
Magnesium sulphate	$(MgSO_4)$			
Calcium sulphate	$(CaSO_4)$	475·6	14·5	
Sodium bicarbonate	$(NaHCO_3)$			
Magnesium bicarbonate	$(Mg(HCO_3)_2)$			
Calcium bicarbonate	$(Ca(HCO_3)_2)$	69·0	2·1	
Strontium bicarbonate	$(Sr(HCO_3)_2)$			
Ferrous bicarbonate	$(Fe(HCO_3)_2)$			
Calcium phosphate	$(Ca_3(PO_4)_2)$			
Ferric oxide	(Fe_2O_3)	1·8		
Alumina	(Al_2O_3)			
Silica	(SiO_2)	12·1	0·4	
		3,279·48	100·0	

ALBERTA

Several strongly saline springs are known in Mackenzie basin, and have been referred to in geological reports by Sir J. Richardson, Mr. R. G. McConnell, and Mr. C. Camsell. They have more recently been described by Mr. L. H. Cole[1] who gives complete references to earlier descriptions, but no analyses have previously been made.

In 1916, Mr. Charles Camsell of the Geological Survey made an examination[2] of the gypsum beds exposed on the lower part of the Peace river, on Slave river and on Salt river in northern Alberta, and in the course of his work collected samples from several springs rising in that region, with the object of ascertaining the possibility of potassium salt deposits being associated with the gypsum. Of the five springs of which analyses were made, three are brines; and Mr. Camsell states his opinion that the saline constituents are derived from the solution of salt crystal disseminated through the gypsum rather than from interstratified salt beds, the more usual origin of brine springs.

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[1] Cole, L. H., The Salt Deposits of Canada, Mines Branch, Report No. 325, pp. 83–90, 1915.

[2] Camsell, Charles, Salt and Gypsum Beds of the Region between Peace and Slave Rivers, Northern Alberta. Geol. Surv., Can., Sum. Rep. 1916, p. 134.

Salt is gathered from two of the springs by the Hudson's Bay Company and by the Roman Catholic Mission. The following description[1] is given of the method of collection.

> In each of the springs the water rises among an accumulation of boulders near the base of an escarpment and flows thence into shallow circular basins after which the water trickles away through barren salt-encrusted clay flats to the river. On evaporation, salt is precipitated from the brine in the basins and is gathered at these points. The basins are usually about 15 or 30 feet in diameter and are in many cases surrounded by a natural dike of clay or gravel 1 to 3 feet high. The bottoms of the basins are floored with a deposit of salt of varying thickness. In other cases hillocks of salt 12 or 15 feet in diameter and up to 2 feet in height are formed at the springs.

The two other springs are much less mineralized, and different in character. That from Sulphur Point may be classified as a moderately-mineralized calcic sulphated saline (sulphuretted) water, and somewhat resembles the Banff Springs, though the percentage of sodium chloride is higher than in those waters. Sulphides are probably also present, but no quantitative determination of them was carried out. The water from Vermilion Chutes is a strongly mineralized, sodic, muriated, saline (sulphuretted) water.

HUDSON'S BAY SPRINGS.

Situated at the forks of Salt River.

Sample collected	August 21, 1916.
Temperature	4·4°C. (40°F).
Flow	1½ gallons a minute from each of eight springs.
Taste	Strongly saline and bitter.
Reaction	
Specific gravity at 15°C	1·204.
Radioactivity	Emanation. Dissolved radium. Emanation in gas evolved.

Properties of reaction in per cent.

Primary salinity	98·2
Secondary salinity	1·8
Primary alkalinity	
Secondary alkalinity	

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[1] Geol. Surv., Can., Sum. Rep. 1916, p. 141.

Analysis.

Constituents:—			Previous analysis.	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4) ...	3,100		1·2	0·7
Bicarbonic acid	(HCO_3).				
Carbonic acid	(CO_3)...				
Nitric acid	(NO_3)...				
Nitrous acid	(NO_2)...				
Phosphoric acid	(PO_4)...				
Metaboric acid	(BO_2)...				
Chlorine	(Cl)...	157,700		59·7	49·3
Bromine	(Br)...				
Iodine	(I)....				
Silica	(SiO_2)...				
Iron	(Fe)....				
Aluminium	(Al)....				
Manganese	(Mn)...				
Calcium	(Ca)....	1,200		0·4	0·7
Strontium	(Sr).....				
Magnesium	(Mg) ...	200		0·1	0·2
Lithium	(Li)				
Potassium	(K).....	500		0·2	0·1
Sodium	(Na)....	101,500		38·4	49·0
Ammonium	(NH_4) ..				
Total.....................		264,200		100·0	100·0 Concentration value. 9,005·1

HYPOTHETICAL COMBINATIONS.

No. 245·4.

Constituent:—		Parts per million.	Total inorganic matter in solution. Per cent.	Previous analysis.
Sodium nitrite	($NaNO_2$)............			
Sodium nitrate	($NaNO_3$)............			
Ammonium chloride	(NH_4Cl)............			
Potassium iodide	(KI)................			
Potassium bromide	(KBr)..............			
Lithium chloride	(LiCl)..............			
Potassium chloride	(KCl)...............	900	0·3	
Sodium chloride	(NaCl)..............	258,000	97·7	
Magnesium chloride	($MgCl_2$)............	800	0·3	
Calcium chloride	($CaCl_2$)............			
Sodium sulphate	(Na_2SO_4)...........	400	0·1	
Magnesium sulphate	($MgSO_4$)............			
Calcium sulphate	($CaSO_4$)............	4,100	1·6	
Sodium bicarbonate	($NaHCO_3$)...........			
Magnesium bicarbonate	($Mg(HCO_3)_2$).........			
Calcium bicarbonate	($Ca(HCO_3)_2$).........			
Strontium bicarbonate	($Sr(HCO_3)_2$).........			
Ferrous bicarbonate	($Fe(HCO_3)_2$).........			
Calcium phosphate	($Ca_3(PO_4)_2$).........			
Ferric oxide	(Fe_2O_3)............			
Alumina	(Al_2O_3)............			
Silica	(SiO_2)..............			
		264,200	100·0	

MISSION SPRINGS.

About six miles south of the forks of Salt River.

Sample collected..............August 26, 1916.
Temperature.................1·7°C. (35°F).
Flow........................3 gallons a minute.
Taste.......................Strongly saline and bitter.
Reaction....................Neutral.
Specific gravity at 15°C........1·202.
Radioactivity...............Emanation.
Dissolved radium.
Emanation in gas evolved.

Properties of reaction in per cent.

Primary salinity..........98·2
Secondary salinity........ 1·8
Primary alkalinity.......
Secondary alkalinity......

Analysis.

Constituents:—			Previous analysis.	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4)...	3,100		1·2	0·7
Bicarbonic acid	(HCO_3)				
Carbonic acid	(CO_3)...				
Nitric acid	(NO_3)...				
Nitrous acid	(NO_2)...				
Phosphoric acid	(PO_4)...				
Metaboric acid	(BO_2)...				
Chlorine	(Cl)....	156,600		59·7	49·3
Bromine	(Br)...				
Iodine	(I).....				
Silica	(SiO_2)...				
Iron	(Fe)....				
Aluminium	(Al)....				
Manganese	(Mn)...				
Calcium	(Ca)....	1,200		0·4	0·7
Strontium	(Sr).....				
Magnesium	(Mg)...	200		0·1	0·2
Lithium	(Li).....				
Potassium	(K).....	400		0·1	0·1
Sodium	(Na)....	100,800		38·5	49·0
Ammonium	(NH_4)..				
Total..................		262,300		100·0	100·0 Concentration value. 8,941·0

HYPOTHETICAL COMBINATIONS.

No. 245·3.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)............			
Sodium nitrate	($NaNO_3$)............			
Ammonium chloride	(NH_4Cl)............			
Potassium iodide	(KI)................			
Potassium bromide	(KBr)...............			
Lithium chloride	(LiCl)..............			
Potassium chloride	(KCl)...............	800	0·3	
Sodium chloride	(NaCl)..............	256,300	97·7	
Magnesium chloride	($MgCl_2$)............	800	0·3	
Calcium chloride	($CaCl_2$)............			
Sodium sulphate	(Na_2SO_4)............	200	0·1	
Magnesium sulphate	($MgSO_4$)............			
Calcium sulphate	($CaSO_4$)............	4,200	1·6	
Sodium bicarbonate	($NaHCO_3$)...........			
Magnesium bicarbonate	($Mg(HCO_3)_2$)........			
Calcium bicarbonate	($Ca(HCO_3)_2$).........			
Strontium bicarbonate	($Sr(HCO_3)_2$).........			
Ferrous bicarbonate	($Fe(HCO_3)_2$).........			
Calcium phosphate	($Ca_3(PO_4)_2$)..........			
Ferric oxide	(Fe_2O_3).............			
Alumina	(Al_2O_3).............			
Silica	(SiO_2)..............			
		262,300	100·0	

SNAKE MOUNTAIN SPRINGS.

About 2 miles east of Mission Springs.

Sample collected.............August 29, 1916.
Temperature................4·4°C. (40°F.)
Flow.......................4 to 5 gallons per minute.
Taste......................Strongly saline and bitter.
Reaction...................Neutral.
Specific gravity at 15°C........1·202.
Radioactivity...............Emanation.
Dissolved radium.
Emanation in gas evolved.

Properties of reaction in per cent.

Primary salinity..........98·2
Secondary salinity........ 1·8
Primary alkalinity........
Secondary alkalinity......

Analysis.

Constituents:—			Previous analysis.	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4)...	3,100		1·2	0·7
Bicarbonic acid	(HCO_3).				
Carbonic acid	(CO_3)...				
Nitric acid	(NO_3)...				
Nitrous acid	(NO_2)...				
Phosphoric acid	(PO_4)...				
Metaboric acid	(BO_2)...				
Chlorine	(Cl)....	156,400		59·7	49·3
Bromine	(Br)...				
Iodine	(I).....				
Silica	(SiO_2)...				
Iron	(Fe)....				
Aluminium	(Al)....				
Manganese	(Mn)...				
Calcium	(Ca)....	1,200		0·4	0·7
Strontium	(Sr).....				
Magnesium	(Mg) ...	200		0·1	0·2
Lithium	(Li).....				
Potassium	(K).....	400		0·2	0·1
Sodium	(Na)....	100,700		38·4	49·0
Ammonium	(NH_4) ..				
Total....................		262,000		100·0	100·0 Concentration value. 8,927·7

HYPOTHETICAL COMBINATIONS.

No. 245·5.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)......			
Sodium nitrate	($NaNO_3$)......			
Ammonium chloride	(NH_4Cl)......			
Potassium iodide	(KI).........			
Potassium bromide	(KBr)........			
Lithium chloride	(LiCl)........			
Potassium chloride	(KCl)........	800·	0·3	
Sodium chloride	(NaCl)........	256,000·	97·7	
Magnesium chloride	($MgCl_2$).......	800·	0·3	
Calcium chloride	($CaCl_2$).......			
Sodium sulphate	(Na_2SO_4)......	200·	0·1	
Magnesium sulphate	($MgSO_4$)......			
Calcium sulphate	($CaSO_4$)......	4,200·	1·6	
Sodium bicarbonate	($NaHCO_3$).....			
Magnesium bicarbonate	($Mg(HCO_3)_2$)..			
Calcium bicarbonate	($Ca(HCO_3)_2$)...			
Strontium bicarbonate	($Sr(HCO_3)_2$)...			
Ferrous bicarbonate	($Fe(HCO_3)_2$)...			
Calcium phosphate	($Ca_3(PO_4)_2$)....			
Ferric oxide	(Fe_2O_3)........			
Alumina	(Al_2O_3)........			
Silica	(SiO_2).........			
		262,000·	100·0	

SULPHUR POINT SPRING.

Situated on the south shore of Great Slave Lake.

Laboratory No. 245·2—1916.

Sample collected............August 4, 1916.
Temperature................
Flow.......................2 gallons a minute.
Taste......................Strongly sulphurous.
Reaction...................
Specific gravity at 15°C.......1·002.
Radioactivity...............Emanation.
Dissolved radium.
Emanation in gas evolved.

Properties of reaction in per cent.
Primary salinity..........20·2
Secondary salinity........66·0
Primary alkalinity........
Secondary alkalinity......13·8

Analysis.

Constituents:—		Previous analysis.	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO_4).........	1,500·		51·8	36·2
Bicarbonic acid (HCO_3).......	370·		12·8	6·9
Carbonic acid (CO_3).........	—			
Nitric acid (NO_3).........	—			
Nitrous acid (NO_2).........	—			
Phosphoric acid (PO_4).........	—			
Metaboric acid (BO_2).........	—			
Chlorine (Cl)......... Bromine (Br)......... Iodine (I).........	213·		7·4	6·9
Silica (SiO_2).........	—			
Iron (Fe).........	—			
Aluminium (Al).........	—			
Manganese (Mn).........	—			
Calcium (Ca).........	480·		16·6	27·6
Strontium (Sr).........	—			
Magnesium (Mg).........	130·		4·5	12·3
Lithium (Li).........	—			
Potassium (K).........	trace		—	
Sodium (Na).........	200·		6·9	10·1
Ammonium (NH_4).........	—			—
Total....................	2,893·		100·0	100·0
Total solids in solution, residue dried at 110°C..............	2,925·			Concentration value. 86·8

Gases:	c.c. per litre.	Parts per million.
Carbon Dioxide CO_2	—	—
Hydrogen Sulphide H_2S.....	26·	42·

HYPOTHETICAL COMBINATIONS.

No. 245·2.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$).......			
Sodium nitrate	($NaNO_3$).......			
Ammonium chloride	(NH_4Cl).......			
Potassium iodide	(KI)..........			
Potassium bromide	(KBr).........			
Lithium chloride	(LiCl).........			
Potassium chloride	(KCl)..........	trace	—	
Sodium chloride	(NaCl).........	351·	12·1	
Magnesium chloride	($MgCl_2$).......	191·	6·6	
Calcium chloride	($CaCl_2$)........			
Sodium sulphate	(Na_2SO_4)......			
Magnesium sulphate	($MgSO_4$)......	644·	22·3	
Calcium sulphate	($CaSO_4$).......	1,220·	42·2	
Sodium bicarbonate	($NaHCO_3$).....			
Magnesium bicarbonate	($Mg(HCO_3)_2$)..			
Calcium bicarbonate	($Ca(HCO_3)_2$)...	486·	16·8	
Strontium bicarbonate	($Sr(HCO_3)_2$)...			
Ferrous bicarbonate	($Fe(HCO_3)_2$)...			
Calcium phosphate	($Ca_3(PO_4)_2$)....			
Ferric oxide	(Fe_2O_3)........			
Alumina	(Al_2O_3)........			
Silica	(SiO_2).........			
		2,892·	100·0	

VERMILION CHUTES SPRING.

