COLORADO GEOLOGICAL SURVEY
BOULDER
R. D. GEORGE, State Geologist

BULLETIN 11

MINERAL WATERS
OF COLORADO

By
R. D. GEORGE, HARRY A. CURTIS,
O. C. LESTER, JAS. K. CROOK,
J. B. YEO, and others

DENVER, COLORADO
EAMES BROS., STATE PRINTERS
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GEOLOGICAL BOARD

His Excellency, Oliver H. Shoup	Governor of Colorado
George Norlin	President University of Colorado
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LETTER OF TRANSMITTAL

State Geological Survey,
University of Colorado, September 22, 1920.

Governor Oliver H. Shoup, Chairman, and Members of the Advisory Board of the State Geological Survey.

Gentlemen: I have the honor to transmit herewith Bulletin 11 of the Colorado Geological Survey.

Very respectfully,

R. D. George,
State Geologist.

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INTRODUCTION

A thorough study of mineral waters includes problems of geology, meteorology, chemistry, physics, medicine. The Survey has found it extremely difficult to secure the desired skill in the various lines necessary to make a complete report. The geological work, the collection of the samples of water, the chemical analyses and the physical examinations were completed in a comparatively short time, but the most thorough search and the most earnest solicitations failed to secure the services of physicians to discuss the value and uses of mineral waters as curative agents. Such discussions and reports were promised, and in one or two instances undertaken, but regular professional duties claimed first consideration and the reports were never completed. As a consequence, after much delay the State Geologist was obliged to secure permission of authors and publishers to adapt and use parts of existing works on the therapeutic value of mineral waters.

The original plan of the work included a chapter on the climate of Colorado in its relation to health and recuperation. This had to be abandoned.

The war made it necessary to drop, for the time being, all work not contributing direct to the welfare of the country. These various obstacles and conditions are mentioned in explanation of the long delay in issuing the report.

The field work involved in the collection of the samples, estimation of flow, measurement of temperature and testing of gases issuing with the waters was done by Mr. Roy M. Butters and assistants. The notes on the springs are prepared from the field notes of Messrs. Butters and Lester.

PART I

GENERAL DISCUSSION OF MINERAL WATERS

BY

R. D. GEORGE

CHAPTER I.

SOURCE AND GEOLOGICAL RELATIONS OF MINERAL WATERS

THE SOURCE OF THE WATERS OF SPRINGS

From earliest recorded history, the origin of the waters of springs has been a subject of speculation and debate. Anaximines taught that water was condensed air, while Anaximander believed that air was rarefied water. Aristotle held that air imprisoned within the earth was condensed to water which found its way to the surface as springs. Descartes explained the existence of springs by saying that sea water entered subterranean caverns, became vaporized and after condensation rose to the surface of the earth by way of crevices.

Water, in the form of vapor, is constantly rising from the surface of the earth and passing into the atmosphere, where it becomes condensed into rain-clouds and after a time falls to the earth. A part of the water falling upon the land runs off over the surface by way of rills, creeks and rivers to the sea, another part is returned to the atmosphere by evaporation, and a third part enters upon a journey of greater or less length beneath the surface of the earth. Of that which enters the ground some is vaporized by the sun's heat and returns to the atmosphere after a very short journey, some is taken up by plants, and some, escaping these, continues its journey for a time and returns to the surface as the waters of ordinary springs, hot springs, mineral springs and geysers.

Again, surface waters may enter and fill the pores of rocks, and may even combine chemically with the mineral matter with which they come into contact. Earth movements and the deposition of other rocks upon them may carry the rocks so charged with surface waters to deeper and warmer parts of the earth's crust, from which the waters may slowly distil toward the surface carrying a load of mineral matter with them. In their upward progress they may mingle with the more recent and shallower waters and issue with them in springs.

But there are other waters which may contribute in some measure to the volume and character of spring waters. When sedimentary rocks are formed on the floor of the sea a certain amount of water will be imprisoned in the rock and will remain in it long after it has been raised above sea level. These waters will contain the salts found in sea waters. When rain water penetrates to such rocks there will be a mingling of the two waters, and that which passes on to the spring outlets will contain a little of the imprisoned water and its salts.

Again, water is present in almost all molten rock masses. As the rock crystallizes this magmatic water is forced out and may find its way to the surface alone or accompanied by waters of strictly atmospheric origin.

All these waters may be charged with mineral matter in solution gathered from the rocks in which they have been stored and through which they have passed in their journey. Some of the mineral matter may be gathered by simple solution and some by solution accompanied by chemical reactions.

The kind and amount of the saline matter gathered by waters will depend upon many factors, among which will be: the chemical and physical character of the rocks with which it has come into contact, the length of the journey, the time occupied, the temperature of the rocks, the temperature of the water, and the extent to which the solvent power of the water has been increased by matter taken into solution. Some rocks contain much matter that is readily soluble, while others contain but little. Some are open and porous, or closely fractured, and as a consequence expose much surface to the water, and so favor the process of solution. Others are dense and comparatively free from fractures, and so offer but little opportunity for the waters to gather mineral matter by solution.

Other things being equal, the longer the underground journey and the longer the time occupied, the greater the load of mineral matter gathered. Occasionally, however, in a long journey the mineral-charged waters may come into contact with other waters or other substances which will cause the precipitation of a part, or perhaps all of the salts they have gathered. Hot waters have a greater solvent power than cold waters, and under similar conditions are likely to become more highly charged with mineral matter.

The solvent power of water is greatly increased by certain substances which may be taken into solution in their journey underground. Among the most important of such substances are the sulphur gases and carbon dioxide, and the salts formed by these gases. There are several possible sources of carbon dioxide. The atmospheric waters may gather it from the air and carry it beneath the surface of the earth on their underground journey. The soil and other forms of mantle rock are charged with carbon dioxide from the atmosphere and from the decay of vegetable matter. Ground water passing through these may collect and carry much carbon dioxide far beneath the surface—possibly through its entire underground journey. But probably by far the greatest part of the carbon dioxide of mineral springs comes from deeper within the earth, reaching the channels of the springs far below the surface and accompanying the waters to their place of issue. Carbon dioxide accompanies practically all volcanic activity, and is especially abundant in regions of dying, dormant, or recently past volcanic activity. Such regions are commonly noted for the abundance of mineral springs charged with carbon dioxide. In some places, as in the vicinity of Rico and elsewhere in Colorado, vast volumes of carbon dioxide reach the surface as gas springs or "blows." The chemical activity of the carbon dioxide results in the formation of the various carbonates and bicarbonates found in mineral waters.

Sulphur gases are also common accompaniments of volcanic activity, and in many places issue from vents in such regions long after all active vulcanism has ceased.

These gases include sulphuretted hydrogen and sulphur dioxide. Sulphur gases may also result from the breaking up of metallic sulphides such as pyrite, marcasite and others. Sulphuretted hydrogen may result from the breaking down of sulphates by organic matter, or other reducing agents.

Chlorine and hydrochloric acid also accompany volcanic activity, and may be responsible for a part of the chlorides of mineral waters. But the greater part of the chlorides probably comes from waters and salts held in sedimentary rocks, from the period of their formation.

The source of the heat of mineral waters is still a matter of discussion. There can be little doubt that in many localities it is due largely to recent volcanic activity. The Yellowstone Park is an area of this kind. In others the mechanical or frictional heat of the rocks, resulting from folding, faulting, uplift and other earth movements is responsible for the heat of the waters.

The sinking of deep mine shafts and the boring of deep wells have established the fact that there is a somewhat regular rise of temperature as depth is attained. It is possible that some spring waters issue from such a depth that a part of their heat may be due to the normal high temperature of the rocks at the depth from which they come. Some writers believe that the heat of some spring waters is due in part to chemical reactions which have evolved heat. Radioactivity has also been regarded as a possible cause of the heat.

The greater abundance of hot springs in mountain regions and regions where vulcanism exists or has recently existed points to the probability that crustal movements resulting in frictional heat, and vulcanism are responsible for the high temperature of a very large proportion of the hot springs.

It is evident from what has been said that the waters of springs may range in mineral content from the merest trace to almost saturation, depending upon the length of their journey and the conditions encountered below the surface of the earth. The question naturally arises, When does a water become a mineral water?

The International Food Congress, which met in Paris in 1909, adopted the following definition:

"A mineral water is a natural water proposed for consumption on account of its therapeutic or hygenic properties."

This definition has been accepted by the United States Bureau of Chemistry and by the United States Geological Survey in its annual volumes on Mineral Resources. The chemist, the mineralogist and the geologist would regard such a definition as entirely too restricted, and would be disposed to accept the broad and very general definition given by F. W. Clarke:[1] "A mineral water is merely a water which differs, either in composition or in concentration from the common potable varieties."

Writing from the standpoint of the physician, Dr. James K. Crook[2] says:

"The term Mineral Waters is applied to those waters which are used in the treatment of disease, either by internal administration or by external application, and which owe their virtue to their solid or gaseous constituents, or to their elevated temperature."

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[1] Data of Geochemistry, U. S. Geol. Surv., Bull. 616, 1916, p. 179.

[2] Crook, Dr. James K., "Mineral Waters of the United States and their Therapeutic Uses," 1899, p. 17.

In his report on "The Natural Mineral Waters of the United States," A. C. Peale[3] defines mineral water from the physician's standpoint as:

"Any water that has an effect upon the human system, no matter how feebly mineralized it may be; that is, it is any water that possesses medicinal virtues, whether they be due to the presence of organic, inorganic, or gaseous contents, or to the principle of heat."

Since mineral waters are of value chiefly because of their healing properties, the physician's definition is the one commonly used in the discussion of mineral springs. In preparing this report on the mineral waters of Colorado the various authors have written with this fact in mind.

THE RELATION OF MINERAL WATERS TO GEOLOGICAL CONDITIONS

The outer part of the earth is composed of a great variety of rocks which differ widely in composition, solubility, structure, porosity and temperature. Since the salts contained in mineral waters are derived from the rocks through which the waters flow it is natural to expect great variety in mineral waters. The kind and quantity of the salts contained, the association or grouping of the salts, and the temperature of the waters, are almost infinitely variable.

In a broad way rocks are grouped as *Igneous, Sedimentary,* and *Metamorphic. Igneous* rocks are those which have solidified from a molten condition. They may be non-crystalline—that is to say, the matter of which they are composed is not formed into mineral grains, but is a uniform mixture of the elements or molecules composing the rock. Or they may be crystalline—the elements are organized into minerals such as feldspar, quartz, mica and others. The rock-making minerals differ in solubility, and therefore in the quantity of material they will yield for the formation of salts in the waters which seep and flow through them.

The *sedimentary* rocks are built up out of materials which come from the breaking down and decay of the surface rocks of the earth. In the process of decay much of the soluble matter is leached out and carried to the sea in solution. The solid residue, largely in the form of clay and sand, finds its way to the sea and

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[3] Peale, Dr. A. C., "The Natural Mineral Waters of the United States," U. S. Geol. Survey Fourteenth Annual Report, 1892-3, part II, p. 57.

is there built up into clay rocks or shales, and sandstones. From the material carried to the ocean in solution are formed limestones, gypsum, rock-salt and similar rocks and minerals.

Residual materials such as clays and sands have, as a rule, been robbed of much of their readily soluble matter, but as they are built into solid rocks on the sea floor they are saturated with sea water. When they are raised above sea level they carry much of this content of sea water with them. Many sandstones and shales contain soluble material in the form of shells and other parts of animals which lived in the sea. Surface waters may also carry into and deposit in them materials gathered from other sources. As a result of these conditions most shales and many sandstones contain soluble matter in considerable quantity which they readily yield to the waters which penetrate them.

Limestone, gypsum and rock-salt are much more soluble than shales and sandstones, and readily yield to the solvent action of water.

Metamorphic rocks are formed by the profound alteration of both igneous and sedimentary rocks, through the action of heat, pressure, moisture and movement.

Such metamorphic rocks as the gneisses, schists and slates are among the least soluble rocks and, as a rule, yield but little material for the formation of salts. But since water is almost a universal solvent, even the most insoluble rocks yield to its action, though some of them very slowly.

Some rocks are very massive and free from fractures and other openings. Their ability to absorb water is very limited, and the flow of water through them is extremely slow. If, in addition to these unfavorable conditions, the rocks themselves are relatively insoluble they will contribute very little to the formation of mineral waters. Other rocks may be broken into large blocks, and the blocks may contain many fractures, or they may be open and porous. Their capacity for taking in water will be great, and the rate of flow of the water through them will be comparatively rapid. If in addition to these favorable conditions they are relatively soluble, they will give up much material to the formation of salts in the circulating waters.

The saline content of spring waters will also be influenced by the length of the journey taken by the waters before their issuance as springs. Other things being equal, the longer the journey underground, the greater will be their load of mineral matter. The structural features of certain regions are such that very few points of issuance are afforded, and the waters reach the surface at a great distance from their place of entering the earth. In this long journey they are likely to come into contact with a greater variety of rock and mineral substances, and they may also reach depths where the temperature and pressure are so high as to increase their solvent power.

In many parts of the earth molten rocks have been forced from deep within the crust to positions at or near the surface. In other places active or recently active volcanoes may exist. The movements of molten rocks, whether through fissures or through volcanic craters, are commonly accompanied by highly heated mineral-laden waters and by gases of various kinds. Such bodies of igneous rocks retain their heat for long periods, and the hot mineralized waters and the accompanying gases issue along their borders and in their neighborhood long after all other evidences of volcanic activity have ceased.

In their underground journey waters may meet with a great variety of conditions which will affect the nature and extent of the charge of gases and salts they will bring to the spring. A rise of temperature increases their power to dissolve almost all kinds of mineral matter, and consequently their power to hold mineral matter in solution. A fall in temperature has the opposite effect, and may even cause the waters to drop, or deposit, salts held in solution at higher temperatures.

The taking of a certain salt into solution may increase the solvent power of the water for some salts, but decrease it for others, and may even cause the precipitation of still others.

In the passage of the waters through the rocks they may come into contact with insoluble substances, either inorganic or organic, which may act as precipitating agents and rob them of the salts they had gathered. They may meet with other mineralized waters which may enrich them by the addition of new salts or may impoverish them by causing the precipitation of the salts previously taken into solution. The mingling of such waters may increase their solvent power, or may decrease it.

Gases may be encountered and taken into solution. Some of these, such as carbon dioxide and sulphur dioxide, will increase the solvent power of the waters by rendering them mildly acidic. Sulphuretted hydrogen may precipitate metallic salts from the waters, and may at the same time increase their solvent power for other substances.

As a rule, increase of pressure gives added solvent power to waters, while decrease of pressure reduces their solvent power, and may cause precipitation. Evaporation about the springs may cause the precipitation of the salts carried by the waters.

Many mineral waters have gathered up radium emanation, and some have taken radium or radium salts into solution. Those having only the emanation in solution are only temporarily radioactive, while those having radium or radium salts in solution are said to be permanently radioactive.

A few springs are believed to have their origin in the waters accompanying and forced out of cooling and solidifying rock masses. Such waters are known as magmatic waters, and are characterized by an unusual richness and variety of mineral matter. The Carlsbad springs of Bohemia may belong to this class.

SALTS AND GASES FROM SEDIMENTARY ROCKS

Spring waters rising from sedimentary rocks may be charged with salts by the direct solution of a part of the rock itself. Limestone yields calcium carbonate; magnesian limestone gives, in addition, magnesium carbonate. Rock salt adds to the waters common salt or sodium chloride, and gypsum gives up calcium sulphate.

Sulphide of iron is common in shales. This breaks up forming sulphuric acid and iron salts. The acid reacts with the materials of the shale forming various sulphates, of which the commonest are those of sodium, magnesium, aluminum, calcium and potassium. Carbon dioxide may also react with the shale materials forming the various carbonates, such as those of sodium, magnesium, potassium and others. The ''alkali'' which often whitens the ground in dry regions commonly contains several of these readily soluble salts. Springs rising from shales are likely to be rich in sodium sulphate, and may contain considerable amounts or traces of the others.

Carbon dioxide may come from the decay of organic matter or from the breaking up of carbonates. Hydrogen sulphide may come from the breaking down of sulphates by organic matter, or may form directly from organic matter containing sulphur.

Certain spring waters containing calcium chloride may derive this salt from sea water imprisoned in the rocks at the time of their formation.

SALTS AND GASES FROM IGNEOUS ROCKS

The origin of the salts of springs flowing from igneous rocks presents many problems which have not been satisfactorily solved. It may be assumed that the calcium, sodium and potassium of these salts are derived mainly from the various feldspars, though nephelite, leucite and sodalite may contribute in a small way, as may also the lime-bearing and soda-bearing amphiboles and pyroxenes. The micas may yield some potassium.

The iron may come in part from the oxidation of pyrite, (iron sulphide), and other sulphides, or from the breaking down of the amphiboles, pyroxenes, biotite and olivine. The magnesium comes from the amphiboles, pyroxenes, micas and olivine.

Silicon comes from the silicates and from the solution of quartz.

The conditioning agent for nearly all chemical changes in the rocks is water. Pure water at ordinary temperatures acts but slowly on the materials of igneous rocks, but pure water is exceedingly rare. As it penetrates the rocks water is a weak but complex solution in which the various dissolved substances such as carbon dioxide, organic matter, sulphur gases and dissolved solids are enabled to react with the various forms of mineral matter encountered. Water charged with carbon dioxide attacks the minerals containing sodium, calcium, potassium, iron and magnesium forming the corresponding bicarbonates. When charged with oxygen it reacts with sulphides forming the sulphur acids, which in turn react with other elements forming sulphates, such as those of sodium, magnesium and others. Water charged with organic matter reacts with sulphates freeing hydrogen sulphide.

The large quantity of chlorine in mineral waters issuing from igneous rocks is hard to explain. Thousands of analyses show that the average content of chlorine in igneous rocks is but 0.07 per cent—an amount much too small to account for the large amount of chlorine present in mineral waters in the form of chlorides of sodium, calcium, potassium, and others. Chlorine is an important element in the gases issuing from volcanoes, and some investigators assert that it is abundant in recently solidified volcanic rocks. The many analyses of older rocks for the measurement of occluded or absorbed gases show but little chlorine. It seems probable that a small part of the chlorine of mineral springs in regions of igneous rocks may come from chlorine-bearing minerals such as scapolite, apatite, sodalite and a few other equally unimportant minerals of igneous rocks. But by far the larger part must be otherwise accounted for. The hot springs of igneous rock regions are commonly in areas of relatively recent volcanic activity. It is possible that chlorine freed by the volcanic activity may have lingered in pores, fractures and crevices about the buried parts of igneous masses. Waters of whatever origin circulating through and about such masses would dissolve the chlorine and thus greatly increase their solvent power. Other elements such as boron, iodine, and bromine are equally hard to account for.

If the planetessimal hypothesis of the earth's origin be correct, it is entirely possible that vast quantities of ancient sediments lie buried far below the present surface of the earth. In these may be bodies of rock salt and other salines, containing chlorine, iodine, fluorine and boron.

The long and obscure history of some mineral waters is suggested by the complex waters of Carlsbad, which are probably in part magmatic in origin, ("juvenile" of some writers). From these waters are reported a total of thirty-four chemical elements as follows: Aluminum, antimony, arsenic, barium, boron, bromine, calcium, carbon, chlorine, chromium, cobalt, copper, fluorine, gold, helium, hydrogen, iodine, iron, lithium, magnesium, manganese, nickel, oxygen, phosphorus, potassium, radium, selenium, silicon, sodium, strontium, sulphur, tin, titanium, and zinc.

It is a remarkable fact that, in some form or other, tributary to the sources supplying these springs there occur more than one-third of the elements known to scientists. Many of these may enter into several combinations in the waters, and thus add to their complexity.

THERMAL SPRINGS

Thermal springs are those whose waters have a temperature above the mean annual temperature of the region in which they are located. Their waters may or may not carry more mineral matter than the common potable waters of the region. In common usage, however, only those springs whose waters have a temperature above 70° F. are termed thermal springs. Those having a temperature between 70° F. and 98° F. are classed as warm springs; those above 98° F. are called hot springs.

That the interior of the earth is very hot is proved by the issuance of lavas from volcanoes, by the higher temperatures at the bottom of deep mines and deep borings, by the heat of waters of geysers and hot springs, and by other observed facts. The average rise of temperature in deep mines and deep borings is about one degree F. for each 50 feet of depth attained. It does not seem probable that the high temperature of geyser and hot spring waters can be due to the normal rise of temperature downward in the earth. It is an accepted fact that a very large proportion of all springs of all kinds are fed chiefly by waters which fell upon the earth as rain, snow and other forms of moisture, and which entered the earth through pores, fractures and fissures in the rocks. The depth to which waters would have to go to reach a temperature of 100° F. will depend upon the mean temperature of the region. In Colorado the mean temperatures differ widely according to the altitude. Assuming a mean temperature of 50° F., to reach a temperature of 100° F., in Colorado, from the normal heat of the earth the water would have to go to a depth of 2,500 feet. The upward journey would take a long time and much heat would be lost. In order to reach the surface at a temperature of 100° F. the water would have to start its return journey at a very much higher temperature—surely not less than 300° F. It would, therefore, have to reach a depth of 12,500 feet before it started its upward journey. While it is possible that the waters of some warm springs may owe their temperature to the normal heat of the earth, it is extremely improbable that many of our hot spring waters come from the necessary depths.

In certain areas molten rocks have risen from deep within the earth to points at or near the surface. The heat from these masses raises the temperature of the rocks on all sides, and groundwaters circulating in such regions and coming into contact with these superheated rocks are highly heated and return to the surface in hot springs and geysers.

It has been thought by some geologists that chemical activity may account for the high temperature of some hot springs. It is true that the breaking down of metallic sulphides, and certain other chemical changes may evolve much heat.

In the lead and zinc mining regions of Wisconsin, Iowa, Missouri and other central states, much iron sulphide in the form of marcasite accompanies the ores of lead and zinc. This form of iron sulphide decomposes very readily in the presence of air and moisture. As a consequence, piles of marcasite on the dumps and in or about the mines readily break down chemically with the evolution of much heat. But beneath the surface of the earth and beyond the access of air such changes are extremely slow, and could not account for the heat of mineral springs.

Earth movements are another recognized cause of heat. In the tremendous upheavals which have produced mountain systems and ranges, the folding, fracturing and crushing of rocks must have produced an extremely large total amount of frictional or mechanical heat. The more rapidly such movements took place the more intense would be the heat developed. The deeper the center of movement the greater would be the overlying load of rock to be moved, and consequently the greater would be the frictional heat evolved. It is possible that in slow earth movements, and especially in those affecting only the surface rocks, the heat evolved would be dissipated almost as fast as it was evolved.

It is a significant fact that thermal springs are most abundant in mountain regions, and especially in those parts where faulting and zones of weakness have favored the movement of rock masses over one another. Thus the zones of contact between the ancient granites and gneisses on the one hand, and the sedimentary formations on the other, are, as a rule, rich in thermal springs.

It seems probable, therefore, that great earth movements have caused the heat which gives many mountain springs their high temperatures. It must be borne in mind, however, that mountain regions are notably regions of volcanic activity, and that in many places highly heated igneous rocks may lie at no great distance below the surface.

In mountain regions, therefore, the two most important heat producing agencies have operated and it would be difficult to determine to which of these the heat of any particular thermal springs may be due. Where the vicinity of a thermal spring shows much evidence of volcanic activity it is reasonable to attribute its heat to vulcanism, but even here movement may have played an important part.

Magnetic and electric phenomena have been named as possible causes of the heat of some thermal springs. But no satisfactory evidence has been offered in support of this view.

The discovery of radium has led to much speculation as to the possible relation of the interior heat of the earth and volcanic phenomena to radioactivity. But there is, as yet, no theory which has found general acceptance. There seems to be no general relationship between the temperature of mineral waters and their radioactivity. In some places thermal spring waters are more radioactive than are cold spring waters. In Colorado the most highly radioactive waters are cold.

It is certain, however, that thermal springs, and mineral springs in general, are more common in mountainous areas than in low, flat plains; and highly mineralized waters are more common in areas where volcanic activity is, or has been, pronounced, than in areas remote from such past or present activity.

HISTORICAL NOTE

The use of waters for medical and bathing purposes antedates written history and appears to have been practiced by all branches of the human race. Many ancient peoples, among whom were the Egyptians and Hebrews, regarded bathing as a sacred rite, and the Christian rite of baptism as a symbol of spiritual healing or cleansing perpetuates the less significant Jewish rite of bathing. In some lands certain rivers were believed to be favored by the gods, and bathing in them was supposed to be attended by miraculous healing. The Nile in Egypt, the Ganges in India, the Jordan in Palestine and the Tiber in Italy were sacred rivers, and the bather in them was healed or otherwise blessed.

The history of mineral waters also dates from very remote times, and the most ancient historians and poets wrote of them. The medical writers of all ages refer to their curative properties and give instructions for their use in the treatment of diseases. Pliny says of mineral waters: "They spring wholesome from the earth on every side, the cold, the hot, the hot and cold together . . . or yet the warm and tepid, announcing relief to the sick, and flowing from the earth only for man, of all living things."

All nations have used them, and among the more advanced peoples of ancient times temples, hospitals, medical schools, baths and resorts were erected in the neighborhood of mineral springs. "For five centuries mineral waters were almost the only medicines used in Rome." In European countries the value of mineral waters seems to be more generally understood and appreciated than in America. In variety, and without doubt in curative value the mineral waters of America equal those of Europe. A prominent physician who has made a study of the subject is authority for the statement that among the mineral springs of Colorado alone there can be found the therapeutic equivalent of every celebrated mineral water of Europe. Certainly the study of the mineral waters of the state has brought out the fact that there is a very wide range of composition, of temperature, and of radioactivity. Many of the springs are surrounded by beauty and grandeur rarely surpassed, and the climatic conditions leave little to be desired. There can be no escape from the conclusion that the very limited use of the springs, and the even more limited sale of Colorado mineral waters, are due to lack of knowledge and lack of appreciation.

CHAPTER II.

CLASSIFICATION OF MINERAL WATERS

BY

R. D. GEORGE

Many classifications of mineral waters have been proposed and used. Some of these have been based on the medicinal effects of the waters, some on their chemical composition, and others have combined these two factors. Of the classifications based on the chemistry of the waters, some have emphasized the gaseous content, some the broad properties of acidity, alkalinity and salinity, paying little attention to the elements or radicles producing those properties. Other classifications have been based on the salts supposed by the analyst to be present in the water. Still other systems combine two or more of these methods.

The following are classifications widely used:

THE GERMAN CLASSIFICATION

I.	Alkaline	Simple carbonated Alkaline Alkali and common salt
II.	Glauber salt	
III.	Iron	Pure Alkaline and saline Earthy and saline
IV.	Common Salt	Simple Concentrated With bromine
V.	Epsom salts	
VI.	Sulphur	
VII.	Earthy and calcareous	
VIII.	Indifferent	

THE FRENCH CLASSIFICATION

I.	Sulphur waters	With salts of sodium With salts of lime
II.	Chloride of sodium waters	Simple With bicarbonates Sulphureted
III.	Bicarbonated waters	Bicarbonate of soda Bicarbonate of lime Mixed bicarbonates
IV.	Sulphated waters	Sulphate of soda Sulphate of lime Sulphate of magnesia Mixed sulphates
V.	Ferruginous waters	Bicarbonated Sulphated With salts of manganese

THE ENGLISH CLASSIFICATION

I. Simple thermal waters
II. Common-salt or muriated waters
III. Alkaline waters
IV. Sulphated alkaline waters
V. Iron or chalybeate waters
VI. Arsenic waters
VII. Sulphur waters
VIII. Earthy or calcareous waters

WALTON'S (AMERICAN) CLASSIFICATION

(Mixed chemical and therapeutical)

- I. Alkaline waters
  - Pure
  - Acidulous (carbonic acid)
  - Muriated (chloride of sodium)
- II. Saline
  - Pure
  - Alkaline
  - Iodo-bromated
- III. Sulphur waters
  - Alkaline
  - Saline (chloride of sodium)
  - Calcic
- IV. Chalybeate
  - Pure
  - Alkaline
  - Saline (chloride of sodium)
  - Calcic
  - Aluminous
- V. Purgative waters
  - Epsom salt (sulphate of magnesia)
  - Glauber salt (sulphate of soda)
  - Alkaline
- VI. Calcic waters
  - Limestone (carbonate of lime)
  - Gypsum (sulphate of lime)
- VII. Thermal waters
  - Pure
  - Alkaline
  - Saline (chloride of sodium)
  - Sulphur
  - Calcic

PEALE'S CLASSIFICATION

- Thermal or Non-Thermal
  - I. Alkaline
  - II. Alkaline-saline
    - Sulphated
    - Muriated
    - Borated
  - III. Saline
    - Sulphated
    - Muriated
    - Borated
  - IV. Acid
    - Sulphated
    - Muriated
    - Silicious
      - Sulphated
      - Muriated
- Sodic
- Lithic
- Potassic
- Calcic
- Magnesic
- Chalybeate
- Aluminous

- Non-gaseous
- Carbonated
- Sulphureted
- Azotized
- Carbureted
- Oxygenated

CROOK'S CLASSIFICATION

- Thermal or Non-Thermal
  - I. Alkaline
    - Sulphated
    - Muriated
  - II. Alkaline-saline
    - Sulphated
    - Muriated
  - III. Saline
    - Sulphated
    - Muriated
  - IV. Chalybeate
    - Alkaline
    - Sulphated
    - Muriated
  - V. Neutral or indifferent
- Sodic
- Lithic
- Potassic
- Magnesic
- Calcic
- Iodic
- Bromic
- Arsenical
- Silicious
- Manganic
- Acid
- Aluminous

- Non-gaseous
- Carbonated
- Sulphureted

While Peale's and Crook's classifications have much to commend them, the classification by J. K. Haywood and B. H. Smith[1] is more in keeping with our present knowledge of chemistry, and is, on the whole, more easily applied.

Group	Class	Sub-class		
Thermal Non-Thermal	I. Alkaline	Carbonated or Bicarbonated Borated Silicated	Sodic Lithic Potassic Calcic Magnesic Ferruginous Aluminic Arsenic Bromic Iodic Silicious Boric	Non-gaseous Carbon-dioxated Sulphureted Azotized Carbureted Oxygenated
	II. Alkaline-saline	Sulphated Muriated Nitrated		
	III. Saline	Sulphated Muriated Nitrated		
	IV. Acid	Sulphated Muriated		

The following discussion and explanation by the authors will make clear the principles on which the classification is based, the meanings of the terms used, and the method of naming mineral waters which has been followed in the present report:

(1) The four classes of thermal and nonthermal waters, i. e., alkaline, alkaline-saline, saline and acid, should be defined, not on the basis of combinations of the ions present, as is done by Peale, but on the basis of the ions themselves, since no chemical methods are known by which we can determine the relative amounts of the acid and basic ions entering into combination with each other to form salts.

(2) The alkaline group should contain not only the carbonated, but also the borated and silicated waters, since waters are known which owe their alkalinity, at least in part, to alkaline borates or silicates.

(3) The alkaline-saline and saline groups should be divided into sulphated, muriated, and nitrated waters, since the authors have found one water at least which makes the introduction of a nitrated group an absolute necessity.

(4) The acid group should be divided into sulphated and muriated only and should not contain the silicious. Any of the four groups may be silicious, so this term should refer to all groups rather than to the acid group alone.

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[1] U. S. Department of Agriculture, Bureau of Chemistry, Bull. 91, pp. 8-11, Washington, 1907.

Alkaline waters are (1) those which have an alkaline reaction and contain carbonic or bicarbonic acid ions in predominating quantities; (2) those which have an alkaline reaction and contain boric or silicic acid ions in predominating quantities, where it can be proved that the alkalinity is largely due to the presence of borates or silicates. The first class of alkaline waters is well known and is given in Peale's classification as constituting the whole class of alkaline waters. The second class of alkaline waters includes those which are more alkaline than can be accounted for by the carbonates or bicarbonates present, and contains predominating quantities of silicates or borates, which evidently cause this excess of alkalinity.

Saline waters are those which have an alkaline or neutral reaction and contain sulphuric, muriatic, or nitric acid ions in predominating quantities.

Alkaline-saline waters are between alkaline and saline. They embrace those which have an alkaline reaction and contain (1) sulphuric, muriatic, or nitric acid ions along with carbonic or bicarbonic acid ions, both classes being present as predominating constituents, or those which have an alkaline reaction and (2) contain sulphuric, muriatic, or nitric acid ions along with boric or silicic acid ions, both classes being present as predominating constituents, where it can be proved that the alkalinity is largely due to the presence of borates or silicates.

Acid waters are those which have an acid reaction, and contain either sulphuric or muriatic acid ions in predominating quantities.

METHOD OF NAMING MINERAL WATERS

If any basic element is prominent in the mineral water this fact may be indicated by prefixing the name of the base to the regular class name; as sodic, lithic, calcic, etc.; carbonated alkaline, borated alkaline, silicated 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 gaseous constituents of all the foregoing classes of water may be designated by the following terms:

Nongaseous	Containing no gas
Carbondioxated	Containing carbon dioxid gas
Sulphureted	Containing hydrogen sulphid gas
Azotized	Containing nitrogen gas
Carbureted	Containing methane gas
Oxygenated	Containing oxygen gas

The following scheme enables one to name any mineral water according to the author's classification:

	Dominant Base	Dominant Acid	Class	Subordinate ions	Gaseous or Non-Gaseous
Thermal or Non-Thermal	Sodic Lithic Potassic Calcic Magnesic Ferruginous Aluminic	Carbonated or Bicarbonated Borated Silicated	Alkaline	Arsenic Bromic Iodic Silicious Boric Lithic Ferruginous Etc.	Non-gaseous Carbon-dioxated Sulphureted Carbureted Oxygenated
		Sulphated Muriated Nitrated	Alkaline-saline		
		Sulphated Muriated Nitrated	Saline		
		Sulphated Muriated	Acid		

The results of the present study of the mineral waters of Colorado are presented in tabular form as follows:

A. Chemical analyses stated in milligrams per litre, (almost equivalent to parts per million), and the reacting values of the radicles in percentages.

B. The gases contained in the waters, the evaporation solids, iron precipitated, etc.

C. The reaction properties of the waters stated in percentages.

D. The hypothetical combinations of the constituents of the waters into salts.

E. The radioactivity of the gases and waters.

It will be observed that radioactivity tests were made on quite a number of waters which were not chemically analysed, and that a number of waters analysed were not tested for radioactivity.

In the present report the analyses are expressed in terms of radicles. A radicle is an atom or a group of atoms acting as a unit in a compound. A radicle composed of two or more atoms does not break up into atoms when the molecule to which it belongs breaks up in chemical reactions.

Radicles are positive or basic and acid or negative. Hydrochloric acid (HCl) is composed of the positive radicle hydrogen (H), and the negative radicle chlorine (Cl). In this compound the radicles are atoms. Calcium sulphate is composed of the positive radicle calcium (Ca) and the negative radicle sulphate (SO_4). The first of these is elemental or atomic, the second is composed of one atom of sulphur and four atoms of oxygen. But in reactions and in (dilute) solutions the group, SO_4, acts as a unit.

The various radicles may be said to do certain work in the chemical reactions in which they take part. This ability to do work is called their "reaction coefficient," and may be defined as the reacting power of a unit weight of the radicle.

For convenience the "reaction coefficient" of 8 parts of oxygen is called 1, and from this are calculated the reacting values of other radicles.

The reacting value of a radicle in a water is found by multiplying the weight of the radicle present by its reaction coefficient. The percentage reaction value of the radicles is obtained by finding the sum of the reacting values of the radicles present and calculating the percentage of that total furnished by each radicle.

In entering into reactions, atoms are valued in relation to hydrogen.

An atom which balances one atom of hydrogen is said to be monovalent—chlorine (Cl) in the compound hydrochloric acid (HCl). An atom which balances two atoms of hydrogen is bivalent —oxygen (O) in the molecule of water (H_2O). An atom which balances three atoms of hydrogen or the equivalent of three atoms of hydrogen is trivalent—aluminum (Al) in the compound Al_2O_3. In this compound (alumina) two atoms of aluminum balance three atoms of oxygen, but each atom of oxygen is able to balance two atoms of hydrogen. In other words one atom of aluminum balances three atoms of hydrogen.

The compound radicles also have valence or hydrogen-balancing power.

The following table presents the principal radicles found in mineral waters grouped according to their reacting character as alkalies, acids, etc., with their symbols, their atomic or molecular weights, their valence and their reaction coefficients:

Radicle Basic or positive Alkalies or primary bases	Symbol	Atomic or Molecular wt.	Valence	Reaction Coefficient
Sodium	Na	23.00	1	0.0435
Potassium	K	39.10	1	0.0256
Lithium	Li	6.94	1	0.1441
Alkaline Earths or Secondary Bases				
Calcium	Ca	40.07	2	0.0499
Magnesium	Mg	24.32	2	0.0822

Hydrogen and Metals (Chemically basic)				
Iron (ferrous)	Fe	55.84	2	0.0358
Aluminum	Al	27.1	3	0.1107
Manganese	Mn	54.93	2	0.0364
Acid or Negative Strong Acids				
Chlorine	Cl	35.46	1	0.0282
Sulphate	SO_4	96.06	2	0.0208
Weak Acids				
Bicarbonic	HCO_3	61.013	1	0.0164
Carbonic	CO_3	60.005	2	0.0333
Sulphide	S	32.06	2	0.0624
Phosphoric	PO_4	95.04	3	0.316

Chase Palmer has proposed a classification based upon the reacting values of the radicles taken according to the groups in the above table.

Two properties, salinity and alkalinity, characterize practically all earth waters. Salinity results from the presence of salts that are not hydrolized or broken up into radicles. Such salts are formed by the union of the strong acid radicles with bases. Salinity is, therefore, proportional to the reacting value of the strong acids. Alkalinity is due to the presence of free alkaline radicles resulting from the breaking up of the salts of the weak acid, and is proportional to the reacting value of the bases in excess of the reacting value of the strong acids.

In stating the value of salinity, the reacting value of the strong acids is multiplied by 2, since in forming a salt there will be involved a basic reacting value equal to that of the strong acids. Likewise the value of the alkalinity will be found by doubling the excess of basic reacting value over the strong acid reacting value.

Palmer divides waters into five classes according to the relation which the reacting value of the strong acids bears to the reacting values of the alkalies; and to the alkalies plus the alkaline earths:

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

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

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

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

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

Practically all mineral waters fall into classes 1, 3 and 5.

The character of the salinity and alkalinity may be sub-classed as follows:

Primary salinity results from the solution of salts formed by the union of the strong acids and the alkalies—sodium chloride ($NaCl$), etc.

Secondary salinity results from the solution of salts formed by the union of the strong acids and the alkaline earths—calcium sulphate ($CaSO_4$).

Tertiary salinity results from the solution of salts formed by the union of the strong acids with the metals—aluminum chloride ($AlCl_3$).

Primary alkalinity results from the solution (hydrolysis) of salts formed by the union of weak acids with the alkalies—sodium bicarbonate ($NaHCO_3$).

Secondary alkalinity results from the solution (hydrolysis) of salts formed by the union of the weak acids and the alkaline earths—calcium bicarbonate ($Ca(HCO_3)_2$).

Tertiary alkalinity results from the solution (hydrolysis) of salts formed by the union of the weak acids and the metals—ferrous bicarbonate ($Fe(HCO_3)_2$).

CHAPTER III.

VALUE AND USES OF MINERAL WATERS

BY

JAMES K. CROOK

ADAPTED BY R. D. GEORGE

THE SOLID AND GASEOUS COMPONENTS OF MINERAL WATERS AND THEIR THERAPEUTIC USES

While it is a growing conviction among physicians that the therapeutic properties of mineral waters depend upon the properties of the ions and not upon the combinations of ions called salts, the average physician in prescribing, and the layman in using medicines thinks in terms of the salts. For this reason the chemical constituents of mineral waters will be discussed in terms of the theoretical combinations commonly supposed to exist in mineral waters.

The following treatment of the subject is quoted, by permission of Mrs. Jas. K. Crook, and the publishers, from "Mineral Waters of the United States and Their Therapeutic Uses," by Dr. James K. Crook. A few minor changes have been made, chiefly in the nature of omission of paragraphs not applicable to the mineral waters of Colorado. Much matter of a general character, though not strictly applicable to Colorado mineral waters, is retained because of its great value.

The solid chemical ingredients of mineral waters are made up as follows:

I. Common ingredients:

- Acids: carbonic, sulphuric, hydrochloric, silicic, etc., usually in combination.
- Aluminum: oxide and sulphate.
- Calcium: carbonate, chloride, sulphate, phosphate.
- Iron: carbonate, bicarbonate, oxide, sulphate.
- Lithium: carbonate, bicarbonate, sulphate, chloride.
- Magnesium: sulphate, carbonate, bicarbonate, chloride.
- Potassium: carbonate, bicarbonate, chloride, sulphate, and phosphate.
- Silicon: usually as silica or silicon dioxide; occasionally as the bicarbonate.
- Sodium: chloride, carbonate, bicarbonate, sulphate.

II. Rarer ingredients:

Acids: crenic and apocrenic, usually as crenates.
Ammonium: nitrate, chloride, crenate.
Antimony: as oxide and sulphate.
Arsenic: arseniate of sodium and potassium; arsenious acid.
Barium: as baryta or barium oxide and the sulphate.
Boron: as biborate of soda, or borax.
Bromine: as bromides of sodium, potassium, etc.
Cadmium: }
Cæsium: } as sulphate } very rare.
Chlorine: as chlorides; rarely free.
Cobalt: }
Copper: } very rare.
Fluorine: as fluorides in two or three springs.
Iodine: as iodides of sodium and potassium.
Lead: very seldom seen.
Rubidium: }
Strontium: } very rare.
Zinc: }

Besides the above-mentioned solids the following gases are commonly found in mineral springs:

Carbon dioxide, or carbonic-acid gas.
Hydrogen sulphide, or sulphureted hydrogen.
Oxygen.
Nitrogen.
Carbureted hydrogen: very rare.

Almost all springs contain an appreciable quantity of organic matter. Besides the two organic acids above mentioned (crenic and apocrenic), three well-defined substances, known as baregine or hydrosin, glairine, and sulfuraria, have been identified. They will be described at the end of this section.

It may be said, without fear of dispute, that the most frequent, as well as the most important, component of a mineral spring is water itself. Aside from its absolute necessity to the preservation of all forms of life, this agent possesses certain very important therapeutic properties, some of which may be considered at this time. When ordinary pure water is swallowed it is almost immediately taken up by the radicles of the gastric veins, passing directly to the liver, and from thence into the systemic circulation. Its manifold functions in the body are fully treated of in the works on physiology. For our purpose it is sufficient to notice its influence on the emunctories. Water is actively diuretic, not only increasing the liquid flow of the urine, but if taken in large quantities greatly augmenting the amount of solids—urea, uric-acid, etc.—escaping from the system in any given length of time. It thus aids in the process of metabolism or tissue metamorphosis, and may be said, so to speak, to "flush the system." It also dilutes the urine, renders it lighter in color and specific gravity, and sometimes relieves it of irritating qualities. Water in large quantities thus becomes useful in certain kidney diseases, characterized by stagnation of the renal circulation and suppression of the urine. It is also valuable in acid states of the urine, characterized by scalding on urination and a frequent desire to empty the bladder, symptoms which are observed in numerous affections of the genito-urinary passages. In warm weather water is also diaphoretic, and, aside from its grateful, cooling, and refreshing effects, it thus has some influence as an anti-pyretic in febrile states of the system. According to Maillart, of Geneva, typhoid fever may be treated internally by copious draughts as a definite method. Five to six quarts may be administered daily during the whole of the febrile period, and there are no contraindications. The good results which have been observed are no doubt due to oxidation of the toxins and refuse material, which are thus rendered soluble and eliminated. When taken cold in considerable quantities, water also stimulates the peristaltic action of the small intestines, and thus has a certain cathartic influence. The various local uses of water in almost every department of medical and surgical practice are too familiar and too numerous to be described here. Some of them will be considered in the chapter devoted to balneo-therapeutics. The therapeutic effects of water are modified by the presence of its mineral and gaseous contents, and it is on account of the presence of one or more of the substances now to be described that a hydriatric course of treatment is inaugurated. It is not proposed to enter into a detailed account of the physiological actions and therapeutical uses of these various bodies, but simply to refer to them in their relations as constituent parts of mineral waters.

Acids.—Numerous acids occur in mineral waters, but they are seldom found in a free or uncombined state, being, as a rule, united with one of the metallic bases—sodium, potassium, iron, etc.—to form salts. However, a number of our springs contain sufficient quantities of free acid to impart certain distinguishing characteristics to the water. These acid or sour waters should not be confounded with those termed acidulous, which derive their name from the presence of carbonic acid. Most of the sour springs contain free sulphuric acid. Free hydrochloric acid has been found in several of the Yellowstone Park Springs; but, in common with phosphoric and silicic acids, it is very rarely observed uncombined. Almost all of the sour springs contain large quantities of other ingredients, especially iron and alum, which increase their therapeutic applicability. Being very astringent, the stronger acid waters are useful in relaxed states of the mucous membrane, especially when characterized by diarrhœa and dysentery. They have also been used with good effect in hæmoptysis, colliquative sweats, and in depraved and impoverished conditions of the body due to intemperance or specific diseases. They also have an extended local field of usefulness, being employed with good results in leucorrhœa, pharyngitis, and conjunctivitis, and in superficial ulcerations.

Aluminum.—This substance is found in springs in the form of the oxide, or alumina, and of the sulphate. It occurs in variable quantities, ranging from a mere trace to sixty or eighty grains per gallon, as seen in some of the Virginia alum springs. The sulphate is almost always present in the sulphureted chalybeate waters, and, as stated above, in the acid springs. The internal use of alum waters is generally governed by these associated ingredients. Some of the alum springs have acquired a considerable reputation in scrofulous diseases and in chronic diarrhœa and dysentery. The iron-alum waters are beneficial in passive hemorrhages and in exhausting night-sweats. Locally their astringent action calls them into service in much the same class of cases as are benefited by the acid waters. They have produced valuable results in conjunctivitis, stomatitis, chronic vaginitis, and other relaxed or inflammatory states of those portions of the mucous surfaces accessible to local treatment. They have also been found to act as a useful auxiliary in the treatment of ulcerated surfaces, abrasions, etc. In large quantities the alum waters have a laxative influence, but they are seldom used in virtue of this action.

Ammonium.—Ammonium, in the form of the chloride and carbonate, is found in a few mineral springs, but in quantities too minute to add to their medicinal value. The nitrate and nitrite are usually present in combination with the organic matter of mineral waters, but are properly classed among the undesirable ingredients, or impurities.

Arsenic occurs in several of the American mineral springs, usually as the arseniate of sodium. Though existing in minute quantities, the well-known physiological effects of this powerful substance may be quickly produced by the imbibition of mineral waters containing it. When taken internally, arsenic promotes the appetite and digestion and improves the body nutrition. It lessens the excretion of carbonic acid, and probably also of urea: in other words, it checks retrograde tissue metamorphosis.. It also increases the secretion of the gastro-intestinal mucous membrane and hastens the peristaltic movements. Arsenic also possesses in a marked degree the peculiar influence upon the nutrition and the general bodily functions which we express under the term alterative. In virtue of these actions the arsenical waters may be used with confidence in a considerable variety of disorders. They are highly extolled in anæmic states, especially when accompanied by dyspepsia and catarrh of the bile-ducts. They are also used with success in menorrhagia and other uterine disorders in the female, and in functional impotence in the male. In large doses they have been found useful in chronic malarial toxæmia after quinine has failed. They are likewise recommended for the cachexias resulting from syphilis, phthisis, and scrofula, and for neurasthenia. Perhaps the most striking results from the use of arsenic have been observed in chronic skin diseases of the squamous variety, especially eczema and psoriasis. To a lesser extent it is also useful in old, long-standing cases of pemphigus and acne. Without mentioning the numerous additional uses of this drug, it may be said that some arsenical waters appear to meet the therapeutic indications more promptly, with more permanent results, and with less constitutional and local irritation than the artificial preparations of arsenic.

Bromides and Iodides.—Bromine is found in some of the American mineral springs combined with sodium, potassium, and magnesium, in the form of bromides. Similar salts of iodine are usually coexistent, so that these components of mineral springs may be described together. Iodine is most frequently found as the iodide of sodium, bromine as the bromide of magnesium. The general effect of these waters may be described as alterative; they promote tissue metamorphosis, and have thus been used with benefit in cases of chronic exudations, old gunshot-wounds, glandular swellings, hypertrophy of the spleen, ovaries, etc., and in tertiary syphilis. Great benefit is also observed in chronic mercurial and saturnine poisoning. The bromides are believed to combine with the metals, forming soluble compounds, which are more easily eliminated from the system. The bromated waters are also given to allay nervous irritation, but they are not equal to the iodides in alterative influence. The speedy curative effects of the iodides are sometimes evinced in a remarkable degree, although they may be present in the springs only in minute quantities. Indeed, certain iodide springs were celebrated for the cure of scrofula, obesity, goitre, etc., long before the presence of these salts had been ascertained. The iodo-bromated waters are further recommended in certain respiratory disorders—chronic bronchitis and asthma—as well as in rheumatism, gout, and chronic Bright's disease. Their effects are usually modified or enhanced by the other chemicals which are almost always coexistent, viz., the chloride of sodium and ferruginous salts. They consequently have a very wide range of applicability in practical medicine.

Calcium.—The salts of lime are among the most constant constituents of mineral waters. They occur as the carbonate or limestone, the chloride, the sulphate or gypsum, and the phosphate. It is the sulphate of lime which gives the property of hardness to many of our ordinary drinking waters, unfitting them for washing purposes. Lime is an essential constituent of the human body, about two pounds existing in the bones of the normal adult. Its loss in children gives rise to the condition known as rhachitis or rickets. It also enters into the composition of the brain-substance—nerves, blood, muscles, saliva, and other tissues and fluids. The carbonate of calcium will be described under Carbonic Acid and the Carbonates.

The chloride of calcium is very soluble, and is frequently found in mineral waters. It is apt to be combined with the chloride of magnesium, from which it is very difficult to separate. It has tonic and deobstruent effects, and appears to promote in some degree the secretion of urine, perspiration, and mucus. The muriated calcic waters may be used in scrofulous diseases and in chronic eczema and impetigo connected with a lymphatic temperament.

Phosphate of calcium.—This is an exceedingly insoluble substance, and consequently does not exist in mineral waters in quantities sufficient to prove of much value. In very large doses the phosphate of lime waters might be of benefit in phthisis, mollities ossium, and other conditions where the lime-salts of the body are deficient.

CARBONIC ACID AND ALKALINE CARBONATES AND BICARBONATES

Most cold mineral springs contain carbon dioxide or carbonic-acid gas in greater or less proportion. They thus become carbonated waters unless some other ingredient is sufficiently prominent to fix its own character upon the water. Those containing an excess of this gas have an acid reaction when first drawn, and an acidulous, pungent, but very agreeable taste. It gives to water a bright and piquant sparkle, and is the gas used in charging all of our synthetic artificial waters—"seltzer," "soda," "vichy," etc. It is also present in many wines. In moderate doses carbonic acid promotes the flow of saliva, tends to allay nausea and gastric irritability, aids digestion, assists in rendering the fluids of the body alkaline, promotes diuresis, and imparts a sense of well being. The carbonic-acid waters are often better borne by the stomach than any other form of drink, and they form a pleasant medium for the administration of milk to fever patients.

The Alkaline Carbonates give character to the important alkaline group of mineral waters. They consist of the carbonates of calcium, iron, lithium, magnesium, potassium, and sodium. They are frequently associated with carbonic acid, which, greatly increasing their solubility, forms with them the bicarbonates. These salts have so many characters in common that it seems proper to consider them in one group, afterward observing their individual properties. Though apt to be acid in reaction when first taken from the fountain, owing to the presence of carbonic anhydride, yet their action in the system is always that of alkalies. They form a very efficacious and speedy remedy in the treatment of acid dyspepsia and flatulence. They also act as stomachics, if given before meals, by stimulating the peptic glands. Having a diuretic tendency, the alkaline carbonated waters tend to correct acidity of the urine, and are of great service in fevers, rheumatism, gout, vesical irritation, diabetes, etc. In Europe they have long held high favor in the treatment of metritis and leucorrhœa, as well as other female pelvic disorders. When combined with salines, as they often are, forming the great alkaline-saline group of waters, they are of much value in catarrhal conditions of the gastro-intestinal tract with engorgement of the portal system. They have further been found useful in obesity. When associated with iron, constituting the much-prized alkaline-chalybeate group, the range of their action is manifoldly extended (vide iron).

Carbonate of calcium.—The familiar "chalk mixture" of the drug stores is largely composed of this substance. It possesses several properties not observed in the other carbonates. Although alkaline in action, it is not evacuant, but in large doses is apt to cause constipation. In virtue of this action the calcic waters have been used with much success in chronic diarrhœa. There is also reason to believe that uric acid, gravel and calculi may be disintegrated and eliminated under their free use.

Carbonate of lithium.—The carbonate of lithium is sparingly, the bicarbonate freely, soluble in water. Solutions of lithia are alkaline. These salts are found in a considerable number of mineral waters in various proportions. Some of those most extensively advertised contain less than half a grain to the gallon, and may be regarded as practically inert so far as this substance goes. Lithia owes its virtues to the fact that it unites readily with uric acid forming the urate of lithia—a freely soluble compound which passes readily from the system. For this reason it finds its most important application in diseases characterized by the uric-acid diathesis, otherwise known as uricæmia, lithæmia, or lithiasis. It is notably useful in cases of uric-acid, sand, gravel and calculi, and in gout and rheumatoid arthritis. It is also stated to be of value in phosphatic deposits in the appendix, and in concretions, tophi, etc.

Carbonate of magnesium.—This is perhaps the most efficient of the antacids. It is mildly alkaline in reaction. Perhaps its best effects are observed in acid eructations, and pyrosis, and in sick headaches, especially when due to or accompanied by constipation. It is also of value in checking the formation of uric-acid gravel and calculi.

Carbonate of potassium.—This salt is usually found in the form of the bicarbonate. It possesses antacid, diuretic, and antilithic effects in connection with the other alkalies, but claims no individual or peculiar virtues.

Carbonate of sodium.—The carbonate of sodium may be taken as the standard of the alkaline carbonates found in mineral waters. This salt, or the bicarbonate, occurs with greater frequency, and, as a rule, in larger quantities than the other compounds of this character. In the body it is found in the blood and saliva, giving to these fluids their alkalinity. It also occurs in the urine, the lymph, the cephalo-rachidian fluid, and in bone. Its function in nutrition is rather accessory than essential. Waters containing the carbonate or bicarbonate of soda may be used whenever an alkaline water is indicated, as these salts possess most of the virtues of the group.

The chlorides.—These salts furnish the active ingredients of the muriated saline waters. They occur in about the same combinations as do the carbonates, viz., the chlorides of calcium, iron, lithium, magnesium, potassium, and sodium.

The chloride of sodium is the most universal of these salts, and it is found in almost all mineral waters, ranging from mere traces to several thousand grains per gallon. It is one of the essential components of the body, being found in every structure except the teeth. A certain daily quantity is required for the needs of the system, and its withdrawal is at once keenly felt. It exercises its chief functions in the fluids, and determines to a great extent the quantities of exudations, regulates absorption, and serves to maintain the albuminoids, especially those contained in the blood, in a state of fluidity. It is, in a word, one of the most important factors in the process of nutrition. The experiments of Bischoff, Voit, and Kaupp show, further, that an increased supply of chloride of sodium causes an augmentation of the amount of nitrogen excreted through the urine.

The chloride of sodium or muriated saline waters, when taken into the stomach in therapeutic doses, cause an increase in the flow of gastric juice, bile, pancreatic juice, and intestinal fluid, promote the appetite, and aid in the process of digestion. They have a mild aperient effect, and have an antiseptic influence on the intestines, preventing or tending to prevent putrefactive changes. Salt promotes tissue metamorphosis, as shown by an increase in the quantity of urea excreted. The mucous secretion of the bronchial tubes is also increased, giving to this substance some expectorant influence. According to Spillman, the chloride of sodium is somewhat sedative to the nervous system.

In virtue of their physiological action, the muriated sodic waters are of great value in gastric, hepatic, and intestinal disorders. In addition to the chloride of sodium, they almost always contain valuable alkaline ingredients, and frequently ferruginous salts, which greatly extend their therapeutic applicability. It would be difficult to mention a chronic affection involving the stomach, liver, or intestinal tract in which one of the muriated saline waters could not at some stage be beneficially exhibited. According to Herman Weber, they are to be preferred even to the bitter or sulphated saline waters in portal and pelvic congestion in thin or spare persons, where emaciation is to be avoided. Their special application, however, is to be found in atonic dyspepsia, insufficiency of the digestive fluids, giving rise to dry, scybalous stools, a furred tongue, disagreeable taste in the mouth, loss of appetite, hebetude, and malaise. These waters are also applicable to some extent in chronic broncho-pulmonary affections with a scanty, tenacious expectoration.

The chloride of potassium usually coexists in mineral springs with chloride of sodium, though in much smaller quantities. It is also less generally distributed in the body, where its functions appear to be analogous to those of the sodium salt.

Chloride of magnesium is also frequently found in saline mineral waters. It forms the bittern of salt works, and occurs in great quantities in the waters of the Dead Sea and in some of the brines of New York and Michigan. It is also present in considerable proportion in sea-water. This substance promotes the flow of bile, acting mildly as a purgative and increasing the appetite.

Chloride of lithium is found in small amount in several Colorado mineral springs. It possesses no therapeutic properties apart from those which have been considered under Carbonate of Lithium.

A small amount of *free chlorine* is stated to exist in a few mineral waters, but it does not seem to have increased their therapeutic efficacy.

Hydrogen sulphide or sulphureted hydrogen gas.—This gas is an important constituent of a large number of our most valuable cold and thermal springs. It occurs most frequently in a free state, but is sometimes found in combination as sulphides with sodium, potassium, calcium, or magnesium. This substance imparts to its waters their peculiar odor of decayed eggs, which, at some springs, may be noticed at a considerable distance if the wind is favorable. The hot sulphureted springs are most frequently observed in mountainous or volcanic regions, and contain sulphates of a number of the elements, and occasionally sulphides and sulphuric acid. Many of them are also strongly impregnated with chloride of sodium. When coming in contact with air these waters usually present a milky appearance, owing to a precipitation of the sulphur, the hydrogen of the compound passing into the atmosphere. Sulphureted hydrogen is an irrespirable gas, and when inhaled in considerable quantities is quickly fatal. Its activity when taken into the stomach in mineral waters is open to some doubt. Dr. Moorman, who observed the effects of the sulphureted waters for many years at the Greenbrier White Sulphur Springs, looked upon it as possessing an alterative action equal to that of mercury in syphilitic diseases. It cannot be disputed that these waters promote the activity of the bowels and kidneys. They are highly advocated by medical practitioners of experience in rheumatism, gout, chronic synovitis, white swelling, and many skin diseases. Many of the sulphur springs are celebrated in the treatment of chronic malarial infection accompanied by an enlarged spleen and liver, and in hepatic congestion, abdominal plethora, and hemorrhoids. They have also been found useful in certain female pelvic disorders, especially in chronic uterine inflammations. The vaunted efficacy of sulphureted hydrogen gas in phthisis has been shown to possess no basis in fact. It is probable that the older writers also overestimated the cholagogue influence of this substance. We may readily believe that not a few of our well-known sulphur springs owe their celebrity more to other coexisting ingredients than to the sulphureted hydrogen which they contain. In the form of bath, the sulphureted waters also possess an extensive sphere of application.

Iron.—This element forms the base of the numerous and important waters of the chalybeate group. In the body it is present as an essential element of hæmoglobin, the coloring matter of the blood and the great oxygen-carrying and distributing agent. Iron also occurs in the lymph, chyle, gastric juice, pigment of the eye, and in traces in the urine. It is also a constant constituent of milk and eggs. The loss of even a small proportion of the normal quantity of iron in the blood is quickly shown by the pallor of the countenance and other symptoms of anæmia which are produced.

Iron is, perhaps, most often found in springs as the bicarbonate, although many analyses show the sulphate, a few the oxide, and others the chloride.

The bicarbonated chalybeate waters are usually most valuable for internal administration. Not only does carbonic acid increase the solubility of the iron, but it disguises its otherwise astringent and ferruginous taste, and aids in its speedy absorption and assimilation. These waters prove of great value in cases of anæmia or poverty of the blood. Clinical experience has shown that they cause an increase in the appetite, a return of the normal color, a gain in weight and strength, and a general improvement of the bodily functions. Investigations with the hæmoglobinometer have further proved that the deficiency of the coloring-matter of the blood observed in anæmic states may be readily made up by the administration of a carefully selected chalybeate water. It matters not though the iron be present in small quantities, and few of the carbonated iron waters contain more than five or six grains per gallon. The blood contains normally about forty-five grains of iron, and this quantity cannot be permanently increased by consuming large quantities. It is probable that the deficiency, no matter how produced, never exceeds fifteen or twenty grains.

An excess of what is actually required, therefore, only defeats its object by disturbing the digestion, exciting the cardiac action, and producing disturbances of the cerebral circulation, mental confusion, and dizziness. A chalybeate water containing not more than one grain to the gallon will speedily show its influence in the returning color and increased tone and vigor of the system.

The indications for the use of the iron waters are numerous. It may be said that they serve a useful purpose in almost all debilitated states of the system accompanied by a loss in the hæmoglobin of the blood. In slow convalescence from acute diseases, the anæmic states resulting from a severe operation or difficult confinement, in all forms of hemorrhage not due to fullness of the vessels or fragility of their coats, in amenorrhœa when due to chlorosis, in the debilitating catarrhs of the uterus and vaginal mucous membrane, and in the various cachexias the chalybeate waters may be confidently expected to render valuable aid.

It is interesting to note, as Dr. Irwin observes, that the more recent and direct is the cause of an anæmic state the more readily is the iron taken up and assimilated to the wants of the system. Iron waters should be taken guardedly by stout, red-faced, plethoric persons. They are directly contraindicated in vertigo or rush of blood to the head, and in all cases where there is reason to suspect the integrity of the blood vessels. The iron waters are best taken half an hour to an hour after meals, in doses ranging from a wine glassful to a tumblerful, according to the strength of the water and the weight of the patient. The gastric mucous membrane is at this time in the best condition to absorb and assimilate it. In severe cases, however—such, for example, as pernicious anæmia, leucocythæmia and extreme debility—when we wish to exert a speedy influence, they may be taken every three hours. The milder iron waters may be consumed *ad libitum*.

The chloride of iron is not often found in mineral waters, and then in very small amount.

The sulphate of iron is found in large quantities in a number of springs. All of the acid and most of the sulphur springs are rich in this salt. The sulphate of iron waters have excellent properties as astringents and tonics, but they are not so palatable nor so well adapted for general use as the carbonated chalybeates.

Lithium. (See the Alkaline Carbonates.)

Magnesium. (See Carbonate of Magnesia, Sulphate of Magnesia, etc.)

Manganese.—This element in the form of the oxide, the carbonate or bicarbonate, and the sulphate has been detected in a few of our American springs. From the circumstance that it exists normally in the blood, it was supposed that it might, like iron, play an important part in the human economy. Manganese promotes the flow of bile, is somewhat emmenagogue, and undoubtedly possesses some reconstructive and tonic properties. In the latter sphere of its influence it is probably a useful auxiliary to iron in several springs, but its claims are not such as to entitle it to an important place in therapeutics.

Nitrogen and oxygen.—These gases, as occurring in mineral waters, have no medicinal application. Several of the combinations of oxygen—oxide of iron, oxide of alumina, etc.—have been mentioned.

Potassium. (See Carbonate of Potassium, Sulphate of Potassium, etc.)

Silicon.—This element is a very common constituent of mineral waters. It occurs in the form of silicon dioxide, or silica. Potassium, sodium, and magnesium silicate, and silicic acid are also noted in several analyses. Silica appears to have some value when taken internally in cancer and lupous ulcerations, according to Dr. Piffard, of New York. It is also stated that albumin and sugar have been caused to disappear from the urine by its use. As a constituent of mineral waters, however, no advantage seems to have been taken of its rather hypothetical virtues.

Sodium.—This element is described under its combinations. (See the Sulphate, the Carbonate, etc.).

Strontium is found in traces in several springs. Its medicinal application is very limited. Being an intestinal antiseptic, however, it is possible that considerable quantities of the strontiated waters might be found useful in flatulence, intestinal torpor, summer diarrhœa, etc.

The Sulphates.—Several of the sulphates have already been spoken of. Those now to be considered are the sulphates of potassium, magnesium, and sodium. The action of the former salt is quite analogous to that of the two latter. It is usually found in very small quantities, however, so that the important class of sulphated salines, or bitter waters, may be said to owe their activity almost entirely to the sulphate of magnesia, or Epsom salt, and the sulphate of soda, or Glauber's salt. The sulphate of soda is a white crystalline powder, bitter and rather nauseous to the taste. It is freely soluble in water, and is one of the most frequent constituents of our mineral springs. The sulphate of magnesia occurs when isolated as a transparent crystalline salt, also bitter, nauseous, and saline, and exceedingly soluble. Both of these salts are laxative or purgative in effect, according to the dose taken. They act by promoting the process of endosmosis and exosmosis, thus abstracting the watery elements of the blood and increasing the intestinal secretions. The observations of Rutherford and Vignal show that the sulphate of soda is also a valuable hepatic stimulant, the effects of the magnesia salt appearing to be confined chiefly to the intestinal glands. Both increase the urinary flow. Waters containing exceedingly small quantities of these salts tend to promote regularity of the bowels when taken continuously. Their best effects are observed in disordered conditions of the stomach, liver and bowels, with the concomitant symptoms of constipation. In sluggish states of the liver, characterized by a sallow countenance, yellowness of the conjunctiva, coating of the tongue, and hemorrhoids, the sulphated saline waters are speedily efficacious. In eliminating the various chronic infections from the system, scrofulous, syphilitic, and malarial, as well as in expelling lead, mercury, and other metallic poisons, they furnish an important and useful application. They are likewise of considerable value in promoting the absorption of pleuritic and peritoneal transudations. They are, further, believed to be useful in corpulency in virtue of their accelerating influence on tissue changes. In organic cardiac disease accompanied by œdema of the lower extremities, with threatened general anasarca, these waters are of great service in relieving the engorgement of the peripheral circulation and partially removing the strain on the heart. The value of a brisk saline will be generally acknowledged in the "rocky" state following alcoholic excesses. When combined with the alkaline carbonates forming the important alkaline-saline group of waters, or with iron producing the useful saline-chalybeates, the sphere of their therapeutic efficacy is greatly extended. For a purgative effect the sulphated sodic and magnesic waters are, as a rule, best taken on an empty stomach, before breakfast, and followed by a brisk walk in the open air. As laxatives they may be taken in smaller doses, but, as before, on an empty stomach. The lighter salines may be drunk or used for the table *ad libitum.* The fact must be remembered, however, that while, as a rule, these waters act as mild, certain, and speedy aperients, they fail absolutely in some cases, and occasionally appear to produce the contrary effect of constipation. Several of the author's own patients, while sojourning at Carlsbad and imbibing daily considerable quantities of the rich saline waters at that well-known spa, have found it necessary to resort to mercurial or vegetable purges. These waters are apt to act injuriously in chronic inflammatory or cancerous states involving the stomach, peritoneum, or intestines. They are, likewise, to be used cautiously in cases of extreme anæmia and great debility.

Organic ingredients.—As previously stated, water when passing through the upper strata of the earth absorbs from the vegetable matter with which it comes in contact certain principles, usually classed collectively as "organic matter," and, as a rule, rated by chemists as an impurity. After percolating through deeper strata most of this material is filtered out, so that when the spring emerges it is apt to be comparatively free from such matter, except in quantities too small to have a deleterious influence when imbibed. This organic matter is almost always simply a product of vegetable decomposition, and hardly admits of a detailed subdivision. Chemists have, however, succeeded in elaborating from it several secondary products, which may be briefly described as follows:

Crenic and apocrenic acids, known as organic acids, have been detected in some waters. The former is a pale yellow, transparent, hard, uncrystallizable substance. It exists in vegetable mould, and is found in the ochreous deposits occurring in ferruginous waters. Apocrenic acid derived from humus, a brown powder resulting from decomposition of wood. It also occurs in chalybeate waters, where it appears as a brownish-colored, amorphous deposit. These acids will be observed in a few analyses as crenates and apocrenates of sodium, potassium, and iron. They possess no known medicinal value, nor, on the other hand, do they appear to be injurious.

Baregine, or *hydrosin,* is a brownish-yellow residue compound of organic azotized matter obtained from certain sulphur waters by evaporating them to dryness. It was first detected in the springs of Bareges, hence its name.

Glairine is an amorphous deposit found in reservoirs where water accumulates. It is insoluble, soft and unctuous to the touch, sometimes transparent, sometimes opaque. It possesses no action, so far as we know.

Sulfuraria is a confervoid growth formed in sulphur waters of which the temperature is below 122° F. In composition it is quite similar to glairin, and leaves a large amount of silicious residue when burned.

In addition to the above-named substances a great variety of microscopic bodies known as algæ are found, though their number is much less in mineral springs than in the waters of ponds, lakes, and streams. Organic matter composed of these growths is not regarded as being harmful; some have even attributed certain medical effects to their presence. The waters of the Red Sulphur Springs of Virginia, which contain an unusually large proportion of the algæ, are said to possess a sedative effect on the circulatory system which cannot be attributed to any of the remaining ingredients. These statements, however, by no means apply to the organic matter due to surface contamination, which occasionally finds its way into springs.

CHAPTER IV

RADIUM AS A CURATIVE AGENT IN MINERAL WATERS

INTRODUCTORY BY R. D. GEORGE

THERAPEUTICS OF RADIOACTIVE WATERS BY JOHN SATTERLY
AND R. T. ELWORTHY

THERAPEUTIC VALUE OF RADIOACTIVE MINERAL WATERS

Physicians, scientists and laymen freely admit that, in many instances, the curative effects of certain mineral waters cannot be explained by reference to the mineral contents of those waters as shown by the most careful chemical analyses. It is customary to refer to the change of surroundings, the restful conditions at the spas, and the psychological influence under which the patients live, as a sufficient explanation of the beneficial results which appear to be out of harmony with the medicinal value of the chemical contents of the waters. It is, however, a proven fact, apart altogether from the experiences of patients at spring resorts, that certain chemicals administered in doses of extremely small size will, in time, produce results quite out of proportion to the amount of such drug or chemical taken into the system. (See p. 34 of this report.)

The study of certain ductless glands long supposed to be functionless, and the study of certain bodies not known to be glandular in character or function have proved the extreme sensitiveness of the human system, and the fact that infinitely small amounts of certain secretions may profoundly affect the well being and functioning of the human machine. Certain foods are found to contain infinitely small quantities of certain vitally necessary ingredients (vitamines) without which the most perfect functioning of the animal system would be impossible.

Is it not possible that a part, perhaps a very important part, of the unexpected and unexplained virtues of certain mineral waters may be directly due to the subtle influence of radioactivity? The study of radium as a curative agent has proved beyond controversy its effectiveness in the treatment of certain diseases, notably cancer, and its influence upon certain bodily functions. If but a small fraction of the healing work attributed to radium by reputable physicians and surgeons is properly so credited, we are obliged to acknowledge the great power of a very small quantity of the element, since the total amount of radium hitherto used by the entire medical profession would scarcely exceed in weight a day's dosage of certain grosser drugs for a single patient.

The following paragraphs are copied from Mineral Springs of Canada, Part I. The Radioactivity of Some Canadian Mineral Springs, by John Satterly and R. T. Elworthy, Canada Department of Mines, Mines Branch, Bull. 16, pp. 50-52, 1917.

THE THERAPEUTICS OF RADIOACTIVE WATERS

It may be interesting to outline the main results of investigations concerning the therapeutic value of radioactive waters, although the greater part of such work has been done using artificially prepared radioactive solution, usually many times more active than naturally found solutions.

In the first place an increased activity of all the processes of nutrition and metabolism occurs. Increased oxidation is evidenced by a rise in the percentage of all urinary solids other than the chlorides, and a considerable multiplication of the red blood cells has been often observed. Difference of opinion exists as to the question of the bactericidal effects of radium and its derivatives. Some authorities have denied any such effects, yet treatment at Bath has shown an antibacterial effect in the case of gonococci. Radium emanation certainly has power to stimulate the elimination of toxins.

Under the influence of radium emanation the insoluble sodium monourate can be changed into a soluble monourate, which subsequently decomposes into ammonia and carbon dioxide. Work upon patients whose blood contained uric acid has shown that a similar process takes place in the human body when treatment in an ''emanatorium'' is given.

The chief agent in the therapeutic use of waters is radium emanation.

There are five ways of absorbing emanation:

1. Through the lungs.
2. Through the digestive organs.
3. Through the skin.
4. Through the medium of different forms of injection.
5. Through the employment of local applications externally.

In the first case the chief source of the emanation would be the gases which are so often evolved from springs. These gases, passed into the air of a suitable room, constitute it an ''inhalatorium.''

The lung is the quickest medium of absorption and discharge, and the radium emanation dissolves in the blood to a certain extent. From the blood it can enter the organs and tissue cells. The most satisfactory condition will arrive when the blood is saturated with emanation.

The second method of absorption will be adopted when waters containing radium or emanation are drunk. In this way the emanation penetrates the stomach and intestines, and diffuses into the capillaries of the lymph and portal vein, and much of the emanation imbibed reaches the arterial blood. In the case of inhalation the emanation is much more rapidly absorbed, but it is retained only as long as it is breathed, while in the drink cure emanation is introduced into the system, and solid decomposition products are deposited, which will continue to send out the radiations which are the valuable agents.

In many cases, relatively strong radium solutions are injected into patients, though such treatment hardly comes within the province of natural water therapy.

Besides inhaling radioactive air, and drinking radioactive water, a variety of baths using radioactive water have been devised, though the question of absorption by the skin is a much discussed one. The majority of authors agree that emanation does not get into the organism through the skin, but it exclusively gets into the blood through the lungs.

However, others arguing on the grounds of their experience state that if baths are taken for sufficiently long time, considerable emanation is absorbed.

THE USE OF THE RADIOACTIVE WATERS AT BATH, ENGLAND[1]

It may be of interest to outline the various ways in which the spring waters at Bath are utilized for therapeutic treatment. Bath is the oldest and most famous health resort in the British Isles.

There are three hot springs at Bath:

(1) The King's Spring rises in the King's Bath, which is surrounded by buildings of great historic interest. Radioactive waters are served from a fountain in the famous pump room which is supplied direct from the King's Spring; (2) The Hetling spring which supplies both drinking water and swimming baths in the old Royal or Hetling baths; and (3) the Cross spring which was the fashionable bath of the seventeenth century, when Pepys bathed there.

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[1] "Notes on the Therapeutics of Radium in the Bath Waters." Compiled by John Hatton, Director of the Baths.

Since Sir William Ramsay's report on the radioactivity of the Bath waters, showing that they were the most active in Great Britain, the latest methods have been employed to utilize this property.

It has been stated that radioactive waters may be used in three ways:—by inhaling the gases given off from the hot waters; by drinking the water, and by external application in the form of baths. Each one of these methods is employed at Bath.

A Radium Inhalatorium has been opened in which apparatus is installed whereby the radioactive waters of the Hot Springs may be inhaled or used for special sprays in a finely atomized form. The gases from the springs are also supplied in conjunction with the waters. The waters are atomized by steam, air, or by the gases, containing considerable amounts of emanation evolved from the springs.

Nasal sprays and douches, and ear and eye sprays are also given.

The radioactive waters are served for drinking in the grand pump room, and during the summer season at the Colonade fountain in the Institute gardens.

The Queens bath adjoining the grand pump room and the New Royal Baths, afford every convenience for all kinds of baths in the radioactive waters. The high temperature at which the water issues from the springs—49° C. or 120° F.—enables baths and douches to be given without any necessity for artificial heating.

There are deep baths with arrangements for lowering helpless patients into the waters, all kinds of reclining baths, douches, and douche-massage baths, such as are employed at Aix-les-Bains, Plombieres, and other famous European spas.

Besides these, there are large and well appointed swimming baths.

CHAPTER V.

BY

I. B. YEO

ADAPTED BY R. D. GEORGE

BATHS AND DOUCHES AND THEIR MEDICINAL USES

The ordinary cold-water bath ranges in temperature from 40° to 60° F.; the temperate bath from 60° to 85° F.; the tepid bath from 85° to 92° F.; the warm bath from 92° to 98° F.; and the hot bath from 98° to 106° F., or a little higher. The warm and hot baths are most frequently employed for medicinal purposes.

In his quest for new therapeutic aids, the inventive genius of man has devised numerous modifications of the simple water bath, some of which appear to us at this day as queer and fantastic. Thus, animal baths, made of blood, milk, bouillon, oils, or fats, have been in vogue and at one time it was customary to envelop the sufferer's naked body in the freshly removed skin of a calf, sheep, wolf, or dog. Vegetable medicated baths were composed of wine, vinegar, solutions of essential oils, infusions of thyme, rosemary, wormwood, lavender, willow, oak, Peruvian bark, etc. Medicated vapor baths contained incense, myrrh, benzoin, amber, sulphur, calomel, etc., and some of these are employed in a limited degree at the present day.

We no longer use animal excrement for bathing purposes, but baths of mud or moor and peat are still retained. It is beyond the province of this work to enter into a detailed description of the various methods of applying water to the cure of disease. We will, therefore, content ourselves with a cursory review of the principal forms of baths and douches in use at the present day, referring the reader to special works on hydrotherapeutics for more minute information.

The first purpose of the bath is that of cleanliness—that is, to remove any foreign impurity from the surface and to prevent the pores from being clogged by their own secretions and by the scaling of the cuticle. We cannot place the same credence in the absorptive power of the skin once accorded to that important organ. The skin undoubtedly absorbs gases to a certain extent, and it is possible that a strong salt solution may be partially absorbed at a favorable temperature—92° to 97° F. It is proper to say, however, that under the ordinary circumstances of the bath the weight of modern testimony opposes the view that there is any appreciable interchange of fluids between the blood and the bath medium. In the case of medicated or mineral baths, therefore, any modification of the effects of the simple bath may be attributed in a great degree, if not altogether, to the local influence of the artificial or natural ingredients of the water upon the skin. It is well known, however, that the human system tolerates changes of temperature in the air to a much greater extent than in water. While the air at 75° is perhaps too warm for most persons, a continued bath at that temperature becomes cold and depressing. Again, a bath at 98° to 102° acts far more energetically than the atmosphere at the same temperature. This is due to the fact that water, being a better conductor than air, brings more heat to the body, and at the same time suppresses cutaneous exhalation, which, as we know, is greatly increased by the air at that temperature.

THE COLD BATH

This is the ordinary natural bath which we take in streams, lakes, spring reservoirs, or the surf. While usually ranging in temperature from 40° to 60°, a hardy person can stand an even lower temperature. It may be stated that a lower degree than 50° F. is always dangerous if long continued.

Physiological Action.—The primary effect of the cold bath is shown in a contraction of the peripheral blood vessels, an acceleration of the pulse and respirations, an increase in the secretion of the urine, and in the general promotion of tissue change. There is an increase in the external expenditure and the internal production of heat, the blood at first probably rising 3° or 4° in temperature. Very soon, however, the period of reaction sets in, when we have an opposite set of phenomena developed. The skin is reddened from expansion of its superficial capillaries, the pulse is diminished in frequency, and the temperature is reduced to a point, perhaps a degree or two, below the normal. If properly employed under favorable conditions, the effect of the cold bath is exhilarating and unquestionably beneficial. When reaction sets in the skin is dry, a warm, grateful glow suffuses the surface, the muscles act with ease and elasticity, the mental faculties are clear, and a decided sense of well-being pervades the system. The individual feels capable of increased exertion, mental as well as physical. The physiological action of the cold bath may thus briefly be described as gently stimulating and decidedly tonic. It augments the appetite, promotes the functions of the skin, kidneys and liver, and, by the increased elimination of carbonic acid and the effete products of tissue combustion, improves the quality of the blood. When the bath has been too much prolonged, the water too cold, or the bather in an improper condition, reaction may be very difficult to establish, and disagreeable or even alarming symptoms ensue. The skin is pale or mottled, and corrugated, the extremities cold, the breathing labored, perhaps gasping, the lips chatter, and speech is difficult. If not relieved the nose and lips become livid blue, painful cramps seize the muscles, a sense of suffocation or constriction is felt in the upper part of the abdomen, and the patient is liable to pass into unconsciousness and death. It is fair to state, however, that such inopportune results from the cold bath are seldom met with, nor are the ordinary colds of every-day life liable to follow.

There are certain contraindications to the use of the cold bath which it is well to observe. In feeble or debilitated persons, or in diseases of the internal organs, where the system is incapable of a rapid and effective response, great care is required. Cold baths are contraindicated in almost every form of organic diseases, especially of the blood vessels, heart, kidneys, liver, or spleen. Old persons, in whom the arteries are liable to be fragile, should avoid such baths. It is eminently proper that every person beginning a course of cold baths be examined by a competent physician.

The best time for the hygienic cold bath is early in the morning, when the stomach is empty. It should not be of longer duration under ordinary circumstances than four or five minutes, and its effects may often be obtained in fifteen or twenty seconds. It is better not to lie in the water longer than ten seconds at a time. At the expiration of that period the patients should stand upright in the tub and rub the body vigorously with the hands. A few seconds under the shower bath often answer the purpose of the cold bath, especially in cold weather. A momentary application of cold water to the skin after the ordinary warm bath will relieve the feeling of weariness and lassitude which sometimes follows the latter bath.

Therapeutics of the Cold Bath.—This bath is employed rather to maintain the health and hardiness of those already well than to heal the sick. It cannot be gainsaid that a quick cold bath, followed by a vigorous rubbing of the skin and a good reaction, affords a preventive influence against "catching cold" and all that the ill-used phrase means. Yet there are not a few diseased and disordered states of the system in which the judicious use of the cold bath may serve as a valuable auxiliary to other modes of treatment.

We cannot here undertake an elaborate account of the various hydriatric uses of cold water. Its introduction as a therapeutic agent in typhoid fever by Ernest Brand in 1861 and its subsequent wide adoption for this purpose as well as for other conditions marked by a high temperature are well known. At this late day no observant practitioner of medicine who has thus employed the cold bath will deny its superlative merits over other methods of reducing the temperature, and the method requires no further words of defense or apology. The graduated bath, the cold pack, cold affusions, spongings, and compresses and frictions with ice, all act in the same manner as the cold bath, and depend for their efficacy upon their influence in abstracting heat from the body, and are useful in accordance with their ability to accomplish this purpose. Cold baths, however, are seldom used for their fever-reducing effects at spring resorts. The following remarks, therefore, will apply more especially to their employment in chronic diseases, to which alone spa treatment is, as a rule, applicable.

Habitual constipation from atony of the muscular coats of the bowels, with a tendency to hemorrhoids and abdominal plethora, is sometimes materially benefited by the systematic use of cold baths. Chronic dyspepsia and catarrh of the stomach may be favorably influenced by the same means. Muscular pains and rheumatism may also be improved by this method, though, as a rule, warm and hot baths are preferred. In allaying the local irritation of urticaria, scabies, prickly heat, and other irritative skin troubles general cold baths may be highly grateful. It is even stated that psoriasis may be cured by their prolonged use. In anæmic states general cold applications have caused an apparent increase of the red blood-globules and hæmoglobin. They are also of undoubted utility in cases of neurasthenia. Rickety, scrofulous, and ill-nourished children often revive speedily under the systematic use of carefully applied cold baths. Salt or sea-water is preferable for the bath in these cases. Even in phthisis a moderate use of the cold bath of a few seconds' duration often proves beneficial. The cold hip or sitz-bath may prove beneficial in certain catamenial irregularities. Profuse menstruation may be checked by a cold hip-bath of three to five minutes' duration, but its application for this purpose should be undertaken only under the advice of a physician. Hysterical atacks may be prevented by systematic hip-baths, and some authors believe that diabetes insipidus may be arrested in the same way. Spermatorrhœa and nocturnal seminal emissions are often benefited by a cold hip-bath at bedtime. Dysmenorrhœa, ovarian neuralgia, nymphomania, and other disorders of the female pelvic organs characterized by pain or nervous excitability may be treated with advantage by this bath.

THE TEMPERATE AND THE TEPID BATH

The temperate bath (60° to 85° F.) and the tepid bath (85° to 92° F.) are usually chosen for purposes of ordinary ablution. They abstract heat from the body and lower the pulse-rate in the same way that cold baths do. They entail little, if any, shock to the system, however, and can be borne for a much longer period than the cold bath. These baths are useful, though in a lesser degree than the cold baths, in febrile states. They may be employed in feeble persons of low vitality where a colder bath would not be well borne. According to Baruch, a lukewarm bath, 70° to 80° F., or beginning with 90° F. and gradually cooling, is valuable as a pelvic antipyretic, and may be employed with friction in utero-vaginal affections when not connected with pus formation. Prof. Leyden recommends baths of five to twenty minutes' duration at 86° to 95° F. in locomotor ataxia. He states that they cause a general improvement and invigoration of the system and a calming of the pain. Though no cures are observed, the beneficial effects of the baths cannot be questioned.

THE WARM BATH

(92° to 98° F.)