From a bore hole 268 feet at Vermilion Chutes on Peace River.

Sample collected	July 13, 1916.
Temperature	5·5°C. (42° F.)
Flow	42 gallons a minute.
Taste	Saline and strongly of hydrogen sulphide.
Reaction	
Specific gravity at 15°C	1·011.
Radioactivity	Emanation. Dissolved radium. Emanation in gas evolved.

Properties of reaction in per cent.

Primary salinity	87·6
Secondary salinity	12·4
Primary alkalinity	
Secondary alkalinity	

Analysis.

Constituents:—			Previous analysis.	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4)	100·		0·7	0·4
Bicarbonic acid	(HCO_3)				
Carbonic acid	(CO_3)				
Nitric acid	(NO_3)				
Nitrous acid	(NO_2)				
Phosphoric acid	(PO_4)				
Metaboric acid	(BO_2)				
Chlorine	(Cl)	8,340·		60·9	49·6
Bromine	(Br)				
Iodine	(I)				
Silica	(SiO_2)				
Iron	(Fe)				
Aluminium	(Al)				
Manganese	(Mn)				
Calcium	(Ca)	289·		2·1	3·0
Strontium	(Sr)				
Magnesium	(Mg)	189·		1·4	3·2
Lithium	(Li)				
Potassium	(K)	12·		0·1	0·2
Sodium	(Na)	4,760·		34·8	43·6
Ammonium	(NH_4)				
Total		13,690·		100·0	100·0
Total solids in solution, residue dried at 110°C		15,250·			

Gases:	c.c. per litre.	Parts per million.
Carbon Dioxide CO_2	——	——
Hydrogen Sulphide H_2S	250·	400·

HYPOTHETICAL COMBINATIONS.

No. 245·1.

Constituent:—		Parts per million.	Total inorganic matter in solution. Per cent.	Previous analysis.
Sodium nitrite	($NaNO_2$)			
Sodium nitrate	($NaNO_3$)			
Ammonium chloride	(NH_4Cl)			
Potassium iodide	(KI)			
Potassium bromide	(KBr)			
Lithium chloride	($LiCl$)			
Potassium chloride	(KCl)	22	0·2	
Sodium chloride	($NaCl$)	12,100	88·4	
Magnesium chloride	($MgCl_2$)	739	5·4	
Calcium chloride	($CaCl_2$)	688	5·0	
Sodium sulphate	(Na_2SO_4)			
Magnesium sulphate	($MgSO_4$)			
Calcium sulphate	($CaSO_4$)	143	1·0	
Sodium bicarbonate	($NaHCO_3$)			
Magnesium bicarbonate	($Mg(HCO_3)_2$)			
Calcium bicarbonate	($Ca(HCO_3)_2$)			
Strontium bicarbonate	($Sr(HCO_3)_2$)			
Ferrous bicarbonate	($Fe(HCO_3)_3$)			
Calcium phosphate	($Ca_3(PO_4)_2$)			
Ferric oxide	(Fe_2O_3)			
Alumina	(Al_2O_3)			
Silica	(SiO_2)			
		13,692	100·0	

SULPHUR SPRING, JASPER PARK, ALBERTA.

(140)

The following analysis is a sample of water collected from a newly discovered spring in Fiddle Creek Canyon, Jasper Park, Alberta.

Only a trace of hydrogen sulphide was detected in the water, owing to the fact that three months had elapsed since the collection of the sample.

It resembles some of the Banff waters in being a calcic, sulphated, saline (sulphuretted) water.

SULPHUR SPRING.

Laboratory No. 140.

Sample collected..............May, 1915.
Temperature................
Flow.......................
Taste........................Slight taste of hydrogen sulphide.
Reaction....................Alkaline.
Specific gravity at 15°C.......1·0004.
Radioactivity................Emanation...............} Not tested.
Dissolved radium.........
Emanation in gas evolved.
Properties of reaction in per cent.
Primary salinity..........26·20
Secondary salinity........18·16
Primary alkalinity........
Secondary alkalinity......55·64

Analysis.

Constituents:—		Previous analysis.	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO_4)...	114·8		18·7	14·46
Bicarbonic acid (HCO_3)	280·6		45·8	27·82
Carbonic acid (CO_3)...	——			
Nitric acid (NO_3)...	——			
Nitrous acid (NO_2)...	——			
Phosphoric acid (PO_4)...	——			
Metaboric acid (BO_2)...	——			
Chlorine (Cl)....	45·0		7·3	7·72
Bromine (Br)....	——			
Iodine (I)......	——			
Oxygen for Fe_2O_3 & Al_2O_3......	2·2		0·4	——
Silica (SiO_2)...	8·9		1·4	——
Iron (Fe)... }	5·1		0·8	——
Aluminium (Al).... }				
Manganese (Mn)...	——			
Calcium (Ca)....	85·9		14·0	26·00
Strontium (Sr).....	trace		——	——
Magnesium (Mg)..	21·8		3·5	10·90
Lithium (Li).....	——		——	——
Potassium (K).....	trace		——	——
Sodium (Na)....	50·0		8·1	13·10
Ammonium (NH_4) ..	——		——	——
Total....................	614·3		100·00	100·00
Total solids in solution, residue dried at 110°C............	503·			Concentration value. 16·52

Gases :	c.c. per litre.	Parts per million.
Carbon Dioxide CO_2....	——	——
Hydrogen Sulphide H_2S	trace.	trace.

HYPOTHETICAL COMBINATIONS.

No. 140.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)			
Sodium nitrate	($NaNO_3$)			
Ammonium chloride	(NH_4Cl)			
Potassium iodide	(KI)			
Potassium bromide	(KBr)			
Lithium chloride	($LiCl$)			
Potassium chloride	(KCl)			
Sodium chloride	($NaCl$)	82·4	13·4	
Magnesium chloride	($MgCl_2$)			
Calcium chloride	($CaCl_2$)			
Sodium sulphate	(Na_2SO_4)	54·4	8·8	
Magnesium sulphate	($MgSO_4$)	100·0	16·3	
Calcium sulphate	($CaSO_4$)			
Sodium bicarbonate	($NaHCO_3$)			
Magnesium bicarbonate	($Mg(HCO_3)_2$)	13·3	2·2	
Calcium bicarbonate	($Ca(HCO_3)_2$)	348·0	56·7	
Strontium bicarbonate	($Sr(HCO_3)_2$)			
Ferrous bicarbonate	($Fe(HCO_3)_2$)			
Calcium phosphate	($Ca_3(PO_4)_2$)			
Ferric oxide	(Fe_2O_3)	7·3	1·2	
Alumina	(Al_2O_3)			
Silica	(SiO_2)	8·9	1·4	
		614·3	100·0	

THE HOT SULPHUR SPRINGS AT BANFF, ALBERTA.

Seven hot springs in the neighbourhood of Banff in the Rocky Mountains National Park, form the third group of springs investigated. They were visited in November and December, 1916, when many tests were carried out—especially in connexion with other radioactive properties. As the famous Harrison Hot Springs and Halcyon Hot Springs in British Columbia have not yet been examined, the Banff Springs are the only thermal waters that have been investigated in Canada. The origin of hot springs is the subject of much discussion among geologists, even at the present day, and numerous theories have been proposed to account for the phenomena of hot springs and geysers. In the case of the Banff Springs, the explanation may most reasonably be sought in the high temperature of the earth's crust in that neighbourhood due to the tremendous stresses and strains that have been set up during the formation of the mountains.[1] Water in its underground circulation, over heated rock-masses, will become heated, and issue as hot springs.

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[1] Camsell, C. The Geology of the Canadian National Parks, Dominion Parks Branch, p. 15, 1914.

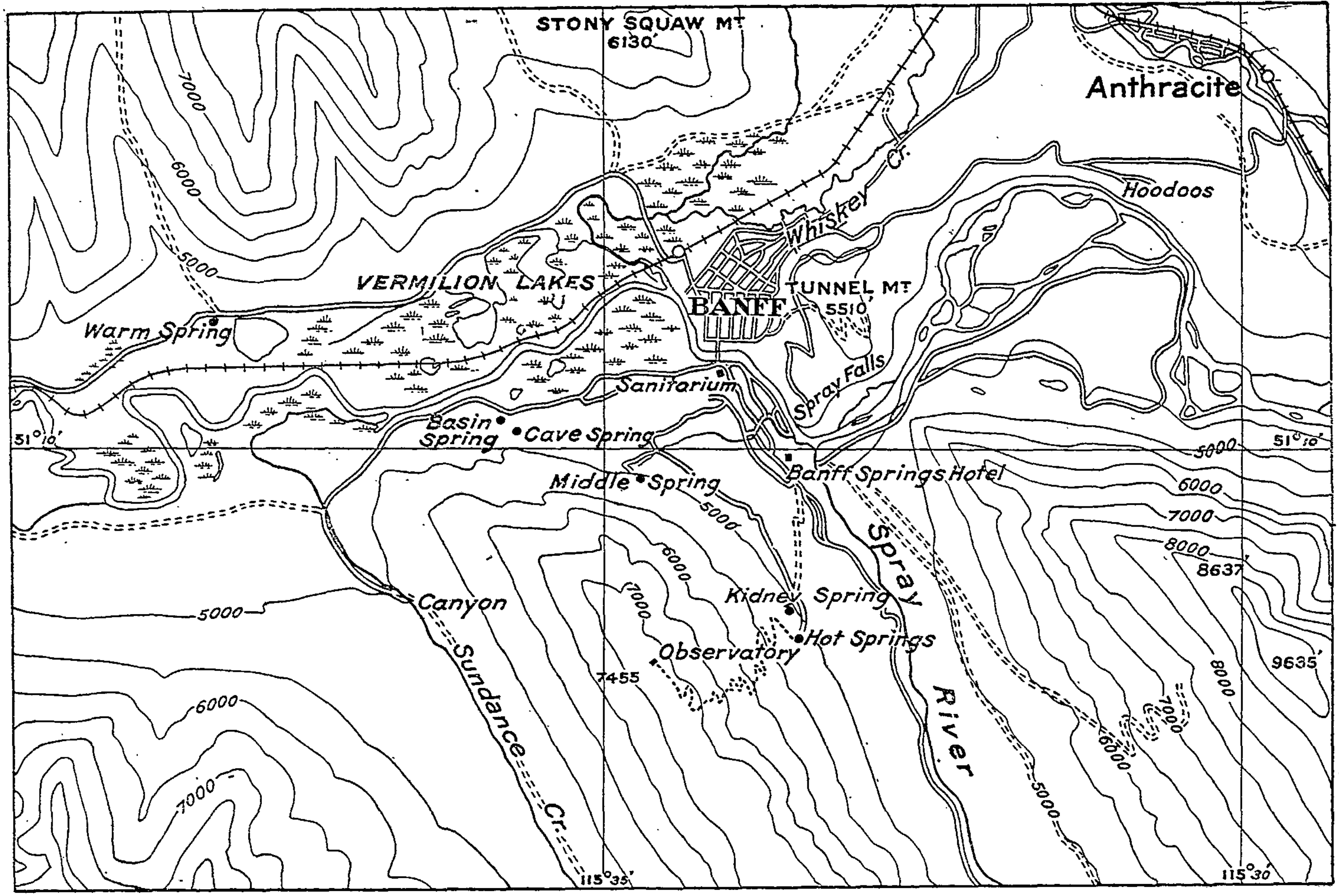

Fig. 2. Map of Banff, Alberta: showing location of hot springs. (Scale : 1 mile to 1 inch.)

The radioactive determinations show the Banff Springs to be the most active of any yet examined in Canada,[1] although the results obtained are not as high as many of the most important European springs.

Individual descriptions of the springs follow. There is a great similarity between the waters from the various sources, as might be expected. They may all be classified as moderately mineralized, calcic, sulphated, saline (sulphuretted) waters. Save in the Basin Spring water, calcium sulphate forms about 60 per cent, magnesium sulphate 18 per cent, and calcium bicarbonate about 15 per cent of the total solid matter in solution. The waters somewhat resemble those of the famous Bath Hot Springs in England, and would, therefore, be of similar therapeutic value. Some notes on the therapeutic properties of sulphur springs are included after the analyses, and a brief account of the way in which the Bath waters are employed in the treatment of disease.

THE UPPER HOT SPRING.

The Upper Hot Spring rises on the northeast side of Sulphur mountain at an altitude of 5,000 feet above sea-level, and about 500 feet above the valley of the Bow river. It is therefore, the most elevated of any of the springs, and was called the Upper Hot Spring to distinguish it from those lower down the mountain. This spring was the first to be used by invalids, who bathed in a hole dug in the ground close to the source of the water. In the early days, many a discarded crutch was to be found in the vicinity, bearing eloquent testimony of the healing powers of the hot sulphur waters.

The spring is reached to-day, by a well-made road winding up the pine covered slopes of Sulphur mountain—a pleasant three mile walk or drive from the town. Starting from Banff avenue, one crosses the Bow bridge, turns to the left along Spray avenue—the road to the Banff Springs Hotel—till a road branching off to the right is reached. This road, called Mountain avenue, is followed, winding up the mountain with many a curve and turn, passing the Club House of the Alpine Club of Canada, about a mile from the fork of the road, until the Hot Spring is reached. Rustic pavilions along the roadside afford both shade and rest. There is also a pony trail through the wood, which can be followed. The road ends at the Upper Hot Springs Bath House, but a bridle path continues for another two miles to an observatory on the summit of Sulphur mountain, 9,484 feet above sea-level.

In this building self-registering instruments record the temperature, barometric pressure, and other data which prove of great meteorological value. The instruments have to be attended to every week, and one can well imagine that the trip from the town in the depth of winter can hardly be enjoyable. The summit of Sulphur mountain is a favourite spot for all night excursions to witness the sun's rising, an experience well worth the exertion of the climb.

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[1] Satterly and Elworthy. Mineral Springs of Canada, Pt. I.—The Radioactivity of Some Canadian Springs, Mines Branch, Bul. 16, p. 39, 1917.

The Hot Springs Hotel—which is open all the year round, and Grand View Villa, a summer hotel, are both situated close to the Upper Hot Spring; the former on the north side, and the latter on higher ground on the south side of the road. The view from the site of the Upper Hot Spring looking down the valley of the Bow river is magnificent.

The spring itself rises in a bricked well about three feet square, and is the only spring source at Banff which has in any way been fixed up. The main volume of the water is carried by a pipe for about fifty feet down hill and across the road, where it runs into the swimming pool of the Upper Hot Spring bath house. Another pipe, three-fourths of a mile in length, conveys the water to the Banff Springs Hotel swimming bath, and to the Brett Hospital. When the flow from the spring is at its maximum, these pipes do not carry away all the water, but an overflow runs in a stream down the hillside. The channel of this stream is lined with a yellowish, sulphur-like substance, formed by deposition of material from the water. The chief constituents of this substance are calcium carbonate or limestone, calcium sulphate or gypsum, and sulphur, together with organic material consisting of the algae, which especially abound in sulphur springs.

The swimming pool is about 20 feet wide, and 40 feet long. Although heat is lost in the passage of the water from the source into the bath, it is almost as hot as one can bear, its temperature being about 95-98°F. There are also, several private baths, in great demand, into which the hot sulphur water is run directly.

The following particulars were obtained as a result of the examination and analysis of the water from the Upper Hot Spring:—

THE UPPER HOT SPRING.

Laboratory No. 65.

Samples collected	December, 1916, and January, 1917.		
Temperature	46°C. (115°F.)		
Flow	120 gallons per minute.		
Taste	Flat with slight evidence of hydrogen sulphide.		
Reaction			
Specific gravity at 15°C	1·002.		
Radioactivity	Emanation	221	units
	Dissolved radium	8·5	„
	Emanation in gas evolved.		
Properties of reaction in per cent.			
	Primary salinity	2·16	
	Secondary salinity	83·92	
	Primary alkalinity		
	Secondary alkalinity	13·92	

Analysis.

Constituents:—			Previous analysis.*	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4)...	634·	660	57·60	42·14
Bicarbonic acid	(HCO_3)	133·	——	12·08	6·96
Carbonic acid	(CO_3)...	——	——	——	——
Nitric acid	(NO_3)...	——	——	——	——
Nitrous acid	(NO_2)...	——	——	——	——
Phosphoric acid	(PO_4)...	——	——	——	——
Metaboric acid	(BO_2)...	——	——	——	——
Chlorine	(Cl)....	10·	6·0	0·91	0·90
Bromine	(Br)....	——	——	——	——
Iodine	(I)......	——	——	——	——
Silica	(SiO_2)...	31·	33·0	2·82	
Iron	(Fe)...	1·7		0·15	0·19
Aluminium	(Al)....				
Manganese	(Mn)...	0·01		——	
Calcium	(Ca)....	239·	254·	21·71	38·07
Strontium	(Sr).....	3·2		0·29	0·23
Magnesium	(Mg) ...	39·7	41·6	3·61	10·43
Lithium	(Li).....	0·1	decided trace	——	0·04
Potassium	(K).....	3·7	6·6	0·34	0·30
Sodium	(Na)....	5·3		0·48	0·73
Ammonium	(NH_4) ..	0·1		0·01	0·01
Total.....................		1,100·81	1,001·2	100·00	100·00 Concentration value.
Total solids in solution, residue dried at 110°C.............		1,098.			31·34

Gases:		c.c. per litre.	Parts per million.
	Carbon Dioxide CO_2....	25·3	49·8
	Hydrogen Sulphide H_2S	1·2	1·83

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* By Dr. A. McGill, Ottawa, 1896.

HYPOTHETICAL COMBINATIONS.

No. 65.

Constituent:—		Parts per million.	Total inorganic matter in solution. Per cent.	Previous analysis.
Sodium nitrite	($NaNO_2$)............			
Sodium nitrate	($NaNO_3$)...........			
Ammonium chloride	(NH_4Cl)...........	0·27	0·02	
Potassium iodide	(KI)...............			
Potassium bromide	(KBr)..............			
Lithium chloride	($LiCl$)..............	0·59	0·05	
Potassium chloride	(KCl)..............	7·08	0·64	
Sodium chloride	($NaCl$).............	9·82	0·89	
Magnesium chloride	($MgCl_2$)............			
Calcium chloride	($CaCl_2$)............			
Sodium sulphate	(Na_2SO_4)...........	4·40	0·40	
Magnesium sulphate	($MgSO_4$)............	196·50	17·85	
Calcium sulphate	($CaSO_4$)............	672·20	61·07	
Sodium bicarbonate	($NaHCO_3$)...........			
Magnesium bicarbonate	($Mg(HCO_3)_2$)........			
Calcium bicarbonate	($Ca(HCO_3)_2$).........	165·80	15·07	
Strontium bicarbonate	($Sr(HCO_3)_2$).........	7·65	0·69	
Ferrous bicarbonate	($Fe(HCO_3)_2$).........	5·43	0·49	
Calcium phosphate	($Ca_3(PO_4)_2$)..........			
Ferric oxide	(Fe_2O_3).............			
Alumina	(Al_2O_3).............			
Silica	(SiO_2)..............	31·0	2·82	
		1,100·74	100·00	

THE KIDNEY SPRING.

(66)

The Kidney Spring rises about 200 yards below the Upper Hot Spring, only a short distance from the road up the mountain side. The channel, white with precipitated lime and sulphur, can be seen on the right bank of the road just before the Upper Hot Spring is reached. In cold weather, its situation is especially made evident by the cloud of steam which ascends, and by the trees in the vicinity—white with rime.

No use is made of the water which issues from several small basins only a foot or two in diameter. The flow is comparatively small, approximately, about a thousand gallons per hour. The temperature is slightly lower than that of the Upper Hot Springs; but analysis proves the water to be almost identical in composition and properties.

THE KIDNEY SPRING.

Laboratory No. 66.

Sample collected	December, 1916.
Temperature	39·0°C. (101°F.)
Flow	20 gallons per minute.
Taste	Flat with evidence of hydrogen sulphide.
Reaction	
Specific gravity at 15°C	1·002
Radioactivity	Emanation 392 units
	Dissolved radium 8·5 „
	Emanation in gas evolved. —

Properties of reaction in per cent.

Primary salinity	1·68
Secondary salinity	81·54
Primary alkalinity	—
Secondary alkalinity	16·78

Analysis.

Constituents:—		Previous analysis.	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO_4)	587·		55·32	40·67
Bicarbonic acid (HCO_3)	154·		14·50	8·39
Carbonic acid (CO_3)	——		——	——
Nitric acid (NO_3)	——		——	——
Nitrous acid (NO_2)	——		——	——
Phosphoric acid (PO_4)	——		——	——
Metaboric acid (BO_2)	——		——	——
Chlorine (Cl)	10·0		0·94	0·94
Bromine (Br)	——		——	——
Iodine (I)	——		——	——
Silica (SiO_2)	31·0		2·92	——
Iron (Fe) Aluminium (Al)	0·7		0·06	0·08
Manganese (Mn)	0·01		——	——
Calcium (Ca)	230·		21·67	38·16
Strontium (Sr)	3·5		0·33	0·26
Magnesium (Mg)	39·0		3·67	10·66
Lithium (Li)	0·1		——	0·05
Potassium (K)	2·0		0·19	0·17
Sodium (Na)	4·0		0·38	0·58
Ammonium (NH_4)	0·2		0·02	0·04
Total	1,061·5		100·00	100·00
Total solids in solution, residue dried at 110°C	1,064·			Concentration value. 30·08

	c.c. per litre	Parts per million.
Gases: Carbon Dioxide CO_2	21·25	41·8
Hydrogen Sulphide H_2S	1·6	2·40

HYPOTHETICAL COMBINATIONS.

No. 66.

Constituent:—		Parts per million.	Total inorganic matter in solution. Per cent.	Previous analysis.
Sodium nitrite	($NaNO_2$)			
Sodium nitrate	($NaNO_3$)			
Ammonium chloride	(NH_4Cl)	0·59	0·06	
Potassium iodide	(KI)			
Potassium bromide	(KBr)			
Lithium chloride	($LiCl$)	0·59	0·06	
Potassium chloride	(KCl)	3·80	0·36	
Sodium chloride	($NaCl$)	10·17	0·96	
Magnesium chloride	($MgCl_2$)	1·52	0·14	
Calcium chloride	($CaCl_2$)			
Sodium sulphate	(Na_2SO_4)			
Magnesium sulphate	($MgSO_4$)	191·00	18·00	
Calcium sulphate	($CaSO_4$)	615·87	58·00	
Sodium bicarbonate	($NaHCO_3$)			
Magnesium bicarbonate	($Mg(HCO_3)_2$)			
Calcium bicarbonate	($Ca(HCO_3)_2$)	196·42	18·50	
Strontium bicarbonate	($Sr(HCO_3)_2$)	8·28	0·78	
Ferrous bicarbonate	($Fe(HCO_3)_2$)	2·22	0·21	
Calcium phosphate	($Ca_3(PO_4)_2$)			
Ferric oxide	(Fe_2O_3)			
Alumina	(Al_2O_3)			
Silica	(SiO_2)	31·0	2·93	
		1,061·46	100·00	

THE MIDDLE SPRINGS.

(67)

The Middle Springs are untouched, and still in their natural state. In fact they are so little known, that they are seldom seen by visitors to Banff, notwithstanding their interest and magnificent situation. Considerable possibilities of their utilization exist on account of the considerable flow of water and the terraced nature of the ground in the vicinity.

They are about two miles from the Bow bridge, and are reached by a good road which branches to the right, about one mile above the bridge from Mountain avenue. The flora and fauna in the neighbourhood are of great interest. In the winter months of the year, deer may be encountered almost daily near the springs. The accompanying photograph (Plate VII) gives a good idea of the situation of the springs, which issue from pools in a small cave at the foot of the upper slope of Sulphur mountain. The stream of sulphur water flows from the source to a terrace where it spreads into a wide marsh before it continues its journey down the hillside to the Bow river. The view from this terrace looking down on Banff and across the valley to Cascade mountain, towering above the town, is superb—one of the finest in Banff.

The waters issue from two sources; one, in a cave, rising in a pool, the surface of which is constantly agitated by rising bubbles of gas; the other, even more voluminous, from under a large rock at the mouth of the cave. The streams join, tumbling in a steep descent, till they run a more leisurely course over the terrace and less steep slopes of the lower mountain to the river. Varieties of algae, vegetable growths, that especially abound in the waters of hot sulphur springs, coat the sides of the channels, and adorn the rocks with vari-coloured filaments. Perhaps none of the springs at Banff can compete with the gorgeous colourings of the famous paint pots of the Yellowstone National Park. The streams are usually too rapid to allow of much growth. The following observations by W. H. Weed,[1] writing of the algae abounding in the Yellowstone Park, apply to the Banff springs.

> The general sequence of colours is well illustrated by the occurrence of such growths in overflow streams with a constant volume, such as the outlet of the Black Sand (a spring in Yellowstone Park). As the water from this spring flows along its channel it is rapidly chilled by contact with the air and by evaporation, and is soon cool enough to permit the growth of the more rudimentary forms which live at the highest temperature. These appear first in skeins of delicate white filaments which gradually change to pale flesh-pink farther downstream. As the water becomes cooler this pink becomes deeper, and a bright orange, and closely adherent fuzzy growth, rarely filamentous, appears at the border of the stream, and finally replaces the first-mentioned forms. This merges into yellowish-green which shades into a rich emerald farther down, this being the common colour of fresh-water algae. In the quiet waters of the pools fed by this stream the algae present a different development, forming leathery sheets of tough gelatinous material with coralloid and vase-shaped forms rising to the surface, and often filling up a large part of the pool. Sheets of brown or green, kelpy or leathery, also line the basins of warm springs whose temperature does not exceed 140°F., but in springs having a higher temperature the only vegetation present forms a velvety, golden-yellow fuzz upon the bottom and sides of the bowl. This growth is rarely noticed in springs where the water exceeds 160° except at the edge of the pool. If the basin is funnel-shaped with flaring or saucer-shaped expansion, algae grow in the cooler and shallower water of the margin, forming concentric rings of yellow, old gold, and orange, shading into salmon-red and crimson, and this to brown at the border of the spring. Around such springs the growth at the margin often forms a raised rim of spongy, stiff jelly, sometimes almost rubber-like in consistency, and red or brown in colour.

THE MIDDLE SPRING.

Laboratory No. 67.