Physiological Action.—This is the bath of luxury *par excellence*, and is the one usually chosen by the timid, especially of the gentler sex. At most of the American thermal spas where the water issues from the ground at a high temperature the plunge baths and swimming pools are cooled down to a degree bringing them well within the classification of the warm baths. Under the influence of this bath a sense of calm enjoyment and tranquillity ensues. The respirations are diminished in frequency, the pulse-rate is lowered, and if the temperature of the water be less than 95° or 96° F. the heat of the body is invariably diminished. The soothing, hypnotic influence of the warm bath is doubtless due to a contraction of the cerebral vessels producing a temporary anæmia of the brain; but Heyermann and Krebs appear to have shown that water at this temperature possesses a direct local effect upon the peripheral cutaneous nerve-endings. The warm bath is undoubtedly the most favorable for the absorption of mineral substances, and exhalation from the skin is also increased by this temperature. This bath may be prolonged with safety for a much greater period than either the cold or the hot bath, but its undue continuance daily for weeks in succession gives rise to an eruption termed by the French *la poussee* and by the Germans the *bad-sturm,* or bath fever. The appearance of these symptoms is a warning that the bath is being overdone, and calls for a diminution in its frequency and duration.

The ultimate physiological effect of a properly conducted warm bath may be described, then, as sedative, restorative, and mildly antipyretic. These results are practically the same as those derived from the cold bath, the difference resting chiefly in the manner of producing them—the cold bath being attended by shock and reaction, the warm bath being devoid of these processes.

Therapeutics of the Warm Bath.—While extensively resorted to for purposes of ablution and as a pastime, the warm bath does not possess so positive a therapeutic influence as the hot bath. Yet it may be found a valuable auxiliary in a number of diseased conditions. Aside from its sedative and mildly antipyretic influence in scarlet fever, infantile pneumonia, and other acute febrile diseases, it is recommended in a considerable range of chronic complaints, and is used at many spring resorts. It is believed by some observers that the general reddening of the superficies produced by a warm bath has a derivative influence upon the deeper structures, and may thus tend to relieve visceral congestion. The fact of the development of a transient cerebral anæmia appears to have been well established, and some go so far as to maintain that a temporary cessation of the bile formation may result from the withdrawal of blood from the liver. The warm bath is thus recommended in icterus, with the belief that the accumulated bile elements might be eliminated by the kidneys and skin. Various forms of hepatic hyperæmia may be benefited by this means.

F. A. Hoffmann, of Leipsic, advocates its use in congestive states of the kidneys, although the hot bath is generally preferable in renal disease. A warm bath of short duration is safely borne in most cases of even advanced cardiac disease, and there is good reason for believing that the general dilatation of the superficial capillaries relieves the organ of some of its labor. The patient should dress in an adjoining room where the air is free from moisture, and should avoid too active friction with towels. A rest of fifteen to thirty minutes in the reclining position should follow the use of the bath. The warm bath is highly recommended by Hoffmann in the anæmia complicating obesity as the most efficient remedy for withdrawing water from the system. The warm bath is of utility in subacute and chronic rheumatism, and in the form of the sitz-bath in painful bladder and uterine disorders, though in a less degree than a bath of higher temperature. As the warm and the hot bath merge into each other, and are often used in similar conditions, further discussion of the subject will be continued in the next paragraph.

THE HOT BATH

(Temperature 98° to 106° F.)

The heat of the hot bath may be regulated to some extent by the susceptibilities of the individual. Some persons shrink in dismay from a temperature of 100° F., while others tolerate without inconvenience a degree of 106° F., or even higher.

Physiological Action.—This is entirely different from that produced by warm water. Its effects are rather of an excitant than a sedative character. The body-temperature is augmented, the pulse and respirations are increased in frequency, and the skin is reddened and congested. Exhalation from the surface and diaphoresis are markedly promoted, while absorption by the skin occurs to a very slight, if any, degree. It is probable that cutaneous absorption ceases altogether in water above 97° F. The secondary effects of the hot bath are liable to be of a depressing character. It is to be borne in mind that whereas the warm bath causes cerebral anæmia, the hot bath gives rise to a determination of blood to the head. It is, therefore, contraindicated in persons suffering from vertigo and a tendency to cerebral apoplexy. It should also be interdicted in organic disease of the heart or great vessels and in the hemorrhagic diathesis.

Therapeutics.—It is not consonant with the scope of this work to discuss the innumerable local uses of hot water in medicine and surgery. Its best application at our thermal springs and baths is found in the treatment of chronic rheumatism and gout, in the removal of chronic exudations from the joints, and in the manifestations of tertiary syphilis. Various local muscular pains and neuralgias are also favorably influenced. The thermal sulphur baths in some localities have attained a wide celebrity in the treatment of some of the obstinate squamous eruptions of the skin, more particularly eczema, psoriasis, and lichen. The hot hip bath is useful in a variety of painful and irritative states of the pelvic viscera. In vesical tenesmus, retention of urine, dysmenorrhœa, ovarian neuralgia, and chronic inflammations of the uterus and adnexa the systematic use of the hot hip-bath is frequently attended by excellent results. The hot bath is very serviceable in infantile and uræmic convulsions and puerperal eclampsia, and in hepatic and renal colic, but it is seldom employed for these conditions at mineral springs. The hot bath as well as the warm bath is best taken early in the morning or in the evening before retiring. The bather should not expose himself to the open air for at least half an hour after the bath.

THE DOUCHE.

This is an ancient method of applying water, and was in active use among the Romans. Through the labors of Charcot, Fleury, and others this hydriatric procedure has been greatly elaborated in France. In one form or another it will be found at all of the principal American spring resorts. To the ordinary thermic action of the water upon the skin is added the mechanical influence of its impact against the body, which may be modified by regulating the size and number of the streams and the force with which they strike. The mechanical effect being instantaneous, the douche may be used at a lower temperature than other baths. The colder the water and the more brief the application, the more complete the reaction. Below 55° F. it should never be applied to one part of the body longer than one minute. In accordance with the manner of projecting the water, douches have received various names.

The ordinary shower-bath is a descending douche. The ascending douche employed in diseases of the rectum, vagina, and uterus, is formed by an elastic rubber tubing of convenient length attached to a reservoir containing the water, and terminated by metal tips perforated by one or many openings, as the case may be. The water of these douches is usually tepid or warm.

The ring or circular douche is a cylinder formed of coiled pipes rising one above the other to a height of six feet, and having a diameter of about two and one-half feet. These pipes are perforated on the inside, and when the patient is within and the water turned on he is showered from every point of the circumference.

The universal douche is a similar contrivance by which the patient is showered from every direction, above and below as well as on all sides.

The *fan douche* is a metal tip spreading out like an ordinary fan, with openings at the distal end of the fan.

The *spout bath* is a douche of great power. It is formed by an orifice of from one to two inches in diameter, from which the water is projected over and downward from a height of five or six feet. The patient, usually reclining on a slab, is placed under the stream, which flows, hot or cold, upon the diseased part.

The *Scotch douche* consists of alternating streams of hot and cold water.

The *douche mobile* is a movable douche, connected by a flexible rubber hose with the reservoir, which enables the attendant to direct the stream upon any part of the body. The size and number of the streams may be changed at will by screwing various nozzles upon the base. We may thus have a movable shower spout or a filiform douche, as desired.

The *rain bath* is a form of douche in which the water is precipitated in fine streams from a height of not less than forty feet.

PHYSIOLOGICAL ACTION OF THE DOUCHE. According to Baruch, this is as follows: The nervous centers are aroused, the respiratory acts are deepened, the circulation invigorated, and the secretions increased. Locally the douche may be described as practically a thermic massage. It intensely excites the nervous and vascular structures and promotes the absorption of pathological products.

THERAPEUTICS. As a general invigorant the douche in its various forms excels all other hydriatric procedures in cases where muscular energy is in abeyance, whether this adynamia be primary or secondary to other conditions. The ergograph of Mosso, which registers automatically the muscular resistance, shows that the Scotch douche doubles, the rain bath trebles, and the ordinary tepid bath greatly increases the amount of work the muscles are capable of doing. It may, therefore, be employed to strengthen the muscles of feeble children and youths and to invigorate the lax fibres of men whom circumstances do not permit to indulge in normal exercise in the open air (Baruch). "In anæmia and chlorosis, in hypertrophies of the liver and spleen, in neurasthenia of the depressed type with morbid introspection and melancholy ideas, and in gastric and other troubles requiring a heightening of muscular energy, in a word, in all those conditions in which an elevation of nerve-tone is demanded, we have in the douche a most powerful weapon for good, and, I may say, for evil." The closing words of this quotation fittingly call attention to the care and circumspection required in handling so potent an agent. The temperature, pressure, and duration of the current, as well as the constitutional peculiarities of the patient, demand the most careful consideration.

THE VAPOR BATH

This is prepared by saturating the atmosphere with hot steam. In the form of the Russian bath it is widely used in our various bathing establishments and hydriatric institutes. The bather enters a dressing-room or antechamber warmed to 90° or 95° F. After undressing he passes, lightly covered, into the bath-chamber, which contains on one side rows of cots or benches, one above the other, like the beds in a state-room. The temperature of the bath will vary with the altitude of the cot, the lowest being about 95° F., while the upper one may be as high as 160°F. The room is saturated with moisture, and the bather on first entering might imagine himself surrounded by a dense fog. Owing to this moisture exhalation from the surface is at once effectually arrested, and this fact, added to the superheating of the air, renders the higher degrees of heat very oppressive, so that few bathers can tolerate a temperature above 120° or 125° F. The bather is made to lie on one of the benches, beginning with the lower temperatures and gradually increasing the heat by mounting to a higher bench. The first sensation on entering the room is one resembling suffocation, but after being subjected for some time to the influence of the hot, moist air, transpiration reaches its full activity, and the sensation is very pleasant. The attendant now comes and rubs the body vigorously with various irritating and cleansing substances, such as a hempen wisp, or the inner bark of a lime-tree previously soaked in soapsuds. He then holds the bather under a jet or shower-bath of ice-cold water. The skin being so intensely hot, the sensation is very agreeable, and no fear of cold need be apprehended, provided the contact of cold be brief. The shock is severe, but is followed by a feeling of great comfort. The duration of the bath for beginners is about fifteen minutes, but old habitues may remain half an hour or even longer. In regular bathing establishments the bather goes, after the bath, to an adjoining room and reclines on a sofa or bed until cool, usually partaking of some warm drink. If copious perspiration is desired, the patient is wrapped in blankets and reclines for a time before issuing forth. The Russians, however, often dress in the open air, and instead of using the jet of cold water go and roll themselves at once in the snow.

Physiological Action.—The hot vapor bath produces reddening and congestion of the surface, quickening of the pulse, fullness of the head, and a sensation of weight and oppression in the chest. The body temperature is undoubtedly elevated for the time being.

A modified Russian bath is in use at a number of our spring resorts. The hot vapors and fumes, chiefly sulphurous, with a certain amount of steam from the water, are conducted into a suitable apartment having a temperature ranging from 100° to 140° F. as desired. The patient remains in this chamber for a few seconds, or several minutes, as the case may be, and is afterward treated to a cold affusion or plunge. Care should be taken that no sulphurous or sulphuric anhydride is present in the vapor, as these gases are poisonous. Several of the Rocky Mountain resorts possess natural caves or caverns of considerable size, the atmosphere of which is saturated at all times with hot sulphurous vapors, maintaining a temperature in the cave ranging in some cases as high as 110° or 120° F. The requisite auxiliary facilities have been provided at some of these resorts, and a very serviceable natural vapor bath is thus improvised.

THE HOT AIR BATH

The form of hot-air bath now in use in this country as well as in Europe is known as the *Turkish bath*. The bather first enters the disrobing room, having a temperature of about 80°. After undressing he is supplied with a light gown and wooden-soled sandals. He next passes into a chamber having a floor of marble or slate, and walls of tile, known as the *tepidarium*, and having a temperature of 120°. Here he reclines on a couch for a period ranging from ten to twenty minutes. He is next conducted into an apartment called the shampooing-room, having about the same temperature. Here he is placed on an elevated marble table, and the body in all portions is thoroughly rubbed, kneaded, and massaged by the attendant. From thence he is ushered into a very hot room, termed the *caldarium*, and having a temperature of 160° to 170° F., or, perhaps, even more. The walls and floors are here found to be burning to the touch, and the need of the sandals becomes apparent. Here the perspiration begins at once to break forth upon all parts of the body, and a pungent, burning sensation is experienced about the nostrils. After ten or twelve minutes the bather is again conducted to the shampooing-room and douched with warm water at 98°, and thoroughly rubbed and flagellated with wisps of hemp or sea-grass, or with a fine, medium, or coarse, flesh-brush, at his own option. In some establishments an implement of antique pattern, known as the *strigil*, is still in use, and with this the attendant scrapes the body and extremities. The bather is next showered with cooler water at 90°, then douched with water at 70°, which causes a good deal of shock and terminates the bath. He is then led to the dressing-room, and after being thoroughly dried, reclines on a couch, enjoying the pleasurable "*dolce far niente*" condition in which he finds himself. This is the hot-air bath usually described in works on balneotherapeutics. In Turkey, however, it appears that the chambers are not heated so high, the temperature of the caldarium not being above 105° F. The technique of the bath varies somewhat at the different resorts and sanitariums in this country.

In some hydriatric establishments hot air or vapor cabinets are provided for those who, for any reason, are disqualified from inhaling the superheated atmosphere of the bath. Both Turkish and Russian baths are contraindicated in organic disease of the heart or blood vessels, lungs or brain, and in all acute diseases. They are to be used with circumspection by stout, full-blooded persons, and especially by those having a tendency to vertigo or fullness in the head.

PHYSIOLOGICAL ACTION OF THE TURKISH BATH. The higher temperatures of the Turkish bath produce a smallness and frequency of the pulse, a feeling of tightness and constriction in the forehead, and in beginners a slight smarting and itching of the entire body. There is a pungent, burning sensation about the nostrils, and the skin feels hot. The pulse soon becomes fuller, although still quick, while the temporal and other superficial arteries throb. The skin is soon covered by a profuse perspiration, and the mouth may be dry. The first effects of the Turkish bath may be somewhat depressing, especially in those unaccustomed to it, but it must be confessed that the old habitue enjoys every moment, from the time he enters the first hot-room until he saunters forth into the open air again to renew his vocation in the busy outside world.

THERAPEUTICS OF THE RUSSIAN AND TURKISH BATHS. Both of these baths are superlatively cleansing and probably contribute to the general well-being by promoting the activity of the skin. By virtue of their stimulating influence on the skin they relieve some of the labor of the kidneys, and may thus become valuable auxiliaries in renal affections, especially when the urine is scanty and of high specific gravity. They are also of considerable benefit in conditions due to the uric-acid diathesis, notably in chronic rheumatism, chronic articular gout, sciatica, lumbodynia, and in eczema and psoriasis. It has seemed to the author that while these baths are followed by a most grateful result in chronic rheumatism with painful, stiffened joints, yet their influence is only temporary, and it is important at the same time to keep the patient fortified with salicylates or alkalies. The Turkish bath is very beneficial in wakefulness, and often induces a refreshing sleep in persons whose minds are disturbed by business cares and anxiety. It has also been found advantageous in some cases of obstinate dyspepsia where other measures have failed. It is further a very useful aid in the treatment of diabetes, torpidity of the liver, and functional jaundice. Hot steam-baths may be used with advantage in catarrhal affections of the nose, throat, and bronchi, and even in the incipient stages of non-hemorrhagic phthisis.

THE ROMAN BATH

is simply an application of massage with the use of unguents, either with or without the Turkish bath. It affords the invigorating results of moderate muscular exercise without the fatigue usually attendant upon walking, riding, or work in the gymnasium.

ELECTRO-THERMAL AND MAGNETIC BATHS

Patients are often treated while in the bath by means of the galvanic or faradic electrical current. It is believed that the moisture upon the surface (water being an excellent conductor) facilitates the operation of the electric current upon the nerve-centers and greatly augments the ordinary therapeutic efficacy of this agent. It was once supposed that several mineral springs in different parts of the United States were naturally charged with magnetism from the earth. It has long since been learned, however, that the magnetic phenomena observed in the water were due to accidental circumstances, although several well-known springs still retain the name of "magnetic."

THE SODA BATH

is simply a bath containing a large percentage of chloride of sodium or common salt.

THE MUD OR MOOR BATH

Mud bathing, or terratherapy, is of ancient origin. Ample evidences exist to show that it was in common use among the American aborigines. At a number of our spring resorts the earth surrounding the fountains becomes more or less saturated with the mineral ingredients of the water. It may be of sufficient heat and of proper consistency to apply directly to the skin; but at most places it is placed in a large vat and mixed with the mineral water, either naturally or artificially heated, until it becomes plastic. The patient then immerses himself in this hot mineral mud, or reclines on a table and is plastered with it by an attendant. The bath may vary in duration from a few minutes to several hours. The mud, being a low conductor of heat, may be used at a higher temperature than water. It is said that 120° F. is well borne. The patient now enters a warm-water bath, where he is thoroughly cleansed, rubbed, and dried, and in some cases treated to a cold shower-bath or other cold affusion.

Physiological Action of the Mud Bath. It was once supposed that the mud applied in this way absorbed toxic and detrimental material, such as uric acid, metallic poisons, etc., from the skin. This theory, however, has been abandoned. Nor, indeed, is it probable that the constitution of the mud materially influences its action, which is essentially that of a universal hot poultice. Its chief effects are shown in a lively excitation of the skin, followed by free perspiration.

Therapeutics. In localities where mud-baths are in vogue it is claimed that they are of great benefit in chronic rheumatism, stiff joints, old glandular swellings, and chronic diseases of the skin. They are also recommended in chronic hypertrophic states of the liver and spleen, in renal diseases, and in old inflammations involving the uterus, ovaries, and bladder. The mud bath is sometimes used locally in the form of a knee-bath, a foot-bath, or an arm-bath.

THE PEAT BATH

This bath is still in high favor at several of the European spas, notably at Franzensbad. Peat consists of a dense mass of decomposed stalks and roots, the product of the decomposition undergone by vegetable growths flourishing in shallow, standing mineral water, in the absence of atmospheric oxygen and at a moderate and equable temperature. Every autumn the peat is dug up by means of specially constructed machines, and thrown upon the slope of a hill, where it lies for months, undergoing a process of oxidation, during which the sulphurets are converted into sulphates, while out of the organic constituents are formed the final products of dry distillation, such as formic, acetic, and humic acids. The dry or weathered peat is ground in mills constructed for the purpose, and the baths are prepared by mixing it with hot mineral water and stirring it vigorously. A peat bath should invariably be followed by a bath of mineral water, using soap, bran, or other substances to secure perfect cleanliness.

PHYSIOLOGICAL ACTION OF THE MINERAL PEAT BATH. On the one hand it is sedative and tonic, and on the other hand it is stated to be absorbent and antimycetic. According to Prof. Frerichs, it is of great value in glandular enlargements, exudative contractions, chronic rheumatism, sciatica, and other affections. It is often used in the form of the half-bath, the hip-bath, the foot-bath, and in the form of fomentations to local, painful conditions.

THE CARBONIC-ACID BATH

In many of our mineral springs carbonic anhydride is an abundant and important gaseous ingredient. Its physiological effects upon the skin are readily appreciated by the bather. The regular carbonic-acid bath, however, is prepared by collecting the air in an impervious box, in which the bather remains seated, while the head is in the outer air, precautions being taken that not enough of the gas escapes from the box to injure the patient. The acid produces on the skin a lively sensation of warmth with redness and formication, attended by a diminished pulse-rate and coldness of the feet. The bath is followed by a sense of vigor and activity.

Carbonic-acid baths have been found useful in recent paralysis, neuralgia, and rheumatism. They are also recommended by Frerichs in sexual neurasthenia, in various nervous disturbances characterized by local anæsthesia and hyperæsthesia, and in reflex and hysterical paralysis. The gas is also used locally in throat and other troubles by means of apparatus devised for the purpose.

THE KNEIPP SYSTEM

A word of explanation regarding the ''Kneipp Cure,'' devised by a priest of Bavaria, may be admissible here. The Kneipp system embraces certain hydriatric procedures, the use of simple household remedies, and a regulation of the mode of life. In order to "strengthen the nervous system" the patient is instructed to bathe his feet in cold water, or, better still, to take regular early morning walks barefooted on the dew-covered grass. This is, perhaps, the most striking feature of the system, but Kneipp also employs the cold pack, the warm bath, cold affusions, and other hydrotherapeutic methods.

The sun-bath and the sand-bath, as well as other procedures which might be termed balneary, hardly warrant a description here.

SCHOTT-NAUHEIM TREATMENT

This chapter would not be complete, however, without a brief reference to the bath and graduated exercise treatment of chronic heart disease, inaugurated at Nauheim by the Messrs. Schott Brothers, and known as the Schott-Nauheim Treatment. The following table shows the composition of the waters of the two principal springs now in use at Nauheim, taken from Eulenberg's *Real Encyclopadie der Gesammten Heilkunde*:

SPRINGS OF NAUHEIM

One U. S. gallon contains: Solids	Friedrich Wilhelm's Quelle. Grains	Grosser Sprudel. Grains
Sodium chloride	1707.84	1272.73
Potassium chloride	65.22	28.97
Calcium chloride	187.95	99.11
Magnesium chloride	30.60	25.65
Calcium sulphate	2.04	1.98
Calcium carbonate	151.63	137.23
Iron carbonate	2.79	2.21
Total	2148.07	1567.88
Carbonic acid (free)	160.52[1]	197.65[1]
Temperature of water	98.5° F.	88.8° F.

In accordance with the classification adopted for this work these waters may be denominated as strong muriated-saline carbonated waters with ferruginous properties. It will be observed that they are also thermal. The springs spout forth in foaming

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[1] In the original analysis the quantitative estimates are made in parts per thousand. The carbonic acid gas is expressed in cubic centimetres, presumably cubic centimetres per litre, which would be equivalent to so many parts per thousand, in conformity with the other chemical contents.

white currents only thirty-two feet apart, high above the surface of the ground. They are connected with five bath-houses, four in the immediate neighborhood and a fifth at a little distance from the others. Drinking of the water plays but a secondary part, but their internal use is of some value in gouty conditions and disorders of the liver. We are informed that the baths at Nauheim regulate the action and improve and strengthen the nutrition of the diseased heart, whether depending upon valvular lesions or upon malnutrition or disease of the muscular structure of the organ. These results are stated to be due to the chloride of sodium, the more irritating chloride of calcium, and to the free carbonic acid, of which, as we have seen, the water contains large quantities. During the bath there is a slowing of the pulse, with increased volume and strength, and irregularity, if any exists, is lessened or disappears. These effects do not appear at once, but persist for a considerable period after the bath.

The baths may be called cool, being used at 92° or 93° F. at first, and gradually lowered to 87° or a little less toward the end of the course. Even at 92° the water imparts a distinct feeling of chilliness as the patient enters the bath. From five to eight minutes as the initial limit, the baths gradually reach a duration of twenty minutes, the time being increased cautiously with the progress of the treatment and the improvement of the patient's condition. The quality and rate of the pulse furnish the most reliable index to the action of the baths. The light exercise, or gymnastics, as the Messrs. Schott choose to term this part of their cardiac therapeutics, is a very simple but exceedingly important adjunct to the baths. The individuality of this treatment lies in the application of counter-resistance made by an attendant trained for that purpose. It is important that the movements be performed slowly and steadily, that they be interrupted by short periods of repose, and that the effort exerted by the patient be not so great as to cause embarrassment of respiration or undue acceleration of the pulse. These exercises exert an effect on the heart and circulation similar to that of the baths, and, therefore, supplement and reinforce the balneary treatment. This method, however, is strongly contraindicated in degenerative changes of the blood vessels and myocardium. They should not be used, for example, in aneurism and advanced arterio-sclerosis, nor in acute softening or advanced fatty degeneration of the heart.

Artificial Nauheim baths may be prepared, as Dr. John Broadbent points out, by the use of sea-water which contains a large proportion of chloride of sodium. For the production of carbonic acid a suitable proportion of commercial muriatic acid and bicarbnate of sodium, or chalk, may be used. A mixture of the bicarbonate and bisulphate of sodium has also been suggested for this purpose. A preparation known as the Nauheim *mutterlauge* (mother-lye) is also on the market. It is the uncrystallizable liquid remaining in the manufacture of salt at Nauheim, and is said to be coming into favor for the artificial production of the baths. Many of our American springs contain the requisite ingredients for these baths, and the Nauheim treatment has been adopted at several home resorts.

CHAPTER VI

THE APPLICATION OF MINERAL WATERS AND BATHS TO THE ALLEVIATION AND CURE OF DISEASE

BY

I. B. YEO

ADAPTED BY R. D. GEORGE

It is exclusively in the treatment of *chronic* disease that courses of mineral waters and baths are applicable, and such courses are most commonly resorted to when other remedial measures and methods of treatment have failed to bring the needed relief. In the term "chronic" we include those conditions of debility, retarded convalescence, and other deviations from health which appear as *sequelae* of acute affections.

COUNTER-INDICATIONS

But there are certain forms and conditions, even of chronic disease, in which mineral-water treatment is *counter-indicated.* It is customary in the descriptions of different mineral springs, after mentioning the various morbid conditions in which their use is indicated, to mention also the "counter-indications" to their use. In these counter-indications there is a remarkable uniformity, and we find the majority of them are of *general* application.

At one period, and that not very long ago, it was customary to include all forms of organic heart disease amongst the cases counter-indicated generally in mineral-water courses. At present the tendency is to the opposite extreme, and nearly every spa claims to be suitable and beneficial in the treatment of certain forms of cardiac disease. This question will be considered later on, but it may be now stated that the physicians, at nearly all spas, regard advanced cardiac disease, and incompletely compensated valvular lesions, as amongst the counter-indications. Advanced arteriosclerosis is universally counter-indicated, so are all forms of malignant and serious organic visceral disease. Advanced hepatic and renal cirrhosis are generally counter-indicated, so are all advanced and febrile and cachectic forms of pulmonary tuberculosis and all cases with a tendency to hæmoptysis, and, indeed, all maladies with a disposition to internal hæmorrhage. Cases of grave diabetes with great emaciation, all forms of advanced renal degeneration with renal inadequacy, aneurisms, cases of true angina pectoris, are all uniformly regarded as unsuitable to treatment by baths and waters. Grave and recent affections of the central nervous system, epilepsy, cases of great nervous depression, and old, confirmed cases of paralysis, with chronic contractures and atrophied muscles, incapable of responding to electrical excitation, are counter-indicated. Maladies complicated with pregnancy are unsuited to thermal treatment.

ANAEMIA AND CHLOROSIS

In bloodless conditions, however induced, whether from profuse or continued loss of blood, or from the functional exhaustion following attacks of acute disease with retarded convalescence, or associated with the developmental and menstrual troubles of puberty in females, or as the consequence of chronic disturbance of the nutritive functions connected with some chronic malady—in most such cases we may often be able to promote hæmogenesis, or blood restoration, by prescribing a course of natural chalybeate water, associated with the stimulating gaseous iron baths usually administered at such spas.

But the success attending such a course will depend very greatly on the choice of a suitable resort, where, besides the presence of a tonic iron spring, the patient will find the climatic, dietetic, social, and other conditions calculated to improve nutrition and adapted to the special circumstances affecting each individual.

We are more especially prone to advise a course of chalybeate waters in the case of those patients who have presented difficulties in the digestion and assimilation of ordinary iron tonics. Every practitioner is familiar with these cases, in which all attempts at tonic treatment, with ferruginous and other drugs, are attended with little or no improvement, and it is precisely in these instances that we find recourse to some Continental iron spring, in a cheerful and bracing locality, succeeds as a blood restorative after all *home* treatment has failed.

It is generally admitted that one of the most readily assimilable forms of iron is the bicarbonate, and when this is held in solution by the presence of and excess of free carbonic acid, as is the case in the best reputed chalybeate springs, it rarely fails to agree with the most sensitive patients. No doubt this result is often greatly due to the combined soothing and stimulating effect of the free carbonic acid on the gastric nerves and mucous membrane.

Nor should we lose sight of the important contributory effect, on the circulation and metabolic activity, of the gaseous steel baths, and their stimulating effect on the peripheral vessels and nerves. In some other spas, the gaseous common salt baths, and in others the ferruginous peat baths, may prove even of greater service, in certain cases, when judiciously applied and supervised.

In those cases in which we are simply concerned to improve the blood condition—to increase its richness in blood cells and hæmoglobin—and in which we have no collateral morbid conditions to take into account, the purest iron springs are the most suitable for our purpose.

Young anæmics, with torpid nervous systems and sluggish circulation, need the strong stimulation of a highly bracing climate.

In cases complicated with gastro-hepatic disorder, constipation, and a tendency to hæmorrhoids, and in malarial cases, with splenic and hepatic enlargements, it is usually desirable to begin the treatment with a saline chalybeate containing some aperient salts, and after the intestinal functions have been improved, a pure iron water may be tolerated and prove useful. In some of these cases the sodium chloride and iron waters agree well; in others the combination of sodium sulphate with iron answers better.

It must be recognized that, in all forms of anæmia, it is of the greatest importance that the nutritive changes should be stimulated and the eliminative functions promoted and regulated; hence the value, in many cases, of waters which contain aperient constituents as well as iron, and of gaseous baths, or gaseous and saline baths, which promote cutaneous excretion and improve the peripheral and general circulation by dilating the superficial capillaries, and so lowering vascular tension. The application of ferruginous peat baths also affords a powerful means of stimulating the cutaneous functions and promoting cutaneous elimination, and they have been found of special service in the treatment of those forms of anæmia and chlorosis which are associated with menstrual disorders and affections of the female pelvic organs.

Many cases of anæmia, especially in young females, require, especially at the beginning of an iron cure, much physical rest, and the aim should be to combine the advantages of a rest cure with those of mineral-water treatment. Later on, when a better state of health has been established, physical exercise, carefully graduated so as not to over-tax the returning strength, may help to confirm the cure.

With regard to the use of the strong arsenical and iron waters these can be taken, if it is thought advisable, at home or at some suitable home health resort, inland or on the sea coast.

All anæmic cases require as long an ''after-cure'' as possible—preferably in a bracing mountain resort, or a suitable seaside station.

SCROFULA AND TUBERCLE

The close relationship, if not identity, of the morbid processes known as *scrofulous* or *strumous* with *tuberculosis* is now generally admitted, although the scrofulous affections are prone to run a more languid and torpid course, and are, no doubt, less actively infective than some other forms of tuberculosis.

Those ''scrofulous'' affections of the lymphatic glands, of the joints, bones, skin and mucous membranes, of such frequent occurrence amongst poor and ''delicate'' children, have usually been regarded by authorities on balneo-therapeutics as suitable for treatment at certain mineral springs, more particularly at the *common salt* baths, and especially at those containing, besides large amounts of sodium chloride, compounds also of iodine and bromine. The usefulness of certain mineral springs in the treatment of scrofulous manifestations is widely accepted.

The French physicians who make use largely of the term ''lymphatism'' to express the existence of a constitutional tendency to glandular enlargements, advocate the treatment of such tendencies, as well as of declared ''scrofulous'' manifestations, not only by sodium chloride waters and ''brine'' baths, but also by the stronger sulphur waters or the springs containing both sodium chloride and sulphur. It is maintained that there are cases of scrofulous disease in which sea air proves too exciting, and which do better under the calming but tonic influence of mild mountain air which can be obtained at most of these spas.

It is believed that the drinking of mild sodium chloride water increases albuminoid metabolism, while the brine baths, and other external appliances, exert a stimulating local effect, and those containing iodine and bromine promote absorption of glandular infiltrations.

PULMONARY TUBERCULOSIS

The success that has attended the ''open-air'' treatment of phthisis, in suitable and well arranged sanatoria, has greatly diminished the interest that was at one time taken in the treatment of these cases by mineral waters.

The mild sodium chloride waters and the alkaline sodium chloride waters have been found useful in relieving the catarrhal symptoms associated with chronic, quiescent, torpid forms of phthisis.

Weissenburg, near Thun, in Switzerland, with warm weakly mineralized calcareous springs, in a sheltered position in a pine forest, at an elevation of nearly 3,000 feet, owes its reputation, in the treatment of early apyretic forms of phthisis, probably quite as much to its favorable subalpine situation as to its mineral waters.

It seems clear that in so chronic and progressive an affection as pulmonary tuberculosis, a mere course of mineral water, of three to six weeks' duration, could exert but little curative effect, although it might be of service, combined with other measures, in relieving certain symptoms.

SYPHILIS

The treatment of constitutional syphilis by mineral waters and baths, and the manner in which they act, has been the subject of much controversy. We shall endeavor to summarize briefly the views now generally accepted. The idea that they exert any specific effect is no longer entertained, but their usefulness, in many cases, is not doubted.

It is believed by the physicians at those spas in which syphilitics are especially treated that the sulphur water enables the patient to bear much more energetic specific treatment than he otherwise could; and that this is mainly due to the fact that the mineral-water and bath treatment increases metabolic activity and promotes general nutrition. Not only are mercurial inunctions freely used—from two to three drachms of mercurial ointment daily—but hypodermic injections of soluble salts of mercury, with or without iodides, are frequently administered. The association of tonic mountain, or forest, air with the thermal treatment, has doubtless an excellent effect in cachectic cases.

This has been remarked upon by the physicians at Luchon, who maintain, and we believe rightly, that this combination is a most valuable auxiliary in the cure of syphilis. At Uriage, also, it has been observed that, in its mountain climate, the mineral-water and bath treatment, combined with mercurial frictions and injections (the patient being able to tolerate much larger doses), has proved of great value in some of the most serious cases of syphilitic infection; as in the pre-ataxic period of tabes, in cerebral syphilis and syphilitic myelitis, and in children the subjects of hereditary syphilis.

In such cases improved nutrition, increase in weight and strength, disappearance of anæmia and cachexia, have been observed.

The diagnostic value of treatment by sulphur baths, in revealing the existence of latent syphilis, is no longer generally admitted.

To sum up, the advantage of sulphur spa treatment in syphilis is that it offers a convenient opportunity for vigorously pursuing specific treatment, and it appears to favor the tolerance of large doses of mercury and to prevent, or counteract, cachectic symptoms.

CHRONIC METALLIC POISONING

Cases of chronic metallic poisoning (lead, mercury, etc.) are benefited by treatment with sulphur waters and baths—it is believed that the elimination of the poison by the intestines, kidneys, and skin is promoted by mild sulphur waters internally, and warm baths. The latter may be of ordinary water or of the indifferent thermal class, and these are probably as useful as sulphur baths.

GLYCOSURIA AND DIABETES

We accept the view that all more or less permanent forms of glycosuria are cases of diabetes, and exclude only those cases of the occasional or temporary appearance of sugar in the urine, which occur in certain persons from the excessive consumption of saccharine substances, which appear to have no serious import, and which may be termed cases of *non-diabetic* or alimentary glycosuria.

It will be convenient, and of some practical importance, especially in connection with the use of mineral waters in this disease, if we recognize three forms of diabetes. First, the *slight* cases—to which the term diabetes is refused by some authorities—such forms often occur in *fat* and *gouty* persons, and the sugar disappears entirely, or almost entirely, from the urine, when carbo-hydrates are excluded from their diet. Such persons are often restored to health by mineral-water treatment and a restricted dietary, but are apt to again become glycosuric on the free consumption of carbo-hydrates. Secondly, the cases of *moderate* severity, of which there may be several degrees, in which there is a greater or less diminution in the excretion of sugar, when a rigid diet is enforced; but it does not entirely disappear from the urine, and the general symptoms also, although capable of considerable amelioration by treatment, are not wholly recovered, and become aggravated by any deviation from a strict dietary. There are differences of opinion, as we shall see, with regard to the utility of mineral-water treatment in this group; these cases are, moreover, prone to be attacked by intercurrent maladies, as pneumonia and phthisis, and to pass into the Third or *grave* form. This form is usually rapidly assumed when diabetes attacks *young* persons; in these the glycosuria is maintained, in spite of the strictest dietetic measures, and the patients quickly pass into a cachectic state and generally die of diabetic coma.

There is a general agreement, amongst all authorities, that these *grave* cases are not benefited by mineral-water treatment, and even if we are desirous of trying the effect of mineral waters, it is best to do so at home, and not run the risk attending a journey to a foreign spa; as such patients bear the fatigue of travel very badly, attacks of diabetic coma often supervening on undue exertion.

The French, in considering the applicability of mineral-water treatment to diabetics, divide them into fat and thin diabetics, or those in which there is diminished and those in which there is increased nitrogenous metabolism. In the latter there is ''azoturia'' as well as ''glycosuria.''

It may, then, be accepted as a sound general conclusion that only diabetics of the first group and the more vigorous and chronic cases of the second group should be submitted to mineral-water treatment. But French authorities are disposed to admit a much wider application of mineral-water treatment, even to somewhat advanced cases, than German or English physicians. The waters best suited to the treatment of diabetes are undoubtedly the warm alkaline waters; the simple alkaline waters, the alkaline and mild sodium chloride waters, the alkaline sodium sulphate waters and the alkaline arsenical waters.

Even thin diabetics, beyond middle age, who retain a fair amount of vigor, and in whom the disease is very chronic, and who suffer from gouty symptoms, often gain advantage from the alkaline sodium sulphate waters. A course of four to five weeks annually is desirable, and in some cases good results follow two courses in the same year, with three or four months' interval.

The same kind of cases also do well with the simple alkaline waters, but this course is also applicable to a rather more extensive group, comprising those in whom the constitutional symptoms are somewhat more severe, with wasting and azoturia. The excretion of urea is often observed to return to the normal—together with a diminution, and, in recent cases, a disappearance of the sugar from the urine; at the same time the nervous irritability and the insomnia are relieved, the dryness of the mouth and throat are removed, and exercise can be taken with less fatigue. Cold alkaline waters are also useful in the fat and gouty cases.

Warm mildly alkaline and common salt springs have proved useful to a vast number of diabetics; they may be prescribed to all cases suitable for spa treatment.

In France nearly all the sodium chloride waters are said to be suitable for the treatment of fat diabetics.

The combination of warm baths with the drinking cure is of service in promoting a healthy action of the skin, in many cases of the fat and gouty type, but it must be borne in mind that such baths prove injurious to those cases in which there is marked azoturia, as they tend to increase the tissue waste, and aggravate the emaciation, and must therefore be avoided.

In all cases in which a mineral-water cure is found to agree, we shall find a great diminution of the sugar in the urine, or its entire disappearance, a removal of the thirst and dryness of the mouth, an improvement in the general nutrition and ability to assimilate normally a certain amount of carbohydrates, an increase of weight, in the emaciated, and a renewed capacity for muscular exercise. In those who are too fat to take much exercise, Swedish gymnastics and massage may prove useful auxiliaries, in promoting oxidation and a more normal metabolism.

It is probable that much of the benefit derived from treatment at a well-organized spa is referable to a well-ordered diet and regimen, a cheerful life, free from care and anxiety, amidst picturesque and healthy surroundings, with a due amount of out-of-door exercise. Residence in an establishment under medical dietetic supervision is a great advantage. Some recommend, in anæmic cases, that a course of chalybeate water and baths should succeed the treatment with alkaline waters; an after cure in some restful and moderately bracing place is certainly desirable.

The general use, at home, of gaseous table waters containing sodium bicarbonate and sodium chloride is to be commended in all cases of glycosuria.

GOUT AND THE URIC ACID DIATHESIS

There is no chronic disease in which recourse is so commonly had to treatment by mineral springs as gout; and nearly every kind of mineral spring has, in its turn, been advocated as a remedy for this disease. The acute arthritic forms of gout are, of course, altogether unsuited to spa treatment, and it is to the various manifestations of chronic gout that treatment by mineral waters is applicable. In all such cases we have mainly two things to consider: (a) the treatment of the general gouty state—the disturbances of normal metabolism, the excessive production of uric acid, and the need for its elimination; (b) the treatment of the particular *local affection* or affections attending it, due to the influence of the excess of uric acid on the joints, muscles, viscera, and other structures.

1. Of the various kinds of mineral springs and baths that are available, and that have been advocated, in the treatment of these morbid states, we may mention first the large group of *simple alkaline* waters which occupy a very important place in the treatment of gout.

These springs, especially when warm, are applicable to the treatment of gouty states associated with acid dyspepsia and chronic gastric and intestinal catarrhs; or with biliary and renal gravel and calculi; or with hepatic congestion in feeble persons; or with vesical catarrh and prostatitis associated with excessively acid urine.

These waters produce free diuresis and promote renal elimination. They also, by diluting the bile, promote its free discharge and so favor hepatic elimination.

They are all of special value in the treatment of the intercurrent attacks of renal and bladder irritation to which the gouty are prone.

2. The warm *alkaline* and *sodium chloride* springs are applicable to much the same class of cases as the preceding, but they are especially suitable to the treatment of *catarrhs of the respiratory organs* in the gouty. The presence of a small amount of common salt increases the expectorant properties of these waters, and acts also as a stimulant to digestion in the frequently co-existing dyspeptic states.

3. Another group of alkaline waters of great importance in the treatment of the gouty is the aperient *alkaline sodium sulphate* waters; they combine an active aperient and eliminative effect, together with the alkaline action of the simple alkaline springs.

At Carlsbad and Marienbad, in Bohemia, the hot mineral mud and vapor baths, together with the application of massage, gymnastics, and electricity, give an additional value to the treatment. Elimination and excretion, which are defective and disturbed in most gouty persons, are powerfully stimulated and promoted by the employment of these mineral waters and baths. The excretory functions of the skin, kidneys, and intestinal canal are brought into greatly increased activity, complete and normal nutritive metabolism is restored, and waste products are eliminated.

This treatment is especially indicated in fairly vigorous patients in whom active eliminative treatment is called for, and in whom the hepatic and intestinal functions are especially sluggish. It is counter-indicated in atonic cases, in cases of advanced arteriosclerosis, or where cardiac debility is pronounced. Recent gouty deposits in the neighborhood of joints will often disappear after treatment of this kind.

4. The class of common salt springs are largely used in the treatment of certain forms of chronic gout. The weaker springs are drunk, and also used as baths. The strong brine springs are mainly used for external treatment. The cold drinking springs are especially applicable to gouty dyspeptics with tendency to constipation and hepatic congestion. They are often found somewhat tonic in their action; and as they are highly impregnated with free carbonic acid, they are usually easily digested, and, in cases of atonic gout, prove somewhat stimulating, and improve the assimilative functions.

In many cases, however, they are not so well tolerated as the alkaline springs. The brine baths, the hot salt springs and the gaseous salt springs are chiefly applicable to the treatment of the chronic joint affections of the gouty—ankyloses, deformities, thickenings and exudations, and neuralgias of the large nerve trunks, etc.

They exercise a stimulating effect on the joints, especially the *gaseous* salt springs; when applied generally or locally they are found to promote the absorption of gouty exudations, and tend, when associated with mechanical treatment, to restore mobility to the stiffened and crippled articulations.

5. The *simple thermal* baths are largely employed in the treatment of chronic articular gout and for the removal of gouty exudations. They are applied to the removal of gouty exudations and in the treatment of peripheral paralyses and neuralgias of gouty

origin. Their efficacy is usually augmented by massage, gymnastics, and electricity.

6. The large class of *sulphur* springs are greatly used in the treatment of the chronic articular, and especially of the chronic cutaneous and respiratory, affections of the gouty.

The *cold* sulphur springs are especially useful in the treatment of chronic gouty catarrhs of the pharynx, larynx, trachea, and bronchi. They are drunk usually in small quantity, previously warmed, and are also used as sprays, gargles, and inhalations, as well as in the form of warm baths.

The chronic articular forms of gout are especially benefited by *hot sulphur baths.* They are found useful in the removal of periarticular gouty exudations, in restoring mobility to crippled limbs, and in relieving certain forms of gouty neuralgias, sciatica, lumbago, etc. The calcareous or earthy springs are of great value in the renal and vesical affections of the gouty, uric acid gravel and calculi, vesical catarrh, prostatitis, etc. It is difficult to understand the precise manner in which these waters act as solvents of uric acid and other urinary concretions, but at these baths, as a rule, very large quantities of the springs are drunk, and a certain amount of mechanical flushing of the urinary passages may probably account for a great part of their action.

At many of these resorts for the gouty, additional remedial influences are brought to bear on the manifestations of this malady in the shape of local or general baths of mineral mud, peat, pine-needle infusions, hot sand, etc.; and, as has already been stated, massage, gymnastics, and light, dry heat, and electrical treatment are obtainable at most.

Another most important remedial agency, which can hardly be over-estimated, is the extremely careful dietetic management which is applied in such resorts as Carlsbad.

We must bear in mind, also, that there is an important condition common to most of these courses of treatment, and that is the regular daily consumption of water, a solvent and eliminative agent of great potency.

LITHIASIS, OXALURIA, PHOSPHATURIA

Lithiasis, the deposition of uric acid and urates in the urine, is closely allied to the gouty state, and commonly arises from like causes, namely, too liberal consumption of rich food and alcoholic beverages, too little ingestion of pure water, insufficient exercise, and consequent hepatic inadequacy and tendency to constipation. It is very amenable to treatment by mineral waters, and with the exception of the sulphur waters, most of the waters that are suitable for the gouty are suitable for the subjects of lithiasis and with the same qualifications. Those of robust habit of body with a tendency to obesity and constipation, should be sent to take the alkaline aperient sodium sulphate waters. The warm springs are best suited to those cases attended with hepatic congestion. The simple warm alkaline waters or the cold gaseous alkaline springs are more suitable to feeble persons or those with a tendency to diarrhœa. Springs, containing some sodium chloride and minute amounts of arsenic and lithium, are especially suited to atonic, feeble patients.

At home much good may be derived from the regular use of the alkaline effervescent table waters. The utility of these waters in lithiasis depends chiefly on their diuretic influence, and not so much on any solvent effect, but this may not be without some influence, as their alkalinity certainly is in many cases. The flushing of the urinary passages is, however, a very important part of their beneficial effects. Careful regulation of diet is an essential auxiliary to these mineral water cures.

The presence of oxalate of lime crystals in the urine (oxaluria) is often found associated with symptoms of dyspepsia and nervous depression. Recourse to suitable mineral waters where the spa is situated in a bracing climate, with quiet but pleasant and cheerful surroundings, often proves effectual in restoring health to such patients. The gaseous alkaline waters may be freely drunk, not necessarily at their sources, but in any convenient health resort where the surroundings might be more congenial and appropriate.

Phosphaturia is apt to occur in the over-worked student or man of business, and is dependent probably on too sedentary a life and insufficient exercise in the open air. It often disappears with ''change of air,'' increased physical exercise, and a cheerful out-of-door life. It is rarely advisable to prescribe a mineral-water course unless other symptoms or conditions are present which render this desirable.

OBESITY

The appropriate mineral-water treatment of *obesity* will depend, to a great extent, on the nature of the conditions which accompany the obesity.

There are the plethoric obese, with abundant muscular activity; there are the pale, feeble, and anæmic obese, with ill-nourished, feeble muscles; there are the young obese and the old obese; there are the gouty obese with feeble fatty hearts and diseased arteries; and there are the diabetic obese. The mineral-water treatment suitable to the two latter groups has already been discussed. The object of treatment in most of these cases is to produce a diminution in adipose tissue without causing any loss in the nitrogenous tissues—a waste of albumen.

In all cases we need the co-operation of dietetic measures and of suitable exercises, which may take the form of massage or Swedish gymnastics.

It is generally admitted that the best results are obtained from the alkaline sodium sulphate waters. Good results also follow the use of the bitter waters'', containing magnesium and sodium sulphates, but these are exclusively for home use; waters containing sodium chloride as well as the aperient sulphates are also very useful.

In France sodium chloride waters are much used in the treatment of obesity; they are believed to stimulate defective metabolism and to promote oxidation. The stronger ones are used only as baths, the weaker springs also as drinking cures.

Some discrimination is needed in the recommendation of these different cures.

Normal metabolism and oxidation are promoted by the free action of the liver, intestines, and kidneys induced by the waters. It must be seen to that free diuresis accompanies the water-drinking, and that vascular pressure is not raised. The course should be of four to eight weeks' duration.

The fat anæmics are difficult cases to deal with. Some are best treated with water containing a combination of iron and sodium sulphate, some by the less energetic cold common salt springs containing iron. Such cases are undoubtedly benefited by being much in the open air in a bracing situation.

Vapor baths, warm peat and brine baths, gaseous brine baths, gaseous steel baths, are all of value in appropriate cases. By stimulating the action of the skin and promoting free cutaneous excretion, they further oxidation and healthy metabolism.

Electric light or radiant heat baths are useful for the same purpose.

RHEUMATISM—CHRONIC, ARTICULAR AND MUSCULAR RHEUMATIC NEURALGIAS (SCIATICA, LUMBAGO) "RHEUMATOID ARTHRITIS"

We include "rheumatoid arthritis," so called, in this group of maladies, not because we think its relation to rheumatism a close one, but because the term is one generally employed, and because the impression is so widely diffused that it is intimately related with rheumatism and gout. So far as we have been able to observe, its closest pathological affinities are with neither, and we have had reason to think that the term is often wrongly applied to some forms of chronic articular gout and rheumatism, and inferences drawn with regard to its treatment which are not to be relied upon.

In approaching the consideration of the treatment of rheumatic affections by mineral waters and baths, the first thing to be noted is that nearly every spa, especially if it possesses *thermal* springs, claims to be a remedy for these maladies. We may conclude, from these facts, that all *hot* baths, and the auxiliary mechanical and other treatments associated with them, are more or less beneficial to most forms of chronic rheumatism.

It is a question whether patients slowly recovering from attacks of *acute* rheumatism, with or without implication of the cardial valves, should be submitted to mineral-water treatment. The tendency in the present day is to answer this question in the affirmative, and to direct such patients to those common salt baths which are rich in free carbonic acid gas.

But it is in those cases of chronic rheumatism, which probably have but little pathological affinity with the acute disease, that spa treatment is so greatly resorted to.

In chronic articular and muscular rheumatism the following classes of mineral springs are commonly used, sometimes one, sometimes the other, according to individual requirements, place of residence, degree of severity and chronicity, or past experience in particular cases, and often because of the perfection of the methods, thermal and auxiliary, put into practice at the particular resort.

1. *Simple thermal springs.*
2. *Thermal sulphur baths;* if cold, the springs are artificially heated.
3. *Thermal salt or brine baths*—or cold waters heated.
4. *Thermal peat and mud baths.*

The object of these baths is to promote absorption of effusions and exudations by stimulating metabolism; to excite and increase the cutaneous functions, and promote elimination by the skin; to influence favorably the circulation by causing dilatation of the capillaries, while the warm temperature of the bath is soothing to the peripheral nerves. It is usual to endeavor to maintain the stimulating action on the skin, by removal, after the bath, to a warm bed, where perspiration is encouraged. The diaphoretic action is further promoted, in the case of the simple thermal baths, by giving the patient some of the hot mineral water to drink.

In nearly all cases the baths and local or general douches are associated with some mechanical treatment, such as massage or Swedish gymnastics. Vapor baths, sand baths, electric light baths, pine-needle baths, and local applications of peat, mineral mud, or "fango," after the manner of poultices, are also employed and prove serviceable in the treatment of these very chronic and often obstinate maladies. Hot compresses, together with friction, have been found useful in relieving the pain referred to particular spots, in lumbago and other forms of muscular pain.

The thermal sulphur and the thermal salt baths are more stimulating than the simple thermal baths, and are usually found more serviceable in obstinate cases of articular rheumatism.

Sciatica and neuralgia of other large nerves is often of a rheumatic or gouty nature, and the mineral-water treatment of such affections is practically identical with that of chronic rheumatism. Apart from those acute cases (neuritis) that require absolute rest, douching and massage, either with the hottest of the simple thermal waters, or the thermal sulphur waters, or the hot common salt springs, are most appropriate.

All those patients require an "after-cure" in as dry and sunny a station as can be conveniently obtained, and to prevent relapses they should, if possible, choose a residence in a dry, sunny district, with a sub-soil of gravel and sand, and good natural drainage. It is good for such patients to be much in the open air, and hence the value of a climate where this kind of life can be followed without risk of chill.

The subject of the treatment of *rheumatoid arthritis* or *osteoarthritis* by mineral waters is one of some difficulty, and a great difference of opinion exists amongst authorities as to the value of such treatment in these cases. Those who believe this disease to be a microbic infection of the joints, having no direct relationship with rheumatism, maintain, and we think justly, that the proper treatment of those cases is a tonic and supporting one, and that change to a dry and bracing climate, and to cheerful and hygienic surroundings, is of great importance, and most serviceable; while little direct benefit can be expected, or is actually found, to accrue from any *special* action of mineral waters. This has been more particularly observed in chronic cases, in which permanent good results from spa treatment must not be expected. In such cases massage, electricity, baths, douches, and passive movements, perseveringly applied, may prevent further deformity and secure some increase of mobility in the affected joints, especially when aided by general tonic influences, such as good air, plenty of sunshine, and a generous diet. In the acute and painful stage, however, rest is essential, even a splint may be needed; but we must, at the same time, bear in mind that some precautions have to be taken to prevent and counteract the great tendency there is to fixation of joints and consequent deformity in this disease, so that, even in the acute stage, occasional passive movements may be indicated.

In early cases the application of the Dowsing hot-air treatment has been strongly advocated, either locally to the joints affected, or to the whole body, and even in chronic cases good results appear sometimes to follow this method, which is now instituted at many English and Continental spas. It has been suggested that where thermal baths are attended with benefit it is wholly due to the heat of the water, and it is to be noted that in France, where bath treatment of these cases is in some repute, it is to the hotter—the ''hyperthermal''—waters that these cases are sent; the authorities at these spas, however, require that the cases should be in the early stage, and do not pretend to cure or permanently benefit the advanced, chronic forms.

CHRONIC MALARIAL AFFECTIONS
MALARIAL CACHEXIA
"IMPALUDISM" OF FRENCH WRITERS

These affections, gastro-intestinal, hepatic, and splenic, associated commonly with an anæmic state, and occasionally with febrile recurrences, the result of residence in tropical climates, are often very favorably influenced and not unfrequently cured by recourse to mineral waters.

It is a distinct advantage if we can find suitable springs, for this purpose, in moderately bracing subalpine districts with tonic air and cheerful, picturesque surroundings. It should, however, be borne in mind that many of these patients are highly sensitive to cold, and apt to become chilled if exposed to too low a temperature.

When there is considerable enlargement of the liver and spleen, and much sluggishness of the hepatic functions, with a tendency to constipation, the warm alkaline aperient (sodium sulphate) waters answer best.

The simple warm alkaline waters of Vichy also enjoy in France "a great reputation in the treatment of these affections"—after a prolonged course the gastro-hepatic troubles are usually greatly relieved, if not entirely cured.

Arsenical waters are especially indicated in the febrile and anæmic cases.

Some consider the simple thermal waters of value when situated in bracing localities.

In cases in which anæmia is the predominating symptom, the sulphate of iron waters have been thought to be indicated, and when there is a tendency to febrile recurrences the arsenical iron waters.

DISEASES OF THE DIGESTIVE ORGANS

DYSPEPSIAS

The same difficulties which we encounter in the *home* treatment of the various forms of disordered digestion, will meet us also when we endeavor to apply mineral-water treatment to their relief.

The obstacles which arise in our endeavor to ascertain the real causes, or to determine, with precision, the true nature of the gastric disorder, impart an element of uncertainty to the results to be expected from the particular course prescribed. The French physicians attempt to establish a marked distinction between what they term dyspepsia from *hyper-chlorhydrie, i. e.,* an excessive formation of hydrochloric acid in the stomach, and dyspepsia from *hypochlor-hydrie,* a defective secretion of that acid. They also recognize a *hypersthenique* and a *hyposthenique form,* but they advocate the same mineral-water treatment in both these last forms. In a semi-official pronouncement as to the applicability of the Vichy springs to the treatment of dyspepsia, it is said, "Painful or *hypersthenic* dyspepsias, simple or complicated with *hyperchlorhydrie* . . . *atonic* flatulent or *hyposthenic* dyspepsias . . . are usually cured or advantageously modified" by treatment there. But they commonly distinguish between the waters suitable for cases of "hyperchlorhydrie" and those indicated in cases of "hypochlorhydrie."

We are accustomed, in this country (England) to recognize chronic gastric catarrh as a dyspeptic state often induced by the abuse of food, alcohol, tobacco, and other irritating agencies. We recognize atonic forms of dyspepsia in the debilitated, as a sequel of acute or chronic illness, in the neurotic (the "nervous dyspepsia," which is the most difficult of all to deal with), in the neurasthenic, as the consequence of over-work and worry; and we are familiar with what is perhaps the most common form, the acid dyspepsia—the hyperchlorhydrie of the French—often intermittent in occurrence, and provoked, in the predisposed, by slight dietetic errors.

In determining the fitness of a particular spa for the treatment of particular cases of dyspepsia, we shall be assisted chiefly by a consideration of the accompanying conditions, the individual constitution, the probable causation, and the co-existence of other maladies. The comparatively robust, vigorous, gouty dyspeptic will usually require different treatment from that suited to the feeble neurotic dyspeptic.

But in prescribing a course of mineral waters, we shall be prescribing conditions, other than the mere water drinking, which are calculated to be beneficial to nearly all dyspeptics. Change of habits of life and of climatic conditions, release from work and home worries, inducements to exercise in the open air, the regulation of diet and the constant medical supervision, the tonic as well as soothing influence of baths and douches—all these influences tend to the restoration of gastric tone and healthy functions.

The following are the different classes of mineral waters that are prescribed for the treatment of dyspeptic states.

1. The *simple alkaline* waters are adapted to the treatment of many forms of dyspepsia, but especially to cases of excessive gastric acidity and of chronic gastric catarrh.

They are of comparatively little use to the neurotic dyspeptic with an insufficient secretion of gastric juice. They are very serviceable in cases of intestinal as well as gastric catarrh, in which constipation and diarrhœa often alternate; but they are not so useful, as certain other springs, for dyspeptics who are the subjects of habitual constipation.

2. The *alkaline weak common salt* waters are suitable to a more limited class of dyspeptics; to those cases of chronic gastric catarrh associated with general debility; and to dyspeptic states in the thin, neurotic, and sensitive, who require very mild and soothing treatment. Dyspeptic symptoms, in the subjects of atonic gout, are likely to be relieved by these waters.

3. The *gaseous common salt* springs are largely prescribed in the treatment of certain forms of dyspepsia. Those springs only are suitable which contain but a *moderate* amount of sodium chloride and a large amount of free carbonic acid.

The dyspeptic cases suited to these waters are those of chronic gastric catarrh with defective secretion, associated with gastric atony.

To these resorts may be sent the large class of dyspeptics, often gouty, often gross feeders, often alcoholic, who, with catarrhal stomachs, have also congested livers, are constipated, suffer from hæmorrhoids, lithiasis, and generally from defective elimination and hyperacidity.

CONSTIPATION

Habitual constipation is often associated with gastric disorders —especially with gastro-intestinal catarrh—and in treating appropriately the dyspeptic conditions, we have to adopt such measures as will remove the constipation, as we have just seen. Constipation may, however, exist without any notable dyspepsia, and recourse to mineral waters may be had for its relief. Waters containing the aperient sulphates of magnesium and sodium and also some chloride of sodium are largely used for this purpose; and the spas visited for the treatment of habitual constipation are those which contain springs rich either in these aperient sulphates or in sodium chloride. The gaseous chloride of sodium springs are found efficient in some cases, while they entirely fail in others. The alkaline sodium sulphate waters are usually found much more effective, but these will wholly fail and even cause constipation in some patients. In persons advanced in life, and in stout women of sedentary habits, the constipation is often due to muscular torpor of the large intestine; in such cases abdominal massage, combined with a course of laxative waters, proves of great value.

CHRONIC DIARRHOEA AND MUCO-MEMBRANOUS COLITIS

The employment of mineral waters in the treatment of chronic diarrhœa is naturally only had recourse to in those cases, and they are not rare, in which ordinary medicinal and dietetic treatment has failed.

In those cases of intestinal catarrh, in which frequent mucous discharges have been the result of previous constipation, or dietetic errors, and consequent irritation of the intestinal mucous membrane, warm alkaline sodium sulphate waters have often proved of great service, and the same has been observed when the diarrhœa has been traceable to disturbed hepatic functions. But this treatment needs the most careful and skilful supervision, and the mildest possible course, at starting, is usually desirable. In cases where there is a probability that portions of irritating fæcal matter are still retained in the bowels, an initial dose of castor oil is sometimes prescribed.

Waters containing sulphate of iron or sulphate of iron and arsenic have been recommended for the diarrhœa of anæmic and feeble children.

LIVER AND BILE DUCTS

Mineral waters are found of great service in the treatment of hepatic disorders.

Congestion of the liver, whether due to over-feeding, to alcoholism, to insufficient exercise, or to malarial influences, is especially amenable to mineral-water treatment. The springs which are found most useful in the treatment of this condition are the warm alkaline sodium sulphate springs, or the cold ones, in obese, vigorous, patients with constipation, or the gaseous common salt waters. These last are more suitable to thin and feeble persons. The simple alkaline waters are also very useful, in the less vigorous malarial, alcoholic, and gouty patients, more particularly if there exists a tendency to diarrhœa rather than to constipation.

The same class of waters are applicable to the treatment of the *large fatty liver* of the obese. The purgative "bitter" waters are also suitable for the treatment of these cases, but they can be, and are, usually drunk at home.

Cases of gallstones, biliary sand, or inspissated bile, are treated with advantage at a very great number of mineral-water resorts. One of the indications in these affections being the dilution of the bile so as to promote its free flow along the bile ducts, it is obvious that many mineral springs may rightly claim to have this property. Their free, prolonged, systematic administration is one of the reasons for drinking them at their source rather than at home. The warm alkaline sodium sulphate waters stand first in repute for this purpose, and the warm simple alkaline waters are of nearly equal importance.

The earthy or calcareous waters are also advocated for the treatment of these cases when they occur in the gouty; they are usually administered in very large doses.

It is generally considered desirable that the course of mineral waters should be repeated annually for a few years to prevent a return of the malady.

Chronic forms of *jaundice,* when believed to be due to catarrh of the bile ducts, or associated with biliary concretions, require the same kind of mineral-water treatment as that pointed out above for the treatment of gallstones, the warm alkaline springs or the warm alkaline sodium sulphate springs being the most appropriate.

Warm peat poultices have been found serviceable in some forms of hepatic enlargement, of gallstones, and of catarrhal jaundice.

RESPIRATORY ORGANS

There are certain chronic diseases of the respiratory organs which are specially suited to treatment by mineral waters, and these are catarrhal affections of the upper air passages, such as chronic rhino-pharyngitis, pharyngo-laryngitis, laryngitis, tracheitis, and certain forms of chronic bronchial catarrh. Pulmonary emphysema, when not too advanced, is benefited as a result of the relief afforded to the bronchial catarrh with which it is commonly associated, and also by the co-operation of pneumatic treatment, which can usually be obtained in the localities in especial repute for the treatment of respiratory affections. The forest air and mildly tonic mountain air, at the moderate elevations at which many of these resorts are situated, undoubtedly prove valuable accessories.

The mineral springs most commonly resorted to for the treatment of these affections are, in the first place, the *warm alkaline weak common salt waters;* secondly, the *warm mild simple common salt waters;* thirdly, the *warm sulphur* springs, especially the sodium sulphide springs, and the warm *sulphur and common salt* springs. In a few special cases, as we shall presently see, the *alkaline aperient sodium sulphate* waters are recommended.

It is needless to say that in the treatment of these chronic respiratory affections, it is often of much consequence that we should select a spa with suitable climatic surroundings, and where the methods applied, especially in connection with *inhalatory* treatment, are of the best and newest.

We shall now pass on to consider the mineral-water treatment of these diseases somewhat more in detail.

Cases of *rhino-pharyngitis,* of *chronic pharyngitis,* and *chronic laryngitis* and *tracheitis* are all amenable to the same forms of mineral-water treatment. The influence of local spraying and douching, which are practised at all the resorts where these affections are treated, and the passing of some considerable time daily in chambers specially arranged for the inhalation of the vapor and spray, at certain of these spas, contribute greatly to the good results obtained.

These measures tend to soften, fluidify, and detach the sticky adherent mucus and mucus crusts that are prone to adhere to the mucous membrane in these chronic maladies; they also soothe the irritated mucous membrane, and some doubtless exert a cleansing, antiseptic action and destroy or diminish bacterial activity.

The alkaline chloride of sodium waters most frequently prescribed for these affections are especially suitable when the secretion from the mucous membrane is scanty and there is an irritative cough. The waters are drunk warm, as well as applied locally as spray or gargle, and favor expectoration by their solvent action on mucus.

CHRONIC BRONCHIAL CATARRH, ETC.

Perhaps the most serviceable waters in this disease are the alkaline common salt waters. The moister climate is advantageous in those cases with scanty secretion and irritative cough.

The local effect of the warm spray of these waters and the influence of the warm alkaline drink are alike beneficial.

The mild sodium chloride waters (or the stronger ones diluted) are better suited to cases with profuse secretion.

Besides the brine spray inhaled, the adjacency of pine woods and the co-existence of pneumatic and inhalatory treatment at some of these resorts are useful aids.

The *sulphur* and the *sulphur and salt* waters have hardly so great a reputation in the treatment of chronic bronchial catarrh as they have in that of catarrh of the pharynx and larynx; they have, however, their application in the cases of long standing bronchial catarrh of a torpid nature, accompanied with abundant secretion.

Inhalations of sulphuretted hydrogen are applied at some sulphur spas to allay irritability of the respiratory mucous membrane. Inhalations also of nitrogen, obtained from some of the earthy and calcareous springs have been advocated as beneficial in the treatment of chronic bronchial catarrh, but it is difficult to understand how they can produce any curative effect.

The addition of a little hot milk or whey to many of these waters renders them more pleasant to drink, and seems also often to promote their beneficial effects.

In cases of chronic bronchial catarrh occurring in the obese and plethoric, in free livers, and those addicted to alcohol, with a tendency to pulmonary and hepatic engorgement, *alkaline aperient sodium sulphate* springs may prove the most useful by causing intestinal derivation and unloading of the portal circulation.

The stimulating and invigorating tonic effect on the skin of warm brine baths, followed in young subjects with friction with cold brine, is believed to prevent relapses by diminishing the sensitiveness of the surface to chill.

Chronic emphysema can only be benefited by mineral waters through their curative influence on co-existing catarrhal states; and to those cases the same indications apply as already set forth. It is, however, a decided advantage, in dealing with such cases, to have the aid of suitable pneumatic treatment.

A suitable "after-cure" is of great importance in all these respiratory catarrhal cases. Places of moderate elevation, with a fairly dry, sunny climate, and in the neighborhood of pine woods, or places on the sea coast which are protected from cold winds and get much sunshine, are specially indicated. A still atmosphere, with abundant sunshine, is what is needed.

DISEASES OF THE CIRCULATORY SYSTEM

Until within comparatively recent years it used to be taught that cardiac maladies were counter-indicated at all baths. But in former times all valvular cardiac diseases were looked upon with much greater concern than in the present day, and it was the custom to give a far graver prognosis of some forms of cardiac disease than would now be thought justifiable. With a much truer appreciation of the nature and course of such affections, a much more hopeful view of their therapeutic management has gained ground, so that remedial appliances are now highly valued in cardiac therapeutics which would have been regarded as attended with great risk less than half a century ago.

Not only are cardiac patients sent to drinking cures for the relief of collateral disturbances of health, whether they are dependent or not on the heart affection, but certain baths are now largely resorted to for their *special* influence in relieving morbid conditions referable directly to cardiac defects, functional and organic. Not only so, but such natural baths are now imitated artificially, and largely and successfully applied at or near home.

In the selection, however, of cases for thermal bath treatment, the modern tendency has been to go to the other extreme and to submit nearly all cases of cardiac disease to bath treatment and the mechanical methods associated with it, and serious results have naturally followed such indiscriminate action. Moreover, there has grown up a tendency, in connection with the popularisation of these therapeutic methods, to discover the presence of heart disease where none exists, and many persons, within our own knowledge, have been persuaded to undergo treatment by baths and "resisted movements" for the relief of cardiac affections which had no existence!—neurotic persons readily lending themselves to these minutely detailed and introspective methods.

In considering the usefulness and applicability of mineral springs to the treatment of cardiac affections, it will be convenient to refer, in the first place, to those waters which are not credited with any *special* influence over these maladies, but are prescribed for their beneficial effect in the removal of collateral functional disturbances, apt to be associated with cardiac disease.

In cases of cardiac hypertrophy, in free livers with threatened arterial changes, and in cases of right-sided hypertrophy and dilatation, associated with chronic pulmonary emphysema, in which our object is to relieve blood stasis and promote the regular distribution and circulation of the blood, by unloading the intestinal veins, and so lessening the labor of the heart, we may have recourse to cold laxative alkaline sodium sulphate waters or cold sodium chloride waters. The *cold* springs are thought more suitable than *warm* ones, because the warmth of the latter may excite cardiac action and may lead to over-filling of the blood vessels. It is also thought desirable to get rid of any free carbonic acid there may be in the water by stirring briskly or pouring from one glass to another, again for fear of over-stimulating the action of the heart.

The above mentioned waters may be appropriate also in compensated valvular lesions when symptoms of venous stasis in the abdominal viscera seem to show that compensation is in danger—such as gastro-intestinal catarrh, hepatic enlargement, hæmorrhoids, and menstrual abnormalities dependent on abdominal stasis.

When there is much cardiac excitement with heightened blood pressure, and when it is important to subdue quickly co-existing symptoms of portal engorgement, the purgative bitter waters are often of much service for home use.

In many of these cases where aterio selerosis is imminent it is highly important to further hepatic and intestinal elimination as well as to promote renal excretion; for this purpose we may combine the use of bitter waters with the use of alkaline common salt waters. They lessen the work of the heart by promoting diuresis and intestinal activity. They should be freed from gaseous carbonic acid, and in mild cases the alkaline water may be given in much larger quantity than the bitter water, one dose daily of the latter being often sufficient.

In certain cardiac neuroses the etiological condition may indicate the use of mineral waters. The palpitations associated with anæmia and chlorosis at puberty may be benefited by iron waters, while the same symptom coming on at the climacteric period, or dependent on intestinal torpor, may be benefited by aperient sodium sulphate waters.

Hitherto we have referred only to the drinking of mineral waters in these cases, but it is to the influence of thermal baths in the treatment of cardiac disease that attention has been chiefly directed of late years, and especially to the gaseous thermal brine baths of Nauheim, which are exceptionally rich in pure carbonic acid.

There can be no doubt of the beneficial effect of these thermal gaseous salt springs in certain cases of cardiac disorder. The following are the cases which have been shown by experience to be most benefited by bath treatment at Nauheim:

1. Cases of dilatation of the heart unaccompanied by hypertrophy and not associated with any cardiac lesion, beyond weakness of the heart muscle, brought about either by excessive physical effort or over-work (heart-strain); or occurring as the result of toxic action, as in the post-influenzal cases; or following attacks of rheumatic endocarditis in young people. These are the cases that do especially well at Nauheim.

2. Valvular disease, in the early stage and in young people, in which compensation has not been thoroughly established or in which it appears, for some reason, to have become temporarily disturbed.

3. It has been stated by those who have had large opportunities of observing cases of convalescence from attacks of acute rheumatism, that during the prolonged period of rest which should always be enjoined after such illnesses a course of Nauheim baths will, at this period, do more than rest alone to prevent the occurrence of valvular lesions; that while undergoing this treatment

murmurs will be observed to disappear. But it must be borne in mind that, in these recent cases, murmurs will also disappear under suitable treatment at home.

Physical examination appears to show that in cases of simple dilation from muscular asthenia, and in dilation the result of valvular lesion, imperfectly compensated, the baths determine a diminution in the size of the heart by restoration of muscular tone, and this result is explained by the following considerations:—The effect of the bath is at first to cause constriction of the cutaneous vessels and a consequent rise of blood pressure which quickly passes away and is succeeded by flushing of the skin through dilatation of superficial aterioles—this change is referred to the stimulating effect on the skin of the constituents of the water, especially the free carbonic acid and the sodium and calcium chlorides, the latter salt being credited with a highly exciting effect. It is argued that this freer distribution of blood to the skin must lead to a withdrawal of blood from the deeper seated tissues and therefore to an acceleration of the circulation through them; that by the dilatation of the peripheral vessels the strain on the heart is lightened, the over-distension of its cavities is removed, and it is rendered fitter for the work it has to do—as a consequence the heart-beat is strengthened and slowed, and the area of cardiac dullness is often notably diminished. The slowing of the heart-beat, notwithstanding the vascular dilatation, has been hypothetically explained by referring it to a reflex stimulation of the cardiac regulator nerves.

4. This treatment is also stated to have been found useful in certain cardiac neuroses, especially in cases of pseudo- or vaso-motor angina, due to arterial spasm, and occurring often in gouty subjects from the presence of irritating substances in the blood. The heart is assumed to be sound, but submitted to sudden and severe strain by more or less suddenly increased arterial resistance. In these cases the Nauheim bath acts, as has been seen, by dilating the superficial arterioles and so diminishing excessive blood pressure.

It is, however, very doubtful if this treatment should ever be applied to cases of true angina; in such cases it is best to avoid all spa treatment and the fatigue of long journeys, and even in the vaso-motor forms the greatest possible caution is needful, and it is questionable whether other spas are not more suitable to these cases than Nauheim.

RENAL AND URINARY DISORDERS

Mineral waters prove of great utility in the treatment of many affections which fall under this head. The *earthy calcareous* waters come into especial prominence in the treatment of *urinary concretions* and the morbid conditions of the bladder and urinary passages associated therewith.

The class of *simple alkaline* waters retain the popularity they have for many years enjoyed in the treatment of urinary concretions.

The alkaline and sodium sulphate waters are to be preferred. In selecting a suitable spring, much must necessarily depend on the constitution of the patient, the cause of the malady, and the co-existence of other morbid states. The occurrence of uric acid gravel and calculi, associated with the gouty constitution, often depends on a disorder of the hepatic functions, and the appropriate treatment must include measures directed to restore healthy action of the liver. For such cases the alkaline sodium sulphate waters or the warm simple alkaline waters may be most appropriate, the former when there is a tendency to constipation and hæmorrhoids.

The free use of the alkaline waters, and also of the calcareous springs in case of renal gravel and calculi (uric acid), often leads to the passage of numerous concretions, and this is dependent not on any solvent action of the water, as was at one time supposed, but on its diuretic action and a mechanical *flushing* of the urinary passages. The alkaline waters also tend to reduce the acidity of the urine and maintain it neutral or slightly alkaline, and to prevent the re-formation of concretions. The action of the stronger alkaline waters should be carefully watched, so that the urine may not be rendered too alkaline and the risk of phosphatic precipitation be incurred.

The alkaline waters are also most useful in the treatment of *catarrhal conditions* of the renal pelvis, and of the urinary passages, when caused by uric acid deposits and hyperacidity of the urine, for, as has been pointed out, the "abundant and long continued drinking of those waters" renders the urine neutral or alkaline, lessens the irritation of the acid urine, liquefies the mucus, and influences favorably the diseased mucous membrane.

But when the mucous secretion is profuse and the disease very chronic (chronic pyelitis), the *earthy calcareous* waters may prove more serviceable, and, indeed, they can always be regarded as an alternative to the alkaline waters, and preferable to them in all those cases that do not well tolerate alkaline remedies.

The cases of great irritability of the vescial mucous membrane, prolonged simple thermal baths combined with the internal use of some mild gaseous alkaline water, have a sedative and soothing effect.

Neither the alkaline nor the earthy waters should be prescribed in cases of phosphate concretions, but springs rich in free carbonic acid, and containing only nominal quantities of sodium bicarbonate and sodium chloride are useful.

In case of concretions of oxalates we may prescribe the free consumption, for long periods, of the mild gaseous simple alkaline waters.

In cases of gouty kidney (interstitial nephritis) in the early stage, with slight albuminuria, mineral-water treatment, directed to the relief of the gouty state, may be of service, and by correcting the gouty state may cause the albumen to disappear; but any such treatment must be carried out with great care and caution, and we must see that the mineral water ingested is freely excreted by the kidneys, for if this is not the case there is the risk of increasing arterial pressure, which we should do our best to avoid in these cases, as arterio-sclerosis is often present, and almost always impending.

In albuminuria, dependent on digestive disturbance (a condition not so common as some seem to imagine), mineral waters directed to the relief of the dyspeptic condition may be useful.

DISEASES OF THE NERVOUS SYSTEM

There are many diseases of the nervous system which are obviously quite unsuited to treatment by mineral waters and baths, and to these we need not refer; there are others in which bath treatment is permissible, but not very hopeful, and still a few others in which treatment at natural thermal baths proves advantageous.

In most of these cases it is the *bath* treatment—the *external* treatment and not the *internal* use of the mineral waters—that is mainly relied upon, and there can be no doubt that much of the benefit experienced at the spas to which these cases resort is to be attributed to the accessory means there applied—to the electrical appliances, the mechanical measures, such as massage, re-educating movements, regulated exercises, and proper periods of rest, and the appropriate diet—as well as to the co-operation of a suitable tonic and sedative climate. It is to the whole system of detailed attention and skillful supervision and management, and the perfection of the physical resources at the disposal of the physicians at these resorts, that the good results, not unfrequently obtained, must be referred.

Locomotor ataxia or tabes is claimed to be amenable to thermal treatment at many spas.

Neuritis (and consequent loss of muscular power), peripheral and multiple, due to alcoholic, metallic, or other intoxication, or to cold (rheumatic) or to injury, may be benefited by suitable thermal treatment. The *simple thermal* baths in cases that require sedative treatment—in those requiring more stimulating treatment we may prescribe *warm sulphur* baths. In the cases due to metallic intoxication (lead, mercury, etc.) the warm sulphur or sulphur and sodium chloride baths are especially indicated.

Chronic neuralgias of various origin, whether due to toxic affections, to constitutional states, to anæmic conditions, or to inflammation of the great nerves or their sheaths, are frequently submitted to thermal treatment, and sciatica perhaps more frequently than any other form. Massage, douching, and electricity are employed as auxiliary influences in many instances. Cases of rheumatic, gouty or syphilitic nature are usually sent to *thermal sulphur* baths or to the *thermal salt* baths.

Cases requiring more soothing treatment are directed to *simple thermal* baths, or to the feebly mineralized thermal baths.

The *anaemic forms* may be treated with the baths and chalybeate waters.

In some cases of *sciatica* associated with habitual constipation and abdominal stasis, laxative waters (with hot mineral or mud baths) may be most appropriate.

The various neuroses and functional nervous disturbances are usually best dealt with at spas situated at moderate elevations in mountainous or forest regions, where a soothing as well as mildly bracing treatment can be applied.

CUTANEOUS DISEASES

There are many mineral springs which have a considerable reputation for the treatment of skin diseases, especially the sulphur springs, warm and cold, sulphur and sodium chloride springs, also arsenical and alkaline springs and iron and arsenical waters; and in a minor degree the simple thermal or thermal earthy waters.

It is, of course, important to consider any co-existing constitutional disease or tendency which may be of etiological importance; for instance, in some gouty cases alkaline sodium sulphate waters may be indicated.

Many skin diseases are associated with the *rheumatic* and *gouty* constitutions, and it will be noted that many of the spas which are recommended, in the treatment of skin affections, are precisely those which are found useful in the treatment of chronic rheumatism and gout.

To many others scrofula is believed to have a casual relation, and for these the sodium chloride, and the sulphur and sodium chloride, baths are considered most appropriate.

It is not improbable that in certain forms of skin disease some of these baths, and particularly the sulphur ones, may exert an anti-bacterial influence. It is naturally the *chronic,* intractable forms of cutaneous disease that are sent to mineral-water resorts.

In some resorts *prolonged maceration* of the skin, by immersion for many hours at a time, is obviously an important physical agency which has the effect of cleansing the skin of adherent secretions and washing away old epidermal scales, and of exerting a tonic and sedative effect on the cutaneous peripheral nerves.

We shall now mention briefly the spa treatment suitable to the chief and most prevalent forms of skin disease.

Eczema.—This is one of the commonest of skin affections, and one that is most frequently benefited by bath treatment. Waters containing free hydrogen sulphide and sodium chloride—sulphur and salt—may be taken as the type of bath which is most universally applicable to the cure of eczema. The *moist* forms are the most favorably influenced, and the course seems to be equally useful in the lymphatic, the scrofulous, the gouty, and the anæmic.

Psoriasis.—This most rebellious of skin affections is often ameliorated, but seldom or never cured, by mineral baths. The skin is often cleansed and freed from scales and crusts, and "whitened" for a time by thermal sulphur, with vapor, or sulphur and sodium chloride baths.

DISEASES OF THE FEMALE GENITAL ORGANS

Chronic disorders of the female sexual organs have been largely dealt with at certain mineral springs: disorders of menstruation—amenorrhœa, dysmenorrhœa, menorrhagia; disturbances of health attending the menopause; catarrhal conditions of the vagina and uterus (vaginal and uterine leucorrhœa); the results of inflammatory affections of the pelvic viscera—metritis; pelvic cellulitis, inflammatory exudations, fibroid tumors; tendency to abortion; the causes of sterility. All these conditions, when no longer attended by acute inflammatory symptoms, have been beneficially influenced by mineral-water treatment.

We will first refer to disorders of menstruation, and in these, as in all other cases, we must, of course, always pay careful attention to etiological considerations and constitutional tendencies.

Amenorrhoea.—In cases dependent on anæmia the chalybeate baths and waters are indicated. If associated with constipation and dyspeptic states, or due to passive uterine congestion, the sodium chloride waters or the gaseous thermal salt waters may be more useful.

If intestinal torpor and tendency to abdominal stasis are very prominent features, the *Moor* baths and the aperient sodium sulphate and iron waters are indicated, as they are also in those cases that occur towards the menopause, often combined with gouty and rheumatic symptoms and a tendency to obesity.

In some of these spas local applications in the form of douches of dry carbonic acid gas, peat poultices, and packing the vagina with peat are employed.

It is always an advantage to select an attractive and bracing or soothing climate (according to the individual needs), where the patient can be tempted to be much in the open air.

Dysmenorrhoea.—In obstinate chronic cases the Moor baths and the ferruginous sodium sulphate waters promise the best results.

In neuralgic and ovarian cases a protracted course of simple thermal baths for their sedative effect, is useful.

The congestive form, with enlarged uterus coming on after abortion or uterine gestation, may be treated at sodium chloride springs or alkaline sodium chloride springs.

It is generally recommended that a prolonged period of bath treatment should be prescribed—eight to ten weeks—during which period the restful life in such pleasantly situated resorts, could not fail to be advantageous.

The troublesome symptoms associated with the menopause—gastric, hepatic and nervous—are often benefited by a course of mineral-water treatment.

In those cases with a tendency to constipation and obesity the sodium sulphate and iron waters prove very useful. In thin subjects the sodium chloride waters are more suitable.

A prolonged after-cure in an agreeable seaside or mountain resort, of moderate elevation, is essential in these cases.

Leucorrhoea.—*Vaginal* leucorrhœa is perhaps best treated with alkaline sodium chloride water. If anæmia is a prominent feature the iron waters are suitable, and if there is habitual constipation, the sodium chloride waters. In *uterine* leucorrhœa mineral-water treatment is not so successful, but co-existing abdominal congestion may be relieved by sodium chloride waters, or alkaline sodium sulphate waters. If pain and tenderness are prominent features, the simple thermal, or the gaseous sodium chloride springs may be applied.

Chronic inflammatory affections of the uterus and its annexes and their consequences are frequently submitted to bath treatment —*endometritis, metritis, perimetritis, parametritis, pelvic cellulitis,* etc.—and a great variety of spas are resorted to for this purpose. Perhaps the most popular are certain *sodium chloride* waters, or the *alkaline sodium chloride* springs, combined with long periods of repose.

Drinking cures with the laxative sodium sulphate or sodium chloride waters are often useful to relieve hyperæmia and stimulate absorption, by lowering blood pressure in the abdominal vessels and relieving co-existing constipation. In chronic painful metritis, and cases requiring soothing treatment, the more sedative springs should be advised. In anæmic forms an after-course of iron waters may prove beneficial.

Uterine fibroids.—It must not be expected that mineral waters will cause the disappearance of these tumors, although very confident statements have occasionally been made to this effect; but no doubt great benefit and relief to symptoms have been found to attend treatment at certain spas, especially the strong thermal sodium chloride springs.

Tendency to miscarriages.—In anæmic cases chalybeate waters, with long periods of rest, may prove useful. In suspected syphilitic cases the usual specific treatment at sulphur baths may be prescribed. Prolonged after-cure in a soothing and bracing resort is always essential.

Sterility.—Many and diverse spas have been credited with the cure of sterility. Mineral waters can only act by causing the disappearance of material or functional defects. Chronic leucorrhœa and acidity of the vaginal secretions may be removed: by the application of vaginal douches the circulation and nutrition of the uterus may be improved; iron tonics and a bracing climate may improve the general health and tone.