Sample collected	December, 1916.		
Temperature	33·5°C. (92°F.)		
Flow	50 gallons per minute.		
Taste	Slight taste of hydrogen sulphide.		
Reaction	Neutral.		
Specific gravity at 15°C	1·0017		
Radioactivity	Emanation	294	units
	Dissolved radium	8·6	„
	Emanation in gas evolved	1910	„

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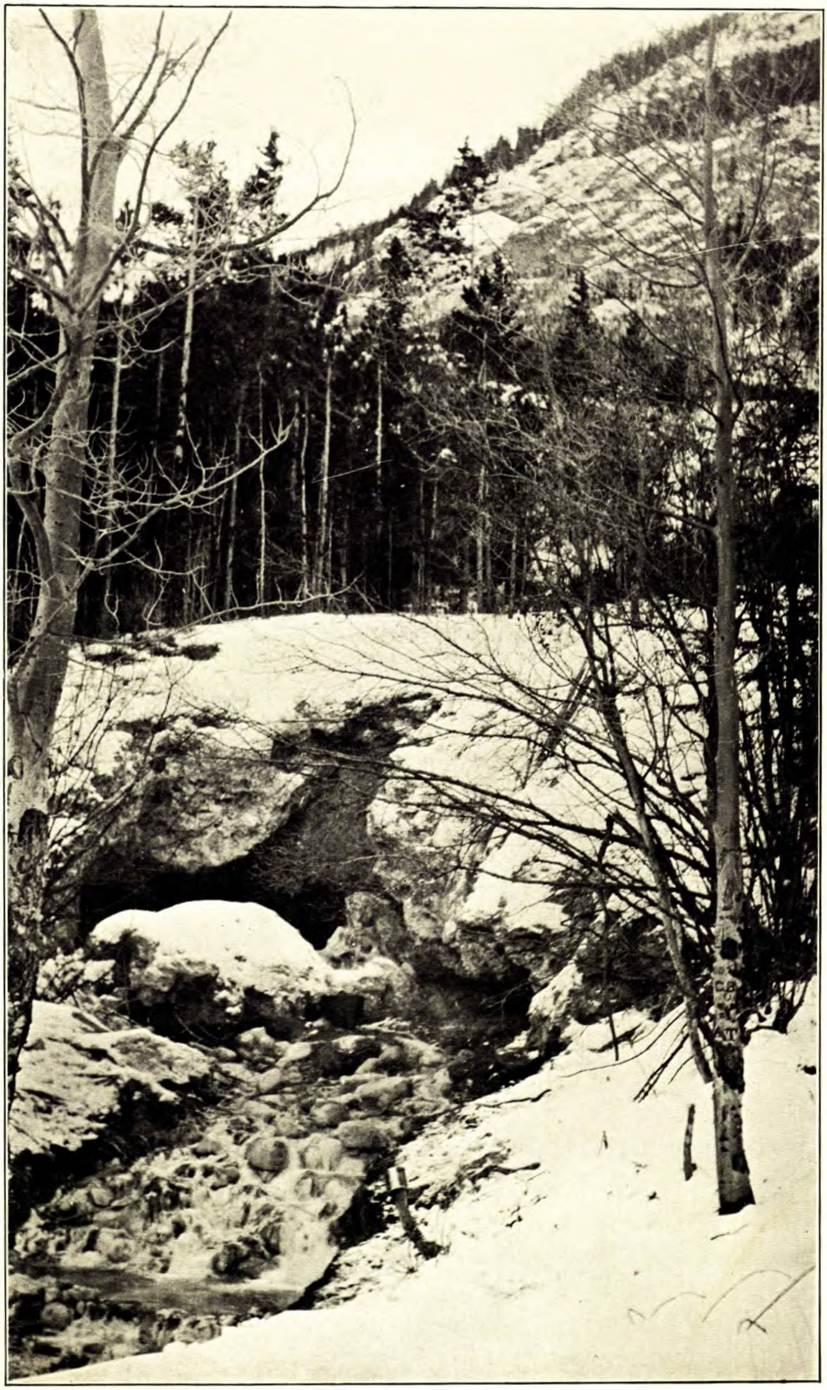
[1] Weed, W. H., Formation of Travertine and Siliceous Sinter by the Vegetation of Hot Springs: U. S. Geol. Surv., Ninth Ann. Rep., pp. 657–658, 1899.



Middle spring, Banff, Alberta.

Properties of reaction in per cent.

Primary salinity	2·10
Secondary salinity	83·94
Primary alkalinity	—
Secondary alkalinity	13·96

Analysis.

Constituents:—		Previous analysis.	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO_4)	610·		57·93	42·27
Bicarbonic acid. (HCO_3)	128·		12·16	6·98
Carbonic acid (CO_3)	—		—	—
Nitric acid (NO_3)	—		—	—
Nitrous acid (NO_2	—		—	—
Phosphoric acid (PO_4)	—		—	—
Metaboric acid (BO_2)	—		—	—
Chlorine (Cl)	8·		0·76	0·75
Bromine (Br)	—		—	—
Iodine (I)	—		—	—
Silica (SiO_2)	27·6		2·62	
Iron (Fe) Aluminium (Al)	3·3		0·31	0·39
Manganese (Mn)	trace		—	—
Calcium (Ca)	228·		21·65	37·84
Strontium (Sr)	1·0		0·10	0·07
Magnesium (Mg)	38·9		3·69	10·65
Lithium (Li)	0·2		0·02	0·09
Potassium (K)	3·3		0·31	0·28
Sodium (Na)	4·6		0·43	0·66
Ammonium (NH_4)	0·1		0·01	0·02
Total	1,053·0		100·00	100·00
Total solids in solution, residue dried at 110°C	1,059·			

Gases:	c.c. per litre.	Parts per million.
Carbon Dioxide CO_2	19·2	37·7
Hydrogen Sulphide H_2S	2·2	3·3

HYPOTHETICAL COMBINATIONS.

No. 67.

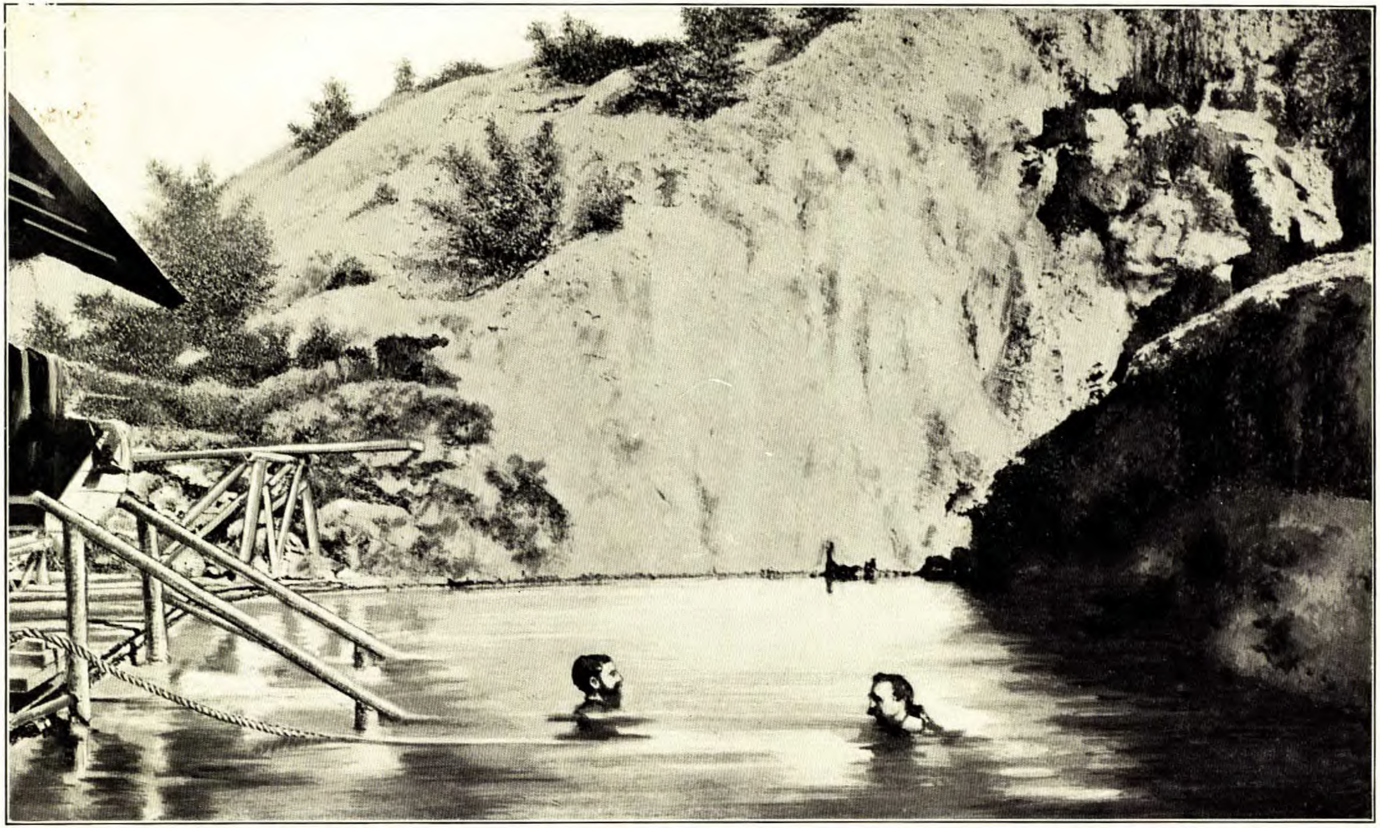
Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)			
Sodium nitrate	($NaNO_3$)			
Ammonium chloride	(NH_4Cl)	0·27	0·03	
Potassium iodide	(KI)			
Potassium bromide	(KBr)			
Lithium chloride	($LiCl$)	1·19	0·11	
Potassium chloride	(KCl)	6·26	0·59	
Sodium chloride	($NaCl$)	6·37	0·60	
Magnesium chloride	($MgCl_2$)			
Calcium chloride	($CaCl_2$)			
Sodium sulphate	(Na_2SO_4)	6·46	0·61	
Magnesium sulphate	($MgSO_4$)	192·51	18·29	
Calcium sulphate	($CaSO_4$)	640·78	60·86	
Sodium bicarbonate	($NaHCO_3$)			
Magnesium bicarbonate	($Mg(HCO_3)_2$)			
Calcium bicarbonate	($Ca(HCO_3)_2$)	158·66	15·07	
Strontium bicarbonate	($Sr(HCO_3)_2$)	2·41	0·23	
Ferrous bicarbonate	($Fe(HCO_3)_2$)	10·50	1·00	
Calcium phosphate	($Ca_3(PO_4)_2$)			
Ferric oxide	(Fe_2O_3)			
Alumina	(Al_2O_3)			
Silica	(SiO_2)	27·6	2·61	
		1,053·01	100·00	

THE CAVE AND BASIN SPRINGS.

(68 and 69)

The Cave and Basin Springs, within easy access of the town, are undoubtedly the best known and most popular of all the hot springs at Banff. They lie, not far apart, on the lower slope of Sulphur mountain, overlooking the Bow valley and Vermilion lake. Crossing the Bow bridge the road from Banff turns to the right and ascends the gentle slope for a mile until at the crown of the hill it emerges from the shady avenue of pine and fir, allowing full view of the splendid new swimming bath and the valley beyond. Leaving the swimming pool for further attention the first object of interest is the Cave. Discovered in the fall of 1880 by surveyors enagaged in locating the track of the Canadian Pacific Railway, it has never since failed to attract attention and interest. The Cave is nearly circular in shape, about 40 feet diameter, and 20 feet high. A pool of bubbling, seething water, four to five feet deep, forms the greater part of the floor, and is roughly in the shape of a horseshoe, about 30 feet across at its widest diameter. Entrance to the cave is obtained through the south-east belvedere of the new bath house, by means of a well-lit tunnel, 30 feet long; at the end of the passage a flight of a few steps leads to the plat-

Sulphur Cave, Banff, Alberta.



Basin spring, Banff, Alberta.

form at the side of the pool. A hole in the roof of the cave, through which the early explorers gained entrance, affords a dim illumination as well as an outlet for the steam and gases rising from the pool. It is said that the walls of the cave were originally covered with stalactites of several feet in length, the icicle-like crystals formed by the drip of water depositing calcium carbonate, but these have long since been carried away. At present, the walls are coated with a crystalline deposit, chiefly composed of calcium sulphate or gypsum formed by the constant evaporation of water containing calcium sulphate in solution on the sides and roof of the cave.

The walls are irregular in shape, and with the obscure lighting, constitute a wonderful field for the imagination to picture almost any fancy, an art the late Mr. Galatly—the popular old Scotch guide to the Cave—possessed to the utmost. His lectures on the Cave had become almost as famous as the Cave itself.

The floor of the pool is covered with black sand, consisting of quartz, limestone, and hornblende, and the various sources of the water, swirling and bubbling up through the quicksand, can easily be made out. Gas bubbles, rising throughout the pool, agitate the waters every few seconds.

The temperature of the water of the pool is lower than that of the other hot springs, being 85°F., while that of the Basin is about 95°. A considerable influx of colder water drips down at the back of the Cave pool, cooling it and lowering its content of dissolved matter.

The flow from the pool is very great, being almost 300 gallons per minute. The water runs off from the pool down the tunnel, continually renewing the water of the swimming bath just outside.

The following particulars were obtained as a result of examination of the water of the Cave Spring:—

THE CAVE SPRING.

Laboratory No. 68.

Sample collected	January, 1917.	
Temperature	29·5°C. (85°F.)	
Flow	250 gallons per minute.	
Taste	Flat, with trace of hydrogen sulphide.	
Reaction		
Specific gravity at 15°C	1·002	
Radioactivity	Emanation	470 units
	Dissolved radium	8·5 „
	Emanation in gas evolved	3340 „
Properties of reaction in per cent.		
	Primary salinity	2·78
	Secondary salinity	81·54
	Primary alkalinity	—
	Secondary alkalinity	15·68

Analysis.

Constituents:—			Previous analysis.	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4)...	580		56·43	41·20
Bicarbonic acid	(HCO_3)..	140		13·62	7·84
Carbonic acid	(CO_3)...	——		——	——
Nitric acid	(NO_3)...	——		——	——
Nitrous acid	(NO_2)...	trace		——	——
Phosphoric acid	(PO_4)...	——		——	——
Metaboric acid	(BO_2)...	——		——	——
Chlorine	(Cl)....	10·0		0·97	0·96
Bromine	(Br)....	——		——	——
Iodine	(I).....	——		——	——
Silica	(SiO_2)...	23·4		2·28	
Iron	(Fe)...	1·6		0·15	0·19
Aluminium	(Al)....				
Manganese	(Mn)...	0·01		——	——
Calcium	(Ca)....	217·		21·11	36·95
Strontium	(Sr).....	6·0		0·58	0·47
Magnesium	(Mg)...	39·2		3·81	11·00
Lithium	(Li)....	0·2		0·02	0·09
Potassium	(K).....	4·5		0·44	0·39
Sodium	(Na)....	6·0		0·58	0·89
Ammonium	(NH_4)...	0·1		0·01	0·02
Total....................		1,028·0		100·00	100·00
Total solids in solution, residue dried at 110°C............		1,017			Concentration value. 29·31

Gases :		c.c. per litre.	Parts per million.
	Carbon Dioxide CO_2....	20·75	40·8
	Hydrogen Sulphide H_2S.	1·6	2·49

HYPOTHETICAL COMBINATIONS.

No. 68.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)............			
Sodium nitrate	($NaNO_3$)............			
Ammonium chloride	(NH_4Cl)............	0·27	0·03	
Potassium iodide	(KI)................			
Potassium bromide	(KBr)..............			
Lithium chloride	($LiCl$)..............	1·19	0·11	
Potassium chloride	(KCl)...............	8·57	0·83	
Sodium chloride	($NaCl$)..............	7·83	0·76	
Magnesium chloride	($MgCl_2$)............			
Calcium chloride	($CaCl_2$)............			
Sodium sulphate	(Na_2SO_4)...........	9·02	0·88	
Magnesium sulphate	($MgSO_4$)............	194·11	18·87	
Calcium sulphate	($CaSO_4$)............	593·84	57·77	
Sodium bicarbonate	($NaHCO_3$)...........			
Magnesium bicarbonate	($Mg(HCO_3)_2$)........			
Calcium bicarbonate	($Ca(HCO_3)_2$).........	170·57	16·59	
Strontium bicarbonate	($Sr(HCO_3)_2$).........	14·46	1·41	
Ferrous bicarbonate	($Fe(HCO_3)_2$).........	4·80	0·46	
Calcium phosphate	($Ca_3(PO_4)_2$)..........			
Ferric oxide	(Fe_2O_3)..............			
Alumina	(Al_2O_3)..............			
Silica	(SiO_2)..............	23·40	2·28	
		1,028·06	100·00	

THE BASIN SPRING.

(69)

At the opposite end of the swimming pool from the Cave is the Basin, a pool of water about 25 feet wide, and 40 feet long, overhung on one side by a wall of rock, and on the other enclosed by the old bathing pavilion. Steps lead down into the pool, which is divided by means of a rope, the left and deeper side being from five to eight feet in depth. The floor of the Basin is thick with black sand, distributed in several places by the strong influx of hot water bubbling up from below. As in the Cave pool, gas bubbles continually rise from the ever-moving sand floor, only to burst at the surface. The overflow, nearly as great as from the Cave spring, flows into the new swimming pool and old bath, at the opposite end of the basin, that was used previous to the completion of the present magnificent bath.

The water is at a temperature of 94°F., warm enough to be comfortable even on the coldest day. Bathing is enjoyed in the Basin the year round, even when there is snow to the depth of several feet and icicles hang from every rock and ledge. The experience of such a bathe is unique.

The water of the Basin Spring was found to contain a larger proportion of constituents than the other springs, and approximates, closely, to the water of the King's Spring, Bath, in its composition.

The following particulars were obtained on examination:—

THE BASIN SPRING.

Laboratory No. 69.

Sample collected	January, 1916.	
Temperature	34·5°C. (94°F.)	
Flow	150 gallons per minute.	
Taste	Flat, with evidence of hydrogen sulphide.	
Reaction		
Specific gravity at 15°C.	1·0026	
Radioactivity	Emanation	232 units
	Dissolved radium	8·5 „
	Emanation in gas evolved	2370 „
Properties of reaction in per cent.		
	Primary salinity	1·50
	Secondary salinity	87·64
	Primary alkalinity	—
	Secondary alkalinity	10·86

Analysis.

Constituents:—			Previous analysis.	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4)...	1,120·00		61·28	44·09
Bicarbonic acid	(HCO_3)	175		9·58	5·43
Carbonic acid	(CO_3)...	—		—	—
Nitric acid	(NO_3)...	trace		—	—
Nitrous acid	(NO_2)...	—		—	—
Phosphoric acid	(PO_4)...	—		—	—
Metaboric acid	(BO_2)...	—		—	—
Chlorine	(Cl)....	9·0		0·49	0·48
Bromine	(Br)....	—		—	—
Iodine	(I)......	—		—	—
Silica	(SiO_2)...	31·		1·70	
Iron Aluminium	(Fe)... (Al)...	4·0		0·22	0·17
Manganese	(Mn)...	—		—	—
Calcium	(Ca)....	400		21·88	37·70
Strontium	(Sr).....	8·0		0·44	0·35
Magnesium	(Mg)..	71·0		3·88	11·03
Lithium	(Li).....	0·1		—	0·03
Potassium	(K).....	3·3		0·18	0·16
Sodium	(Na)....	6·3		0·33	0·52
Ammonium	(NH_4)...	0·4		0·02	0·04
Total.....................		1,828·1		100·00	100·00
Total solids in solution, residue dried at 110°C.............		1,905			

Gases :		c.c. per litre.	Parts per million.
	Carbon Dioxide CO_2....	20·	39·4
	Hydrogen Sulphide H_2S.	3·2	4·89

HYPOTHETICAL COMBINATIONS.

No. 69.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)............			
Sodium nitrate	($NaNO_3$)............	trace		
Ammonium chloride	(NH_4Cl)............	1·18	0·06	
Potassium iodide	(KI)..............			
Potassium bromide	(KBr).............			
Lithium chloride	(LiCl).............	0·59	0·03	
Potassium chloride	(KCl)..............	6·26	0·34	
Sodium chloride	(NaCl)..............	7·83	0·43	
Magnesium chloride	($MgCl_2$)............			
Calcium chloride	($CaCl_2$)............			
Sodium sulphate	(Na_2SO_4)............	9·94	0·54	
Magnesium sulphate	($MgSO_4$)............	351·63	19·24	
Calcium sulphate	($CaSO_4$)............	1,180·10	64·57	
Sodium bicarbonate	($NaHCO_3$)..........			
Magnesium bicarbonate	($Mg(HCO_3)_2$)........			
Calcium bicarbonate	($Ca(HCO_3)_2$).........	212·22	11·61	
Strontium bicarbonate	($Sr)HCO_3)_2$).........	19·18	1·05	
Ferrous bicarbonate	($Fe(HCO_3)_2$).........	8·10	0·43	
Calcium phosphate	($Ca_3(PO_4)_2$)..........			
Ferric oxide	(Fe_2O_3).............			
Alumina	(Al_2O_3).............			
Silica	(Si_2O)..............	31·0	1·70	
		1,828·01	100·00	

GASES EVOLVED FROM THE BASIN POOL.

A considerable quantity of gas bubbles up in the Basin; the amount, it is said, is dependent to some extent on the barometric pressure.

The gas was found to be radioactive, that is containing radium emanation. The value for its radioactivity obtained was 2,370 units. Analysis of the gas showed it to be mainly composed of nitrogen, about 98%; while the remaining constituents were carbon dioxide, methane, oxygen, and a trace of hydrogen. On account of the large percentage of nitrogen and its radioactive character, it seemed of interest to examine it for the presence of the rare gases of the atmosphere, especially for helium, which being one of the products of radioactive decomposition, is almost certain to be present.

As a result of tests it was proved that about 1·3% of the nitrogen was argon, the first of the rare gases of the atmosphere—in which it occurs to the extent of 0·93 volumes per hundred volumes of air—to be discovered by Sir William Ramsay and Lord Rayleigh in 1894. A trace of helium was also detected in the gas.

The complete analysis of the gases from the Basin, the Cave, and the Middle Springs, is given below, together with an analysis of the gas from the King's Well, Bath, particulars of which have already been stated:—

PLATE X.

Government Swimming Bath, Banff, Alberta.

	Middle. %	Cave. %	Basin. %	King's Well, Bath. %
Methane	0·15	0·11	0·19	—
Hydrogen	0·07	0·09	0·04	—
Oxygen	0·81	0·45	0·50	—
Carbon dioxide	1·18	1·11	1·34	3·60
Nitrogen	97·79	98·24	96·68	95·45
Argon and helium			1·25	0·95

A study of the composition of these gases leads to the conclusion that their origin is the dissolved air of the rain and snow water which supplies the springs. The oxygen of this dissolved air, during the underground passage of the water, is used up in chemical processes such as the oxidation of iron pyrites and of organic matter with which it comes in contact. Nitrogen being chemically inactive passes on unaffected, and thus becomes relatively more concentrated in the gases which finally emerge. The greater argon nitrogen ratio of the gas compared to the proportion in which they exist in the atmosphere is owing to the greater solubility of argon in water. Air dissolved in rain water contains a greater percentage of argon than the free air. Argon, like nitrogen, is inert, and passes through its subterranean journey without change.

THE CAVE AND BASIN SWIMMING BATH.

In 1914, a magnificent swimming pool was completed by the Rocky Mountains National Park authorities. The bath is 35 feet wide by 150 feet long, and is the largest of its kind in Canada. The depth increases gradually from 3 to 8 feet. The pool itself has no roof, and the longer side, overlooking the valley, is formed by massive plate-glass windows, allowing full view of the snow-capped mountains beyond. Two terraces run the full length of the opposite side, under which are the numerous dressing rooms, equipped with the latest sanitary arrangements. At the east end of the pool, a sun room affords a pleasant resting place after the exertions of the bath. The old bath house of the Basin pool encloses the opposite end of the bath.

The water of the bath, at a temperature of 90°F. and of varying hue, from a milky sapphire blue to a deep emerald green, constantly renewed by the overflows from the Cave and the Basin Springs is most inviting. The bath is said to be one of the finest in America, and it is certain that no swimming pool could have more picturesque surroundings.

WARM SPRING ON AUTOMOBILE ROAD.

(70)

Two other springs exist within a short distance of Banff, which have also been examined. One of these, a sulphur spring, rises close to the shore of

Vermilion lake on the side of the automobile road, three miles out of Banff. Its flow is not large, and its temperature as well as its compositon are lowered by the influx of colder surface water. It rises in a small pool, and spreads out into a wide marsh, seldom freezing over even in the coldest weather. On this account it proves an attractive watering place for animals. During the winter months mountain sheep may constantly be seen in its vicinity.

Particulars of the examination made upon it are as follows:—

WARM SPRING ON AUTOMOBILE ROAD.

Laboratory No. 70.

Sample collected	December, 1916.	
Temperature	19·4°C. (67°F.)	
Flow	50 gallons per minute.	
Taste	Flat with slight indication of hydrogen sulphide.	
Reaction	Alkaline.	
Specific gravity at 15°C	1·0015	
Radioactivity	Emanation	640 units.
	Dissolved radium	23·5 „
	Emanation in gas evolved.	
Properties of reaction in per cent.		
	Primary salinity	1·94
	Secondary salinity	60·70
	Primary alkalinity	—
	Secondary alkalinity	37·36

Analysis.

Constituents:—		Previous analysis.	Total inorganic matter in solution.	Reacting value.
	Parts per million.		Per cent.	Per cent.
Sulphuric acid (SO_4)	147·5		30·79	22·62
Bicarbonic acid (HCO_3)	155·		32·37	18·68
Carbonic acid (CO_3)	—		—	—
Nitric acid (NO_3)	trace		—	—
Nitrous acid (NO_2)	—		—	—
Phosphoric acid (PO_4)	—		—	—
Metaboric acid (BO_2)	trace		—	—
Chlorine (Cl)	42·0		8·77	8·70
Bromine (Br)	—		—	—
Iodine (I)	—		—	—
Silica (SiO_2)	12·4		2·59	
Iron (Fe) Aluminium (Al)	0·7		0·14	0·18
Manganese (Mn)	—		—	—
Calcium (Ca)	95·0		19·83	34·92
Strontium (Sr)	trace		—	—
Magnesium (Mg)	23·0		4·80	13·93
Lithium (Li)	0·05		—	—
Potassium (K)	1·1		0·23	0·21
Sodium (Na)	2·0		0·42	0·64
Ammonium (NH_4)	0·3		0·06	0·12
Total	479·05		100·00	100·00
Total solids in solution, residue dried at 110°C	434			Concentration value. 13·60

Gases:	c.c. per litre.	Parts per million.
Carbon Dioxide CO_2	5·0	9·8
Hydrogen Sulphide H_2S	0·4	0·63

HYPOTHETICAL COMBINATIONS.

No. 70.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$).......			
Sodium nitrate	($NaNO_3$).......	trace		
Ammonium chloride	(NH_4Cl).......	0·86	0·18	
Potassium iodide	(KI).........			
Potassium bromide	(KBr).........			
Lithium chloride	(LiCl).........	0·30	0·06	
Potassium chloride	(KCl).........	2·09	0·44	
Sodium chloride	(NaCl)........	5·09	1·06	
Magnesium chloride	($MgCl_2$).......	49·76	10·39	
Calcium chloride	($CaCl_2$)........			
Sodium sulphate	(Na_2SO_4)......			
Magnesium sulphate	($MgSO_4$)......	50·98	10·64	
Calcium sulphate	($CaSO_4$).......	151·73	31·66	
Sodium bicarbonate	($NaHCO_3$).....			
Magnesium bicarbonate	($Mg(HCO_3)_2$)..			
Calcium bicarbonate	($Ca(HCO_3)_2$)...	203·79	42·52	
Strontium bicarbonate	($Sr (HCO_3)_2$)...			
Ferrous bicarbonate	($Fe(HCO_3)_2$)...	2·23	0·46	
Calcium phosphate	($Ca_3(PO_4)_2$)....			
Ferric oxide	(Fe_2O_3)........			
Alumina	(Al_2O_3.).......			
Silica	(SiO_2)	12·4	2·59	
		479·23	100·00	

It is readily seen by the analysis, that this water resembles, to some extent, the other waters in composition; but it is less concentrated, and contains a relatively greater amount of calcium bicarbonate, accounting for the higher secondary alkalinity.

The radioactivity is comparatively high, but such surface waters often contain relatively large amounts of emanation.

ALPINE CLUB SPRING.

(71)

This spring, rises about fifty yards up the mountain side at the back of the club house of the Alpine Club of Canada, on Mountain avenue. The water is piped down to the house, but the pipe was disconnected in the winter time when the spring was examined.

The flow was then about 150 gallons per hour. There was no taste of hydrogen sulphide gas, and the temperature of the water was that of an ordinary cold spring. The spring is probably of shallow or surface origin, and like many springs of that nature, possesses a comparatively high temporary radioactivity, but no trace of dissolved radium.

The particulars are as follows:—

ALPINE CLUB SPRING.

Laboratory No. 71.

Sample collected	December, 1916.	
Temperature	7°C. (44°F.)	
Flow	20-30 gallons per minute.	
Taste	Fresh.	
Reaction	Alkaline.	
Specific gravity at 15°C.	1·001	
Radioactivity	Emanation	475 units
	Dissolved radium	
	Emanation in gas evolved	
Properties of reaction in per cent.		
	Primary salinity	96·
	Secondary salinity	38·2
	Primary alkalinity	
	Secondary alkalinity	52·2

Analysis.