CHAPTER VII

CHEMISTRY OF MINERAL WATERS

BY

H. A. CURTIS

INTRODUCTION

The chemical examination of the mineral waters of Colorado was begun in June, 1911, and finished in the following winter. The samples were collected by Mr. Roy M. Butters. Bottles for this purpose were cleaned at the laboratory in Boulder, boxed in wooden crates and shipped to convenient points. In collecting the samples the bottle was first rinsed with the spring water, then completely filled, tightly corked and shipped to the laboratory. The temperature of the spring was taken with an ordinary thermometer. Where the flow was small and could be conveniently measured, this was done. In other cases the flow was estimated. The rates given must therefore be considered as approximate. The hydrogen sulphide content of the water was determined at the spring, as indicated under ''Methods of Analysis.'' Mr. Butters also noted the location of the spring, the geologic formations appearing in the neighborhood, and the other points of interest regarding the spring.

In the analytical work the writer was assisted by Dr. Paul M. Dean, now instructor in chemistry, University of Colorado; by Mr. H. R. Mosley, now chemist for the Black Metal Reduction Company, Boulder, and later by Mr. Roy M. Butters, now a consulting geologist in Mexico. All calculations were made by the writer. During the summer of 1911 the work was much facilitated by the loan of several hundred dollars worth of platinum-ware by the Colorado School of Mines.

LOCATION OF SPRINGS

In the table below will be found the location of springs by county, nearest post office, name, and by natural surroundings. Wherever the spring sampled had been given a name which was used to any extent by people living in the neighborhood, this name will be found in the table below, printed in ordinary type. The names printed in italics were given the other springs in order to facilitate the making of field and laboratory notes. These names in many cases refer to either the location or ownership of the springs and may become permanent.

The numbers given the springs are those used to refer to the springs throughout this bulletin. It will be noted that not all of the two hundred fifty-four springs listed were analyzed. The table includes all the springs analyzed as well as those on which radioactivity measurements were made. The springs analyzed are indicated by the sign † after the number.

No.	County	Postoffice	Name	Location
1†	Jefferson	Arvada	Golden Lithia Water	Well 4 mi. N. W. of Arvada, ¼ mi. S. of Arapahoe Station on the Leyden electric railroad. Foley Ranch and Sanatarium.
2†	Pitkin	Aspen	Conundrum Spring	At timberline above head of Conundrum Creek, near Castle Peak.
3†	Delta	Austin	Cold Sulphur Spring	250 yds. N. of State Bridge over Gunnison River near Austin.
4†	Delta	Austin	Alkali Spring	Between No. 3 and State Bridge.
4A	Delta	Austin	Black Canyon Well	Near the mouth of Black Canon, a short distance above the State Bridge.
5†	Pitkin	Avalanche	Bath House Spring	In bath house in bottom of pool, on opposite side of Crystal River from Avalanche Station.
6†	Pitkin	Avalanche	Iron Spring	½-¾ mi. down Crystal River from Avalanche on east bank of river.
7†	Pitkin	Avalanche	Hot Iron Spring	In meadow on east bank of Crystal River, ¼ mi. up river from No. 5.
8†	Pitkin	Avalanche	Hot Iron Spring	100 yds. up river from No. 7.
9†	Pitkin	Avalanche	River Spring	Within 2 ft. of river near Avalanche Station.
10†	Pitkin	Avalanche	Hot Sulphur Spring	50 yds. below No. 5, across river from Avalanche, at foot of rock slide at water's edge.
11†	Adams	Barr	Colorado Carlsbad Water	Well on plains 6 mi. W. of Barr at old bottling works.
12†	Pueblo	Beulah	Beulah Spring	Inclosed spring on north bank of creek, 15 ft. from creek.
13†	Pueblo	Beulah	Pavilion Spring	In pavilion on south bank of creek.
14	Boulder	Boulder	Gregory Canon Spring	¼ mi. up Gregory Canon, on south side of creek, about 75 ft. up mountain from creek.
15	Boulder	Boulder	Sunshine Canon Spring	Spring near creek on Sunshine Canon road, about 300 yds. S. W. of Colorado Sanatarium.
16	Boulder	Boulder	Crystal Spring	Spring near site of old Crystal Springs brewery, between Arapahoe and Marine Streets.
17	Boulder	Boulder	Chautauqua Spring	Spring in Bluebell Canon, ¾ mi. S. W. Chautauqua.
18†	Chaffee	Buena Vista	Buena Vista Hot Springs	6 mi. W. of Buena Vista on Cottonwood Creek.
19	Chaffee	Buena Vista	Buena Vista Hot Springs	Probably same as No. 18. Landslide has changed conditions and made identification uncertain.
20†	Fremont	Canon City	Fremont Natatorium	Well 1,650 ft. deep, 3 mi. E. and 2 mi. N. of Canon City.
21†	Fremont	Canon City	Canon City Hot Spring	Old resort near mouth of Royal Gorge on south bank of Arkansas River, 40 ft. from river.
22†	Fremont	Canon City	Soda Spring	Near State Penitentiary.
23†	Fremont	Canon City	Iron Duke	Near State Penitentiary.
24†	Fremont	Canon City	Grape Creek Spring	On Grape Creek, 12-14 mi. from mouth. Spring 25 ft. from creek bottom.
25	Fremont	Canon City	Green's Well	4½ mi. N. and ½ mi. E. of Canon City. Well about 600 ft. deep.
26	Garfield	Cardiff	Sulphur Spring	3 mi. S. of Cardiff on west branch of creek, about 50 ft. from creek.
27†	Pueblo	Carlile	Carlile Spring	On top of large mound ½ mi. W. of Carlile Station, midway between D. and R. G. track and Arkansas River, about 100 ft. from each.

28†	Montrose	Cimarron	Cimarron Soda Spring	On east side of creek, about 200 ft. up mountain side near junction of Cimarron Creek and Gunnison River.
29†	Gunnison	Crested Butte	Ranger's Spring	Just below ranger's cabin, 1½ mi. above mouth of Cement Creek, about 7 mi. from Crested Butte.
30†	Gunnison	Crested Butte	Cement Creek Spring	In park about 2½ mi. up Cement Creek from No. 29.
31†	Gunnison	Crested Butte	Jarvis Spring No. 1	On Jarvis Ranch, 8 mi. N. E. of Crested Butte. Spring on hillside opposite house.
32†	Gunnison	Crested Butte	Jarvis Spring No. 2	On Jarvis Ranch, ½ mi. above No. 31.
33†	Gunnison	Crested Butte	Iron Spring	Between Irwin and Crested Butte, 3 mi. from Crested Butte, on side hill near road.
34†	Teller	Cripple Creek	Beaver Valley Ranch Spring	On Beaver Valley Ranch, 6 mi. S. E. Cripple Creek, near old townsite of Love, at foot of low hill, 200 yds. N. of ranch barn.
35†	Boulder	Crisman	Crisman Spring	1 mi. E. of Crisman, below old stone building. Spring inclosed in small building.
36†	Fremont	Dean	Company Well	Well, 3 mi. E. of Florence, 100 yds. N. of railroad track and 30 ft. E. of road. On land owned by Rainbow Park Co. of Florence.
37†	Douglas	Deckers	Decker's Mineral Spring	On south fork of South Platte, about 14 mi. S. of South Platte Station on the C. and S. Railroad.
38†	Rio Grande	Del Norte	Shaw's Spring	6 mi. N. of Del Norte, about ¼ mi. N. W. of Del Norte-Saguache road.
39†	Rio Grande	Del Norte	Town Well	Well on main street of Del Norte. Well 500 ft. deep, water rising nearly to top.
40†	Denver	Denver	Deep Rock Artesian	Well on Lot 30, Block 151, Stiles & Park Addition to Denver. Near corner of 27th and Welton St.
41†	Summit	Dillon	Soda Creek No. 1	2 mi. E. of Dillon near a ranch house on west bank of Soda Creek, a branch of the Snake River. Lower spring.
42	Summit	Dillon	Park Spring	Same as No. 44.
43†	Summit	Dillon	Soda Creek No. 2	100 ft. up creek from No. 41.
44†	Summit	Dillon	Park Spring	In park 1 mi. S. E. of Dillon.
45†	Eagle	Dotsero	Big Dotsero Spring	1½ mi. below Dotsero on Rainbow Route along Grand River. North bank of river, near stream.
46†	Eagle	Dotsero	Old Bath House Spring	About ½ mi. above No. 45. Old bath house spring.
47	La Plata	Durango	Pinkerton Springs	N. W. Pinkerton Spring, on Pinkerton Ranch, 4½ mi. N. of Trimble.
48	La Plata	Durango	Pinkerton Springs	Pool Spring, on Pinkerton Ranch, 4½ mi. N. of Trimble.
49	La Plata	Durango	Pinkerton Springs	Cedar Spring, on Pinkerton Ranch, 4½ mi. N. of Trimble.
50†	La Plata	Durango	Pinkerton Springs	North Pinkerton Spring, on Pinkerton Ranch, 4½ mi. N. of Trimble. Largest spring on north edge of group (probably No. 47).
51†	La Plata	Durango	Pinkerton Springs	S. E. Pinkerton Spring, on Pinkerton Ranch, 4½ mi. N. of Trimble. Spring 75 yds. S. E. of No. 50 (may be 48 or 49).
52†	Boulder	Eldorado Springs	Pool Spring	Main spring feeding outdoor swimming pool.
53†	Park	Fairplay	Rhodes' Spring	In South Park, 8 mi. S. of Fairplay on Rhodes' Ranch, in small gulch on side hill.
54†	Garfield	Glenwood Springs	Drinking Spring	About 75 ft. from Mammoth Spring.

No.	County	Postoffice	Name	Location
55†	Garfield	Glenwood Springs	Mammoth Spring	Spring feeding large outdoor swimming pool.
56†	Garfield	Glenwood Springs	Bath Spring	Spring at bath house, South Canon, 4 mi. W. of Glenwood Springs. Spring is ¼ mi. up creek from South Canon.
57†	Garfield	Glenwood Springs	Camp Spring	At South Canon, 4 mi. W. of Glenwood Springs, near No. 56.
58†	Garfield	Glenwood Springs	Vapor Bath, Old Cave Spg. No. 2	Below pipe line on east side of river and near river. Water piped 200 ft. to bath house.
59†	Garfield	Glenwood Springs	Old Cave Spring No. 1	Spring in vapor bath cave near No. 58.
60†	Garfield	Glenwood Springs	Iron Spring	Between Nos. 58 and 59, 25 feet from No. 58.
61†	Garfield	Glenwood Springs	West Glenwood Springs	Spring nearest bath house, about 50 yds. from creek.
62†	Garfield	Glenwood Springs	West Glenwood Springs	Spring 25 ft. from No. 61.
63†	Garfield	Glenwood Springs	Vapor Cave No. 3	Across river from Old Vapor Cave No. 1.
64	Garfield	Glenwood Springs	Air Sample	Air sample from the Inhalatorium, a room arranged for breathing gases from the Mammoth Spring.
65†	Park	Guffey	Hodge's Spring	On Hodge's Ranch, 14 mi. S. W. of Guffey, at foot of Castle Rock.
66†	Park	Guffey	Currant Creek Spring	On S. W. bank of Currant Creek, 1 mi. below Guffey.
67†	Park	Hartsel	Salt Works Spring	Old Colorado Salt Works, near road, 12 mi. W. of Hartsel.
68†	Park	Hartsel	63 Ranch Spring	Near the "63" Ranch, 4 mi. N. and 3 mi. W. of No. 67.
69†	Park	Hartsel	Stinking Springs	On Mills Ranch, 10 mi. E., 4 mi. N. of Hartsel.
70†	Park	Hartsel	Cold Soda Spring	Spring feeding a watering trough at head of little draw 1½ mi. S. of Hartsel.
71†	Park	Hartsel	Hartsel Hot Springs	Near the bath house at Hartsel.
72†	Park	Hartsel	Iron Spring	Spring in meadow at foot of sandstone ridge, ½ mi. N. of Hartsel.
73†	Delta	Hotchkiss	Doughty Springs	Drinking spring, Doughty Ranch, near Gunnison River, 3 mi. S. W. Hotchkiss.
74†	Delta	Hotchkiss	Doughty Springs	Spring between Bird's Nest Spring and Bath Tub Spring, Doughty's Ranch, 3 mi. S. W. Hotchkiss.
75†	Delta	Hotchkiss	Doughty Springs	Spring between No. 74 and Bird's Nest Spring, Doughty's Ranch, 3 mi. S. W. Hotchkiss.
76	Delta	Hotchkiss	Doughty Springs	Spring 50 feet below No. 73, Doughty's Ranch, 3 mi. S. W. Hotchkiss.
77	Delta	Hotchkiss	Bath House Spring	Bath house spring, Doughty Ranch, 3 mi. S. W. Hotchkiss.
78†	Grand	Hot Sulphur Springs	Big Spring	Spring beside lower gate to bath house grounds.
79†	Grand	Hot Sulphur Springs	Bath House Spring	In upper corner of pool.
80†	Grand	Hot Sulphur Springs	Combined Spring	North opening in rock back of bath house.
81†	Grand	Hot Sulphur Springs	Little Sulphur Spring	Big Sulphur, Little Sulphur and Combined Spring from same rock and near each other.
82†	Grand	Hot Sulphur Springs	Big Sulphur Spring	See No. 81.
83†	Grand	Hot Sulphur Springs	Pool Spring	Spring back of swimming pool.
84†	Boulder	Hygiene	Sulphur Spring	2½ mi. N. W. of Hygiene. Several springs close together here. Owner, Sam Beshor.
85†	Clear Creek	Idaho Springs	Hot Soda Spring	At bath house. (Same as 88.)
86†	Clear Creek	Idaho Springs	Cold Soda Spring	Spring 600 yds. down creek. Owned by city. Water lifted by pump.

87†	Clear Creek	Idaho Springs	Blue Ribbon Spring	From tunnel in hill between river and gulch where Hot Soda Springs are located.
88_1	Clear Creek	Idaho Springs	Main Hot Soda Springs	First pool in men's tunnel.
88_2	Clear Creek	Idaho Springs	Hot Soda Springs	Second pool in men's tunnel.
89	Clear Creek	Idaho Springs	Hot Soda Hotel No. 3	About 40 ft. west of men's tunnel.
90	Clear Creek	Idaho Springs	Lower Spring No. 1	Lowest spring on east side of stream.
91	Clear Creek	Idaho Springs	Lower Spring No. 2	Next to lowest spring on east side of stream.
92	Clear Creek	Idaho Springs	Pavilion Spring	In pavilion about 75 ft. N. E. of tunnel building.
93_1	Clear Creek	Idaho Springs	Hot Soda Springs	First pool in ladies' tunnel.
93_2	Clear Creek	Idaho Springs	Hot Soda Springs	Cold pool in ladies' tunnel.
94	Clear Creek	Idaho Springs	Pump Spring	S. W. corner of hotel.
95	Clear Creek	Idaho Springs	Old Tunnel Spring	100 ft. W. of hotel in old tunnel.
96†	Ouray	Ironton	Ironton Park Spring	Spring near road at head of park.
97†	Moffat	Juniper	Lower Bath House Spring	About 75 ft. from river at foot of hill.
98†	Moffat	Juniper	Upper Bath House Spring	Larger spring at upper end of bath house.
99†	Moffat	Juniper	Hill Spring	Spring on top of hill above bath house, 150 yds. up hill from the Hot Sulphur Spring.
100†	Moffat	Juniper	Meadow Spring	Spring in meadow ¼ mi. below bath house.
101†	Moffat	Juniper	River Spring	Spring in river bottom opposite No. 100, ¼ mi. down river from bath house.
102†	Conejos	La Jara	McIntyre Spring	On McIntyre Ranch 8 mi. E. of La Jara, near ranch house ½ mi. E. of Conejos River.
103†	Hinsdale	Lake City	Sparlin Gulch Spring	In Sparlin Gulch, 4 mi. E. of Lake City, back of Baker's Ranch.
104†	Hinsdale	Lake City	Slumgullion Spring	7 mi. up Slumgullion Creek from Lake City, just N. of Lake San Cristobel.
105†	Huerfano	La Veta	Mack Spring No. 1	At Mack Ranch on Cucharas River, 7 mi. from Cucharas.
106†	Huerfano	La Veta	Mack Spring No. 2	At Mack Ranch on Cucharas River. Spring across creek from No. 105.
107†	Huerfano	La Veta	White Sulphur Spring	On Springer's Ranch, 6½ mi. W. of La Veta on Indian Creek.
108†	Huerfano	La Veta	Black Sulphur Spring	On Springer's Ranch, 6½ mi. W. of La Veta on Indian Creek, 40-50 feet from No. 107, west and higher.
109†	Huerfano	La Veta	Iron Spring	On Springer's Ranch, 6½ mi. W. of La Veta on Indian Creek. Spring near creek 75 yds. S. E. of No. 107.
110†	Lake	Leadville	McMahon Spring	5 mi. W. of Leadville, close to lake owned by C. F. and I. Co.
111†	Lake	Leadville	Ximo Soda Springs	5 mi. W. of Leadville, near fish hatchery.
112†	Lake	Leadville	Tessy's Spring	¼ mi. down creek from No. 110.
113†	Lake	Leadville	Dunn Spring	Beside road ¼ mi. N. E. of the U. S. fish hatchery on property of Jos. Dunn.
114	Montrose	Long Park	Long Park Spring	At camp of National Radium Institute, Paradox Valley.
115†	Larimer	Loveland	Buckingham No. 1	On Buckingham Ranch, 3 mi. W. of Loveland, at east foot of sandstone bluff, ¼ mi. S. of Big Thompson River.
116†	Larimer	Loveland	Buckingham No. 2	On Buckingham Ranch, 3 mi. W. of Loveland, 50 yds. N. W. of No. 115.
116A	Larimer	Loveland	Artesian Well	
117†	El Paso	Manitou	Ute Iron Spring	Drilled to 400 ft. Flows from small pipe in pavillion.
118†	El Paso	Manitou	Ouray Iron Spring	Piped to pavilion over Ute Iron Spring, 200 ft.

No.	County	Postoffice	Name	Location
119†	El Paso	Manitou	Hiawatha	About 20 ft. S. of Ute Magnetic.
120†	El Paso	Manitou	Ute Chief Magnetic	On east side of creek about 75 ft. from bottling works.
121†	El Paso	Manitou	Ute Chief	Between road and creek on west side of creek.
122†	El Paso	Manitou	Little Spring	Small spring ¼ mi. above Ute Chief.
123†	El Paso	Manitou	Mansion Hotel No. 1	In Mansion Hotel.
124†	El Paso	Manitou	Mansion Hotel No. 2	In Mansion Hotel pavilion, south side of creek.
125	El Paso	Manitou	Seven Minute Spring	About 100 yds. N. E. of Mansion Hotel at mouth of small gully on opposite side of creek.
126†	El Paso	Manitou	Navajo Geyser	Drilled 365 ft. Water stands near top of casing and spouts occasionally. In restaurant on main street 100 ft. E. of Navajo Hotel.
127†	El Paso	Manitou	Navajo	150 ft. west of bottling works.
128†	El Paso	Manitou	Cheyenne	100 ft. west of Navajo Spring.
129†	El Paso	Manitou	Manitou	In pavilion 75 ft. N. of Cheyenne Spring.
130†	El Paso	Manitou	Shoshone	30 ft. east of bottling works.
131†	El Paso	Manitou	Iron Geyser	Drilled to 285 ft. Located 300 ft. down creek from No. 117.
132	El Paso	Manitou	New Geyser	Across road from Ute Chief, 20 yds. distant.
133	El Paso	Manitou	Little Chief	In yard of cog railroad, about 200 yds. up creek from No. 117, about 40 yds. S. W. of cog road depot.
134†	Las Animas	Mesa de Maya	Iron Spring	On Van Brinnen Ranch, N. of Mesa de Maya, about 40 mi. E. of Trinidad. Largest of three springs here.
135†	Las Animas	Mesa de Maya	Sack Spring	1 mi. N. E. of No. 134, large spring coming out of sandstone in arroya.
136†	Saguache	Mineral Hot Springs	Mound Spring	From top of large mound of sinter, 300 yds. E. of railroad track. S. E. mound of eastmost group. Largest spring of group.
137	Saguache	Mineral Hot Springs		
139	Saguache	Mineral Hot Springs	North Mound Spring	In top of the north mound of the eastmost group.
140†	Saguache	Mineral Hot Springs	Railroad Spring	Near railroad tracks. Largest of group.
141†	Montrose	Montrose	Town Well	Well in Montrose, 900 ft. deep. Corner of So. 1st and Uncompahgre Streets.
142†	Chaffee	Mt. Princeton	Hortense Hot Spring	About 250 yds. up side of mountain above Mt. Princeton Sta.
143†	Chaffee	Mt. Princeton	Bath House Spring	Below Heywood Hotel.
144†	Chaffee	Mt. Princeton	Big Flat Spring	Big spring at lower end of flat between hotel and bath house.
145†	Chaffee	Mt. Princeton	Drinking Spring	Near Heywood Hotel, east.
146†	Chaffee	Mt. Princeton	Hayes' Spring	On Hayes' Ranch about 1 mi. above the Mt. Princeton Station. In a meadow on Chalk Creek.
147†	Jefferson	Morrison	Soda Lake Spring	½ mi. S. E. of Morrison Postoffice, 150 yds. W. of Soda Lake, on hillside.
148†	Jackson	North Park	Hunter's Spring	In meadow on Hunter's Ranch, 3 mi. N. of Cowdrey, 15 mi. N. of Walden, near fork of roads to Encampment and Walden.
149†	Jackson	North Park	Hill's Spring	At ranch house on Hill's Ranch, 12 mi. W. of Cowdrey.
150†	Jackson	North Park	Brand's Spring No. 1	About 100 yds. from ranch house on Brand's Ranch, 13 mi. W. of Walden, 1½ mi. N. W. of Higho Postoffice. Drinking spring.

151	Jackson	North Park	Brand's Spring No. 2	100 yds. down stream from No. 150.
152†	Saguache	Orient	Old Bath House Spring	Spring at old bath house, 12 mi. S. E. of Villa Grove, 6 mi. E. ½ mi. N. of Mineral Hot Springs.
153†	Saguache	Orient	Old Plunge Spring	Big spring about 50 ft. E. of No. 152.
154†	Ouray	Ouray	Fishpond Hot Spring	Hot spring in bottom of fish pond just N. of Ouray.
155	Ouray	Ouray	Fishpond Cold Spring	Cold spring in corner of fish pond, about 15 ft. from No. 154.
156†	Ouray	Ouray	Bath Spring	Warm spring at head of street in eastern side of Ouray. Water comes from an old tunnel and is piped to bath house pool.
157†	Ouray	Ouray	Pavillion Spring	Spring at city pavilion at mouth of Box Canon.
158	Ouray	Ouray	Cogar Spring	On property of Richard Cogar, south side of Ouray.
159	Ouray	Ouray	Weehawken	On Weehawken Creek, 4 mi. west of Ouray.
160†	Archuleta	Pagosa Springs	Arlington Hotel	Well 387 ft. deep at Arlington Hotel.
161†	Archuleta	Pagosa Springs	Cold Soda Spring	Spring about 1¼ mi. down river from town, on east side of river and on west side of brook emptying into river.
162†	Archuleta	Pagosa Springs	Big Pagosa Spring	Very large, hot spring on east side of river, about 100 yds. from stream.
163†	Archuleta	Pagosa Springs	Sawmill Spring	Cold spring back of sawmill at mouth of a little gulch, on west bank of river about ½ mi. from railroad station.
164†	Archuleta	Pagosa Springs	Soda Spring	Spring on lower road in sawmill grounds about ½ mi. from railroad station.
165†	San Miguel	Placerville	Warm Geyser Spring	In a cave on west side of river, on property of Geo. Lemon.
166†	Jefferson	Platte Canon	Strontia Springs	About 28 mi. from Denver on the Platte Canon branch of the C. & S. Railroad. Spring in shallow gulch on west side of river.
167†	Mesa	Plateau Creek	Silver Spring	On Rainbow Route, 14 mi. S. of DeBeque, at junction of road to Mesa.
168†	Mesa	Plateau Creek	Hains' No. 1	Spring on Hains' Ranch, ¼ mi. down the road from the Atwell Bridge over Plateau Creek.
169†	Mesa	Plateau Creek	Alkali Spring	Spring across creek from Hains' ranch house.
170†	Mesa	Plateau Creek	Sulphur Spring	Spring 3 mi. below the Atwell Bridge on Plateau Creek.
171†	Routt	Phippsburg	Scott's Spring	Spring on Scott's Ranch, Morrison Creek, 15 mi. E. of Phippsburg. Spring close to creek.
172†	Routt	Phippsburg	Smith's Spring	Spring on Smith's Ranch, ¼ mi. down creek from No. 171. Spring on mound 6 or 7 feet high.
173†	Routt	Phippsburg	Jones' Mineral Spring	On Bear Creek 5 mi. E. of Phippsburg.
174†	Chaffee	Poncha Springs	Laundry Spring	Largest of the springs back of the laundry, supplying water to laundry.
175†	Chaffee	Poncha Springs	West Mound Spring	On largest of the mounds.
176†	Chaffee	Poncha Springs	East Mound Spring	About 75 ft. from No. 175 across small gully.
177†	Chaffee	Poncha Springs	Gulch Spring No. 1	In gulch east of East Mound Spring, about 100 yds. distant.
178†	Chaffee	Poncha Springs	Gulch Spring No. 2	Cold spring in gulch ¾ mi. above Gulch Spring No. 1.
179	Gunnison	Powderhorn	Old Plunge Spring	About 50 ft. down creek from new bath house.
180†	Gunnison	Powderhorn	Cabin Spring	Spring in front of lower cabin, between Nos. 181 and 182.
181†	Gunnison	Powderhorn	Drinking Spring	Spring 100 yds. below bath house and 150 yds. from Cebolla Creek.
182†	Gunnison	Powderhorn	New Bath House Spring	

o.	County	Postoffice	Name	Location
183†	Gunnison	Powderhorn	Lower Hot Spring	About 300 yds. above Nichol's Spring, on lower side of road, 125 yds. from creek.
184†	Gunnison	Powderhorn	Schrecker's No. 1	On Schrecker's property 200 yds. S. of Powderhorn P. O., about 50 yds. from creek.
185†	Gunnison	Powderhorn	Schrecker's No. 2	On Schrecker's property, about 10 ft. from creek, across from Schrecker's house.
186†	Gunnison	Powderhorn	Nichol's Spring	By roadside 100 yds. E. of Powderhorn Postoffice.
187†	Pueblo	Pueblo	Sisters' Hospital	Well in grounds of Sisters' Hospital.
188†	Pueblo	Pueblo	Ferris Artesian Well	Well over 1,500 ft. deep.
189†	Pueblo	Pueblo	Pueblo Lithia Water	Well 1,200 ft, deep at Congress Hotel.
190†	Pueblo	Pueblo	Clark's Magnetic Mineral Water	Well 1,425 ft. deep at B and Spring Streets.
191†	Dolores	Rico	Railroad Spring	By railroad track ¾ mi. N. of Rico.
192†	Dolores	Rico	Rico Spring	In N. W. corner of city, on west side of Dolores River, 25 ft. from stream near large pine tree at end of bridge.
193†	Dolores	Rico	Dolores Spring	Spring 100 yds. S. of No. 192.
194†	Dolores	Rico	River Spring No. 1	In old river bed 50 ft. from No. 193.
195†	Dolores	Rico	River Spring No. 2	Spring 30 ft. S. E. of No. 194.
196†	Ouray	Ridgway	Orvis Spring	On Orvis Ranch, 2 mi. S. E. of Ridgway, spring at foot of hill about 300 yds. from river.
197†	Ouray	Ridgway	Ridgway Spring	Spring ½ mi. S. W. of Ridgway, at ranch house, on south side of small stream.
198†	Larimer	Rustic Lodge	Rustic Lodge Spring	Spring 3½ mi. W. of the Rustic Lodge, on Cache La Poudre River.
199†	Pueblo	Siloam Bubbling Sp.	Red Creek Springs No. 1	In bottom of gulch, near granite contact on south side of gulch. Red Creek Springs near head of Red Creek, 12 mi. S. of Siloam.
200†	Pueblo	Siloam Resort Sp.	Red Creek Springs No. 2	Across gulch from No. 199, near site of old resort.
201†	Pueblo	Siloam Clear Sp.	Red Creek Springs No. 3	In gulch 100 yds. below No. 199, at foot of a 12-ft. drop in gulch bed.
202†	Pueblo	Siloam Iron Sp.	Red Creek Springs No. 4	In gulch 75 ft. below No. 201.
203†	Pueblo	Siloam Mound Sp.	Red Creek Springs No. 5	On mound 50 yds. up hill from No. 202.
204†	Pueblo	Siloam	Artesian Well	Well used for irrigation, 1 mi. N., 1 mi. E. of Siloam Postoffice.
205†	San Juan	Silverton	Mineral Creek Spring	4 mi. up So. Mineral Creek.
206†	Rio Grande	South Fork	Million's Spring	5 mi. up So. Fork of Rio Grande River from South Fork Postoffice, in Million's pasture, in draw 100 yds. east of river.
207†	Boulder	Springdale	Tile Spring	Beside Jimtown road on Left Hand Creek, near site of old Springdale P. O., on north side of creek.
208†	Boulder	Springdale	Tunnel Spring	About 50 ft. up stream, on same side of creek as No. 207.
209†	Boulder	Springdale	Bath Spring	Above No. 208, about 50 ft. distant.
210†	Boulder	Springdale	Well Spring	Above No. 209, about 75 ft. distant.
211†	Routt	Steamboat Springs	Milk (Lithia, etc.) Spring	¼ mi. S. W. of Cabin Hotel on south side of river, 400 yds. S. of Moffat depot.
212†	Routt	Steamboat Springs	Bath House Spring	Just north of large bath house at east end of main street.
213†	Routt	Steamboat Springs	Heron Spring	Across street N. of Cabin Hotel. Called also the Iron Spring.
214†	Routt	Steamboat Springs	Bubbling (Sulphur) Spring	300 ft. W. of Cabin Hotel in round cement pool, 30 ft. from north bank of river.

215†	Routt	Steamboat Springs	Hot Springs	Hot spring group on creek 8 mi. N. of Steamboat.
216†	Routt	Steamboat Springs	Steamboat Spring	Near bridge.
217†	Routt	Steamboat Springs	Crawford Spring	
218†	Routt	Steamboat Springs	Soda Spring	In pavilion about 200 ft. N. W. of Cabin Hotel.
219†	Routt	Steamboat Springs	Magnesia Spring	
220†	Routt	Steamboat Springs	Moffat Spring	Under Moffat railroad.
221†	Routt	Steamboat Springs	Sulphur No. 2	Second spring above No. 216.
222†	Routt	Steamboat Springs	Rumbling Spring	In cut on Moffat railroad. Also called Bitter Spring.
223	Routt	Steamboat Springs	Navajo Spring	150 yds. E. and a little S. of the Milk Spring, No. 211.
224	Routt	Steamboat Springs	Little Steamboat	35 yds. S. W. of cave spring in hillside.
225	Pueblo	Swallows	Hobson's Well	Artesian well on Hobson Ranch, 540 ft. deep, near ranch house.
226	Pueblo	Swallows		
227†	Otero	Symons	Symon's No. 1	Spring in an arroya ¾ mi. S. W. of Symons, near group of old buildings.
228†	Otero	Symons	Symon's No. 2	Near old stone house by road, about 100 yards W. of No. 227.
229†	La Plata	Trimble	Bath Spring	Spring at bath house by road, ¾ mi. N. of Trimble on west side of Animas River.
230†	La Plata	Trimble	Main Spring	Spring feeding swimming pool. Main spring of the group.
231	La Plata	Trimble	North Spring	Northernmost spring of the group, near hotel.
232†	Pitkin	Thomasville	Bridge Spring	Under Colo. Midland R. R. Bridge No. 168A, 50 ft. from creek, 3½ mi. W. of Thomasville.
233†	Pitkin	Thomasville	Meadow Spring	Spring in field 100 yds. from creek, ¼ mi. east of No. 232.
234†	Mineral	Wagon Wheel Gap	Boiling Spring	Resort about 1 mi. from railroad station. Large spring near hotel on same side of creek.
235†	Mineral	Wagon Wheel Gap	Hot Saline Spring	At foot of hill about 100 yds. from the Hot Sulphur Spring and on opposite side of creek.
236†	Mineral	Wagon Wheel Gap	Hot Soda Spring	At foot of hill across creek from Hot Sulphur Spring. Spring cemented up.
237	Mineral	Wagon Wheel Gap	Little Spring	Small spring beside No. 234.
238†	Gunnison	Waunita	Hotel No. 1	In lower group, ½ mi. below postoffice. Uppermost spring on south bank of Hot Springs Creek.
239	Gunnison	Waunita	Hotel No. 2	In lower group.
240	Gunnison	Waunita	Hotel No. 3	In lower group.
241	Gunnison	Waunita	Hotel No. 4	In lower group.
242	Gunnison	Waunita	Hotel No. 5	In lower group.
243	Gunnison	Waunita	Hotel No. 6	In lower group.
244	Gunnison	Waunita	Hotel No. 7	In lower group.
245†	Gunnison	Waunita	Hotel No. 8	In little gully well up on hill on south bank of creek, about two-thirds way down springy area in lower group of springs.
246†	Gunnison	Waunita	Hotel No. 9	In lower group, on north bank of creek, about 4 ft. from stream, near site of old hotel.
247	Gunnison	Waunita	Hotel No. 10	In lower group.
248	Gunnison	Waunita	Hotel No. 11	In lower group.
249	Gunnison	Waunita	Hotel No. 12	In upper group.
250	Gunnison	Waunita	Hotel No. 13	In upper group. Long oval pool near hotel.
251†	Gunnison	Waunita	Hotel No. 14	In upper group. Pavillion spring.
252†	Fremont	Wellsville	Wellsville Spring	From tunnel feeding swimming pool.
253	Jefferson	Wheatridge	Reservoir Spring	Yousse Radium Springs.
254	Jefferson	Wheatridge	Palmer Spring	Yousse Radium Springs.

METHODS OF ANALYSIS

The methods of analysis used were essentially those given in Bul. 91, U. S. Bureau of Chemistry, and are briefly outlined below.

SILICA

A one-liter sample of the water, filtered if not clear, was evaporated on the water bath in a platinum dish. The dish was then covered with a watch glass, and hydrochloric acid added, a little at a time, until effervescence ceased and the solution was decidedly acid. This solution was brought to boiling to expel dissolved CO_2, after which the watch glass was rinsed over the dish in the usual way. The solution was next evaporated to dryness, on the water bath, the residue dehydrated for two hours at 130°, taken up in 1:1 hydrochloric acid, filtered and washed with hot water. The residue on the filter was placed in a weighed platinum crucible, ignited, cooled in a dessicator and weighed as silicon dioxide.

IRON AND ALUMINUM

The filtrate from which the silica was removed was caught in a 250cc. graduated flask and the volume made up to 250cc. with distilled water after cooling. The solution was made of uniform concentration by pouring it out into a dry beaker and back into the flask several times. Two samples of 50cc. each were then withdrawn by means of pipettes placed in covered beakers, and duplicate analyses made as follows: Ammonium hydroxide was added to each until the solutions smelled strongly of ammonia. The solutions were then boiled until they smelled but faintly of ammonia. The precipitated hydroxides were filtered off, redissolved in warm dilute hydrochloric acid and reprecipitated as usual, after which they were ignited in a platinum crucible and weighed together as aluminum oxide and ferric oxide. If the combined oxides ran low and the duplicate analyses checked, the oxides were not separated. When the combined oxides ran high, the iron and aluminum were separated as indicated below.

IRON

Several grams of acid potassium sulphate were added to each of the crucibles containing the combined oxides. The oxides were brought into solution by very slow and careful fusion. The melts were cooled, dissolved out with water, the solutions made acid with sulphuric acid, the iron reduced by pure sheet aluminum and titrated with standard potassium permanganate solution.

ALUMINUM

In those cases where the iron and aluminum were separated, the aluminum was calculated from the combined oxides of iron and aluminum by difference.

CALCIUM

The filtrates from the two samples used in determining iron and aluminum were made distinctly alkaline with ammonium hydroxide and then an excess of ammonium oxalate solution added. The solutions were kept hot for an hour and then allowed to settle for an hour or longer, after which the calcium oxalate was filtered off, washed with hot water, ignited and weighed as calcium oxide, CaO.

MAGNESIUM

The filtrates from which the calcium had been removed as indicated above, were evaporated to dryness in platinum dishes, the excess of ammonium salts removed by heating, the residue taken up in a small amount of dilute hydrochloric acid and filtered. The filtrates were made strongly alkaline with ammonium hydroxide, an excess of sodium acid phosphate added, and the solutions allowed to stand overnight. The precipitated ammonium magnesium phosphate was then filtered off, washed with ammoniacal ammonium nitrate solution, dried and ignited very slowly with the usual precautions to insure complete combustion of the filter paper and complete transformation of the solid to magnesium pyrophosphate, in which form it was weighed.

SULPHATES

Two 50cc. samples of the original filtrates from the silica were measured out into beakers, brought to boiling and a hot 10% solution of barium chloride added. The solutions were kept hot for an hour, then filtered and the barium sulphate washed with hot water. The barium sulphate was then ignited and weighed in the usual way.

ALKALIES

The filtrates from the sulphate determination were evaporated to dryness in a platinum dish and the residue taken up in water. An excess of barium hydroxide solution was added, the magnesium hydroxide filtered off, washed free of mother liquor, and discarded. To the filtrates were added ammonium hydroxide, ammonium carbonate and ammonium oxalate and the mixture allowed to stand overnight. The precipitate was removed, washed and discarded. The filtrate was evaporated to dryness, the ammonium salts removed by heating, and the residue taken up in water. The treatment with ammonium hydroxide, ammonium carbonate and ammonium oxalate, etc., was repeated twice to make sure that all barium, calcium, etc., were removed from the solution.

The ammonium salts were now removed by evaporating the solutions to dryness and heating. The residues were dissolved in water containing a little hydrochloric acid and filtered, the process being repeated until there remained pure white crystals of the alkali chlorides, which gave no white fumes and no blackening on heating. When considerable quantities of alkali chlorides were obtained, it was found necessary to dry the residue for several hours in the air bath in order to avoid loss by decrepitation when the residues were heated to remove the ammonium salts. The pure dry alkali metal chlorides were now weighed, and the preparation of the alkalies made as indicated below.

Lithium was first tested for by means of the spectroscope. If the lithium line was bright, the lithium was determined as sulphate by the Gooch method, as follows: The dry chlorides were moistened with a few drops of water and then 30cc. of amyl alcohol added. The liquid was brought to boiling, one drop of hydrochloric acid added, and the boiling continued until the volume of the liquid reached 15cc. The amyl alcohol solution was then run through a dry filter paper and caught in a weighed platinum dish. The undissolved salts were washed twice by decantation with a little amyl alcohol. The amyl alcohol was evaporated from the platinum dish, a few drops of sulphuric acid added, the dish heated gently until the residue was almost white, and the lithium sulphate weighed. From the weight of the sulphate, 0.0017 gram was subtracted to correct for the solubility of sodium and potassium chlorides in 15cc. of amyl alcohol.

The chlorides of potassium and sodium remaining in the platinum dish and on the filter were dried to remove amyl alcohol and then dissolved in water. The amount of hydrochlorplatinic acid necessary to combine with the alkalies was calculated, considering the whole of the alkali chlorides to be sodium chloride. A slight excess of hydrochlorplatinic acid in 56% solution was then added to the solution of the alkali chlorides and the solution evaporated in a porcelain dish over a simmering (not boiling) water bath until a pasty mass remained in the dish. About 20cc. of 80% ethyl alcohol were now added and the mass thoroughly worked up in the alcohol. The mixture was filtered, then a small dry filter and the insoluble potassium chlorplatinate washed on the filter with 80% alcohol. The filter paper was dried, the potassium chlorplatinate dissolved out with a little warm water, the solution evaporated to dryness in a small weighed platinum dish and the weight of the potassium chlorplatinate determined. Knowing the weight of the lithium sulphate, the potassium chlorplatinate and the combined chlorides of lithium, potassium and sodium, it is evident that the weights of the three alkali metals could be calculated.

PHOSPHORIC ACID

The remaining 50cc. of the original filtrate from the silica were used to test for phosphates by the usual ammonium molybdate method. The amount of ammonium phosphomolybdate obtained was not large enough in any case to warrant a quantitative determination, and the phosphates reported as a trace in those cases in which any of the yellow phosphomolybdate appeared.

HYDROGEN SULPHIDE

This determination was made at the spring by the collector of the samples. The hydrogen sulphide was titrated with tenth normal iodine solution, using 500cc. of the mineral water when the sulphide was low and a smaller amount when the mineral water ran high in hydrogen sulphide.

The tenth normal iodine solution for this purpose was standardized in the laboratory and fresh amounts sent to the collector in the field from time to time.

CARBONATES AND BICARBONATES

Two 100cc. samples of the mineral water were pipetted out and a few drops of phenolphthalein added. Normal carbonates give a red color. The samples were titrated with twentieth normal hydrochloric acid until colorless. This occurs when the carbonates have been converted into bicarbonates, thus: $2MCO_3+2HCl=MCl_2+M(HCO_3)_2$, from which the amount of carbonates may be calculated. Methyl orange was then added, and the samples again titrated to an end with the standard acid: $M(HCO_3)_2+2HCl=MCl_2+2H_2O+2CO_2$.

In this second titration it is to be noted that both the bicarbonates originally present and those formed by the titration of the normal carbonates consume the standard acid. Therefore the volume of acid used in the first titration must be subtracted from the volume used in the second titration, since only one-half of the carbonates were converted to chlorides in the first titration, the other half being converted from bicarbonates to chlorides during the second titration.

CHLORIDES

Two 100cc. samples of the mineral water were measured out by means of a pipette. To these samples a couple of drops of phenolphthalein were added. If a red color developed, showing carbonates, the solution was titrated to colorless by means of acid potassium sulphate solution. A little potassium chromate solution was then added as an indicator and the chlorides titrated with standard silver nitrate solution.

OXYGEN CONSUMING CAPACITY

Two 200cc. samples of the mineral water were measured out, and 2cc. of sulphuric acid added to each. They were then brought to boiling and standard potassium permanganate added until the color was red. The boiling was continued for ten minutes, adding more potassium permanganate solution if the color faded out, and the excess of permanganate then determined by titrating back to an end with standard ammonium oxalate solution.

PRECIPITATED IRON

On standing, especially in the light, an iron containing mineral water will lose most of the iron by reason of the precipitation of basic iron salts. In order to avoid the absurdity of reporting a trace of iron in a mineral water which, at the time of collection, may have contained a considerable quantity of iron, the precipitated iron was determined as follows: The whole sample was filtered and the filtrate set aside. The iron adhering to the inside of the container was dissolved in a little hydrochloric acid, reprecipitated with ammonium hydroxide and the hydroxide washed on to the filter. The whole of the iron salt was now dissolved from the filter in warm dilute sulphuric acid, the iron reduced by aluminum and titrated with standard permanganate solution. The total volume of the sample was measured and the precipitated iron calculated to parts per million.

EXCESS CARBON DIOXIDE

By this term is meant, in this report, the amount of carbon dioxide given off when the bicarbonates are converted to carbonates, as occurs during evaporation of the mineral water. The excess carbon dioxide was calculated from the known amounts of bicarbonates present according to the following equation: $M(HCO_3)_2 = MCO_3+CO_2+H_2O$. The amount of free carbon dioxide dissolved in the water was not determined. Under "Remarks" in connection with the analyses it is indicated in many places that the water was saturated with the gas, shown by the fact that gas was bubbling through the water.

EVAPORATION SOLIDS

One hundred cubic centimeters of the water were evaporated to dryness in a weighed platinum dish on the water bath. The residue was dried for two hours in an air oven at about 120° and the weight of the residue determined.

In evaporating a mineral water, the bicarbonates are converted to normal carbonates, causing the residue to weigh less than the sum of the constituents shown in the analysis. This may be in part or wholly compensated by the fact that certain of the salts in the residue, notably the calcium sulphate, retain some water of crystallization at 120°. For these reasons the amount of residue to be obtained upon evaporating a given weight of a mineral water can be calculated only approximately from the amount of bases and acid radicles shown in the analysis.

SUMMARY

In the table below is shown the form in which the various constituents were determined and the form to which they were calculated for report.

Form in Which Reported	Form in Which Determined
SiO_2, silica	SiO_2
Fe, iron	Fe, by titration with permanganate
Al, aluminum	Al_2O_3 by difference
Fe_2O_3 Al_2O_3 iron and aluminum oxides	$Fe_2O_3+Al_2O_3$
Ca, calcium	CaO
Mg, magnesium	$Mg_2P_2O_7$
SO_4, sulphate	$BaSO_4$
K, potassium	KCl and K_2PtCl_6
Na, sodium	NaCl and difference
Li, lithium	Spectroscope and Li_2SO_4
H_2S, hydrogen sulphide	H_2S, titration with iodine
CO_3 carbonates	CO_3, titration with acid sulphate
HCO_3, bicarbonates	HCO_3, titration with acid sulphate
Cl, chloride	AgCl by titration with silver nitrate

Oxygen capacity	Titration with permanganate
Precipitated iron	Titration with permanganate

FORM OF REPORT

Following the scheme used in the older U. S. government bulletins, both the radicles and the hypothetical combinations are given in parallel columns in the present report. The amounts of the various constituents are reported in milligrams per liter. For a water not highly mineralized this is essentially equivalent to parts per million. In fact, in most published reports indicating parts per million the analyses were actually made on the basis of milligrams per liter. The following table shows the relations between the various units commonly used:

Milligrams per liter×0.0583 =grains per U. S. gallon.
Milligrams per liter×0.07 =grains per imperial gallon.
Milligrams per liter×0.00000833=avoirdupois pounds per U. S. gallon.

Milligrams per liter÷sp. gravity of mineral water=parts per million.

In calculating the "hypothetical combinations" the bases are taken in the order: lithium, potassium, sodium, magnesium, calcium, iron,. aluminum, and are combined with the acid radicles in the order: chloride, sulphate, carbonate, bicarbonate, silicate.

Since the column of hypothetical combinations is calculated from the column of bases and acid radicles, it is well to show this fact by making the sums of the two columns equal. Obviously, the unavoidable errors of experiment will result in there being a small amount of base or acid radicle in excess of the theoretical amounts necessary in the hypothetical combinations. The scheme of calculating a part of the silica to silicates gives some leeway in adjusting the two columns to a balance, and where this does not permit the desired adjustment, the small excess of base or acid radicle has been neglected and the theoretical value used. The adjustment can usually be made in the bicarbonate, so that the agreement between theoretically required and experimentally determined amounts of bicarbonates furnishes a check upon the accuracy of the analysis. This adjustment to make the columns check is open to the criticism that it substitutes for an experimentally determined value a slightly different theoretical value. Undoubtedly this offers a temptation to patch up poor work, but it must be said on this point that the value of an analysis always depends upon the honesty as well as the skill of the chemist who makes it.

It is with considerable reluctance that the "hypothetical combinations" column is included in the reports. There are many arguments against this form of report, and some of these arguments are mentioned below, in the hope that they will help in giving those interested in water analyses a clear idea of the facts in the case. In spite of these arguments, it has seemed best to include this form of report parallel with that which indicates bases and acid radicles, for the reason that water analyses have long been reported in terms of these hypothetical combinations and those who make use of water analyses have long been familiar with reports in this form. To abandon the custom would lessen the usefulness of the analyses to those familiar only with the older form, and until a wider knowledge of chemistry obtains among laymen, and especially until our physicians have learned to interpret analyses reported in the newer form, it does not appear that the time is ripe to discard the scheme of "hypothetical combinations."

The custom of reporting water analyses in terms of "hypothetical combinations," is, however, a most unfortunate one. It implies that the chemist knows from his analysis which bases and acids are associated in a mineral water. Such is not the case. It is probable that the basic elements and acid radicles are associated to only a very small extent in so dilute a solution as a mineral water. In terms of the electrolytic dissociation theory in its simplest form, whenever a salt is put into aqueous solution the salt partly dissociates and there results an equilibrium between the undissociated part of the salt and the detached parts, or ions, as they are called. This state of affairs is usually represented in the following way:

$NaCl \rightleftarrows \overset{+}{Na} + \overset{-}{Cl}$, the double arrows indicating the reversible nature of the process and the + and — signs the kind of electrical charges on the ions.

As the solution is diluted, more and more of the salt dissociates into ions and at great dilution the salt is almost completely dissociated. This theory is strongly supported by a mass of experimental evidence and is accepted by most chemists. If the theory be true, the discussion of how the acid radicles and bases are combined in a mineral water is futile, and we should seek to express the therapeutic or other properties of a mineral water in relation to the ions which it contains, rather than hypothetical salts. Entirely aside from the fact that the practice of indicating the presence of certain salts in a mineral water runs counter to our best substantiated theory of solutions, the method of calculating hypothetical combinations is largely an arbitrary one. It is well known that if two salts, such as sodium chloride and potassium nitrate, are put together in solution, and the solution evaporated to dryness, not two, but four salts will be found in the residue, namely sodium chloride, potassium nitrate, potassium chloride and sodium nitrate. Similarly three such salts put together in solution will yield a residue containing nine salts, and in general n such salts, having different bases and acid radicles, will form n^2 compounds between acid radicles and bases. In other words, every base will be found linked to every acid radicle, the amounts of the various salts formed depending upon a number of factors, the principal of which is the solubility of the individual salts in the presence of all the other salts.

It will be seen that residue from a mineral water containing say eight bases and five acid radicles will be much more complex than the hypothetical combinations would indicate. To be sure, some of the salts in the residue will be present in relatively large amounts and others in negligibly small amounts, but at best the residue will be a complex mixture of salts and will certainly not correspond, even approximately, to the hypothetical combinations.

One of the most frequently advanced arguments for reporting water analyses in hypothetical combinations is that these combinations aid the physician, and even the layman, in estimating the therapeutic value of the water. Here again the hypothetical combinations are likely to mislead. Most people are familiar with the medical value of magnesium sulphate, and would readily guess the effect of freely imbibing a water the analysis of which showed magnesium sulphate to be present. Suppose that we take a quart of pure water and add to it an ounce of crystallized magnesium sulphate. This solution would have decided medicinal properties. Suppose now that we add to said solution an ounce of sodium bicarbonate. The most characteristic property of the water will not have been affected in the least, but if this solution of the two salts be analyzed, and reported as hypothetical combinations, the analysis will not show the presence of magnesium sulphate at all, but of magnesium bicarbonate, a salt not familiar to the layman at least.

To sum up the objections to the practice of reporting analyses as hypothetical combinations: It is probable that the bases and acid radicles are mostly free and not combined in the mineral water; on evaporating the water the residue obtained does not correspond to the hypothetical combinations; the calculation of the analytical results obtained to hypothetical combinations, which are largely fictitious, may frequently mask the real nature of the water so far as the average man, and often the physician, is able to interpret the analysis.

It is to be earnestly hoped that the engineer, the physician, the geologist, and all others who have occasion to interpret water analyses, will learn to dispense with the hypothetical combinations and to use the unmitigated results of the laboratory. The later U. S. government bulletins on water analysis report only the bases and acid radicles, and it is likely that this form of report, or one closely allied to it, will be generally adopted in the near future.

Chase Palmer, in his "Geochemical Interpretation of Water Analyses,"* pleads for the use of "reaction capacities" obtained by dividing the weight of each radicle present by its respective combining weight. In chemical terminology, the elements and radicles are reported in gram equivalents instead of parts per million. This method of reporting analyses has a distinct advantage in that not only the quantity but the valence of each radicle and element is included in the values reported. This scheme has much to recommend it and may offer a satisfactory substitute for the hypothetical, or rather fictitious, combinations insisted upon by the physician and engineer especially.

ACCURACY OF EXPERIMENTAL WORK

Extreme analytical accuracy was not possible under the conditions imposed in this work. A moderate accuracy, with a sufficient number of checks on the work to preclude gross errors from creeping in, was maintained throughout. The determinations of sodium, potassium, calcium, magnesium, iron, aluminum, chloride, carbonate, bicarbonate, hydrogen sulphide and sulphate were made in duplicate. The average value was taken in each case if the duplicates checked closely; otherwise the determination was repeated. Silica, oxygen capacity, lithium, precipitated iron and evaporation solids were determined in single samples, and occasionally it was necessary to combine samples in determining sodium and potassium in order to avoid large percentage errors, because of the small amounts of these elements present.

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*U. S. G. S. Bull. 479.

Bulletin 11 - 1920
"Mineral Waters of Colorado" -
By: R.D.George, Harry A.Curtis,
O.C.Lester,Jas.K.Crook; J.B.
Yeo, and Others.

Several chemists were engaged in the work at various times, a circumstance which usually decreases accuracy of results; but extreme familiarity with the various analytical steps involved was soon reached by all of them, and a skill was attained in the operations which the average chemist, who makes an occasional water analysis, does not possess.

By working with larger samples of water, the accuracy of certain determinations could have been increased and various constituents of the water, present in minute percentages, could have been determined. In this class fall manganese, phosphate, strontium, barium, arsenic, copper, etc. Determination of these elements would have increased greatly the dimensions of an analytical task already very large and the additional information secured would scarcely have justified the increased cost of the work.

Unfortunately the samples could not always be analyzed as soon as they reached the laboratory. It was rather necessary to complete the collecting during the summer months, both because of difficulty of travel at other times and because of the danger of breaking shipping bottles by freezing of samples during cold weather.

SAMPLE OF FORM FOR ANALYSES

No. 85.

Rate of flow: 12 to 15 gallons per minute from the tunnel
Temperature: 105 degrees Fahrenheit.

Analysis.

Formula and Name	Milligrams per Liter
SiO_2, silica	68.0
SO_4, sulphate	396.3
HCO_3, bicarbonate	1513.8
CO_3, carbonate	None
PO_4, phosphate	None
Cl, chloride	71.47
Fe_2O_3 Al_2O_3 } iron and aluminum oxides	2.0
Mn, manganese	None
Ca, calcium	145.4
Mg, magnesium	39.43
K, potassium	Trace
Na, sodium	573.3
Li, lithium	None
Oxygen for SiO_3	2.62
	2812.32

Hypothetical Combinations	Milligrams per Liter
KCl, potassium chloride	Trace
NaCl, sodium chloride	117.82
Na_2SO_4, sodium sulphate	586.1
$Ca(HCO_3)_2$, calcium bicarbonate	561.4
Fe_2O_3 Al_2O_3 } iron and aluminum oxides	2.0
$CaSiO_3$, calcium silicate	19.05
SiO_2, silica	58.13
$Mg(HCO_3)_2$, magnesium bicarbonate	237.26
$NaHCO_3$, sodium bicarbonate	1230.1
	2811.86

H_2S, hydrogen sulphide	None
Oxygen capacity	0.55
Excess carbon dioxide	545.8

Evaporation solids	2045.
Iron precipitated	2.38

Remarks:

GENERAL DISCUSSION OF MINERAL WATERS

I. CLASSIFICATION

Most of the mineral waters of Colorado are to be classed as alkaline-saline, there being a few which would be classed as alkaline and a few as saline under the Peale scheme of classification.[1]

Amongst those which are typically alkaline may be mentioned Nos. 167 and 168 on Plateau Creek, and Nos. 171, 172 and 173, east of Phippsburg. Nos. 147 and 150, and springs Nos. 97, 98 and 99, of the Juniper group, have but little saline constituents.

Those which are typically saline are Nos. 37, 157 and 166. No. 67 and several of the springs of the Glenwood group are very high in saline constituents and low in alkaline. The alkaline-saline class includes, as said, most of the springs, but the constituents of the springs in this group range between very wide limits, giving a great variety of waters, as is shown by the analyses.

II. TEMPERATURE OF THE MINERAL SPRINGS

In the table below, the springs are grouped under temperature intervals of ten degrees and in Fig. I the data of the table are shown graphically. Of course, the number of samples taken in each group of springs will affect the distribution curve, but in two hundred analyses this factor will not be of great weight, and the curve represents fairly well the grouping of the springs with regard to temperature.

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[1] Mineral Waters of the United States, Fourteenth Annual Report, Part II., U. S. Geol. Survey, 1892-3.

TEMPERATURE OF SPRINGS, FAHRENHEIT

40°–50°	50°–60°	50°–60° con.	60°–70°	70°–80°	80°–90°	90°–100°	100°–110°	110°–120°	120°–130°	130°–140°	140°–150°	150°–160°	160°–170°	170°–180°	180°–190°
31	1	134	3	4	29	20	2	5	7	10	162	157	246	......	142
32	6	147	22	30	36	78	21	8	9	71	177	175	251		
34	11	148	23	51	38	152	62	56	18	136	215	176			
67	12	150	27	52	45	153	81	57	54	144	238	245			
68	13	161	66	53	46	182	83	79	55	145					
70	24	163	69	141	50	229	85	80	58	174					
72	28	164	73	189	60	252	97	82	59	160					
104	33	169	74	190	183		98	179	61	234					
110	35	170	75	199	191		100		63						
111	37	171	87	204			154		143						
113	39	172	102	211			156		196						
146	41	186	108	213			212		230						
149	43	192	116	214					235						
178	44	194	117	216					236						
184	65	205	119	222											
186	84	207	122												
198	86	210	127												
232	96	218	129												
233	99	227	130												
	101	228	135												
	103		166												
	105		167												
	106		168												
	107		173												
	109		180												
	112		181												
	115		200												
	118		201												
	120		202												
	121		203												
	123														
	124														
	126														
	128														
	131														

Table I

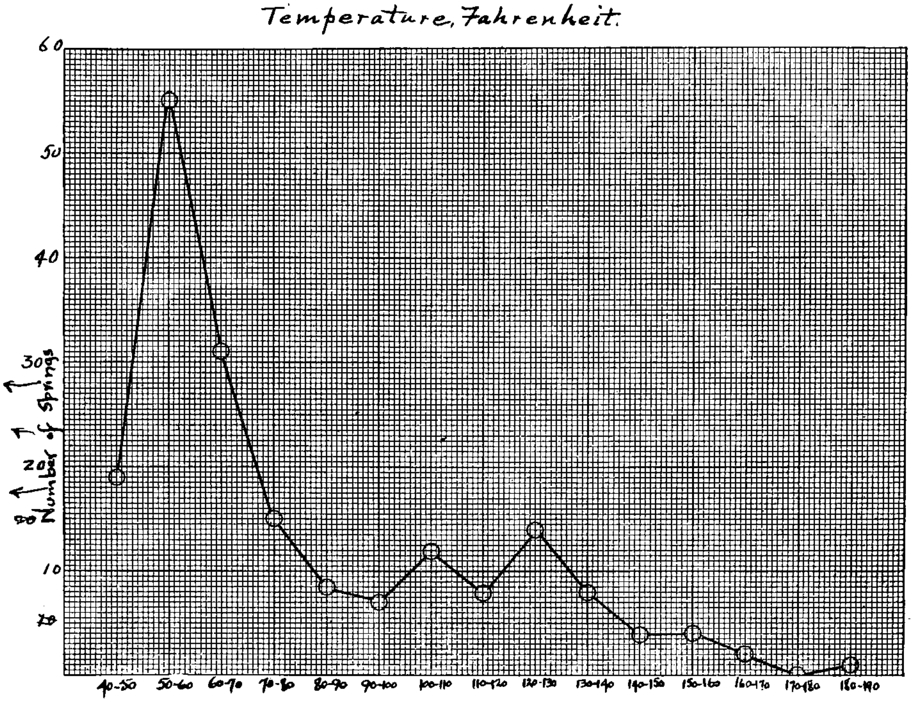


Fig. I

III. MINERALIZATION OF THE SPRINGS

In the following table the springs are grouped on the basis of the amount of mineral matter in the water, as indicated under "Evaporation Solids" in the analyses. It will be noted that of the 202 springs listed 86.44% have a mineral content of less than 4000 milligrams per liter. The spring at the old salt works in South Park stands highest with 31,166 milligrams per liter, next come the Glenwood Springs group, ranging from 13,772 to 23,246 milligrams per liter, two springs on the Gunnison River near Austin, two springs on the Grand River below Dotsero, and Hodge's Spring.

A number of the springs listed in the first column of the table are so low in minerals as not to be properly classed as mineral springs. In a few cases, however, the nature of the mineral matter present is such as to make the water valuable in spite of its low mineral content.

MINERALIZATION OF SPRINGS, IN PARTS PER MILLION

0–500	500–1000	1000–1500	1500–2000	2000–2500	2500–3000	3000–3500	3500–4000	4000–4500	4500–5000	5000–5500	5500–6000	6000–10000	10000–20000	20000–30000	Over 30000
18	31	20	6	2	5	23	1	37	66	214	216	24	3	55	67
29	41	21	11	9	7	73	22		101	219	217	35	4	61	
30	56	27	13	12	8	100	50				220	211	45	62	
32	57	43	28	39	10	111	51				222	221	46		
33	96	44	36	71	68	123	69					166	54		
34	115	78	70	85	127	126	74						58		
38	116	79	86	113	129	130	75						59		
40	136	80	117	121	161	160	208						60		
52	140	81	118	122	165	162	209						63		
53	148	82	120	124	169	164	229						65		
72	150	83	131	128	191	199									
102	154	84	135	163	203	200									
104	167	87	141	196	210	207									
106	168	97	157	201	213										
107	170	98	184	204											
108	171	99	186	218											
109	172	103	198	232											
110	174	105	234	233											
119	175	112	236												
142	176	134													
143	177	149													
144	189	156													
145	193	180													
146	194	181													
147	195	182													
152	197	183													
153	202	185													
173	212	187													
178	215	188													
192	238	190													
205	245	227													
206	246	228													
252	251	230													
		235													
33	33	34	19	18	14	13	10	1	2	2	4	5	10	3	

Table II

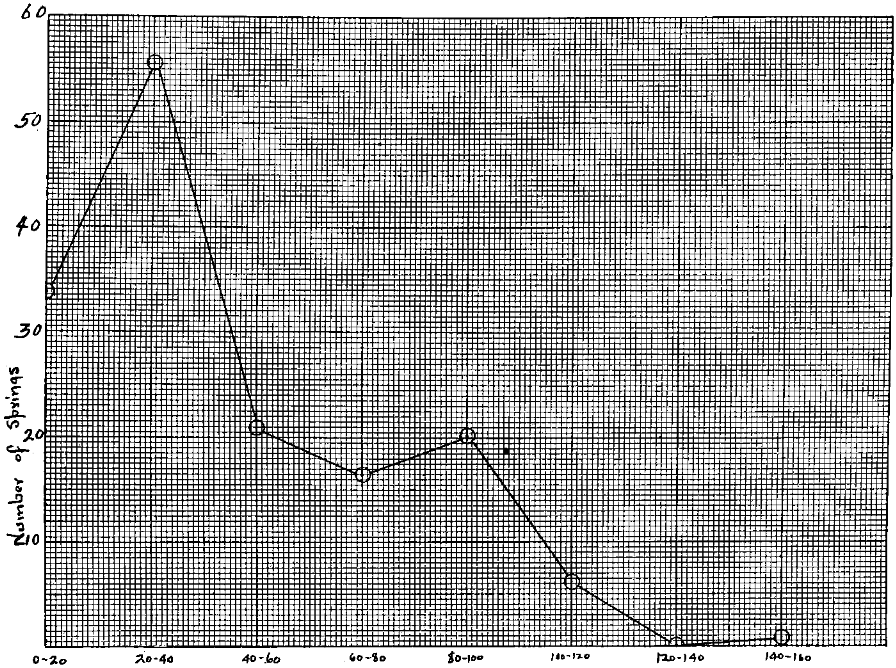
IV. SILICA CONTENT

Each of the 202 waters analyzed contained silica, the amount varying from seven or eight milligrams per liter to more than a hundred. No. 160 has the highest silica content, 160.2 milligrams per liter. Others high in silica are Nos. 171, 199, 200, 203 and 251. In the following table the springs are grouped in the various columns according to their silica content, and in Fig. III these data are shown graphically.

SILICA CONTENT IN PARTS PER MILLION

0–20	20–40	40–60	60–80	80–100	100–120	120–140	140–160
6	1	2	5	7	171	......	160
25	3	12	10	8	199		
28	4	13	35	9	200		
31	11	20	39	10	203		
33	21	57	65	24	251		
40	22	58	66	38			
41	23	59	85	62			
46	29	61	86	67			
52	30	71	96	140			
53	32	75	104	165			
69	34	87	118	172			
70	36	102	130	175			
73	37	111	131	176			
84	43	113	142	181			
105	44	117	144	191			
106	45	126	145	207			
107	50	127	162	208			
108	51	128	177	209			
109	54	129	180	210			
110	55	136	182	211			
115	56	143	183	215			
119	60	157	235	229			
134	63	174		234			
135	68	196		236			
146	72	198		238			
147	74	201		245			
167	78	206		246			
173	79	212					
178	80						
184	81						
185	82						
186	83						
187	97						
188	98						
189	99						
190	100						
192	101						
193	103						
194	112						
195	116						
213	120						
227	121						
228	122						
232	123						
233	124						
	141						
	148						
	149						
	150						
	152						
	153						
	154						
	156						
	161						
	163						
	164						
	166						
	168						
	169						
	170						
	197						
	202						
	204						
	205						
	214						
	216						
	217						
	218						
	219						
	220						
	221						
	222						
	230						
	252						
45	74	28	22	27	5		1

Table III



Silica Content in parts per million
Fig. III

V. SULPHATE CONTENT

In the following table the springs are grouped according to sulphate content. It will be noted that sulphate is present in all the waters, the amount varying from a few milligrams per liter up to 2700 milligrams per liter. It is to be noted that 50% of all the mineral waters analyzed have less than 200 milligrams per liter of sulphate, and that only a few have more than 1600 milligrams per liter. Calcium sulphate is found crystallizing out about a number of the mineral springs. The sulphate content of a water is of importance therapeutically because of the purgative effect of sulphates.

SULPHATE CONTENT IN PARTS PER MILLION

0–200		200–400	400–800	800–1200	1200–1600	1600–2000	2000–2400	2400–2800
18	124	13	12	5	2	1	61	62
21	131	27	20	10	6	3		67
22	136	28	37	11	7	4	1	
23	140	35	45	54	8			2
24	142	36	46	55	9	3		
29	143	43	50	58	160			
30	144	44	51	59	162			
31	145	68	60	63	164			
32	146	71	75	74	169			
33	147	73	96	135	196			
34	148	84	134	157	207			
38	150	85	154	161	108			
39	152	86	156	163	209			
40	153	87	166	165	210			
41	167	103	187	191	229			
52	168	117	188	227	232			
53	170	118	190		233			
56	171	123	211	16				
57	172	126	214		17			
65	173	127	216					
66	175	128	217					
69	176	129	219					
70	178	130	220					
72	180	141	221					
78	181	149	222					
79	182	174	228					
80	183	177	230					
81	185	184						
82	192	186	27					
83	193	189						
97	194	197						
98	195	204						
99	198	213						
100	199	218						
101	200	234						
102	201							
104	202	35						
105	203							
106	205							
107	206							
108	212							
109	215							
110	235							
111	236							
112	238							
113	245							
115	246							
116	251							
119	252							
120								
121	101							
122								

Table IV

Sulphate content in parts per million.

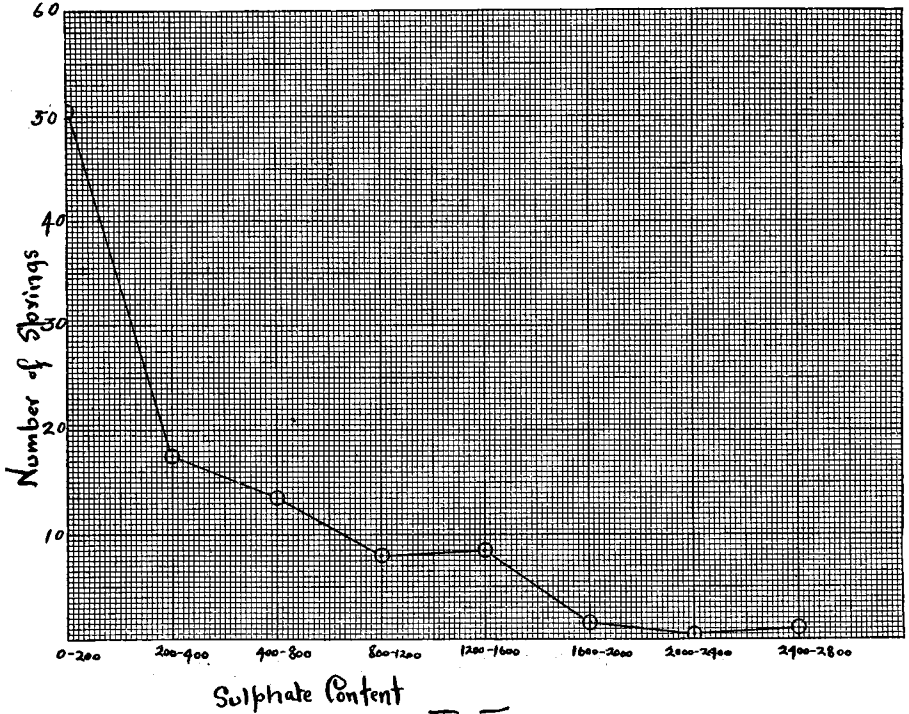


Fig. IV

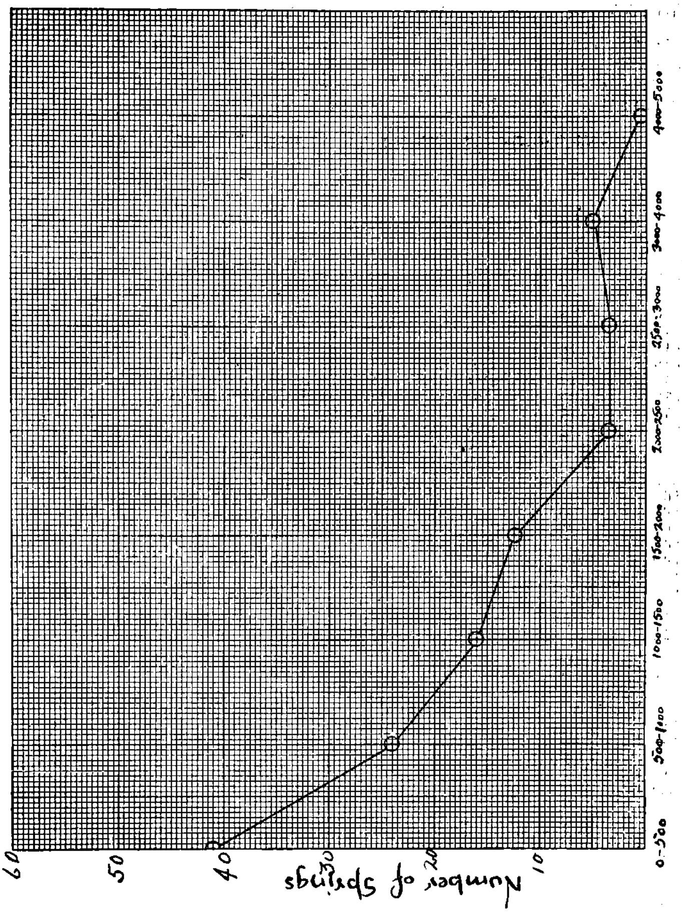
VI. BICARBONATE CONTENT

In the following table the waters are grouped on the basis of bicarbonate content. All the mineral waters analyzed contain bicarbonate, the amount varying between wide limits, as will be noted in the table.

BICARBONATE CONTENT IN PARTS PER MILLION

0–500		500–1000		1000–1500	1500–2000	2000–2500	2500–3000	3000–4000	4000–5000
2	152	1	198	12	22	101	66	3	4
6	153	5	202	13	23	121	126	24	—
9	154	7	210	28	39	122	127	35	1
11	156	8	235	36	69	123	128	65	
18	157	10	—	50	73	129	130	211	
29	166	20	48	51	75	199	219	214	
30	169	21		74	85	200	222	216	
31	173	27		86	118	—	—	217	
32	174	41		98	120	7	7	220	
33	175	42		99	124			221	
34	176	44		100	141			—	
37	177	54		111	171			10	
38	178	59		113	172				
40	187	60		117	203				
45	188	61		131	218				
46	189	62		149	—				
52	190	63		165	15				
53	192	78		180					
55	196	79		181					
56	197	80		182					
57	205	81		183					
58	206	82		184					
67	212	83		186					
68	213	84		191					
70	215	87		201					
71	227	97		204					
72	228	103		207					
96	230	105		208					
102	232	112		209					
104	233	115		229					
106	238	148		234					
107	245	150		236					
108	246	160		—					
109	251	161		32					
110	252	162							
116	—	163							
119	82	164							
134		167							
135		168							
136		170							
140		185							
142		193							
143		194							
144		195							
145									
146									
147									

Table V



Bicarbonate Content in parts per million

Fig. V.

VII. CARBONATE CONTENT

Only a few of the mineral waters analyzed contained normal carbonates. No. 18 contains 8.21 milligrams per liter; No. 212 contains 11.73 milligrams per liter; and No. 215 contains 4.69 milligrams per liter. It is to be noted that these three are hot springs, the temperatures being 120, 104 and 148 deg. F. It is also to be noted that the presence of normal carbonates is associated with a low calcium content. The three springs named above show calcium contents of 4.65, 20.76 and 7.58 milligrams per liter.

Several other springs contain traces of normal carbonates. These are Nos. 38, 70, 73, 115, 116, 145, 146, 170, 206 and 251. Of these springs only one has a calcium content of more than 30 milligrams per liter.

VIII. CHLORIDE CONTENT

Chloride is present in every mineral water analyzed, the amounts varying between wide limits. Table VI shows the grouping of the springs on the basis of chloride content, and these data are represented graphically in Fig. VI.

CHLORIDE CONTENT IN PARTS PER MILLION

0–200		200–400	400–800	800–1600	1600–3200	3200–6400	6400–12800	Above 12800
1	144	5	70	22	3	4	54	67
2	145	7	73	23	37	45	55	
6	146	8	74	24	101	46	58	1
11	147	9	75	50		65	59	
18	148	10	113	51	3	166	60	
20	149	12	199	66			61	
21	150	13	200	68		5	62	
27	152	39	203	71			63	
28	153	57	213	100				
29	154	112	218	111			8	
30	156	117		211				
31	157	123	10	214				
32	162	125		216				
33	163	127		217				
34	164	128		219				
35	167	129		220				
36	168	130		221				
38	169	160		222				
40	170	161						
41	171	165		18				
43	172	198						
44	173	201						
52	174	204						
53	175	212						
56	176	229						
69	177	234						
72	178	235						
78	180	236						
79	181							
80	182	28						
81	183							
82	184							
83	185							
84	186							
85	187							
86	188							
87	189							
96	190							
97	191							
98	192							
99	193							
102	194							
103	195							
104	196							
105	197							
106	202							
107	205							
108	206							
109	207							
110	208							
115	209							
116	210							
118	215							
119	227							
120	228							
121	230							
122	232							
124	233							
131	238							
134	245							
135	246							
136	251							
140	252							
141								
142	129							
143								

Table VI

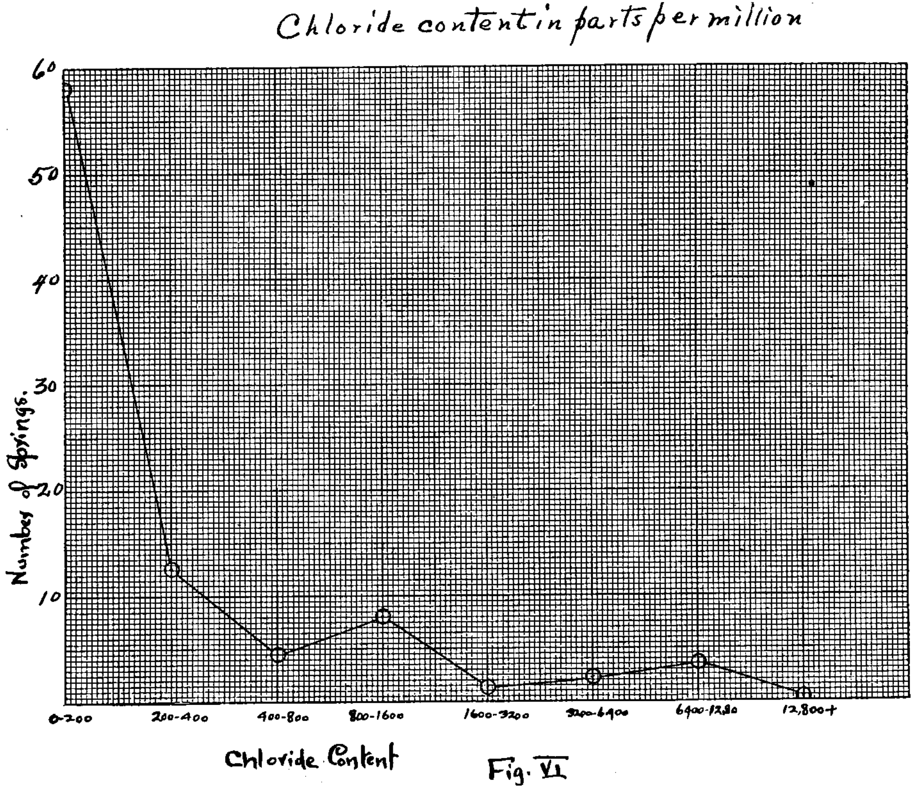

Chloride content in parts per million
60
50
40
30
20
10
Number of Springs.
0-200
200-400
400-800
800-1600
1600-3200
3200-6400
6400-12,80
12,800+
Chloride Content

Fig. VI

IX. IRON AND ALUMINUM OXIDES

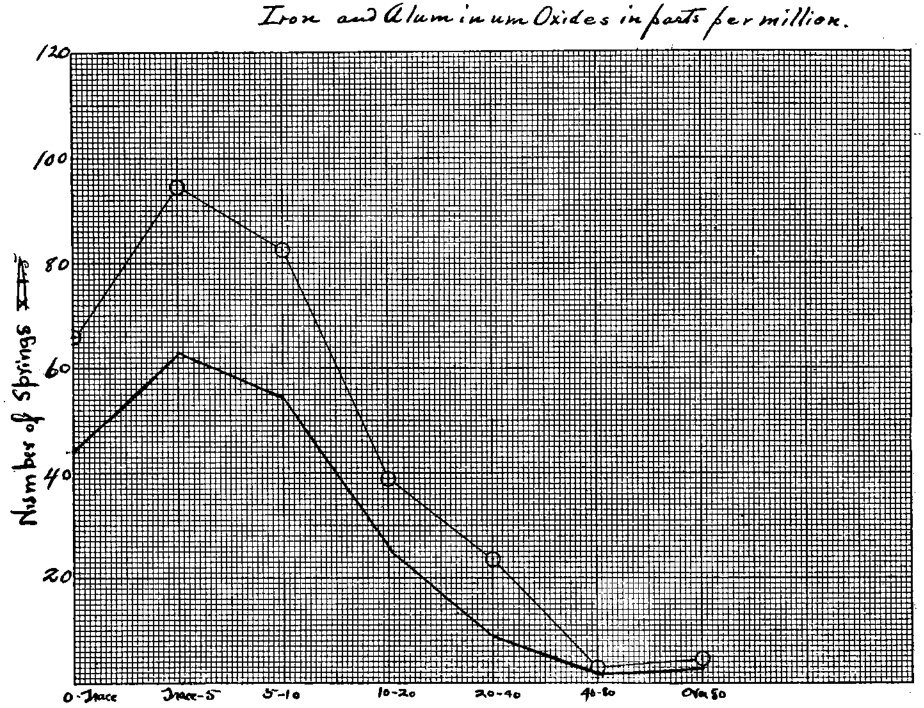
In the table below, the springs are grouped on the basis of their iron and aluminum content. For this purpose the "iron precipitated" has been calculated to the oxide and added to the "iron and aluminum oxides."

It is to be noted that there are not many springs in Colorado properly to be classed as iron springs, although nearly every spring contains a little iron.

IRON AND ALUMINUM OXIDES IN PARTS PER MILLION

0–Trace	Trace–5	5–10	10–20	20–40	40–80	Over 80
3	1	10	9	7	41	33
4	2	29	24	8	157	86
5	12	31	28	35	2	96
6	13	45	37	39		205
11	20	65	46	67		4
18	23	68	51	75		
21	27	73	60	191		
22	32	74	66	227		
30	38	78	104	9		
34	40	79	111			
36	43	80	112			
50	44	85	113			
54	52	87	118			
55	53	103	123			
57	56	106	135			
58	62	117	150			
59	63	121	162			
61	69	126	166			
70	71	127	173			
72	81	128	184			
99	82	129	186			
100	83	131	192			
101	84	134	198			
102	97	146	211			
110	98	147	216			
119	105	148	235			
120	107	152	26			
142	108	153				
143	109	160				
144	115	161				
145	116	171				
154	122	172				
163	124	180				
164	130	181				
165	136	182				
167	140	183				
168	141	185				
169	149	187				
170	156	189				
193	174	190				
197	175	194				
200	176	209				
201	177	210				
234	178	213				
44	188	218				
	195	219				
	196	220				
	199	228				
	202	229				
	203	230				
	204	232				
	206	233				
	207	236				
	208	251				
	212	252				
	214	55				
	215					
	217					
	221					
	222					
	237					
	245					
	246					
	63					

Table VII



Iron and Aluminom Oxides
Fig. VII.

X. CALCIUM CONTENT

Calcium is present in all the mineral waters analyzed, the amount varying from a few milligrams per liter to more than 1300 milligrams per liter. The water from a number of springs is so high in both calcium and sulphate as to be saturated with calcium sulphate, which salt separates in clear, needle shaped crystals when the water stands exposed to air for a short time. In Table VIII and Fig. VIII the springs are grouped with regard to calcium content.

CALCIUM CONTENT IN PARTS PER MILLION

0–25	25–50	50–100	100–200	200–400	400–800	800–1600	Over 1200
18	4	3	11	7	1	61	166
33	32	29	12	8	2	62	
38	34	30	13	9	5	67	
40	53	44	20	10	6	130	
52	56	71	21	45	35	166	
57	70	73	22	46	37		
69	72	87	23	58	50		
78	82	101	24	60	51		
79	84	112	27	66	54		
80	100	119	28	96	55		
81	105	140	31	117	59		
83	106	141	36	120	63		
97	107	147	39	124	65		
98	108	152	41	135	121		
99	109	187	43	149	122		
102	136	197	68	154	123		
104	148	202	74	156	126		
110	153	219	75	157	127		
115	178	234	85	160	128		
116	188	235	86	161	129		
142	205	236	103	162	131		
143		252	111	163	191		
144			113	164	207		
145			118	169	208		
146			134	171	209		
167			150	172	229		
168			165	184	232		
170			180	190	233		
173			181	193			
174			182	194			
175			183	195			
176			185	196			
177			186	199			
189			192	200			
206			198	210			
212			201	227			
215			203	230			
238			204				
245			211				
246			213				
251			214				
			216				
			217				
			218				
			220				
			221				
			222				
			228				
41	21	22	48	37	28	5	1

Table VIII

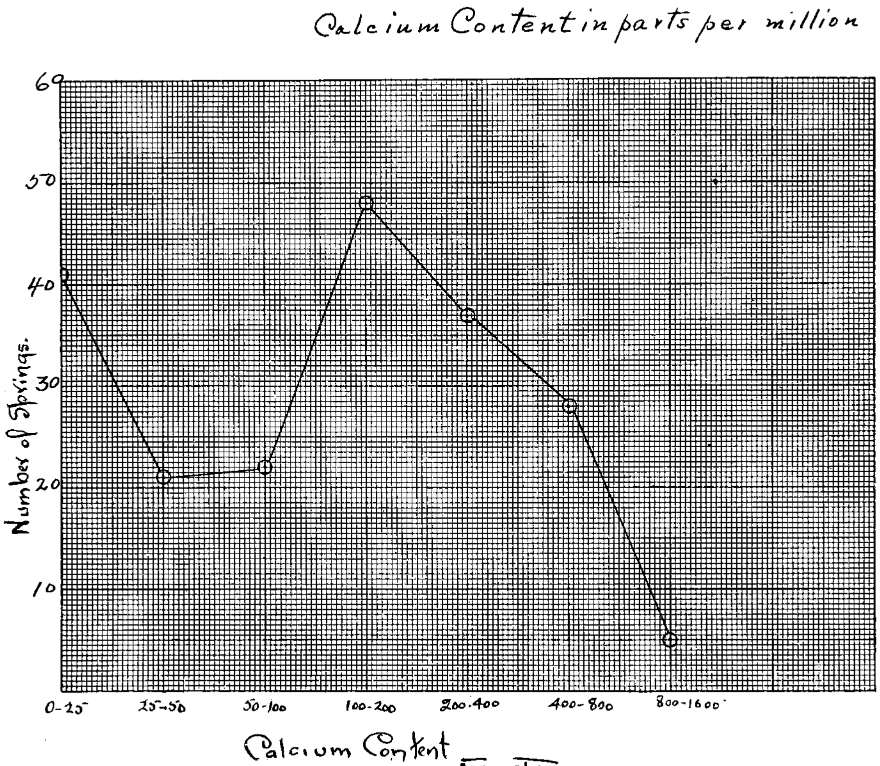

Calcium Content in parts per million
60
50
40
30
20
10
Number of Springs.
0-25
25-50
50-100
100-200
200-400
400-800
800-1600
Calcium Content

Fig. VIII.

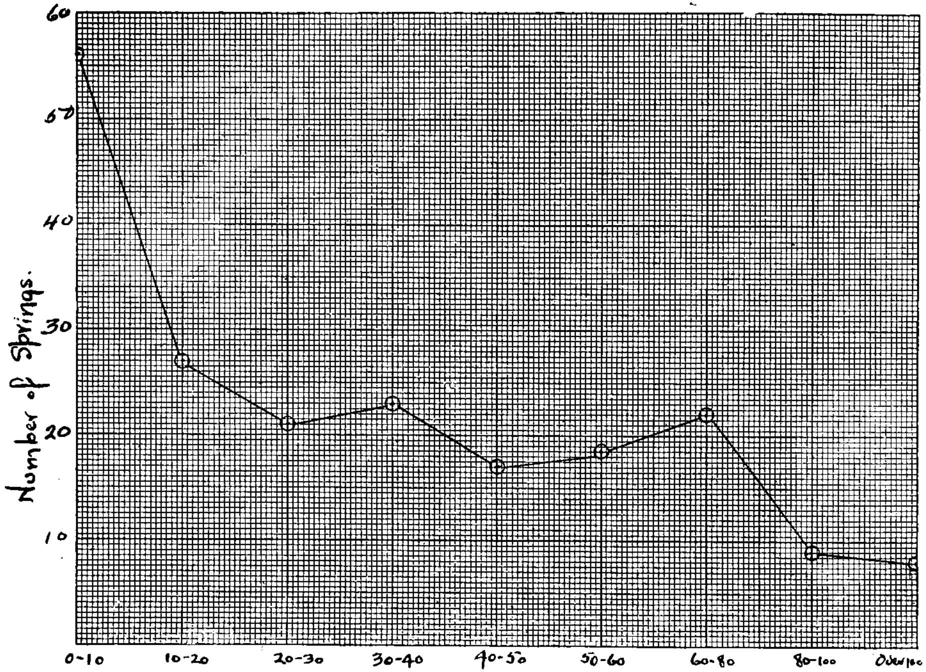
XI. MAGNESIUM CONTENT

Magnesium is present in nearly all the mineral waters analyzed. The amount ranges from only a trace to 112 milligrams per liter. In Table IX and Fig IX the springs are grouped according to magnesium content.

MAGNESIUM CONTENT IN PARTS PER MILLION

0–10	10–20	20–30	30–40	40–50	50–60	60–80	80–100	Over 100
2	32	13	28	9	3	1	35	24
18	41	29	50	10	4	20	54	62
33	43	30	51	11	5	27	55	65
34	44	53	56	12	6	45	58	66
37	70	71	60	22	7	46	59	74
38	72	87	68	31	8	61	67	123
40	84	101	69	73	21	63	75	169
52	100	119	85	117	23	111	149	171
57	103	150	112	163	36	121	172	8
78	105	160	118	181	39	122	9	
79	131	184	129	182	113	126		
80	136	188	141	186	120	127		
81	140	195	161	197	124	128		
82	147	196	164	204	134	130		
83	152	198	190	208	180	135		
86	153	202	201	209	183	191		
96	157	216	207	229	213	199		
97	162	219	210	17	218	200		
98	165	222	211		232	203		
99	185	230	214		19	227		
102	187	252	217			228		
104	189	21	220			233		
106	192		221			22		
107	193		23					
108	234							
109	235							
110	236							
115	27							
116								
142								
143								
144								
145								
146								
148								
154								
156								
166								
167								
168								
170								
173								
174								
175								
176								
177								
178								
194								
205								
206								
212								
215								
238								
245								
246								
251								
56								

Table IX



Magnesium Content in parts per million
Fig IX.

XII. ALKALI METALS

In the next table the springs are grouped on the basis of the combined sodium, potassium and lithium content. For the purpose of this discussion this is better than a grouping based on either sodium or potassium because of the errors which are liable to be made in separating these metals.

ALKALI METALS IN PARTS PER MILLION

0-200		200-400	400-800	800-1600	1600-3200	3200-6400	6400-12800
2	215	5	1	22	24	3	54
6	227	20	7	23	65	4	55
18	228	27	8	35	101	45	59
21	230	36	9	66	211	46	61
29	232	41	10	69	214	58	62
30	233	43	11	73	216	60	63
31	238	57	12	74	217	—	67
32	245	87	13	75	219	6	—
33	246	97	28	100	220		7
34	251	103	37	111	221		
38	252	112	39	160	222		
40	—	115	44	162	—		
52	71	116	50	165	11		
53		120	51	166			
56		121	68	199			
72		122	70	200			
96		148	71	203			
102		167	78	—			
104		168	79	17			
106		169	80				
107		170	81				
108		175	82				
109		177	83				
110		180	84				
119		181	85				
130		182	86				
131		183	98				
134		185	99				
135		187	105				
136		188	113				
140		189	117				
142		212	118				
143		—	123				
144		32	124				
145			126				
146			127				
147			128				
149			129				
150			141				
152			161				
153			163				
154			164				
156			184				
157			186				
171			196				
172			198				
173			201				
174			204				
176			207				
178			208				
190			209				
191			210				
192			213				
193			218				
194			229				
195			234				
197			235				
202			236				
205			—				
206			58				

TABLE X

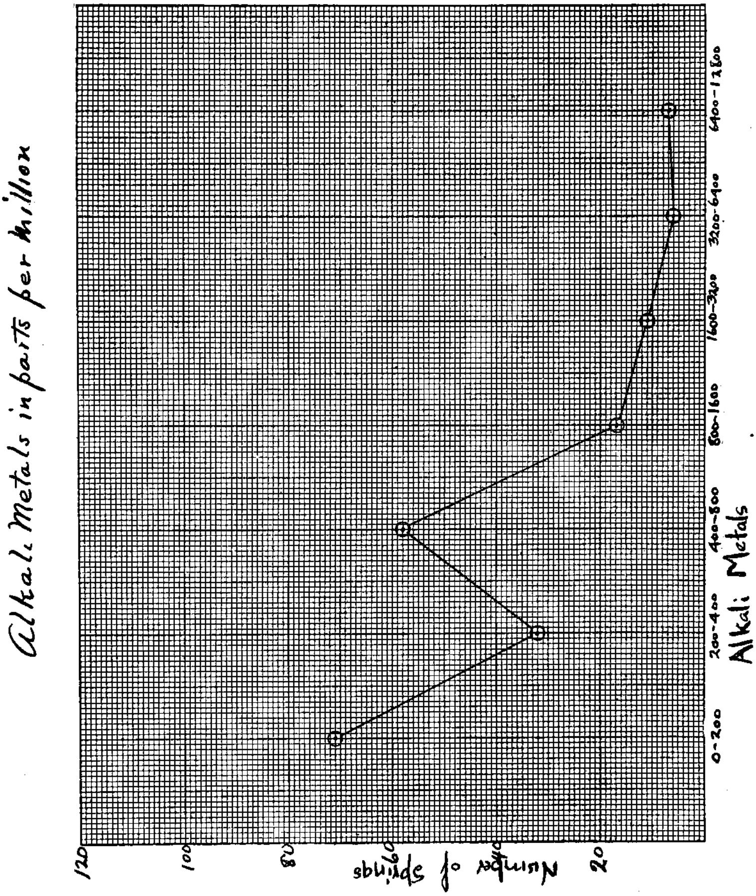

Alkali Metals in parts per million
Number of Springs
120
100
80
60
40
20
0-200
200-400
400-800
800-1600
1600-3200
3200-6400
6400-12800
Alkali Metals

Fig. X.

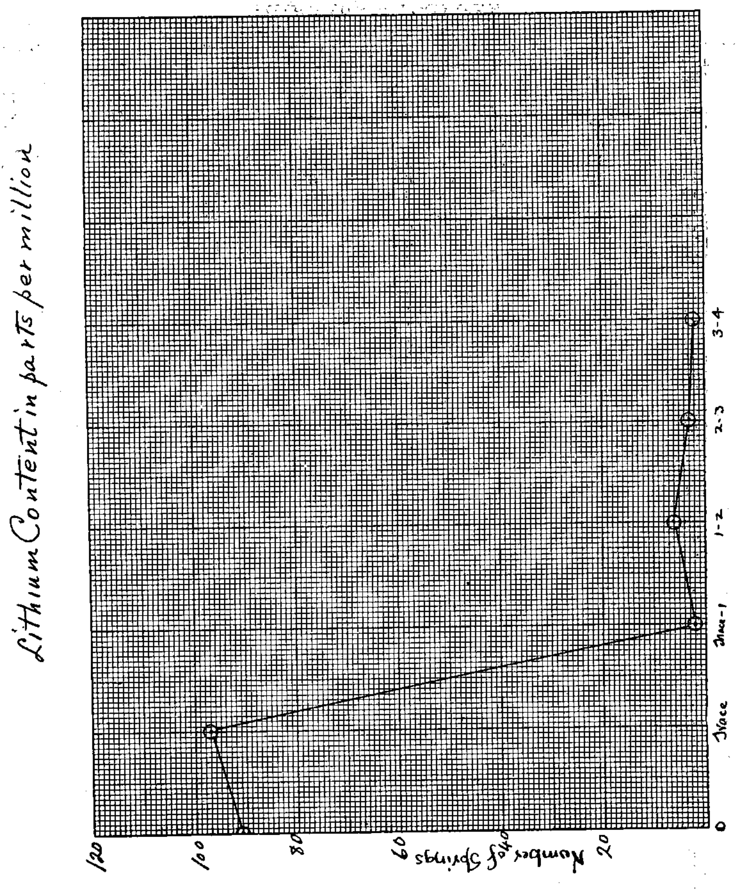
XIII. LITHIUM CONTENT

By means of the spectroscope the presence of lithium was noted in 111 of the waters analyzed. In only twelve waters, however, did the lithium spectrum appear bright enough to warrant the separation of the lithium. Since the amount separated amounted, in some cases, to less than one milligram per liter, it is safely assumed that where a trace of lithium is reported the amount present is not more than one milligram per liter.

LITHIUM CONTENT IN PARTS PER MILLION

None		Trace		Trace-1	1-2	2-3	3-4	Not det.
2	148	1	123	103	111	160	50	51
6	149	3	124	106	157	162	165	——
8	150	4	126	——	163	164	——	1
11	152	5	127	2	229	——	2	
24	153	7	128		234	3		
29	154	9	129		235			
30	166	10	130		——			
31	167	12	131		6			
32	168	13	136					
33	169	18	141					
34	170	20	142					
38	173	21	144					
40	174	22	145					
45	175	23	156					
46	176	27	161					
52	177	28	171					
53	178	35	172					
54	181	36	180					
55	192	37	182					
56	193	39	183					
57	194	41	184					
58	195	43	185					
59	197	44	186					
60	205	65	187					
61	206	66	188					
62	207	69	189					
63	208	70	190					
67	209	71	191					
68	210	72	196					
83	212	73	198					
85	213	74	199					
86	214	75	200					
87	215	78	201					
96	218	79	202					
98	227	80	203					
99	232	81	204					
102	233	82	211					
104	238	84	216					
110	245	97	217					
115	246	100	219					
116	252	101	220					
119	——	105	221					
120	91	107	222					
121		108	228					
134		109	230					
135		112	236					
140		113	251					
143		117	——					
146		118	97					
147		122						

TABLE XI



Lithium Content. Fig. XI.

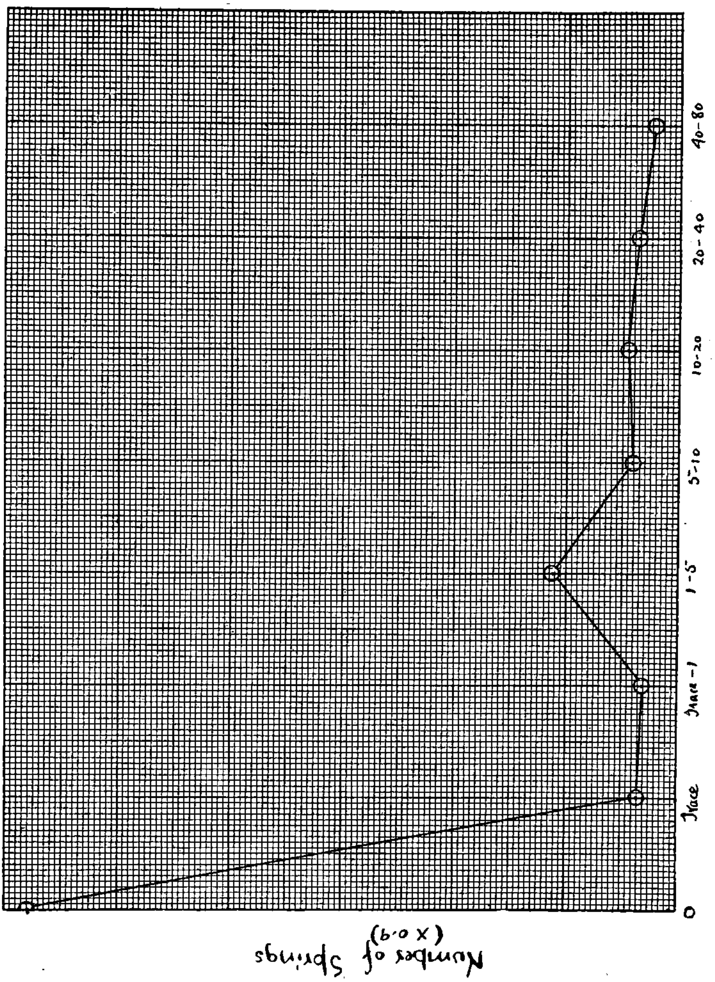
XIV. HYDROGEN SULPHIDE CONTENT

In Table XII and Fig. XII the springs are grouped on the basis of the hydrogen sulphide content. It is to be noted that sixty-four springs in Colorado contain more than a trace of hydrogen sulphide and that a number of them are highly sulphureted.

HYDROGEN SULPHIDE

None		Trace	Trace-1	1-5	5-10	10-20	20-40	40-80
1	134	20	99	31	10	3	107	73
2	135	38	123	32	58	79	108	74
4	136	39	190	54	78	81	115	75
5	140	101	235	55	80	82	116	84
6	141	147	238	56	98	83	170	105
7	142	167	245	57	129	164	219	—
8	143	211	246	59	160	214	221	5
9	144	212	—	60	161	216	222	
11	145	—	7	61	163	217	—	
12	146	8		62	—	220	8	
13	150			63	9	—		
18	152			69		10		
21	153			86				
22	154			97				
23	156			100				
24	157			148				
25	166			149				
28	168			162				
29	169			165				
30	171			206				
33	172			232				
34	173			233				
35	174			234				
36	175			236				
37	176			251				
40	177			—				
41	178			25				
43	180							
44	181							
45	182							
46	183							
50	184							
51	185							
52	186							
53	187							
65	188							
66	189							
67	191							
68	192							
70	193							
71	194							
72	195							
85	196							
87	197							
96	198							
102	199							
103	200							
104	201							
106	202							
109	203							
110	204							
111	205							
112	207							
113	208							
117	209							
118	210							
119	213							
120	215							
121	218							
122	227							
124	228							
126	229							
127	230							
128	252							
130	—							
131	130							

TABLE XII



Hydrogen Sulphide

Fig. XII

SUMMARY OF GROUPINGS BY NOTABLE FEATURES

Very Large Flow	High Temperature	High Mineralization	High in Silica	High in Sulphate
No. 162, Big Pagosa Spring No. 102, McIntyre Spring No. 45, Big Dotsero Spring No. 29, Ranger's Spring on Cement Creek No. 55 In Glenwood No. 59 Group No. 212 In No. 214 Steamboat No. 222 Group No. 53, Rhodes' Spring. No. 234, Boiling Spring at Wagon Wheel Gap No. 152 At No. 153 Orient No. 252, Wellsville No. 146 Hayes Spring	No. 142, Hortense Hot Springs No. 246 No. 245 Waunita No. 251 Group No. 238 No. 157 at Ouray No. 175 No. 176 Poncha No. 177 Group No. 162 of Pagosa Group No. 215 of Steamboat Springs	No. 67 at old Colorado Salt Works, So. Park. No. 55 No. 54 No. 58 No. 59 No. 60 Glenwood No. 61 Group No. 62 No. 63 No. 3 Near No. 4 Austin No. 45 Near No. 46 Dotsero No. 65, Hodges' Spring	No. 160 of the Pagosa Group No. 171 Scott's Spring No. 199 Red No. 200 Creek No. 203 Springs No. 251 of the Waunita Group	No. 62 of the Glen- No. 61 wood Group No. 67 at old Colorado Salt Works, So. Park. No. 1, Golden Lithia Water. No. 3 Near No. 4 Austin

High in Bicarbonate	High in Chloride	High in Iron and Aluminum	High in Calcium	High in Magnesium
No. 4 Near No. 3 Austin No. 24 on Grape Creek No. 35, east of Crisman No. 65, Hodges' Spring No. 211 No. 214 In No. 216 Steamboat No. 217 Springs No. 220 Group No. 221	No. 67 at old Colorado Salt Works, So. Park. No. 54 No. 55 No. 58 No. 59 In No. 60 Glenwood No. 61 Group No. 62 No. 63 No. 4, near Austin No. 45 Near No. 46 Dotsero No. 65, Hodges' Spring No. 166, Strontia Springs	No. 33, Iron Spring near Crested Butte. No. 205, Mineral Creek Spring near Silverton. No. 96, Ironton Park Spring. No. 41, on Soda Creek, near Dillon. No. 157, Pavilion Spring at Ouray.	No. 166, Strontia Spgs. No. 67, old Salt Works No. 130 in the Manitou Group No. 61 In Glenwood No. 62 Group	No. 24 on Grape Creek No. 62 of the Glenwood Group. No. 65, Hodges' Spring No. 66 near Guffey No. 74 of the Doughty Group. No. 123 of the Manitou Group No. 169 on Plateau Creek No. 171, Scott's Spring

High in Alkali Metals	High in Lithium	High in Sulphur	Miscellaneous	
No. 54 No. 55 No. 59 No. 61 No. 62 No. 63 } All these in the Glenwood Group	No. 50 in Pinkerton Group No. 160 No. 162 No. 163 No. 164 } These four in the Pagosa Group	No. 73—61.0 mg. per L. No. 74—51.1 mg. per L. No. 75—59.3 mg. per L. The above three are all from the Doughty Group.		
No. 67 at the old Colorado Salt Works in So. Park.	No. 165 at Placerville No. 157 at Ouray No. 111 near Leadville No. 229 near Trimble No. 234 No. 235 } Wagon Wheel Gap.	No. 84—61.09 mg. per L. Near Hygiene. No. 105—77.95 mg. per L. Mack Spring.		

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Note

I wished to comply with the request of Professor Curtis that he be permitted to read the proof of his part of the report, but I regret that the urgency for immediate action in the printing of the report made this impossible.

R. D. GEORGE.

CHAPTER VIII

RADIOACTIVITY

BY O. C. LESTER

INTRODUCTION

At the present time there is a widespread popular interest in radium and in radioactivity. Its growth in recent years has been especially marked in Colorado, where there are large deposits of radioactive ores and numerous hot and cold radioactive mineral springs. The active production of radium through the operations of the United States Bureau of Mines and of private companies, its peculiar properties and fabulous price, and the increasing use of mineral springs for therapeutic purposes have all conspired to create an interest in radioactivity which is more than curiosity. This has been indicated by numerous requests for information both from persons having a general interest in the subject and from others with a definite interest in some ore or mineral water. These inquiries have shown that there is a considerable amount of misinformation concerning radioactivity passing as reliable, and that there is a desire for accurate knowledge. Although authoritative information is available in many books and journals, these are usually inaccessible and even unknown except to those with special training. Furthermore, the best of them are too technical for popular reading. Hence it has seemed worth while to preface the technical part of this investigation with a brief non-technical discussion of radioactivity in general with special reference to those phases of it which are usually found in connection with natural waters and gases.

Methods of testing and of measuring radioactivity have also become of general interest. The electroscope is no longer a laboratory instrument, but is found in mine and mill, and even in the prospector's camp. It is for such reasons that both methods and results have been discussed in this report with more detail than would be justifiable otherwise. Those desiring further information are referred to the list of treatises and articles in the appended bibliography.

Certain substances such as uranium, radium, thorium and their compounds send out spontaneously radiations which are capable of passing through materials opaque to ordinary light. These radiations will also affect a photographic plate, discharge electrified bodies and, when intense, will render luminous certain sensitive bodies brought near them. Substances which emit such radiations are said to be *radioactive* and to possess the property of *radioactivity*.

These radiations are of three types and have been given the names *alpha-rays, beta-rays,* and *gamma-rays.* The first two named are of the nature of material particles projected from a radioactive substance with great velocities, while the gamma-rays have the nature of ordinary light and are similar to X-rays of very short wave length. The alpha-rays are particles having the mass of a helium atom and carry an excess positive electric charge of two units. As soon as they pick up two negative charges and become electrically neutral, they are helium atoms. They have small penetrating power, being stopped by thin metal foil or by less than four inches of air at normal pressure. The beta-rays behave in general like minute particles of exceedingly small mass, far less than the mass of even the lightest atom, the atom of hydrogen. They carry a unit charge of negative electricity and are identical with the cathode rays of a vacuum tube except that they move with far greater velocities. Their penetrating power is roughly one hundred times that of the alpha-rays. The gamma-rays are the most penetrating of all. Those from radium have been detected after passing through a foot of iron. The application of a strong electric or magnetic field causes a slight deviation of the alpha-rays in one direction and a much stronger deviation of the beta-rays in the opposite direction, while the gamma-rays are unaffected.

As indicated above, the property of radioactivity is investigated by one of three general methods which depend upon the action of the rays:

(1) On a photographic plate;

(2) In increasing the electrical conductivity of a gas;

(3) In producing temporary luminosity on thin screens of certain substances such as barium platino-cyanide, willemite, and zinc sulphide.

Although each of these methods has its uses and for certain measurements few or no substitutes, the second is by far the most important and generally useful. It is much the most sensitive, is applicable to the measurement of all three types of radiation, and lends itself more easily to quantitative determinations than the other methods. It is the method upon which the use of the electroscope is based.

A pure dry gas is a very poor conductor of electricity, in fact it belongs to the class of good insulators. However, when it is subjected to the action of the radiations from a radioactive substance there is produced in it small electrically charged particles called ions and in this state the gas is said to be ionized. Some of these ions are positively charged, others negatively, and all are too small to be seen even in the most powerful microscope. An insulated charged body surrounded by an ionized gas will lose its charge more or less rapidly and the rate at which its charge is lost serves as a measure of the amount of ionization and thus of the strength of the radiations from the active source. In the production of ionization in a gas the alpha-rays are by far the most important. This is due to their greater energy, which is nearly all used up in the production of ions in ordinary electroscopes. Even if all three types of radiation are present, nearly all the ionization produced is due to the alpha-rays.

Two of the common forms of the electroscope are shown in Fig. XV, page 163, and in Fig. XIX, page 184. In Fig. XV the charged insulated body consists of the electrode E and the leaf system A, L. This is surrounded by an outer metallic case I, which is connected electrically to the earth. Attached by one end to the support A is a thin narrow metallic leaf L, usually of aluminum or gold. When the insulated system is charged the free end of this leaf stands out from the support and remains steady in a fixed position so long as the charge is not escaping. The space between the electrode E and the outer case is filled with air which, when ionized, allows an electric current, usually of very small magnitude, to pass through the gas. This electric current is maintained at the expense of the electric charge on the central insulated body. As the charge decreases the leaf falls and the rate at which it moves is observed. Its rate of motion is proportional to the amount of radioactivity present and is usually observed through a microscope magnifying ten to twenty times and having a suitable scale in the eyepiece.

The property of radioactivity was discovered in 1896 by Professor Henri Becquerel while working with compounds of the element uranium. Some two years later G. C. Schmidt and Mme. Curie independently discovered this property in connection with thorium and thorium compounds and minerals. About the same time Mme. Curie discovered that certain uranium bearing minerals, pitchblende in particular, showed an activity of about four times that of the element uranium when equal weights were considered. This fact suggested that there might be in such minerals small amounts of one or more unknown substances much more highly radioactive than those known. Acting upon this hypothesis Professor and Mme. Curie proceeded to examine pitchblende chemically to see if it were possible to isolate these more active substances. Their operations proved the soundness of their reasoning, for they soon found two highly active substances. One of these separating out with bismuth was called *polonium* in honor of Mme. Curie's native country. The other which separated with barium and is closely allied to it chemically the discoverers called *radium.*

Since these initial discoveries the number of distinct radioactive substances has been increased to more than thirty through the labors of a host of investigators. Most of these substances exist in excessively minute quantities. Compared to many of the radio-elements, radium itself is relatively abundant, but even in the case of radium there is only about one part in three hundred and fifty million present in a carnotite ore containing 1 per cent of uranium. Aside from uranium and thorium only two others, radium and radium emanation, have yet been obtained in sufficient quantities to be examined in the same way as the ordinary elements. Except for their property of radioactivity they would still be unknown. However, thanks to the sensitiveness of the methods of measuring radioactivity, far exceeding the most delicate chemical tests, it has been possible to accumulate an astonishing amount of information concerning them. These radioactive elements, as they are called, all appear to be derived from uranium and thorium which have the heaviest and presumably the most complex atoms of any of the elementary substances.

Radioactivity is a property of the atom. It is not affected by either physical conditions or chemical combination. So far it has not been found possible to destroy or to change the activity of a radioactive substance nor has it yet been produced artificially in an inactive substance. Extremes of cold and heat and all other conditions yet devised by man have been without influence either on its nature or on its amount.

A theory which explains all the phenomena of radioactivity and which accounts satisfactorily for the facts of observation so far discovered was proposed by Rutherford and Soddy in 1903. According to this theory the atoms of the radio-elements are undergoing spontaneous disintegration and are continuously changing at definite rates into other elements chemically different from themselves. In other words we have here a veritable transmutation of matter, one element changing into another, that into a second and so on through a series of changes apparently ending in the element lead which is either inactive or so feebly active as to escape our present methods of detection.

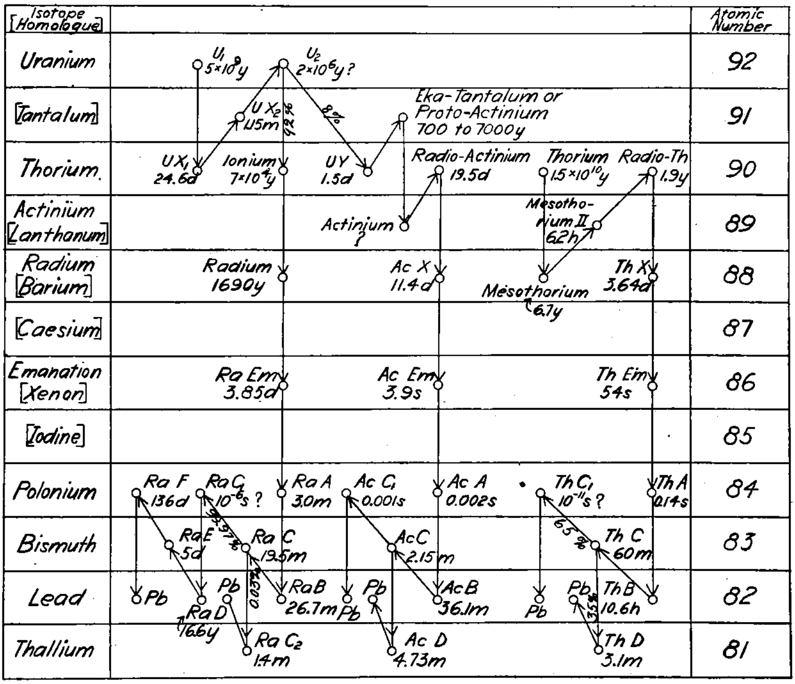

Fig. XIII

Figure XIII [arranged from Soddy (11), and from Darwin (12)], shows the order of succession in the transformation products of the radio-elements and much of the important information known concerning them. On the right-hand margin are given the atomic numbers corresponding to the various radio-elements. Elements having the same atomic number are called *isotopes.* Isotopes occupy the same place in the periodic table and are chemically identical and inseparable though they may differ in atomic weight. On the left-hand margin are given the chemical elements with which the radio-elements are either isotopic or closely allied. The allied elements are included in brackets [ ]. The number written beside the name of a radio-element denotes the interval necessary for one-half its mass to be transformed into the next element in the series. The arrows pointing downward indicate a transformation taking place by the expulsion of an alpha particle with a loss in atomic weight of four units, and a shift of two places downward in the periodic table. The arrows pointing upward indicate beta-ray charges or rayless charges with no appreciable change in atomic weight, but with a shift of one place upward in the periodic table. Actinium and mesothorium I are examples of atoms with rayless charges, i. e., they emit such weak beta-rays as to produce little or no ionization.

The order of UX_1, UX_2 and U_2 is not certain. Neither is it definitely known whether the actinium series originates as a branch of U_2 or from an isotope of U.

The amount of radiation emitted in a given time affords a measure of the rate at which disintegration takes place. The energy with which the alpha-rays, beta-rays and gamma-rays are endowed is derived from the internal energy of the atom itself, which thus appears as a complex structure, a storehouse of energy, matter, and of positive and negative electricity. Such a view of the constitution of the atom is indicated also by experimental evidence derived from sources entirely different from radioactivity.

The rate of disintegration is very rapid for some radio-elements and very slow for others, but in all cases it follows an exponential law, by which is meant that the average number of atoms disintegrating per second is proportional to the number of unchanged atoms present. If the time necessary for the transformation of one-half of a given amount of a radioactive substance is taken as a measure of its rate of change we find this period indicated by fractions of a second, seconds, minutes, hours, days, months, years, and hundreds, thousands, and even millions of years when applied to the various radio-elements. The half-value periods for the uranium-radium series are given in Fig. XIII above. In some cases where the rate of transformation is rapid and the parent substance exists in sufficient quantity, the transformation products can be obtained in large enough amount to be examined by ordinary physical and chemical methods. Direct experimental proof has been obtained of the continuous production of the rare gas helium by radioactive substances. Also radium emanation, a rare gas and the direct product of radium, has been isolated and its physical and chemical properties determined. This and much other evidence all tends to confirm the soundness of the Rutherford-Soddy theory.

In natural waters and gases the radio-element which occurs by far the most commonly is radium emanation. Thorium emanation is also found occasionally. These two radioactive gases are dissolved in water like ordinary gases. Agitation of the water allows them to escape and they can be removed completely by boiling. Like other gases also the volume of emanation absorbed by water depends upon its temperature. Other things being equal, cold water will absorb more than hot water. The radioactivity of waters and gases, due to the presence of radium or thorium emanation is not permanent, but decreases at the rates given above.

Sometimes compounds of radium and thorium occur in solution in mineral waters, especially in hot mineral waters. Dissolved salts of radium are found most frequently, but even they are comparatively rare and always of very small amount. The radioactivity of water when due to dissolved radioactive compounds may be considered as permanent.

Deposits formed around mineral springs usually show more or less radioactivity which, curiously enough, seems to bear no quantitative relation to the activity found in the waters which produce them. These deposits are often considerably more active than the rocks and soil of the surrounding region, although they rarely if ever show a degree of activity equal to that of a very low grade radioactive ore.

A discussion of the probable origin of the radioactivity occurring in connection with natural waters and gases will be found on page 189 of this report.

It is customary to express the radioactivity of waters and gases as so many units per liter, a liter being a little less than a quart. For measurements based upon radium emanation the accepted international unit is called the *curie* in honor of the discoverers of radium. The curie is defined as the amount of emanation in equilibrium with one gram of the element radium (453.6 grams=one pound approximately). The reasons for choosing the fundamental unit in this manner are as follows:

A given amount of radium freed from its emanation immediately begins to reproduce it at a definite rate. The emanation thus produced in turn disintegrates or is transformed according to the exponential law mentioned above. For a time the rate at which it is produced exceeds that at which it is transformed. However, after about a month the production and the disintegration balance each other and there is then a definite quantity of emanation associated with the given amount of radium. In this state the emanation is said to be *in equilibrium with the radium*. Since the gram is the unit of mass in general use in pure science it was natural to choose as the unit of emanation the amount in equilibrium with the unit of mass. At normal temperature and pressure this amounts to about 0.6 cubic millimeter.

Although the curie is a natural unit it has the disadvantage of being inconveniently large. Its use in the measurement of relatively small activities such as those of natural waters and gases is something like using a mile as the unit in measuring the thickness of a sheet of paper. Suppose a sheet of paper is one five-hundredth of an inch thick. As a decimal fraction this would be 0.002 inch=0.000167 feet=0.0000000315 mile. Hence, in expressing the measurement of a small quantity in terms of a large unit the result is a small decimal fraction, a few significant figures preceded by a string of zeros. Instead, however, of writing these decimal fractions as above it is more convenient to write them in terms of negative powers of 10. Thus, 0.002 inch=$2\text{x}10^{-3}$ inch and 0.0000000315 mile=$3.15\text{x}10^{-8}$ mile. The activities listed in the tables in the main body of this report are expressed in the latter form.

Smaller units, subdivisions of the curie, are in common use also. These are the millicurie and the microcurie, signifying respectively the amount of emanation in equilibrium with a thousandth and with a millionth part of a gram of radium. Similarly the micromillicurie denotes the millionth of a millicurie, or 10^{-9} curie.

In addition to the foregoing there is another unit known as the *Mache* unit in general use, particularly among persons interested in the physiological effects of radioactivity. This unit is somewhat difficult of definition and comparison and furthermore is needless. It is defined and further discussed on pages 172-176.

In the measurement of the activity of solids by the emanation method the results are usually expressed in terms of curies per gram or of radium per gram of material. From the known ratio between uranium and radium in equilibrium the results may be expressed also in terms of uranium per gram.

Since uranium has a definite and constant alpha-ray activity, especially when used in the form of thin films, it is sometimes employed as a standard of radioactivity in the examination of solids. Thin films of the oxide U_3O_8 prepared in a special way have been found very satisfactory for this purpose.

ACKNOWLEDGMENTS

In addition to acknowledgments which have been made in their proper places, it is a pleasure to mention the uniform courtesy and helpfulness of the Director of the Colorado Geological Survey and of his assistants in meeting many unexpected difficulties. The Survey has also kindly furnished the author much important information regarding geological formations.

During the work in the field courtesies were extended by Dr. R. B. Moore and by Dr. S. C. Lind of the United States Bureau of Mines, and by Prof. L. F. Miller of the Colorado School of Mines in the matter of the recalibration of the ionization chambers.

To the many citizens of the State who have taken the trouble to collect samples of water in their several localities, and to the still greater number whose interest, courtesy and general helpfulness have contributed much to the pleasure and success of this work, thanks are hereby gratefully tendered.

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THE RADIOACTIVE PROPERTIES OF THE MINERAL SPRINGS OF COLORADO

THE SCOPE AND THE GENERAL PLAN OF THE WORK

In the summer of 1914 the author undertook an investigation of the radioactivity of the numerous mineral springs found chiefly in the mountainous region of Colorado.[1]

This work was done for the Colorado Geological Survey which had begun some time previously a study of these springs in relation to the geology of their surroundings and the chemical constituents of their waters. This previous study had provided a list of some two hundred springs, giving locations, chemical analyses, and considerable information of a general nature. Most of these springs are highly mineralized, many of them are very hot, and many give off large quantities of gas. The present study was confined chiefly to the springs in this list, although not all of them are included. On the other hand some springs not on the list have

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[1] The general distribution of the springs examined may be understood by a glance at the map in pocket.

been included when they appeared to promise results of interest. It was impossible for several reasons to examine all the known springs and there are doubtless many more unknown to us that might well be worthy of investigation. A few springs are located in regions where travel was practically impossible except on foot or on horseback. Others, owing to an unusually rainy summer for Colorado, were rendered temporarily inaccessible by damage to roads and bridges. Also a few springs were either under a considerable depth of water at the time they were visited or were covered by the debris of washouts.

The first plan considered was to travel the longer distances by rail and to carry as small an equipment as possible, using some form of the Engler-Sieveking fontaktometer or fontaktoscope (1)[1] for the field tests. It was soon found, however, that this method of travel would not only be expensive, but far too inconvenient, as the trains on many roads were few, and the springs in most cases were located at distances varying from a few miles to fifty miles or more from the nearest railroad. It was decided finally to do all traveling by automobile. In no other way would it have been possible in one summer to examine the large number of springs scattered over the entire mountainous region of Colorado. The increased convenience and saving of time were vital to the success of the undertaking and the cost of transportation was at the same time reduced to a minimum.

A large box divided into convenient trays and compartments was built into the back part of the automobile. This held all the necessary apparatus and supplies for a well equipped field laboratory and made it possible to substitute for the fontaktometer the more accurate boiling-out method described by Boltwood. Mr. J. H. V. Finney, an instructor in the department of physics of the University of Colorado and a skilled automobile driver and mechanic, acted as general assistant not only in the field work but also in the tests and in the reduction of observations made later in the laboratory. He also constructed all the apparatus used in this investigation and without his untiring and efficient services the work would not have gone so smoothly nor could so much have been accomplished.

The general plan of the work was to visit each spring and to make tests on the spot for the immediate activity in both water and gas. By immediate activity is meant the radioactivity of freshly collected samples. Whenever it was possible the gases

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[1] Such numbers indicate references to be found at the end of this report.

were also tested for thorium emanation. Samples of water and mud or sinter (if any) were collected chiefly from springs showing fair to high activity and shipped to the laboratory at the University to be tested later for dissolved or deposited radioactive substances. The field tests occupied the whole of the summer of 1914. A few short trips were made in the fall of 1914 and in the summer of 1915. Tests for activity due to salts dissolved in the waters or deposited in mud and sinter continued at various times during the winter of 1914, most of the summer of 1915 and for some time in 1916. During this time tests were made also on the immediate activity of waters shipped in from a number of springs not examined during the work in the field for reasons given above.

APPARATUS FOR TESTING WATERS AND GASES—STANDARDIZATION AND CONSTANTS

Boiling out apparatus.—For the work in the field the apparatus shown in Fig. XIV was constructed. The water to be tested was carefully introduced into a vessel I having a stopcock O and communicating through the cock H and a ⅜-inch brass tube with the collecting chamber BB made of brass tubing 2 inches in diameter and 10 inches long. The neck J was made airtight by the rubber gasket b. G is a glass tube serving as a water gauge. The vessel I was made in three sizes with capacities 0.5 liter, 1 liter and 2 liters respectively. The 2 liter size was used in most cases, although there were some springs for which the 1 liter vessel was convenient and a few for which the half liter was used. The whole apparatus except the drying tube D was supported on a very tall and heavy ring stand with suitable clamps. Two gasoline torches served as sources of heat.

The method of operating was as follows: The vessel I, containing some caustic soda when necessary, was filled by immersing it gently in the water at the source of the spring when possible. In all cases care was taken to avoid agitating the water more than was necessary. With O and H closed, BB was next screwed on at J. Then boiling hot water was poured into the vessel C and the latter raised until BB was filled, through the cock F, practically to the top. The cock A was then closed and C hung from a support in the ring stand so that the water level in C was slightly below that in BB. Next H was opened and the torches applied to I. The water would boil ten minutes or more before enough live steam began to collect in BB to force the water toward the

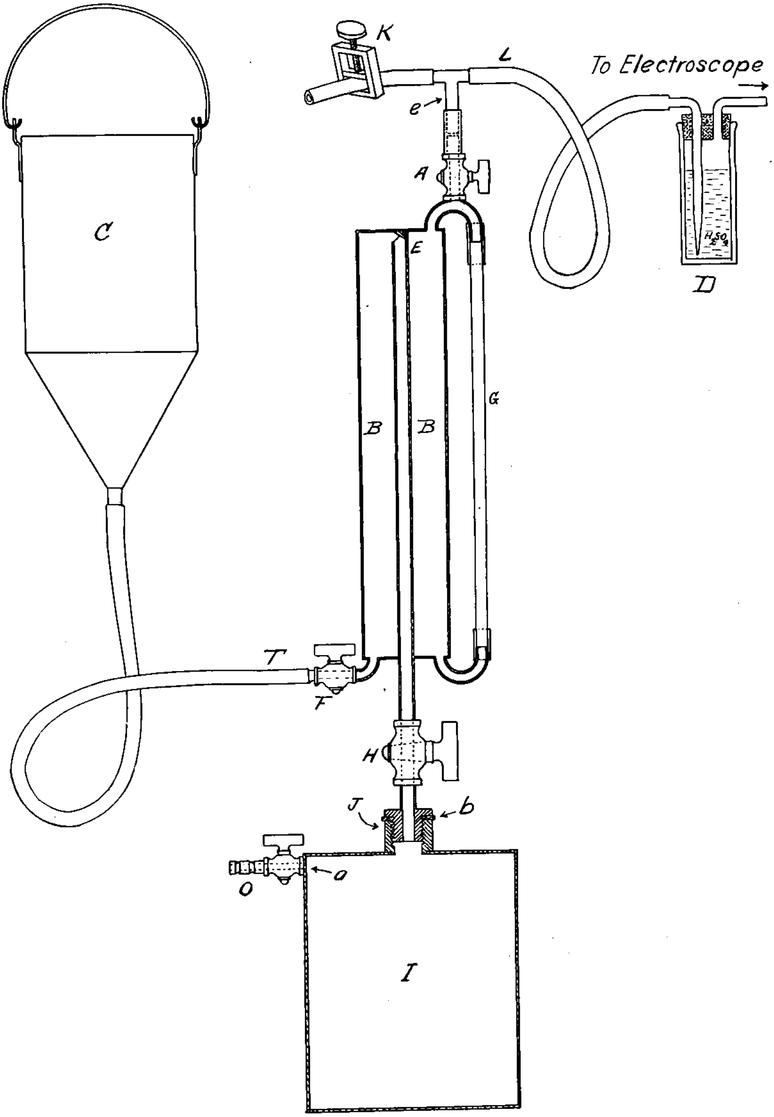

Fig. XIV.

bottom of the gauge. Boiling was kept up some minutes after live steam began to pass into BB. The steam passing up through the central tube served to keep the water in BB hot. At the beginning of the boiling the steam would condense quite rapidly at the top until the temperature of the whole apparatus had risen nearly to the boiling point, when a touch of the flame on I would cause the water in the gauge to descend quickly. With care, however, boiling could be continued as long as desirable.

After the boiling was completed F was closed and the tube T was disconnected and placed on O which was then opened, allowing the hot water in C to enter I and drive all remaining gas up through the central tube into BB. The ionization chamber of the electroscope, having been partially evacuated, was next attached to the drying tube D, K was closed, A opened, and the gas allowed to pass slowly into the electroscope. When the water had risen to e, A was again closed and K opened so as to allow air to flow through the connecting tubes into the electroscope until atmospheric pressure was again established.

Emanation electroscopes.—To avoid loss of time in waiting for an electroscope contaminated by active deposit to become usable again, several instruments or their equivalent were necessary. On the other hand our carrying capacity though large was not unlimited nor did we wish to have the care of packing and repacking and of keeping in order a number of pieces of apparatus as delicate as the leaf system of an electroscope. The problem was solved by constructing a number of ionization chambers to which could be attached in turn the same electroscope head and leaf. In general the apparatus is similar to that described by Lind. (3). Its essential features are shown in Fig. XV. I is an airtight, cylindrical, brass ionization chamber having brass stopcocks V near the top and bottom. Altogether four such chambers were used, all of them taking the same electroscope head but each having its own electrode E. The inside dimensions of the ionization chambers and the outside dimensions of their electrodes are given in the following table. The electrodes were made of light brass tubing capped at each end.

TABLE I.

Ionization vessel	Length cm.	Diameter cm.	Electrode	
			Length cm.	Diameter cm.
No. 2	24.8	11.1	19.0	1.6
No. 3	25.1	15.6	19.6	1.6
Nos. 6 and 7	21.2	13.6	13.1	1.6

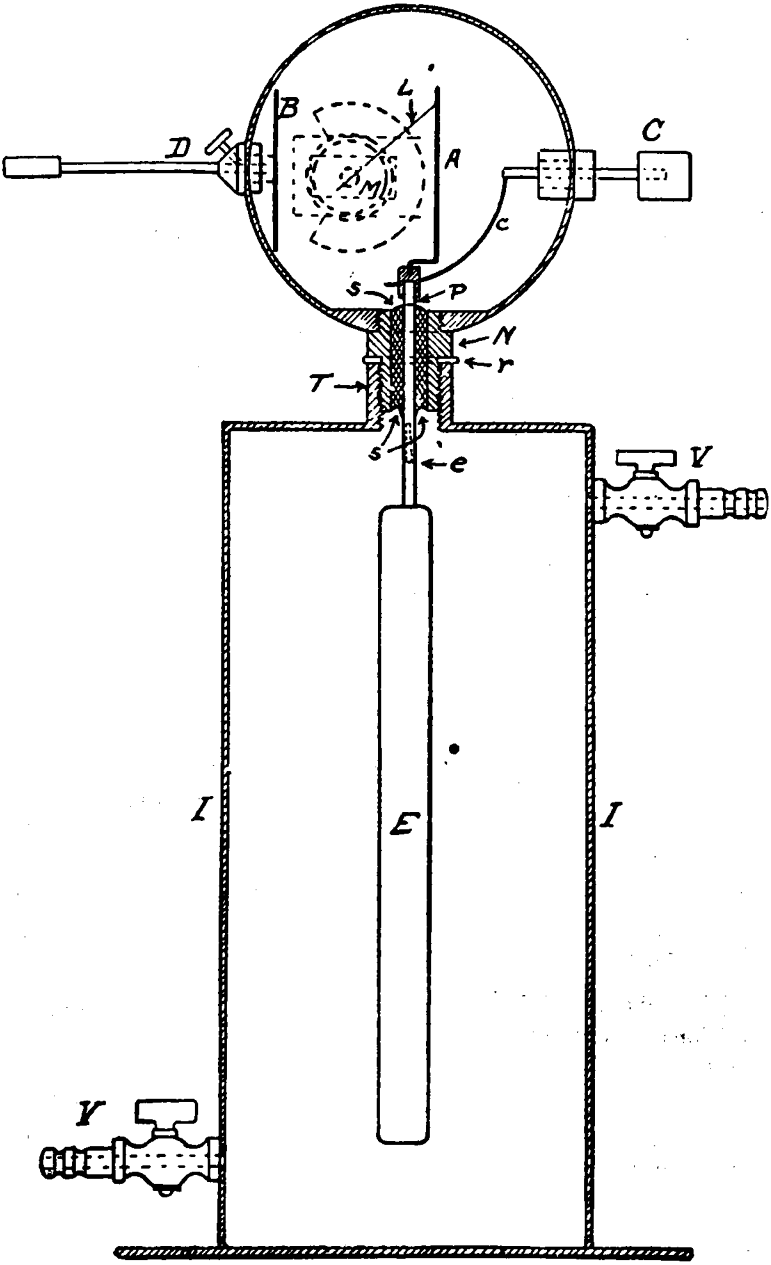

Fig. XV.

Most of the work was done with vessels No. 2 and No. 3, the latter being the most sensitive of the four. Nos. 6 and 7 were constructed after the experience of the first summer and are, on the whole, the most satisfactory. They were designed to have approximately a volume of 3 liters and a distance of 6 cm. between the electrode and the outer wall.

The head screws on at T and is made airtight by the rubber gasket r. S is an insulation made of Banker's Specie sealing wax. Through this passes a brass rod P threaded at e for the attachment of the electrode and carrying on its upper end the leaf support A which is firmly attached to the rod by means of a four-jawed friction clamp. The heavy front and back plates of the head which carry small windows are not shown in the figure. They are easily removed by taking out a few screws when it is necessary to get at the leaf system. A Pye telemicroscope serves to read the deflections of the leaf. The microscope is rigidly attached to the head in such a way that it cannot change its focusing position on the leaf. C is a charging device which is grounded on the case when not in use and DB is merely an arrangement for protecting the leaf when traveling.

The parts of the head inclosing the leaf were carefully machined so as to form a chamber tight enough for the electroscope to be used in the open with little or no disturbance to the leaf even when a considerable breeze was blowing. To cut down the natural leak due to ionization produced by sunlight a strong corrugated pasteboard box with suitable openings was fitted over and around the electroscope when in use in the open. This box also served as a protection in bad weather. In the field the leaf system was charged negatively by means of a metal tipped celluloid "charging rod."[1] The outer case was grounded by means of a wire attached to a long iron pin driven into wet earth.

The behavior of the electroscope often under very trying field conditions was practically perfect. Even in rainy weather the only trouble experienced was in keeping the charging rod dry. After standing charged for about half an hour the natural leak was usually between 0.05 and 0.15 division per minute, although there were a few occasions when it amounted to nearly 0.40 division per minute.

When emanation mixed with air is first introduced into the electroscope it has a certain activity due wholly to the emanation

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[1] See catalogue of almost any scientific instrument company.

itself. At once, however, the activity begins to increase due to the formation of the short-lived disintegration products Ra. A, Ra. B, and Ra. C. This increase in activity is very rapid for the first ten minutes, after which it increases more slowly until the end of three or three and one-half hours, when the activity reaches a maximum and begins to decrease slowly. At maximum activity the emanation is in equilibrium with its products Ra.A, Ra.B and Ra.C. If the activity, represented by scale divisions per minute, passed over by the leaf, is platted as ordinates and the elapsed time as abscissae, a curve showing the relation between activity and time and characteristic of radium emanation is obtained. Such a curve obtained in the calibration of the ionization chamber No. 6, is shown in Fig. XVI.

Standardization and constants.—Each electroscope consisting of the common head and an ionization chamber with its appropriate electrode was carefully standardized a number of times by means of known quantities of radium emanation obtained from pitchblende (2). For this purpose some finely ground pitchblende containing $2.10x10^{-10}$ curie of radium emanation per milligram was kindly furnished by Dr. Richard B. Moore of the United States Bureau of Mines, Denver. The emanation from several milligrams of pitchblende was introduced into the electroscope and the activity observed every few minutes until it reached its maximum. In each case curves similar to that of Fig. XVI were platted. Thus if 12.45 mgs. of pitchblende containing $26.145x10^{-10}$ curie of radium emanation gives a maximum activity of 12.14 divisions per minute, $26.145x10^{-10} \div 12.14 = 2.15x10^{-10}$ curie, which is called the *constant of the electroscope* and denotes the amount of emanation which will produce a movement of the leaf of one division per minute at maximum activity. Readings must always be taken between the same points in the scale or symmetrically about the middle point of the portion used in calibration. Thus, if the electroscope is standardized for the portion of the scale lying between the divisions 70 and 30, the same constant will hold for readings taken between 60 and 40, but not, for example, if they are taken between 70 and 40 or between 60 and 30. The shorter distance is sometimes convenient when dealing with weak activity.

The constants of each ionization chamber as determined at Boulder at a pressure of 62 cm. and at a temperature of about 22° C. are $2.34x10^{-10}$ curie for No. 2, $1.89x10^{-10}$ curie for No. 3, and $2.07x10^{-10}$ curie for Nos. 6 and 7. Their values are the means of six or more concordant determinations for each chamber.

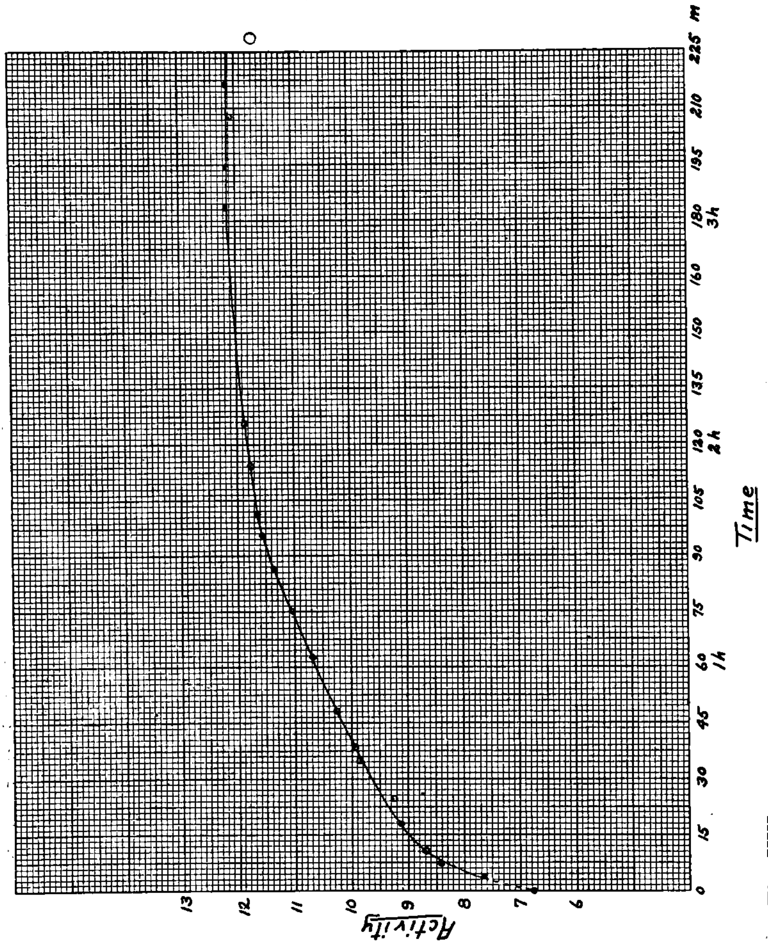
Time
0
15
30
45
60
1h
75
90
105
120
2h
135
150
160
180
3h
195
210
225 m
Activity
13
12
11
10
9
8
7
6

Fig. XVI.

Strictly speaking, these constants hold only for a given pressure and temperature in the case of chambers whose volume or air density is not large. As the springs examined are at elevations varying approximately from 5,000 feet to 10,000 feet, which causes changes in barometric pressure from about 64 cm. to 53 cm., the constants given above were of little value in the field work. This made necessary an investigation of the way in which the ''constants'' varied with the pressure. Previous investigations on the variation of ionization with pressure such as these of Rutherford (4) and Owens (5) do not fit the conditions of the present work, as they used radiations from layers of solid substances in vessels of wholly different shape. The investigations of W. Wilson (6), C. T. R. Wilson (7), McLennan and Burton (8), and Patterson (9), deal with the general question, but again under different conditions. Furthermore, they are not all in agreement.

In order, therefore, to find how the activity at its maximum varied with the pressure when emanation was mixed with air in cylindrical vessels and incidentally also to see how nearly the maxima were proportional to the amount of emanation present, a series of tests were run on each vessel. The procedure followed was similar to that described by Mme. Curie (10). However, what was sought was a relation which would give the ''constant'' corresponding to any barometric pressure and thus permit the reduction of the results of observation immediately to curies, rather than a correction term to be applied to the observed ionization current, as in Mme. Curie's method.

The air pressure in the vessel was reduced to a few centimeters and a known amount of emanation introduced. During this process the pressure increased to 10 cm. or 20cm. After the electroscope had stood charged for a little more than three hours the activity was measured at various pressures, determined by a mercury manometer. The relations between pressure and activity in vessel No. 2 may serve as a typical example. These relations for varying amounts of emanation are shown in Table II and by curves in Fig. XVII. The figures in the body of the table are maximum activities in divisions per minute taken from the curves.

TABLE II.

Mgs: P. B.	400	500	600	700	800	Pressure in mm.
5.06	3.14	3.82	4.40	4.86	5.21	
10.55 ?	6.42	7.73	8.78	9.42	9.71	
15.35	9.61	11.49	13.01	14.02	14.58	
20.57	13.10	16.00	17.90	19.18	19.95	
25.20	15.84	19.31	22.19	23.93	24.93	

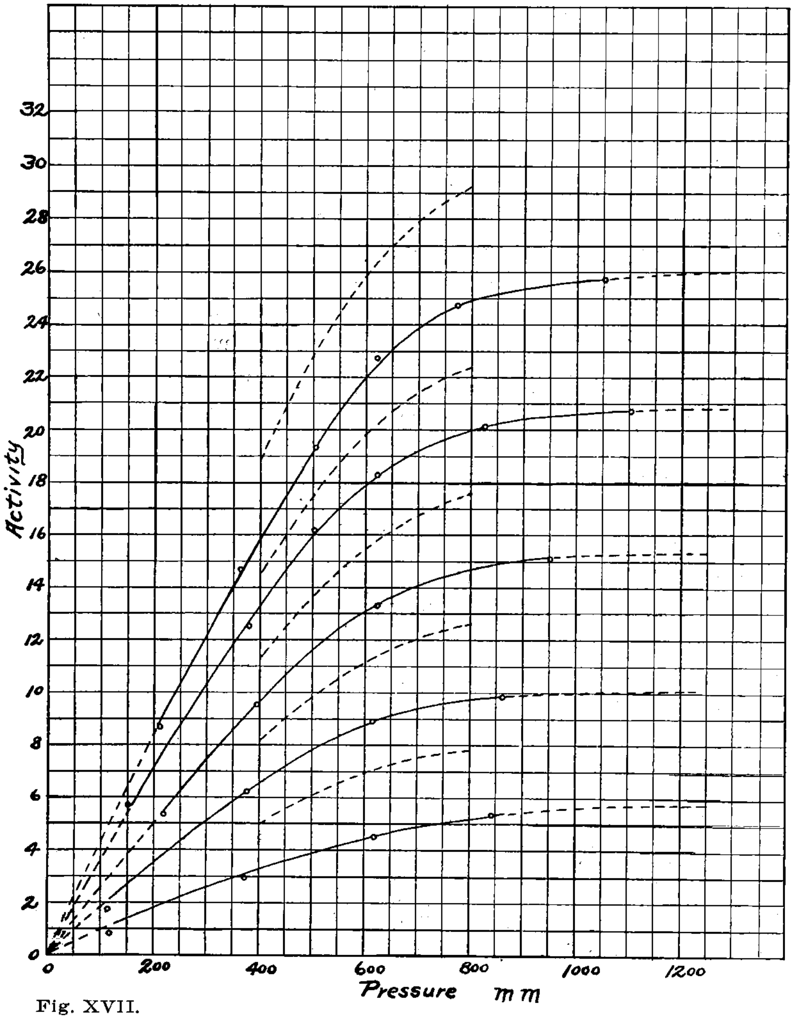
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
Activity
0
200
400
600
800
1000
1200
Pressure mm

Fig. XVII.

Table III shows that the ratio of the activity to the amount of emanation is approximately constant at a given pressure at least for a range of activity which is about that encountered in the present work. There is good reason to suspect the weight given for the second sample.

TABLE III.

	400	500	600	700	800	Pressure in mm.
	.620	.755	.869	.960	1.03	
	.608	.732	.832	.892	.920	
	.626	.748	.848	.913	.950	
	.637	.776	.871	.934	.971	
	.628	.766	.880	.950	.990	
Mean	.624	.756	.860	.93	.972	

The maximum activity multiplied by the "constant" of the electroscope and divided by the volume of the water or gas taken gives the number of curies of emanation present per unit volume. This is a fixed quantity. However, since the maximum activity varies with the pressure the "constant" does also, but we should always have activity x constant=curies or

1. $$mk=C$$

which is the familiar Boyle's Law or equilateral hyperbola equation.

The constants of each vessel are known for a temperature of 22° C. and a pressure of 62.5 cm. From the curves of Fig. XVII we find the corresponding mean maximum activities per milligram of pitchblende to be 0.881 divisions per minute for vessel No. 2 and 1.077 divisions per minute for vessel No. 3. Hence the constant k for any pressure p is found from

2. $$k\,Mp=2.053\times10^{-10} \text{ for vessel No. 2}$$
$$k\,Mp=2.036\times10^{-10} \text{ for vessel No. 3}$$

where Mp denotes the maximum activity per milligram at the given pressure.

The constant-pressure curve for vessel No. 2, shown in Fig. XVIII, is obtained from the above equation. The values of Mp are the mean values from Table III. It is evident that even the daily variation in barometric pressure is often sufficient to make a decided difference in the value of the "constant."

Strictly speaking, the curve of Fig. XVIII gives the constant at various pressures for a temperature of 22° C. Changes in temperature will affect the constant also in so far as they affect the density of the air in the ionization chamber. However, the work

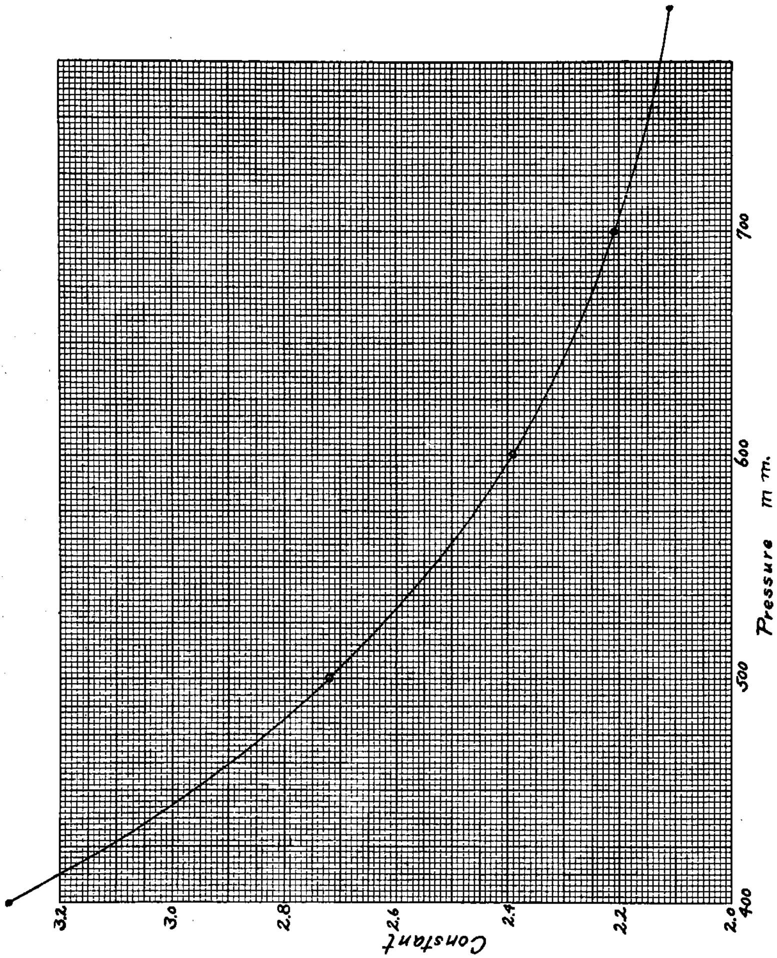

Fig. XVIII.

done in the laboratory was all at or near a temperature of 22° C., while that in the field was nearly all at temperatures ranging from 19° to 25° C. There were a few cases where the temperatures differed from 22° C. by as much as 6°, which would make a difference in the constant of about 2 per cent. Hence corrections in the constants due to variations in the temperature of the air have generally been neglected.

In the actual work of testing waters and gases the maximum activity was seldom determined by direct observation. From the curves of a number of calibration tests run for the full 3.5 hours the activities were taken at 10-minute intervals from 10 minutes to 90 minutes. These values expressed as percentages of the maximum formed always a closely agreeing scale, for a given vessel, over a wide range of activity. In the following table is given the mean of seven such determinations for vessel No. 2.

TABLE IV

Activity at	Per cent of max.	Activity at	Per cent of max.
10 min.	72.3	60 min.	87.4
20 min.	77.1	70 min.	89.6
30 min.	80.1	80 min.	91.3
40 min.	82.9	90 min.	93.0
50 min.	85.3		

The largest variation of a single percentage from the mean was 1.6 per cent and most of them agreed more closely than 1 per cent. Actual trial showed that after 40 minutes or 50 minutes the maximum could be calculated with practically the same exactness that it could be observed. Such a scale, therefore, is among the most useful constants of the electroscope.

While not strictly necessary to the demands of the present investigation, certain other constants of each complete electroscope were determined for the purpose of checking the results by different methods of calculation. These constants included the electrical capacities, the fall in volts per division on the eyepiece scale, the percentage of the maximum activity due to the active deposit, and the amount of ionization absorbed by the walls of the chambers.

The capacities were measured by the divided charge method. A condenser made of two coaxial cylinders, having cylindrical guard rings and a calculated capacity of 25 cm. was used as a standard. The means of a number of concordant determinations gave capacities as follows: 8.4 cm. for vessel No. 2; 7.8 cm. for vessel No. 3, and 8.0 cm. for vessels No. 6 and No. 7.[1]

The calibration of the eyepiece scale in volts gave, quite accurately, straight lines for each ionization vessel. The number of volts per division varied from 1.22 to 1.35. The average potential used on the leaf system over the working part of the scale was about 340 volts. The same leaf, 4 cm. long, was used in all the work except that done during the first ten days.

Owing to the wide use of the Maché unit among persons interested in the medicinal properties of mineral waters, the results given in Table VI have been expressed in terms of this unit as well as in curies. The reduction to Maché units has been made by means of the relation—

3. $1 \text{ curie} = 2.7 \times 10^9$ Maché units

and the results confirmed from the ionization current as follows:

First, the percentage of activity due to the active deposit at maximum activity was determined for each vessel in several ways: by projecting backward the curves similar to that of Fig. XV until they cut the axis of zero time; by projecting backward the curves representing the decay of the active deposit when maximum activity had been reached; by determining graphically and by calculation (11) the maximum activity due to Ra.C alone and from this estimating the total activity due to the deposit; by calculation with the aid of tables (12) and with the formula of Curie and Danne (13). The various methods gave fairly concordant results for each vessel. Four different methods gave for vessel No. 2 the percentages 42.5, 41.9, 42.7 and 43.2. While each of these numbers is the mean of several determinations so close an agreement was scarcely to be expected and is no doubt accidental. The values adopted were 42 per cent for vessel No. 2, 46 per cent for vessel No. 3, and 44.3 per cent for vessels Nos. 6 and 7.

The Maché unit is defined as 1,000 times the saturation ionization current due to one curie of emanation without disintegration products when all the radiation is absorbed in the air of the ionization chamber (14). Now it is evident from the dimensions of the vessels used the density of the air in the chambers, and the differences of potential between the electrodes and walls that there was neither opportunity for the production of all the ions possible nor a sufficiently strong electric field to remove all these that were

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[1] During a visit in the summer of 1915, Prof. J. C. Hubbard very kindly offered to check some of these measurements. Although lacking ideal conditions he obtained results in practical agreement with those given by using a bare wire standard.

produced. This makes no difference for the determinations in curies if the vessels have been properly calibrated (15). However, it is possible from the work of Duane (12a) and of Duane and Laborde (12b) to calculate, for such vessels as were used, the relation between the maximum ionization current actually observed and the number of curies which would produce it if the radiations had been completely absorbed and saturation had obtained (16, See also 14a and 14c, Chap. VIII). In this way it was found that the loss, due to lack of range and saturation, in the ionization current upon which the Maché unit is based, amounted to 48 per cent in vessel No. 2, to 46.7 per cent in vessel No. 3, and to 44 per cent in vessels No. 6 and No. 7. Hence in all the chambers used except No. 2 it happens that the loss in activity due to the above mentioned causes is almost exactly counterbalanced by that added by the active deposit.

The ionization current i in electrostatic units (E.S.U.) is given by the relation

$$4. \qquad i = \frac{q.m.c.}{300t} \text{ E.S.U.}$$

where q is the drop in potential in volts per scale division; m is the number of scale divisions passed over by the leaf in the time t expressed in seconds; and c is the electrical capacity of the instrument. In the case of vessel No. 2, $q=1.22$, $c=8.4$ cm. and if m is the number of divisions per minute passed over by the leaf of maximum activity due to emanation from v liters of water or gas, equation 4 becomes

$$5. \qquad I = \frac{(1.22)\ (8.4)}{(300)\ (60)} \cdot \frac{m}{v} = 0.5693 \times 10^{-3} \frac{M}{v} \text{ E.S.U. per liter}$$

When corrected by Duane's factor for the absorption due to the walls of the vessel and for the activity due to the decay products, according to the percentages given above 5 becomes

$$6. \qquad I = 0.635 \times 10^{-3} \frac{m}{v} \text{ E.S.U. per liter}$$

where I denotes the total ionization current which could be produced by the emanation alone if all its radiation was absorbed in air.

Equation 6 holds for a barometric pressure of 62.5 cm. only and the observed values of m must still be corrected by a factor b which varies with the pressure in exactly the same way as the "constant" expressed in curies. The value of b for various pressures may be taken from a curve easily derived from the activity pressure curves (Fig. XVII) or better from the constant-pressure curve (Fig. XVIII). The latter curve and the b curve have exactly the same form since the value of b is directly proportional to the value of the "constant" at a given pressure. For vessel No. 2 the values of b at pressures of 40, 50, 60, 70 and 80 cm. are respectively 1.41, 1.166, 1.025, 0.949 and 0.905. On putting in the pressure factor equation 6 becomes

7. $$I = 0.635 \times 10^{-3}\, b \frac{m}{v} \text{ E.S.U. per liter}$$

This again must be multiplied by 1,000 in calculating Maché units. Hence from the ionization current

8. $$\text{Maché units} = 0.635\, b \frac{m}{v}$$

But from the generally accepted relation between the Maché unit and the curie and from the calibration of the vessel directly in curies we have

9. $$\text{Maché units} = (2.7 \times 10^9) \times (\text{curies}) = 2.7 \times 10^9\, k \frac{m}{v}$$

where k is the constant of the electroscope defined by equation 2.

In Table V are given a few results of the calculations in Maché units by both methods for vessel No. 2. The data given are based upon observations taken in the field.

TABLE V.

Bar Press in cm.	$\frac{m}{v}$	$K \times 10^{-10}$	b	Mache Units From Equation 8	Mache Units From Equation 9
64	7.965	2.307	0.989	5.0	4.97
60	40.60	2.39	1.025	26.40	26.20
60	5.58	2.39	1.025	3.63	3.60
57.3	5.245	2.462	1.0575	3.64	3.60
54.35	51.60	2.557	1.099	36.0	35.61
53.6	267.70	2.583	1.110	188.7	186.7

It may be noted that the values computed from equation 8 run slightly higher than those from equation 9. If we equate the two expressions for Maché units, writing X for 2.7×10^9, we get

10. $$X = \frac{0.635\, b}{k}$$

If now we take the values of b and k corresponding to the pressures given in the above table and compute the several values of X we find that they agree closely and give as a mean value

11. $$X = 2.726 \times 10^9$$

which is the relation between the Maché unit and the curie necessary for exact agreement between the results by the two methods, if we assume that the saturation ionization current is accurately determined by the constants found and the corrections applied. This value is about half way between the theoretical value 2.75×10^9 sometimes used, and the experimental value 2.7×10^9 (approx.) usually taken and which has been used in this work. To be exact, 2.75×10^9 gives the theoretical relation between the Maché unit and the curie on the Rutherford-Boltwood standard. According to Rutherford (7) it is 2.89×10^9 on the International Standard and Maché and St. Meyer (14a) give it as 2.67×10^9 on the Viénna Standard.

When divided by 1,000, this number also represents the total ionization current which could be produced by 1 curie of emanation without disintegration products.

Among investigations on the radioactivity of mineral springs, and in particular among those on European mineral springs, there can be found often the results of several observers on the same water or gas. It is rarely that these results agree closely and those of one observer may range anywhere from many times to a fraction of those given by another. With precautions, field work can be made practically as accurate as that done in the laboratory. Hence discrepancies in the work of equally careful observers have often been attributed to variations in the activity of the source. On the other hand there are springs which have shown no appreciable variation in activity when examined systematically at different times of the year by the same observer using the same apparatus. Undoubtedly some springs do vary in activity, but the question of their variability and even the amount of their activity can scarcely be determined from the work of different observers so long as there is no uniformity in standards, in methods, and in the nature and the number of the corrections to be applied to the observations. This is particularly true of results expressed in Mache units based upon ionization currents. In many cases Mache units are apparently calculated from the observed ionization current and not from the saturation ionization current when all radiation is absorbed in the air of the chamber. In the first case the Mache unit is dependent upon the dimensions of the particular apparatus used and upon the potential applied to the insulated system which is clearly not intended by its definition.

For the reasons just mentioned the work of European observers in general presents an almost hopeless confusion when accurate comparisons are attempted. It is true that much work had been done before suitable units and methods were devised and we find therefore many results expressd in terms of the fall of the leaf in volts per unit time or in units ever more arbitrary. These admit of no comparison with other work. Other units used are the milligram-second, milligram-minute, gram second, etc., meaning the amount of emanation produced by a certain amount of a radioactive substance in the specified time. The substance is usually the element radium or a radium salt and when this is specified, as well as its degree of purity, measurements based upon such units can be reduced to curies.

Most European observers, outside of France and England, express their results in terms of the Mache unit. Generally the corrections which have been made are clearly stated, but not always. Furthermore, the correction for absorption by the walls of the chamber (Duane's factor) has usually been omitted in work where most of the other corrections have been applied. This has been pointed out by Berndt (16) in an elaborate series of calculations undertaken with the aim of making possible the comparison of the results of different observers. He shows that, depending upon the size of the ionization chamber, the correction for absorption alone may amount to from 10% to 155%.

A given instrument can be calibrated simply and accurately in terms of a known quantity of radium emanation. If the Maché unit is to be retained it would seem easier and more accurate to reduce results measured in curies to this unit by means of the theoretical relation between them than to calculate Maché units from the ionization current which involves the determination of several more constants and the application of troublesome corrections. As has been shown above the two methods, when all corrections are applied, give identical results within the limits of experimental error.

RADIOACTIVITY OF THE WATERS AND GASES

The results on the activity of both waters and gases are given in Table VI.[1] The individual springs are designated by numbers.[2] Those marked with an asterisk (*) were tested by means of samples shipped to the laboratory and while allowance has been

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[1] All the measurements in this table are on springs located in Colorado. Tests were also run on samples sent from Bajada Hot Springs, New Mexico, from Saratoga Springs, Wyoming, and from a spring in the canon of the Colorado River near Hite, Utah. The sample from the latter spring had the color of a strong solution of Copper Sulphate and showed the remarkably high permanent activity of 12.12×10^{-10} gram Ra. per liter.

[2] For a general description of the springs coresponding to the numbers see page 202.

made for the decay of the emanation from the time of collection, our experience shows that such results are always too low. The gases were collected in the usual way over water in glass vessels graduated in cubic centimeters. The apparent volumes of the gas samples were corrected for the pressure due to water vapor and reduced to standard conditions of temperature and barometric pressure.

Columns 4, 5, 6 and 7 give the activity per liter of freshly collected samples. The headings of columns 4, 5 and 8 indicate that the numbers found in them are to be multiplied by 10^{-10}. Column 8 gives the results of a number of tests on the permanent activity of spring waters. These were made at the laboratory after the samples had been acidified to prevent the formation of deposits and sealed for over a month. Several of the samples were lost during shipment and some were accidentally destroyed where they were stored, but it is scarcely to be expected that a greater number of tests would change the general character of the results.

Thorium.—Tests for thorium emanation were made in a great many places where there was a sufficient flow of gas. No indication of thorium was found anywhere except in spring No. 186, in Gunnison County, near Powderhorn post office. A roughly quantitative determination deduced from the activity curve of the combined radium and thorium emanation and from the activity curve of the radium emanation alone gave practically the same amount of activity for each.

This scarcity of thorium emanation was somewhat unexpected as monazite is found in the sand of most of the creek and river beds so far examined along the whole eastern slope of the Continental Divide. Similar data for the western slope is lacking, but the probabilities are that monazite exists there also. So far as is known no thorium bearing ores are found in place anywhere in the region over which the springs extend.

Previous investigations of the radioactivity of a few of the springs listed in Table VI have been made by E. R. Wolcott (18), W. P. Headden (19), J. C. Shedd (20), and Hermann Schlundt (21). Professor Wolcott made some tests on the Yampah Spring at Glenwood Springs but his method gave only qualitative results. The work of Professor Headden on the Doughty Springs near Hotchkiss was done by the photographic method and the results given are also qualitative. A few springs at Manitou were investigated by Professor Shedd and his results show a fair agreement with recent observations considering the lack of precision in his apparatus and the fact that he did not use an emanation standard.

The most extensive investigation up to the present is that of Professor Schlundt, who tested a number of springs near Boulder, at Manitou, at Steamboat Springs and at least one spring at Glenwood Springs. He used a fontactometer having a volume of about 15 liters. His results, which can be identified with springs listed in this work, are also given in Table VI and are indicated by the letter S. The two sets of measurements sometimes agree, but often one of them differs by amounts ranging from about one-fourth to five times the other. These differences are due partly to the methods used, to the corrections applied and partly perhaps to variations in the activity of the sources. An examination of the two sets of temperature readings shows that the temperatures of twelve springs are the same to within less than a degree, while seven others show changes in temperature ranging from 3° to 8° C. This would seem to indicate that changes have occurred in the condition of some of the springs. At Steamboat Springs in particular the testimony of local observers indicates that some of the springs have become connected recently by underground channels. The differences in the measurement of activity, however, appear to have no relation to these indicated changes.

TABLE VI.

No.	Temp. of Spring		Curies Ra Emanation per liter x10^{-10}		Mache Units per liter		Permanent Activity of Water	Remarks
	°C	°F	Water	Gas	Water	Gas	Grams Ra. per liter x10^{-10}	
1	11	51.8	2.15		0.58			
3	15.5	60.0	1.53		0.41			
5	44.5	112.1	6.70		1.81			
7	48.0	118.5		27.84		7.52		
11	20.5	69.0	Trace		Trace			
12	13.5	56.3	26.75		7.22			
13	12.0	53.7	41.44		11.19		None	
14	10.0	50.0	4.33		1.17			
15	15.0	59.1	6.08		1.64			
15	12.3		14.7		2.49			S
16			12.61		3.40			
17	10.0	50	0.92		0.25			
17	12.5		2.7		0.43			S
18	42.5	108.5	10.35		2.80			Sample taken from pipe
21	34.6	94.2	3.58		0.97			
22	19.5	67.0		None		None		Sample taken from pipe
23	15.6	60.1	2.05		0.55			
*25	14.0	57.4	1.04		0.28			
26	8.5	47.4	5.85		1.58			
27	18.5	65.3	16.80	78.0	4.54	21.05	0.074	
28	14.5	58.1	21.02		5.68			
*31	6.7	44.0	2.38		0.64			
*32	6.7	44.0	0.91		0.25			
34	8.0	46.5	23.63		6.38			
35	14.3	57.8	10.73		2.90			
35	14.5		22.4		3.74			S
36	29.4	85.0		23.2		6.26		
38	26.8	80.2	None		None			
39	12.8	55.0	Trace		Trace			
*42	9.4	49.0	1.87		0.51			
43	13.0	55.5	6.41		1.73			
45	28.3	83.0	15.04	129.5	4.06	34.98		
*47			0.73		0.2			
*48			0.27		0.07			
*49			10.10		2.73			
52	26.0	78.8	8.35	101.6	2.25	27.42	None	
52	21.0		19.6		3.25			S
53	25	77	4.73		1.28			
54	51.5	124.7		13.74		3.71		
55	51.0	123.9		19.68		5.32		
58	51.5	124.7	0.87		0.24			
63	50	122		27.30		7.37	0.197	
64				0.44		0.12		

TABLE VI—Continued

No.	Temp. of Spring		Curies Ra Emanation per liter $x10^{-10}$		Mache Units per liter		Permanent Activity of Water	Remarks
	°C	°F	Water	Gas	Water	Gas	Grams Ra. per liter $x10^{-10}$	
67	9.5	49.1	None		None			
69			None		None			
71	56.5	133.7	15.14	414.0	4.09	111.8	0.180	
72	8.5	47.4	11.30		3.05			
73	16.0	60.9	18.40		4.97			
76	16.1	61.0		229.0		61.85	None	
77	20.5	69.0	24.55		6.63		None	
78	35.0	95.0	5.99		1.62			
80	44.5	112.0		60.32		16.29	None	
81							Trace	
82	45.0	113.0	3.60		0.97		None	
83	43.0	109.4	3.27		0.88			
84	17.0	62.6	4.92		1.33			
85							None	
86	13.7	56.7	4.54		1.23		None	
87	13.0	55.5	6.58		1.78		None	
88–1	43.0	109.4	7.53	117.0	2.03	31.6		
88–2	43.0	109.4	11.49		3.10			
89	40.0	104.0	15.51		4.19			
90	41.6	106.8	2.20		0.69			
91	35.5	95.9	2.78	146.10	0.75	39.45		
92	32.5	90.5	9.24		2.50			
93–1	40.0	104.0	6.81	180.15	1.84	48.63		
93–2			6.58		1.78			
94				100.10		27.02		
95	38.7	101.6	9.42		2.54			
102	18.5	65.3	1.87		0.51			
107	10.0	50.0	47.23	164.0	12.75	44.3	None	
108	10.0	50.0	50.20		13.56		None	
109	9.3	48.8	11.07		2.99			
111	8.5	47.4	42.38		11.44			
112	9.5	49.1	28.37		7.66		None	
113	8.5	47.4	38.07	131.6	10.28	35.52	Trace	
*114			0.95		0.26			
115	16.3	61.4	4.57		1.23			
117	10.5	51.0	16.42		4.44			
117	10.2		20.0		3.25			Sample taken from pipe S
118	10.0	50.0	3.24		0.88			Sample from pipe near Spring S
118	15.1		8.45		1.41			
119	16.0	60.9	3.56		0.96			
120	13.5	56.3	None	Trace	None	Trace		

TABLE VI—Continued

No.	Temp. of Spring		Curies Ra Emanation per liter x10^{-10}		Mache Units per liter		Permanent Activity of Water	Remarks
	°C	°F	Water	Gas	Water	Gas	Grams Ra. per liter x10^{-10}	
120	13.7		8.2		1.35			S
121	14.2	57.5		11.94		3.23		
124	14.0	57.4	2.35	11.49	0.63	3.10		
124	14.7		22.4	15.4	3.74	2.6		S
125	12.0	53.7	7.30		1.97		None	
125	12.8		11.5		1.98			S
126	18.0	64.4	15.35	77.6	4.14	20.95	None	
126	13.0		26.7	47.0	4.49	8.0		S
127	22.3	72.2	12.07	73.15	3.26	19.75	None	From pipe 200 ft. from Spring
127			20.1	48.1	3.36	8.03		S
128	15.5	60.0	8.89		2.40		None	
128	12.7		13.1		2.32			S
129	14.5	58.1	2.68	16.22	0.72	4.38	None	Sample from bubble fountain
129	14.5		17.6		3.04			S
130	15.5	60.0	16.60	155.2	4.48	41.92	None	
130	14.9		47.3	205.0	8.25	31.2		S
131	11.0	51.9	4.62	21.93	1.25	5.92		
131	11.2		14.0	28.8	2.34	4.77		S
132				19.65		5.31		
133	9.5	49.1	16.84		4.55		0.08	
133	17.2		19.5		3.16			S
136	47.0	116.7	4.93	262.0	1.33	70.75	Trace	
139	51.0	123.9		391.5		105.7		
141	22.0	71.6	Trace		Trace			Sample from outlet at well
142	83.8	183.0		656.0		177.15	None	
144	46.0	114.8	9.41		2.54			
145				202.2		54.6	None	
146	9.5	49.1	13.35		3.61		None	
147	12.0	53.7	69.40		18.74		Trace.	
148	13.5	56.3	2.47		0.67			
150	10.0	50.0	273.0		73.7			
151	11.5	52.7		334.5		90.34		
152	34.7	94.4	10.38		2.80		None	
153	36.1	97.0		152.35		41.14		
155	18.5	65.3	27.2		7.34		None	
156	34.0	93.1	36.9		9.99		None	

TABLE VI—Continued

No.	Temp. of Spring		Curies Ra Emanation per liter $x10^{-10}$		Mache Units per liter		Permanent Activity of Water	Remarks
	°C	°F	Water	Gas	Water	Gas	Grams Ra. per liter $x10^{-10}$	
157	51.5	124.7	6.38		1.72			
158	47.5	117.5	11.53		3.11		0.096	
*159			None		None			
160	50.0	122.0		6.63		1.79		
161	12.5	54.6	2.30		0.62			
162	65.0	149.0		12.36		3.34		
164	15.0	59.1	None		None			
*165			0.83		0.22		Trace	
167	15.5	60.0	1.42		0.38			
170	14.5	58.1	None		None			
175	71.5	160.7	18.62	760.0	5.03	205.2	0.091	
*176			13.58		3.67		0.121	
177	64.5	148.1	263.9		71.25		0.063	
178							0.186	
179	33.5	92.2	8.31		2.24			
182	40.5	104.9		128.5		34.7		
183	26.4	79.6		229.7		62.0	Trace	
184	9.9	49.9	41.1	112.5	11.1	30.38	None	
186	10.3	50.6	79.25	375.6	21.4	101.41	None	Contains Thorium Emanation
189	24.0	75.2	2.05		0.55			
190	26.5	79.7	Trace		Trace			From pipe 90 ft. from well
191	27.5	81.5	2.54		0.69			
192	11.3	52.4		4.97		1.34		
194	13.0	55.5		1.90		0.51		
196	53.5	128.3	8.75	36.2	2.36	9.78		
199	22.5	72.5		5.66		1.53		
*200	14.0	57.4	1.03		0.29		Trace	
203	20.5	69.0	11.86		3.20		None	
206	20.0	68.0	2.64			0.71		
207	14.5	58.1	305.5	2725.0	82.5	735.8	Trace	
208	12.5	54.6	108.3		29.25		0.28	
209	14.0	57.4	138.4		37.37		0.283	
210	15.5	60.0	97.03	614.8	26.2	166.0	0.233	
211	24.0	75.2	Trace	Trace	Trace	Trace		
211				10.9		1.79		S
212	39.5	103.0		13.35		3.61		
212	39.5		1.2	7.9	0.21	1.31		S
213	24.0	75.2	9.05	35.0	2.44	9.45	None	
213	23.8		14.3	51.5	2.39	9.05		S
214	23.5	74.3		63.25		17.08		
216				2.39		0.65		

TABLE VI—Continued

No.	Temp. of Spring		Curies Ra Emanation per liter x10^{-10}		Mache Units per liter		Permanent Activity of Water	Remarks
	°C	°F	Water	Gas	Water	Gas	Grams Ra. per liter x10^{-10}	
218	15.0	59.1	13.58	60.30	3.67	16.28	None	
218	14.8		2.55	20.5	0.43	3.46		S
222	24.5	76.1		3.29		0.89		
223	13.5	56.3	1.64		0.44			
223	13.0		1.9		0.32			
224				25.58		6.91		
225	21.0	69.9	2.62		0.71			
229	30.5	86.9	3.75		1.01			
230	49.5	121.1	5.14	10.11	1.39	2.73		
231	49.5	121.1		12.03		3.25		
*232	6.7	44.0	0.78		0.21			
*233	10.0	50.0	0.68		0.18			
234	52.0	125.7		15.76		4.26		
235	42.5	118.5	2.28	136.6	0.62	36.88		
236	39.5	103.0		19.97		5.39		
237	52.0	125.7		111.8		30.20		
238	64.0	147.2	10.69	562.0	2.89	151.7	None	
239	70.0	158.0	19.80	956.8	5.35	258.35	Trace	
240	68.5	155,3	19.54	1155.0	5.29	311.8		
241	70.0	158.0	21.51	1280.0	5.81	345.6	Trace	
242	71.0	159.8	27.94	1147.0	7.54	309.7		
243	59.5	139.1	12.66	690.9	3.42	186.5		
244	43.0	109.4	16.56		4.47			
245	64.0	147.2	28.57	687.5	7.71	185.6	0.083	
246	68.0	154.4	18.66	1243.5	5.04	335.5		
247	66.3	151.3	12.62	555.0	3.41	149.85		
248	5.5	42.0	13.85		3.74		0.085	
249	72.0	161.6	1.18		0.32			
250				36.2		9.77		
*251	55.5	131.9		58.3		15.74		
252	35.5	95.9	4.40		1.19			
*253			5.84		1.58		None	‡
*254			13.63		3.68		None	

‡Rockwood, Colorado School of Mines, has found for No. 253 a permanent activity of 2.015 10^{-10} gram Ra per liter.