Constituents:—			Previous analysis.	Total inorganic matter in solution.	Reacting value.
		Parts per million.		Per cent.	Per cent.
Sulphuric acid	(SO_4)	153·		30·22	23·3
Bicarbonic acid	(HCO_3)	218·		43·05	26·1
Carbonic acid	(CO_3)	—		—	—
Nitric acid	(NO_3)	—		—	—
Nitrous acid	(NO_2)	—		—	—
Phosphoric acid	(PO_4)	—		—	—
Metaboric acid	(BO_2)	—		—	—
Chlorine	(Cl)	2·5		0·49	0·6
Bromine	(Br)	—		—	—
Iodine	(I)	—		—	—
Silica	(SiO_2)	12·6		2·49	
Iron Aluminium	(Fe) (Al)	1·1		0·22	0·3
Manganese	(Mn)	—		—	—
Calcium	(Ca)	75·		14·81	27·5
Strontium	(Sr)	trace		—	—
Magnesium	(Mg)	29·		5·73	17·4
Lithium	(Li)	—		—	—
Potassium Sodium	(K) (Na)	15·1		2·98	4·8
Ammonium	(NH_4)	0·1		0·01	—
Total		506·4		100·00	100·0
Total solids in solution, residue dried at 110°C		441		—	Concentration value. 13·67

	c.c. per litre.	Parts per million.
Gases: Carbon Dioxide CO_2	12·6	24·7
Hydrogen Sulphide H_2S	—	—

HYPOTHETICAL COMBINATIONS.

No. 71.

Constituent:—		Parts per million.	Total inorganic matter in solution.	Previous analysis.
			Per cent.	
Sodium nitrite	($NaNO_2$)			
Sodium nitrate	($NaNO_3$)			
Ammonium chloride	(NH_4Cl)	0·26	0·05	
Potassium iodide	(KI)			
Potassium bromide	(KBr)			
Lithium chloride	($LiCl$)			
Potassium chloride	(KCl)			
Sodium chloride	($NaCl$)	3·80	0·75	
Magnesium chloride	($MgCl_2$)			
Calcium chloride	($CaCl_2$)			
Sodium sulphate	(Na_2SO_4)	42·00	8·29	
Magnesium sulphate	($MgSO_4$)	143·50	28·34	
Calcium sulphate	($CaSO_4$)	14·56	2·87	
Sodium bicarbonate	($NaHCO_3$)			
Magnesium bicarbonate	($Mg(HCO_3)_2$)			
Calcium bicarbonate	($Ca(HCO_3)_2$)	286·20	56·52	
Strontium bicarbonate	($Sr(HCO_3)_2$)			
Ferrous bicarbonate	($Fe(HCO_3)_2$)	3·47	0·68	
Calcium phosphate	($Ca_3(PO_4)_2$)			
Ferric oxide	(Fe_2O_3)			
Alumina	(Al_2O_3)			
Silica	(SiO_2)	12·6	2·49	
		506·39	100·00	

THE RESEMBLANCE BETWEEN THE BANFF AND THE BATH HOT SPRINGS.

The most interesting comparison is to be made between the waters at Banff, Canada, and the hot springs at Bath, England—the famous spa that dates its foundation from the Roman occupation of Britain.

Especially during the eighteenth century, Bath flourished, when it was the most fashionable resort of society in England, and the centre of attraction for all the famous people of the period.

In recent years the springs have been the subject of examination by several prominent scientists, especially by the late Sir William Ramsay, who directed attention to their radioactive properties, and to their value on that account.

They were shown to be the richest in radium and radium emanation of any spring in Great Britain, and no expense has been spared in developing the springs to the fullest extent that they might successfully compete with the continental spas.

There are three springs at Bath, all of similar composition. The temperature of the hottest is 120°F., slightly higher than that of the Upper Hot Spring at Banff. Each spring is enclosed by bath houses and pump rooms; buildings dating from the eighteenth century; a great contrast to the wild and natural surroundings of the Banff Springs. But a comparative study of the constituents of the waters, reveals the similarity between the springs, the chief substances present in both waters being calcium salts. Slightly more sodium and iron exist in the Bath waters, and the concentration of all the constituents is a little greater than in all the Banff waters, save the Basin Spring.

The gases evolved from the Bath Springs have been investigated by Professor Sir James Dewar, who demonstrated the presence of argon helium, krypton, and xenon,—the rare gases of the atmosphere, in them; and later by Sir William Ramsay, who showed their high radioactivity. The composition of the Banff gases is almost similar, as the analyses on page 143 show. Therefore, all that applies to the thermal waters of Bath is equally true of the Banff waters.

VALUE OF THE SULPHUR SPRINGS AT BANFF.

The value of the sulphur springs at Banff may be estimated from two points of view. They serve as an added attraction for the tourists who come to Banff from all quarters of the globe, as the hotel lists strikingly testify, and it is mainly with this in view that recent improvements in connexion with the springs have been carried out. No finer bathing establishments exist on the continent—one might almost say in the world—than the Cave and Basin pools, and the swimming baths at the Banff Springs Hotel, surrounded as they are by gigantic peaks and snow-capped mountains, and fed by continual streams of warm sulphur water.

But they may also be considered from the medicinal standpoint, especially in the light of the recent knowledge of their radioactive properties. The well known therapeutic value of the sulphur waters, together with the bracing climate of the mountains, combine to make Banff one of the finest health resorts in America.

THE THERAPEUTICS OF SULPHUR SPRING WATERS.

A brief outline of the therapeutic value of certain waters, due to their radioactive properties, has already been given, and, therefore, this aspect will not be further treated. The following remarks, however, on the use of sulphur waters in the treatment of disease are taken from various authors of works[1] on mineral springs. The chief ailments in which such waters have proved efficacious are diseases of the skin, gout, chronic rheumatism, for the treatment of stiff joints, and gunshot wounds, and in poisoning by metals.

There is, of course, no doubt that the drinking of larger quantities of water than usual has considerable beneficial effects in washing out the

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[1] The Hot Springs of Bath, compiled by John Hatton, Director of the Baths.
Deutsches Baderbuch.
The Principles and Practice of Medical Hydrology, Fortesque Fox, 1913.
Mineral Waters of the United States and their Therapeutic Uses, J. K. Crook, 1899.

alimentary canal, and in the dilution of the secretions of the liver and kidneys.

In the drink cure with a sulphur spring water, it seems to be of no importance whether sulphur is contained in the form of free hydrogen sulphide or of sulphides. (In the Banff waters it occurs as hydrogen sulphide). In both cases, sulphur is absorbed from the stomach and intestines. In the use of water for baths, it is assumed that hydrogen sulphide enters into the body through the skin. In the blood iron sulphide will be formed through the iron of the blood, and consequently a normal reformation of blood globules will be quickened and assimulation stimulated. At the same time, a strong influence takes place upon the liver, the bile secretion being greatly increased.

It is probable that mineral nutriment can be given to the system by the other usual constituents of sulphur waters, such as calcium salts and silica. From 100 to 1,000 c.c., (up to two pints) of water is the usual amount drunk daily at continental spas, taken cold or warm, sometimes with hot milk. Baths are taken at a temperature of 90°F. to 98°F., and of different duration; between 10 and 40 minutes. Prolonged baths for three hours, as are usual at some health resorts in Switzerland, are not given in Germany, although it is said they have an antimicrobic effect, and so prolonged sulphur baths have had a high reputation for ages as a valuable remedy for wounds.

THE THERAPEUTIC USE OF THE HOT SPRINGS AT BATH.

Attention has already been drawn to the similarity of the Bath and the Banff waters, and, therefore, the observations that have been made on the value and use of the Bath hot spring waters apply equally to Banff. The following extract is from a report on the springs, published by "The Lancet"—the chief British medical journal:—

> The thermal waters of Bath exert a distinct solvent action on uric acid. In our experiments, for example, it was shown that Bath water dissolved over five times the amount of uric acid that distilled water would similarly take up at blood heat, i.e., just under 100°F. Since the waters are drunk hot and used hot for bathing purposes, this fact may have an important relation to the therapeutics of Bath waters in the treatment of chronic gouty affections and rheumatism.

It has been pointed out by Dr. Luff[1] that, owing to the undoubted fact that sodium salts are directly detrimental to the removal of gouty deposits, those springs should be avoided which owe their activity to those salts when the removal of the deposits is the main object to be attained. The springs which contain no sodium salts or traces only are the ones suitable for such cases.

Bath waters have a comparatively low sodium content, and in the Banff waters, sodium is yet less in amount. The inference is simple.

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[1] Gout, Its Pathology and Treatment.

Bath waters are utilized in all manner of baths and douches: deep baths, holding 800 to 900 gallons of water; reclining baths; various forms of continental douches; and vapour baths; besides large swimming baths.

In the Grand Pump Room, reminiscent of the historic days of the eighteenth century, drinking water is served from a many sprayed fountain, supplied direct from the King's spring. During the summer season, water is served from the Colonnade fountain, in the Institution gardens.

The Radium Inhalatorium contains apparatus by which the radioactive water, atomized by steam, air, or even by the natural radioactive gases themselves, can be inhaled. Other forms enable nasal sprays and douches, ear and eye douches to be similarly given.

All these ways of using the hot sulphur waters can be equally well adopted at Banff when the demand arises.

In a young country like Canada, no leisured class yet exists, from which the clientele of a spa is naturally drawn; and future developments at Banff will cater more to the tourist than to the invalid. There are great possibilities for Banff as a health resort, however, especially when normal conditions obtain.

With suitable facilities for comfortable and rapid travelling, many wealthy tourists and seekers after health may be attracted from the allied countries of Europe to Banff, when they seek for substitutes for the spas of Germany and Austria. The future of Banff is fraught with great possibilities.

THE RELATION OF THE CHEMICAL CONSTITUENTS TO GEOLOGIC FORMATIONS.

The constituents of a mineral water depend on the nature of the rocks over which it has passed in its underground passage, and therefore, some similarity would be anticipated between the substances present in the water and the constituents of the rocks. But the reactions that take place when water from one formation penetrates rocks of different composition, are complex, and can only be studied in individual cases.

F. W. Clarke[1] states:—

> It is exceedingly difficult to generalize on relations between the composition of a water and its geologic history. Reactions which take place deep within the earth cannot easily be traced, especially as a water may undergo various modifications before it reaches the surface. A spring may be a blend from different sources—either a direct mixture or a solution from which ingredients have been removed—and it is only in specific cases that an interpretation of the phenomena can be found.

Several broad generalizations, however, may be stated. Waters from sedimentary formations are usually more concentrated, and contain a greater number of constituents, than waters issuing from igneous formations.

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[1] F. W. Clarke, Data of Geochemistry, Bul. 491, 2nd edition, U. S. Geol. Surv., 1911, p. 200.

Primary and secondary salinity are the principal properties possessed by waters from limestone strata, that is, sodium, calcium and magnesium salts of the strong acids, hydrochloric and sulphuric, predominate; while in waters from argillaceous strata, bicarbonates of the alkalies and the alkali earths—resulting in the properties primary and secondary alkalinity—are found in greater quantity.

Most of the waters treated in this report are situated in the great palæozoic plain, forming the basin of the St. Lawrence and the Lower Ottawa Valley. They especially occur in the more distributed eastern region. Fewer springs exist in the less disturbed western area; those at St. Catharines, Preston, and Hallowell, being the chief.

Dr. Sterry Hunt exhaustively studied the origin of many of the eastern waters, as outlined in the chapter on mineral springs in "The Geology of Canada," 1863; and as developed more extensively in a series of essays, entitled Chemical and Geological Essays. (Scientific Publishing Company, New York, 1897). Consideration of the recent analyses amply confirms his statements and opinions.

The chief formations of the Upper Cambrian and the Ordovician underlying the St. Lawrence plain are the following, in descending order:—

Lorraine or Hudson River: slightly bituminous sandy shales and thinly bedded limestones.
Utica shale: thinly laminated, black and brownish shales.
Trenton group: dark grey limestones, with some argillaceous material.
Chazy limestone: grey, semi-crystalline limestone, with interstratified, shaly layers.
Beekmantown or Calciferous sand rock: greyish, semi-crystalline dolomite, generally arenaceous, and sometimes argillaceous.
Potsdam: largely evenly stratified, fine grained quartzose sandstone.

Extended descriptions of these formations are given in "The Geology of Canada" 1863, chapters 3, 4, 5, 6, 7, 8, 9, 10, and 13, and in other reports[1] issued by the Geological Survey, since that date.

Dr. Sterry Hunt shows that the normal reaction of surface water in argillaceous strata will be conducive to the retention of principally alkali and alkali-earth carbonates in the water, while the source of the neutral salts which consist of alkaline and alkaline-earth chlorides is the limestone and other strata from the Potsdam to the Trenton. He supposes that most of the mineral springs are combinations of the two classes of water, and proposes a classification[2] based on this assumption, which is quite satisfactory from a geochemical standpoint. Springs are often found rising in

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[1] Ells, R. W., Report on a portion of the Province of Quebec, comprised in the southwest sheet of the Eastern Townships. Geol. Surv. Can., Vol. VII, 1896, pp. 44–50, 74–75, 85–86.

Ells, R. W., Report on the Geology of a portion of Eastern Ontario, Ann. Rep., Vol. XIV, Part J, 1904.

Adams, F. D., and LeRoy, O. E. The Artesian and other deep wells on the Island of Montreal. Part O, Ann. Rep., Vol. XIV, 1904, pp. 19–22.

[2] Sterry Hunt, Chemical and Geological Essays, p. 114.

close proximity, and yet showing great difference in composition. This is explained by the fact that while perhaps only a few feet apart, they rise from different strata, or more often are mixtures of waters from the different formations. The group at Caledonia Springs where a sulphur and a saline spring rise close together, affords an illustration. The springs at Carlsbad Springs offer another and even more striking example. The Magi water, from a considerable depth, is strongly saline, while twenty yards away, the Soda spring issues, quite different in composition and character. The Sulphur and Lithia are intermediate in character and properties, and undoubtedly are blends of the saline and the alkaline water.

The following table gives the probable geologic formation from which the various waters issue, and also includes their classification according to Chase Palmer's method. Class I contains alkaline and alkaline-saline waters; Class III saline waters. No other types were found, though several are on the border line of I, being more nearly saline than alkaline-saline. According to the generalization just put forward, waters rising from Hudson River or Utica shales should all fall into Class I, while those issuing from limestones should be saline or Class III waters. This holds for the springs rising from the shales, but there are many exceptions in the case of waters having their origin in the Trenton limestones.