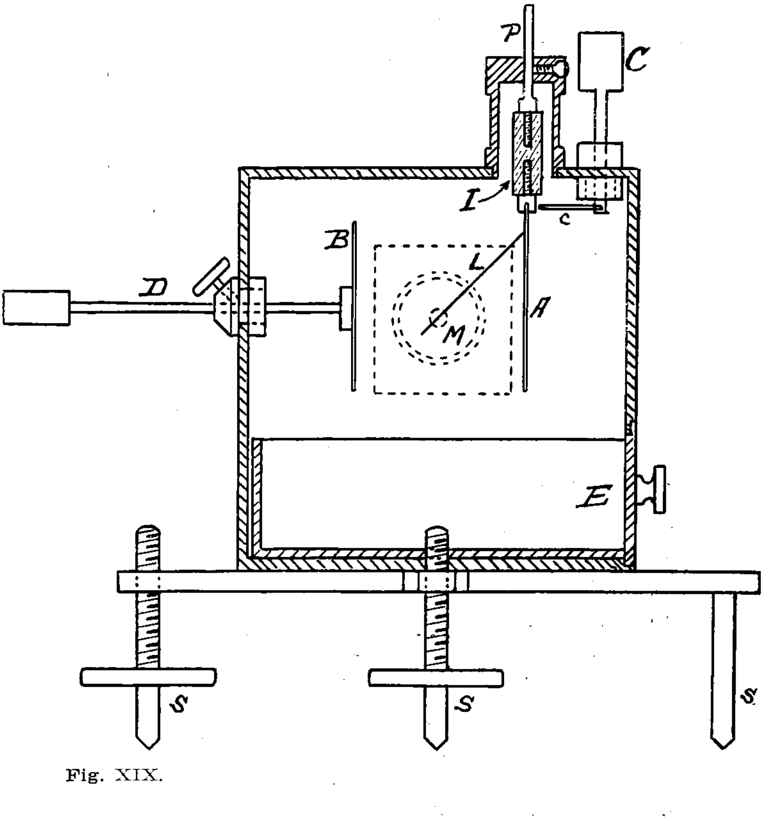

Fig. XIX.

RADIOACTIVITY OF SPRING SEDIMENTS AND DEPOSITS

For testing the activity of spring deposits in the solid form an electroscope of the usual type, shown in Fig. XIX, was built It is a cubical brass box having a volume of one liter. The narrow leaf L is 4 cm. long. Its brass support A is insulated by a piece of amber I and projects downward into the ionization chamber at the bottom of which is a closely fitting drawer E for the introduction of the active material. Cc is the usual charging device. B is an arrangement to protect the leaf during transportation and is drawn back against the wall of the electroscope when observations are being made.

The instrument has a measured electrical capacity of 1.06 cm. and was standardized by means of thin films of black uranium oxide made up according to the method of McCoy (22), but following the specifications of Boltwood (23). Ten standard films were made from some very pure uranium oxide kindly furnished by Professor Boltwood. In no case did these films weigh as much as 5 mgs. and the material was spread uniformly on thin sheet aluminum over a surface of 64 sq. cm. The ten films gave an average activity per milligram of 3 divisions per minute and 1 division per minute corresponds to 2.82×10^{-4} gram uranium.

Dry samples of the materials to be examined, weighing roughly from 0.5 lb. to 3 lbs., were first pulverized so as to pass through a 100-mesh screen. Small portions of these were further ground with freshly distilled chloroform in an agate mortar and this material was thinly painted with a camel's hair brush over sheet aluminum of the same area as the standard films. These films were made much thicker, however, than the standard films, so that considerable absorption undoubtedly occurred for which no correction has been made.

The activities of the deposits, muds or sediments from a number of the springs listed in Table VI are given in Table VII. It was not possible to collect such samples from all the springs. The samples taken were usually from springs which showed at least a fair amount of activity in the water or gas. From some springs more than one sample was taken when the deposits appeared to differ in nature, color, or age. These are indicated in the table by a repetition of the spring number.

In the column headed "material" will be found a classification made by the Colorado State Geological Survey, but no formal analysis has been attempted. Column 3 expresses the activity as equivalent to that of so many grams of uranium per gram. Up to the present it has not been possible to do the work necessary to determine the exact substances to which this activity is due. Small portions only, even of what appeared to be calecareous deposits, were soluble in nitric or hydrochloric acids. The deposits contain large amounts of clay and silica and the radioactive salts occur generally in the form of sulphates.

The values given in column 4 were obtained by the well known method of fusion with mixed carbonates. A few grams of material, finely ground with five or six times their weight of carbonates, were placed in combustion tubing between glass wool plugs, sealed and stored for over a month. The mass was then fused and boiled for fifteen to twenty minutes and the gases driven off were collected in the usual way over hot water where the pressure was kept continually a little lower than atmospheric pressure. Near the end of the boiling outside air was allowed to filter through the combustion tube to remove any remaining emanation and the mixed gases were then transferred to the emanation electroscope.

The values given in column 5 were obtained by the boiling out method from complete solutions of a few grams of material. This of course is the ideal way to make all the tests in order to get reliable quantitative results. However, aside from the fact that lack of time has prevented this work from being done completely, it is scarcely to be expected that the results would show anything beyond the presence of small amounts of radium and perhaps also of thorium in a few cases.

TABLE VII.

ACTIVITY OF SPRING SEDIMENTS AND DEPOSITS.

No.	Material	Equivalent Act Grams Uran. per Gram x 10^{-10}	Grams Ra per Gram x10^{-10}		Remarks
			Fusion	Solution	
12	Quarts Sand and Orthoclase	0.474			
12	Sand	0.423			
13	Mud and Organic Matter..	1.865			
27	Limonite and Calcareous Sinter	0.299			
27	Limonite and Calcar. Clay...	0.141			
27	Calcareous Clay	0.588			
27	Calcareous Clay	0.907	None		
28	Mud and Limonite	1.328			
71	Mud and Muscovite	0.251			
73,	Clay	15.11	3.62		
73,	Clay	16.88	8.67		See footnote
‡76	Sulphur	8.74	1.88		
77	Clay	0.732			
77	Clay	0.265			
108	Sand	0.349			
142	Clay	0.444			
147	Carbonaceous Clay	1.245			
147	Carbonaceous Clay	1.54	0.291		
150	Linmonite and Calcareous Sinter	9.36		2.07	
150	Limonite and Calcerous Sinter	20.73		3.21	
152	Calcareous Clay	0.007			
153	Calcareous Clay	0.263	None		
153	Calcareous Tufa	0.527			
154	Limonite and Clay	0.321			
158	Calcareous Sinter	1.72		1.14	
175	Clay and Calcareous Sinter.	1.14	Trace		
175	Clay and Calcareous Sinter.	0.485			
177	Tufa	1.345			
182	Limonite and Clay	0.639			
182	Limonite and Clay	0.855			
183	Limey Clay	0.724			
183	Calcareous Clay	0.449			
184	Calcareous Clay	0.603			
200	Black Porous Sinter and Sulphur	0.161			
203	Yellow Sinter	0.233			
203	Tufa	0.604	0.085		
207	Limonite and Sand	0.073	Trace		
207	Limonite and Sand	0.273	0.125		
235	....	0.216			
238	Calcareus Clay	0.123			
238	Calcareus Clay	0.397			Sulphur pure enough to burn
238	Mud	0.057			
165	Cave Encrustation	Trace			
165	Rusty Clay	None			

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‡Sulphur pure enough to burn. The springs 73-77 are peculiar. Schlundt (21) finds that part of the sinter deposited by them is 87% pure barium sulphate. He also finds a sample of tufa from one of these springs showing 14.8$10^{-10}$ grams Ra per gram.

DISCUSSION OF RESULTS

An examination of the Tables VI and VII indicates that although there are a few springs which show no activity the general average is high. The most active waters show the highest activity yet found in the United States and are surpassed by but few foreign springs. The greatest activity found in the spring gases is exceeded in the United States by a few springs in the Yellowstone National Park and is approached by but two or three European springs.

A careful comparison of the radioactivity measurements with the data obtained from the chemical analyses shows that there is no connection between radioactivity and any chemical property. Neither is there any connection between activity and temperature nor between the activity in water or gas and that in the deposits. Some springs situated near each other have shown activities of very different magnitude and again the individual springs of a closely associated group have shown quite similar activities. In the first case the waters of the separate springs usually had the appearance of being different in character but not always.

Results similar to the foregoing have been recorded by many previous observers, both in this country and in Europe. There is a general agreement that springs from igneous rocks are more active than those from sedimentary rocks.[1] This general result is likewise shown by the present investigation. If we take the ninety-five springs of Table VI, which show an activity of 10×10^{-10} curie or more, we find that 58 or 61% are in pre-Cambrian formations or near a pre-Cambrian contact; 14 or 14.7% are in igneous rock or near igneous and sedimentary contacts. Approximately 75% of the more active springs are thus in or near metamorphic and igneous formations. Some of the most active springs, however, are found in sedimentaries. Nos. 73-77 in the Cretaceous and Nos. 136-139 in the Miocene are examples.

At the beginning of this investigation it was anticipated that some springs of extraordinarily high radioactivity would be found since Colorado contains quite extensive deposits of radioactive ores. This expectation, however, was not fulfilled. No large mineral springs were found in regions where radioactive ores are most abundant. A number of springs, often highly gaseous, situated

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[1] Since this article was written there has appeared an extensive investigation in the Radioactivity of the Archean rocks from the Mysore State by Smeeth and Watson (24). All these rocks considered to be of igneous origin contain remarkably little radium. The igneous magmas not only contain different amounts of radium but the radioactive material seems to be subject to magmatic segregation.

not far outside such regions, showed in general the least activity of any examined. On the other hand some quite active springs such as Nos. 107-109 near La Veta, and No. 71 at Hartsel in South Park, are in regions where radioactive ores are found to some extent. Autunite occurs in the La Veta region and some Carnotite is found in South Park. Generally speaking, however, the most active springs are found on both slopes of the Continental Divide and not far from it. So far as is known, there are no radioactive ore bodies near them.

There are several instances of groups of springs situated just at the foot or within a few miles of a high mountain range the individual peaks of which reach elevations as high as 12,000 to 14,000 feet. These groups are sometimes arranged in a more or less definite line, as if along an old fault, and again are gathered together in an irregular area whose opposite sides are only a few hundred feet apart. In such areas springs as widely different as a cold soda spring and a hot sulphur spring may be found separated by only a few feet. Obviously, they come through widely different formations and their activities usually differ greatly. These areas seem to be merely the common outlets for underground waters draining often from many square miles of high mountainous country which frequently includes formations of widely different age and character.

As to the origin of the radioactivity found in natural waters there seems to be a general agreement that it is picked up little by little during the underground flow from the minute amounts of radioactive substances known to be widely diffused through all rocks and soils. According to Dienert and Guillard (25) the radioactivity of subterranean waters arises *exclusively* from this source. They point out further that when water comes from great depths as in Plombieres it is possible to find springs very near together, coming from the same geological beds and having very different activity. Similarly the work of Schmidt and Kurz (40), while indicating that there is no dependency of emanation content or depth, strength of flow, chemical properties, or temperature, does show that springs from eruptive rocks are in general much more active than those from sedimentaries. This agrees with the observations of Strutt (26), Joly (27) and others that the granites and other igneous rocks found in the earth's crust contain relatively the most radium.

If a spring happened to be so situated that its waters came in contact with a material which could be classified as even a low-grade radioactive ore it would almost certainly show an activity of a different order of magnitude from those recorded in the tables above.

The question as to whether an underground water or gas collects its radioactive substances near the outlet or far removed from it cannot be answered without more information than is usually known about the underground water course. Mining operations have shown that quite extensive open underground water channels are not uncommon. In a water course which permits free and rapid flow radium emanation could be absorbed at a very great distance and brought to the surface before it would have time to lose much by disintegration. Likewise a gradual absorption during a rapid flow through a long underground channel could give at the outlet a very active water or gas which need not have encountered any particularly active material. In the case of slow seepage flows which may collect in the open channel extending only a short distance from the outlet or which may empty into the pool which forms the spring itself, most of the emanation is undoubtedly collected not far away. Even though such a spring should show high activity it does not mean necessarily that there is highly active material near by. The slow flow and shorter distance of travel are compensated by the greater area of the undergound stream and by its intimate contact with a greater amount of weakly emanating material. This argument of course does not exclude the possibility of the underground flow touching very active substances, but the presence of such material cannot be inferred from the existence of a highly radioactive water or gas without other evidence.

THE RADIOACTIVITY OF SOME OTHER SPRINGS IN THE UNITED STATES AND FOREIGN COUNTRIES

For purposes of comparison the radioactivity of a number of other springs in the United States is given in Table VIII and that of certain well known foreign springs in Table IX. Where the activities were originally given in terms of the uranium standard they have been reduced to the radium standard by means of the relation, 1 gram uranium $=3.33\times10^{-7}$ gram radium, or 3.33×10^{-7} curie of radium emanation. The results given for Hot Springs, Ark., and for Yellowstone National Park have been reduced in this way.

With reference to foreign springs an attempt has been made to choose reliable data. Few of the results here given are fully corrected and equally careful work on certain springs can be found in which the values given for the activities are quite different from those here recorded. The tables will serve, however, to give an approximate comparison between the radioactivity of American and foreign springs.

TABLE VIII.

Radioactivity of Some Other Springs in the United States

HOT SPRINGS ARKANSAS*

Location and Name of Spring	Temp.	Curies Ra. Em. per liter x10^{-10}		Act. of Deposit	Permanent Activity of Water	Observer and Remarks
	°C	Water	Gas	Gms. Ra. per Gram x10^{-10}	Grams Ra. per liter x10^{-10}	
Imperial Spring	60.8	88.58		Varying from less than 0.004 to 16.88 in 17 samples	None	Boltwood (28). 46 water tests given. Also tests on gases and deposits
Twin Spring (North)	62.4	21.8				
Arsenic Spring (North)	56.4	7.96				
Liver Spring	8.0	5.8				
Dripping Spring	57.8	2.57				
Cave Spring	57.2	1.23				
56B (Test Number)		0.26				
47A (Test Number)		7.83				
YELLOWSTONE NATIONAL PARK						
Mammoth Hot Springs						
Main Spring	71	None	None	0.099		
Hymen Spring	71	Trace	None	0.043		
Orange Spring	63.5	None	Trace			
Hot River (1a)	51.0	14.1		0.091		
Hot River (2)	-	9.76		0.083		
Soda Springs	15.5	1.07	5.0			
Squirrel Springs	32.0	0.62	2.50			
Norris Geyser Basin						
Congress Geyser	89	0.383		0.012		
"Black Sulphur" Spring	90	> 1.53	131.9	0.014		
Opal Spring	58	> 0.366	59.96	0.003		
Locomotive	82	> 0.40	173.2	0.023		
Primrose Spring	88	> 0.333	43.3	0.016		
Orpiment Pool			225.4	0.006		
Lower Geyser Basin						
Terrace Spring (2)	40	0.80	> 43.29	0.019		
Fountain Geyser	88	None	None			
Pool, Clepsytra Geyser	85	5.43	3997.0	0.001		
White Sulphur Spring (1)	59	10.85	389.7	0.005		
Firehole Lake (2)	85		1592.0	0.069		
Mushroom Pool	75	3.33	2517.0			
Upper Geyser Basin						
Cauliflower Pool	61	2.16	406.2			
Spring, Gem Geyser	64	23.47	2807.0			
Bench Spring	86	2.13	1219.0	0.011		
Giant Geyser			None	0.005		
Pool Model Geyser	82	2.03	4058.0			
Old Faithful	88	None	Present			
Handkerchief Pool	82	1.60	1385.0			

Location and Name of Spring	Temp. °C	Curies Ra. Em. per liter x10⁻¹⁰ Water	Curies Ra. Em. per liter x10⁻¹⁰ Gas	Act. of Deposit Gms. Ra. per Gram x10⁻¹⁰	Permanent Activity of Water Grams Ra. per liter x10⁻¹⁰	Observer and Remarks
Shoshone Geyser Basin						
Wave Spring			> 2498.0	0.005		
Three Crater Spring		1.97	2868.0			
A Sulphur Spring		13.62	2984.0	0.013		
Heart Lake Geyser Basin						
Hillside Pool, Rustic Geyser		6.36	> 2331.0	0.014		
Orange Pool		1.57	809.0	0.018		
West Thumb Yellowstone Lake						
Pool Spring (a)		12.49	1272.0			
Paint Pot			> 499.5	0.023		
Fish Cone			409.7	0.002		
Yellowstone Lake		0.47	886.0			
Yellowstone River Localities						
Pool, Mud Geysers		5.03	163.1			
Pool, East Mud Geysers		18.18	516.0			
Devil's Ink Pot		0.20	133.2	0.003		
Nymph Spring, Tower Falls		2.30	63.93			

SWEET SPRINGS, MO.

Location and Name of Spring	Temp. °C	Water	Gas	Act. of Deposit	Permanent Activity of Water	Observer and Remarks
	cold	7.89				Moore and Schlundt (31)

WILLIAMSTOWN, MASS.

Location and Name of Spring	Temp. °C	Water	Gas	Act. of Deposit	Permanent Activity of Water	Observer and Remarks
Sand Spring	20.3	1.22	65.3		None	Shrader (32)
Wampanoag	21.7	2.16	72.9		None	
Rich Spring	18.2	0.09	7.59		None	
Cold Spring		0.13			None	

SARATOGA SPRINGS, N. Y.

Location and Name of Spring	Temp. °C	Water	Gas	Act. of Deposit	Permanent Activity of Water	Observer and Remarks
Emperor	9.7	0.70	2.21		0.68	Moore & Whittemore (33). Tests given on 14 waters, 11 gases 8 deposits
Coesa	10.2	0.97	0.81	0.79		
Hathorn No. 1	10.2	1.42	2.13	7.69	0.42	
Geyser	9.7	0.39	0.34	0.17		
Adams	11.0	1.22	1.17	0.88	0.51	
Island		1.18		1.05		
Crystal Rock	10.0	8.80	8.47		0.09	

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*These spring names and temperatures are taken from Bulletin 395, U. S. Geological Survey, Schlundt and Moore. See reference (29). The given activities of deposits are due to Schlundt.

TABLE IX.

RADIOACTIVITY OF SOME FOREIGN SPRINGS

ENGLAND

Location and Name of Spring	Temperature	Cu. Ra. Em. per liter x10^{-10}		Observer Remarks
	°C	Water	Gas	
Bath, Kings Well..........		17.3	336.5	Sir. Wm. Ramsay (34) King's well shows 1.387 10^{-10} curies per liter permanent activity
Bath, Cross Bath..........		11.9		
Bath, Hetling Bath........		17.0		

FRANCE

Location and Name of Spring	Temperature	Cu. Ra. Em. per liter x10^{-10}		Observer Remarks
	°C	Water	Gas	
Plombieres, Vanquelin.......	69	0.617	10.94	A. Brochet (35)
Thalweg No. 3	63		9.98	
Savonneuse No. 2	28	0.947	4.48	
Robinet Romain		0.316		
Des Capucins.............	51	1.49		A. Lepape A. Laborde (36)
Vichy, Chomel...............	43.6	6.53	41.0	
Celestine (Embouteillage)..	15.0	5.28	15.8	
Mesdames	16.5	1.69	7.70	
Luicas	27.8	1.47	7.70	
Boussange	41.5	1.03	6.02	
Grund Grille	41.7	0.66	3.00	
Hopital	33.8	0.22	1.40	
Other Localities				
LaBourboule (S. Chaussy)		229.0	1415.0	
Baucens (S. de la Grange)		30.3	103.6	
Soutenay (S. Carnet)...		15.3	46.2	
Audinac (S. Chade).....		1.4	5.9	
Aix les Bains (Alaunquelle)		207.4		(G)*
Bourbon Lancy (Saone et Loire)		74.4		(G)

AUSTRIA

Location and Name of Spring	Temperature	Maché Units per liter		Observer Remarks
	°C	Water	Gas	
Karlsbad, Bohemia				H. Mache and St. Meyer (37) About 92 waters and gases examined. Results partially corrected.
Muhlbrunnen (Vor. Quelle)	39.2	31.5	94.2	
Schlossbrunnen	30.2	17.4	50.2	
Bernhardsbrunnen	61.1	1.58	4.0	
Sprudel	71.3	0.1	0.88	
Kaiserbrunnen...........	46.2	2.54		

Austria—Continued

Location and Name of Spring	Temperature	Maché Units per liter		Observer Remarks
	°C	Water	Gas	
Marienbad, Bohemia				
Waldquelle	7.0	4.57	10.9	
Kreuzbrunnen	7.5	4.26	8.68	
Ambrosiusquelle	7.8	1.62	1.48	
Ferdinandsbrunnen	9.5	0.66		
Teplits-Schonau, Bohemia				
Urquelle	45.9	4.96	21.9	
Augenquelle	21.9	3.13		
Fransenbad, Bohemia				
Laimannsquelle	(Cool)	0.95	0.67	
Nataliequelle	(Cool)	0.47	0.23	
Baden bei Wien				
Johannesbad	30.0	4.54	16.6	
Ursprung	34.1	3.12	13.1	
Franzenbad	33.8	7.88		
Voslau bei Wien, Hauptquelle	23.3	0.71	2.60	
St. Joachimsthal, Mine Water		185-2050		(G)
Bad Gastein, Grabenbackerquelle	36.3	155.0	564.0	
Elisabethstollen	42.5-46.8	26.8-133	412.0	
Chirurgenquelle	47.1	54.5		
Rudolph-Stollen	46.9	24.7		

BELGIUM

Location and Name of Spring	Temperature	Maché Units per liter		Observer Remarks
	°C	Water	Gas	
Spa, 13 Iron Springs		0.34-4.08		Gerard and Chauvin (38)
Spa, 9 Non-Mineral Springs		0.43-8.08		

GERMANY

Black Forest Region.

Location and Name of Spring	Temperature	Maché Units per liter		Observer Remarks
	°C	Water	Gas	
Baden-Baden, Buettquelle	23.5	82-125		Engler and Sieveking (39a). Engler (39b) Examination of more than 58 waters. Results par-
Murquelle	59.0	24.0		
Kuhlquelle	52.9	5.8		
Kirchenquelle	56.3	3.3		

GERMANY—Continued. Black Forest Region

Location and Name of Spring	Temperature	Maché Units per liter		Observer Remarks
	°C	Water	Gas	
Badenweiler, Hauptbadquelle	27.5	7.6		tially corrected.
Gemeindequelle	22.5	10.1		
Wildbad, Warme Quelle	36±	1.6-3.3		
Bad Antogast, Antonius-	Cold	26		
Undinenquelle	Cold	13.0		
"Linde" Quelle	Cold	3.9		
Bad Peterstal, Petersquelle	Cold	4.0		
Bad Freyersbach, Gasquelle	Cold	7.4		
Lithiumquelle	Cold	1.7		
Bad Antogast, Antoniusquelle	Cold	16.0		
Schwefelquelle	Cold	5.8		
Bad Rippoldsau, Wenzelquelle	Cold	2.1		
Sammelschacht	Cold	12.1		

Hesse and Neighboring Regions

Location and Name of Spring	Temperature	Maché Units per liter		Observer Remarks
	°C	Water	Gas	
Odenwald (19 springs)	8.2-19.5	0.9-12.5		Schmidt and Kurg (40). Tests given on about 117 springs. Results fully corrected
Spessart (5 springs)		2.7- 7.1		
Westerwald (12 springs)		0.5- 9.0		
Environs of Giessen (17 springs)		0.7- 4.5		
Wetterau (19 springs		0.0-16.2		
S. E. Taunusrand, Bad Neuheim				
Sprudel	33	1.6		
Karlsbrunnen	15	25.28		
Bad Homberg V. d. Hoehe				
Elisabethbrunnen	10.6	8.0		
Luisenbrunnen	11.2	2.3		
Bad Soden am Taunus				
Wilhelmsbrunnen	14.0	18.2		
Solbrunnen	16.3	4.3		
Nahethal (18 springs)				
Bad Kreuznach, Inselquelle	12.5	20.4		
Theodorshalle	7.1	6.6		
Bad Muensteram Stein, Hauptbrunnen	30.6	23.4		

Hesse and Neighboring Regions—Continued

Location and Name of Spring	Temperature	Maché Units per liter		Observer Remarks
	°C	Water	Gas	
Wiesbaden, Kochbrunnen	68.7	1.2	30.5	F. Henrich (41). 9 waters and 4 gases. Results partially corrected.
Spiegelquelle	66.2	0.9		
Odlerquelle	64.6	0.9	22.7	
Schutzenhofquelle	49.2	6.9	64.2	
Goldener Brunnen		2.7	42.8	
Kissinger, Racoczy		2.8		(G)
Maxquelle		4.3		(G)
Saxony, Bambrach, Neue Quelle	7	1964.0		(G)
Sohl bei Bad Elster	9	3.7-15.4		(G)
Wurttemberg (19 springs)		0.5- 3.1		K. R. Koch (42)

HUNGARY

Location and Name of Spring	Temperature	Maché Units per liter		Observer Remarks
	°C	Water	Gas	
Pistyan, Brunnenschacht	60	2.03		Maché and Meyer. B Szilard (43). These values reduced from Curies (G)
St. Lucasbad		9.05	24.52	

SWITZERLAND

Location and Name of Spring	Temperature	Maché Units per liter		Observer Remarks
	°C	Water	Gas	
Baden	47-48	0.3-1.31	2.7-3.7	
Disentis	7.9	47.7	45.4	
Leuk	51	0.3		
Lavey, Waadt		11.0		
St. Moritz, Engadin, Paracelsusquelle	4.9	1.4		
Pfafers-Ragaz Stollenquelle	36	0.7		
Schuls, Sotsassquelle	Cold	1.0		
Tarasp, Carolaquelle	Cold	1.1	0.6	

ITALY

Location and Name of Spring	Temperature	Maché Units per liter		Observer Remarks
	°C	Water	Gas	
Near Padua				Engler
Abano, Sorgente, Montirone	87	5.0		
Battaglia, Surgone Gratta	74	5.7		
Castellamare, Acidola	13.3	22.6		
Magnesiaca	14.7	4.0		
Near Naples				
Bagnoli, Mangenello		2.6		
Agnano Purgativo	90	1.9		
Island, Ischia				
Porto d'Ischia, Stabilimento Communale	65	4.7		
Casamicciola, Manzi I	85	1.4		
Lacco Ameno, Regina Isabella		36.9		
Lacco Ameno, Old Roman Spring		372.0		

JAPAN

Location and Name of Spring	Temperature	Cu. Ra. Em. per liter x10^{-10}		Observer Remarks
	°C	Water	Gas	
Beppu, Kojimaya-no-yu No. 1		0.21		R. Ishisu (44) Gives complete data on an immense number of springs.
Dogo, Yo-jo-yu		4.42		
Shin-Onsen	Cold	6.61		
Kami-no-yu	Hot	3.98	23.38	
Ikeda, Nobata-Shin-yu	Cold	187.74	359.48	
Kami-Suwa, Shojin-yu		1.29		
Masutomi, Kamigawara No. 1	Cold	828.34		
Kuridaira No. 1	Cold	590.44	1514.23	
Misasa, Private Bath (T. Matsubara)	Hot	142.14		
Seito-Kwan-no-yu	Hot	102.25		
Kobu-yu	Hot	10.23	62.75	
Takayama, Ena-Kasen	Cold	281.09		
Tamatsukuri, Kami-no-yu	Hot	2.97	27.99	
Wakuri, Wakazaki-no-yu No. 1	Hot	6.93	93.31	
Yudani, Kabu-yu	Cold	4.24	23.80	
Yugawera, Uenoya-no-yu		0.05		

*(G) indicates that results so marked have been taken from Gockel (14c). These two values were given in maché units but have been reduced by the relation 1 curie=2.7×10^{-9} maché units.

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CHAPTER IX

GENERAL DESCRIPTIONS OF THE MINERAL SPRINGS

BY
R. D. GEORGE

ARVADA, JEFFERSON COUNTY

1. Macalso Sulphate Water, also called Golden Lithia Water, Kearney Ranch, 4 miles northwest of Arvada.

There was formerly a spring, but the digging of a well 65 feet deep diverted the water, and it is now taken from the well. Plans have been made for bottling and shipping the waters and for erecting the necessary buildings for a resort. The surface formation is the Arapahoe of Tertiary Age.

CONUNDRUM SPRINGS NEAR ASPEN, PITKIN COUNTRY

2. The springs are in an area of Carboniferous rocks at timber line, near the head of Conundrum Creek, in the Sopris National Forest. They are about 14 miles south of Aspen, the most convenient railway point. There are two groups of springs issuing from the same limestone ledge, but only the southern group is important. This consists of two fairly large springs and several small ones. The largest spring has a flow estimated at 25 gallons per minute. The temperature of the water is 100° F.

AUSTIN AND VICINITY, DELTA COUNTY

3. *Cold Sulphur Spring* is near the entrance to the Black Canyon, about 450 yards up the river from the State Bridge. The waters issue from a Cretaceous sandstone (probably Dakota), in an area of rounded shale hills. The flow is about 15 gallons per minute. The water is rather strongly mineralized and is accompanied by much carbon dioxide, and some hydrogen sulphide.

4. *Alkali Spring.* This is really a group of small springs between the Sulphur Spring and the State Bridge. The water issues from a sandstone (probably Dakota), at a point about 40 or 50 feet above the Sulphur Spring. The total flow is small, but proper excavation would probably increase it.

4a. *Black Canyon Well.* The well was drilled by the Black Canyon Oil Company on an anticline a short distance up the river from the State Bridge, near Austin. At a depth of 225 feet it developed a strong artesian flow of highly saline water accompanied by much carbon dioxide. The analysis of the brine was made by Von Schulz and Low.

This is the most highly mineralized water analyzed for this report. It is also prominent in the matter of its lithium content.

AVALANCHE AND VICINITY, PITKIN COUNTY

The springs are along the Crystal River in the vicinity of Avalanche, a station on the Crystal River Railway in Pitkin County. The springs are in an area of Carboniferous and Permian sedimentary rocks cut by a diorite intrusion.

The flow of several of the springs is large, and that of the others could be considerably increased by proper excavation.

5. *The Bath House Spring* issues from the diorite on the very bank of the river at Avalanche Station, and is developed by a log bath house and a pool.

6. *The Cold Iron Spring* is located in a swampy area on the east bank of the river, ½ to ¾ of a mile below the station. It has formed a large deposit, but now issues at a point nearer the river.

7. *The Hot Iron Spring* is in a meadow about ¼ mile up the river on the east bank. Gas accompanies the water. Much salt is deposited in the marshy area about the spring. The content of ferrous bicarbonate is quite large.

8. This spring is about 100 yards above the last, but the notable differences in the basic elements make it clear that they draw their waters from different sources. The iron bicarbonate content is like that of the preceding spring.

9. *River Spring* is on the very brink of the river at Avalanche, and is covered by the river at high water. The flow is small, but could be increased.

10. *Hot Sulphur Spring* is about 50 yards below the Bath House Spring but on the opposite side of the river. The opening has been covered by slide rock from the diorite and the water flows through the base of the talus.

BARR AND VICINITY, ADAMS COUNTY

11. *Colorado Carlsbad Water.* The water comes from a well 90 feet deep, located 6 miles east of Barr. The place was once

quite well developed as a health resort. The water was formerly bottled and shipped in large quantity, and the possible supply is still large.

BEULAH SPRINGS, PUEBLO COUNTY

12, 13. The Beulah Springs are located along the North Fork of the St. Charles near the town of Beulah in Pueblo County. They issue from the pre-Cambrian granite which, at this point, extends farther east than it does to the north or the south. The granite hills are rounded and timbered, but the sedimentary rocks to the east form sharp ridges and valleys. The springs are reached by stage from Pueblo, 30 miles distant. Some of the springs are walled up and protected by pavilions. The flow is small, but there is good reason to believe it could be greatly increased.

Only two of the springs were sampled, and the analyses show that the waters are very similar. Nonmineralized springs also occur. The town has hotel accommodations.

BOULDER AND VICINITY, BOULDER COUNTY

14. *Gregory Canyon Spring.* The spring is on the south side of the canyon about 400 yards from the mouth. The water issues from the Carboniferous sedimentary rocks a short distance from their contact with the pre-Cambrian granites. It is not appreciably mineralized, and so was not analyzed. Radioactivity tests were made.

15. *Sunshine Canyon Spring* (Sanitarium Spring). The spring is about 300 yards beyond the Colorado Sanitarium, in the mouth of Sunshine Canyon. The water issues from the alluvium a short distance below the outcrop of the Carboniferous strata. There is such a slight mineralization that no analysis was made. The water is used by the people at the sanitarium and to a limited extent by the townspeople. It was tested for radioactivity.

16. *Crystal Spring* (Old Brewery Spring). It is near the site of the old Crystal Springs Brewery, between Marine and Arapahoe streets, Boulder. The water is fresh and was used in the brewery for many years. No analysis was made, but it was tested for radioactivity.

17. *The Chautauqua Spring* is in Bluebell Canyon, about ¾ mile above the Chautauqua grounds. This is also essentially a fresh water spring, and was tested only for radioactivity.

BUENA VISTA, CHAFFEE COUNTY

18, 19. The springs are located on Cottonwood Creek 6 miles west of the town, in Chaffee County. They must be near the contact between the pre-Cambrian granites and the great monzonite intrusion from which are carved some of the peaks of the Collegiate Range. The springs have been developed by the opening of short tunnels but little above the creek level. The temperature of the water varies from 120° F. to 144° F., and the flow is estimated at 125 gallons per minute from 4 to 5 openings. The waters from the various openings are the same.

The water is piped about 3/8 of a mile to the bath house where there are two plunges.

The surroundings are similar to those of the Hortense and Heywood springs and the waters are much the same.

CANON CITY, FREMONT COUNTY.

20. *Well at Fremont Natatorium.* The natatorium is located about 3 miles east of Canon City, Fremont County. The water is supplied by an artesian well 1,655 feet deep and flowing about 140 gallons per minute. The Dakota formation should be reached at this depth, and it is probable that this is the source of the water. As it enters the swimming pool the water has a temperature of 100° F. A deposit of iron oxide forms on the floor of the pool, and hydrogen sulphide accompanies the water as it issues from the well.

There are accommodations for 250 people at one time.

21. *Canon City Hot Spring.* The "spring" is on the south side of the Arkansas River at the lower end of the Royal Gorge. It was obtained by sinking a hole about 10 or 12 feet deep to the sub-surface flow which comes to within a few feet of the surface. The water must come from the granite. It is reported that similar sub-surface flows occur at the junction of Grape Creek and the river, and on Grape Creek. The water is pumped from the well. The water has a temperature of 101° F.

There is a hotel with some baths, but the swimming pool is no longer used.

22. *Soda Spring at the Penitentiary.* This spring is walled up, but the waters are free to the public. Gas issues in considerable quantity but intermittently. It is probable that the water rises from the Dakota formation. The flow could not be determined.

The water is piped to the pavilion otuside the penitentiary walls.

23. *Iron Spring at the Penitentiary.* The spring is close to the Soda Spring, and has a flow of about a gallon per minute. The water is piped to the pavilion outside the penitentiary walls. The scource of the water is the Dakota sandstone.

24. *Grape Creek.* The spring is 12 to 14 miles up Grape Creek from Canon City, in the pre-Cambrian granite area. It issues from the creek bottom about 25 feet from the channel. The flow is about 3 gallons per minute and much gas accompanies the water.

There is some doubt as to the accuracy of the sodium and potassium content, and the two are recorded together. The hypothetical combinations are given only in part. They show much sodium chloride, magnesium and calcium bicarbonates, and an appreciable amount of iron bicarbonate.

Much carbon dioxide accompanies the water.

CARDIFF, GARFIELD COUNTY

26. Cardiff Sulphur Spring is on the west bank of the Roaring Fork about 3 miles south of Cardiff on the Carbondale road. The water was tested for radioactivity but was not analyzed. There is no development for resort purposes. The water is cold.

CARLILE AND VICINITY, PUEBLO COUNTY

27. This spring is on the Arkansas River bank west of Carlile switch on the Denver and Rio Grande Railway. It issues from the Cretaceous sandstone and has built a mound of considerable size. The flow is about 15 gallons per minute, and gas accompanies the water.

CIMARRON AND VICINITY, MONTROSE COUNTY

28. Soda Spring is on the hillside about ¼ mile from the depot on Cimarron Creek, a tributary of the Gunnison. The country rock is granite and the stream has formed a canyon. The so-called Iron Spring is about 200 yards west of the Soda Spring, but it is now merely a seep and was not sampled.

CRESTED BUTTE, GUNNISON COUNTY

29-33. A sulphur spring issues from the Cretaceous sedimentary rocks about 3 miles northwest of Crested Butte.

The spring is not developed nor cared for in any way. A ditch cuts through it. Sulphur is deposited by the water for some distance from the spring. It was impossible to get a fair sample and no analysis of the water is available.

29. *Ranger's Spring.* The spring is located below the Forest Ranger's cabin at a point about 1½ miles above the mouth of the creek, and about 7 miles southeast of Crested Butte. The water issues from the sedimentary rocks and the flow is estimated at 300 to 400 gallons per minute. A large mound of travertine has been built about the spring. The temperature of the water is 83° F.

30. *Cement Creek Spring or Park Spring.* The spring is in the park about 4 miles above the mouth of Cement Creek, or 2½ miles above the Forest Ranger's cabin. A body of pre-Cambrian granite lies between this and the Ranger's Spring, but the waters issue from a limestone and have deposited considerable calc sinter. The flow is estimated at 40 gallons per minute. The water is similar to that of the Ranger's Spring, but differs in not being so highly mineralized.

31. *Jarvis Spring No.* 1. The spring is on the Jarvis ranch about 8 miles northeast of Crested Butte, and appears to issue from sedimentary rocks. Gas accompanies the water, which flows about 20 gallons per minute. A deposit of sinter surrounds the spring.

32. *Jarvis Spring No.* 2. This spring is about ½ mile above the last. The water is similar, but less highly mineralized and the flow is much less.

33. *Iron Spring.* The spring issues from the Cretaceous rocks about 3 miles above Crested Butte beside the Crested Butte-Irwin road. A deposit of iron has colored the rocks near the spring. The flow is small, and the analysis shows that the water contains only 87 parts of mineral matter per million.

CRIPPLE CREEK AND VICINITY, TELLER COUNTY

34. *Beaver Valley Ranch Spring.* The spring is located at the town of Love, about 5 miles east of Cripple Creek. The water comes from the pre-Cambrian granite, and is relatively free from mineral matter.

CRISMAN, BOULDER COUNTY

35. The spring issues from the granite about a mile east of Crisman and about 5 miles northwest of Boulder. The spring is developed by a cement basin protected by a stone house. The waters

are still used, but the spring has had little care of late years. The flow is small and is accompanied by carbon dioxide.

FLORENCE, FREMONT COUNTY

36. *Dean Artesian Wells.* These three wells are located about 3 miles east of Florence at a station called Dean. They are said to be about 2,000 feet deep, and are believed to draw their waters from the Dakota formation. The flow is very large, and except for a limited local use the waters go to waste. Much carbon dioxide accompanies the water.

At one time there were a bath house and a swimming pool at the wells, but these have disappeared.

Soda Springs, 3 miles east of Florence, are about 100 yards north of the Santa Fe tracks and a few yards east of the Rainbow Route road. There is a rather strong soda spring. This and the near-by artesian wells belong to the Rainbow Park Company.

DECKERS SPRINGS, DOUGLAS COUNTY

37. Deckers Springs are about 14 miles south and a little west of South Platte, a station on the Platte Canyon branch of the Colorado and Southern Railway in Douglas County. A daily stage runs from the station to the springs.

The springs are near the junction of Trout Creek and the Platte River. The principal spring is walled up, and under normal conditions has a flow of 3 to 4 gallons per minute. By placing the smaller springs under control a much greater volume of water could be secured. The water is bottled, crated and shipped mainly to Denver.

The elevation at the springs is about 6,500 feet and the immediately surrounding country is occupied by low, rounded granite hills. To the east is the Rampart Range. The Tarryall and Kenosha mountains are to the west and southwest.

DEL NORTE, RIO GRANDE COUNTY

38. *Shaw's Warm Spring* is located about 6 miles north of Del Norte, and about 1/4 mile northwest of the Del Norte and Saguache road. The spring issues from the Santa Fe sandstone of Tertiary age a short distance from outcrops of igneous rocks.

The spring was once developed as a resort, but it has fallen into neglect and the buildings have disappeared.

39. *Del Norte Town Well.* The well is about 500 feet deep, and the water rises nearly to the top. Much carbon dioxide accom-

panies the water. The well is within the area of the Santa Fe formation of Tertiary age, but it probably reaches the igneous rocks below.

DENVER, DENVER COUNTY

40. *Denver Deep Rock Artesian Well.* The well is near the corner of Twenty-seventh and Welton streets. The analysis shows that it yields a very pure artesian water. No medicinal properties are claimed for it.

DILLON, SUMMIT COUNTY

41, 42. These springs are located at a point 2 miles east of Dillon on Soda Creek, a branch of Snake River, in Summit County. The rocks of the region are mainly pre-Cambrian granites and gneisses, but isolated patches of Cretaceous rocks occur in lines parallel to the Blue River. The springs have built mounds about 15 feet high and 100 feet wide. Considerable iron is deposited along the stream course. The water issues from the Dakota sandstone. The upper spring has a flow of 3 gallons per minute.

43, 44. Spring in a little park about 1 mile southeast of Dillon. The spring issues from a shale sandstone contact at the base of the Dakota sandstone ledge. A rough wall protects the spring, and the flow is about 1 gallon per minute. Seepage indicates that a greater flow could be developed. Gas accompanies the water.

DOTSERO, EAGLE COUNTY

45. *Big Dotsero Spring.* This spring is about 1¼ miles below the station on the north bank of the Grand River. It issues from a blue sandy limestone and has a flow estimated at 400 to 500 gallons per minute. The water is highly mineralized with sodium chloride. A tunnel was driven into the river bank to control the spring, but most of the water issues to the west of the tunnel. There was an old bath house at this spring.

The country is occupied by Carboniferous sedimentary rocks.

46. *The Old Bath House Spring.* This spring is about ¼ to ½ mile above the Big Spring, and the waters are almost identical in composition. The old bath house has disappeared but the boarded pool remains.

Several small springs on the south side of the river issue from the same formation, and their waters are probably very similar. They were not sampled.

DURANGO, LA PLATA COUNTY

47-51. These warm springs are on the Pinkerton ranch in the Las Animas Valley, about half way between Trimble and Rockwood. They are west of the wagon road, and are convenient to the Denver and Rio Grande Railway.

The rock formations of the immediate neighborhood are of Paleozoic age, but pre-Cambrian rocks outcrop a short distance to the north. The elevation is about 7,500 feet.

The group includes five large springs and several smaller ones, all issuing from a sandstone formation. The waters of only two of the springs were analyzed, but radioactivity tests were made on those of five springs. The two waters analyzed are similar in most respects, but the north spring contains 20 parts of lithium chloride per million, and in this respect is one of the three highest in the State.

Practically nothing has been done to develop the springs for health or pleasure resort purposes.

ELDORADO SPRINGS, BOULDER COUNTY

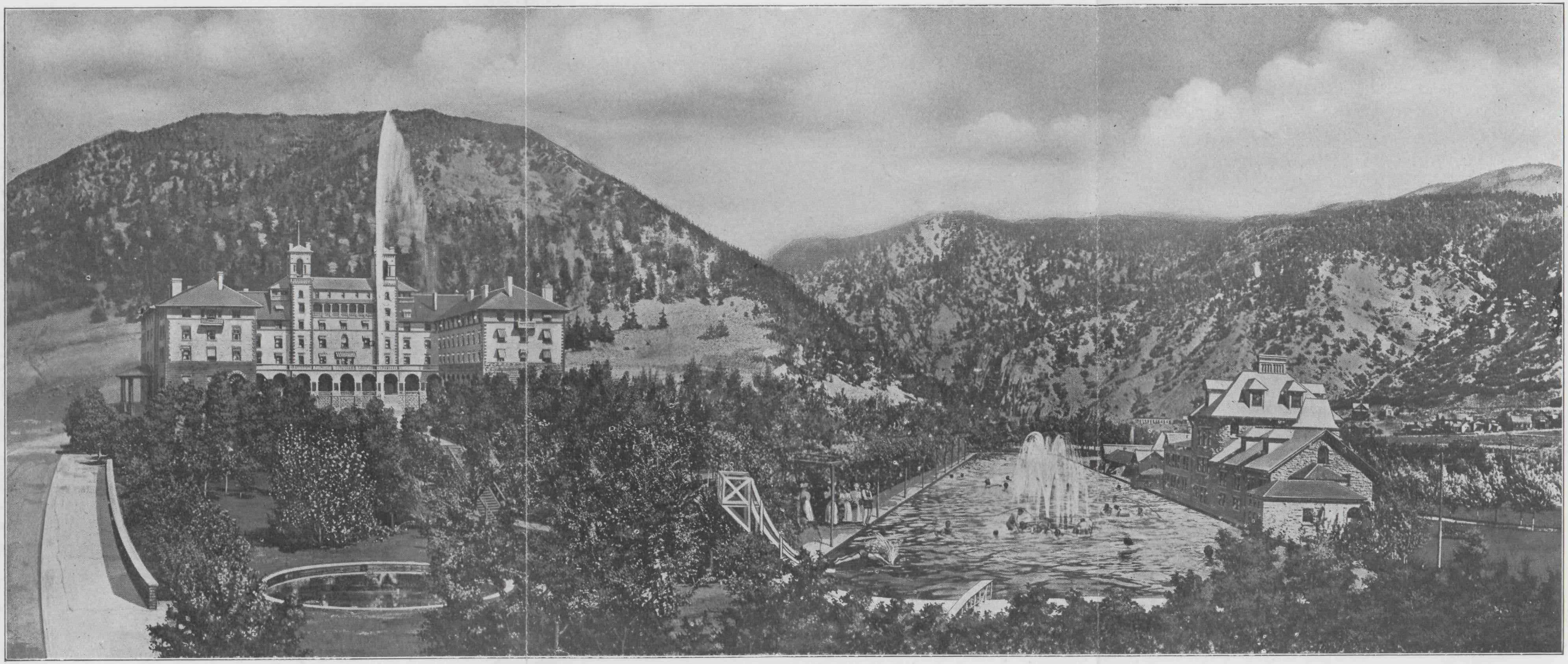
52. There are several cold springs and one warm spring which is weakly mineralized. The rocks are the upturned sandstones and shales of the Carboniferous formations. The warm spring has a flow of about 12 gallons per minute. The waters are used in a large swimming pool. The springs are developed by a good hotel, swimming pools, bath houses, pleasure ground and cottages.

FAIRPLAY, PARK COUNTY

53. *Warm Spring.* South and southwest of the town of Fairplay, Park County, there stretches a broad alluvial area on both sides of Fourmile Creek, a tributary of the South Platte. The surface of the alluvial plain is somewhat hilly and in places is cut by ravines. The spring comes from a side hill in a small gulch. The flow is estimated at 250 to 300 gallons per minute. The water is but weakly mineralized, and has a temperature of 79° F.

GLENWOOD SPRINGS, GARFIELD COUNTY

54-64. The Glenwood Springs are located toward the eastern end of Garfield County on both sides of the Grand River, both above and below the mouth of Roaring Fork. They are among the most highly mineralized waters of the State, and are well charged with gases. Carbon dioxide occurs in considerable excess and hydrogen sulphide is present in all the spring waters. The temperatures of



GLENWOOD SPRINGS

the hot springs differ within comparatively narrow limits, and range from 106° F. to 125° F.

The total flow of the springs is very large, and the range is from less than a gallon per minute to probably 400 gallons per minute.

The waters all fall in one class, but they differ widely in the proportions of the various elements and in the quantities of the hypothetical salts they contain. In all but one of the springs sodium is the most important base, but in two the quantity of potassium is very large.

The geology of the region includes a wide range of formations. Some of the springs rise through Cretaceous sedimentary rocks, others through Carboniferous sediments. The pre-Cambrian rocks outcrop a short distance to the north, and great bodies of Tertiary basalt cap the formations both to the east and the west.

Many of the springs are well developed and provided with good bath houses and good pools. The Colorado Hotel and the town hotels furnish ample and excellent accommodations.

The Denver and Rio Grande and Colorado Midland railways provide good railway facilities.

GUFFEY, PARK COUNTY

65. *Soda Spring, Cottonwood Creek, South Park.* The spring is in Hodge's pasture, about 14 miles southwest of Guffey, and about 7 miles south and a little west of Walker's ranch in the southern part of South Park in Park County. It is in an area of low, rounded, grass-covered granite hills at the foot of a steep outcrop of quartz porphyry called Castle Rock. There is but a small free flow, but considerable water is lost by seepage. The spring has built up a mound about 50 feet wide and 3 to 4 feet high forming a bowl-like crater for itself. Gas escapes with the water.

66. *Guffey's Soda Spring, Mound Spring.* The spring is located on Currant Creek about a mile below Guffey, Park County, in a hilly granite area. Mound Spring has built up a mound about 75 to 100 feet wide and 12 or 15 feet high. The water fills a pool in the mound but there is no free flow from the spring, but much water seeps away. Much gas accompanies the water. The spring is used for stock.

HARTSEL AND VICINITY, PARK COUNTY

67. The Salt Springs which were developed for the production of salt in the territorial days of Colorado are 12 miles southwest of Hartsel in Park County, about 4 miles from Platte River station on the Colorado and Southern Railway. The country rock is mapped upper Carboniferous, but it is thought by geologists that the brines come from Permian or possibly Juratrias strata.

The flow of the springs is small, but the waters contain 24,162 parts per million of sodium chloride, and at one time yielded a very large proportion of the salt used in the state.

68. The "63" Ranch Spring is about 5 miles northwest of the old salt works. It is in an area of Carboniferous rocks, but not far from a large body of Tertiary volcanic rock. The flow is estimated at 60 to 75 gallons per minute. The water belongs to the same general class as does that of the old salt works, but is relatively weakly mineralized, and differs in important details. It contains the bicarbonates of iron and sodium which were not found in the salt springs.

69. *Stinking Springs.* These are a group of springs on a tributary of South Platte River, about 10 miles east and 4 miles north of Hartsel Sulphur Springs, Park County. The surrounding country is park like, and diversified by rounded granite hills. The springs are very close together, and may be regarded as several openings of a single spring. The total flow is estimated at 4 to 6 gallons per minute.

70. *Cold Soda Spring.* This is located in a granite area about 1½ miles south of Hartsel. The flow is about 1 gallon per minute. The spring is covered and the water is piped to a trough for cattle. The surroundings suggest the presence of other springs which have been so trampled by stock as to be reduced to seepage.

71. *Hartsel Hot Springs.* Hartsel is on the Colorado Midland railway in South Park, Park County. The springs flow about 3 gallons per minute, and at the point of outlet the waters have a temperature of 134° F. The springs are near the contact of the granites and sedimentary rocks of Mesozoic age—Dakota, Jurassic and Triassic.

A good bath house, and a good hotel accommodate the patients and other guests.

72. *Iron Spring.* This spring is located at the foot of a sandstone ridge about ½ mile north of Hartsel. The flow is small, but there is a considerable seepage.

DOUGHTY SPRINGS, HOTCHKISS, DELTA COUNTY

73-77. The springs are on the North Fork of the Gunnison River, 3 miles southwest of Hotchkiss. They issue from near the base of a cliff of Dakota sandstone, and have built up an immense deposit of sinter. The river has cut into and undoubtedly has removed a large volume of sinter, but there remains a body 400 feet long, 115 feet wide and 20 feet thick. The principal constituent of the sinter is calcium carbonate, about 75 per cent, but barium sulphate is present in surprisingly large amount. Samples taken from near the Drinking Spring contained from 67 to 94 per cent of barium sulphate. It is probable that this spring is the chief or only source of the barium salt.

The various analyses show very notable differences in the details of composition. Carbon dioxide and hydrogen sulphide accompany the waters.

The analyses of Black Spring (73a), Bird's Nest (74a), No. 3 of Headden's Report (75a), and Bath Tub Spring (75b) are by Dr. W. P. Headden.

HOT SULPHUR SPRINGS, GRAND COUNTY

78, 83. This is a large group of hot sulphur springs on the Grand River in that part of Grand County included in Middle Park. They range in temperature from 90° F. to 118° F., and in flow from 1 or 2 gallons per minute to 40 or more. The waters issue from crevices in the Cretaceous sandstone, and are rather strongly mineralized. The marked similarity in composition points to a common origin for the waters of the various springs.

Sedimentary rocks of Tertiary age cover large areas both north and south of the river, but the springs are near the contact of the Cretaceous sedimentary rocks with the pre-Cambrian granites and gneisses. At a short distance east and north of the springs recent igneous rocks occur in large volumes. Middle Park is surrounded by high mountain ranges, and the topography about the Hot Springs is steep and rugged. The elevation is somewhat over 8,000 feet.

Bath houses and a swimming pool are provided, and hotel accommodation may be had in the town.

The Denver and Salt Lake Railway and good automobile roads pass through the town.

HYGIENE, BOULDER COUNTY

84. *Hygiene Sulphur Springs.* There are several small sulphur springs in a group between 2 and 3 miles northwest of Hygiene. They issue from a Cretaceous sandstone, and have a total flow of about 7 gallons per minute. The waters are accompanied by a considerable quantity of carbon dioxide and a notable amount of hydrogen sulphide. Sodium bicarbonate is the chief salt.

IDAHO SPRINGS, CLEAR CREEK COUNTY

85-95. The town of Idaho Springs is located on Clear Creek about 30 miles from Denver. It is at the point where the higher foothills merge into the mountain zone.

The mineral springs are located in an area of pre-Cambrian rocks intruded by an alkali syenite porphyry. Many deposits of travertine mark the vents of extinct springs and show that hot-spring action was more widespread than it is at present. The springs may be divided into three groups differing but little in the general composition of their waters. Of these groups, the Hot Springs, issuing from near the contact of the pre-Cambrian rocks and a considerable body of intruded alkali syenite porphyry, have a temperature ranging from 98° to 108° F. The Blue Ribbon Springs are at the contact of a small body of the same syenite but the waters are cold. The Cold Soda Springs issue through the alluvium of Clear Creek Valley, but undoubtedly come from a deeper source in the bedrock below. A small amount of hydrogen sulphide issues with the water.

The similarity of composition of the waters of the three groups of springs points to a common origin. Sodium is the most important base, but calcium, potassium and magnesium are also present.

The Hot Soda Springs are developed by a system of short tunnels and artificial pools. The bathing facilities are excellent and a large swimming pool is maintained. A small amount of the water is bottled and shipped. The flow of the springs furnishes an ample supply for baths and swimming pool.

The Blue Ribbon Spring is developed by a branching tunnel. The temperature of the water is about 60° F. The flow is at times rather limited, but it is probable that it can be developed to much greater volume if desired. The water is bottled and shipped.

The waters of all the springs are radioactive. See table, p. 179.

The entertainment of guests is provided for in the Hot Springs Hotel, and in the city hotels and rooming houses.

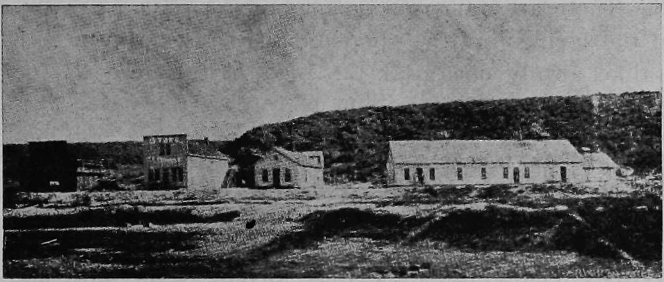


Fig. 20. Juniper, Moffat County.

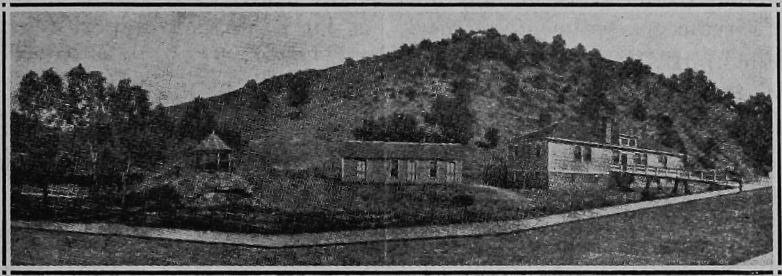


Fig. 21. Drinking Spring and New Bath House Spring, Idaho Springs.

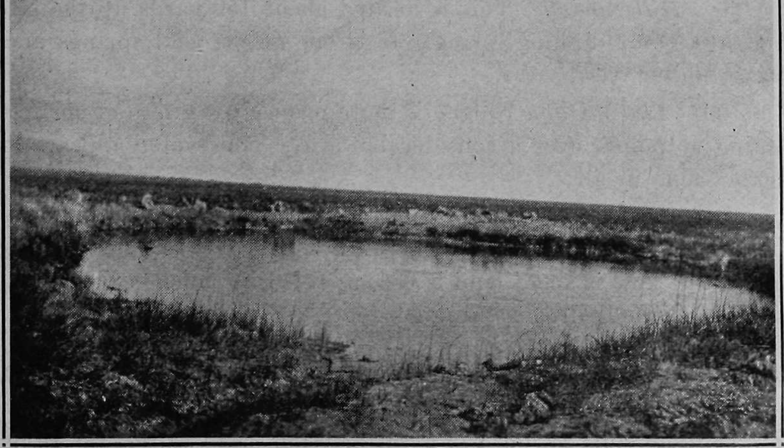


Fig. 22. Radio Spring, Mineral Hot Springs.

IRONTON AND VICINITY, OURAY COUNTY

96. There are numerous springs in the park. The surroundings of the springs are the same and the waters appear to be very much alike. Only one, near the road at the head of the park, was sampled. The most striking feature of the water is its high content of ferrous bicarbonate — 73.2 parts per million. The springs are undeveloped.

JUNIPER MINERAL SPRINGS, MOFFAT COUNTY

97-101. The Juniper Springs include both hot and cold springs. They are located along the Yampa or Bear River in Moffat County. The temperature of the hot springs is a little above 100° F., and that of the cold springs a little above the mean annual temperature of that part of the State. The region is one of Cretaceous sedimentary rocks, not far from the Juniper Mountain uplift.

The route of the proposed extension of the Denver and Salt Lake Railway passes about 6 miles to the north of Juniper. There is a general similarity in the waters, but wide differences occur in the proportions of the various salts.

97, 98. *Lower and Upper Bath House Springs.* These springs are on the river flat about 75 yards from the river. They issue from Cretaceous shales and sandstones. They have a combined flow of 25 to 35 gallons per minute. The waters are accompanied by much excess carbon dioxide. The development consists of baths with three pools.

99. *Hill Spring.* This is located about 150 yards up the hill from the Hot Sulphur Spring. It is one of the cold springs and has a limited flow.

100. *The Meadow Spring* is more properly a group of springs issuing at points over a considerable area. The water appears to be the same in all.

101. *The River Spring* is on the bank of the river opposite the bath house and Post Office. It is covered when the river is high. The flow is small, and is accompanied by much carbon dioxide and a little hydrogen sulphide.

THE SAN LUIS VALLEY, PARTS OF SAGUACHE, RIO GRANDE, ALAMOSA, CONEJOS AND COSTILLA COUNTIES

The San Luis Valley is a great artesian basin whose waters lie at no great depth below the surface. The water-bearing strata are of Tertiary age and rest upon and abut against formations of much greater age. In some parts of the valley the contacts between the old and the new strata are probably fault scarps. As a consequence of these conditions the borders of the valley are structurally favorable for the escape of some of the pent up waters as springs.

Of the many springs and groups of springs by far the larger number may be classed as cold springs. Their waters differ but little from the artesian waters of the same neighborhood. A few springs are distinctly warmer than the well waters, and two groups must be classed as hot springs.

Only the hot springs and a few of the other spring groups were studied for the purpose of this report, but the better known groups of cold and warm springs are briefly described.

LA JARA, CONEJOS COUNTY

102. *McIntyre Warm Springs,* formerly known as Los Ojos, are on the McIntyre ranch, on the south side of Conejos River in Sec. 13, T. 35 N., R. 10 E., about 8 miles east of La Jara, in Conejos County. They rise at the foot of one of the San Luis Hills, and some of the springs appear to come up through crevices in the recent lavas. The group is limited to an area not more than 300 feet in diameter. The total flow exceeds 9,000 gallons per minute and unites into a single stream having a temperature of 60° F. The waters are but slightly mineralized, and differ but little, except in temperature, from the artesian waters of that part of the valley.

LAKE CITY, HINSDALE COUNTY

103. *Sparlin Gulch Soda Spring.* The spring is in Sparlin Gulch about 4 miles northeast of Lake City. The spring is in an area of Tertiary igneous rocks, back of Baker's ranch. The flow is small. There is no improvement.

104. *Slumgullion Spring.* The spring is about 7 miles up Slumgullion Gulch from Lake City, on the road between Lake City and Creede. It is in a region of recent volcanic rocks, at an elevation of 10,000 feet.

LA VETA, HUERFANO COUNTY

105. *Mack Spring No. 1* is 7 miles up Cuchara Creek from La Veta, a town on the Denver and Rio Grande in Huerfano County. The spring rises through sedimentary rocks. But the Spanish Peaks a few miles to the southeast are the center of one of

the most remarkable regions of recent igneous (volcanic) activity in the state. Dikes radiate in all directions, and sheets of igneous rocks follow the stratification of the sedimentary rocks.

The topography is steep and rugged. The Veta Pass is about 4 miles to the west. The flow of the spring is small, but it could probably be increased by a little excavation. A little gas issues with the water.

106. *Mack Spring No.* 2. This spring is on a tributary of Cuchara Creek a short distance from the last. The geological conditions and surroundings are the same. The flow is about 10 gallons per minute.

THE SPRINGER RANCH SPRINGS

107-109. These springs are located on the Springer ranch about 6½ miles southwest of La Veta. The geological features and the general surroundings are the same as those of the last two. Within the last few years considerable money has been spent in developing the springs, providing accommodations for patients and other guests, and giving them attractive surroundings.

107. *White Sulphur Spring.* This is a small spring issuing from a crevice in the upturned sandstone.

108. *Black Sulphur Spring.* A few yards to the east of the White Sulphur Spring is another small one known as Black Sulphur Spring. The two springs differ quite widely in the kinds and proportions of sodium and potassium salts.

109. *Iron Spring.* This is a small spring about 25 yards distant from the White Sulphur Spring. In composition the water differs from both the others. The most important salt of the two sulphur springs is sodium bicarbonate, which is not present in the water of the Iron Spring.

LEADVILLE, LAKE COUNTY

110. *McMahon's Spring.* The spring is close to a little lake about 6 miles west of Leadville. There is only a little free flow, but much water is lost by seepage. The alluvium of the valley floor is probably underlain by pre-Cambrian granite.

111. *Ximo Soda Springs,* 5 miles west of Leadville. The springs are close to the fish hatchery. They are boarded up and properly protected by a building. The flow is about a gallon per minute.

112. *Lessy's Soda Spring,* about a quarter of a mile down the creek below the McMahon place. The spring is walled up with

cement, and protected by a roof. It is in an area of granite. The flow is small.

113. *Iron Spring,* or *Dunn,* beside the road about a quarter of a mile north of the fish hatchery. This also probably issues from granite. The spring is cemented up, and has a flow of about 1 gallon per minute. Much gas accompanies the water.

LOVELAND, LARIMER COUNTY

115, 116. Buckingham Springs are on the Buckingham ranch, 3 miles west of Loveland. They issue from a ledge of Cretaceous sandstone and have a total flow of 2 or 3 gallons per minute. The waters have been used for medicinal purposes, but there is no development for a health resort.

116a. The Loveland Artesian Well is 1,260 feet deep and flows about ½ gallon per minute. Inflammable gas issues from the well. The analysis following was made by Dr. W. P. Headden of the Agricultural College, Fort Collins.

	Grains per Gallon
SiO_2	0.8828
Fe_2O_3	Trace
Al_2O_3	0.4115
$CaCO_3$	2.5560
$MgCO_3$	1.0337
$HaHSO_4$	1.8673
Na_2CO_3	79.4631
Lithia	Trace
Ignition	5.2000
NaCl	284.2876
	375.7020

MANITOU SPRINGS, EL PASO COUNTY

117-133. This is a large group of rather highly mineralized springs and wells at the city of Manitou in the foothills of El Paso County 3 or 4 miles northwest of Colorado Springs. The Midland and Denver and Rio Grande railways and an interurban line serve the town.

Most of the springs rise through sedimentary rocks of Paleozoic age near their fault contact with the pre-Cambrian granites and gneisses. A few issue through the granites. The temperature of the waters ranges but little above the mean annual temperature of that part of the State. The flow of the springs ranges from 1 or 2 gallons per minute to about 15.

Fig. 23. Iron Springs Geyser, Manitou.

Fig. 24. Manitou Springs.

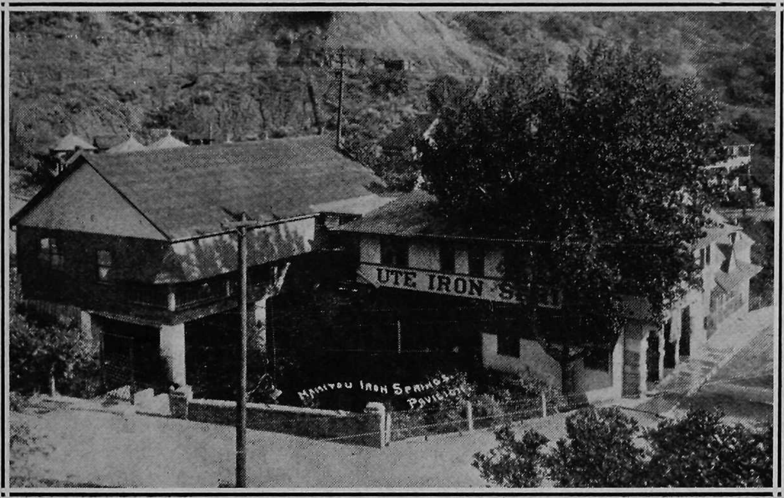


Fig. 25. Ute Iron Spring, Manitou.

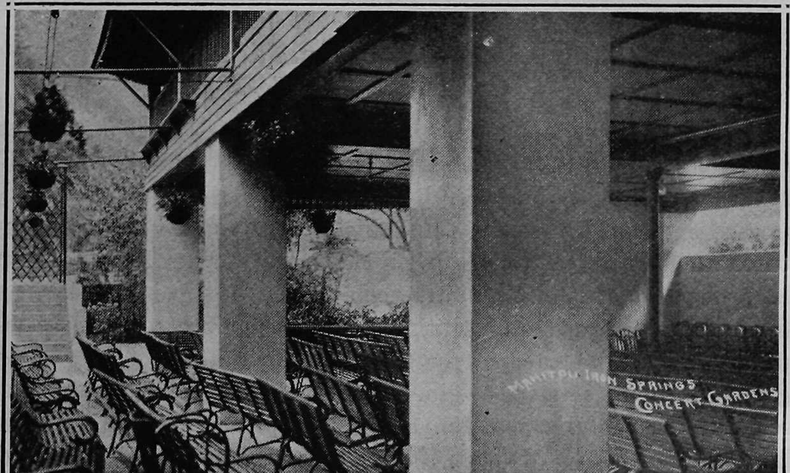


Fig. 26. Manitou Iron Springs, concert gardens.

The waters are used in drinking fountains, baths and pools, and large quantities are bottled and shipped. Many soft drinks are made from the waters, bottled and shipped. Nearly all the springs and wells are walled, enclosed and cared for and are an important source of revenue to the owners.

The town is first of all a health and recreation resort. During the season the hotel accommodation is good but none too abundant. The surroundings are those characteristic of the eastern foothills of the range.

MESA DE MAYA, LAS ANIMAS COUNTY

134. Van Brinnen's Ranch Springs. These springs are probably in Sec. 6, T. 33 S., R. 56 W., on the east side of Chauquaqua Creek, north of Mesa de Maya in Las Animas County. Of the four springs three are charged with iron, and deposit iron along the ditch into which they flow. The springs issue from a ledge of Cretaceous sandstone along an arroyo and have a flow of about 15 gallons, 10 gallons and 8 gallons per minute. The water is used for household and stock purposes.

There is a spring of soft water from which drinking water is obtained. This contains no iron.

135. *Jack Spring.* This is a spring of very similar character to the last, but is much more highly mineralized and has a flow of about 45 gallons per minute. It is located about a mile northeast of the Van Brinnen ranch.

MINERAL HOT SPRINGS, CHAMBERLAIN HOT SPRINGS, SAGUACHE COUNTY

136-140. The springs are at Mineral Hot Springs station on the Denver and Rio Grande Railroad. They include about 30 separate openings in two groups. The flows range from a fraction of a gallon to probably 10 gallons per minute. The temperatures range from 90° to 133° F. Some of the springs have built up large deposits of laminated tufaceous sinter. The group of springs east of the railroad and south of the station are of lower temperature, but the analyses suggest that the waters of the whole group have a common origin. One spring in each group was selected for analysis, but No. 136 is the spring in the top of the large mound 300 yards east of the railway—the southeast mound of the eastern group of springs. No. 140 is the large spring between 136 and the railway.

The area surrounding the springs has been parked, and bath houses, a swimming pool and a hotel furnish accommodations for health and pleasure seekers.

MONTROSE, MONTROSE COUNTY

141. *Montrose Artesian Well.* The well is located at the corner of South First and Uncompahgre streets, and is said to be 900 feet deep. The log of the well, as reported, shows 28 feet of surface material followed by 500 to 600 feet of shale, then an 8-foot seam of coking coal, followed by shale to the bottom. This is probably inaccurate. The surface rock about Montrose is Mancos, but this formation is coal bearing only in the sandy transitional zone between it and the Dakota. The log records no sandstone, either accompanying the coal or as a source of the artesian water. The well flows from 8 to 10 gallons per minute.

MOUNT PRINCETON SPRINGS, CHAFFEE COUNTY

142. *Hortense Hot Spring.* The spring is located about 250 yards north of the railway at Mount Princeton station in Chaffee County. The immediate vicinity of the spring is an area of alluvium, but the source of the water is undoubtedly the contact of the great monzonite mass of which Mount Princeton is a part. This is the hottest spring in the State, having a temperature of 183° F. at the point of issue. The rate of flow is about 30 gallons per minute.

There is a small hotel at the spring and a bath house with tubs and a plunge furnishes limited bathing facilities.

143-145. *Heywood Hot Springs.* These are located a short distance below Hortense Hot Spring. There are between 35 and 40 openings through the alluvial deposits between the Hortense Hot Spring and the river. The waters range in temperature from 125° to 145° F. The geological conditions are the same as those of the Hortense Hot Spring and the waters probably come from the same source.

The total flow is large, probably reaching 250 to 300 gallons per minute.

The Mount Princeton Hotel is a fine structure. There are tub baths and plunges.

Cold water springs are also numerous, but are not mineral waters.

146. *Hayes' Iron Spring.* The spring is located 1 mile above Heywood on the Hayes ranch on the south side of Chalk Creek.

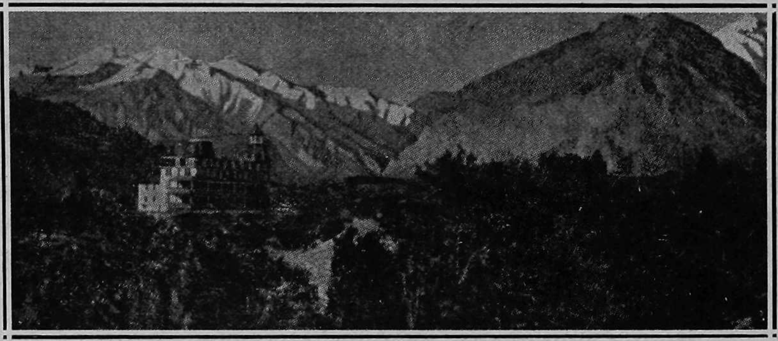


Fig. 27. Radium Hot Springs, Mt. Princeton.

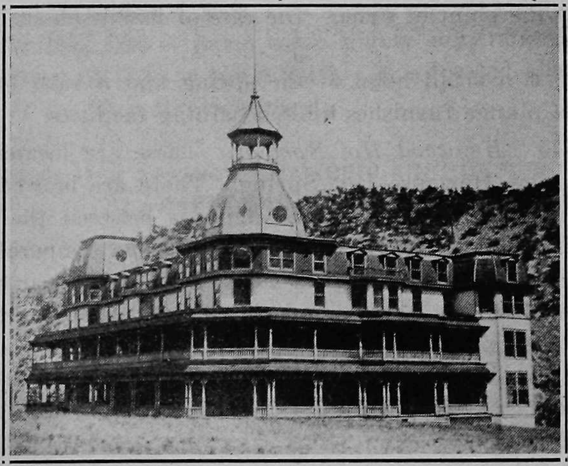


Fig. 28. Radium Hot Springs hotel, Mt. Princeton.

It is possible that this spring has its source in the granites of pre-Cambrian age, but alluvium covers the contact between the granite and the monzonite. The spring has a flow estimated at 150 gallons per minute.

The waters contain only 82 parts of mineral matter per million and consequently cannot be classed as mineral waters.

MORRISON, JEFFERSON COUNTY

147. The spring is in the Benton shales just outside the Dakota Hogback, ½ mile north of Morrison.. The flow is small and the water is accompanied by carbon dioxide and a trace of hydrogen sulphide. It is said that the water was once used quite extensively in the manufacture of soft drinks.

NORTH PARK, JACKSON COUNTY

148. *Hunter's Spring* is on Hunter's meadow ranch about 3 miles west of Northgate a station on the Laramie and Hahns Peak Railway, about 15 miles north of Walden, and about ½ mile from the Platte River. The spring sampled is the largest and strongest of a large group of sulphur springs and has a flow of 50 to 60 gallons per minute. Much gas accompanies the water. There is no development for resort purposes. The springs are near the contact of the Cretaceous and Tertiary sedimentary rocks.

149. *Hill's Spring* is on the Hill ranch 12 miles west of Cowdrey and 22 miles northwest of Walden. It rises through grayish black shales and has a flow of 2 gallons per minute. The spring is not developed for resort purposes. A noteworthy feature of the water is the rather high magnesium bicarbonate content.

150. *Brand's Springs* are on Brand's ranch, 13 miles west of Walden and about 2 miles northwest of Higho post office. They consist of one large spring and several small ones. The large spring flows about 5 gallons per minute and is used for drinking. This was sampled for analysis.

A short distance from this group are two springs flowing about 5 gallons each per minute. One of these is used for bathing purposes, and a bath house has been built near it. Much carbon dioxide issues with the water, and small deposits of iron-stained sinter surround the springs. All the springs issue from the east side of a small granite ridge surrounded by sedimentary rocks.

ORIENT, SAGUACHE COUNTY

152, 153. *Valley View Hot Springs.* They are in Sec. 31, T. 46 N., R. 10 E., not far from the Orient iron mine, about 10 miles southeast of Villa Grove. The five springs issue from the mountain side just above the upper limit of the alluvial slope. The north spring has a temperature of 72° F. The next spring to the south and the largest of the group has a temperature of 97° F. A bath house, now a ruin, once covered this spring. The flow is estimated at 200 gallons per minute. The third spring to the south has a temperature of 96°, and the one on the south fork issues at 99° F.

The total flow of the group probably reaches 1,000 to 1,200 gallons per minute. The springs were once improved by a hotel, a bath house and several cottages, and were once a popular resort.

OURAY AND VICINITY, OURAY COUNTY

154-159. Mineral springs, mostly hot, occur at numerous points in and about the city, but the waters of only a few of these could be analyzed. A few others were tested for their radioactivity. The flow of the springs ranges from a gallon or less per minute to probably 20 gallons per minute.

The city is nearly surrounded by sedimentary rocks of Paleozoic and Mesozoic ages. A short distance to the east and to the west Tertiary volcanic rocks cover large areas. To the south the Uncompahgre formation of pre-Cambrian age forms outcrops along the valley.

The waters analyzed are all sulphated, but they differ considerably in details of composition. Some of the springs have formed large deposits of mineral matter. The development is meager. The waters of Bath House Spring at the mouth of Box Canyon are piped across the city to the City Bath House, which is provided with tubs and a large plunge. Another spring in the mouth of Box Canyon is developed by piping the water to a pavilion.

The scenery of the San Juan is typically represented in the neighborhood of Ouray.

PAGOSA SPRINGS AND VICINITY, ARCHULETA COUNTY

160-164. The town of Pagosa Springs grew up in the hot and cold spring area toward the head of San Juan River in Archuleta County. The country rock of this part of the county is mainly black shale of Upper Cretaceous age; and the waters are characteristic of such geological conditions. The Arlington hot artesian well, the Big Pagosa Spring (hot), and three cold springs were sampled, analyzed and tested for radioactivity. Gas accompanies the waters of all the springs, and some are highly charged. The waters all belong to the same large class, but they differ in temperature, details of composition and in the proportions of the saline contents.

The Arlington artesian well is 387 feet deep and has a flow of 100 gallons per minute. The water has a temperature of 140° F., and is used to supply a large bathing pool and to heat the hotel.

Big Pagosa Spring, on the east side of the river, is one of the largest hot springs in America. The flow is estimated at about 700 gallons per minute. A large deposit of sinter has been formed. The water is piped to a bathing pool.

PLACERVILLE, SAN MIGUEL COUNTY

165. *The Geyser Warm Spring* was discovered in the course of placer mining on the banks of the San Miguel opposite the Denver and Rio Grande depot, Placerville. The water issues from Mesozoic sedimentary rocks at a temperature of 94° F. The flow is fairly large and the waters have formed a large deposit of mineral matter of complex composition, but principally travertine, into which the waters have carried and deposited sodium sulphate, sodium bicarbonate, potassium chloride and other saline matter.

The spring is developed by the driving of tunnels and rooms in which bath tubs are set. The temperature of the tunnels is about 82° F. Much carbon dioxide and a little sulphureted hydrogen issue with the waters.

STRONTIA SPRINGS, JEFFERSON COUNTY

166. Strontia Springs are on the Platte Canyon branch of the Colorado and Southern Railway in Jefferson County, about 28 miles from Denver.

At this point the Platte River runs in a comparatively narrow canyon, and the springs are in a small tributary valley from the west. Ragged hills of gray gneissoid granite form attractive surroundings, and the higher ranges occupy the distant horizons. The elevation is about 5800 feet above sea level.

The springs have an average flow of about 6 gallons per minute, and a part of the water is piped to the hotel—a distance of about 400 yards.

PLATEAU CREEK SPRINGS, MESA COUNTY

167. *Silver Spring* is 14 miles south of De Beque on Plateau Creek at the point where the road to Mesa branches from the Rainbow Route. It issues from a sandstone member not far from the top of the Wasatch (Tertiary) formation. The flow is small, and hydrogen sulphide accompanies the water.

168. *Hains Spring* is on Hains ranch about ¼ mile down the road from Atwell bridge on Plateau Creek. It issues from a sandstone in the Wasatch (Tertiary) formation. The flow is small.

169. *Alkali Spring* is across the creek from Hains' ranch. This is in reality a group of springs, having an aggregate flow of about 50 gallons per minute. The water rises from a point near the surface, and gypsum is the most abundant salt contained. The country rock is the Wasatch (Tertiary).

170. *Sulphur Spring* is located about 3 miles below Atwell bridge on Plateau Creek. It issues from a sandstone contact in the Wasatch formation. It has formed a pool 25 feet across. The flow is about 5 or 6 gallons per minute.

PHIPPSBURG, ROUTT COUNTY

Several springs occur along Morrison Creek, about 16 miles due east of Phippsburg, Routt County. As they are similarly situated in a granite area and rise through the alluvium of the creek valley within a comparatively short distance of one another only two were sampled for analyses. These are on the Scott and Smith ranches.

171. *Scott's Spring.* This spring is on the creek bank, and at high water the creek surrounds the barrel which protects it. The flow is estimated at about 2 gallons per minute. A much larger flow could be developed by controlling the waters from small springs near the main one. The granite hills are sharp and angular, but well covered by vegetation. The Park Range lies to the east.

172. *Smith's Spring.* This spring is located about a quarter of a mile down the creek from the Scott spring. Its surroundings are of the same kind as those of the Scott spring and the analysis shows that the waters are almost identical but slightly less highly mineralized. This may be due to access of rain water or water from the creek. The spring has built itself a mound 6 or 7 feet high and 30 feet wide.

173. *Jones Mineral Spring.* This spring is located on the Bear River in an area of sedimentary rocks about 5 miles east of Phippsburg. The flow is estimated at about 40 gallons per minute, and is accompanied by a considerable volume of carbon dioxide.

PONCHA SPRINGS, CHAFFEE COUNTY

174-178. The springs are in the valley of Poncha Creek, a tributary of the Arkansas, about 7 miles southwest of Salida. The Denver and Rio Grande furnishes railway facilities. There are about 40 springs ranging in flow from 2 gallons per minute to 15 gallons or more per minute. The total flow probably exceeds 100 gallons per minute. The temperature ranges from 140° to 155° F. The country rock is granite. Sinter mounds of considerable size have been built up. One cold spring was examined.

There are several bath houses, a swimming pool, a dancing pavilion and an eating house. More extensive developments are planned.

Four hot springs and a cold spring were selected for analysis. The waters are mildly mineralized with sulphate of sodium, the chlorides of potassium and sodium, and the bicarbonates of sodium, calcium, magnesium and iron. The waters belong to one class and differ but little in details of composition.

The scenic surroundings of the springs are imposing.

CEBOLLA HOT SPRINGS, POWDERHORN, GUNNISON COUNTY

179-186. The springs are on Cebolla Creek about 16 miles above its junction with the Gunnison River at an elevation of 8,000 feet above sea level. They issue from both sides of a hill in the angle between the Cebolla and the Powderhorn creeks. Iola on the Denver and Rio Grande is the most convenient railway point and is 18 miles from the springs. There are about 20 springs, ranging in temperature from 48° to 115° F. or higher. Many of the springs have made mounds of sinter about their mouths. The flows range from 1 or 2 gallons per minute to 15 or 20 gallons per minute, and carbon dioxide accompanies the waters of most of the springs.

The country rocks of the region are of pre-Cambrian age, and consist of granites, gneisses and schists intruded by dikes of later age.

The waters belong to a single general class, but differ in details of composition. Noteworthy features are the magnesium bicarbonate and the iron bicarbonate present in all the waters analyzed.

Only a few of the springs have been developed, and these but meagerly, by cabins and bath houses. (Since the springs were examined by Mr. Butters changes have occurred and one or two of the springs sampled by him are either diverted or have dried up.)

179. *Old Plunge Spring.* This is a few yards down the creek from the new bath house. There are two plunges.

180. *Cabin Spring.* This is a warm spring of small flow.

181. *The Drinking Spring* is about 100 yards below the bath house spring and 150 yards from Cebolla Creek.

182. *New Bath House Spring.* This is, in reality, a group of springs of small flow accompanied by much gas. Practically all the recent development of the Cebolla Springs is centered about this group. There are two bath houses, an outside plunge, and several cabins.

183. *Lower Hot Spring* is about 300 yards above Nichol's Spring. It has formed a considerable deposit of sinter. The water is piped for stock use.

184. *Schrecker's Iron Spring* is on Schrecker's ranch, about ½ mile above the mouth of Powderhorn Creek. It flows about 15 gallons per minute, and leaves an ochreous deposit on the creek bed.

185. *Schrecker's Soda Spring* is about 200 yards from the Iron Spring. It has a flow of about 2 gallons per minute, accompanied by much gas. The flow could probably be increased.

186. *Nichol's Spring* is on the road between Cebolla and Powderhorn creeks. The flow is small but could be increased.

PUEBLO, PUEBLO COUNTY

187. *Artesian Well, Sisters' Hospital.* This well does not flow.

188. *The Ferris Artesian Well.* This well was drilled over 30 years ago, and is said to be between 1,500 feet and 1,800 feet deep. The flow is said to fill a 3-inch pipe. The water is sold for local use.

189. *Pueblo Lithia Water Well.* This is an artesian well 1,200 feet deep at the Congress Hotel. The waters are used in the hotel, and are bottled and placed on the market. Soft drinks are also made and marketed.

190. *Clarke's Magnetic Mineral Spring.* This is a flowing well 1,425 feet deep at B and Spring streets, Pueblo. The well is under control and the flow fills a 2-inch pipe. Steel left in the

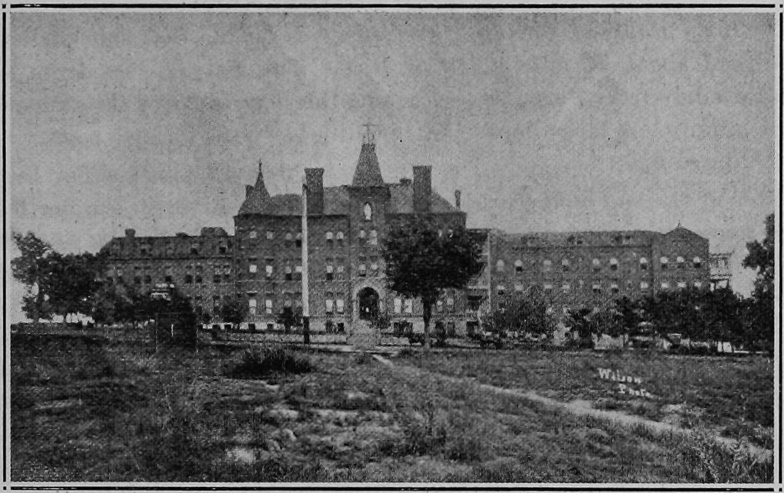


Fig. 29. St. Mary's sanatorium.

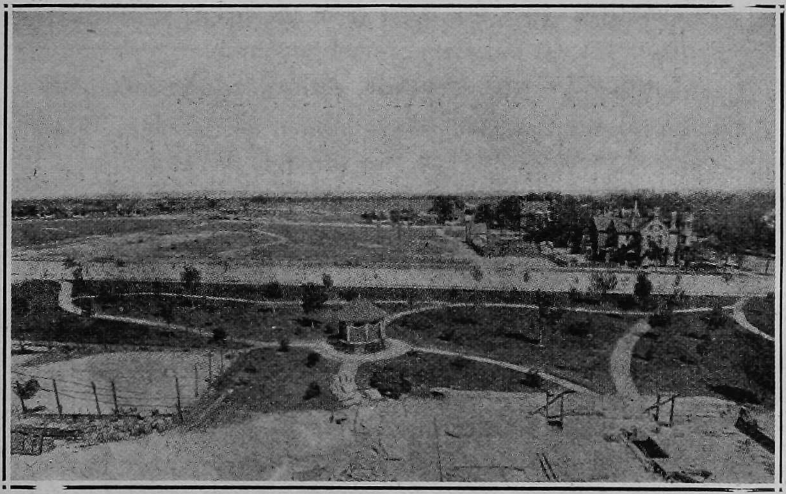


Fig. 30. St. Mary's sanatorium.

water a few hours becomes magnetized. The water has been bottled and sold locally.

There is a sanitarium at this spring (or well).

RICO AND VICINITY, DOLORES COUNTY

191. *Railroad Spring.* The spring is on the east side of the railroad about ¾ mile north of Rico. The water issues from a tunnel driven in Permian rocks, and the flow is 25 or 30 gallons per minute. A large deposit of limonite has been formed.

192. *Rico Spring.* The spring is about 25 feet from the water at the end of the bridge over the Dolores River in the northwest corner of the city. This is known as the Soda Spring and is one of a group probably having a common source. Much gas accompanies the water but the flow is small.

193. *Dolores Spring.* This is located about 100 yards south of the Rico Spring, in the old river bed. The flow of water is very small, but a considerable volume of gas bubbles up.

194. *River Spring No. 1.* The visible flow of the spring is very small, but it is probable that much of the water seeps away in the river gravels. The waters are not used.

195. *River Spring No. 2.* It is located about 30 feet southeast of River Spring No. 1, and is used for drinking. It is a cold, clear spring, with a flow of 5 or 6 gallons per minute. Gas accompanies the water.

Soda Lake is a marshy pond, from which gas issues in considerable quantity. It is 1½ miles from the town.

RIDGWAY HOT SPRINGS, OURAY COUNTY

196. *Ridgway Hot Springs* are located on the Ouray road, 2 miles south of the town. They rise through the alluvium of the river bottom at a distance of about 300 yards from the stream. A short distance from the present point of issue there is a large spring deposit marking a former point of issuance. Gas accompanies the water. The flow is estimated at 15 gallons per minute.

197. *Ridgway Spring.* The spring is located on a ranch about 1½ miles southwest of Ridgway in an area of Mancos shales. The flow of 15 gallons per minute is apparently not accompanied by gas of any kind. The water is used for ranch purposes, but the spring is not developed for resort purposes.

RUSTIC LODGE SPRING, LARIMER COUNTY

198. The spring is on Cache La Poudre River about 3½ miles west of the lodge, which is 55 miles by stage northwest of Fort Collins. The rocks of the area are pre-Cambrian granites. The flow is comparatively small, but could be increased by proper development.

SILOAM, PUEBLO COUNTY

The Red Creek Springs are near the town of Siloam, toward the head of Red Creek, a tributary of the Arkansas River, about 30 miles a little south of west from Pueblo, in Pueblo County. The nearest railway point is Swallows, about 8 miles distant on the Arkansas River. About a quarter of a century ago this was a popular resort, having 25 or 30 springs, a hotel and a permanent tenting ground. At present it is little more than a memory. Many of the springs have been trampled by cattle, others are dry and but few are usable.

The springs are near the contact of the sedimentary rocks and the pre-Cambrian formations.

199. *Bubbling Spring.* This spring issues from the early Paleozoic sedimentary rocks close to the granite in the bottom of the gulch. Much carbon dioxide accompanies the water. The free flow does not exceed 5 gallons per minute, but there appears to be a large seepage. Recent floods have so cut the gulch that the original channels of some of the springs have been destroyed and the waters issue as springs or as seepage farther down.

Large masses of spring deposit surround the old channels.

200. *Resort Spring.* On the opposite side of the gulch is a large seep which marks the site of the spring around which the resort of former days was built. Other springs once issued in this vicinity, but they have been so trampled by stock that only seeps remain. They could be reopened at no great expense.

201. *Clear Spring.* This is in the gulch about 100 yards below the Bubbling Spring. It has a small flow. Other springs could be developed both above and below this one.

202. *The Iron Spring* is also in the gulch about 25 yards below Clear Spring. It has a small free flow and considerable water seeps away. The deposit of limonite in the spring and the scum of iron on the seepage pools have suggested the name here applied. Carbon dioxide escapes in small quantity. The spring is not walled up or protected in any way.

203. *The Mound Spring* is about 50 yards up the hill from the Iron Spring. A mound of spring-deposited material 100 feet wide and 10 to 12 feet high represents the work of springs now reduced to mere seepages. There are several openings in the mound and from these water seeps and gas bubbles. The waters of these springs were believed to contain arsenic, but the analysis did not show its presence.

Waters of the Bubbling Spring, the spring across the gulch and the Mound Spring are very similar in composition, and probably have a common origin. The water of Clear Spring is quite similar to these, but much less strongly mineralized. That of the Iron Spring belongs to the same general class, but is comparatively weakly mineralized. It differs in details from all the others.

204. *The Watson Artesian Well* is located 1 mile south and ½ mile east of Siloam post office. The water flows from a 10-inch pipe which stands about 2 feet out of the ground. The yield is very large and the water is used for irrigation. Gas is abundant.

SILVERTON, SAN JUAN COUNTY

205. *Mineral Creek Spring.* This is known as an iron spring and is located about 4 miles up South Mineral Creek. The surroundings of the spring suggest the possibility of developing a considerable flow, but the water is very weakly mineralized. Its most important constituent is ferrous bicarbonate. The water issues from a sandstone.

SOUTH FORK, RIO GRANDE COUNTY

206. *Million's Springs.* The group of cold springs is located on the South Fork of the Rio Grande about 5 miles above South Fork station and post office. Three of the springs have a flow of 8 to 10 gallons each per minute. They issue from a granite cut by porphyry dikes. The waters are weakly mineralized.

SPRINGDALE, BOULDER COUNTY

207-210. The springs are on Lefthand Creek about 8 miles northwest of Boulder, and 2 miles below the mining camp of Jamestown. They are reached by a good automobile road from Boulder.

The country rock is pre-Cambrian granite and gneiss. There are four springs yielding waters very similar in character and probably rising from the same deep source. The differences of composition are in the proportion of the salts contained. Two are notably higher in iron bicarbonate than the others.

The total flow is sufficient to justify development, and at one time Springdale was a popular health resort. Much water was bottled and shipped. The hotel was burnt and has not been rebuilt. Some water is still used.

These waters are the most highly radioactive in the State.

STEAMBOAT SPRINGS, ROUTT COUNTY

211-224. This is the greatest group of springs in Colorado, and is located along the Bear or Yampa River in Routt County on the western slope of the Park Range. One of the springs which formerly made a noise resembling the puffing of a steamboat gave the name to the whole group and to the thriving town which has grown up about the springs. The Denver and Salt Lake Railway furnishes easy access to this inviting resort.

The waters of the springs vary in temperature from 56° to 104° F. The mineral content is equally variable, and the flow of the springs ranges from 1 to 2 gallons per minute to possibly 300 gallons per minute for the Bath House Spring. As a whole, the waters may be classed as *saline sulphureted.* In the flow of hydrogen sulphide gas, the springs range from a mere trace to a considerable volume. The quantity of carbon dioxide issuing is also remarkably varied from spring to spring.

The flow of several of the springs is immediately increased by rain storms, showing that the surface waters must have ready access to the spring channels. This fact makes it difficult to estimate the salinity of the spring waters proper, or the volume of gas compared with the volume of water under normal conditions.

The springs are near the contact of the pre-Cambrian area of the Park Range and the steeply upturned Mesozoic sedimentary rocks flanking the mountains. The lowest and oldest of the stratified rocks are probably of Jura-Triassic age. Following these are the Dakota sandstones and shales, which are, in turn, overlaid by the Mancos group. In the spring zone these sedimentary rocks are charged with sulphur and salts deposited from spring waters. At a distance from the spring area the formations have their normal appearance and composition.

In all the spring waters analyzed sodium is by far the most important base. It appears to occur mainly in the form of bicarbonate and the chloride. Next in importance as bases come potassium and calcium, but they fall far short of the rank of sodium.

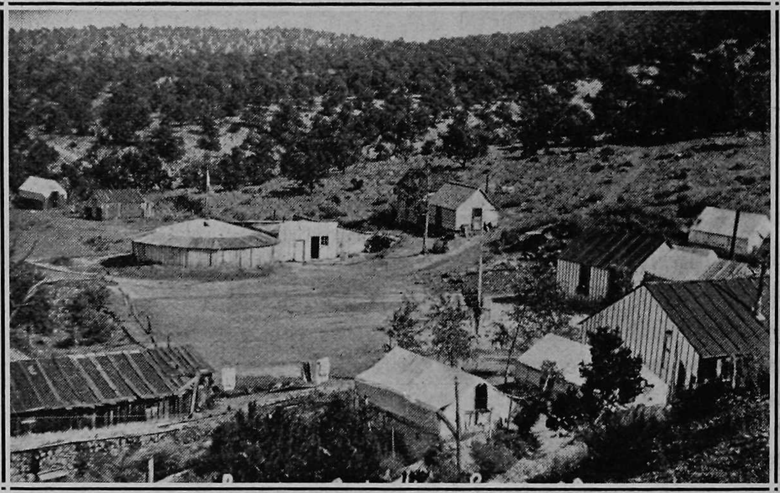


Fig. 31. Poncha Hot Springs.

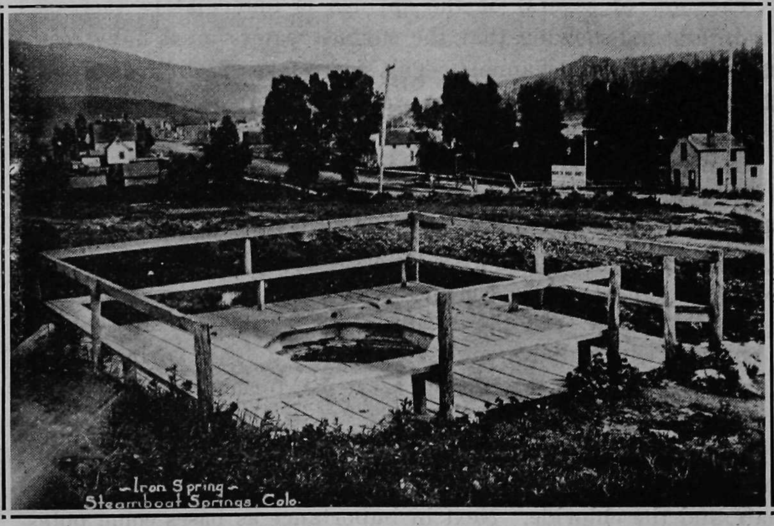


Fig. 32. Iron Spring, Steamboat Springs.

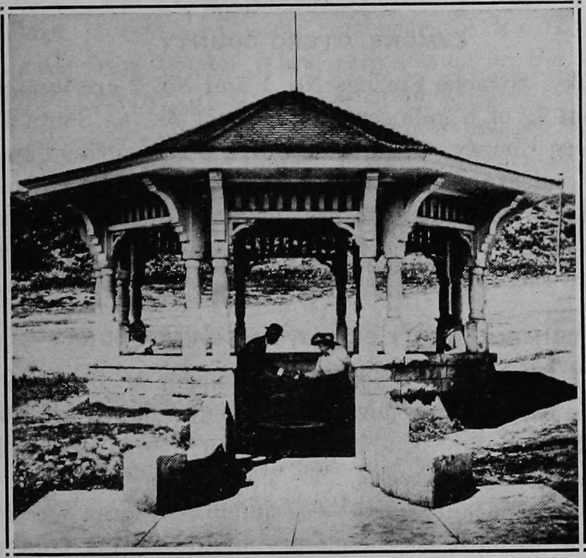


Fig. 33. Soda Springs, Steamboat Springs.

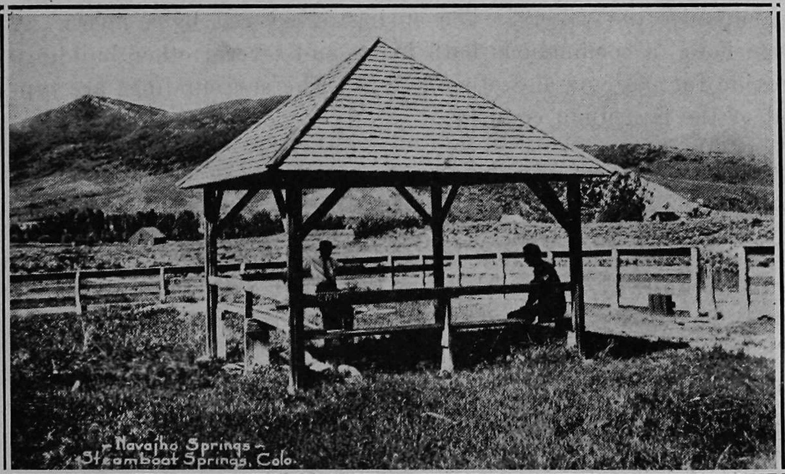


Fig. 34. Navajho Springs, Steamboat Springs.

In some of the springs the potassium leads, while in others the calcium is more abundant.

SYMONS, OTERO COUNTY

227, 228. Symons Springs No. 1 and No. 2 are located in an arroyo about ¾ of a mile south of Symons on the Santa Fe Railway in Otero County. The waters of the two springs are of the same class and are similarly mineralized. The flow is small, and no attempt has been made to use the waters for resort purposes. One of the springs is boxed in and protected. At high water the creek covers the springs.

TRIMBLE AND VICINITY, LA PLATA COUNTY

229-231. Trimble is about 5 miles north of Durango on the Las Animas River, at an elevation of about 7,000 feet. This part of the Animas Valley is a broad canyon floored and walled by Paleozoic and Mesozoic rocks.

About ¾ of a mile north of Trimble is a large warm spring having a flow of 50 to 60 gallons per minute issuing from a sandstone formation. A small bath house and a pool provide for a limited use of the springs.

The Trimble Hot Springs have built up a large mound through which they issue by several closely grouped channels. The total flow is estimated at 150 to 200 gallons per minute. Much gas accompanies the waters. The spring is covered by a house. A large hotel, a commodious bath house and several other buildings provide for patients and other guests. The surroundings are typical of the San Juan country.

THOMASVILLE, PITKIN COUNTY

232. *Big Sulphur Spring* is near Frying Pan Creek, 3½ miles west of Thomasville, under bridge 168A of the Colorado Midland Railway, at an elevation of about 8,000 feet above sea level. The area is occupied by sedimentary rocks of Carboniferous age, but the exact nature of the formation from which the waters came could not be determined. The flow is very large, and the waters are fairly strongly mineralized. The spring is not improved.

233. Meadow Spring. This spring is about ¼ mile east of the Big Sulphur Spring, in Sec. 15, T. 8 S., R. 84 W. The flow is very large, but probably less than that of the Big Sulphur Spring. The waters are very similar in composition. The spring is not improved.

WAGON WHEEL GAP, MINERAL COUNTY

234-237. The group consists of four hot springs and two cold springs, located on Goose Creek near the Rio Grande River, about a mile from Wagon Wheel Gap station on the Denver and Rio Grande Railway, at an altitude of 8,500 feet. The country rocks of the immediate vicinity are granites cut by dikes and in places capped by volcanic flows. Tertiary sedimentary rocks outcrop a short distance to the north.

234. *The Boiling Spring* is the largest of the group and its waters are most used for bathing, drinking and swimming. It has a flow of 50 gallons per minute.

235. *The Hot Saline Spring* is across the creek from the Boiling Spring. Its waters are used in the bath house.

236. *The Hot Soda Spring* is a few hundred feet south of the Hot Saline Spring, and on the same side of Goose Creek. Its waters are used only for drinking.

237. *The Cold Lithia Spring* is but a few feet from the Boiling Spring. Its waters are used for drinking.

The waters of the various springs belong to the same general class, but differ quite notably in details of composition. Carbon dioxide accompanies the waters of all the springs.

A good hotel, numerous cottages, well appointed bath houses and other conveniences are provided for the accommodation of patients and other guests.

WAUNITA HOT SPRINGS, GUNNISON COUNTY

238-251. The springs are on Hot Springs Creek, a short distance north of Tomichi Dome, about 10 miles northeast of Doyleville on the Denver and Rio Grande, and about 6 miles southeast of Ohio on the Colorado and Southern.

There are two groups of springs about ½ mile apart. The upper group has been developed by a large and well appointed hotel, a sanitarium, bath house, plunges and other improvements.

The lower group is larger and has a greater flow than the upper group, but in temperature and composition the waters of the two groups are very similar. The lower group springs were once used as a resort, but the hotel is gone and the plunge and other improvements have disappeared.

The Upper Springs issue from a sandstone which is probably of Paleozoic age.

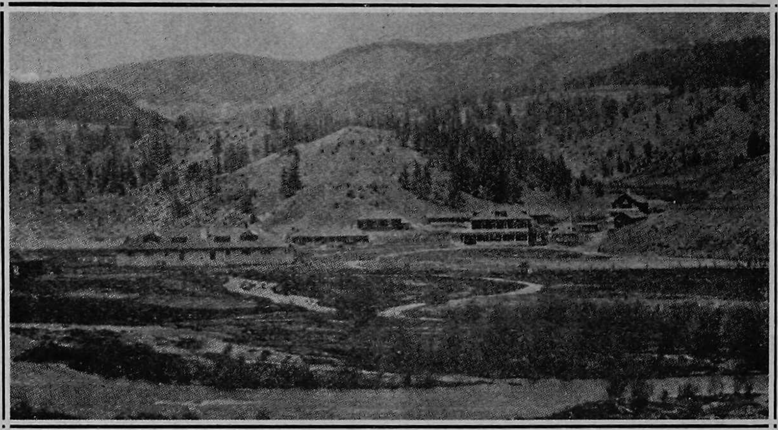


Fig. 35. Hot Springs hotel, bath house and cottages, Wagon Wheel Gap.

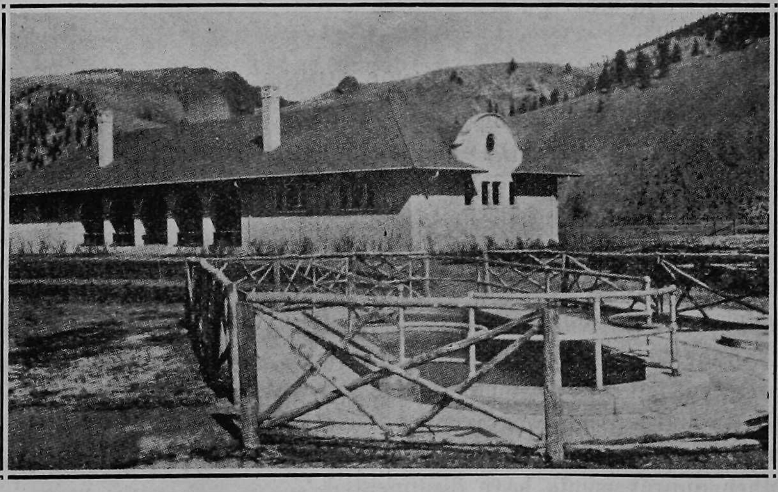


Fig. 36. Bath house and springs, Wagon Wheel Gap.

Fig. 37. Waunita Hot Springs.

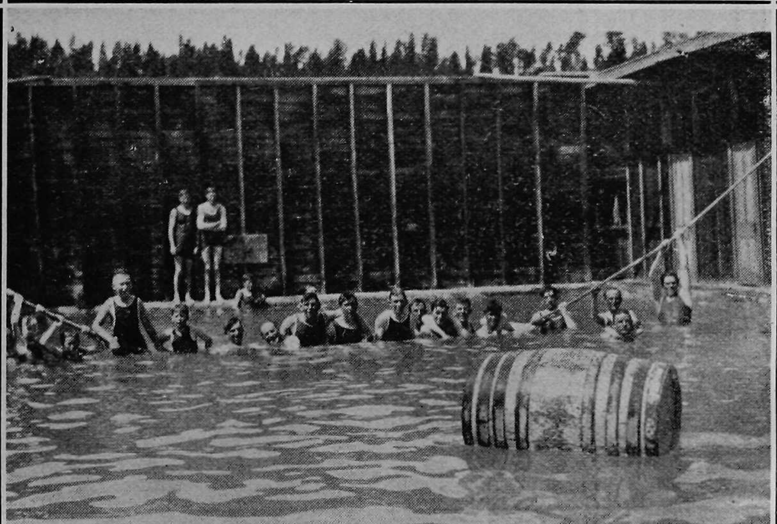


Fig. 38. Big bathing pool, Waunita.

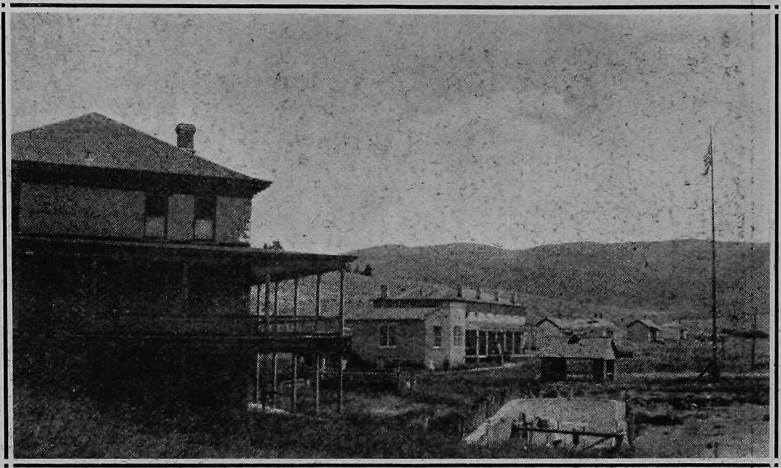


Fig. 39. Waunita Hot Springs.

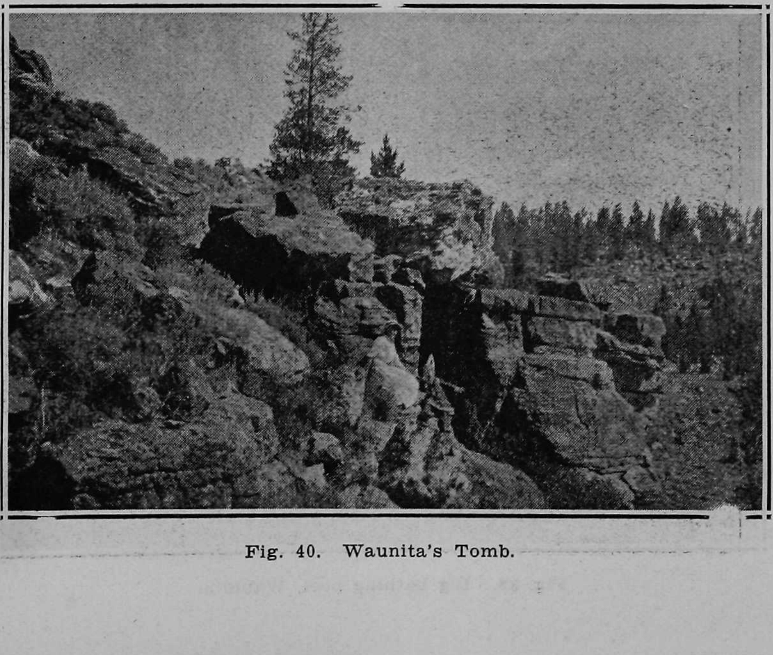


Fig. 40. Waunita's Tomb.

Waunita Hot Springs is a popular health and pleasure resort during the summer months.

The water of the lower group was formerly bottled and shipped in considerable quantity. The waters of both groups belong to the same class, and are similar in details of composition.

WELLSVILLE, FREMONT COUNTY

252. The water issues from a tunnel about 30 feet long driven into the Carboniferous formation. The flow is large, and the temperature is about 94° F. The development consists of several plunges, a swimming pool and bath houses. The place appears to have been a popular resort, but it is now neglected.

SPRINGS NOT ANALYZED

Hunt Springs are a group of about a dozen cold springs issuing at the foot of a small lava hill in Sec. 3, T. 44 N., R. 8 E., about 4 miles east of Saguache. They were not tested.

Antelope Springs are near the middle of the south side of the Luis Maria Baca Spanish grant in Saguache County.

Medano Springs are in the great sand dune area in T. 40 N., R. 12 E., Alamosa County. They are believed to represent the reappearance of the waters of Medano and Mosca creeks.

Washington Springs are in the sand hills just north of the Denver and Rio Grande Railroad in Sec. 14, T. 37 N., R. 11 E., about 8 miles east of Alamosa, Alamosa County. Since the development of the artesian waters of the vicinity the springs have been neglected.

Dexter Spring is on the Austin ranch in Sec. 9, T. 35 N., R. 11 E., about 2 miles northeast of the McIntyre Springs, in Conejos County. The water issues from the edge of the lava bench, and has a temperature of 71° F. An analysis of the water shows that it contains only 198 parts of solids per million.

Russell Springs are in Sec. 24, T. 43 N., R. 7 E. They rise in an area underlain by a peaty black mud. The group includes about 25 springs whose waters have no taste and deposit no mineral matter.

GENERAL CHARACTER OF SOME FAMOUS EUROPEAN MINERAL WATERS

Aix la Chapelle (Germany),—Numerous hot springs ranging up to a temperature of 172° F. They differ but little in composition. A typical analysis shows, in milligrams per liter:

Sodium chloride	2,640.0
Sodium bicarbonate	920.0
Sodium sulphate	150.0
Sodium sulphide	11.0
Calcium bicarbonate	230.0
Magnesium bicarbonate	77.0
Iron bicarbonate	13.0
	4041.0

Sulphureted hydrogen.

Aix la Bains (France),—Two hot springs of very great flow but feeble mineralization. The waters contain considerable organic matter. The total salt content is only 499 milligrams per liter and is mainly bicarbonate of lime. Sulphureted hydrogen occompanies the water.

Apenta (Hungary),—A cold water from shallow depths containing mainly magnesium and sodium sulphates. The analysis shows in milligrams per liter.:

Magnesium sulphate	23,430.0
Sodium sulphate	15,530.0
Calcium and potassium sulphates	2,670.0
Sodium carbonate	1,010.0
Sodium chloride	1,720.0
Iron in oxide form	50.0
	44,410.0

Apollinaris (Germany),—A group of springs yielding a typical alkaline carbonated table water. The analysis shows in milligrams per liter:

Sodium carbonate	1,250.0
Magnesium carbonate	465.0
Sodium chloride	421.0
Sodium sulphate	250.0
Calcium carbonate	250.0
Iron protoxide	3.0
	2,639.0

Carbon dioxide, rich.

Baden-Baden (Germany),—A large number of hot sodium chloride springs of very similar composition, and ranging in temperature from 112° to 154° F. Analyses show in milligrams per liter:

Sodium chloride	2,000.0
Calcium chloride	160.0
Calcium carbonate	160.0
Lithium chloride	53.0
	2,373.0

Arsenic, trace.

Bath (England),—Three hot springs of weak mineralization and ranging in temperature from 104° to 120° F. The principal salts are, in milligrams per liter:

Calcium sulphate	1,300.0
Sodium sulphate	300.0
Sodium chloride	200.0
Magnesium chloride	200.0
Potassium sulphate	100.0
Calcium carbonate	100.0
Carbonate of iron	20.0
Nitrogen, argon, helium	....
	2,220.0

The waters are radioactive.

Buxton (England),—A simple thermal spring having a temperature of 82° F., and a very weak mineralization. The saline constituents are calcium bicarbonate, magnesium bicarbonate and sodium chloride.

Carlsbad (Austria): About twenty springs of the same composition but different temperatures which range from 48° to 162° F. The waters contain in milligrams per liter:

Sodium sulphate	2,400.0
Sodium bicarbonate	1,200.0
Sodium chloride	1,000.0
	4,600.0

Contrexville (France),—A number of springs of *cold earthy calcareous waters* in which the principal saline constituents are calcium sulphate and calcium carbonate. Minute quantities of sodium sulphate, magnesium sulphate, magnesium carbonate, and even smaller quantities of iron carbonate, lithium carbonate, sodium chloride and potassium chloride.

Dax (France),—Many very hot feebly mineralized springs carrying considerable organic matter. The saline matter amounts to about one gramme per liter and consists mainly of calcium, sodium and potassium sulphates, calcium and magnesium carbonates, calcium silicate, and traces of iron, manganese, iodine and bromine.

In the same neighborhood are strong salt springs, sulphur springs, and sulphur and salt springs which are also used.

The vegeto-mineral mud baths are much used.

Elster (Germany),—Chiefly cold alkaline, saline, gaseous, chalybeate springs. The richest of the springs contains in milligrams per liter:

Sodium sulphate	5,200.0
Sodium bicarbonate	1,600.0
Sodium chloride	800.00
Iron bicarbonate	60.0
	7,660.0

Carbon dioxide abundant.

Some of the springs are richer in iron and one is said to contain a "remarkable quantity of lithium."

Ems (Germany),—Hot and warm springs of the alkaline-saline group. The waters contain about 2,000 milligrams of sodium bicarbonate, and 1,000 milligrams of sodium chloride per liter. They also contain a little lime and magnesia, and yield much carbon dioxide. One spring is mildly chalybeate.

Evian (Switzerland),—Five very feebly mineralized cold springs accompanied by oxygen, nitrogen and carbon dioxide. The saline constituents total less than 500 milligrams per liter, and are in order of importance: Calcium bicarbonate, magnesium bicarbonate, sodium bicarbonate, sodium sulphate, potassium sulphate and sodium chloride.

Franzensbad (Bohemia),—Twelve cold mineral springs, some of which contain a notable amount of iron. The moor or mud baths are also noted. Typical analyses of the spring waters show in milligrams per liter:

Sodium sulphate	2,802.0	1,614.0
Sodium carbonate	677.0	574.0
Sodium chloride	1,140.0	612.0
Calcium carbonate	183.0	199.0
Magnesium carbonate	103.0	53.0
Iron carbonate	3.0	78.0
	4,908.0	3,130.0

Harrogate (England),—Large number of cold sulphur springs of varying strength, most of them containing sodium sulphide, sodium chloride and sulphureted hydrogen gas. A few have notable amounts of iron in chloride, sulphate or carbonate form. Aluminum, calcium and magnesium sulphates are found in some springs, and at least one contains barium chloride.

Kissingen (Germany),—Several cold common salt springs of moderate strength and an abundance of carbon dioxide. The principal spring for drinking purposes contains 6,000 milligrams of sodium chloride, 1,000 milligrams of calcium carbonate, 30 milligrams of iron carbonate per liter, and a small quantity of the chlorides of magnesium, potassium and lithium. Mud baths are given and provision is made for pine-needle inhalation.

Monte Dore (France),—Eleven weakly mineralized hot springs differing but little in composition. Carbon dioxide accompanies the waters. There is one cold spring used for table purposes. The waters of all the springs are weakly alkaline, the chief salts in milligrams per liter being:

Sodium bicarbonate	530.0
Sodium chloride	360.0
Iron bicarbonate	20.0
Silica	160.0

Great stress is laid upon the presence of a very minute trace of arsenic.

Nauheim (Germany),—Several warm springs of which three are used exclusively for bathing, and two exclusively for drinking. The most important bathing spring contains in milligrams per liter:

Sodium chloride	25,000.0
Calcium chloride	2,500.0
Iron bicarbonate	Small amount
Carbon dioxide	Much

The principal drinking spring contains in milligrams per liter:

Sodium chloride	10,000 to 15,000
Calcium chloride	1,000

Carbon dioxide, considerable.

The waters of the drinking springs are diluted before used.

Plombieres (France),—Thirty very weakly mineralized thermal springs ranging in temperature from 55° to 165° F., and one cold ferruginous spring.

The principal constituents of the waters are silicate of aluminum, bicarbonate of sodium and traces of arsenic, making a total solid content of about 390 milligrams per liter:

Royat les Bains (France),—Four or more thermal springs of alkaline common salt water containing a small amount of arsenic, iron and lithium. The Eugenie spring is mineralized as follows, in milligrams per liter:

Bicarbonates of sodium, calcium and magnesium	3,460.0
Sodium chloride	1,720.0
Lithium chloride	35.0
Iron and manganese salts	56.0
Arsenic	Trace
Other minor constituents	349.0
	5,620.0

Salso Maggiore (Italy),—The oil wells of this resort yield strong brine and natural gas. Common salt is separated from the brine. For medicinal purposes the pure brine may be used or the mother liquor from which the common salt has been separated. For some baths the brine is diluted with pure hot water, for others sodium carbonate is added and the water concentrated. Mud baths are also given. The waters are not used for drinking. Analysis shows the brine contains in milligrams per liter:

Sodium chloride	146,300.00
Chlorides of calcium, magnesium, ammonium, strontium and lithium	22,060.00

Iodine and bromine compounds are present in appreciable quantity. The mother liquor is much richer in all the constituents except the sodium chloride.

Spa (Belgium),—Springs of almost pure gaseous chalybeate waters containing much carbon dioxide. The strongest spring contains: Bicarbonate of iron 112 milligrams per liter and small quantities of sodium bicarbonate and sodium chloride. Mud or turf baths are also given.

Vichy (France),—Simple alkaline springs rich in sodium bicarbonate. They also contain the bicarbonates of potassium, magnesium, strontium, and calcium, chloride and phosphate of sodium. Some of the springs contain a trace of arsenic, and several have carbonate of iron.

CHAPTER X

ANALYSES

NUMBER 1

GOLDEN LITHIA WATER

Location—¼ mile south of Arapahoe Station on Leyden Electric.

Rate of Flow—.............. Temperature—54° F.

Class of Water—Sodic, calcic, sulphated, saline, potassic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	28.5	....
Sulphate	SO_4	1999	36.66
Bicarbonate	HCO_3	630.2	9.10
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	171	4.24
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	Trace	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	441.4	19.41
Magnesium	Mg	73.2	5.29
Potassium	K	117	2.65
Sodium	Na	591.9	22.65
Lithium	Li	High trace	....
	Total	4052.2	100.00

Concentration value	113.58	Excess carbon dioxide	227.3
Hydrogen sulphide, H_2S	None	Iron precipitated	3.05
Arsenic, As	....	Evaporation solids	3990
Strontium, Sr	....	Oxygen consuming capacity	2.60

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	High trace	Calc. bicarb., $Ca(HCO_3)_2$	837.3
Pot. chlor., KCl	223.1	Iron and alum. oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	107.0		
Sod. sulph., Na_2SO_4	1698.1	Calc. silicate, $CaSiO_3$	....
Mag. sulph., $MgSO_4$	362.4	Silica, SiO_2	28.5
Calc. sulph., $CaSO_4$	795.8	Mang. oxide, Mn_3O_4	....
Ferrous bicarb., $Fe(HCO_3)_2$	....	Mag. bicarb., $Mg(HCO_3)_2$	....
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	....
			4052.2

Properties of Reaction in Percent

Primary salinity	50.60	Primary alkalinity	....
Secondary salinity	31.20	Secondary alkalinity	18.20
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 11. Temperature, °F, 51.8.
Curies Ra Emanation per liter x 10^{-10}, Water, 2.15.
Mache Units per liter, Water, 0.58.

NUMBER 2

CONUNDRUM

Location—Near head of Conundrum Creek, Aspen.

Rate of Flow—20 to 25 gal. per min. Temperature—100° F.

Class of water—Calcic, sulphated, saline, carbondioxated.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	44.4	....
Sulphate	SO_4	1521.6	46.66
Bicarbonate	HCO_3	37.4	.90
Silicate	SiO_3	....	2.16
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	6.8	.28
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	5.0	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	626.7	46.05
Magnesium	Mg	8.6	1.04
Potassium	K	9	.34
Sodium	Na	40.3	2.57
Lithium	Li	None	
Oxygen to form SiO_3		11.8	
	Total	2311.6	100.00

Concentration value	67.98	Excess carbon dioxide	13.5
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	2262
Strontium, Sr	....	Oxygen consuming capacity	0.78

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	None	Iron and alum. oxides,	
Pot. chlor., KCl	14.3	Fe_2O_3, Al_2O_3	5.0
Sod. chlor., NaCl	....	Calc. silicate, $CaSiO_3$	85.7
Sod. sulph., Na_2SO_4	124.5	Silica, SiO_2	....
Mag. sulph., $MgSO_4$	42.6	Mang. oxide, Mn_3O_4	....
Calc. sulph., $CaSO_4$	1986.5	Mag. bicarb., $Mg(HCO_3)_2$	....
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	....
Ferrous bicarb., $Fe(HCO_3)_2$	....	Pot. sulph., K_2SO_4	3.3
Calc. bicarb., $Ca(HCO_3)_2$	49.7		
Total			2311.6

Properties of Reaction in Per Cent

Primary salinity	5.82	Primary alkalinity	....
Secondary salinity	88.06	Secondary alkalinity	6.12
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 3

COLD SULPHUR SPRING

Location—250 yds. north of State Bridge over Gunnison River.

Rate of Flow—12 to 15 gal. per min. Temperature—62° F.

Class of Water—Sodic, bicarbonated, muriated, sulphated, alkaline-saline, potassic, (sulphuretted, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	24.2	....
Sulphate	SO_4	1764	10.91
Bicarbonate	HCO_3	3057.4	14.88
Carbonate	CO_3	None	....
Phosphate	PO_4	Trace	....
Chloride	Cl	2890	24.21
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	Trace	....
Aluminum oxide	Al_2O_3		....
Manganese	Mn	None	....
Calcium	Ca	86.1	1.28
Magnesium	Mg	50.5	1.23
Potassium	K	567	4.32
Sodium	Na	3344	43.17
Lithium	Li	Trace	....
	Total	11783.1	100.00

Concentration value	336.82	Excess carbon dioxide	1104
Hydrogen sulphide, H_2S	17.8	Iron precipitated	None
Arsenic, As	....	Evaporation solids	10209
Strontium, Sr	....	Oxygen consuming capacity	16.3

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	348.2
Pot. chlor., KCl	1081.0	Iron and alum. oxides, Fe_2O_3, Al_2O_3	Trace
Sod. chlor., NaCl	3917.0	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	2608.6	Silica, SiO_2	24.2
Mag. sulph., $MgSO_4$	....	Mang. oxide., Mn_3O_4	....
Calc. sulph., $CaSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	303.9
Calc. carb., $CaCO_3$	....	Sod. bicarb, $NaHCO_3$	3500.2
Ferrous bicarb., $Fe(HCO_3)_2$	....		
Total			11783.1

Properties of Reaction in Per Cent

Primary salinity	70.24	Primary alkalinity	24.74
Secondary salinity	....	Secondary alkalinity	5.02
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 15.5. Temperature, °F, 60.

Curies Ra Emanation per liter x 10^{-10}, Water 1.53.

Mache Units per liter, Water, 0.41.

NUMBER 4

ALKALI SPRING

Location—Between No. 3 and State Bridge, Austin.

Rate of Flow—2 to 3 gal. per min. Temperature—72° F.

Class of Water—Sodic, muriated, bicarbonated, sulphated, alkaline-saline, potassic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	22.8	....
Sulphate	SO_4	1699.2	7.68
Bicarbonate	HCO_3	4542.4	16.16
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	4275	26.16
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	Trace	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	34.3	.37
Magnesium	Mg	57.6	1.03
Potassium	K	650.0	3.60
Sodium	Na	4768.3	45.00
Lithium	Li	Trace	....
	Total	16049.6	100.00

Concentration value	460.83	Excess carbon dioxide	1638
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	13927
Strontium, Sr	....	Oxygen consuming capacity	16.1

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	138.7
Pot. chlor., KCl	1239.5	Iron and alum. oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	6076.0	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	2512.8	Silica, SiO_2	22.8
Mag. sulph., $MgSO_4$	....	Mang. oxide., Mn_3O_4	....
Calc. sulph., $CaSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	346.4
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_2$	5713.4
Ferrous bicarb., $Fe(HCO_3)_2$	Trace		
Total			16049.6

Properties of Reaction in Per Cent

Primary salinity	67.68	Primary alkalinity	29.52
Secondary salinity	....	Secondary alkalinity	2.80
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 4a

BLACK CANYON OIL COMPANY'S WELL—DELTA WELL

Location—Austin.

Rate of Flow—........ Temperature—........

Class of Water—Sodic, lithic, muriated, saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	19.0	....
Sulphate	SO_4	2877.4	4.72
Bicarbonate	HCO_3	3692.8	4.76
Carbonate	CO_3	....	....
Phosphate	PO_4	....	....
Chloride	Cl	18242.3	40.52
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	23.4	....
Aluminum oxide	Al_2O_3		
Manganese oxide	Mn_3O_4	12.2	....
Calcium	Ca	1416.1	5.56
Magnesium	Mg	248.9	1.61
Potassium	K	1001.6	2.02
Sodium	Na	11823.9	40.48
Lithium	Li	28.6	.33
	Total	39386.2	100.00

Concentration value	1270.00	Excess carbon dioxide	550
Hydrogen sulphide, H_2S	....	Iron Precipitated	....
Arsenic, As	....	Evaporation solids	....
Strontium, Sr	....		

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	173.1	Calc. bicarb., $Ca(HCO_3)_2$	4906.0
Pot. chlor., KCl	1909.1	Iron and alum. oxides, Fe_2O_3, Al_2O_3	23.4
Sod. chlor., NaCl	28340.0	Calc. silicate, $CaSiO_3$	0.0
Sod. sulph., Na_2SO_4	2081.0	Silica, SiO_2	19.0
Mag. sulph., $MgSO_4$	1232.0	Mang. Oxide, Mn_3O_4	12.2
Calc. sulph., $CaSO_4$	690.4	Mang. bicarb., $Mg(HCO_3)_2$	0.0
Calc. carb., $CaCO_3$	0.0	Sod. bicarb., $NaHCO_3$	0.0
Ferrous bicarb., $Fe(HCO_3)_2$	0.0		
Total			39386.2

Properties of Reaction in Per Cent

Primary salinity	85.66	Primary alkalinity	....
Secondary salinity	4.82	Secondary alkalinity	9.52
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 5

BATH HOUSE SPRING

Location—3 miles down the river from Redstone.

Rate of Flow—30 to 35 gal. per min. Temperature—112° F.

Class of Water—Calcic, sodic, sulphated, alkaline-saline, magnesic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	78.1	....
Sulphate	SO_4	1068	29.67
Bicarbonate	HCO_3	524.1	11.45
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	236	8.88
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	Trace	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	403.3	26.87
Magnesium	Mg	59.39	6.51
Potassium	K	25	.85
Sodium	Na	272.2	15.77
Lithium	Li	Trace	....
	Total	2666.1	100.00

Concentration value	75.00	Excess carbon dioxide	189
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	2656
Strontium, Sr	....	Oxygen consuming capacity	0.58

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. carb., $Ca(HCO_3)_2$	696.3
Pot. chlor., KCl	47.67	Iron and alum. oxides, Fe_2O_3, Al_2O_3	Trace
Sod. chlor., NaCl	351.7	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	413.3	Silica, SiO_2	78.1
Mag. sulph., $MgSO_4$	294.0	Mang. oxide., Mn_3O_4	....
Calc. sulph., $CaSO_4$	785.0	Mag. bicarb., $Mg(HCO_3)_2$	....
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	....
Ferrous bicarb., $Fe(HCO_3)_2$	....		

Total 2666.07

Properties of Reaction in Per Cent

Primary salinity	33.24	Primary alkalinity	....
Secondary salinity	43.86	Secondary alkalinity	22.90
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 44.5. Temperature, °F, 112.1.

Curies Ra Emanation per liter x 10^{-10}, Water, 6.70.

Mache Units per liter, Water, 1.81.

NUMBER 6

IRON SPRING

Location—2½ miles down Crystal River from Avalanche.

Rate of Flow—50 gal. per min. Temperature—54° F.

Class of Water—Calcic, sulphated, saline, magnesic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	7.5	....
Sulphate	SO_4	1203.1	43.47
Bicarbonate	HCO_3	224.6	6.36
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	3.4	.17
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	Trace	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	471.8	40.86
Magnesium	Mg	50.37	7.17
Potassium	K	Trace	....
Sodium	Na	26.4	1.97
Lithium	Li	None	....
	Total	1987.2	100.00

Concentration value	57.76	Excess carbon dioxide	81.0
Hydrogen sulphide, H_2S	None	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	1903
Strontium, Sr	....	Oxygen consuming capacity	0.58

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	....	Calc. bicarb., $Ca(HCO_3)_2$	298.4
Pot. chlor., KCl	Trace	Iron and alum. oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	5.6	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	74.7	Silica, SiO_2	7.5
Mag. sulph., $MgSO_4$	249.3	Mang. oxide., Mn_3O_4	....
Calc. sulph., $CaSO_4$	1351.7	Mag. bicarb., $Mg(HCO_3)_2$	....
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	....
Ferrous bicarb., $Fe(HCO_3)_2$	....		
Total			1987.2

Properties of Reaction in Per Cent

Primary salinity	3.94	Primary alkalinity	....
Secondary salinity	83.34	Secondary alkalinity	12.72
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 7

HOT IRON SPRING

Location—In meadow ¼ mile below Avalanche.

Rate of Flow—100 gal. per min. Temperature—122° F.

Class of Water—Calcic, sodic, bicarbonated, sulphated, alkaline-saline, potassic, ferruginous, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	85.4	....
Sulphate	SO_4	1226	30.19
Bicarbonate	HCO_3	611.5	11.85
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	239.4	7.96
Iron	Fe	....	.53
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	18.2	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	368.8	21.77
Magnesium	Mg	51.6	5.02
Potassium	K	191	5.76
Sodium	Na	329.2	16.92
Lithium	Li	Trace	....
		3121.1	100.00
Oxygen in Fe_2O_3		5.5	
	Total	3115.6	

Concentration value	84.64	Excess carbon dioxide	220.5
Hydrogen sulphide, H_2S	None	Iron precipitated	2.19
Arsenic, As	....	Evaporation solids	2850
Strontium, Sr.	....	Oxygen consuming capacity	1.17

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	775.5
Pot. chlor., KCl	364.2	Iron and alum. oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	109.1	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	884.2	Silica, SiO_2	85.4
Mag. sulph., $MgSO_4$	255.5	Mang. oxide., Mn_3O_4	....
Calc. sulph., $CaSO_4$	601.2	Mag. bicarb., $Mg(HCO_3)_2$	....
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	....
Ferrous bicarb., $Fe(HCO_3)_2$	40.5		
			3115.6

Properties of Reaction in Per Cent

Primary salinity	45.36	Primary alkalinity	....
Secondary salinity	30.94	Secondary alkalinity	22.64
Tertiary salinity	....	Tertiary alkalinity	1.06

Radioactivity

Temperature, °C, 48. Temperature, °F, 118.5.

Curies Ra Emanation per liter x 10^{-10}, Gas, 27.84.

Mache Units per liter, Gas, 7.52.

NUMBER 8

HOT IRON SPRING

Location—100 yds. above No. 7, Avalanche.

Rate of Flow—.......... Temperature—118° F.

Class of Water—Sodic, calcic, sulphated, alkaline-saline, ferruginous, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	78.6	....
Sulphate	SO_4	1241	29.51
Bicarbonate	HCO_3	561.6	10.48
Silicate	SiO_3	....	2.97
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	218.9	7.04
Iron	Fe	....	.49
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	17.2	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	392.3	22.37
Magnesium	Mg	50.8	4.76
Potassium	K	17.5	.50
Sodium	Na	441.5	21.88
Lithium	Li	None	....
Oxygen to form SiO_3		20.8	....
		3040.2	100.00
Oxygen in Fe_2O_3		5.2	
		3035.0	

Concentration value	87.75	Excess carbon dioxide	202.5
Hydrogen sulphide, H_2S	None	Iron precipitated	2.04
Arsenic, As	....	Evaporation solids	2779
Strontium, Sr	....	Oxygen consuming capacity	0.73

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	....	Calc. bicarb., $Ca(HCO_3)_2$	711.2
Pot. chlor., KCl	33.38	Iron and alum. oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	334.7	Calc. silicate, $CaSiO_3$	151.7
Sod. sulph., Na_2SO_4	956.8	Silica, SiO_2	....
Mag. sulph., $MgSO_4$	251.5	Mang. oxide., Mn_3O_4	....
Calc. sulph., $CaSO_4$	557.4	Mag. bicarb., $Mg(HCO_3)_2$	....
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	....
Ferrous bicarb., $Fe(HCO_3)_2$	38.32		
Total			3035.0

Properties of Reaction in Per Cent

Primary salinity	44.76	Primary alkalinity	....
Secondary salinity	28.34	Secondary alkalinity	25.92
Tertiary salinity	....	Tertiary alkalinity	.98

NUMBER 9

RIVER SPRING

Location—Within 2 ft. of the river, Avalanche.

Rate of Flow—2 to 3 gal. per min. Temperature—129° F.

Class of Water—Calcic, sodic, sulphated, saline, potassic, ferruginous, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	98.0	....
Sulphate	SO_4	1214	31.33
Bicarbonate	HCO_3	472.6	9.60
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	259.9	9.07
Iron	Fe	....	.41
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	13.5	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	382.8	23.70
Magnesium	Mg	48.1	4.89
Potassium	K	90	2.85
Sodium	Na	337	18.15
Lithium	Li	Trace	....
		2915.9	100.00
Oxygen in Fe_2O_3		4.1	
	Total	2911.8	

Concentration value	80.75	Excess carbon dioxide	170.4
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	2479
Strontium, Sr	....	Oxygen consuming capacity	0.63

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	Trace	Calc. bicarb., $Ca(HCO_3)_2$	600.5
Pot. chlor., KCl	171.6	Iron and alum. oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., $NaCl$	293.9	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	683.9	Silica, SiO_2	98.0
Mag. sulph., $MgSO_4$	238.2	Mang. oxide, Mn_3O_4	....
Calc. sulph., $CaSO_4$	795.8	Mag. bicarb., $Mg(HCO_3)_2$	....
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	....
Ferrous bicarb., $Fe(HCO_3)_2$	30.1		

Total 2911.9

Properties of Reaction in Per Cent

Primary salinity	42.00	Primary alkalinity	....
Secondary salinity	38.80	Secondary alkalinity	18.38
Tertiary salinity	....	Tertiary alkalinity	.82

NUMBER 10

HOT SULPHUR SPRING

Location—50 yds. below No. 5.

Rate of Flow—50 to 75 gal. per min. Temperature—134° F.

Class of Water—Sodic, calcic, bicarbonated, sulphated, alkaline-saline, ferruginous, (sulphuretted and carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	94.8	....
Sulphate	SO_4	1072	28.99
Bicarbonate	HCO_3	599	12.74
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	225.7	8.27
Iron	Fe	....	.30
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	9.0	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	341.5	22.15
Magnesium	Mg	43.3	4.62
Potassium	K	28	.93
Sodium	Na	390.1	22.00
Lithium	Li	Trace	....
		2803.4	100.00
Oxygen in Fe_2O_3		2.7	
		2800.7	

Concentration value	77.06	Excess carbon dioxide	216.0
Hydrogen sulphide, H_2S	5.67	Iron precipated	None
Arsenic, As	....	Evaporation solids	2600
Strontium, Sr	....	Oxygen consuming capacity	0.78

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	777.6
Pot. chlor., KCl	53.4	Iron and alum. oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	330.2	Calc. silicate, $CaSiO_3$	....
Sod. sulph, Na_2SO_4	803.7	Silica, SiO_2	94.8
Mag. sulph., $MgSO_4$	214.3	Mang. oxide, Mn_3O_4	....
Calc. sulph., $CaSO_4$	506.7	Mag. bicarb., $Mg(HCO_3)_2$	....
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	....
Ferrous bicarb., $Fe(HCO_3)_2$	20.1		

Total 2800.8

Properties of Reaction in Per Cent

Primary salinity	45.86	Primary alkalinity	....
Secondary salinity	28.66	Secondary alkalinity	24.88
Tertiary salinity	....	Tertiary alkalinity	.60

NUMBER 11

COLORADO CARLSBAD WATER

Location—6 mi. E. of Barr.

Rate of Flow—.............. Temperature—54° F.

Class of Water—Sodic, sulphated, saline, magnesic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	23.3	....
Sulphate	SO_4	871.2	32.28
Bicarbonate	HCO_3	313.2	9.14
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	171	8.58
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	Trace	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	126.9	11.32
Magnesium	Mg	40.8	5.99
Potassium	K	32.5	1.44
Sodium	Na	404.2	31.25
Lithium	Li	None	....
	Total	1983.1	100.00

Concentration value	56.16	Excess carbon dioxide	112.9
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	1894
Strontium, Sr	....	Oxygen consuming capacity	1.66

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	....	Calc. bicarb., $Ca(HCO_3)_2$	416.1
Pot. chlor., KCl	62.0	Iron and alum. oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	233.3	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	964.9	Silica, SiO_2	23.3
Mag. sulph., $MgSO_4$	202.0	Mang. oxide, Mn_3O_4	....
Calc. sulph., $CaSO_4$	81.5	Mag. bicarb., $Mg(HCO_3)_2$	....
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	....
Ferrous bicarb., $Fe(HCO_3)_2$	....		

Total 1983.1

Properties of Reaction in Per Cent

Primary salinity	65.38	Primary alkalinity	....
Secondary salinity	16.34	Secondary alkalinity	18.28
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 20.5. Temperature, °F, 69.0.
Curies Ra Emanation per liter x 10^{-10}, Water, trace.
Mache Units per liter, Water, trace.

NUMBER 12

BEULAH SPRING

Location—Inclosed spring on north bank of creek, 15 feet from creek, Beulah.

Rate of Flow—½ gal. per min. Temperature—58° F.

Class of Water—Sodic, calcic, bicarbonated, sulphated, alkaline-saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	40.7	....
Sulphate	SO_4	403.3	12.03
Bicarbonate	HCO_3	1149.24	26.94
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	274.0	11.03
Iron	Fe	....	.08
Aluminum	Al	....	....
Aluminum oxide	Al_2O_3	2.25	....
Iron oxide	Fe_2O_3		
Manganese	Mn	None	....
Calcium	Ca	178.6	12.76
Magnesium	Mg	40.96	4.82
Potassium	K	44.0	1.63
Sodium	Na	494.5	30.71
Lithium	Li	Trace	....
	Total	2627.55	100.00

Concentration value	69.93	Excess carbon dioxide	414.4
Hydrogen sulphide, H_2S	None	Iron precipitated	0.97
Arsenic, As	....	Evaporation solids	2126
Strontium, Sr	....	Oxygen consuming capacity	1.81

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	722.2
Pot. chlor., KCl	83.9	Iron and alum. oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	385.9	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	596.4	Silica, SiO_2	40.7
Mag. sulph., $MgSO_4$	....	Mang. oxide, Mn_3O_4	....
Calc. sulph., $CaSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	246.47
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	546.26
Ferrous bicarb, $Fe(HCO_3)_2$	5.01		
Total			2626.84

Properties of Reaction in Per Cent

Primary salinity	46.12	Primary alkalinity	18.56
Secondary salinity	....	Secondary alkalinity	35.32
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 13.5. Temperature, °F, 56.3.
Curies Ra Emanation per liter x 10^{-10}, Water, 26.75.
Mache Units per liter, Water, 7.22.

NUMBER 13

PAVILION SPRING

Location—In pavilion on south bank of creek, Beulah.

Rate of Flow—.............. Temperature—56° F.

Class of Water—Sodic, calcic, bicarbonated, sulphated, alkaline-saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	41.3	....
Sulphate	SO_4	396.0	12.74
Bicarbonate	HCO_3	1059.33	26.81
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	241.6	10.47
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	Trace	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	155.5	12.02
Magnesium	Mg	25.12	3.18
Potassium	K	17.0	.68
Sodium	Na	509.7	34.10
Lithium	Li	Trace	....
	Total	2445.55	100.00

Concentration value	64.75	Excess carbon dioxide	156.4
Hydrogen sulphide, H_2S	None	Iron precipitated	0.97
Arsenic, As	....	Evaporation solids	1960
Strontium, Sr	....	Oxygen consuming capacity	1.35

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	628.8
Pot. chlor., KCl	32.24	Iron and alum. oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	372.9		
Sod. sulph., Na_2SO_4	585.6	Calc. silicate, $CaSiO_3$	....
Mag. sulph., $MgSO_4$	....	Silica, SiO_2	41.3
Calc. sulph., $CaSO_4$	....	Mang. oxide, Mn_3O_4	....
Calc. carb., $CaCO_3$	....	Mag. bicarb., $Mg(HCO_3)_2$	151.16
Ferrous bicarb., $Fe(HCO_3)_2$	Trace	Sod. bicarb., $NaHCO_3$	633.3

Total 2445.48

Properties of Reaction in Per Cent

Primary salinity	46.42	Primary alkalinity	23.14
Secondary salinity	....	Secondary alkalinity	30.44
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 12.0. Temperature, °F, 53.7.
Mache units per liter, Water, 11.19.
Curies Ra Emanation per liter x 10^{-10}, Water, 41.44.

NUMBER 14

GREGORY CANYON SPRING

Location—¼ mile up Gregory Canyon on south side of creek, about 75 feet from creek.

Radioactivity

Temperature, °C, 10.0. Temperature, °F, 50.0.
Curies Ra Emanation per liter x 10^{-10}, Water, 4.33.
Mache Units per liter, Water, 1.17.

NUMBER 15

SANITARIUM SPRING

Location—Spring near creek on Sunshine Canyon road ,about 300 yards S. W. of Colorado Sanitarium.

Radioactivity

Temperature, °C, 15, 12.3 Temperature, °F, 59.1.
Curies Ra Emanation per liter x 10^{-10}, Water, 6.08, 14.7.
Mache Units per liter, Water, 1.64, 2.49.

NUMBER 16

CRYSTAL SPRING

Location—Spring near site of old Crystal Springs Brewery, between Arapahoe and Marine streets.

Radioactivity

Curies Ra Emanation per liter x 10^{-10}, Water, 12.61.
Mache Units per liter, Water, 3.40.

NUMBER 17

CHAUTAUQUA SPRING

Location—Spring in Bluebell Canyon, ¾ mile S. W. of Chautauqua.

Radioactivity

Temperature, °C, 10, 12.5. Temperature, °F, 50.
Curies Ra Emanation per liter x 10^{-10}, Water, 0.92, 2.7.
Mache Units per liter, Water, 0.25, 0.43.

NUMBER 18

COTTONWOOD SPRINGS

Location—6 miles west of Buena Vista.

Rate of Flow—100 to 150 gal. per min. Temperature—120° to 144° F.

Class of Water—Sodic, potassic, sulphated, carbonated, alkaline-saline.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	61.2	2.37
Sulphate	SO_4	108.03	23.21
Bicarbonate	HCO_3	79.24	13.40
Carbonate	CO_3	8.21	2.78
Phosphate	PO_4	None	....
Chloride	Cl	28.36	8.24
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	None	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	4.65	2.37
Magnesium	Mg	2.73	2.27
Potassium	K	34.2	9.07
Sodium	Na	81.0	36.29
Lithium	Li	Trace	....
Oxygen to form SiO_3		1.86	....
	Total	409.48	100.00

Concentration value	9.70	Excess carbon dioxide	28.57
Hydrogen sulphide, H_2S	None	Iron precipitated	....
Arsenic, As	....	Evaporation solids	382
Strontium, Sr	....	Oxygen consuming capacity	None

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Iron and alum. oxides, Fe_2O_3, Al_2O_3	....
Pot. chlor., KCl	59.63	Calc, silicate, $CaSiO_3$	13.5
Sod. chlor., NaCl	....	Silica, SiO_2	54.2
Sod. sulph., Na_2SO_4	154.5	Mang. oxide, Mn_3O_4	....
Mag. sulph., $MgSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	16.43
Calc. sulph., $CaSO_4$	....	Sod. bicarb., $NaHCO_3$	90.25
Calc. carb., $CaCO_3$	....	Pot. sulph., K_2SO_4	6.53
Ferrous bicarb., $Fe(HCO_3)_2$	....	Sod. carb., Na_2CO_3	14.51
Calc. bicarb., $Ca(HCO_3)_2$	....		

Total 409.55

Properties of Reaction in Per Cent

Primary salinity	62.90	Primary alkalinity	27.82
Secondary salinity	....	Secondary alkalinity	9.28
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 42.5. Temperature, °F, 108.5.
Curies Ra Emanation per liter x 10^{-10}, Water, 10.35.
Mache Units per liter, Water, 2.80.

NUMBER 20

FREMONT NATATORIUM

Location—3 mi. E. Canon City.

Rate of Flow—125 to 150 gal. per min. Temperature—99½° F.

Class of Water—Sodic, calcic, potassic, bicarbonated, sulphated, alkaline-saline, magnesic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	42.6	....
Sulphate	SO_4	584.5	27.15
Bicarbonate	HCO_3	563.8	20.63
Carbonate	CO_3	None	....
Phosphate	PO_4	Trace	....
Chloride	Cl	35.36	2.22
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	None	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	150.9	16.81
Magnesium	Mg	65.21	11.94
Potassium	K	79.7	4.55
Sodium	Na	172.0	16.70
Lithium	Li	Trace	....
	Total	1694.07	100.00

Concentration value	44.85	Excess carbon dioxide	203.3
Hydrogen sulphide,, H_2S	Slight Tr.	Iron precipitated	0.72
Arsenic, As	....	Evaporation solids	1376
Strontium, Sr.	....	Oxygen consuming capacity	0.93

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Iron and alum. oxides, Fe_2O_3, Al_2O_3	....
Pot. chlor., KCl	74.35	Calc. silicate, $CaSiO_3$	....
Sod. chlor, NaCl	....	Silica, SiO_2	42.6
Sod. sulph., Na_2SO_4	531.2	Mang. oxide, Mn_3O_4	....
Mag. sulph., $MgSO_4$	219.7	Mag. bicarb., $Mg(HCO_3)_2$	125.34
Calc. sulph., $CaSO_4$	....	Sod. bicarb, $NaHCO_3$	....
Calc. carb., $CaCO_3$	....	Pot. sulph., K_2SO_4	90.72
Ferrous bicarb., $Fe(HCO_3)_2$	....		
Calc. bicarb., $Ca(HCO_3)_2$	610.2		
Total			1694.11

Properties of Reaction in Per Cent

Primary salinity	42.50	Primary alkalinity	....
Secondary salinity	16.24	Secondary alkalinity	41.26
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 21

CANON CITY HOT SPRING

Location—Mouth of Royal Gorge, Canon City.

Rate of Flow—.............. Temperature—101° F.

Class of Water——Calcic, sodic, bicarbonated, muriated, alkaline-saline, magnesic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	26.1	....
Sulphate	SO_4	111.9	5.72
Bicarbonate	HCO_3	803.8	31.78
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	184.1	12.50
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	None	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	169.4	20.43
Magnesium	Mg	53.58	10.64
Potassium	K	33.2	2.05
Sodium	Na	160.8	16.88
Lithium	Li	Trace	....
	Total	1542.92	100.00

Concentration value	41.46	Excess carbon dioxide	289.9
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	1184
Strontium, Sr	....	Oxygen consuming capacity	1.8

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	685.0
Pot. chlor., KCl	63.31	Iron and alum. oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	253.9	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	165.5	Silica, SiO_2	26.1
Mag. sulph., $MgSO_4$	....	Mang. oxide, Mn_3O_4	....
Calc. sulph., $CaSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	322.4
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	26.77
Ferrous bicarb., $Fe(HCO_3)_2$	....		
Total			1542.98

Properties of Reaction in Per Cent

Primary salinity	36.44	Primary alkalinity	1.42
Secondary salinity	....	Secondary alkalinity	62.14
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 34.6. Temperature, °F, 94.2.
Curies Ra Emanation per liter x 10^{-10}, Water, 3.58.
Mache Units per liter, Water, 0.97.
Remarks—Sample taken from pipe.

NUMBER 22

SODA SPRING

Location—Near State Penitentiary, Canon City.

Rate of Flow—Small. Temperature—67° F.

Class of Water—Sodic, bicarbonated, muriated, alkaline-saline, potassic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	23.8	....
Sulphate	SO_4	171.5	2.81
Bicarbonate	HCO_3	1627.5	21.02
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	1177	26.17
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	None	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	120.4	4.73
Magnesium	Mg	48.12	3.12
Potassium	K	186.0	3.75
Sodium	Na	1120.5	38.40
Lithium	Li	Trace	....
	Total	4474.82	100.00

Concentration value	126.92	Excess carbon dioxide	586.9
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	3886
Strontium, Sr	....	Oxygen consuming capacity	1.8

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	486.9
Pot. chlor., KCl	354.7	Iron and alum. oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	1662.3	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	253.6	Silica, SiO_2	23.8
Mag. sulph., $MgSO_4$	....	Mang. oxide, Mn_3O_4	....
Calc. sulph., $CaSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	289.6
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	1403.95
Ferrous bicarb., $Fe(HCO_3)_2$	....		4474.85

Properties of Reaction in Per Cent

Primary salinity	57.96	Primary alkalinity	26.34
Secondary salinity	....	Secondary alkalinity	15.70
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 19.5. Temperature, °F, 67.
Remarks—Sample taken from pipe.

NUMBER 23

IRON DUKE SPRING

Location—State Penitentiary, Canon City.

Rate of Flow—1 gal. per min. Temperature—64° F.

Class of Water—Sodic, bicarbonated, muriated, alkaline-saline, potassic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	22.3	....
Sulphate	SO_4	167.3	3.02
Bicarbonate	HCO_3	1624.0	23.17
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	970.8	23.81
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	None	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	114.2	4.96
Magnesium	Mg	54.29	3.89
Potassium	K	80.0	1.77
Sodium	Na	1041.2	39.38
Lithium	Li	Trace	....
	Total	4074.1	100.00

Concentration value	114.98	Excess carbon dioxide	585.6
Hydrogen sulphide, H_2S	None	Iron precipitated	0.52
Arsenic, As	....	Evaporation solids	3379
Strontium, Sr	....	Oxygen consuming capacity	2.25

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	461.8
Pot. chlor., KCl	152.6	Iron and alum. oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	1480.8	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	247.4	Silica, SiO_2	22.3
Mag. sulph., $MgSO_4$	....	Mang. oxide, Mn_3O_4	....
Calc. sulph, $CaSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	326.7
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	1382.4
Ferrous bicarb., $Fe(HCO_3)_2$	....		
Total			4074.0

Properties of Reaction in Per Cent

Primary salinity	53.66	Primary alkalinity	28.64
Secondary salinity	....	Secondary alkalinity	17.70
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 15.6. Temperature, °F, 60.1.
Curies Ra Emanation per liter x 10^{-10}, Water, 2.05.
Mache Units per liter, Water, 0.55.

NUMBER 24

IRON SODA SPRING—GRAPE CREEK SPRING

Location—On Grape Creek above Canon City.

Rate of Flow—2 to 2½ gal. per min. Temperature—56° F.

Class of Water—Sodic, bicarbonated, muriated, alkaline-saline, magnesic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	91.1	....
Sulphate	SO_4	176.4	1.83
Bicarbonate	HCO_3	3525	28.74
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	1385	19.43
Iron	Fe	....	.14
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	11.0	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	193.7	4.81
Magnesium	Mg	192.2	7.85
Potassium	K	Trace	....
Sodium	Na	1719.6	37.20
Lithium	Li	None	....
		7294.0	100.00
Oxygen in Fe_2O_3		3.3	
	Total	7290.7	

Concentration value	201.05	Excess carbon dioxide	1271.1
Hydrogen sulphide, H_2S	None	Iron precipitated	3.63
Arsenic, As	....	Evaporation solids	6039
Strontium, Sr	....	Oxygen consuming capacity	2.68

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	....	Calc. bicarb., $Ca(HCO_3)_2$	783.2
Pot. chlor., KCl	Trace	Iron and alum. oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	2283.3	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	260.9	Silica, SiO_2	91.9
Mag. sulph., $MgSO_4$	....	Mang. oxide, Mn_3O_4	....
Calc. sulph., $CaSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	1156.3
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	2691.4
Ferrous bicarb., $Fe(HCO_3)_2$	24.5		
Total			7290.7

Properties of Reaction in Per Cent

Primary salinity	42.52	Primary alkalinity	31.88
Secondary salinity	....	Secondary alkalinity	25.60
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 25

GREEN'S WELL

Location—Canon City.

Radioactivity

Temperature, °C, 14. Temperature, °F, 57.4.

Curies Ra Emanation per liter x 10^{-10}, Water, 1.04.

Mache Units per liter, Water, 0.28.

NUMBER 26

SULPHUR SPRING

Location—West bank of Roaring Fork Creek, 3 mi. South of Cardiff.

Radioactivity

Temperature, °C, 8.5. Temperature, °F, 47.4.

Curies Ra Emanation per liter x 10^{-10}, 5.85.

Mache Units per liter, Water, 1.58.

NUMBER 27

CARLILE IRON AND SODA SPRING

Location—½ mi. west of switch at Carlile.

Rate of Flow—12 to 15 gal. per min. Temperature—67° F.

Class of Water—Sodic, calcic, bicarbonated, sulphated, alkaline-saline, magnesic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	14.2	....
Sulphate	SO_4	303.5	12.30
Bicarbonate	HCO_3	986.8	31.47
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	113.4	6.23
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	Trace	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	160.5	15.62
Magnesium	Mg	63.35	10.13
Potassium	K	46.2	2.30
Sodium	Na	259.5	21.95
Lithium	Li	Trace	....
	Total	1947.45	100.00

Concentration value	51.40	Excess carbon dioxide	355.8
Hydrogen sulphide, H_2S	None	Iron precipitated	0.97
Arsenic, As	....	Evaporation solids	1390
Strontium, Sr	....	Oxygen consuming capacity	1.13

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	649.0
Pot. chlor., KCl	88.1	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	117.4	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	448.8	Silica, SiO_2	14.2
Mag. sulph., $MgSO_4$	....	Mang. oxide, Mn_3O_4	....
Calc. sulph., $CaSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	381.2
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	248.4
Ferrous bicarb., $Fe(HCO_3)_2$	Trace		
Total			1947.1

Properties of Reaction in Per Cent

Primary salinity	37.06	Primary alkalinity	11.44
Secondary salinity	....	Secondary alkalinity	51.50
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 18.5. Temperature, °F, 65.3.

Curies Ra Emanation per liter x 10^{-10}, Water, 16.80; Gas, 78.0.

Mache Units per liter, Water, 4.54; Gas, 21.05.

Permanent Activity, Grams Ra per liter x 10^{-10}, 0.074.

NUMBER 28

SODA SPRING

Location—East side of creek on mountain side, Cimarron.

Rate of Flow—½ gal. per minute. Temperature—56° F.

Class of Water—Sodic, bicarbonated, sulphated, alkaline-saline, potassic, ferruginous, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	10.8	....
Sulphate	SO_4	333.0	10.50
Bicarbonate	HCO_3	1317.6	32.80
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	157.3	6.70
Iron	Fe	....	.18
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	5.0	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	141.5	10.73
Magnesium	Mg	36.0	4.49
Potassium	K	100	3.88
Sodium	Na	466	30.72
Lithium	Li	Trace	....
		2567.2	100.00
Oxygen in Fe_2O_3		1.5	
	Total	2565.7	

Concentration value	65.96	Excess carbon dioxide	475.2
Hydrogen sulphide, H_2S	None	Iron precipitated	3.71
Arsenic, As	....	Evaporation solids	1902
Strontium, Sr	....	Oxygen consuming capacity	1.07

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	572.2
Pot. chlor., KCl	190.7	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	109.8	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	492.4	Silica, SiO_2	10.8
Mag. sulph., $MgSO_4$	....	Mang. oxide, Mn_3O_4	....
Calc. sulph., $CaSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	216.6
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	962.1
Ferrous bicarb., $Fe(HCO_3)_2$	11.1		
Total			2565.7

Properties of Reaction in Per Cent

Primary salinity	34.40	Primary alkalinity	34.80
Secondary salinity	....	Secondary alkalinity	30.80
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 14.5. Temperature, °F, 58.1.
Curies Ra Emanation per liter x 10^{-10}, Water, 21.02
Mache Units per liter, Water, 5.68.

NUMBER 29

RANGER'S SPRING

Location—1½ mi. above mouth of Cement Creek.

Rate of Flow—300 to 400 gal. per min. Temperature—83° F.

Class of Water—Calcic, bicarbonated, sulphated, alkaline-saline, potassic, ferruginous, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	27.7	....
Sulphate	SO_4	101.7	12.43
Bicarbonate	HCO_3	349.9	33.64
Carbonate	CO_3	None	....
Phosphate	PO_4	Trace	....
Chloride	Cl	23.9	3.93
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	8.7	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	74.9	21.92
Magnesium	Mg	24.3	11.72
Potassium	K	32.5	4.86
Sodium	Na	45.1	11.50
Lithium	Li	None	....
	Total	688.7	100.00

Concentration value	17.06	Excess carbon dioxide	126.2
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	494
Strontium, Sr	....	Oxygen consuming capacity	19

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	....	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	8.7
Pot. chlor., KCl	50.3	Calc. silicate, $CaSiO_3$	....
Sod. chlor., $NaCl$	....	Silica, SiO_2	27.7
Sod. sulph., Na_2SO_4	139.3	Mang. oxide, Mn_3O_4	....
Mag. sulph., $MgSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	146.2
Calc. sulph., $CaSO_4$	....	Sod. bicarb., $NaHCO_3$	....
Calc. carb., $CaCO_3$	....	Pot. sulph., K_2SO_4	13.6
Ferrous bicarb., $Fe(HCO_3)_2$	....		
Calc. bicarb., $Ca(HCO_3)_2$	302.9		
Total			688.7

Properties of Reaction in Per Cent

Primary salinity	32.72	Primary alkalinity	....
Secondary salinity	....	Secondary alkalinity	67.28
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 30

CEMENT CREEK SPRING

Location—In park about 2½ mi. up Cement Creek from No. 29.

Rate of Flow—40 gal. per min. Temperature—76° F.

Class of Water—Calcic, sulphated, bicarbonated, alkaline-saline, magnesic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	34.8	....
Sulphate	SO_4	80.1	11.38
Bicarbonate	HCO_3	251.3	28.13
Silicate	SiO_3	....	7.83
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	13.7	2.66
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	Trace	
Aluminum oxide	Al_2O_3		....
Manganese	Mn	None	....
Calcium	Ca	79.2	26.98
Magnesium	Mg	22.7	12.74
Potassium	K	8.0	1.43
Sodium	Na	30.0	8.85
Lithium	Li	None	....
Oxygen to form SiO_3		9.2	....
	Total	529.0	100.00

Concentration value	14.68	Excess carbon dioxide	54.6
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	438
Strontium, Sr	....	Oxygen consuming capacity	0.58

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	....	Calc. bicarb., $Ca(HCO_3)_2$	226.5
Pot. chlor., KCl	15.3	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	10.6	Calc. silicate, $CaSiO_3$	67.2
Sod. sulph., Na_2SO_4	79.7	Silica, SiO_2	....
Mag. sulph., $MgSO_4$	32.8	Mang. oxide, Mn_3O_4	....
Calc. sulph., $CaSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	96.8
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	....
Ferrous bicarb., $Fe(HCO_3)_2$	....		

Total 529.0

Properties of Reaction in Per Cent

Primary salinity	20.56	Primary alkalinity	....
Secondary salinity	27.52	Secondary alkalinity	71.92
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 31

JARVIS SPRING No. 1

Location—8 mi. N. E. of Crested Butte. Temperature—44° F.

Rate of Flow—20 gal. per min.

Class of Water—Calcic, bicarbonated, sulphated, alkaline-saline, magnesic, ferruginous, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	17.6	....
Sulphate	SO_4	196.2	17.81
Bicarbonate	HCO_3	403.0	28.80
Silicate	SiO_3	....	2.56
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	6.8	.83
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	5.5	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	121.2	26.36
Magnesium	Mg	44.8	16.06
Potassium	K	Trace	....
Sodium	Na	40.0	7.58
Lithium	Li	None	....
Oxygen to form SiO_3		4.7	....
	Total	.839.8	100.00

Concentration value	22.98	Excess carbon dioxide	145.3
Hydrogen sulphide, H_2S	1.20	Iron precipitated	None
Arsenic, As	....	Evaporation solids	690
Strontium, Sr	....	Oxygen consuming capacity	0.50

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	....	Calc. bicarb., $Ca(HCO_3)_2$	442.8
Pot. chlor., KCl	Trace	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	5.5
Sod. chlor., NaCl	11.2	Calc. silicate, $CaSiO_3$	34.0
Sod. sulph., Na_2SO_4	109.9	Silica, SiO_2	....
Mag. sulph., $MgSO_4$	152.8	Mang. oxide, Mn_3O_4	....
Calc. sulph., $CaSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	83.6
Calc. carb., $CaCO_3$	....	Sod. bicarb, $NaHCO_3$	....
Ferrous bicarb., $Fe(HCO_3)_2$	....		
Total			839.8

Properties of Reaction in Per Cent

Primary salinity	15.16	Primary alkalinity	....
Secondary salinity	22.12	Secondary alkalinity	62.72
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 6.7. Temperature, °F, 44.0.
Curies Ra Emanation per liter x 10^{-10}, Water, 2.38.
Mache Units per liter, Water, 0.64.

NUMBER 32

JARVIS SPRING No. 2

Location—½ mi. above No. 31.

Rate of Flow—4 to 5 gal. per min. Temperature—44° F.

Class of Water—Calcic, bicarbonated, alkaline, magnesic, ferruginous, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	22.7	....
Sulphate	SO_4	50.1	10.30
Bicarbonate	HCO_3	238.3	38.71
Carbonate	CO_3	None	....
Phosphate	PO_4	Trace	....
Chloride	Cl	3.4	.99
Iron	Fe	....	.89
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	3.5	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	46.6	23.08
Magnesium	Mg	18.0	14.64
Potassium	K	9.5	2.38
Sodium	Na	21.0	9.01
Lithium	Li	None	....
		413.1	100.00
Oxygen in Fe_2O_3		1.1	
		412.0	

Concentration value	10.10	Excess carbon dioxide	85.9
Hydrogen sulphide, H_2S	1.60	Iron precipitated	None
Arsenic, As	....	Evaporation solids	234
Strontium, Sr	....	Oxygen consuming capacity	1.22

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	....	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	....
Pot. chlor., KCl	7.1	Calc. silicate, $CaSiO_3$	....
Sod. chlor., $NaCl$	....	Silica, SiO_2	22.7
Sod. sulphate, Na_2SO_4	63.6	Mang. oxide, Mn_3O_4	....
Mag. sulph., $MgSO_4$	....	Mag. bicarb, $Mg(HCO_3)_2$	108.0
Calc. sulph., $CaSO_4$	....	Sod. bicarb., $NaHCO_3$	1.5
Calc. carb., $CaCO_3$	....	Pot. sulph., K_2SO_4	12.9
Ferrous bicarb., $Fe(HCO_3)_2$	7.8		
Calc. bicarb., $Ca(HCO_3)_2$	188.4		
Total			412.0

Properties of Reaction in Per Cent

Primary salinity	22.58	Primary alkalinity	.20
Secondary salinity	....	Secondary alkalinity	75.44
Tertiary salinity	....	Tertiary alkalinity	1.78

Radioactivity

Temperature, °C, 6.7. Temperature, °F, 44.0.

Curies Ra Emanation per liter x 10^{-10}, Water, 0.91.

Mache Units per liter, Water, 0.25.

NUMBER 33

IRON SPRING

Location—3 miles from Crested Butte toward Irwin.

Rate of Flow—1 gal. per minute. Temperature—56° F.

Class of Water—Ferruginous, bicarbonated, sulphated, alkaline-saline, (weakly carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	14.7	....
Sulphate	SO_4	17.9	20.07
Bicarbonate	HCO_3	25	22.18
Carbonate	CO_3	None	....
Phosphate	PO_4	Trace	....
Chloride	Cl	5.1	7.75
Iron	Fe	....	6.73
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	10.7	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	5.4	14.53
Magnesium	Mg	3.2	14.21
Potassium	K	Trace	....
Sodium	Na	6.2	14.53
Lithium	Li	None	....
		88.2	100.00
Oxygen in Fe_2O_3		1.5	
	Total	86.7	

Concentration value	1.858	Excess carbon dioxide	9.0
Hydrogen sulphide, H_2S	None	Iron precipitated	54.6
Arsenic, As	....	Evaporation solids	80
Strontium, Sr	....	Oxygen consuming capacity	4.02

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	None	Calc. bicarb., $Ca(HCO_3)_2$	21.8
Pot. chlor., KCl	Trace	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	5.7
Sod. chlor., NaCl	8.4		
Sod. sulph., Na_2SO_4	9.0	Calc. silicate, $CaSiO_3$	....
Mag. sulph., $MgSO_4$	14.8	Silica, SiO_2	14.7
Calc. sulph., $CaSO_4$	....	Mang. oxide, Mn_3O_4	....
Calc. carb., $CaCO_3$	....	Mag. bicarb., $Mg(HCO_3)_2$	1.2
Ferrous bicarb., $Fe(HCO_3)_2$	11.1	Sod. bicarb, $NaHCO_3$	....
Total			86.7

Properties of Reaction in Per Cent

Primary salinity	29.06	Primary alkalinity	....
Secondary salinity	26.58	Secondary alkalinity	30.90
Tertiary salinity	....	Tertiary alkalinity	13.46

NUMBER 34

BEAVER RIVER RANCH SPRING

Location—At Love, Colorado, 5 miles east of Cripple Creek.

Rate of Flow—1 and 2 gal. per min. Temperature—48°, 46°, 47° F.