Hudson River or Utica Shale.			Limestone.		
No.	Spring.	Classification.	No.	Spring.	Classification.[1]
19	Carlsbad Soda	I	6	Borthwick	III
15	„ Sulphur	I	13	Dominion	III
20	„ Lithia	I	14	Sanitaris	I
16	„ Magic	III	26	Caledonia Sulphur	I
17	Russel Lithia	I	25	„ Saline	I
	Adanac	I	27	„ Gas	I
44	Abenakis West House	III	28	„ Duncan	I
45	„ East House	III	29	„ Artesian Sulphur	I
48	Varennes	I	31	Plantagenet	III
49	Richelieu	I	33	Gurd's more Saline	III
53	St. Leon (old)	III	34	Gurd's less Saline	I
57	St. Leon (Lupien)	III	42	Viauville	I
55	St. Hyacinthe, Philudor	I	36	Laurentian Spring	I
56	St. Hyacinthe, La Providence	I	52	Radnor	III
58	St. Severe	III	59	St. Genevieve	III
50	Bluebonnets	I	62	Berthier	I
46	St. Bruno	I	64	St. Benoit	III
63	Maskinonge	I	65	Banff, Upper Hot Spring	III
			66	„ Kidney „	III
			67	„ Middle „	III
			68	„ Cave „	III
			69	„ Basin „	III
			70	„ Auto Road „	III
			71	„ Alpine Club „	III

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[1] According to Chase Palmer's method.

Although it is conjectured that the Trenton formation was put down under long-continued and oceanic conditions, it contains a considerable amount of argillaceous material, in many cases even forming thin layers. These strata would be less permeable to water than limestone, and thus would react relatively longer with the circulating water than the limestone. Therefore such a cause might be put forward to account for the frequent addition of alkaline constituents to an otherwise saline water.

Relations between radioactivity and geologic formation have been sought for, but as the waters principally issue from two sedimentary formations, the Utica shale or Trenton limestone, both of which have a very small and similar radium content—Professor A. S. Eve[1] of McGill University found 0·92 units radium per gram of rock for the Trenton limestone in the neighbourhood of Montreal—little radioactivity would be expected. It has been shown[2] that the most radioactive waters rise from primary formations.

THE THERAPEUTIC VALUE OF MINERAL SPRINGS.

From the earliest times mineral springs have been known for their curative properties. Greek and Roman literature contains many references to the value and use of such springs, and at no time in history have mineral waters been held in such high repute as they were in the days of the Roman Empire. Remains of magnificent baths built by the Roman invaders are found to-day at many of the principal mineral spring resorts in Europe, and are eloquent proof of their habitual use of such waters as remedial agents.

Almost every mineral spring of note is the subject of innumerable legends and tales, telling of its discovery by wandering hunters or Indians, and relating the miraculous restoration to health of all invalids carried to the source to be cured by its healing waters.

The beneficial effects of mineral waters, however, have been much overrated in the past, though nowadays there is, perhaps, a tendency to minimize their therapeutic value; a reaction in this scientific age against the atmosphere of quackery so often surrounding mineral spring resorts. The mineral constituents of spring waters are often accredited with the sole responsibility, when the beneficial effects contributing to speedy restoration to health have been due to other potent influences. Change of air, of scenery, of climate, of habits, of diet, and especially stimulated auto-suggestion, play a not inconsiderable part in the work of recovery; potent influences that have received too little attention in the past.

One of the chief curative agencies of mineral waters is, undoubtedly, the water itself. A greatly increased amount of water is imbibed by the patient at a spring resort; an action itself attended by good results. It is a

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[1] Eve, A. S. Phil. Mag., Aug., p. 231, 1907.

[2] Part I of this report, page 48.

well known fact that few persons drink as much water as should be taken. Water is the most important inorganic constituent of the body, forming two-thirds of its substance, and almost every gland and organ has need of this fluid to enable it to satisfactorily fulfil its function. Rheumatism, gout, and disorders of the digestive organs would be far less prevalent if more water were drunk, not necessarily mineral water, but water from any pure city supply.

Again, many mineral waters contain substances which readily act on the intestines, stimulating the kidneys and bowels, and, therefore, generally improving metabolism. No attempt will be made to specify individually the therapeutic effects of these constituents, many of which occur only in minute amounts, and their effects in such small quantities is rather open to discussion.

The following statements are the conventional ones found in most books dealing with mineral springs.[1]

Alkaline waters, that is those with high primary alkalinity (sodium bicarbonate) are of chief value in the treatment of digestive derangements. They stimulate digestion, neutralize acidity of the stomach, increase metabolism, augment the action of the kidneys, and dissolve uric acid deposits, especially if lithium forms a relatively high proportion of the alkalies present in the water. They are, therefore, chiefly used in catarrhal conditions of the mucous membrane, in rheumatism, gout, and diabetes. The most celebrated European waters of this class are Aix la Chapelle, Apollinaris, Taunus, and Ems in Germany, and Vichy, Perrier, Evian, and Aix les Bains, in France.

Apollinaris and Vichy are very popular table waters,[2] especially in Europe; considerable quantities also are imported into America. None of the springs so far examined yield alkaline waters, of this character, similar to Vichy or Apollinaris, though Adanac and Laurentian Spring waters mostly nearly approach them in composition. Several wells were found giving alkaline waters, though usually the chief base present is calcium.

Alkaline-saline waters, those in which bicarbonic acid ion and strong acid ions, chiefly hydrochloric, equally predominate, possess especial value in catarrhal conditions of the mucous membrane, stomach, intestines, biliary passages, and urinary tract, besides often stimulating the appetite and power of digestion. They augment the flow of urine, increase secretion of the mucous membrane and flow of bile, and are, therefore, used in the

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[1] Dr. G. E. Walton. The Mineral Springs of the United States and Canada. Chapters 4 and 6, 1892, New York.

Dr. J. K. Crook. The Mineral Waters of the United States and their Therapeutic Uses. New York, 1899.

E. H. S. Bailey. Special report on Mineral Waters, University Geol. Surv. of Kansas, Vol. 7, 1902.

J. K. Haywood, Mineral Waters of the United States. U. S. Dept. Agr., Bur. of Chem., Bul. 91, 1907.

For fuller information see:—

S. S. Cohen. A System of Physiological Therapeutics, Vol. 9, 1902, Philadelphia.

J. F. Fox. The Principles and Practice of Medical Hydrology, 1913.

Deutsches Baderbuch, 1907.

[2] See page 160.

treatment of scrofula, gout, chronic rheumatism and dyspepsia. The most notable foreign waters are those at Kissingen, Homburg, Nauheim, Wiesbaden and Baden Baden in Germany, Bourbonne les Bains, Royat and La Bourboule in France, and Saratoga Springs in the United States.

Many springs of this class occur in Canada, the chief of which are the Sanitaris, Carlsbad Lithia, Russell Lithia, Caledonia Saline—bottled as Magi—Caledonia water, Caledonia Sulphur and Gas, Richelieu, Philudor at St. Hyacinthe, Maskinonge, Varennes and Laurentian waters.

Many muriated, strongly saline waters occur in Canada; such waters increase the appetite and have a general stimulating effect on the organs of the digestion. Some, containing principally the sulphate radicle or magnesium, have a cathartic effect, and are much used as purgatives. The Caledonia Duncan water is a good example of this type of water. The most widely known European waters of this character are Aesculap, Apenta, and Hunyadi Janos.

No chalybeate springs are included in the report, though such springs occur in Canada, at Tuscarora. These waters find their principal application in anaemia, and general debility.

Sulphur waters, such as the well known Banff Springs, are found in considerable frequency. The chief therapeutic agent is assumed to be the hydrogen sulphide gas, the substance responsible for the unpleasant "bad egg" smell and flavour. Such sulphur waters are taken internally or are applied externally by bathing in the heated water. The chief ailments for which sulphur waters are stated to be efficacious are: diseases of the skin, gout, chronic rheumatism, and syphilis, for the treatment of stiff joints, and gunshot wounds, besides in cases of chronic poisoning by mercury or lead. The Banff waters, Potton, Viauville, Caledonia Sulphur, and Carlsbad Sulphur, are waters of this nature.

Further details on the medicinal value of sulphur waters will be found on pages (149-150), describing the Banff springs.

The subject of the therapeutic value of springs, on account of their radioactive properties, is treated in Part I of this report, pages 50-51.

THE ECONOMIC VALUE OF CANADIAN MINERAL WATERS.

STATISTICS.—

The value[1] of mineral water shipped from mineral springs in bottles or barrels during 1916, amounted to \$127,806, as compared with \$115,274 in 1915; \$134,111 in 1914; \$173,677 in 1913; and \$172,465 in 1912. These figures do not include the value of the mineral waters used at spring resorts for drinking or bathing purposes, nor, of course, the money spent by visitors to such resorts, primarily attracted there by the proximity of the springs.

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[1] John McLeish, Annual Report on the Mineral Production of Canada during 1916; Canada Mines Branch, Dept. of Mines.

The value of pure spring waters, sold in the bottled form in considerable quantity, is also not included in the above returns.

The imports of mineral and aerated waters during the calendar year 1916 were valued at $130,933; during 1915, $126,569; during 1914, $199,327; during 1913, $257,153; and during 1912 at $273,698. The exports of mineral water during 1916 were valued at $1,598, as compared with $3,578 in 1915; $2,367 in 1914; and $1,496 in 1913.

Further statistics of the production, imports, and exports, are given in the annual reports on the mineral production of Canada, published by the Mines Branch, Department of Mines.

The following is a list of the principal producers of mineral water. Those marked with an asterisk, were idle during 1916. Brands of water denoted by a dagger have been analysed in the course of this work.

Mineral Water.

Operator.	Address.	Brand of Water.	Location of Mineral Spring.			Local Office.	Representative, Supt., or Manager.
			County.	Township.	Concession, lot.		
			NEW BRUNSWICK.				
Havelock Min. Spring Co., Ltd.	Moncton, N.B.	Havelock	Kings			Havelock	J. A. Marven.
			QUEBEC.				
Veillet & Cie.	St. Geneviève	Star†	Bastican				
T. R. Ridgeway	Montreal, 14 St. John	Richelieu†	Chambly			Chambly	
Radnor Water Co., Ltd	Montreal, 402 McGill Bldg.	Radnor†	Champlain			Radnor Forges.	J. B. Giles, Man. Dir. G. C. Kemp.
Cyprien Roy	St. Germain	St. Germain	Kamouraska.			L'Islet-Plate.	C. Roy, Prop.
*Viauville Mineral Springs	Montreal. 24 Board of Trade Bldg.		Hochelaga			Viauville	Dan Bergevin, Prop.
*St. Leon Waters, Ltd	Toronto, 1 Toronto	Mirack	Maskinonge			St. Leon	C. E. Buckley, Secy-Treas.
Ratté & Frère	Quebec, 22 Bigouette	St. Leon†	"			Nancy	C. E. Pichette.
M. Timmons & Son	Quebec, 92 Cote d'Abraham	Claire Fontaine	Quebec			Quebec	J. J. Timmons, Mgr.
Regal Bottling Works	St. Hyacinthe	Radium†	St. Hyacinthe				
*J. T. Lemyre	Three Rivers	Aetna†	St. Maurice			St. Sévère	
		Ste. Ursule†.	Maskinonge			Ste. Ursule	
Alfred Ferland	Montreal, 1661 Bordeaux		Two M'nt'ns.			St. Benoit	
*Chas. Gurd & Co., Ltd	Montreal, 76 Bleury	Varennes†	Verchères			Varennes	
Abenakis Springs Co., Ltd	Abenakis Springs	Abenakis†	Yamaska			Abenakis Springs	W. E. Watt, Mgr.
			ONTARIO.				
Saugeen Mineral Water Co.	Southampton	Saugeen	Bruce			Southampton	Becker & Frank.
The Carlsbad, Ltd	Carlsbad Springs	Carlsbad†	Carleton	Gloucester	VII 3	CarlsbadSp'gs	T. L. Boyd.
Borthwick Mineral Water Co	Ottawa, 48 Fourth Ave.	Borthwick†	"	"	IV 19		Wm. Borthwick.
*Goderich Mineral Water Co.	Goderich	Minisitung	Huron			Goderich	P. L. Walton.
*Dominion Springs Mineral Water	Pakenham, R.R. No. 4.	Dominion†	Lanark	Fitzroy	II 10		W. J. Gillan.
Sanitaris Limited	Arnprior	Sanitaris†	" N.	Pakenham		Pakenham	L. Macnamara.
Arthur Bélanger	Papineauville, Que.	St. George	Prescott	Plantagenet			
Allan's Limited	Montreal, 86 Dorchester W.	Caledonia	"	Caledonia		Caledonia Springs.	
Chas. Gurd & Co., Ltd	Montreal, 76 Bleury	Gurds Caledonia.†	"	"		"	
Lyall, Trenholme & Macdonnell	Montreal West 8 Ballantyne Ave.	Beaver	"	"		"	D. Gauthier, Shipper. W. F. Macdonnell, Agent.
A. Sabourin	Hawkesbury	Maple Leaf	"	"		"	
The Caledonia Springs Co., Ltd.	Montreal, 360 Craig E.	Magi†	"	"		"	
		Duncan†	"	"		"	
		Adanac†	Russell			Bourget	

F. Deneault	Bourget	Brook	„			„	
*The Canada Mineral Waters, Ltd.	Toronto, 65 Bellwoods Ave.	RusselLithia†	„		20	„	Chas. A. Watson.
Stanley Mineral Springs Co., Ltd.	Winnipeg, c-o Nat'l Trust Co.	Stanley	Thunder Bay			Stanley	
				SASKATCHEWAN.			
Manitou Mineral Water Co., Ltd.	Watrous	Manitou		Manitou lake		Tp. 32 R25-2	Jno. N. Cumming.
				B. COLUMBIA.			
Halcyon Bottling Co	Halcyon, B.C.	Halcyon Lithia	W. Kootenay		Arrow Lake	Halcyon	Wm. McCombie.
*M. Grady	St. Leon Hot Springs. B.C.	St. Leon	„		Arrow Lake (Upper)	St. Leon Hot Springs.	
*F. F. Siemens	Winnipeg, Empress Hotel		„		Arrow Lake	Renata	

*Idle during 1916. †Water has been analysed.

THE DEVELOPMENT OF CANADIAN MINERAL WATERS.

In comparatively newly settled countries, such as the United States and Canada, mineral springs are considered much less worthy of attention than they are in Europe. Many springs which are allowed to run to waste in Canada would be of considerable value in Germany, France, or Italy. They form a small but not inconsiderable fraction of the natural wealth of a country, and the time is opportune to draw attention to possibilities of development of Canadian mineral springs.

Mineral springs may be developed in two directions: water from the springs may be bottled and sold as table or aperient water, according to its composition, or sanitoria may be established near the springs to enable patients to drink the waters at the source. The waters may sometimes be used for baths, especially in the case of sulphur waters. Unfortunately, there are no statistics to show the relative value of the two methods. In Europe it is probable that greater financial returns are obtained from the development of mineral springs as health resorts or spas. Yet some of the European bottling plants have a very large trade. In 1912 for example, the Apollinaris Company in Germany had an output of thirty-seven million bottles of water.

Mineral waters, both table and aperient waters, have been imported into Canada in increasingly large amounts, especially from Europe, and a glance at the statistics shows that even now the value of the imported waters is greater than that of the domestic waters consumed. In this report, it is shown that attempts have been made to find Canadian waters of equal value, which can replace the imported waters.

A list has already been given of the chief producers of bottled mineral waters in Canada, and reference has been made to such of those waters as have been analysed in the course of this investigation, and which are on the market. The chief of these are Borthwick, Sanitaris, Russell Lithia, Caledonia, Magi, Adanac and Duncan, Laurentian, Gurd's Caledonia water, Viauville, Richelieu, Radnor, St. Leon, St. Severe, and St. Genevieve. These are chiefly used as table waters, especially after they have been carbonated. They are more saline than most of the popular European table waters, chief among which are Vichy, Apollinaris, Perrier, St. Galmier, Taunus and Seltzer waters. Such waters are alkaline, and highly charged with carbon dioxide.

Of these, Vichy and Apollinaris are imported in the largest quantity. The chief constituent of the Vichy waters is sodium bicarbonate, and the quantity of solids in solution is small—only about 400 parts per million. None of the waters included in this report have a similar composition.

The three principal springs at Vichy are the Grand Grille, Hôpital, and Celestins, all under the control of the French Government. They yield thermal waters which contain much free carbon dioxide, but little mineral matter in solution. Springs of similar composition, unless they were also the thermal, might fail to attract attention in Canada. It is not improbable, however, that similar waters exist.

Analyses of Imported Table Waters.

Hypothetical Combinations.	Vichy* (Celestins). Parts per million.	Apollinaris.† Parts per million.
Sodium chloride	30·6	438
Sodium sulphate	16·6	247
Sodium phosphate	5·1	—
Potassium bicarbonate	18·0	—
Sodium bicarbonate	291·6	2,015
Magnesium bicarbonate	18·7	858
Calcium bicarbonate	26·4	400
Strontium bicarbonate	0·3	—
Ferrous bicarbonate	0·3	84
Silica	3·4	30
	411·0	4,072

Constituents:—		Vichy: Parts per million.	Vichy: Reacting values per cent.	Apollinaris: Parts per million.	Apollinaris: Reacting values per cent.
Sulphuric acid	(SO_4)	11·2	2·26	167	3·30
Bicarbonic acid	(HCO_3)	258·6	41·72	2,538·1	39·60
Phosphoric acid	(PO_4)	3·0	0·09	265·4	7·10
Chlorine	(Cl)	18·6	0·52		
Silica	(SiO_2)	3·4	—	30	—
Iron	(Fe)	0·1	0·04	26·4	0·89
Calcium	(Ca)	6·5	3·19	98·8	4·69
Strontium	(Sr)	0·1	0·02	—	—
Magnesium	(Mg)	3·1	2·50	141·6	11·09
Potassium	(K)	7·0	1·77	—	—
Sodium	(Na)	99·4	42·48	804·7	33·33
		411·0	100·00	4,072·0	100·00
Concentration value			10·16		105·08

Properties of Reaction:—	Vichy: Per cent	Apollinaris: Per cent
Primary salinity	16·56	20·80
Secondary salinity	—	—
Primary alkalinity	71·94	45·86
Secondary alkalinity	11·50	33·34

*Analyses in parts per million calculated from those given in Mineral and Aerated Waters, by C. A. Mitchell, expressed in grains per pint, p. 16.

†Ibid: reference to analysis by Kyll (1907), p. 29.

The principal imported American table waters are White Rock, Buffalo Lithia, and Poland. Analyses of these are given in Bulletin No. 91, on "the Mineral Waters of the United States," issued by the U.S. Dept. of Agriculture, Bureau of Chemistry, 1907.

Several of the Canadian waters already examined, have a somewhat similar composition to the well known imported Apollinaris water, though absolute identity can scarcely be expected considering the numerous constituents of a mineral water and the complex conditions of its formation.

While the principal constituent of Apollinaris water may be considered to be sodium bicarbonate, other salts, such as sodium chloride, sodium sulphate, calcium and magnesium bicarbonates, also form part of the total mineral matter in solution. Several Canadian waters, such as Laurentian (No. 36); Bluebonnets (No. 50); Richelieu (No. 49); Mount Bruno (No. 46); Gurd's Well, Beaudry St., Montreal, (No. 37); Philudor (No. 55) and La Providence (No. 56) might replace Apollinaris, though almost all of these waters contain relatively more sodium chloride and less sodium bicarbonate.

Many mineral waters find their chief value as aperients; especially when sulphates of sodium or magnesium form a considerable proportion of the saline constituents. The best known European waters of this character are Apenta, Hunyadi Janos, and Aesculap, the sources of which are all situated in Hungary. These have been imported in large quantities, and have had a considerable sale. Pluto concentrated water—the source of which is at French Lick, Indiana—is also popular. Other imported American aperient waters are Red Raven, and Mount Clemens. All these waters are concentrated, and contain large quantities of magnesium and sodium sulphates. No similar Canadian waters have as yet been examined. Viauville water, Montreal, somewhat resembles them, though it is much less concentrated, and contains a larger proportion of sodium chloride. Concentrated Caledonia Duncan water is, however, successfully replacing the foreign waters to some extent.

Analyses of Imported Aperient Waters.

Hypothetical Combinations.	Hunyadi Janos.*	Aesculap.† Parts per million.	Apenta.‡
Sodium sulphate........	22,551	13,906	18,722
Potassium sulphate......	121	trace	83
Magnesium sulphate.....	22,350	17,280	21,103
Calcium sulphate........	——	2,079	2,639
Lithium sulphate........	——	——	75
Sodium carbonate.......	——	999	479
Calcium carbonate......	——	——	118
Magnesium carbonate....	——	——	182
Manganous carbonate....	——	43	——
Ferrous carbonate.......	——	——	76
Sodium bicarbonate......	675	——	——
Calcium bicarbonate.....	799	——	——
Strontium bicarbonate...	27	——	——
Ferrous bicarbonate.....	6	——	——
Sodium chloride.........	1,705	2,905	——
Magnesium bromide.....	——	——	11
Alumina...............	——	35	30
Silica.................	10	trace	32
	48,244	37,247	43,550

Constituents.		Parts per million.	Reacting values, per cent.	Parts per million.	Reacting values, per cent.	Parts per million.	Reacting values, per cent.
Sulphuric acid	(SO_4)...	33,146·2	46·79	24,658·5	44·05	31,470·2	48·72
Bicarbonic acid	(HCO_3)	1,111·6	18·22	——	——	——	——
Carbonic acid	(CO_3)...	——	——	587·9	1·69	510·8	1·27
Chlorine	(Cl)....	1,033·2	29·14	1,760·5	4·26	——	——
Bromine	(Br)....	——	——	——	——	8·5	0·01
Silica	(SiO_2)...	10·0	——	trace	——	32	——
Alumina	(Al_2O_3)..	——	——	35·0	——	30	——
Iron	(Fe)....	1·9	——	——	——	36·7	0·10
Manganese	(Mn)...	——	——	20·5	0·06	——	——
Calcium	(Ca)....	197·3	0·66	611·0	2·61	823·2	3·05
Strontium	(Sr).....	11·3	0·01	——	——	——	——
Magnesium	(Mg)....	4,515·0	25·17	3,490·0	24·63	4,317·9	26·40
Lithium	(Li).....	——	——	——	——	9·5	0·10
Potassium	(K).....	54·3	24·06	trace	——	37·3	0·07
Sodium	(Na)....	8,163·2	0·10	6,083·6	22·70	6,273·9	20·28
		48,244·0	100·00	37,247·0	100·00	43,550·0	100·00
Concentration value.....		1,475·9		1,116		1,345·6	
Properties of reaction in per cent:—							
Primary salinity......		48·32		45·40		40·90	
Secondary salinity.....		49·20		51·22		56·56	
Primary alkalinity...		——		——		——	
Secondary alkalinity.		2·48		3·38		2·54	

*Analyses calculated in parts per million from those given in Mineral and Aerated Waters, by C. A. Mitchell, expressed in grains per pint. Analysis by Bunsen, p. 23.

†Ibid: Analysis by Mohr, p. 22.

‡Ibid: Analysis by Tichbourne, p. 22.

Reference has already been made to the similarity of some of the strongly saline waters, such as the Abenakis waters, St. Genevieve, St. Severe, Varennes, and St. Leon, to the strongly saline European waters, particularly those at Homburg, Kissingen, and Nauheim.

When more of the principal Canadian mineral springs have been examined—especially those in the Niagara peninsula, and in British Columbia—it is probable that Canadian waters will be found equal in every respect to any of the famous European waters above referred to.

CANADIAN MINERAL SPRING RESORTS.

Not more than a dozen mineral spring resorts in Canada are open at the present time. Several have been temporarily closed on account of the falling off in business due to war conditions. Many of the following springs at which sanitoria have been established are included amongst those described in this report, and it is hoped that the remainder will eventually be the subject of a similar examination.

Passing from east to west, Abenakis Springs, Que., on the St. François river, in Yamaska county, is one of the few health resorts in Quebec. A description of the springs has already been given. They yield saline waters and somewhat resemble those of Kissingen or Nauheim Spas in Germany. A sanitorium is also established at Potton Springs in Brome county, Que. Potton sulphur spring is a calcic, alkaline (sulphuretted) water.

Caledonia Springs is the site of an hotel and sanitorium, under the management of the Canadian Pacific Railway. The hotel is situated close to three of the springs—the Caledonia Saline, Sulphur, and Gas springs.

A sanitorium is established at Carlsbad Springs, near Ottawa. Further particulars are given in the description of the springs, which range from alkaline to strongly saline, with intermediate mixtures of the two types of waters.

St. Catherines, near Niagara Falls, is one of the oldest of Canadian mineral water resorts. One spring is reported to have been in use since 1812. Several sanitoria enable visitors to utilize the waters with the greatest benefit. The springs yield strongly saline, bromic, and iodic waters, and resemble the celebrated waters of Kreuznach in Prussia. No work has yet been done by the Mines Branch on these waters, nor on the Preston mineral springs, which are a group of sulphur waters situated in Waterloo county, Ontario.

A sanitorium is also situated in Winnipeg: the Winnipeg Mineral Springs Sanitorium, under the direction of Dr. A. D. Carscallen. No examination of these springs has yet been made.

The most famous of all Canadian springs is undoubtedly the group of hot sulphur springs at Banff, Alberta, full details of which have already been given, and attention has been drawn to the great possibilities of Banff as a health resort, combining as it does magnificent scenery, bracing climate, and valuable, radioactive hot sulphur springs. A sanitorium has been established in Banff for many years, and a modern hydropathic establishment has more recently been built, besides the provision made at Banff Springs Hotel for many of the special European baths and massage. Although at present Banff owes its popularity almost entirely as a tourist centre, there are great possibilities in its development as a health resort.

Harrison Hot Sulphur Springs in British Columbia—famed in the west for their curative properties, and visited by invalids from many places on the Pacific Coast—have not as yet, been examined, nor the noted Halcyon Hot Springs on Arrow Lake, B.C. Hotels are situated at both of these springs. It is desirable that a complete investigation should be made of these waters as soon as opportunity occurs.

Great development and improvements, however, will be necessary before these mineral spring resorts can compare with European or even American spas, such as Saratoga Springs, the Glen Springs, N.Y., and the Arkansas Hot Springs. When one considers the conditions which have, up to the present, prevailed in Canada, it is hardly to be expected that in so young a country much attention would have been given to the development of its mineral water resources. Nevertheless, the waters compare favourably with similar European waters, and when the demand arises, such artificial attractions as well equipped hotels, sanitoria and baths will soon be established.

Table of Springs Arranged According to Class.

		PAGE
Alkaline:		
Bicarbonated—		
Watson Foster Well, Montreal,	No. 43	70
Bluebonnets Well, „	No. 50	74
Celestins Springs, Vichy, France		160
Calcic—		
Adanac, Bourget	No. 30	61
Guaranteed Milk Co's Well, Montreal,	No. 35	63
Potton Sulphur Spring	No. 54	92
Alkaline-Saline:		
Muriated—		
Sodic.		
Berthier, Que	No. 62	105
Caledonia, Artesian Sulphur	No. 29	55
„ Duncan	No. 28	53
„ Gas	No. 27	50
„ Saline	No. 25	45
„ Sulphur	No. 26	48
„ Gurd's less saline	No. 34	59
Carlsbad Lithia	No. 20	39
„ Soda	No. 19	41
„ Sulphur	No. 15	37
Laurentian Spring, Montreal,	No. 36	65
Maskinonge, Que.,	No. 63	107
Mount St. Bruno, Que.,	No. 46	72
Richelieu, Chambly, Que.,	No. 49	86
Russell Lithia, Bourget, Ont.,	No. 17	30
Sanitaris, Ont.,	No. 14	28
St. Hyacinthe, Que., Philudor	No. 55	94
„ Que., La Providence,	No. 56	96
St. Leon, (Lupien), Que.,	No. 57	98
St. Severe, Que.,	No. 58	100
Varennes, Que.,	No. 48	84
Sodic and calcic—		
Gurd's well, Beaudry St., Montreal,	No. 37	68
Saline:		
Sulphated—		
Calcic.		
Banff, Alpine Club Spring,	No. 71	146
„ Automobile Rd. Spring,	No. 70	143
„ Cave Spring,	No. 68	137

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