Class of Water—Calcic, bicarbonated, alkaline, sodic, (siliceous), (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	25.5	....
Sulphate	SO_4	Trace	....
Bicarbonate	HCO_3	106.1	37.15
Silicate	SiO_3	....	8.78
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	6.8	4.07
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	Trace	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	25.2	26.93
Magnesium	Mg	6.8	11.95
Potassium	K	Trace	....
Sodium	Na	12	11.12
Lithium	Li	None	....
Oxygen to form SiO_3		3.3	....
	Total	185.7	100.00

Concentration value	4.68	Excess carbon dioxide	38.3
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	130
Strontium, Sr	....	Oxygen consuming capacity	1.07

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	....	Calc. bicarb., $Ca(HCO_3)_2$	68.8
Pot. chlor., KCl	Trace	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	11.2	Calc. silicate, $CaSiO_3$	23.8
Sod. sulph., Na_2SO_4	....	Silica, SiO_2	13.2
Mag. sulph., $MgSO_4$	....	Mang. oxide, Mn_3O_4	....
Calc. sulph., $CaSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	40.9
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	27.8
Ferrous bicarb., $Fe(HCO_3)_2$	....		
Total			185.7

Properties of Reaction in Per Cent

Primary salinity	8.14	Primary alkalinity	14.10
Secondary salinity	....	Secondary alkalinity	77.76
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 8.0. Temperature, °F, 46.5.

Curies Ra Emanation per liter x 10^{-10}, Water, 23.63.

Mache Units per liter, Water, 6.38.

NUMBER 35

IRON SODA SPRING

Location—1 mi. East of Crisman.

Rate of Flow—½ to ¾ gal. per min. Temperature—56° F.

Class of Flow—Sodic, calcic, bicarbonated, sulphated, alkaline-saline, magnesic, ferruginous, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	69.9	....
Sulphate	SO_4	2128.0	22.13
Bicarbonate	HCO_3	3271.4	26.73
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	80.7	1.14
Iron	Fe	....	.11
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	8.7	
Aluminum oxide	Al_2O_3		....
Manganese	Mn	None	....
Calcium	Ca	473.4	11.82
Magnesium	Mg	99.1	4.06
Potassium	K	23.5	.31
Sodium	Na	1555	33.70
Lithium	Li	High trace	....
		7709.7	100.00
Oxygen in Fe_2O_3		2.6	
	Total	7707.1	

Concentration value	200.50	Excess carbon dioxide	1180
Hydrogen sulphide, H_2S	None	Iron precipitated	11.2
Arsenic, As	....	Evaporation solids	6090
Strontium, Sr	....	Oxygen consuming capacity	2.09

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	High trace	Calc. bicarb, $Ca(HCO_3)_2$	1914.3
Pot. chlor., KCl	44.8	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	97.9	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	3146.8	Silica, SiO_2	69.9
Mag. sulph., $MgSO_4$	....	Mang. oxide, Mn_3O_4	....
Calc. sulph., $CaSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	596.3
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	1817.9
Ferrous bicarb., $Fe(HCO_3)_2$	19.4		
Total			7707.3

Properties of Reaction in Per Cent

Primary salinity	46.54	Primary alkalinity	21.48
Secondary salinity	....	Secondary alkalinity	31.98
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 14.3, 14.5. Temperature, °F, 57.8

Curies Ra Emanation per liter x 10^{-10}, Water, 10.73, 22.4.

Mache Units per liter, Water, 2.90, 3.74. Remarks, S.

NUMBER 36

ARTESIAN WELL AT DEAN

Location—3 mi. E. Florence, 100 yds. N. of R. R. Track 30 ft. east of Road.

Rate of Flow—100 gal. per min. Temperature—86° to 84° F.

Class of Water—Sodic, calcic, bicarbonated, sulphated, alkaline-saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	26.4	....
Sulphate	SO_4	216.2	8.66
Bicarbonate	HCO_3	1111.3	34.97
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	117.8	6.37
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	None	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	157.7	15.13
Magnesium	Mg	62.23	9.83
Potassium	K	42.5	2.09
Sodium	Na	275.2	22.95
Lithium	Li	Trace	....
	Total	2009.3	100.00

Concentration value	52.08	Excess carbon dioxide	400.7
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	1594
Strontium, Sr	....	Oxygen consuming capacity	0.68

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. carb., $Ca(HCO_3)_2$	637.7
Pot. chlor., KCl	81.0	Iron and aluminum oxides,	
Sod. chlor., NaCl	130.7	Fe_2O_3, Al_2O_3	....
Sod. sulph., Na_2SO_4	319.7	Calc. silicate, $CaSiO_3$	....
Mag. sulph., $MgSO_4$	....	Silica, SiO_2	26.4
Calc. sulph., $CaSO_4$	....	Mang. oxide, Mn_3O_4	....
Calc. carb., $CaCO_3$	....	Mag. bicarb., $Mg(HCO_3)_2$	374.5
Ferrous bicarb., $Fe(HCO_3)_2$	....	Sod. bicarb, $NaHCO_3$	439.4
Total			2009.4

Properties of Reaction in Per Cent

Primary salinity	30.06	Primary alkalinity	20.02
Secondary salinity	....	Secondary alkalinity	49.92
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 29.4. Temperature, °F, 85.0.

Curies Ra Emanation per liter x 10^{-10}, Gas, 23.2.

Mache Units per liter, Gas, 6.26.

NUMBER 37

DECKER'S SPRING

Location—On south fork of South Platte.

Rate of Flow—From 1½ to 4 gal. per min. Temperature—52° F.

Class of Water—Sodic, calcic, muriated, saline, ferruginous, (weakly carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	31.0	....
Sulphate	SO_4	429.86	6.94
Bicarbonate	HCO_3	40.54	.52
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	1950.3	42.54
Iron	Fe	....	.09
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	4.7	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	673	26.02
Magnesium	Mg	7.1	.45
Potassium	K	16.49	.33
Sodium	Na	688	23.11
Lithium	Li	Trace	....
		3840.99	100.00
Oxygen in Fe_2O_3		1.41	
	Total	3839.58	

Concentration value	129.30	Excess carbon dioxide	14.62
Hydrogen sulphide, H_2S	None	Iron precipitated	9.74
Arsenic, As	....	Evaporation solids (approx.)	4302
Strontium, Sr	None	Oxygen consuming capacity	0.55

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	....
Pot. chlor., KCl	31.44	Calc. silicate, $CaSiO_3$	....
Sod. chlor., NaCl	1748.5	Silica, SiO_2	31.0
Sod. sulph., Na_2SO_4	....	Mang. oxide, Mn_3O_4	....
Mag. sulph., $MgSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	....
Calc. sulph., $CaSO_4$	609.2	Sod. bicarb., $NaHCO_3$	....
Calc. carb., $CaCO_3$	....	Mag. chlor., $MgCl_2$	27.8
Ferrous bicarb., $Fe(HCO_3)_2$	10.47	Calc. chlor., $CaCl_2$	1331.5
Total			3839.23

Properties of Reaction in Per Cent

Primary salinity	46.88	Primary alkalinity	....
Secondary salinity	52.08	Secondary alkalinity	1.04
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 38

SHAW'S SPRING

Location——6 mi. N. of Del Norte.

Rate of Flow—10 to 12 gal. per min. Temperature—88° F

Class of Water—Sodic, bicarbonated, alkaline-saline, (siliceous, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	96.2	....
Sulphate	SO_4	54.1	10.50
Bicarbonate	HCO_3	229.7	35.04
Carbonate	CO_3	Trace	....
Phosphate	PO_4	Trace	....
Chloride	Cl	17.1	4.46
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	1.5	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	4.1	1.86
Magnesium	Mg	2.5	1.95
Potassium	K	5	1.21
Sodium	Na	111.5	44.98
Lithium	Li	None	....
	Total	521.7	100.00

Concentration value	10.76	Excess carbon dioxide	82.8
Hydrogen sulphide, H_2S	Trace	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	415
Strontium, Sr	....	Oxygen consuming capacity	1.56

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	....	Calc. bicarb., $Ca(HCO_3)_2$	16.0
Pot. chlor., KCl	9.5	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	1.5
Sod. chlor., NaCl	20.8	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	80.0	Silica, SiO_2	96.2
Mag. sulph., $MgSO_4$	....	Mang. oxide, Mn_3O_4	....
Calc. sulph., $CaSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	15.0
Calc. carb., $CaCO_3$	Trace	Sod. bicarb., $NaHCO_3$	282.7
Ferrous bicarb., $Fe(HCO_3)_2$	....		
Total			521.7

Properties of Reaction in Per Cent

Primary salinity	29.92	Primary alkalinity	62.46
Secondary salinity	....	Secondary alkalinity	7.62
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 26.8. Temperature, °F, 80.2.

Curies Ra Emanation per liter x 10^{-10}, Water, None.

Mache Units per liter, Water, None.

NUMBER 39

TOWN WELL

Location—Well on Main street of Del Norte.

Rate of Flow—No flow. Temperature—55° F.

Class of Water—Sodic, bicarbonated, muriated, alkaline-saline, magnesic, ferruginous, carbondioxated.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	74.1	....
Sulphate	SO_4	96.6	2.64
Bicarbonate	HCO_3	1782.8	38.46
Carbonate	CO_3	None	....
Phosphate	PO_4	Trace	....
Chloride	Cl	239.4	8.90
Iron	Fe	....	.34
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	10.5	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	132.1	8.73
Magnesium	Mg	53.3	5.77
Potassium	K	22.5	.76
Sodium	Na	602	34.40
Lithium	Li	Trace	....
		3013.3	100.00
Oxygen in Fe_2O_3		3.1	
	Total	3010.2	

Concentration value	76.00	Excess carbon dioxide	642.9
Hydrogen sulphide, H_2S	Trace	Iron precipitated	10.21
Arsenic, As	....	Evaporation solids	2332
Strontium, Sr	....	Oxygen consuming capacity	0.78

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	534.1
Pot. chlor., KCl	42.9	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	361.0	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	142.9	Silica, SiO_2	74.1
Mag. sulph., $MgSO_4$	....	Mang. oxide, Mn_3O_4	....
Calc. sulph., $CaSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	320.7
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	1511.1
Ferrous bicarb., $Fe(HCO_3)_2$	23.4		
Total			3010.2

Properties of Reaction in Per Cent

Primary salinity	23.08	Primary alkalinity	47.24
Secondary salinity	....	Secondary alkalinity	29.00
Tertiary salinity	....	Tertiary alkalinity	.68

Radioactivity

Temperature, °C, 12.8. Temperature, °F, 55.0.
Curies Ra Emanation per liter x 10^{-10}, Water, trace.
Mache Units per liter, Water, trace.

NUMBER 40

DEEP ROCK ARTESIAN

Location—Denver.

Rate of Flow—............... Temperature—...............

Class of Water—Sodic, bicarbonated, alkaline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	11.4	....
Sulphate	SO_4	14.2	4.68
Bicarbonate	HCO_3	159.76	42.25
Silicate	SiO_3	....	3.07
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	Trace	....
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	1.5	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	4.03	3.23
Magnesium	Mg	Trace	....
Potassium	K	3.34	1.29
Sodium	Na	64.82	45.48
Lithium	Li	None	....
Oxygen to form SiO_3		1.52	....
	Total	260.57	100.00

Concentration value	6.20	Excess carbon dioxide	57.61
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	210
Strontium, Sr	....	Oxygen consuming capacity	None

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	....	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	1.5
Pot. chlor., KCl	Trace	Calc. silicate, $CaSiO_3$	11.09
Sod. chlor., NaCl	....	Silica, SiO_2	5.65
Sod. sulph., Na_2SO_4	14.93	Mang. oxide, Mn_3O_4	....
Mag. sulph., $MgSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	....
Calc. sulph., $CaSO_4$	....	Sod. bicarb., $NaHCO_3$	219.10
Calc. carb., $CaCO_3$	....	Pot. sulph., K_2SO_4	7.44
Ferrous bicarb., $Fe(HCO_3)_2$	....		
Calc. bicarb., $Ca(HCO_3)_2$	0.85		

Total 260.56

Properties of Reaction in Per Cent

Primary salinity	9.36	Primary alkalinity	84.18
Secondary salinity	....	Secondary alkalinity	6.46
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 41

IRON SPRING—SODA CREEK No. 1

Location—2 miles east of Dillon on Soda Creek.

Rate of Flow—.................. Temperature—51° F.

Class of Water—Sodic, calcic, bicarbonated, sulphated, alkaline-saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	16.7	....
Sulphate	SO_4	181.8	11.21
Bicarbonate	HCO_3	679.0	32.88
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	70.9	5.91
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	Trace	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	Trace	....
Calcium	Ca	139.6	20.63
Magnesium	Mg	16.02	3.90
Potassium	K	34.0	2.57
Sodium	Na	178.5	22.90
Lithium	Li	Trace	....
	Total	1316.52	100.00

Concentration value	33.84	Excess carbon dioxide	244.8
Hydrogen sulphide, H_2S	None	Iron precipitated	49.6
Arsenic, As	....	Evaporation solids	981
Strontium, Sr	....	Oxygen consuming capacity	1.86

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	564.5
Pot. chlor., KCl	64.83	Iron and alum. oxides, Fe_2O_3, Al_2O_3	Trace
Sod. chlor., NaCl	66.06	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	268.8	Silica, SiO_2	16.7
Mag. sulph., $MgSO_4$	....	Mang. oxide, Mn_3O_4	Trace
Calc. sulph., $CaSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	96.4
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	239.2
Ferrous bicarb., $Fe(HCO_3)_2$	....		
Total			1316.49

Properties of Reaction in Per Cent

Primary salinity	34.24	Primary alkalinity	16.70
Secondary salinity	....	Secondary alkalinity	49.06
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 42

PARK SPRING—SAME AS No. 44.

Location—Dillon, Colorado.

Radioactivity

Temperature, °C, 9.4. Temperature, °F, 49.0.
Curies Ra Emanation per liter x 10^{-10}, Water, 1.87.
Mache Units per liter, Water, 0.51.

NUMBER 43

SODA CREEK No. 2

Location—100 ft. up creek from 41, Dillon.

Rate of Flow—2½ to 3 gal. per min. Temperature—56° F.

Class of Water—Sodic, calcic, bicarbonated, sulphated, alkaline-saline, potassic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	23.0	....
Sulphate	SO_4	254.2	11.62
Bicarbonate	HCO_3	902.98	32.55
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	95.71	5.83
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	Trace	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	182.3	19.98
Magnesium	Mg	14.06	2.54
Potassium	K	58.5	3.27
Sodium	Na	254	24.21
Lithium	Li	Trace	....
	Total	1784.75	100.00

Concentration value	45.62	Excess carbon dioxide	325.6
Hydrogen sulphide, H_2S	None	Iron precipitated	1.51
Arsenic, As	....	Evaporation solids	1209
Strontium, Sr	....	Oxygen consuming capacity	10.21

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	Trace	Calc. bicarb., $Ca(HCO_3)_2$	737.1
Pot. chlor., KCl	111.6	Iron and alum. oxides, Fe_2O_3, Al_2O_3	Trace
Sod. chlor., $NaCl$	70.25	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	375.9	Silica, SiO_2	23
Mag. sulph., $MgSO_4$	....	Mang. oxide, Mn_3O_4	....
Calc. sulph., $CaSO_4$	....	Mag. bicarb., $Mg(HCO_3)_2$	84.6
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	382.3
Ferrous bicarb., $Fe(HCO_3)_2$	....		

Total 1784.75

Properties of Reaction in Per Cent

Primary salinity	34.90	Primary alkalinity	20.06
Secondary salinity	....	Secondary alkalinity	45.04
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 13.0. Temperature, °F, 55.5.
Curies Ra Emanation per liter x 10^{-10}, Water, 6.41.
Mache Units per liter, Water, 1.73.

NUMBER 44

PARK SPRING

Location—Spring in Park 1 mi. S. E. Dillon.

Rate of Flow—¾ to 1 gal. per min. Temperature—53° F.

Class of Water—Sodic, potassic, bicarbonated, sulphated, alkaline-saline, ferruginous, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	23.7	....
Sulphate	SO_4	252.1	11.32
Bicarbonate	HCO_3	874.95	30.98
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	127.6	7.70
Iron	Fe	....	.26
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	4.75	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	68.26	7.35
Magnesium	Mg	17.39	3.06
Potassium	K	67.5	3.73
Sodium	Na	379.7	35.60
Lithium	Li	Trace	....
		1815.95	100.00
Oxygen in Fe_2O_3		1.43	
	Total	1814.52	

Concentration value	46.38	Excess carbon dioxide	315.5
Hydrogen sulphide, H_2S	None	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	1493
Strontium, Sr	....	Oxygen consuming capacity	0.93

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	276.0
Pot. chlor., KCl	128.7	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	109.5		
Sod. sulph., Na_2SO_4	372.8	Calc. silicate, $CaSiO_3$	....
Mag. sulph., $MgSO_4$	....	Silica, SiO_2	23.7
Calc. sulph., $CaSO_4$	....	Mang. oxide, Mn_3O_4	....
Calc. carb., $CaCO_3$	....	Mag. bicarb., $Mg(HCO_3)_2$	104.64
Ferrous bicarb, $Fe(HCO_3)_2$	10.58	Sod. bicarb., $NaHCO_3$	788.6
Total			1814.52

Properties of Reaction in Per Cent

Primary salinity	38.04	Primary alkalinity	40.62
Secondary salinity	....	Secondary alkalinity	20.82
Tertiary salinity	....	Tertiary alkalinity	.52

NUMBER 45

BIG SPRING

Location—On Rainbow Route 1½ miles below Dotsero on N. bank of Grand River.

Rate of Flow—400 to 500 gal. per minute. Temperature—83° F.

Class of Water—Sodic, muriated, saline, potassic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	21.4	....
Sulphate	SO_4	495.4	2.95
Bicarbonate	HCO_3	449.2	2.11
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	5575	44.94
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	8.5	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	278 8	3.99
Magnesium	Mg	67.3	1.58
Potassium	K	460	3.38
Sodium	Na	3304	41.05
Lithium	Li	None	....
	Total	10660.3	100.00

Concentration value	349.86	Excess carbon dioxide	162
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	10446
Strontium, Sr	....	Oxygen consuming capacity	15.49

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	None	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	8.5
Pot. chlor., KCl	877.2	Calc. silicate, $CaSiO_3$	....
Sod. chlor., $NaCl$	8399.8	Silica, SiO_2	21.4
Sod. sulph., Na_2SO_4	....	Mang. oxide, Mn_3O_4	....
Mag. sulph., $MgSO_4$	226.8	Mag. bicarb., $Mg(HCO_3)_2$	....
Calc. sulph., $CaSO_4$	445.6	Sod. bicarb., $NaHCO_3$	....
Calc. carb., $CaCO_3$	....	Mag. chlor., $MgCl_2$	84.2
Ferrous bicarb., $Fe(HCO_3)_2$	....		
Calc. bicarb., $Ca(HCO_3)_2$	596.8		
Total			10660.3

Properties of Reaction in Per Cent

Primary salinity	88.86	Primary alkalinity	....
Secondary salinity	6.92	Secondary alkalinity	4.22
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 28.3. Temperature, °F, 83.0.

Curies Ra Emanation per liter x 10^{-10}, Water, 15.04; Gas, 129.5.

Mache Units per liter, Water, 4.06; Gas, 34.98.

NUMBER 46

OLD BATH HOUSE SPRING

Location—¼ to ½ mi. above No. 45.

Rate of Flow—1 gal. per min. Temperature—84° F.

Class of Water—Sodic, muriated, saline, potassic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	18.8	....
Sulphate	SO_4	459.4	2.71
Bicarbonate	HCO_3	399.3	1.86
Carbonate	CO_3	None	....
Phosphate	PO_4	None	....
Chloride	Cl	5677	45.43
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	10.3	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	260.2	3.70
Magnesium	Mg	62.2	1.45
Potassium	K	470	3.42
Sodium	Na	3360	41.43
Lithium	Li	....	....
	Total	10717.2	100.00

Concentration value	352.50	Excess carbon dioxide	144
Hydrogen sulphide, H_2S	None	Iron precipitated	1.77
Arsenic, As	....	Evaporation solids	10642
Strontium, Sr	....	Oxygen consuming capacity	13.83

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	....	Iron and alum. oxides., Fe_2O_3, Al_2O_3	10.3
Pot. chlor., KCl	896.3	Calc. silicate, $CaSiO_3$	....
Sod. chlor., NaCl	8540.0	Silica, SiO_2	18.8
Sod. sulph., Na_2SO_4	....	Mang. oxide, Mn_3O_4	....
Mag. sulph., $MgSO_4$	188.4	Mag. bicarb., $Mg(HCO_3)_2$	....
Calcium sulphate, $CaSO_4$	438.1	Sod. bicarb., $NaHCO_3$	....
Calc. carb., $CaCO_3$	....	Mag. chlor., $MgCl_2$	94.8
Ferrous bicarb., $Fe(HCO_3)_2$	....		
Calc. bicarb., $Ca(HCO_3)_2$	530.5		
Total			10717.2

Properties of Reaction in Per Cent

Primary salinity	89.70	Primary alkalinity	....
Secondary salinity	6.58	Secondary alkalinity	3.72
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 47

PINKERTON SPRINGS—N. W. PINKERTON SPRING

Location—On Pinkerton Ranch, 4½ miles north of Trimble.

Radioactivity

Curies Ra Emanation per liter x 10^{-10}, Water, 0.73.

Mache Units per liter, Water, 0.2.

NUMBER 48

PINKERTON SPRINGS, POOL SPRING

Location—Durango.

Radioactivity

Curies Ra Emanation per liter x 10^{-10}, Water, 0.27.

Mache Units per liter. Water, 0.07.

NUMBER 49

PINKERTON SPRINGS, CEDAR SPRING

Location—Durango.

Radioactivity

Curies Ra Emanation per liter x 10^{-10}, Water, 10.10.

Mache units per liter, Water, 2.73.

NUMBER 50

NORTH PINKERTON SPRING

Location—Between Trimble and Rockwood.

Rate of Flow—4 to 8 and 7 to 8 gal. per min. Temperature—87° F.

Class of Water—Sodic, calcic, bicarbonated, muriated, alkaline-saline, lithic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	35.3	....
Sulphate	SO_4	634.3	10.80
Bicarbonate	HCO_3	1310.4	17.60
Carbonate	CO_3	None	....
Phosphate	PO_4	Trace	....
Chloride	Cl	935.8	21.60
Iron	Fe	....	....
Aluminum	Al	....	....
Iron oxide	Fe_2O_3	Trace	....
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	....
Calcium	Ca	537.5	21.94
Magnesium	Mg	37.2	2.51
Potassium	K	120	2.51
Sodium	Na	636.1	22.64
Lithium	Li	3.4	.40
	Total	4250.0	100.00

Concentration value	122.20	Excess carbon dioxide	472.5
Hydrogen sulphide, H_2S	None	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	3829
Strontium, Sr	....	Oxygen consuming capacity	4.68

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	20.4	Calc. bicarb., $Ca(HCO_3)_2$	1741.0
Pot. chlor., KCl	228.8	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	1335.4	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	341.8	Silica, SiO_2	35.3
Mag. sulph., $MgSO_4$	184.2	Mang. oxide, Mn_3O_4	....
Calc. sulph., $CaSO_4$	363.1	Mag. bicarb., $Mg(HCO_3)_2$	....
Calc. carb., $CaCO_3$	....	Sod. bicarb., $NaHCO_3$	....
Ferrous bicarb., $Fe(HCO_3)_2$	....		
Total			4250.0

Properties of Reaction in Per Cent

Primary salinity	51.10	Primary alkalinity	....
Secondary salinity	13.70	Secondary alkalinity	35.20
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 51

SOUTHEAST PINKERTON SPRING

Location—Durango.

Rate of Flow—3 gal. per minute. Temperature—................

Class of Water—Sodic, calcic, bicarbonated, muriated, sulphated, alkaline-saline, ferruginous, carbondioxated.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	38.0	......
Sulphate	SO_4	638.2	11.08
Bicarbonate	HCO_3	1200	16.40
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	957.6	22.52
Iron	Fe	......	.29
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	14.1	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	488.2	20.34
Magnesium	Mg	36.6	2.51
Potassium	K	80	1.71
Sodium	Na	694.5	25.15
Lithium	Li	Not run	......
		4147.2	100.00
Oxygen in Fe_2O_3		4.2	
	Total	4143.0	

Concentration value	120.00	Excess carbon dioxide	432.7
Hydrogen sulphide, H_2S	None	Iron precipitated	Trace
Arsenic, As	......	Evaporation solids	3786
Strontium, Sr	......	Oxygen consuming capacity	2.14

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	....	Calc. bicarb., $Ca(HCO_3)_2$	1243.4
Pot. chlor., KCl	152.6	Iron and alum. oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., NaCl	1459.0	Calc. silicate, $CaSiO_3$	....
Sod. sulph., Na_2SO_4	89.6	Silica, SiO_2	38.0
Mag. sulph., $MgSO_4$	181.2	Mang. oxide, Mn_3O_4	....
Calc. sulph., $CaSO_4$	613.7	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	334.1
Ferrous bicarb., $Fe(HCO_3)_2$	31.4		
Total			4143.0

Properties of Reaction in Per Cent

Primary salinity	53.72	Primary alkalinity	....
Secondary salinity	13.48	Secondary alkalinity	32.22
Tertiary salinity	....	Tertiary alkalinity	.58

NUMBER 52

POOL SPRING

Location—Eldorado Springs.

Rate of Flow—10 to 15 gal. per min. Temperature—70° F.

Class of Water—Sodic, calcic, bicarbonated, sulphated, alkaline-saline, (ferruginous.)

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	16.6	......
Sulphate	SO_4	37.6	22.55
Bicarbonate	HCO_3	46.1	21.98
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	6.8	5.47
Iron	Fe	......	2.60
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	3.7	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	10.2	14.75
Magnesium	Mg	4.4	10.40
Potassium	K	1.2	.86
Sodium	Na	17	21.39
Lithium	Li	None	......
		143.6	100.00
Oxygen in Fe_2O_3		1.1	
	Total	142.5	

Concentration value	3.46	Excess carbon dioxide	16.6
Hydrogen sulphide, H_2S	None	Iron precipitated	Trace
Arsenic, As	....	Evaporated solids	110
Strontium, Sr	....	Oxygen consuming capacity	0.68

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	41.2
Pot. chlor., KCl	2.3	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	9.4	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	41.1	Silica, SiO_2	16.6
Mag. sulph., $MgSO_4$	12.3	Mang. oxide, Mn_3O_4	.....
Calc. sulphate, $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	11.4
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	8.2		
Total			142.5

Properties of Reaction in Per Cent

Primary salinity	44.50	Primary alkalinity	....
Secondary salinity	11.54	Secondary alkalinity	38.76
Tertiary salinity	....	Tertiary alkalinity	5.20

Radioactivity

Temperature °C, 26.0, 21.0. Temperature, °F, 78.8.
Curies Ra Emanation per liter x 10^{-10}, 8.35, 19.6; Gas, 101.6
Mache Units per liter, Water, 2.25, 3.25; Gas, 27.42.
Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

NUMBER 53

RHODES SPRING

Location—8 miles southwest of Fairplay.

Rate of Flow—250 to 300 gal. per minute. Temperature—79° F.

Class of Water—Calcic, magnesic, muriated, bicarbonated, alkaline-saline.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	12.0	5.36
Sulphate	SO_4	17.53	4.18
Bicarbonate	HCO_3	163.33	31.17
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	44.3	14.65
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	1.2	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	Trace	......
Calcium	Ca	36.45	21.16
Magnesium	Mg	22.97	21.97
Potassium	K	5.0	1.51
Sodium	Na	10.6	......
Lithium	Li	None	......
	Total	313.38	100.00

Concentration value	8.60	Excess carbon dioxide	58.9
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	236
Strontium, Sr	....	Oxygen consuming capacity	0.28

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	None	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	1.2
Pot. chlor., KCl	9.54	Calc. silicate, $CaSiO_3$	.....
Sod. chlor., NaCl	26.94	Silica, SiO_2	12.0
Sod. sulph., Na_2SO_4	.....	Mang. oxide, Mn_3O_4	.....
Mag. sulph., $MgSO_4$	21.97	Mag. bicarb., $Mg(HCO_3)_2$	62.82
Calc. sulphate, $CaSO_4$	.....	Sod. bicarb., $NaHCO_3$	.....
Calc. carb., $CaCO_3$	.....	Mag. chlor., $MgCl_2$	31.69
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Calc. bicarb., $Ca(HCO_3)_2$	147.4		
Total			313.56

Properties of Reaction in Per Cent

Primary salinity	13.74	Primary alkalinity	....
Secondary salinity	23.92	Secondary alkalinity	62.34
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 25. Temperature, °F, 77.
Curies Ra Emanation per liter x 10^{-10}, Water, 4.73.
Mache Units per liter, Water, 1.28.

NUMBER 54

DRINKING SPRING

Location—Glenwood Springs.

Rate of Flow—50 gal. per min. Temperature—124½° F.

Class of Water—Sodic, potassic, muriated, sulphated, saline, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	36.3	......
Sulphate	SO_4	1177	3.75
Bicarbonate	HCO_3	736.3	1.84
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	10289.4	44.41
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	507.3	3.88
Magnesium	Mg	88.16	1.11
Potassium	K	2187	8.56
Sodium	Na	5479.3	36.45
Lithium	Li	None	......
	Total	20500.76	100.00

Concentration value	653.68	Excess carbon dioxide	265.5
Hydrogen sulphide, H_2S	2.06	Iron precipitated	None
Arsenic, As	....	Evaporation solids	19858
Strontium, Sr	....	Oxygen consuming capacity	18.77

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	978.2
Pot. chlor., KCl	4170.4	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	Trace
Sod. chlor., NaCl	13693	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	285.1	Silica, SiO_2	36.3
Mag. sulph., $MgSO_4$	436.4	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	901.4	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			20500.8

Properties of Reaction in Per Cent

Primary salinity	90.02	Primary alkalinity	....
Secondary salinity	6.30	Secondary alkalinity	3.68
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 51.5. Temperature, °F, 124.7.

Curies Ra Emanation per liter x 10^{-10}, Gas, 13.74.

Mache Units per liter, Gas, 3.71.

NUMBER 55

MAMMOTH SPRING

Location—Feeding Pool, Glenwood Springs.

Rate of Flow—400 gal. per min. Temperature—124° F.

Class of Water—Sodic, muriated, sulphated, saline, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	37.4	......
Sulphate	SO_4	1194.0	3.62
Bicarbonate	HCO_3	436.8	1.04
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	11025.0	45.34
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	430.8	3.14
Magnesium	Mg	91.2	1.09
Potassium	K	460.0	1.72
Sodium	Na	6949.6	44.05
Lithium	Li	None	......
	Total	20624.8	100.00

Concentration value	686.00	Excess carbon dioxide	157.5
Hydrogen sulphide, H_2S	2.12	Iron precipitated	None
Arsenic, As	....	Evaporation solids	20056
Strontium, Sr	....	Oxygen consuming capacity	24.16

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	None	Calc. bicarb., $Ca(HCO_3)_2$	580.3
Pot. chlor., KCl	877.2	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	Trace
Sod. chlor., NaCl	17488	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	215.	Silica, SiO_2	37.4
Mag. sulph., $MgSO_4$	451.3	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	975.8	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			20625.0

Properties of Reaction in Per Cent

Primary salinity	91.54	Primary alkalinity	....
Secondary salinity	6.38	Secondary alkalinity	2.08
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 51.0. Temperature, °F, 123.9.

Curies Ra Emanation per liter x 10^{-10}, Gas, 19.68.

Mache Units per liter, Gas, 5.32.

Remarks: Schlundt.

NUMBER 56

BATH SPRING

Location—4 mi. west of Glenwood Springs.

Rate of Flow—10 gal. to 12 gal. per min. Temperature—116° F.

Class of Water——Potassic, sodic, bicarbonated, alkaline-saline, magnesic, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter. Approximately parts per million	Reacting value percentage
Silica	SiO_2	35.1	......
Sulphate	SO_4	71.8	8.82
Bicarbonate	HCO_3	355.28	34.12
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	42.54	7.06
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	42.53	12.45
Magnesium	Mg	33.62	16.21
Potassium	K	57.5	8.64
Sodium	Na	49.7	12.70
Lithium	Li	None	......
	Total	688.07	100.00

Concentration value	17.02	Excess carbon dioxide	128.1
Hydrogen sulphide, H_2S	2.04	Iron precipitated	1.64
Arsenic, As	....	Evaporation solids	566
Strontium, Sr	....	Oxygen consuming capacity	2.53

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	.....	Calc. bicarb., $Ca(HCO_3)_2$	171.97
Pot. chloride, KCl	89.45	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	Trace
Sod. chlor., $NaCl$	.....	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	86.85	Silica, SiO_2	35.1
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulphate, $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	202.30
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	78.71
Ferrous bicarb., $Fe(HCO_3)_2$	.....	Pot. sulph., K_2SO_4	23.60
Total			688.08

Properties of Reaction in Per Cent

Primary salinity	31.76	Primary alkalinity	10.92
Secondary salinity	....	Secondary alkalinity	57.32
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 57

CAMP SPRING AT SOUTH CANYON

Location—4 mi. west of Glenwood Springs near 56.

Rate of Flow—6 to 8 gal. and 4 to 6 gal. per min. Temperature—119° F.

Class of Water—Sodic, bicarbonated, muriated, alkaline-saline, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	40.9	......
Sulphate	SO_4	90.11	7.00
Bicarbonate	HCO_3	299.5	18.04
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	241.1	24.96
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	9.29	1.70
Magnesium	Mg	0.55	.20
Potassium	K	11.7	1.07
Sodium	Na	293.79	47.03
Lithium	Li	None	......
	Total	986.94	100.00

Concentration value	27.12	Excess carbon dioxide	108
Hydrogen sulphide, H_2S	2.09	Iron precipitated	None
Arsenic, As	....	Evaporation solids	941
Strontium, Sr	....	Oxygen consuming capacity	3.51

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	37.57
Pot. chlor., KCl	22.31	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	Trace
Sod. chlor., NaCl	380	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	133.2	Silica, SiO_2	40.9
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	3.31
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	369.65
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			986.94

Properties of Reaction in Per Cent

Primary salinity	63.92	Primary alkalinity	32.28
Secondary salinity	....	Secondary alkalinity	3.80
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 58

VAPOR BATH, OLD CAVE SPRING

Location—Below pipe line, Glenwood Springs.

Rate of Flow—30 to 35 gal. per minute. Temperature—124° F.

Class of Water—Sodic, muriated, sulphated, saline, potassic, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	49.4	......
Sulphate	SO_4	1002.3	3.60
Bicarbonate	HCO_3	312	.88
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	9359	45.52
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	382.4	3.30
Magnesium	Mg	82.91	1.18
Potassium	K	106.7	.47
Sodium	Na	6009.8	45.05
Lithium	Li	None	......
Total		17304.48	100.00

Concentration value	579.96	Excess carbon dioxide	112.5
Hydrogen sulphide, H_2S	7.85	Iron precipitated	None
Arsenic, As	....	Evaporation solids	17144
Strontium, Sr	....	Oxygen consuming capacity	None

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	414.5
Pot. chlor., KCl	203.5	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	15270		
Sod. sulph., Na_2SO_4	6.08	Calc. silicate, $CaSiO_3$	.....
Mag. sulph., $MgSO_4$	410.4	Silica, SiO_2	49.4
Calc. sulph., $CaSO_4$	950.6	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....	Sod. bicarb., $NaHCO_3$	.....
Total			17304.48

Properties of Reaction in Per Cent

Primary salinity	91.04	Primary alkalinity	....
Secondary salinity	7.20	Secondary alkalinity	1.76
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 51.5. Temperature, °F, 124.7.
Curies Ra Emanation per liter x 10^{-10}, Water, 0.87.
Mache Units per liter, Water, 0.24.

NUMBER 59

OLD CAVE SPRING No. 1

Location—Glenwood Springs.

Rate of Flow—150 gal. per minute. Temperature—150° F.

Class of Water—Sodic, muriated, sulphated, saline, potassic, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	48.6	......
Sulphate	SO_4	1032	3.53
Bicarbonate	HCO_3	711.3	1.91
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	9607	44.56
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	
Aluminum oxide	Al_2O_3		......
Manganese	Mn	None	......
Calcium	Ca	460.3	3.78
Magnesium	Mg	85.31	1.16
Potassium	K	475	1.99
Sodium	Na	6024.6	43.07
Lithium	Li	None	......
	Total	18444.11	100.00

Concentration value	608.22	Excess carbon dioxide	256.5
Hydrogen sulphide, H_2S	2.18	Iron precipitated	None
Arsenic, As	....	Evaporation solids	17778
Strontium, Sr	....	Oxygen consuming capacity	6.62

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	.....	Calc. bicarb., $Ca(HCO_3)_2$	376.4
Pot. chlor., KCl	905.8	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	Trace
Sod. chlor., $NaCl$	15128		
Sod. sulph., Na_2SO_4	224.9	Calc. silicate, $CaSiO_3$	.....
Mag. sulph., $MgSO_4$	.....	Silica, SiO_2	48.6
Calc. sulph., $CaSO_4$	1247.1	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	513.3
Ferrous bicarb., $Fe(HCO_3)_2$	.....	Sod. bicarb., $NaHCO_3$	.....
Total			18444.1

Properties of Reaction in Per Cent

Primary salinity	90.12	Primary alkalinity	....
Secondary salinity	6.06	Secondary alkalinity	3.82
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 60

IRON SPRING

Location—25 ft. from No. 58, Glenwood Springs.

Rate of Flow—1½ gal. per min. Temperature—85° F.

Class of Water—Sodic, potassic, muriated, saline, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	31.4	......
Sulphate	SO_4	786.5	3.48
Bicarbonate	HCO_3	698.8	2.42
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	7356	44.10
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	6.8	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	374.5	3.98
Magnesium	Mg	34.62	.61
Potassium	K	2187	11.88
Sodium	Na	3629.6	33.53
Lithium	Li	None	......
	Total	15105.22	100.00

Concentration value	470.64	Excess carbon dioxide	252
Hydrogen sulphide, H_2S	2.11	Iron precipitated	6.34
Arsenic, As	....	Evaporation solids	13772
Strontium, Sr	....	Oxygen consuming capacity	2.73

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	697.8
Pot. chlor., KCl	4170.4	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	6.8
Sod. chlor., NaCl	8857.3	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	447.5	Silica, SiO_2	31.4
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	685.7	Mag. bicarb., $Mg(HCO_3)_2$	208.3
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			15105.2

Properties of Reaction in Per Cent

Primary salinity	90.82	Primary alkalinity	....
Secondary salinity	4.34	Secondary alkalinity	4.04
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 61

WEST GLENWOOD SPRING

Location—Spring nearest Bath House, Glenwood Springs.

Rate of Flow—10 to 12 gal. per minute. Temperature—125° F.

Class of Water—Sodic, muriated, sulphated, saline, potassic, (sulphuretted, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	43.0	......
Sulphate	SO_4	2103	5.89
Bicarbonate	HCO_3	748.7	1.65
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	11177	42.46
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	820.9	5.52
Magnesium	Mg	69.45	.77
Potassium	K	500	1.72
Sodium	Na	7171.35	41.99
Lithium	Li	None	......
	Total	22633.4	100.00

Concentration value	742.64	Excess carbon dioxide	270
Hydrogen sulphide, H_2S	2.17	Iron precipitated	None
Arsenic, As	....	Evaporation solids	22460
Strontium, Sr	....	Oxygen consuming capacity	11.98

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	531.8
Pot. chlor., KCl	953.45	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	Trace
Sod. chlor., NaCl	17679	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	666.7	Silica, SiO_2	43
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	2341.6	Mag. bicarb., $Mg(HCO_3)_2$	417.9
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			22633.45

Properties of Reaction in Per Cent

Primary salinity	87.42	Primary alkalinity	....
Secondary salinity	9.28	Secondary alkalinity	3.30
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 62

WEST GLENWOOD SPRINGS

Location—Spring 25 feet from No. 61, Glenwood Springs.

Rate of Flow—12 to 15 gal. per minute. Temperature—106° F.

Class of Water—Sodic, calcic, muriated, sulphated, saline, potassic, (sulphuretted, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	99.6	......
Sulphate	SO_4	2693	7.08
Bicarbonate	HCO_3	798.7	1.65
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	11593	41.27
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	None	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	853.1	5.38
Magnesium	Mg	140.2	1.45
Potassium	K	477.5	1.54
Sodium	Na	7585.5	41.63
Lithium	Li	......	......
	Total	24240.6	100.0

Concentration value	792.40	Excess carbon dioxide	288
Hydrogen sulphide, H_2S	2.13	Iron precipitated	1.76
Arsenic, As	....	Evaporated solids	23246
Strontium, Sr	....	Oxygen consuming capacity	14.12

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	1061.1
Pot. chlor., KCl	910.5	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	18399.0	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	1070.2	Silica, SiO_2	99.6
Mag. sulph., $MgSO_4$	694.0	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	2006.2	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			24240.6

Properties of Reaction in Per Cent

Primary salinity	86.34	Primary alkalinity	....
Secondary salinity	10.36	Secondary alkalinity	3.30
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 63

VAPOR CAVE NO. 3

Location—Glenwood Springs.

Rate of Flow—35 to 40 gal. per min. Temperature—122° F.

Class of Water—Sodic, muriated, sulphated, saline, potassic, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	32.4	......
Sulphate	SO_4	1087	3.52
Bicarbonate	HCO_3	761.2	1.94
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	10140	44.54
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	504.6	3.92
Magnesium	Mg	79.30	1.02
Potassium	K	400	1.59
Sodium	Na	6420.3	43.47
Lithium	Li	None	......
	Total	19424.8	100.00

Concentration value	642.22	Excess carbon dioxide	274.5
Hydrogen sulphide, H_2S	2.10	Iron precipitated	None
Arsenic, As	....	Evaporation solids	19044
Strontium, Sr	....	Oxygen consuming capacity	3.70

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	1011.3
Pot. chlor., KCl	762.8	Iron and aluminum oxides,	
Sod. chlor., NaCl	16119.0	Fe_2O_3, Al_2O_3	Trace
Sod. sulph., Na_2SO_4	242.4	Calc. silicate, $CaSiO_3$	.....
Mag. sulph., $MgSO_4$	392.5	Silica, SiO_2	32.4
Calc. sulph., $CaSO_4$	864.4	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....	Sod. bicarb., $NaHCO_3$	.....
Total			19424.8

Properties of Reaction in Per Cent

Primary salinity	90.12	Primary alkalinity	....
Secondary salinity	6.00	Secondary alkalinity	3.88
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 50. Temperature, °F, 122.
Curies Ra Emanation per liter x 10^{-10}, Gas, 27.30.
Mache Units per liter, Gas, 7.37.
Permanent Activity, Grams Ra per liter, x 10^{-10}, 0.197.

NUMBER 64

AIR SAMPLE

Location—Air Sample in Inhalatorium, Glenwood Springs.

Radioactivity

Curies Ra Emanation per liter x 10^{-10}, Gas, 0.44.
Mache Units per liter, Gas, 0.12.

NUMBER 65

SALINE SPRING

Location—14 mi. S. W. Guffey in Hodges Pasture.

Class of Water—Sodic, calcic, muriated, bicarbonated, alkaline-saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	76.5	......
Sulphate	SO_4	120.5	.72
Bicarbonate	HCO_3	3634.0	17.43
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	3857.0	31.85
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	None	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	639.6	9.33
Magnesium	Mg	127.2	3.06
Potassium	K	191.3	1.43
Sodium	Na	2842.2	36.18
Lithium	Li	Trace	......
	Total	11488.3	100.00

Concentration value	341.66	Excess carbon dioxide	1130.5
Hydrogen sulphide, H_2S	None	Iron precipitated	4.19
Arsenic, As	....	Evaporation solids	10130
Strontium, Sr	....	Oxygen consuming capacity	3.95

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith chlor., $LiCl$	Trace	Calc. bicarb., $Ca(HCO_3)_2$	2586.4
Pot. chlor., KCl	364.9	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	6072.3		
Sod. sulph., Na_2SO_4	178.2	Calc. silicate, $CaSiO_3$	.....
Mag. sulph., $MgSO_4$	.....	Silica, SiO_2	76.5
Calc. sulph., $CaSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	765.4
Ferrous bicarb., $Fe(HCO_3)_2$	.....	Sod. bicarb., $NaHCO_3$	1444.2
Total			11487.9

Properties of Reaction in Percent

Primary salinity	65.14	Primary alkalinity	10.08
Secondary salinity	....	Secondary alkalinity	24.78
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 66

MOUND SPRING—CURRANT CREEK SPRING

Location—1 mile below Guffey on Currant Creek.

Rate of Flow— Temperature—68° F.

Class of Water—Sodic, muriated, bicarbonated, alkaline-saline, potassic, magnesic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	77.5	......
Sulphate	SO_4	157.8	1.92
Bicarbonate	HCO_3	2759.0	26.54
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	1302.0	21.54
Iron	Fe	......	.19
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	13.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	250.5	7.33
Magnesium	Mg	105.2	5.07
Potassium	K	181.2	2.72
Sodium	Na	1360	34.69
Lithium	Li	Trace	......
		6206.2	100.00
Oxygen in Fe_2O_3		3.91	
	Total	6202.29	

Concentration value	170.50	Excess carbon dioxide	995.0
Hydrogen sulphide, H_2S	None	Iron precipitated	3.10
Arsenic, As	....	Evaporated solids	4620
Strontium, Sr	....	Oxygen consuming capacity	3.01

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	1013.0
Pot. chlor., KCl	345.5	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	1875.6	Calc. silicate, $CaSiO_3$	.....
Sodium sulph., Na_2SO_4	233.35	Silica, SiO_3	77.5
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	633.0
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1995.3
Ferrous bicarb., $Fe(HCO_3)_2$	28.96		
Total			6202.21

Properties of Reaction in Per Cent

Primary salinity	46.92	Primary alkalinity	27.90
Secondary salinity	....	Secondary alkalinity	25.18
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 67

SALT WORKS SPRING

Location—12 mi. West of Hartsel.
Rate of Flow—5 to 6 gal. per min. Temperature—48° F.
Class of Water—Sodic, muriated, sulphated, saline, potassic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	92.0	......
Sulphate	SO_4	2700	5.64
Bicarbonate	HCO_3	330.7	.54
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	15472	43.82
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	17	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	1074	5.39
Magnesium	Mg	94.6	.78
Potassium	K	900	2.30
Sodium	Na	9512.5	41.53
Lithium	Li	None	......
	Total	30192.8	100.00

Concentration value	996.24	Excess carbon dioxide	119.2
Hydrogen sulphide, H_2S	None	Iron precipitated	3.93
Arsenic, As	....	Evaporation solids	31166
Strontium, Sr	....	Oxygen consuming capacity	26.4

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	439.4
Pot. chlor., KCl	1716.2	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	17.0
Sod. chlor., NaCl	24162.0	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	19.5	Silica, SiO_2	92.0
Mag. sulph., $MgSO_4$	468.3	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	3278.4	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			30192.8

Properties of Reaction in Per Cent

Primary salinity	87.66	Primary alkalinity	....
Secondary salinity	11.26	Secondary alkalinity	1.08
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 9.5. Temperature, °F, 49.1.
Curies Ra Emanation per liter x 10^{-10}, Water, none.
Mache Units per liter, Water, none.

NUMBER 68

SALT SPRING NEAR "63" RANCH

Location—3 miles west and 4 miles north of 67.

Rate of Flow—60 to 75 gal. per min. Temperature—46° F.

Class of Water—Sodic, muriated, saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	20.4	......
Sulphate	SO_4	316	8.02
Bicarbonate	HCO_3	230.9	4.61
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	1087	37.37
Iron	Fe	......	.17
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	6.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	108.7	6.63
Magnesium	Mg	30.9	3.10
Potassium	K	85	2.64
Sodium	Na	706.5	37.46
Lithium	Li	None	......
		2591.9	100.00
Oxygen in Fe_2O_3		2.0	
	Total	2589.9	

Concentration value	82.02	Excess carbon dioxide	83.3
Hydrogen sulphide, H_2S	None	Iron precipitated	1.29
Arsenic, As	....	Evaporation solids	2506
Strontium, Sr	....	Oxygen consuming capacity	3.02

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	112.4
Pot. chlor., KCl	162.1	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	1665	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	.....	Silica, SiO_2	20.4
Mag. sulph., $MgSO_4$	153.0	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	274.8	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	......	Sod. bicarb., $NaHCO_3$	187.7
Ferrous bicarb., $Fe(HCO_3)_2$	14.5		
Total			2589.9

Properties of Reaction in Per Cent

Primary salinity	80.20	Primary alkalinity	....
Secondary salinity	10.58	Secondary alkalinity	9.22
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 69

STINKING SPRING

Location—10 miles east of Hartsel on Mills Ranch.

Rate of Flow—4 to 5 gal. per min. Temperature—61° F.

Class of Water—Sodic, muriated, bicarbonated, alkaline-saline, potassic, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	12.8	......
Sulphate	SO_4	15.22	.26
Bicarbonate	HCO_3	1806.69	23.60
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	1163.0	26.14
Iron	Fe	......	.03
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	1.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	22.16	.89
Magnesium	Mg	34.62	2.27
Potassium	K	112.5	2.29
Sodium	Na	1285	44.52
Lithium	Li	Trace	......
		4453.49	100.00
Oxygen in Fe_2O_3		.45	
	Total	4453.04	

Concentration value	125.48	Excess carbon dioxide	651.5
Hydrogen sulphide, H_2S	2.08	Iron precipitated	1.41
Arsenic, As	....	Evaporation solids	3659
Strontium, Sr	....	Oxygen consuming capacity	Trace

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	89.61
Pot. chlor., KCl	214.5	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	1749.2	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	22.51	Silica, SiO_2	12.8
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	208.3
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	2153.2
Ferrous bicarb., $Fe(HCO_3)_2$	3.34		

Total 4453.46

Properties of Reaction in Per Cent

Primary salinity	52.80	Primary alkalinity	40.82
Secondary salinity	....	Secondary alkalinity	6.38
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Curies Ra Emanation per liter x 10^{-10}, Water, none.
Mache Units per liter, Water, none.

NUMBER 70

COLD SODA SPRING

Location—½ mi. S. of Hartsel.

Rate of Flow—1 gal. per min. Temperature—49° F.

Class of Water—Sodic, muriated, saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	19.5	......
Sulphate	SO_4	89.7	4.52
Bicarbonate	HCO_3	257	10.15
Carbonate	CO_3	Trace	......
Phosphate	PO_4	None	......
Chloride	Cl	519.3	35.33
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	27.70	3.33
Magnesium	Mg	11.10	2.19
Potassium	K	26.2	1.61
Sodium	Na	408.7	42.87
Lithium	Li	Trace	......
	Total	1359.8	100.00

Concentration value	41.46	Excess carbon dioxide	92.9
Hydrogen sulphide, H_2S	None	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	1569
Strontium, Sr	....	Oxygen consuming capacity	None

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	112.0
Pot. chlor., KCl	49.96	Iron and aluminum oxides,	
Sod. chlor., NaCl	817.0	Fe_2O_3, Al_2O_3	Trace
Sod. sulph., Na_2SO_4	132.6	Calc. silicate, $CaSiO_3$	.....
Mag. sulph., $MgSO_4$	.....	Silica, SiO_2	19.5
Calc. sulph., $CaSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	66.79
Ferrous bicarb., $Fe(HCO_3)_2$	.....	Sod. bicarb., $NaHCO_3$	161.95
Total			1359.8

Properties of Reaction in Per Cent

Primary salinity	79.70	Primary alkalinity	9.26
Secondary salinity	....	Secondary alkalinity	11.04
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 71

HARTSEL HOT SPRINGS

Location—Hartsel.
Rate of Flow—2½ to 3 gal. per min. Temperature—134° F.
Class of Water—Sodic, muriated, sulphated, saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	45.8	......
Sulphate	SO_4	333.3	10.03
Bicarbonate	HCO_3	310.0	7.35
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	801.2	32.62
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	1.7	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	Trace	......
Calcium	Ca	99.0	7.14
Magnesium	Mg	29.09	3.44
Potassium	K	24.2	.90
Sodium	Na	613.45	38.52
Lithium	Li	Trace	
	Total	2257.74	100.00

Concentration value	69.20	Excess carbon dioxide	111.8
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	2091
Strontium, Sr	....	Oxygen consuming capacity	None

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	218.01
Pot. chlor., KCl	46.15	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	1.7
Sod. chlor., NaCl	1284.7	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	333.5	Silica, SiO_2	45.8
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	152.8	Mag. bicarb., $Mg(HCO_3)_2$	175.04
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			2257.7

Properties of Reaction in Per Cent

Primary salinity	78.84	Primary alkalinity	....
Secondary salinity	6.46	Secondary alkalinity	14.70
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 56.5. Temperature, °F, 133.7.
Curies Ra Emanation per liter x 10^{-10}, Water, 15.14; Gas, 414.0.
Mache Units per liter, Water, 4.09; Gas, 111.8.
Permanent Activity, Grams Ra per liter x 10^{-10}, 0.180.

NUMBER 72

IRON SPRING

Location—½ mi. N. of Hartsel.

Rate of Flow— Temperature—48° F.

Class of Water—Sodic, calcic, sulphated, bicarbonated, alkaline-saline, magnesic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	26.1	......
Sulphate	SO_4	89.29	14.04
Bicarbonate	HCO_3	205.1	25.38
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	49.63	10.58
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	33.60	12.69
Magnesium	Mg	19.8	12.32
Potassium	K	13	2.49
Sodium	Na	68.45	22.50
Lithium	Li	Trace, faint	......
	Total	505.0	100.00

Concentration value	13.24	Excess carbon dioxide	73.96
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	427
Strontium, Sr	....	Oxygen consuming capacity	None

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Faint trace	Calc. bicarb., $Ca(HCO_3)_2$	135.9
Pot. chlor., KCl	24.79	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	Trace
Sod. chlor., NaCl	62.28	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	31.69	Silica, SiO_2	26.1
Mag. sulph., $MgSO_4$	85.04	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	15.77
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	123.4
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			504.97

Properties of Reaction in Per Cent

Primary salinity	49.24	Primary alkalinity	0.74
Secondary salinity	....	Secondary alkalinity	50.02
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 8.5. Temperature, °F, 47.4.
Curies Ra Emanation per liter x 10^{-10}, Water, 11.30.
Mache Units per liter, Water, 3.05.

NUMBER 73

DOUGHTY SPRINGS—DRINKING SPRING

Location—Hotchkiss 3 mi. S. W. Hotchkiss.

Rate of Flow—5 to 6 gal. per min. Temperature—62° F.

Class of Water—Sodic, bicarbonated, muriated, alkaline-saline, potassic, (sulphuretted, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	17.0	......
Sulphate	SO_4	229.6	4.49
Bicarbonate	HCO_3	1785.0	27.45
Carbonate	CO_3	Trace	......
Phosphate	PO_4	None	......
Chloride	Cl	682.6	18.06
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	8.2	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	59.2	2.78
Magnesium	Mg	44.7	3.46
Potassium	K	205.0	4.93
Sodium	Na	952.5	38.83
Lithium	Li	Trace	......
	Total	3983.8	100.00

Concentration value	106.58	Excess carbon dioxide	643
Hydrogen sulphide, H_2S	61.0	Iron precipitated	None
Arsenic, As	....	Evaporation solids	3008
Strontium, Sr	....	Oxygen consuming capacity	3.12

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	239.5
Pot. chlor., KCl	390.9	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	8.2
Sod. chlor., NaCl	818.9	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	339.5	Silica, SiO_2	17.0
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	269.0
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1900.8
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			3983.8

Properties of Reaction in Per Cent

Primary salinity	45.10	Primary alkalinity	42.42
Secondary salinity	.....	Secondary alkalinity	12.48
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 16.0. Temperature, °F, 60.9.
Curies Ra Emanation per liter x 10^{-10}, Water, 18.40.
Mache Units per liter, Water, 4.97.

NUMBER 73A

BLACK SPRING (HEADDEN'S REPORT)

Location—Doughty Springs, Hotchkiss.

Rate of Flow— Temperature—63.5° F.

Class of Water—Sodic, lithic, (manganic), muriated, bicarbonated, bromic, alkaline-saline, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams Approximately parts per million	Reacting value percentage
Silica	SiO_2	18.6	......
Sulphate	SO_4	273.1	4.36
Bicarbonate	HCO_3	2159.7	27.21
Silicate	SiO_3	......	.48
Thiosulphate	S_2O_3	10.8	.15
Carbonate	CO_3	......	......
Metaborate	BO_2	.1	......
Chloride	Cl	815.7	17.66
Bromium	Br	14.7	.14
Iron	Fe	1.2	......
Aluminum	Al	4.6	......
Iron oxide	Fe_2O_3	......	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	4.0	......
Calcium	Ca	126.1	4.81
Strontium	Sr	3.5	.06
Magnesium	Mg	60.9	3.83
Potassium	K	58.9	1.15
Sodium	Na	1197.8	39.92
Lithium	Li	1.6	.18
Ammonium	NH_4	1.3	.05
Oxygen to form SiO_3		4.9	......
Oxygen in Fe_2O_3		.50	......
Oxygen to form Al_2O_3		4.07	......
Oxygen to form Mn_3O_4		1.55	......
	Total	4763.62	100.00

Concentration value	130.40	Excess carbon dioxide	977.2
Hydrogen sulphide, H_2S	49.2	Iron precipitated	....
Arsenic, As	....	Evaporation solids	3682.5

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Ammon. chlor., NH_4Cl	3.86	Calc. carb., $CaCO_3$	.....
Lith. chlor., LiCl	9.70	Ferrous bicarb., $Fe(HCO_3)_2$	.....
Pot. brom., KBr	21.89	Calc. bicarb., $Ca(HCO_3)_2$	.....
Pot. chlor., KCl	98.59	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	10.49
Sod. chlor., NaCl	1249.87	Calc. silicate, $CaSiO_3$	35.84
Sod. metaborate, $NaBO_2$	.15	Silica, SiO_2	.....
Sod. sulph., Na_2SO_4	403.86	Mang. oxide, Mn_3O_4	5.55
Sod. thiosulph., $Na_2S_2O_3$	21.38	Mag. bicarb., $Mg(HCO_3)_2$	366.50
Mag. sulph., $MgSO_4$	.....	Sod. bicarb., $NaHCO_3$	2067.50
Calc. sulph., $CaSO_4$	.....	Stront. bicarb., $Sr(HCO_3)_2$	8.40
Total			4763.58

Properties of Reaction in Percent

Primary salinity	44.32	Primary alkalinity	38.28
Secondary salinity	....	Secondary alkalinity	17.40
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 74

DOUGHTY SPRINGS

Location—Hotchkiss between Bird's Nest and Bath Tub Spring.

Rate of Flow—8 gal. per min. Temperature—64° F.

Class of Water—Sodic, bicarbonated, sulphated, muriated, alkaline-saline, potassic, magnesic, (sulphuretted, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	24.5	......
Sulphate	SO_4	1053	17.75
Bicarbonate	HCO_3	1250.5	16.62
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	684	15.63
Iron	Fe	......	.15
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	7.5	
Aluminum oxide	Al_2O_3		......
Manganese	Mn	None	......
Calcium	Ca	161	6.51
Magnesium	Mg	100.2	6.67
Potassium	K	210	4.36
Sodium	Na	917	32.31
Lithium	Li	Trace	......
		4407.7	100.00
Oxygen in Fe_2O_3		2.2	
	Total......	4405.5	

Concentration value	123.46	Excess carbon dioxide	450.9
Hydrogen sulphide, H_2S	51.1	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	3712
Strontium, Sr	....	Oxygen consuming capacity	3.41

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	651.0
Pot. chlor., KCl	400.5	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	813.6	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	1557.0	Silica, SiO_2	24.5
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	602.9
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	339.3
Ferrous bicarb., $Fe(HCO_3)_2$	16.7		
Total			4405.5

Properties of Reaction in Per Cent

Primary salinity	66.76	Primary alkalinity	6.58
Secondary salinity	.....	Secondary alkalinity	26.66
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 74A

No. II., BIRD'S NEST (HEADDEN'S REPORT)

Location—Doughty Springs, Hotchkiss.
Class of Water—Sodic, lithic, manganic, muriated, bicarbonated, borated, bromic, alkaline-saline, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	16.8	......
Sulphate	SO_4	141.7	2.15
Bicarbonate	HCO_3	2452.8	29.44
Silicate	SiO_3	......	.41
Carbonate	CO_3	......	......
Phosphate	PO_4	......	......
Metaborate	BO_2	7.9	.13
Chloride	Cl	861.5	17.78
Bromium	Br	9.5	.09
Iron	Fe	.3	......
Aluminum	Al	.5	......
Iron oxide	Fe_2O_3	......	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	2.2	......
Calcium	Ca	118.6	4.34
Strontium	Sr	3.5	.06
Magnesium	Mg	54.3	3.28
Potassium	K	66.1	1.24
Sodium	Na	1273.6	40.50
Lithium	Li	4.9	.51
Ammonium	NH_4	1.7	.07
Oxygen to form SiO_3		4.5	......
Oxygen in Fe_2O_3		.13	......
Oxygen to form Al_2O_3		.45	......
Oxygen to form Mn_3O_4		.85	......
	Total	5021.83	100.00

Concentration value	136.50	Excess carbon dioxide	862.0
Hydrogen sulphide, H_2S	38.7	Iron precipitated	....
Arsenic, As	....	Evaporation solids	3744.2
Strontium, Sr	....		

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Ammon. chlor., NH_4Cl	5.04	Ferrous bicarb., $Fe(HCO_3)_2$	.....
Lith. chlor., LiCl	29.72	Calc. bicarb., $Ca(HCO_3)_2$	434.24
Pot. brom., KBr	14.15	Stront. bicarb., $Sr(HCO_3)_2$	8.37
Pot. chlor., KCl	117.18	Iron and aluminum oxides, Fe_2O_3, Al_2O_5	1.20
Sod. metaborate, $NaBO_2$	12.09	Calc. silicate, $CaSiO_3$	32.52
Sod. chlor., NaCl	1282.00	Silica, SiO_2	.....
Sod. sulph., Na_2SO_4	209.55	Mang. oxide, Mn_3O_4	3.05
Mag. sulph., $MgSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	326.74
Calc. sulph., $CaSO_4$	.....	Sod. bicarb., $NaHCO_3$	2546.00
Calc. carb., $CaCO_3$	.....		
Total			5021.85

Properties of Reaction in Percent

Primary salinity	40.04	Primary alkalinity	44.60
Secondary salinity	....	Secondary alkalinity	15.36
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 75

DOUGHTY SPRINGS

Location—Between Bird's Nest Spring and No. 74.

Rate of Flow—3 gal. per min. Temperature—66° F.

Class of Water—Sodic, bicarbonated, sulphated, muriated, alkaline-saline, potassic, magnesic, ferruginous, (sulphuretted, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	58.7	......
Sulphate	SO_4	791	12.43
Bicarbonate	HCO_3	1760.6	21.83
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	738.7	15.74
Iron	Fe	......	.56
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	29.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	Trace	......
Calcium	Ca	183	6.90
Magnesium	Mg	91.8	5.71
Potassium	K	210	4.05
Sodium	Na	997.5	32.78
Lithium	Li	Trace	......
		4860.8	100.00
Oxygen in Fe_2O_3		8.9	
	Total	4851.9	

Concentration value	132.32	Excess carbon dioxide	634.9
Hydrogen sulphide, H_2S	59.3	Iron precipitated	None
Arsenic, As	....	Evaporation solids	3936
Strontium, Sr	....	Oxygen consuming capacity	2.53

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	740.0
Pot. chlor., KCl	400.5	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	903.8	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	1169.8	Silica, SiO_2	58.7
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	Trace
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	552.4
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	961.0
Ferrous bicarb., $Fe(HCO_3)_2$	67.5		
Total			4851.9

Properties of Reaction in Per Cent

Primary salinity	56.34	Primary alkalinity	17.32
Secondary salinity	....	Secondary alkalinity	25.22
Tertiary salinity	....	Tertiary alkalinity	1.12

NUMBER 75A

NUMBER III. OF HEADDEN'S REPORT

Location—Doughty Springs, Hotchkiss.

Class of Water—Sodic, lithic, manganic, muriated, bicarbonated, borated, alkaline, saline, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	15.6	......
Sulphate	SO_4	200.4	3.18
Bicarbonate	HCO_3	2278.7	28.59
Silicate	SiO_3	......	.31
Carbonate	CO_3	......	......
Metaborate	BO_2	10.0	.18
Chloride	Cl	820.0	17.70
Bromium	Br	4.2	.04
Iron	Fe	3.5	......
Aluminum	Al	.4	......
Iron oxide	Fe_2O_3	......	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	2.3	......
Calcium	Ca	120.4	4.59
Strontium	Sr	3.3	.03
Magnesium	Mg	55.2	3.46
Potassium	K	63.2	1.23
Sodium	Na	1200.2	39.89
Lithium	Li	6.8	.75
Ammonium	NH_4	1.1	.05
Oxygen to form SiO_3		4.1	......
Oxygen in Fe_2O_3		1.50	......
Oxygen to form Al_2O_3		.35	......
Oxygen to form Mn_3O_4		.89	......
	Total	4792.14	100.00

Concentration value	130.94	Excess carbon dioxide	1242.4
Hydrogen sulphide, H_2S	38.5	Iron precipitated	....
Arsenic, As	....	Evaporation solids	3632
Strontium, Sr	....		

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Ammon. chlor., NH_4Cl	3.26	Ferrous bicarb., $Fe(HCO_3)_2$	.....
Lith. chlor., LiCl	41.25	Calc. bicarb., $Ca(HCO_3)_2$	445.00
Pot. brom., KBr	6.26	Stront. bicarb., $Sr(HCO_3)_2$	7.89
Pot. chlor., KCl	116.58	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	5.75
Sod. chlor., NaCl	1200.10	Calc. silicate, $CaSiO_3$	30.05
Sod. metaborate, $NaBO_2$	15.30	Silica, SiO_2	.....
Sod. sulph., Na_2SO_4	296.35	Mang. oxide, Mn_3O_4	3.19
Mag. sulph., $MgSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	332.15
Calc. sulph., $CaSO_4$	.....	Sod. bicarb., $NaHCO_3$	2289.00
Calc. carb., $CaCO_3$	.....		
Total			4792.13

Properties of Reaction in Percent

Primary salinity	41.84	Primary alkalinity	42.00
Secondary salinity	....	Secondary alkalinity	16.16
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 75B

NO. V. BATH TUB, HEADDEN'S REPORT

Location—Doughty Springs, Hotchkiss.

Class of Water—Sodic, lithic, manganic, muriated, bicarbonated, alkaline-saline.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	21.0	......
Sulphate	SO_4	478.6	7.80
Bicarbonate	HCO_3	1912.8	24.56
Silicate	SiO_3	......	.54
Carbonate	CO_3	......	......
Phosphate	PO_4	......	......
Chloride	Cl	774.9	17.10
Iron	Fe	.5	......
Aluminum	Al	.7	......
Iron oxide	Fe_2O_3	......	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	1.3	......
Calcium	Ca	118.2	4.61
Strontium	Sr	2.9	.05
Magnesium	Mg	64.8	4.16
Potassium	K	59.4	1.19
Sodium	Na	1163.9	39.59
Ammonium	NH_4	.5	.02
Lithium	Li	3.4	.38
Oxygen to form SiO_3		5.6	......
Oxygen in Fe_2O_3		.2	......
Oxygen to form Al_2O_3		.6	......
Oxygen to form Mn_3O_4		.5	......
	Total......	4609.82	100.00

Concentration value	127.80	Iron precipitated	....
Hydrogen sulphide, H_2S	....	Evaporation solids	3446.3
Arsenic, As	....	Oxygen consuming capacity.	....
Excess carbon dioxide	None		

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Ammon. chlor., NH_4Cl	1.48	Stront. bicarb., $Sr(HCO_3)_2$	6.94
Lith. chlor., LiCl	17.02	Calc. bicarb., $Ca(HCO_3)_2$	421.35
Pot. chlor., KCl	113.27	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	2.03
Sod. chlor., NaCl	1159.00	Calc. silicate, $CaSiO_3$	40.57
Sod. sulph., Na_2SO_4	707.75	Silica, SiO_2	.....
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	1.81
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	389.93
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1748.60
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			4609.75

Properties of Reaction in Percent

Primary salinity	49.80	Primary alkalinity	32.56
Secondary salinity	....	Secondary alkalinity	17.64
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 76

DOUGHTY SPRINGS

Location—50 feet below No. 73, Drinking Spring.

Radioactivity

Temperature, °C, 16.1. Temperature, °F, 61.0.

Curies Ra Emanation per liter x 10^{-10}, Gas, 229.0.

Mache Units per liter, Gas, 61.85.

Permanent Activity, Grams Ra per liter x 10^{-10}, none.

NUMBER 77

BATH HOUSE SPRING

Location—3 miles southwest of Hotchkiss.

Radioactivity

Temperature, °C, 20.5. Temperature, °F, 69.0.

Curies Ra Emanation per liter x 10^{-10}, Water, 24.55.

Mache Units per liter, Water, 6.63.

Permanent Activity, Grams Ra per liter x 10^{-10}, none.

NUMBER 78

BIG SPRING

Location—Big Spring by lower gate, Hot Sulphur Springs.

Rate of Flow—75 gal. per min. Temperature—96° and 109° F.

Class of Water—Sodic, bicarbonated, alkaline, ferruginous, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	31.6	......
Sulphate	SO_4	137.4	7.31
Bicarbonate	HCO_3	769.5	32.22
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	145.3	10.47
Iron	Fe	......	.43
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	6.75	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	16.07	2.04
Magnesium	Mg	1.64	.36
Potassium	K	80	5.16
Sodium	Na	378.2	42.01
Lithium	Li	Trace	......
		1566.46	100.00
Oxygen in Fe_2O_3		2.03	
	Total	1564.43	

Concentration value	39.14	Excess carbon dioxide	277.5
Hydrogen sulphide, H_2S	8.22	Iron precipitated	None
Arsenic, As	.....	Evaporation solids	1189
Strontium, Sr	None	Oxygen consuming capacity	0.55

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	64.98
Pot. chlor., KCl	152.55	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	119.93	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	203.2	Silica, SiO_2	31.6
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	9.87
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	968.6
Ferrous bicarb., $Fe(HCO_3)_2$	15.04		
Total			1565.77

Properties of Reaction in Per Cent

Primary salinity	35.56	Primary alkalinity	58.78
Secondary salinity	.....	Secondary alkalinity	4.80
Tertiary salinity	....	Tertiary alkalinity	0.86

Radioactivity

Temperature, °C, 35.0. Temperature, °F, 95.0.
Curies Ra Emanation per liter x 10^{-10}, Water, 5.99.
Mache Units per liter, Water, 1.62.

NUMBER 79

BATH HOUSE SPRING

Location—Upper corner of pool, Hot Sulphur Springs.

Rate of Flow—8 to 10 gal. per min. Temperature—117° F.

Class of Water—Sodic, bicarbonated, alkaline, ferruginous, potassic, (sulphuretted, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	32.5	......
Sulphate	SO_4	121.6	6.42
Bicarbonate	HCO_3	789.45	33.00
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	146.9	10.58
Iron	Fe	......	.31
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	6.25	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	15.86	2.02
Magnesium	Mg	1.86	.38
Potassium	K	77.2	5.03
Sodium	Na	380.5	42.26
Lithium	Li	Trace	......
		1572.12	100.00
Oxygen in Fe_2O_3		1.88	
	Total	1570.24	

Concentration value	39.16	Excess carbon dioxide	284.7
Hydrogen sulphide, H_2S	10.79	Iron precipitated	None
Arsenic, As	....	Evaporation solids	1209
Strontium, Sr	....	Oxygen consuming capacity	1.10

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	64.13
Pot. chlor., KCl	147.2	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	126.8	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	179.8	Silica, SiO_2	32.5
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	11.2
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	994.6
Ferrous bicarb., $Fe(HCO_3)_2$	13.92		
Total			1570.15

Properties of Reaction in Per Cent

Primary salinity	34.00	Primary alkalinity	60.58
Secondary salinity	.....	Secondary alkalinity	4.80
Tertiary salinity	....	Tertiary alkalinity	0.62

NUMBER 80

COMBINED SPRING

Location—Back of bath house, Hot Sulphur Springs.

Class of Water—Sodic, bicarbonated, alkaline, ferruginous, (sulphuretted, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	32.3	......
Sulphate	SO_4	136.6	7.14
Bicarbonate	HCO_3	792.17	32.50
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	146.9	10.36
Iron	Fe	......	.43
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	6.75	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	16.6	2.08
Magnesium	Mg	2.68	.55
Potassium	K	30.0	1.93
Sodium	Na	413.7	45.01
Lithium	Li	Trace	......
		1577.7	100.00
Oxygen in Fe_2O_3		2.03	
	Total	1575.67	

Concentration value	39.96	Excess carbon dioxide	285.7
Hydrogen sulphide, H_2S	9.74	Iron precipitated	None
Arsenic, As	....	Evaporation solids	1199
Strontium, Sr	....	Oxygen consuming capacity	0.37

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	Trace	Calc. bicarb., $Ca(HCO_3)_2$	67.12
Pot. chlor., KCl	57.21	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	197.3	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	202.0	Silica, SiO_2	32.3
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	16.13
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	988.55
Ferrous bicarb., $Fe(HCO_3)_2$	15.04		
Total			1575.65

Properties of Reaction in Per Cent

Primary salinity	35.00	Primary alkalinity	58.88
Secondary salinity	.....	Secondary alkalinity	5.26
Tertiary salinity	....	Tertiary alkalinity	0.86

Radioactivity

Temperature, °C, 44.5. Temperature, °F, 112.0.
Curies Ra Emanation per liter x 10^{-10}, Gas, 60.32.
Mache Units per liter, Gas, 16.29.
Permanent Activity, Grams Ra per liter x 10^{-10}, none.

NUMBER 81

LITTLE SULPHUR SPRING

Location—Hot Sulphur Springs.

Class of Water—Sodic, bicarbonated, alkaline, potassic, (sulphuretted, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	31.2	......
Sulphate	SO_4	120.3	6.25
Bicarbonate	HCO_3	810.8	32.94
Silicate	SiO_3	......	.54
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	146.9	10.27
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	5.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	15.50	1.91
Magnesium	Mg	Trace	......
Potassium	K	35.2	2.23
Sodium	Na	425.2	45.86
Lithium	Li	Trace	......
Oxygen to form SiO_3		1.8	......
	Total	1591.9	100.00

Concentration value	40.32	Excess carbon dioxide	292.4
Hydrogen sulphide, H_2S	11.11	Iron precipitated	None
Arsenic, As	....	Evaporation solids	1201
Strontium, Sr	....	Oxygen consuming capacity	2.05

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	44.64
Pot. chlor., KCl	67.12	Iron and aluminum oxides,	
Sod. chlor., NaCl	189.6	Fe_2O_3, Al_2O_3	5.0
Sod. sulph., Na_2SO_4	177.9	Calc. silicate, $CaSiO_3$	12.95
Mag. sulph., $MgSO_4$	.....	Silica, SiO_2	24.5
Calc. sulph., $CaSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	Trace
Ferrous bicarb., $Fe(HCO_3)_2$	.....	Sod. bicarb., $NaHCO_3$	1070.2

Total 1591.9

Properties of Reaction in Per Cent

Primary salinity	33.04	Primary alkalinity	63.14
Secondary salinity	.....	Secondary alkalinity	3.82
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Permanent Activity, Grams Ra per liter x 10^{-10}, trace.

NUMBER 82

BIG SULPHUR SPRING

Location—Hot Sulphur Springs.

Rate of Flow— Temperature—115° F.

Class of Water—Sodic, bicarbonated, muriated, alkaline, potassic, (sulphuretted, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	37.5	......
Sulphate	SO_4	121.3	6.07
Bicarbonate	HCO_3	857.5	33.84
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	148.6	10.09
Iron	Fe	......	.14
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	2.25	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	32.93	3.95
Magnesium	Mg	Trace	......
Potassium	K	95.0	5.85
Sodium	Na	382.8	40.06
Lithium	Li	Trace	......
		1677.88	100.00
Oxygen in Fe_2O_3		.67	
	Total	1677.2	

Concentration value	41.54	Excess carbon dioxide	309.2
Hydrogen sulphide, H_2S	12.47	Iron precipitated	None
Arsenic, As	....	Evaporation solids	1200
Strontium, Sr	....	Oxygen consuming capacity	0.73

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	133.2
Pot. chlor., KCl	181.25	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	102.95	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	179.4	Silica, SiO_2	37.5
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	Trace
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1038.1
Ferrous bicarb., $Fe(HCO_3)_2$	5.0		

Total 1677.4

Properties of Reaction in Per Cent

Primary salinity	32.32	Primary alkalinity	49.50
Secondary salinity	....	Secondary alkalinity	8.18
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 45.0. Temperature, °F, 113.0.
Curies Ra Emanation per liter x 10^{-10}, Water, 3.60.
Mache Units per liter, Water, 0.97.
Permanent Activity, Grams Ra per liter x 10^{-10}, none.

NUMBER 83

POOL SPRING

Location—Spring back of swimming pool, Hot Sulphur Springs.

Class of Water—Sodic, bicarbonated, muriated, alkaline, potassic, (sulphuretted, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	29.1	......
Sulphate	SO_4	126.1	6.47
Bicarbonate	HCO_3	822	33.10
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	150.3	10.43
Iron	Fe	......	.10
Aluminum	Al	......	
Iron oxide	Fe_2O_3	1.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	16.52	2.04
Magnesium	Mg	Trace	......
Potassium	K	66.7	4.21
Sodium	Na	408.7	43.65
Lithium	Li	None	......
		1620.92	100.00
Oxygen in Fe_2O_3		.45	
	Total	1620.47	

Concentration value	40.70	Excess carbon dioxide	296.4
Hydrogen sulphide, H_2S	11.73	Iron precipitated	None
Arsenic, As	....	Evaporation solids	1208
Strontium, Sr	....	Oxygen consuming capacity	3.09

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	66.8
Pot. chlor., KCl	127.2	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	148.05	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	186.5	Silica, SiO_2	29.1
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	Trace
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1059.4
Ferrous bicarb., $Fe(HCO_3)_2$	3.34		
Total			1620.39

Properties of Reaction in Per Cent

Primary salinity	33.80	Primary alkalinity	61.92
Secondary salinity	.....	Secondary alkalinity	4.28
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 43.0. Temperature, °F, 109.4.
Curies Ra Emanation per liter x 10^{-10}, Water, 3.27.
Mache Units per liter, Water, 0.88.

NUMBER 84

SULPHUR SPRING

Location—2½ mi. northwest Hygiene.

Rate of Flow—2½ to 3 gal. per min. Temperature—53° F.

Class of Water—Sodic, bicarbonated, alkaline, (sulphuretted & carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	16.5	......
Sulphate	SO_4	232.5	10.97
Bicarbonate	HCO_3	948.4	35.26
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	58.8	3.77
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide Aluminum oxide	Fe_2O_3 Al_2O_3	Trace	......
Manganese	Mn	None	......
Calcium	Ca	33.6	3.81
Magnesium	Mg	10.8	2.02
Potassium	K	42.5	2.48
Sodium	Na	423	41.69
Lithium	Li	Trace	......
	Total	1766.1	100.00

Concentration value	44.10	Excess carbon dioxide	342
Hydrogen sulphide, H_2S	61.09	Iron precipitated	1.14
Arsenic, As	....	Evaporation solids	1253
Strontium, Sr	....	Oxygen consuming capacity	1.22

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	135.9
Pot. chlor., KCl	81.0	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	33.5	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	343.8	Silica, SiO_2	16.5
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	65.0
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1090.4
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			1766.1

Properties of Reaction in Per Cent

Primary salinity	29.48	Primary alkalinity	58.86
Secondary salinity	.....	Secondary alkalinity	11.66
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 17.0. Temperature, °F, 62.6.
Curies Ra Emanation per liter x 10^{-10}, Water, 4.92.
Mache Units per liter, Water, 1.33.

NUMBER 85

HOT SODA SPRING

Location—Idaho Springs.

Rate of Flow—35 to 50 gal. per min. Temperature—102° F.

Class of Water—Sodic, bicarbonated, sulphated, alkaline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	68.0	......
Sulphate	SO_4	396.3	11.64
Bicarbonate	HCO_3	1513.8	35.06
Silicate	SiO_3	......	.47
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	71.47	2.83
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	2.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	145.4	10.23
Magnesium	Mg	39.43	4.57
Potassium	K	Trace	......
Sodium	Na	573.3	35.20
Lithium	Li	None	......
Oxygen to form SiO_3		2.62	......
	Total	2812.32	100.00

Concentration value	70.82	Excess carbon dioxide	545.8
Hydrogen sulphide, H_2S	None	Iron precipitated	2.38
Arsenic, As	....	Evaporation solids	2045
Strontium, Sr	....	Oxygen consuming capacity	0.55

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	561.4
Pot. chlor., KCl	Trace	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	2.0
Sod. chlor., NaCl	117.82	Calc. silicate, $CaSiO_3$	19.05
Sod. sulph., Na_2SO_4	586.1	Silica, SiO_2	58.13
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	237.26
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1230.1
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			2811.86

Properties of Reaction in Per Cent

Primary salinity	28.94	Primary alkalinity	41.46
Secondary salinity	.....	Secondary alkalinity	29.60
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Permanent Activity, Grams Ra per liter x 10^{-10}, none.

NUMBER 86

COLD SODA SPRING

Location—Idaho Springs.
Rate of Flow— Temperature—58° F.
Class of Water—Sodic, aluminic, ferruginous, bicarbonated, alkaline-saline, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	62.0	......
Sulphate	SO_4	310.1	10.88
Bicarbonate	HCO_3	1293.64	35.64
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	73.47	3.48
Iron	Fe	43.75	2.64
Aluminum	Al	......	2.72
Iron oxide	Fe_2O_3	84.45	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	120.64	10.11
Magnesium	Mg	8.63	1.19
Potassium	K	63.24	2.72
Sodium	Na	419.04	30.62
Lithium	Li	None	......
		2478.96	100.00
Oxygen to form Al_2O_3		12.84	
	Total	2466.12	

Concentration value	59.50	Excess carbon dioxide	466.48
Hydrogen sulphide, H_2S	2.35	Iron precipitated	1770
Arsenic, As	....	Evaporation solids	15.26
Strontium, Sr	Trace	Oxygen consuming capacity	4.33

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Ferrous bicarb., $Fe(HCO_3)_2$	112.50
Pot. chlor., KCl	120.6	Calc. bicarb., $Ca(HCO_3)_2$	487.8
Sod. chlor., NaCl	26.58	Alum. oxide, Al_2O_3	57.11
Sod. sulph., Na_2SO_4	458.6	Calc. silicate, $CaSiO_3$	.....
Mag. sulph., $MgSO_4$	.....	Silica, SiO_2	62
Calc. sulph., $CaSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	51.93
Alum. bicarb., $Al(HCO_3)_2$	139.3	Sod. bicarb., $NaHCO_3$	949.7
Total			2466.12

Properties of Reaction in Per Cent

Primary salinity	28.72	Primary alkalinity	37.96
Secondary salinity	....	Secondary alkalinity	22.60
Tertiary salinity	....	Tertiary alkalinity	10.72

Radioactivity

Temperature, °C, 13.7. Temperature, °F, 56.7.
Curies Ra Emanation per liter x 10^{-10}, 4.54.
Mache Units per liter, Water, 1.23.
Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

NUMBER 87

BLUE RIBBON SPRING

Location—Idaho Springs.

Rate of Flow—10 gal. to 12 gal. per min. Temperature—61° F.

Class of Water—Sodic, calcic, bicarbonated, muriated, alkaline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	55.2	......
Sulphate	SO_4	223.17	11.24
Bicarbonate	HCO_3	835.15	33.08
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	83.49	5.68
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	None	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	89.5	10.82
Magnesium	Mg	23.21	4.62
Potassium	K	48.8	3.02
Sodium	Na	300.76	31.54
Lithium	Li	None	......
	Total	1659.18	100.00

Concentration value	41.36	Excess carbon dioxide	301.1
Hydrogen sulphide, H_2S	None	Iron precipitated	3.76
Arsenic, As	....	Evaporation solids	1244
Strontium, Sr	....	Oxygen consuming capacity	0.50

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	361.9
Pot. chlor., KCl	93.06	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	64.68	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	330.0	Silica, SiO_2	55.2
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	139.66
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	614.53
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			1659.13

Properties of Reaction in Per Cent

Primary salinity	33.84	Primary alkalinity	35.28
Secondary salinity	....	Secondary alkalinity	30.88
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 13.0. Temperature, °F, 55.5.

Curies Ra Emanation per liter x 10^{-10}, Water, 6.58.

Mache Units per liter, Water, 1.78.

Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

NUMBER 88

IDAHO SPRINGS

Radioactivity

Temperature, °C, 43.0, 43.0. Temperature, °F, 109.4, 109.4.
Curies Ra Emanation per liter x 10^{-10}, Water, 7.53, 11.49; Gas. 117.0.
Mache Units per liter, Water, 2.03, 3.10; Gas, 31.6.

NUMBER 89

IDAHO SPRINGS

Location—Hot Soda, Hotel No. 3.

Radioactivity

Temperature, °C, 40.0. Temperature, °F, 104.0.
Curies Ra Emanation per liter x 10^{-10}, Water, 15.51.
Mache Units per liter, Water, 4.19.

NUMBER 90

IDAHO SPRINGS

Location—Lowest Spring E. side stream.

Radioactivity

Temperature, °C, 41.6. Temperature, °F, 106.8.
Curies Ra Emanation per liter x 10^{-10}, Water, 2.20.
Mache Units per liter, Water, 0.69.

NUMBER 91

IDAHO SPRINGS

Radioactivity

Temperature, °F, 35.5. Temperature, °F, 95.9.
Curies Ra Emanation per liter x 10^{-10}, Water, 2.78; Gas, 146.10.
Mache Units per liter, Water, 0.75; Gas, 39.45.

NUMBER 92

IDAHO SPRINGS

Location—Pavilion Spring.

Radioactivity

Temperature, °C, 32.5. Temperature, °F, 90.5.

Curies Ra Emanation per liter x 10^{-10}, Water, 9.24.

Mache Units per liter, Water, 2.50.

NUMBER 93

IDAHO SPRINGS

Radioactivity

Temperature, °C, 40.0. Temperature, °F, 104.0.
Curies Ra Emanation per liter x 10^{-10}, Water, 6.81, 6.58; Gas, 180.15.
Mache Units per liter, Water, 1.84, 1.78; Gas, 48.63.

NUMBER 94

IDAHO SPRINGS

Radioactivity

Curies Ra Emanation per liter x 10^{-10}, Gas, 100.10.
Mache Units per liter, Gas, 27.02.

NUMBER 95

IDAHO SPRINGS

Location—Old tunnel Spring.

Radioactivity

Temperature, °C, 38.7. Temperature, °F, 101.6.
Curies Ra Emanation per liter x 10^{-10}, Water, 9.42.
Mache Units per liter, Water, 2.54.

NUMBER 96

IRONTON PARK SPRING

Location—Ironton.

Rate of Flow— Temperature—59° F.

Class of Water—Calcic, ferruginous, sulphated, saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	61.2	......
Sulphate	SO_4	572.8	43.35
Bicarbonate	HCO_3	99.8	5.96
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	6.8	.69
Iron	Fe	......	2.96
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	48.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	237.7	43.08
Magnesium	Mg	6.1	1.89
Potassium	K	10.2	.94
Sodium	Na	7.1	1.13
Lithium	Li	None	......
		1050.2	100.00
Oxygen in Fe_2O_3		9.9	
	Total	1040.3	

Concentration value	27.52	Excess carbon dioxide	36.0
Hydrogen sulphide, H_2S	None	Iron precipitated	26.06
Arsenic, As	....	Evaporation solids	964
Strontium, Sr	....	Oxygen consuming capacity	1.07

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	65.9
Pot. chlor., KCl	14.3	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	15.6
Sod. chlor., NaCl	.....	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	21.9	Silica, SiO_2	61.2
Mag. sulph., $MgSO_4$	30.2	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	752.0	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	73.2	Pot. sulph., K_2SO_4	6.0
Total			1040.3

Properties of Reaction in Per Cent

Primary salinity	4.14	Primary alkalinity	....
Secondary salinity	83.94	Secondary alkalinity	6.00
Tertiary salinity	....	Tertiary alkalinity	5.92

NUMBER 97

LOWER BATH HOUSE SPRING

Location—Juniper, Colorado.

Rate of Flow—25 to 35 gal. per min. Temperature—102° F.

Class of Water—Sodic, bicarbonated, alkaline, ferruginous, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	37.2	......
Sulphate	SO_4	27.88	1.77
Bicarbonate	HCO_3	833.27	41.68
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	76.07	6.55
Iron	Fe	......	.37
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	4.75	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	5.18	.79
Magnesium	Mg	5.41	1.34
Potassium	K	50.0	3.91
Sodium	Na	328.5	43.59
Lithium	Li	Trace, faint	......
		1368.26	100.00
Oxygen in Fe_2O_3		1.43	
	Total......	1366.83	

Concentration value	32.76	Excess carbon dioxide	300.5
Hydrogen sulphide, H_2S	1.94	Iron precipitated	None
Arsenic, As	....	Evaporation solids	1224
Strontium, Sr	....	Oxygen consuming capacity	2.92

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	Faint trace	Calc. bicarb., $Ca(HCO_3)_2$	20.95
Pot. chlor., KCl	95.34	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	50.66	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	41.23	Silica, SiO_2	37.2
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	32.55
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1078.30
Ferrous bicarb., $Fe(HCO_3)_2$	10.58		
Total			1366.81

Properties of Reaction in Per Cent

Primary salinity	16.64	Primary alkalinity	78.36
Secondary salinity	....	Secondary alkalinity	4.26
Tertiary salinity	....	Tertiary alkalinity	.74

NUMBER 98

UPPER BATH HOUSE SPRING

Location—Juniper, Colorado.

Rate of Flow—20 gal. per min. Temperature—104° F.

Class of Water—Sodic, bicarbonated, alkaline, ferruginous, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	37.9	......
Sulphate	SO_4	27.68	1.40
Bicarbonate	HCO_3	1034.46	41.15
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	109.4	7.45
Iron	Fe	......	1.2
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	2.0	
Aluminum oxide	Al_2O_3		......
Manganese	Mn	None	......
Calcium	Ca	7.33	.90
Magnesium	Mg	4.37	.87
Potassium	K	30	1.86
Sodium	Na	438.7	46.25
Lithium	Li	None	......
		1691.84	100.00
Oxygen in Fe_2O_3		.60	
	Total	1691.24	

Concentration value	41.28	Excess carbon dioxide	373
Hydrogen sulphide, H_2S	6.37	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	1236
Strontium, Sr	....	Oxygen consuming capacity	2.92

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	29.64
Pot. chlor., KCl	57.21	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	135.5	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	40.93	Silica, SiO_2	37.9
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	26.3
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1359.3
Ferrous bicarb., $Fe(HCO_3)_2$	4.46		
Total			1691.24

Properties of Reaction in Per Cent

Primary salinity	17.70	Primary alkalinity	78.52
Secondary salinity	....	Secondary alkalinity	3.78
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 99

HOT SPRING

Location—On hill above Bath House above Juniper.

Rate of Flow—6 to 7 gal. per min. Temperature—58° F.

Class of Water—Sodic, bicarbonated, alkaline, (carbondioxated and weakly sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	24.3	......
Sulphate	SO_4	5.97	.30
Bicarbonate	HCO_3	1097.18	45.34
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	61.56	4.36
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	6.07	.76
Magnesium	Mg	2.89	.60
Potassium	K	19.2	1.23
Sodium	Na	432.7	47.41
Lithium	Li	None	......
	Total	1649.87	100.00

Concentration value	39.68	Excess carbon dioxide	395.7
Hydrogen sulphide, H_2S	0.73	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	1191
Strontium, Sr	....	Oxygen consuming capacity	2.44

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	24.55
Pot. chlor., KCl	36.61	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	72.79	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	8.83	Silica, SiO_2	24.3
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	17.39
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1465.4
Ferrous bicarb., $Fe(HCO_3)_2$	Trace		
Total			1649.87

Properties of Reaction in Per Cent

Primary salinity	9.32	Primary alkalinity	87.96
Secondary salinity	....	Secondary alkalinity	2.72
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 100

MEADOW SPRING

Location—¼ mi. below Bath House, Juniper.

Rate of Flow— Temperature—105½° F.

Class of Water—Sodic, bicarbonated, muriated, alkaline-saline, potassic, (sulphuretted, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	37.3	......
Sulphate	SO_4	9.57	.20
Bicarbonate	HCO_3	1468.59	25.40
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	820.8	24.40
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	32.7	1.72
Magnesium	Mg	12.02	1.04
Potassium	K	95.0	2.56
Sodium	Na	974.5	44.68
Lithium	Li	Trace	......
	Total	3450.48	100.00

Concentration value	94.84	Excess carbon dioxide	529.6
Hydrogen sulphide, H_2S	2.14	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	3125
Strontium, Sr	....	Oxygen consuming capacity	2.05

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	132.2
Pot. chlor., KCl	181.2	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	1211.1	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	14.15	Silica, SiO_2	37.3
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	72.33
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1802.2
Ferrous bicarb., $Fe(HCO_3)_2$	Trace		
Total			3450.48

Properties of Reaction in Per Cent

Primary salinity	49.20	Primary alkalinity	45.28
Secondary salinity	....	Secondary alkalinity	5.52
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 101

RIVER SPRING

Location—Opposite No. 100, Juniper.

Rate of Flow—1 to 1½ gal. per min. Temperature—58° F.

Class of Water—Sodic, bicarbonated, muriated, alkaline-saline, potassic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	33.4	......
Sulphate	SO_4	6.38	.08
Bicarbonate	HCO_3	2279.27	22.07
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	1669	27.85
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	Trace	......
Calcium	Ca	98.64	2.91
Magnesium	Mg	22.45	1.09
Potassium	K	247	3.74
Sodium	Na	1644	42.26
Lithium	Li	Trace	......
	Total	6000.14	100.00

Concentration value	169.20	Excess carbon dioxide	821.9
Hydrogen sulphide, H_2S	Trace	Iron precipitated	None
Arsenic, As	....	Evaporation solids	4852
Strontium, Sr	....	Oxygen consuming capacity	None

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	398.9
Pot. chlor., KCl	471.0	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	2382.3	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	9.44	Silica, SiO_2	33.4
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	Trace
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	135.1
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	2570.0
Ferrous bicarb., $Fe(HCO_3)_2$	Trace		
Total			6000.14

Properties of Reaction in Per Cent

Primary salinity	55.86	Primary alkalinity	36.14
Secondary salinity	....	Secondary alkalinity	8.00
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 102

WARM SPRING, McINTYRE SPRING

Location—McIntyre Ranch 8 mi. E. of La Jara.

Rate of Flow—600 to 800 gal. per min. Temperature—62° F.

Class of Water—Potassic, calcic, bicarbonated, alkaline-saline, (siliceous).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	49.3	......
Sulphate	SO_4	18.5	10.36
Bicarbonate	HCO_3	76.6	33.25
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	8.6	6.39
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	21.6	28.72
Magnesium	Mg	1.6	3.46
Potassium	K	15.0	10.11
Sodium	Na	6.7	7.71
Lithium	Li	None	......
	Total	197.9	100.00

Concentration value	3.76	Excess carbon dioxide	27.6
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	152
Strontium, Sr	....	Oxygen consuming capacity	0.97

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	87.3
Pot. chlor., KCl	18.1	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	.....	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	17.3	Silica, SiO_2	49.3
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	9.6
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	4.0
Ferrous bicarb., $Fe(HCO_3)_2$	Trace	Pot. sulph., K_2SO_4	12.3
Total			197.9

Properties of Reaction in Per Cent

Primary salinity	33.50	Primary alkalinity	2.14
Secondary salinity	....	Secondary alkalinity	64.36
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 18.5. Temperature, °F, 65.3.
Curies Ra Emanation per liter x 10^{-10}, Water, 1.87.
Mache Units per liter, Water, 0.51.

NUMBER 103

SODA SPRING—SPARLIN GULCH SPRING

Location—4 mi. E. of Lake City.

Rate of Flow—1 to 1½ gal. per min. Temperature—56° F.

Class of Water—Sodic, calcic, bicarbonated, sulphated, alkaline-saline, lithic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	33.5	......
Sulphate	SO_4	325.2	15.17
Bicarbonate	HCO_3	792.4	29.09
Silicate	SiO_3	......	1.65
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	65.0	4.09
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	4.7	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	135.8	15.17
Magnesium	Mg	19.1	3.52
Potassium	K	34.1	1.97
Sodium	Na	299.1	29.09
Lithium	Li	0.78	.25
Oxygen to form SiO_3		5.9	......
	Total	1715.6	100.00

Concentration value	44.68	Excess carbon dioxide	285.7
Hydrogen sulphide, H_2S	None	Iron precipitated	3.48
Arsenic, As	....	Evaporation solids	1302
Strontium, Sr	....	Oxygen consuming capacity	0.78

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	4.7	Calc. bicarb., $Ca(HCO_3)_2$	489.2
Pot. chlor., KCl	65.0	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	4.7
Sod. chlor., NaCl	49.8	Calc. silicate, $CaSiO_3$	43.0
Sod. sulph., Na_2SO_4	480.9	Silica, SiO_2	11.2
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	114.9
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	452.2
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			1715.6

Properties of Reaction in Per Cent

Primary salinity	38.52	Primary alkalinity	24.10
Secondary salinity	....	Secondary alkalinity	37.38
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 104

IRON SPRING, SLUMGULLION SPRING

Location—7 mi. up Slumgullion Creek from Lake City.

Rate of Flow—4 to 5 gal. per min. Temperature—44° F.

Class of Water—Sodic, calcic, sulphated, alkaline-saline, ferruginous, (siliceous).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	60.3	......
Sulphate	SO_4	77.2	40.25
Bicarbonate	HCO_3	11.9	5.00
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	6.8	4.75
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	4.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	14.3	18.00
Magnesium	Mg	4.1	8.50
Potassium	K	Trace	......
Sodium	Na	21.7	23.50
Lithium	Li	None	......
	Total	200.8	100.00

Concentration value	4.00	Excess carbon dioxide	4.3
Hydrogen sulphide, H_2S	None	Iron precipitated	6.28
Arsenic, As	....	Evaporation solids	177
Strontium, Sr	....	Oxygen consuming capacity	0.68

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	None	Calc. bicarb., $Ca(HCO_3)_2$	15.8
Pot. chlor., KCl	Trace	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	4.5
Sod. chlor., NaCl	11.2	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	53.4	Silica, SiO_2	60.3
Mag. sulph., $MgSO_4$	20.3	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	35.3	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			200.8

Properties of Reaction in Per Cent

Primary salinity	47.00	Primary alkalinity	43.00
Secondary salinity	.....	Secondary alkalinity	10.00
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 105

MACK SPRING NO. 1

Location—At Mack Ranch on Cucharas River, 7 mi. from Cucharas.

Rate of Flow—1½ gal. per min. Temperature—59° F.

Class of Water—Sodic, bicarbonated, sulphated, alkaline (sulphuretted, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	14.9	......
Sulphate	SO_4	135.9	6.99
Bicarbonate	HCO_3	973	39.42
Silicate	SiO_3	......	1.21
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	33.88	2.38
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	3.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	28.26	3.49
Magnesium	Mg	16.99	3.46
Potassium	K	85.5	5.42
Sodium	Na	350.35	37.63
Lithium	Li	Trace	......
Oxygen to form SiO_3		3.95	......
	Total	1646.13	100.00

Concentration value	40.46	Excess carbon dioxide	350
Hydrogen sulphide, H_2S	77.95	Iron precipitated	None
Arsenic, As	....	Evaporation solids	1113
Strontium, Sr	....	Oxygen consuming capacity	0.91

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	74.2
Pot. chlor., KCl	71.24	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	3.5
Sod. chlor., NaCl	.....	Calc. silicate, $CaSiO_3$	28.76
Sod. sulph., Na_2SO_4	113.5	Silica, SiO_2	.....
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	102.2
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1145.5
Ferrous bicarb., $Fe(HCO_3)_2$	.....	Pot. sulph., K_2SO_4	107.3
Total			1646.2

Properties of Reaction in Per Cent

Primary salinity	18.74	Primary alkalinity	67.36
Secondary salinity	.....	Secondary alkalinity	13.90
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 106

LA VETA

Location—7 mi. up Cucharas Creek on river bank.

Rate of Flow—10 gal. per min. Temperature—54° F.

Class of Water—Calcic, bicarbonated, alkaline, lithic, ferruginous.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	13.3	......
Sulphate	SO_4	Trace	......
Bicarbonate	HCO_3	181.76	43.44
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	16.2	6.56
Iron	Fe	......	.73
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	2.2	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	42.11	30.60
Magnesium	Mg	2.08	2.48
Potassium	K	9.5	3.50
Sodium	Na	17.6	11.23
Lithium	Li	0.7	1.46
		285.45	100.00
Oxygen in Fe_2O_3		.66	
	Total	284.79	

Concentration value	6.86	Excess carbon dioxide	65.54
Hydrogen sulphide, H_2S	None	Iron precipitated	3.76
Arsenic, As	....	Evaporation solids	188
Strontium, Sr	....	Oxygen consuming capacity	1.36

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	4.25	Calc. bicarb., $Ca(HCO_3)_2$	170.28
Pot. chlor., KCl	18.12	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	6.64		
Sod. sulph., Na_2SO_4	Trace	Calc. silicate, $CaSiO_3$	.....
Mag. sulph., $MgSO_4$	.....	Silica, SiO_2	13.3
Calc. sulph., $CaSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	12.52
Ferrous bicarb., $Fe(HCO_3)_2$	4.90	Sod. bicarb., $NaHCO_3$	54.79
Total			284.80

Properties of Reaction in Per Cent

Primary salinity	13.12	Primary alkalinity	19.26
Secondary salinity	....	Secondary alkalinity	66.16
Tertiary salinity	....	Tertiary alkalinity	1.46

NUMBER 107

WHITE SULPHUR SPRING

Location—Springer Ranch La Veta, Colorado.

Rate of Flow—½ gal. per min. Temperature—52° F.

Class of Water—Sodic, calcic, bicarbonated, alkaline, potassic, (sulphuretted, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	14.9	......
Sulphate	SO_4	42.8	6.85
Bicarbonate	HCO_3	269.5	34.00
Silicate	SiO_3	......	3.77
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	23.57	5.38
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	1.25	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	31.32	12.08
Magnesium	Mg	Trace	......
Potassium	K	27.0	5.38
Sodium	Na	97.3	32.54
Lithium	Li	Trace	......
Oxygen to form SiO_3		3.95	......
	Total	511.59	100.00

Concentration value	13.00	Excess carbon dioxide	97.17
Hydrogen sulphide, H_2S	25.56	Iron precipitated	None
Arsenic, As	....	Evaporation solids	372
Strontium, Sr	....	Oxygen consuming capacity	0.82

Hypothetical Combinations

Milligrams per liter, approximately parts per million

		Calc. bicarb., $Ca(HCO_3)_2$	86.57
Lith. chlor., LiCl	Trace	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	1.25
Pot. chlor., KCl	49.56	Calc. silicate, $CaSiO_3$	28.76
Sod. chlor., NaCl	.....	Silica, SiO_2	.....
Sod. sulph., Na_2SO_4	60.88	Mang. oxide, Mn_3O_4	.....
Mag. sulph., $MgSO_4$	Trace	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. sulph., $CaSO_4$	.....	Sod. bicarb., $NaHCO_3$	283.4
Calc. carb., $CaCO_3$	.....	Pot. sulph., K_2SO_4	2.47
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			512.89

Properties of Reaction in Per Cent

Primary salinity	24.46	Primary alkalinity	51.38
Secondary salinity	....	Secondary alkalinity	24.16
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 10.0. Temperature, °F, 50.0.
Curies Ra Emanation per liter x 10^{-10}, Water, 47.23; Gas, 164.0.
Mache Units per liter, Water, 12.75; Gas, 44.3.
Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

NUMBER 108

BLACK SULPHUR SPRING

Location—Springer Ranch, La Veta.

Rate of Flow—½ to ¾ gal. per min. Temperature—64° F.

Class of Water—Sodic, calcic, bicarbonated, alkaline, (carbondioxated and strongly sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	8.5	......
Sulphate	SO_4	57.0	9.34
Bicarbonate	HCO_3	262.32	33.82
Silicate	SiO_3	......	2.28
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	20.62	4.56
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	1.75	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	31.88	12.51
Magnesium	Mg	Trace	......
Potassium	K	3.7	.77
Sodium	Na	107.34	36.72
Lithium	Li	Trace	......
Oxygen to form SiO_3		2.66	......
	Total	495.77	100.00

Concentration value	12.72	Excess carbon dioxide	94.59
Hydrogen sulphide, H_2S	21.94	Iron precipitated	....
Arsenic, As	....	Evaporation solids	360
Strontium, Sr	....	Oxygen consuming capacity	0.64

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	106.06
Pot. chlor., KCl	7.06	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	1.75
Sod. chlor., NaCl	28.45	Calc. silicate, $CaSiO_3$	16.41
Sod. sulph., Na_2SO_4	84.29	Silica, SiO_2	.....
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	Trace
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	251.2
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			495.22

Properties of Reaction in Per Cent

Primary salinity	27.80	Primary alkalinity	47.18
Secondary salinity	....	Secondary alkalinity	25.02
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 10.0. Temperature, °F, 50.0.
Curies Ra Emanation per liter x 10^{-10}, 50.20.
Mache Units per liter, Water, 13.56.
Permanent Activity, Grams Ra per liter, x 10^{10}, None.

NUMBER 109

IRON SPRING

Location—Springer Ranch, La Veta.

Rate of Flow—½ gal. per min. Temperature—50° F.

Class of Water—Calcic, sulphated, alkaline-saline.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	16.6	......
Sulphate	SO_4	100.7	26.34
Bicarbonate	HCO_3	86.6	17.74
Silicate	SiO_3	......	3.78
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	6.0	2.14
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	None	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	48.78	30.60
Magnesium	Mg	5.24	5.42
Potassium	K	6.15	2.02
Sodium	Na	21.9	11.96
Lithium	Li	Trace	......
Oxygen to form SiO_3		2.39	......
	Total	293.76	100.00

Concentration value	7.94	Excess carbon dioxide	31.0
Hydrogen sulphide, H_2S	None	Iron precipitated	2.84
Arsenic, As	....	Evaporation solids	248
Strontium, Sr	....	Oxygen consuming capacity	0.68

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	114.25
Pot. chlor., KCl	11.73	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	0.69	Calc. silicate, $CaSiO_3$	17.42
Sod. sulph., Na_2SO_4	66.80	Silica, SiO_2	7.58
Mag. sulph., $MgSO_4$	25.94	Mang. oxide, Mn_3O_4	None
Calc. sulph., $CaSO_4$	49.36	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			293.77

Properties of Reaction in Per Cent

Primary salinity	27.96	Primary alkalinity	....
Secondary salinity	29.00	Secondary alkalinity	43.04
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 9.3. Temperature, °F, 48.8.
Curies Ra Emanation per liter x 10^{-10}, Water, 11.07.
Mache Units per liter, Water, 2.99.

NUMBER 110

McMAHON SPRING

Location—5 mi. W. Leadville.

Rate of Flow—Very little. Temperature—49° F.

Class of Water—Calcic, sodic, sulphated, saline, magnesic.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	15.2	......
Sulphate	SO_4	108.02	46.11
Bicarbonate	HCO_3	5.72	1.84
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	3.54	2.05
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	22.87	23.38
Magnesium	Mg	9.13	15.35
Potassium	K	Trace	......
Sodium	Na	12.7	11.27
Lithium	Li	None	......
	Total	177.18	100.00

Concentration value	4.88	Excess carbon dioxide	2.06
Hydrogen sulphide, H_2S	None	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	189
Strontium, Sr	....	Oxygen consuming capacity	10.21

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	None	Calc. bicarb., $Ca(HCO_3)_2$	7.6
Pot. chlor., KCl	Trace	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	Trace
Sod. chlor., NaCl	5.81	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	32.12	Silica, SiO_2	15.2
Mag. sulph., $MgSO_4$	45.2	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	71.22	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			177.18

Properties of Reaction in Per Cent

Primary salinity	22.54	Primary alkalinity	....
Secondary salinity	73.78	Secondary alkalinity	3.68
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 111

XIMO SODA SPRING

Location—5 mi. W. Leadville.

Rate of Flow—1 gal. per min. Temperature—........

Class of Water—Sodic, potassic, muriated, bicarbonated, alkaline-saline, lithic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	44.2	......
Sulphate	SO_4	96.18	1.93
Bicarbonate	HCO_3	1316	20.78
Silicate	SiO_3	......	1.42
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	952.6	25.87
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	Trace	......
Calcium	Ca	125.9	6.05
Magnesium	Mg	77.38	6.12
Potassium	K	522.5	12.88
Sodium	Na	591.5	24.79
Lithium	Li	1.2	.16
Oxygen to form SiO_3		11.74	......
	Total	3739.2	100.00

Concentration value	103.80	Excess carbon dioxide	478.2
Hydrogen sulphide, H_2S	None	Iron precipitated	11.72
Arsenic, As	....	Evaporation solids	3330
Strontium, Sr	....	Oxygen consuming capacity	17.64

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	7.3	Calc. bicarb., $Ca(HCO_3)_2$	390.3
Pot. chlor., KCl	996.4	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	Trace
Sod. chlor., NaCl	779.1	Calc. silicate, $CaSiO_3$	85.3
Sod. sulph., Na_2SO_4	142.2	Silica, SiO_2	.....
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	Trace
Calc. sulph, $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	465.6
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	873.0
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			3739.2

Properties of Reaction in Per Cent

Primary salinity	55.60	Primary alkalinity	20.06
Secondary salinity	....	Secondary alkalinity	24.34
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 8.5. Temperature, °F, 47.4.

Curies Ra Emanation per liter x 10^{-10}, Water, 42.38.

Mache Units per liter, Water, 11.44.

NUMBER 112

SODA SPRING

Location—¼ mi. down creek from No. 84.

Rate of Flow—¼ to ½ gal. per min. Temperature—53° F.

Class of Water—Sodic, calcic, bicarbonated, muriated, alkaline-saline, ferruginous, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	35.5	......
Sulphate	SO_4	31.27	1.78
Bicarbonate	HCO_3	689.97	30.98
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	223.3	17.24
Iron	Fe	......	.33
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	5.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	70.94	9.66
Magnesium	Mg	34.23	7.72
Potassium	K	47.5	3.31
Sodium	Na	243.5	28.98
Lithium	Li	Trace	......
		1382.71	100.00
Oxygen in Fe_2O_3		1.5	
	Total	1381.21	

Concentration value	36.54	Excess carbon dioxide	248.8
Hydrogen sulphide, H_2S	None	Iron precipitated	3.63
Arsenic, As	....	Evaporation solids	1045
Strontium, Sr	....	Oxygen consuming capacity	0.93

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	286.85
Pot. chlor., KCl	90.58	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	297.1	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	46.24	Silica, SiO_2	35.5
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	206.0
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	407.8
Ferrous bicarb., $Fe(HCO_3)_2$	11.14		
Total			1381.21

Properties of Reaction in Percent

Primary salinity	38.04	Primary alkalinity	26.54
Secondary salinity	....	Secondary alkalinity	34.76
Tertiary salinity	....	Tertiary alkalinity	.66

Radioactivity

Temperature, °C, 9.5. Temperature, °F, 49.1.
Curies Ra Emanation per liter x 10^{-10}, Water, 28.37.
Mache Units per liter, Water, 7.66.
Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

NUMBER 113

IRON SPRING

Location—¼ mi. N. Fish Hatchery, Leadville.

Rate of Flow—1 gal. per min. Temperature—48° F.

Class of Water—Sodic, calcic, bicarbonated, muriated, alkaline-saline, ferruginous (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	41.1	......
Sulphate	SO_4	57.81	1.41
Bicarbonate	HCO_3	1463.2	28.14
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	618.6	20.45
Iron	Fe	......	.21
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	7.25	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	Trace	......
Calcium	Ca	173.3	10.12
Magnesium	Mg	54.36	5.24
Potassium	K	72.5	2.17
Sodium	Na	632	32.26
Lithium	Li	Trace	......
		3120.12	100.00
Oxygen in Fe_2O_3		2.18	
	Total	3117.94	

Concentration value	85.24	Excess carbon dioxide	527.6
Hydrogen sulphide, H_2S	None	Iron precipitated	4.61
Arsenic, As	....	Evaporation solids	2228
Strontium, Sr	....	Oxygen consuming capacity	10.21

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	700.9
Pot. chlor., KCl	138.2	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	911.5	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	85.5	Silica, SiO_2	41.1
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	Trace
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	327.1
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	897.5
Ferrous bicarb., $Fe(HCO_3)_2$	16.15		
Total			3117.95

Properties of Reaction in Percent

Primary salinity	43.72	Primary alkalinity	25.14
Secondary salinity	....	Secondary alkalinity	31.14
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 8.5. Temperature, °F, 47.4.
Curies Ra Emanation per liter x 10^{-10}, Water, 38.07; Gas, 131.6.
Mache Units per liter, Water, 10.28; Gas, 35.52.
Permanent Activity, Grams Ra per liter, x 10^{-10}, Trace.

NUMBER 115

SOUTH SPRING

Location—3 miles west of Loveland.

Rate of Flow—½ gal. per min. Temperature—58° F.

Class of Water—Sodic, bicarbonated, sulphated, alkaline, (sulphuretted, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	17.1	......
Sulphate	SO_4	197.1	15.02
Bicarbonate	HCO_3	580.1	34.76
Carbonate	CO_3	Trace	......
Phosphate	PO_4	None	......
Chloride	Cl	2.0	.22
Iron	Fe	......	.18
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	2.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	7.7	1.39
Magnesium	Mg	4.4	1.32
Potassium	K	12.5	1.17
Sodium	Na	288.7	45.94
Lithium	Li	None	......
		1111.6	100.00
Oxygen in Fe_2O_3		0.6	
	Total	1111.0	

Concentration value	27.34	Excess carbon dioxide	209.2
Hydrogen sulphide, H_2S	31.59	Iron precipitated	None
Arsenic, As	....	Evaporation solids	817
Strontium, Sr	....	Oxygen consuming capacity	0.68

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	.....	Calc. bicarb., $Ca(HCO_3)_2$	31.1
Pot. chlor., KCl	4.2	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	.....	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	272.7	Silica, SiO_2	17.1
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	26.5
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	732.0
Ferrous bicarb., $Fe(HCO_3)_2$	4.4	Pot. sulph., K_2SO_4	23.0
Total			1111.0

Properties of Reaction in Percent

Primary salinity	30.48	Primary alkalinity	63.74
Secondary salinity	....	Secondary alkalinity	5.78
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 16.3. Temperature, °F, 61.4.
Curies Ra Emanation per liter x 10^{-10}, Water, 4.57.
Mache Units per liter, Water, 1.23.

NUMBER 114

LONG PARK

Location—Spring at Camp of National Radium Institute.

Radioactivity

Curies Ra Emanation per liter x 10^{-10}, Water, 0.95.
Mache Units per liter, Water, 0.26.

NUMBER 116

NORTH SPRING

Location—3 mi. W. of Loveland.
Rate of Flow—2 gal. per min. Temperature—54° to 62° F.
Class of Water—Sodic, bicarbonated, sulphated, alkaline, ferruginous, (sulphuretted, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	20.9	......
Sulphate	SO_4	195.0	16.05
Bicarbonate	HCO_3	497.4	32.06
Carbonate	CO_3	Trace	......
Phosphate	PO_4	None	......
Chloride	Cl	17.1	1.89
Iron	Fe	......	.25
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	2.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	12.2	2.40
Magnesium	Mg	3.3	1.06
Potassium	K	94	9.50
Sodium	Na	215	36.79
Lithium	Li	None	......
		1057.4	100.00
Oxygen in Fe_2O_3		0.8	
	Total	1056.6	

Concentration value	25.40	Excess carbon dioxide	179.4
Hydrogen sulphide, H_2S	22.7	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	775
Strontium, Sr	....	Oxygen consuming capacity	1.17

Hypothetical Combinations

Milligrams per liter, approximately parts per million

		Calc. bicarb., $Ca(HCO_3)_2$	49.3
Lith. chlor., LiCl	.....	Iron and aluminum oxides,	
Pot. chlor., KCl	36.0	Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	.....	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	151.9	Silica, SiO_2	20.9
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	19.9
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	605.6
Ferrous bicarb., $Fe(HCO_3)_2$	5.6	Pot. sulph., K_2SO_4	167.4

Total 1056.6

Properties of Reaction in Percent

Primary salinity	35.88	Primary alkalinity	56.70
Secondary salinity	....	Secondary alkalinity	6.92
Tertiary salinity	....	Tertiary alkalinity	.50

NUMBER 117

UTE IRON SPRING

Location—Manitou, Colorado.

Rate of Flow—1½ gal. per min. Temperature—67½° F.

Class of Water—Sodic, calcic, bicarbonated, sulphated, muriated, alkaline-saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	55.6	......
Sulphate	SO_4	331.5	10.53
Bicarbonate	HCO_3	1132.8	28.34
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	258.8	11.13
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	247.5	18.83
Magnesium	Mg	40.8	5.12
Potassium	K	40.31	1.57
Sodium	Na	368.7	24.48
Lithium	Li	Trace	......
	Total	2476.01	100.00

Concentration value	65.54	Excess carbon dioxide	408.5
Hydrogen sulphide, H_2S	None	Iron precipitated	3.52
Arsenic, As	....	Evaporation solids	1530
Strontium, Sr	....	Oxygen consuming capacity	0.27

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	1000.8
Pot. chlor., KCl	76.87	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	366.3	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	490.2	Silica, SiO_2	55.6
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	245.5
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	240.7
Ferrous bicarb., $Fe(HCO_3)_2$	Trace		
Total			2475.97

Properties of Reaction in Percent

Primary salinity	43.32	Primary alkalinity	8.78
Secondary salinity	....	Secondary alkalinity	47.90
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 10.5, 10.2. Temperature, °F, 51.0.
Curies Ra Emanation per liter x 10^{-10}, Water, 16.42, 20.0.
Mache Units per liter, Water, 4.44, 3.25.
Remarks—Sample from pipe near Spring.

NUMBER 118

OURAY IRON SPRING

Location—Manitou, Colorado.

Rate of Flow—2 gal. per min. Temperature—58° F.

Class of Water—Sodic, calcic, sulphated, bicarbonated, alkaline, ferruginous, potassic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	73	......
Sulphate	SO_4	213.4	6.57
Bicarbonate	HCO_3	1531	37.10
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	151.95	6.33
Iron	Fe	......	.50
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	13.7	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	173.1	12.75
Magnesium	Mg	30.85	3.76
Potassium	K	72.25	2.74
Sodium	Na	470.6	30.25
Lithium	Li	Trace	......
		2729.85	100.00
Oxygen in Fe_2O_3		4.12	
	Total	2725.73	

Concentration value	67.64	Excess carbon dioxide	552.1
Hydrogen sulphide, H_2S	None	Iron precipitated	3.17
Arsenic, As	....	Evaporation solids	1664
Strontium, Sr	....	Oxygen consuming capacity	0.91

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	699.9
Pot. chlor., KCl	137.8	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	142.5	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	315.6	Silica, SiO_2	73
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	185.6
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1140.8
Ferrous bicarb., $Fe(HCO_3)_2$	30.5		
Total			2725.7

Properties of Reaction in Percent

Primary salinity	25.80	Primary alkalinity	40.18
Secondary salinity	....	Secondary alkalinity	33.02
Tertiary salinity	....	Tertiary alkalinity	1.00

Radioactivity

Temperature, °C, 10.0, 15.1. Temperature, °F, 50.0.

Curies Ra Emanation per liter x 10^{-10}, Water, 3.24, 8.45.

Mache Units per liter, Water, 0.88, 1.41.

Remarks—Sample from pipe near Spring.

NUMBER 119

HIAWATHA SPRING

Location—Manitou, Colorado.

Rate of Flow—No flow. Temperature—64° F.

Class of Water—Calcic, bicarbonated, alkaline, magnesic (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	18.5	......
Sulphate	SO_4	46.92	7.42
Bicarbonate	HCO_3	308.45	38.34
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	20	4.24
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	77.94	29.47
Magnesium	Mg	21.57	13.48
Potassium	K	Trace	......
Sodium	Na	21.5	7.05
Lithium	Li	None	......
	Total	514.88	100.00

Concentration value	13.2	Excess carbon dioxide	111.2
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	373
Strontium, Sr	....	Oxygen consuming capacity	0.45

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	315.2
Pot. chlor., KCl	Trace	Iron and aluminum oxides,	
Sod. chlor., NaCl	32.97	Fe_2O_3, Al_2O_3	.....
Sod. sulph., Na_2SO_4	26.34	Calc. silicate, $CaSiO_3$	.....
Mag. sulph., $MgSO_4$	36.48	Silica, SiO_2	18.5
Calc. sulph., $CaSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	85.45
Ferrous bicarb., $Fe(HCO_3)_2$	.....	Sod. bicarb., $NaHCO_3$	.....
Total			514.94

Properties of Reaction in Percent

Primary salinity	14.10	Primary alkalinity	....
Secondary salinity	9.22	Secondary alkalinity	76.68
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 16.0. Temperature, °F, 60.9.
Curies Ra Emanation per liter x $10.^{10}$, Water, 3.56.
Mache Units per liter, Water, 0.96.

NUMBER 120

UTE CHIEF MAGNETIC SPRING

Location—Manitou, Colorado.

Rate of Flow—2½ gal. per min. Temperature—57° F.

Class of Water—Calcic, sodic, bicarbonated, alkaline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	21.8	......
Sulphate	SO_4	120.2	3.49
Bicarbonate	HCO_3	1821.5	41.54
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	126.9	4.97
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	384.3	26,67
Magnesium	Mg	52.53	6.02
Potassium	K	2.7	.10
Sodium	Na	284.5	17.21
Lithium	Li	Trace	......
	Total......	2814.43	100.00

Concentration value	71.90	Excess carbon dioxide	656.8
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	1974
Strontium, Sr	....	Oxygen consuming capacity	0.36

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	Trace	Calc. bicarb., $Ca(HCO_3)_2$	1554.0
Pot. chlor., KCl	5.15	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	Trace
Sod. chlor., $NaCl$	205.2	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	177.8	Silica, SiO_2	21.8
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	316.1
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	534.1
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			2814.15

Properties of Reaction in Percent

Primary salinity	16.92	Primary alkalinity	17.70
Secondary salinity	....	Secondary alkalinity	65.38
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 13.5, 13.7. Temperature, °F, 56.3.
Curies Ra Emanation per liter x 10^{-10}, Water, None, 8.2; Gas, Trace.
Mache Units per liter, Water, None, 1.35; Gas, Trace.
Remarks—S.

NUMBER 121

UTE CHIEF

Location—Manitou.

Rate of Flow— Temperature—57½° F.

Class of Water—Calcic, sodic, bicarbonated, alkaline, potassic, (carbon-dioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	28.0	......
Sulphate	SO_4	130.2	3.27
Bicarbonate	HCO_3	2088.0	41.32
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	159.1	5.41
Iron	Fe	......	.16
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	5.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	436.2	26.25
Magnesium	Mg	61.3	6.08
Potassium	K	56.0	1.75
Sodium	Na	299.8	15.76
Lithium	Li	None	......
		3264.5	100.00
Oxygen in Fe_2O_3		1.5	
	Total	3263.0	

Concentration value	82.84	Excess carbon dioxide	752.9
Hydrogen sulphide, H_2S	None	Iron precipitated	0.82
Arsenic, As	....	Evaporation solids	2238
Strontium, Sr	....	Oxygen consuming capacity	0.73

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	1763.8
Pot. chlor., KCl	108.5	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	177.2	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	192.5	Silica, SiO_2	28.0
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	369.0
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	612.9
Ferrous bicarb., $Fe(HCO_3)_2$	11.1		
Total			3263.0

Properties of Reaction in Percent

Primary salinity	17.36	Primary alkalinity	17.66
Secondary salinity	....	Secondary alkalinity	64.98
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 14.2. Temperature, °F, 57.5.
Curies Ra Emanation per liter x 10^{-10}, Gas, 11.94.
Mache Units per liter, Gas, 3.23.

NUMBER 122

LITTLE SPRING ABOVE UTE CHIEF SPRING

Location—Manitou.

Rate of Flow—No flow. Temperature—62° F.

Class of Water—Calcic, sodic, bicarbonated, alkaline, magnesic, ferruginous, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	27.0	......
Sulphate	SO_4	143.3	3.50
Bicarbonate	HCO_3	2073.0	40.31
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	185.5	6.19
Iron	Fe	......	.11
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	4.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	462.4	27.35
Magnesium	Mg	68.76	6.71
Potassium	K	60	1.81
Sodium	Na	272.2	14.02
Lithium	Li	Trace	......
		3296.16	100.00
Oxygen in Fe_2O_3		1.2	
	Total	3294.96	

Concentration value	84.40	Excess carbon dioxide	747.5
Hydrogen sulphide, H_2S	None	Iron precipitated	....
Arsenic, As	....	Evaporation solids	2330
Strontium, Sr	....	Oxygen consuming capacity	0.73

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	Trace	Calc. bicarb., $Ca(HCO_3)_2$	1869.8
Pot. chlor., KCl	114.4	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	216.1	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	211.9	Silica, SiO_2	27.0
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	413.75
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	433.0
Ferrous bicarb., $Fe(HCO_3)_2$	8.91		
Total			3295.86

Properties of Reaction in Percent

Primary salinity	19.38	Primary alkalinity	12.28
Secondary salinity	....	Secondary alkalinity	68.34
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 123

MANSION HOTEL NO. 1

Location—Manitou.

Rate of Flow—½ gal. per min. Temperature—56½° F.

Class of Water—Sodic, calcic, bicarbonated, muriated, alkaline, magnesic, (carbondixated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	21.4	......
Sulphate	SO_4	267.2	5.01
Bicarbonate	HCO_3	2440	35.92
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	358	9.07
Iron	Fe	......	.09
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	3.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	466.1	20.89
Magnesium	Mg	112.0	8.28
Potassium	K	76	1.75
Sodium	Na	486.7	18.99
Lithium	Li	Trace	......
		4230.9	100.00
Oxygen in Fe_2O_3		0.67	
	Total	4,230.23	

Concentration value	111.32	Excess carbon dioxide	879.7
Hydrogen sulphide, H_2S	0.73	Iron precipitated	5.75
Arsenic, As	....	Evaporation solids	3174
Strontium, Sr	....	Oxygen consuming capacity	0.91

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	Trace	Calc. bicarb., $Ca(HCO_3)_2$	1884.6
Pot. chlor., KCl	144.95	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	476.6	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	395.1	Silica, SiO_2	21.4
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	673.9
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	625.5
Ferrous bicarb., $Fe(HCO_3)_2$	7.8		
Total			4229.85

Properties of Reaction in Percent

Primary salinity	28.16	Primary alkalinity	13.32
Secondary salinity	....	Secondary alkalinity	58.52
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 124

MANSION HOTEL NO. 2

Location—Manitou Colorado.

Rate of Flow—3 gal. per min. Temperature—56° F.

Class of Water—Sodic, calcic, bicarbonated, alkaline, carbondioxated.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	26.1	......
Sulphate	SO_4	161.9	4.15
Bicarbonate	HCO_3	1940.3	39.12
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	194.5	6.73
Iron	Fe	......	.09
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	2.8	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	334.2	20.48
Magnesium	Mg	51.07	5.16
Potassium	K	63.9	2.01
Sodium	Na	415.9	22.26
Lithium	Li	Trace	......
		3190.67	100.00
Oxygen in Fe_2O_3		.84	
	Total	3189.83	

Concentration value	81.30	Excess carbon dioxide	699.7
Hydrogen sulphide, H_2S	None	Iron precipitated	1.53
Arsenic, As	....	Evaporation solids	2290
Strontium, Sr	....	Oxygen consuming capacity	0.45

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	1351.4
Pot. chlor., KCl	121.85	Iron and aluminum oxides, Fe_2O_3; Al_2O_3	.....
Sod. chlor., NaCl	225.11		
Sod. sulph., Na_2SO_4	239.4	Calc. silicate, $CaSiO_3$	.....
Mag. sulph., $MgSO_4$	.....	Silica, SiO_2	26.1
Calc. sulph., $CaSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	307.3
Ferrous bicarb., $Fe(HCO_3)_2$	6.24	Sod. bicarb., $NaHCO_3$	912.4
Total			3189.80

Properties of Reaction in Percent

Primary salinity	21.76	Primary alkalinity	26.78
Secondary salinity	....	Secondary alkalinity	51.46
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 14.0, 14.7. Temperature, °F, 57.4.

Curies Ra Emanation per liter x 10^{-10}, Water, 2.35, 22.4; Gas, 11.49, 15.4.

Mache Units per liter, Water, 0.63, 3.74; Gas, 3.10, 2.6.

Remarks—S.

NUMBER 125

Location—Manitou.

Radioactivity

Temperature, °C, 12.0, 12.8. Temperature, °F, 53.7.

Curies Ra Emanation per liter x 10^{-10}, Water, 7.30, 11.5.

Mache Units per liter, Water, 1.97, 1.98.

Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

Remarks—Schlundt.

NUMBER 126

NAVAJO GEYSER SPRING

Location—Manitou.
Rate of Flow—3½ to 4 gal. per min. Temperature—59° F.
Class of Water—Sodic, calcic, bicarbonated, muriated, alkaline, magnesic, ferruginous, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	48.6	......
Sulphate	SO_4	235.4	4.29
Bicarbonate	HCO_3	2723.3	39.10
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	268.1	6.61
Iron	Fe	......	.16
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	7.2	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	468.8	20.50
Magnesium	Mg	79.58	5.74
Potassium	K	104	2.33
Sodium	Na	559.4	21.27
Lithium	Li	Trace	......
		4494.38	100.00
Oxygen in Fe_2O_3		2.16	
	Total	4492.22	

Concentration value	114.20	Excess carbon dioxide	982.0
Hydrogen sulphide, H_2S	Trace	Iron precipitated	0.95
Arsenic, As	....	Evaporation solids	3006
Strontium, Sr	....	Oxygen consuming capacity	1.27

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	1895.6
Pot. chlor., KCl	198.3	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	286.5	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	348.1	Silica, SiO_2	48.6
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	478.9
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1220.0
Ferrous bicarb., $Fe(HCO_3)_2$	16.04		
Total			4492.04

Properties of Reaction in Percent

Primary salinity	21.80	Primary alkalinity	25.40
Secondary salinity	....	Secondary alkalinity	52.80
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 18.0, 13.0. Temperature, °F, 64.4.

Curies Ra Emanation per liter x 10^{-10}, Water, 15.35, 26.7; Gas, 77.6, 47.0.

Mache Units per liter, Water, 4.14, 4.49; Gas, 20.95, 8.0.

Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

Remarks—S.

NUMBER 127

NAVAJO SPRING

Location—Manitou.

Rate of Flow— Temperature—62° F.

Class of Water—Sodic, calcic, bicarbonated, muriated, alkaline, magnesic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	49.0	......
Sulphate	SO_4	232.4	4.49
Bicarbonate	HCO_3	2556.2	38.89
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	253.4	6.62
Iron	Fe	......	.17
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	7.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	464.4	21.48
Magnesium	Mg	72.7	5.55
Potassium	K	72.2	1.71
Sodium	Na	522.5	21.09
Lithium	Li	Trace	......
		4229.8	100.00
Oxygen in Fe_2O_3		2.1	
	Total	4227.7	

Concentration value	107.80	Excess carbon dioxide	921.8
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	2994
Strontium, Sr	....	Oxygen consuming capacity	1.27

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	1877.8
Pot. chlor., KCl	137.7	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	309.8	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	343.7	Silica, SiO_2	49.0
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	437.5
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1056.7
Ferrous bicarb., $Fe(HCO_3)_2$	15.6		
Total			4227.8

Properties of Reaction in Percent

Primary salinity	22.22	Primary alkalinity	23.38
Secondary salinity	....	Secondary alkalinity	54.40
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 22.3. Temperature, °F, 72.2.

Curies Ra Emanation per liter x 10^{-10}, Water, 12.07, 20.1; Gas, 73.15, 48.1.

Mache Units per liter, Water, 3.26, 3.36; Gas, 19.75, 8.03.

Remarks—From pipe 200 ft. from Spring. Schlundt.

NUMBER 128

Cheyenne Spring

Location—Manitou, Colorado.

Rate of Flow—2½ gal per min. Temperature—56½° F.

Class of Water—Sodic, calcic, bicarbonated, muriated, alkaline, (carbon-dioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	42.5	......
Sulphate	SO_4	213.8	4.21
Bicarbonate	HCO_3	2533.2	39.19
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	249.0	6.60
Iron	Fe	......	.13
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	5.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	434.4	20.46
Magnesium	Mg	63.35	4.90
Potassium	K	112.2	2.71
Sodium	Na	531.5	21.80
Lithium	Li	Trace	......
		4185.45	100.00
Oxygen in Fe_2O_3		1.65	
	Total	4183.80	

Concentration value	106.00	Excess carbon dioxide	913.5
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	2446
Strontium, Sr	....	Oxygen consuming capacity	0.91

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	Trace	Calc. bicarb., $Ca(HCO_3)_2$	1756.5
Pot. chlor., KCl	213.95	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	....
Sod. chlor., $NaCl$	242.76	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	316.2	Silica, SiO_2	42.5
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	381.2
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1218.5
Ferrous bicarb., $Fe(HCO_3)_2$	12.25		
Total			4183.86

Properties of Reaction in Percent

Primary salinity	21.62	Primary alkalinity	27.40
Secondary salinity	....	Secondary alkalinity	50.98
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 15.5, 12.7. Temperature, °F, 60.0.

Curies Ra Emanation per liter x 10^{-10}, Water, 8.89, 13.1.

Mache Units per liter, Water, 2.40, 2.32.

Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

Remarks—Schlundt.

NUMBER 129

MANITOU SPRING

Location—Manitou.

Rate of Flow—3½ to 4 gal. per min. Temperature—61° F.

Class of Water—Sodic, calcic, bicarbonated, muriated, alkaline, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	43.4	......
Sulphate	SO_4	228.1	4.85
Bicarbonate	HCO_3	2254.83	37.73
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	257.8	7.42
Iron	Fe	......	.20
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	8.2	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	456.6	23.25
Magnesium	Mg	30.42	2.56
Potassium	K	61.6	1.61
Sodium	Na	504	22.38
Lithium	Li	Trace	......
		3844.95	100.00
Oxygen in Fe_2O_3		2.47	
	Total	3842.48	

Concentration value	97.90	Excess carbon dioxide	813.1
Hydrogen sulphide, H_2S	5.43	Iron precipitated	None
Arsenic, As	....	Evaporation solids	2972
Strontium, Sr	....	Oxygen consuming capacity	0.55

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	1846.3
Pot. chlor., KCl	117.5	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	332.95	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	337.3	Silica, SiO_2	43.4
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	183.1
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	963.4
Ferrous bicarb., $Fe(HCO_3)_2$	18.27		
Total			3842.22

Properties of Reaction in Percent

Primary salinity	24.54	Primary alkalinity	23.44
Secondary salinity	....	Secondary alkalinity	52.02
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 14.5, 14.5. Temperature, °F, 58.1.

Curies Ra Emanation per liter x 10^{-10}, Water, 2.68, 17.6; Gas, 16.22.

Mache Units per liter, Water, 0.72, 3.04; Gas, 4.38.

Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

Remarks—Sample from bubble fountain. Schlundt.

NUMBER 130

SHOSHONE SPRING

Location—Manitou.
Rate of Flow— Temperature—61° F.
Class of Water—Calcic, bicarbonated, alkaline, magnesic, ferruginous, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	58.1	......
Sulphate	SO_4	225	4.01
Bicarbonate	HCO_3	2812	39.48
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	269.6	6.51
Iron	Fe	......	.11
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	5.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	1021.54	43.64
Magnesium	Mg	76.13	5.37
Potassium	K	Trace	......
Sodium	Na	23.7	.88
Lithium	Li	None	......
		4491.07	100.00
Oxygen in Fe_2O_3		1.50	
	Total	4489.57	

Concentration value	116.80	Excess carbon dioxide	1014
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	3006
Strontium, Sr	....	Oxygen consuming capacity	0.36

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	None	Iron and aluminum oxides,	
Pot. chlor., KCl	Trace	Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	60.25	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	.....	Silica, SiO_2	58.1
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	318.9	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	11.14	Mag. chlor., $MgCl_2$	298.14
Calc. bicarb., $Ca(HCO_3)_2$	3725.8	Calc. chlor., $CaCl_2$	17.31
Total			4489.64

Properties of Reaction in Percent

Primary salinity	1.76	Primary alkalinity	....
Secondary salinity	19.28	Secondary alkalinity	78.96
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 15.5, 14.9. Temperature, °60.0.

Curies Ra Emanation per liter x 10^{-10}, Water, 16.60, 47.3; Gas, 155.2, 205.0.

Mache Units per liter, Water, 4.48, 8.25; Gas, 41.92, 31.2.

Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

Remarks—Schlundt.

NUMBER 131

IRON GEYSER SPRING

Location—Manitou.

Rate of Flow—16 gal. per min. Temperature—53° F.

Class of Water—Calcic, bicarbonated, alkaline, saline, sodic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	76.3	......
Sulphate	SO_4	190.7	6.82
Bicarbonate	HCO_3	1231.95	34.62
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	176.8	8.56
Iron	Fe	......	.15
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	3.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	438.91	37.53
Magnesium	Mg	15.89	2.25
Potassium	K	13.8	.60
Sodium	Na	126.6	9.47
Lithium	Li	Trace	......
		2274.75	100.00
Oxygen in Fe_2O_3		1.05	
	Total	2273.40	

Concentration value	58.34	Excess carbon dioxide	444.2
Hydrogen sulphide, H_2S	None	Iron precipitated	2.0
Arsenic, As	....	Evaporation solids	1651
Strontium, Sr	....	Oxygen consuming capacity	0.45

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	1629.7
Pot. chlor., KCl	26.32	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	270.85	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	61.92	Silica, SiO_2	76.3
Mag. sulph., $MgSO_4$	78.66	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	121.97	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	7.8		
Total			2273.42

Properties of Reaction in Percent

Primary salinity	20.14	Primary alkalinity	....
Secondary salinity	10.62	Secondary alkalinity	69.24
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 11.0, 11.2. Temperature, °F, 51.9.

Curies Ra Emanation per liter x 10^{-10}, Water, 4.62, 14.0; Gas, 21.93, 28.8.

Mache Units per liter, Water, 1.25, 2.34; Gas, 5.92, 4.77.

Remarks—Schlundt.

NUMBER 132

MANITOU.

Location—New Geyser across road from Mt. Chief.

Radioactivity

Curies Ra Emanation per liter x 10^{-10}, Gas, 19.65.

Mache Units per liter, Gas, 5.31.

NUMBER 133

MANITOU

Location—Little Chief in Cog R. R. yard.

Radioactivity

Temperature, °C, 9.5, 17.2. Temperature, °F, 49.1.

Curies Ra Emanation per liter x 10^{-10}, Water, 16.84, 19.5.

Mache Units per liter, Water, 4.55, 3.16.

Permanent Activity, Grams Ra per liter, x 10^{-10}, 0.08.

Remarks—S.

NUMBER 134

IRON SPRING

Location—Van Brinnen ranch, 40 miles E. of Trinidad.

Rate of Flow—15 gal. per min. Temperature—58° F.

Class of Water—Sodic, calcic, sulphated, saline, magnesic, ferruginous.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	10.1	......
Sulphate	SO_4	617.9	38.41
Bicarbonate	HCO_3	196.48	9.62
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	23.57	1.97
Iron	Fe	......	.36
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	4.7	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	111.1	16.53
Magnesium	Mg	59.31	14.56
Potassium	K	9.6	.75
Sodium	Na	137.2	17.80
Lithium	Li	None	......
		1169.86	100.00
Oxygen in Fe_2O_3		1.41	
	Total	1168.45	

Concentration value	33.50	Excess carbon dioxide	70.85
Hydrogen sulphide, H_2S	None	Iron precipitated	1.29
Arsenic, As	....	Evaporation solids	1182
Strontium, Sr	....	Oxygen consuming capacity	0.27

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	None	Calc. bicarb., $Ca(HCO_3)_2$	251.5
Pot. chlor., KCl	18.31	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	25.07	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	393.95	Silica, SiO_2	10.1
Mag. sulph., $MgSO_4$	293.6	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	166.1	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	10.47		
Total			1169.10

Properties of Reaction in Percent

Primary salinity	37.10	Primary alkalinity	....
Secondary salinity	43.66	Secondary alkalinity	18.52
Tertiary salinity	....	Tertiary alkalinity	.72

NUMBER 135

JACK SPRING

Location—1 mi. N. E. of No. 48.

Rate of Flow—45 gal. per min. Temperature—60° F.

Class of Water—Calcic, sulphated, saline, magnesic, ferruginous (carbon-dioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	8.6	......
Sulphate	SO_4	881.3	34.76
Bicarbonate	HCO_3	355.3	11.01
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	79.55	4.23
Iron	Fe	......	.28
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	6.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	336.8	31.75
Magnesium	Mg	76.02	11.84
Potassium	K	9.4	.44
Sodium	Na	69.3	5.69
Lithium	Li	None	......
		1822.27	100.00
Oxygen in Fe_2O_3		1.8	
	Total	1820.47	

Concentration value	52.86	Excess carbon dioxide	128.1
Hydrogen sulphide, H_2S	None	Iron precipitated	6 46
Arsenic, As	....	Evaporation solids	1700
Strontium, Sr	....	Oxygen consuming capacity	0.55

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	459.9
Pot. chlor., KCl	17.92	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	117.1	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	68.69	Silica, SiO_2	8.6
Mag. sulph., $MgSO_4$	376.3	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	757.6	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	13.36		
Total			1819.47

Properties of Reaction in Percent

Primary salinity	12.26	Primary alkalinity	....
Secondary salinity	65.72	Secondary alkalinity	21.46
Tertiary salinity	....	Tertiary alkalinity	.56

NUMBER 136

MINERAL HOT SPRING

Location—6 mi. S. of Villa Grove.

Rate of Flow—½ to 8 or 10 gal. per min. Temperature—116° to 133° F.

Class of Water—Sodic, calcic, alkaline-saline, ferruginous, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	57.1	......
Sulphate	SO_4	175.2	18.43
Bicarbonate	HCO_3	310.1	25.77
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	41.0	5.80
Iron	Fe	......	.66
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	5.0	
Aluminum oxide	Al_2O_3		......
Manganese	Mn	None	......
Calcium	Ca	44.7	11.25
Magnesium	Mg	14.1	5.87
Potassium	K	5	.66
Sodium	Na	143.7	31.56
Lithium	Li	Trace	......
		795.9	100.00
Oxygen in Fe_2O_3		1.5	
	Total	794.4	

Concentration value	19.80	Excess carbon dioxide	111.8
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	636
Strontium, Sr	....	Oxygen consuming capacity	0.68

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	180.7
Pot. chlor., KCl	9.5	Iron and aluminum oxides,	
Sod. chlor., NaCl	60.2	Fe_2O_3, Al_2O_3	.....
Sod. sulph., Na_2SO_4	259.1	Calc. silicate, $CaSiO_3$	.....
Mag. sulph., $MgSO_4$	.....	Silica, SiO_2	57.1
Calc. sulph., $CaSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	84.8
Ferrous bicarb., $Fe(HCO_3)_2$	11.1	Sod. bicarb., $NaHCO_3$	131.9
Total			794.4

Properties of Reaction in Percent

Primary salinity	48.46	Primary alkalinity	15.98
Secondary salinity	....	Secondary alkalinity	34.24
Tertiary salinity	....	Tertiary alkalinity	1.32

Radioactivity

Temperature, °C, 47.0, °F, 116.7.

Curies Ra Emanation per liter x 10^{-10}, Water, 4.93; Gas, 262.0.

Mache Units per liter, Water, 1.33; Gas, 70.75.

Permanent Activity, Grams Ra per liter, x 10^{-10}, Trace.

NUMBER 139

MINERAL HOT SPRINGS

Location—Spring in top N. Mound E. group.

Radioactivity

Temperature, °C, 51.0. Temperature, °F, 123.9.
Curies Ra Emanation per liter x 10^{-10}, Gas, 391.5.
Mache Units per liter, Gas, 105.7.

NUMBER 140

RAILROAD SPRING

Location—Mineral Hot Springs.
Rate of Flow—40 to 50 gal. per min. Temperature—101° and 112° F.
Class of Water—Sodic, calcic, bicarbonated, alkaline-saline, (ferruginous, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	81.2	......
Sulphate	SO_4	177.0	17.73
Bicarbonate	HCO_3	332.9	26.26
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	44.5	6.01
Iron	Fe	......	.62
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	5.0	
Aluminum oxide	Al_2O_3		......
Manganese	Mn	None	......
Calcium	Ca	51.8	12.40
Magnesium	Mg	15.1	5.97
Potassium	K	20.0	2.45
Sodium	Na	136.5	28.56
Lithium	Li	None	......
		864.0	100.00
Oxygen in Fe_2O_3		1.5	
	Total	862.5	

Concentration value	20.8	Excess carbon dioxide	120
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	672
Strontium, Sr	....	Oxygen consuming capacity	0.68

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	209.5
Pot. chlor., KCl	38.1	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	43.7	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	261.7	Silica, SiO_2	81.2
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	90.9
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	126.4
Ferrous bicarb., $Fe(HCO_3)_2$	11.1		
Total			862.6

Properties of Reaction in Percent

Primary salinity	47.48	Primary alkalinity	14.54
Secondary salinity	....	Secondary alkalinity	36.74
Tertiary salinity	....	Tertiary alkalinity	1.24

NUMBER 141

ARTESIAN WELL

Location—Montrose.
Rate of Flow—8 to 10 gal, per min. Temperature—73° F.
Class of Water—Sodic, potassic, bicarbonated, alkaline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	20.7	......
Sulphate	SO_4	265.5	7.58
Bicarbonate	HCO_3	1710.2	38.29
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	109.4	4.13
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	97.8	6.66
Magnesium	Mg	33.9	3.83
Potassium	K	147.0	5.13
Sodium	Na	580.0	34.38
Lithium	Li	Trace	......
	Total	2964.5	100.00

Concentration value	73.32	Excess carbon dioxide	616.7
Hydrogen sulphide, H_2S	None	Iron precipitated	3.05
Arsenic, As	....	Evaporation solids	1981
Strontium, Sr	....	Oxygen consuming capacity	2.43

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	395.5
Pot. chlor., KCl	230.0	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	.....	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	344.7	Silica, SiO_2	20.7
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	204.0
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1710.8
Ferrous bicarb., $Fe(HCO_3)_2$	Trace	Pot. sulph., K_2SO_4	58.8
Total			2964.5

Properties of Reaction in Percent

Primary salinity	23.42	Primary alkalinity	55.60
Secondary salinity	....	Secondary alkalinity	20.98
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 22.0. Temperature, °F, 71.6.
Curies Ra Emanation per liter x 10^{-10}, Trace.
Mache Units per liter, Water, Trace.
Remarks—Sample from outlet at well.

NUMBER 142

HORTENSE SPRING

Location—Mt. Princeton.

Rate of Flow—22 to 33 gal. per min. Temperature—183° F.

Class of Water—Sodic, sulphated, alkaline-saline, (siliceous).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	76.1	......
Sulphate	SO_4	103.3	24.72
Bicarbonate	HCO_3	104.2	19.65
Carbonate	CO_3	Trace	......
Phosphate	PO_4	Trace	......
Chloride	Cl	17.68	5.63
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	None	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	4.37	2.53
Magnesium	Mg	Trace	......
Potassium	K	1.5	.46
Sodium	Na	94.2	47.01
Lithium	Li	Trace	......
	Total	401.35	100.00

Concentration value	8.70	Excess carbon dioxide	37.58
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	357
Strontium, Sr	....	Oxygen consuming capacity	1.85

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	17.67
Pot. chlor., KCl	3.25	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	26.61	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	152.8	Silica, SiO_2	76.1
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	Trace
Calc. carb., $CaCO_3$	Trace	Sod. bicarb., $NaHCO_3$	125.2
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			401.62

Properties of Reaction in Percent

Primary salinity	60.70	Primary alkalinity	34.24
Secondary salinity	....	Secondary alkalinity	5.06
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 83.8. Temperature, °F, 183.0.
Curies Ra Emanation per liter x 10^{-10}, Gas, 656.0.
Mache Units per liter, Gas, 177.15.
Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

NUMBER 143

HEYWOOD SPRING

Location—Bath House Spring, Mt. Princeton.

Rate of Flow— Temperature—100° to 120° F.

Class of Water—Sodic, sulphated, bicarbonated, alkaline-saline (siliceous).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	52.0	......
Sulphate	SO_4	51.24	19.04
Bicarbonate	HCO_3	85.8	25.09
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	11.78	5.87
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	None	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	8.96	8.01
Magnesium	Mg	Trace	......
Potassium	K	5.5	2.49
Sodium	Na	51.0	39.50
Lithium	Li	None	......
	Total......	266.28	100.00

Concentration value	5.62	Excess carbon dioxide	30.96
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	225
Strontium, Sr	....	Oxygen consuming capacity	0.7

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	.....	Calc. bicarb., $Ca(HCO_3)_2$	36.22
Pot. chlor., KCl	10.49	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	11.19	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	75.77	Silica, SiO_2	52.0
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	Trace
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	80.61
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			266.28

Properties of Reaction in Percent

Primary salinity	49.82	Primary alkalinity	34.16
Secondary salinity	....	Secondary alkalinity	16.02
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 144

BIG SPRING

Location—At lower end of flat, Mt. Princeton.

Rate of Flow—250 to 300 gal. per min. Temperature—126° to 130° F.

Class of Water—Sodic, potassic, bicarbonated, sulphated, alkaline-saline, (siliceous).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	60.5	......
Sulphate	SO_4	61.94	21.29
Bicarbonate	HCO_3	85.8	23.26
Carbonate	CO_3	Trace	......
Phosphate	PO_4	None	......
Chloride	Cl	11.78	5.45
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	None	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	10.74	8.91
Magnesium	Mg	Trace	......
Potassium	K	32.0	13.52
Sodium	Na	38.5	27.57
Lithium	Li	Trace	......
	Total......	301.26	100.00

Concentration value	6.06	Excess carbon dioxide......	30.96
Hydrogen sulphide, H_2S....	None	Iron precipitated	None
Arsenic, As	....	Evaporated solids	270
Strontium, Sr	....	Oxygen consuming capacity	0.7

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl..........	Trace	Calc. bicarb., $Ca(HCO_3)_2$...	43.44
Pot. chlor., KCl...........	24.77	Iron and aluminum oxides,	
Sod. chlor., NaCl..........	.....	Fe_2O_3, Al_2O_3	.....
Sod. sulph., Na_2SO_4........	57.08	Calc. silicate, $CaSiO_3$......	.....
Mag. sulph., $MgSO_4$.......	.....	Silica, SiO_2	60.5
Calc. sulph., $CaSO_4$........	.....	Mang. oxide, Mn_3O_4........	.....
Calc. carb., $CaCO_3$.........	Trace	Mag. bicarb., $Mg(HCO_3)_2$...	Trace
Ferrous bicarb., $Fe(HCO_3)_2$	.....	Sod. bicarb., $NaHCO_3$......	73.12
		Pot. sulph., K_2SO_4..........	42.34
Total		....	301.25

Properties of Reaction in Percent

Primary salinity	53.48	Primary alkalinity	28.70
Secondary salinity	....	Secondary alkalinity	17.82
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature—°C, 46.0. Temperature, °F, 114.8.
Curies Ra Emanation per liter x 10^{-10}, Water, 9.41.
Mache Units per liter, Water, 2.54.

NUMBER 145

SPRING NEAR HEYWOOD HOTEL

Location—Mt. Princeton.

Rate of Flow—40 gal. per min. Temperature—137° to 141° F.

Class of Water—Sodic, potassic, bicarbonated, sulphated, alkaline-saline, (siliceous).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	67.2	......
Sulphate	SO_4	58.75	21.20
Bicarbonate	HCO_3	81.1	23.07
Carbonate	CO_3	Trace	......
Phosphate	PO_4	None	......
Chloride	Cl	11.78	5.73
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	None	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	7.11	6.24
Magnesium	Mg	Trace	......
Potassium	K	23.2	10.42
Sodium	Na	44.2	33.34
Lithium	Li	Trace	......
	Total	293.34	100.00

Concentration value	5.76	Excess carbon dioxide	29.24
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	265.0
Strontium, Sr	....	Oxygen consuming capacity	0.7

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	28.74
Pot. chlor., KCl	24.77	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	.....	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	67.26	Silica, SiO_2	67.2
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	Trace
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	81.89
Ferrous bicarb., $Fe(HCO_3)_2$	.....	Pot. sulph., K_2SO_4	23.52
Total			293.38

Properties of Reaction in Percent

Primary salinity	53.86	Primary alkalinity	33.66
Secondary salinity	....	Secondary alkalinity	12.48
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Curies Ra Emanation per liter x 10^{-10}, Gas, 202.2.
Mache Units per liter, Gas, 54.6.
Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

NUMBER 146

IRON SPRING

Location—1 mi. above Hotel Heywood, Mt. Princeton.

Rate of Flow—150 gal, per min. Temperature—48° F.

Class of Water—Too weakly mineralized to be classed as a mineral water.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	8.5	......
Sulphate	SO_4	11.01	11.65
Bicarbonate	HCO_3	35.8	29.84
Carbonate	CO_3	Trace	......
Phosphate	PO_4	None	......
Chloride	Cl	5.9	8.51
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	None	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	13.52	34.38
Magnesium	Mg	Trace	......
Potassium	K	Trace	......
Sodium	Na	7.08	15.62
Lithium	Li	None	......
	Total......	81.81	100.00

Concentration value	1.966	Excess carbon dioxide	12.9
Hydrogen sulphide, H_2S	None	Iron precipitated	3.88
Arsenic, As	....	Evaporation solids	103
Strontium, Sr	....	Oxygen consuming capacity	2.09

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	None	Calc. bicarb., $Ca(HCO_3)_2$	47.56
Pot. chlor., KCl	Trace	Iron and aluminum oxides, Fe_2O_3 Al_2O_3	.....
Sod. chlor., NaCl	9.73	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	10.04	Silica, SiO_2	8.5
Mag. sulph., $MgSO_4$	Trace	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	5.98	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	Trace	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			81.81

Properties of Reaction in Percent

Primary salinity	31.24	Primary alkalinity	...
Secondary salinity	9.08	Secondary alkalinity	59.68
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 9.5. Temperature, °F, 49.1.

Curies Ra Emanation per liter x 10^{-10}, Water, 13.35.

Mache Units per liter, Water, 3.61.

Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

NUMBER 147

MINERAL SPRINGS

Location—Morrison, ½ mi. S. E. Post Office, 150 yds. back of Soda Lake.

Rate of Flow—1 to ½ gal per min. Temperature—56° F.

Class of Water—Calcic, magnesic, bicarbonated, alkaline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	15.3	......
Sulphate	SO_4	34.1	6.82
Bicarbonate	HCO_3	262.3	41.35
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	6.8	1.83
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	54.6	26.16
Magnesium	Mg	18.1	14.33
Potassium	K	4.2	1.06
Sodium	Na	20.1	8.45
Lithium	Li	None	......
	Total	415.5	100.00

Concentration value	10.4	Excess carbon dioxide	94.6
Hydrogen sulphide, H_2S	Trace	Iron precipitated	5.17
Arsenic, As	....	Evaporation solids	292
Strontium, Sr	....	Oxygen consuming capacity	1.12

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	220.8
Pot. chlor., KCl	8.0	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	4.9	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	50.3	Silica, SiO_2	15.3
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	108.9
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	7.3
Ferrous bicarb., $Fe(HCO_3)_2$	Trace		
Total			415.5

Properties of Reaction in Percent

Primary salinity	17.30	Primary alkalinity	1.72
Secondary salinity	....	Secondary alkalinity	80.98
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 12.0. Temperature, °F, 53.7.
Curies Ra Emanation per liter x 10^{-10}, Water, 69.40.
Mache Units per liter, Water, 18.74.
Permanent Activity, Grams Ra per liter x 10^{-10}, Trace.

NUMBER 148

SULPHUR SPRING IN HUNTER'S MEADOW

Location—15 mi. N. W. of Walden.

Rate of Flow—50 to 60 gal. per min. Temperature—58° F.

Class of Water—Sodic, potassic, bicarbonated, muriated, alkaline-saline, ferruginous, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	22.1	......
Sulphate	SO_4	110.8	8.12
Bicarbonate	HCO_3	503.4	29.00
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	130.0	12.88
Iron	Fe	......	.56
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	6.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	32.0	5.62
Magnesium	Mg	9.5	2.74
Potassium	K	59	5.31
Sodium	Na	234	35.77
Lithium	Li	None	......
		1107.3	100.00
Oxygen in Fe_2O_3		2	
	Total	1105.3	

Concentration value	28.46	Excess carbon dioxide	181.5
Hydrogen sulphide, H_2S	4.53	Iron precipitated	None
Arsenic, As	....	Evaporation solids	898
Strontium, Sr	....	Oxygen consuming capacity	1.07

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	129.4
Pot. chlor., KCl	112.5	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	126.1	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	163.9	Silica, SiO_2	22.1
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	57.2
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	479.6
Ferrous bicarb., $Fe(HCO_3)_2$	14.5		
Total			1105.3

Properties of Reaction in Percent

Primary salinity	42.00	Primary alkalinity	40.16
Secondary salinity	....	Secondary alkalinity	16.72
Tertiary salinity	....	Tertiary alkalinity	1.12

Radioactivity

Temperature, °C, 13.5. Temperature, °56.3.

Curies Ra Emanation per liter x 10^{-10}, Water, 2.47.

Mache Units per liter, Water, 0.67.

NUMBER 149

SODA SPRING

Location—Hill ranch, 12 mi. West of Cowdrey, about 22 mi. N. W. Walden.

Rate of Flow—2 gal per min. Temperature—46° F.

Class of Water—Calcic, magnesic, bicarbonated, sulphated, alkaline, (carbondioxated), possibly alkaline-saline.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	28.0	......
Sulphate	SO_4	252.0	10.12
Bicarbonate	HCO_3	1192	37.72
Silicate	SiO_3	......	1.79
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	6.8	.37
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	4.7	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	322.2	31.02
Magnesium	Mg	98.3	15.62
Potassium	K	Trace	......
Sodium	Na	40.2	3.36
Lithium	Li	None	......
Oxygen to form SiO_3		7.4	......
	Total	1951.6	100.00

Concentration value	51.82	Excess carbon dioxide	430
Hydrogen sulphide, H_2S	Trace	Iron precipitated	None
Arsenic, As	....	Evaporation solids	1326
Strontium, Sr	....	Oxygen consuming capacity	1.02

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	1227.7
Pot. chlor., KCl	Trace	Iron and aluminum oxides, Fe_2O_3. Al_2O_3	4.7
Sod. chlor., NaCl	11.2	Calc. silicate, $CaSiO_3$	54.0
Sod. sulph., Na_2SO_4	110.6	Silica, SiO_2	.....
Mag. sulph., $MgSO_4$	222.1	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	321.3
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			1951.6

Properties of Reaction in Percent

Primary salinity	6.72	Primary alkalinity	....
Secondary salinity	14.26	Secondary alkalinity	79.02
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 150

IRON SODA SPRING

Location—Brands Ranch, 13 mi. W. of Walden.
Rate of Flow—4 to 5 gal. per min. Temperature—50° F.
Class of Water—Calcic, bicarbonated, alkaline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	39.7	......
Sulphate	SO_4	45.8	4.07
Bicarbonate	HCO_3	561.6	39.10
Silicate	SiO_3	......	5.60
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	10.3	1.23
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	1.2	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	154.1	32.62
Magnesium	Mg	28.9	10.12
Potassium	K	6.2	.68
Sodium	Na	35.5	6.58
Lithium	Li	None	......
Oxygen to form SiO_3		10.5	......
	Total	893.8	100.00

Concentration value	23.56	Excess carbon dioxide	202.5
Hydrogen sulphide, H_2S	None	Iron precipitated	12.26
Arsenic, As	....	Evaporation solids	547
Strontium, Sr	....	Oxygen consuming capacity	0.68

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	516.2
Pot. chlor., KCl	11.8	Iron anl aluminum oxides,	
Sod. chlor., NaCl	7.7	Fe_2O_3, Al_2O_3	1.2
Sod. sulph., Na_2SO_4	67.7	Calc. silicate, $CaSiO_3$	76.6
Mag. sulph., $MgSO_4$	.....	Silica, SiO_2	.....
Calc. sulph., $CaSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	173.9
Ferrous bicarb., $Fe(HCO_3)_2$	.....	Sod. bicarb., $NaHCO_3$	38.7
Total			893.8

Properties of Reaction in Percent

Primary salinity	10.60	Primary alkalinity	3.92
Secondary salinity	....	Secondary alkalinity	85.48
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 10.0. Temperature, °F, 50.0.
Curies Ra Emanation per liter x 10^{-10}, Water, 273.0.
Mache Units per liter, Water, 73.7.

NUMBER 151

NORTH PARK

Location—100 yds. down creek from 150.

Radioactivity

Temperature, °C, 11.5. Temperature, °F, 52.7.
Curies Ra Emanation per liter x 10^{-10}, Gas, 334.5.
Mache Units per liter, Gas, 90.34.

NUMBER 152

BATH HOUSE SPRING—ORIENT

Location—12 mi. S. E. Villa Grove.

Rate of Flow—200 gal. per min. Temperature—97° F

Class of Water—Calcic, bicarbonated, sulphated, alkaline-saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	29.2	......
Sulphate	SO_4	94.0	20.84
Bicarbonate	HCO_3	137.3	23.95
Silicate	SiO_3	......	2.66
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	8.6	2.55
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	7.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	59.0	31.39
Magnesium	Mg	16.0	14.04
Potassium	K	8.0	2.23
Sodium	Na	5.0	2.34
Lithium	Li	None	......
Oxygen to form SiO_3		1.9	......
	Total	366.5	100.00

Concentration value	9.40	Excess carbon dioxide	49.5
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	265
Strontium, Sr	....	Oxygen consuming capacity	1.85

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	.....
Pot. chlor., KCl	15.3	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	7.5
Sod. chlor, NaCl	2.1	Calc. silicate, $CaSiO_3$	13.7
Sod. sulph., Na_2SO_4	13.0	Silica, SiO_2	22.1
Mag. sulph., $MgSO_4$	79.2	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	31,2	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	182.4
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			366.5

Properties of Reaction in Percent

Primary salinity	9.14	Primary alkalinity	....
Secondary salinity	37.64	Secondary alkalinity	53.22
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 34.7. Temperature, °F, 94.4.

Curies Ra Emanation per liter x 10^{-10}, Water, 10.38.

Mache Units per liter, Water, 2.80.

Permanent Activity, Grams Ra per liter, 10^{-10}, None.

NUMBER 153

BIG SPRING

Location—E. of Bath House Spring, Orient.

Rate of Flow—250 to 300 gal. per min. Temperature—97° to 98° F.

Class of Water—Calcic, bicarbonated, sulphated, alkaline-saline, ferruginous.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	23.1	......
Sulphate	SO_4	78.4	20.38
Bicarbonate	HCO_3	133.1	27.24
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	6.8	2.38
Iron	Fe	......	1.87
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	6.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	49.5	30.87
Magnesium	Mg	12.8	13.14
Potassium	K	5.7	1.87
Sodium	Na	4.2	2.25
Lithium	Li	None	......
		319.6	100.00
Oxygen in Fe_2O_3		1.8	
	Total	317.8	

Concentration value	8.00	Excess carbon dioxide	48.0
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	232
Strontium, Sr	....	Oxygen consuming capacity	1.75

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	164.6
Pot. chlor., KCl	10.9	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	2.6	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	9.8	Silica, SiO_2	23.1
Mag. sulph., $MgSO_4$	63.4	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	30.0	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	13.4		
Total			317.8

Properties of Reaction in Percent

Primary salinity	8.24	Primary alkalinity	....
Secondary salinity	37.28	Secondary alkalinity	50.74
Tertiary salinity	....	Tertiary alkalinity	3.74

Radioactivity

Temperature, °C, 36.1. Temperature, °F, 97.0.

Curies Ra Emanation per liter, x 10^{-10}, Gas, 152.35.

Mache Units per liter, Gas, 41.14.

NUMBER 154

FISH POND.

Location—Hot Spring—Ouray.
Rate of Flow—10 gal. per min. Temperature—100° F.
Class of Water—Calcic, sulphated, saline, sodic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	37.4	......
Sulphate	SO_4	476.0	36.42
Bicarbonate	HCO_3	172.3	10.39
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	30.8	3.19
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	203.9	37.38
Magnesium	Mg	5.4	1.65
Potassium	K	17.0	1.61
Sodium	Na	58.7	9.36
Lithium	Li	None	......
	Total	1001.5	100.00

Concentration value	27.24	Excess carbon dioxide	62.1
Hydrogen sulphide, H_2S	None	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	872
Strontium, Sr	....	Oxygen consuming capacity	1.56

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	.....	Calc. bicarb., $Ca(HCO_3)_2$	228.9
Pot. chlor., KCl	32.4	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	25.4	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	150.4	Silica, SiO_2	37.4
Mag. sulph., $MgSO_4$	26.7	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	500.3	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	Trace		
Total			1001.5

Properties of Reaction in Percent

Primary salinity	78.06	Primary alkalinity	....
Secondary salinity	1.16	Secondary alkalinity	20.78
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 155

OURAY

Location—Cold Spring in corner of fish pond.

Radioactivity

Temperature, °C, 18.5. Temperature, °F, 65.3.
Curies Ra Emanation per liter x 10^{-10}, Water, 27.2.
Mache Units per liter, Water, 7.34.
Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

NUMBER 156

HOT SPRING

Location—At head of street eastern end of Ouray.

Rate of Flow—20 to 30 gal. per min. Temperature—120° F.

Class of Water—Calcic, sulphated, saline, sodic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	39.0	......
Sulphate	SO_4	572.0	36.86
Bicarbonate	HCO_3	212.2	10.75
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	27.4	2.39
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	246.2	38.02
Magnesium	Mg	4.5	1.15
Potassium	K	26.7	2.10
Sodium	Na	65.0	8.73
Lithium	Li	Trace	......
	Total	1193.0	100.00

Concentration value	32.3	Excess carbon dioxide	76.5
Hydrogen sulphide, H_2S	None	Iron precipitated	0.94
Arsenic, As	....	Evaporation solids	1116
Strontium, Sr	....	Oxygen consuming capacity	5.94

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	281.9
Pot. chlor., KCl	50.9	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	5.3		
Sod. sulph., Na_2SO_4	194.3	Calc. silicate, $CaSiO_3$	.....
Mag. sulph., $MgSO_4$	22.2	Silica, SiO_2	39.0
Calc. sulph., $CaSO_4$	599.4	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	Trace	Sod. bicarb., $NaHCO_3$	.....
Total			1193.0

Properties of Reaction in Percent

Primary salinity	21.66	Primary alkalinity	....
Secondary salinity	56.84	Secondary alkalinity	21.50
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 34.0. Temperature, °F, 93.1.
Curies Ra Emanation per liter x 10^{-10}, Water, 36.9.
Mache Units per liter, Water, 9.99.
Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

NUMBER 157

PAVILION SPRING

Location—Mouth of Box Canyon, Ouray.

Rate of Flow—10 to 20 gal. per min. Temperature—159° F.

Class of Water—Calcic, sulphated, saline, lithic, ferruginous.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	52.3	......
Sulphate	SO_4	1015.8	42.54
Bicarbonate	HCO_3	37.4	1.23
Silicate	SiO_3	......	3.34
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	51.3	2.89
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	41.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	383.3	38.47
Magnesium	Mg	11.1	1.83
Potassium	K	45.0	2.31
Sodium	Na	81.0	7.07
Lithium	Li	1.1	.32
Oxygen to form SiO_3		13.3	......
	Total	1732.6	100.00

Concentration value	49.74	Excess carbon dioxide	13.5
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	1667
Strontium, Sr	....	Oxygen consuming capacity	0.88

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	6.8	Calc. bicarb., $Ca(HCO_3)_2$	49.7
Pot. chlor., KCl	85.8	Iron and aluminum oxides,	
Sod. chlor., NaCl	7.7	Fe_2O_3, Al_2O_3	41.0
Sod. sulph., Na_2SO_4	240.9	Calc. silicate, $CaSiO_3$	97.0
Mag. sulph., $MgSO_4$	54.9	Silica, SiO_2	2.1
Calc. sulph., $CaSO_4$	1146.7	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....	Sod. bicarb., $NaHCO_3$	.....
Total			1732.6

Properties of Reaction in Percent

Primary salinity	19.40	Primary alkalinity	....
Secondary salinity	71.46	Secondary alkalinity	9.14
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 51.5. Temperature, °F, 124.7.
Curies Ra Emanation per liter, x 10^{-10}, Water, 6.38.
Mache Units per liter, Water, 1.72.

NUMBER 158

OURAY

Location—Cogar Spring.

Radioactivity

Temperature, °C, 47.5. Temperature, °F, 117.5.

Curies Ra Emanation per liter, x 10^{-10}, Water, 11.53.

Mache Units per liter, Water, 3.11.

Permanent Activity, Grams Ra per liter, x 10^{-10}, 0.096.

NUMBER 159

OURAY

Radioactivity

Curies Ra Emanation per liter, x 10^{-10}, Water, None.

Mache Units per liter, Water, None.

NUMBER 160

ARTESIAN WELL

Location—At Arlington Hotel, Pagosa Springs.

Rate of Flow—About 100 gal. Temperature—140° F.

Class of Water—Sodic, potassic, calcic, sulphated, saline, lithic, ferruginous, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	160.2	......
Sulphate	SO_4	1494	33.04
Bicarbonate	HCO_3	631.3	10.98
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	200.5	5.98
Iron	Fe	......	.27
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	10.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	230.2	12.18
Magnesium	Mg	24	2.09
Potassium	K	260	7.07
Sodium	Na	607	28.02
Lithium	Li	2.4	.37
		3619.6	100.00
Oxygen in Fe_2O_3		3	
	Total	3616.6	

Concentration value	94.20	Excess carbon dioxide	227.7
Hydrogen sulphide, H_2S	7.4	Iron precipitated	None
Arsenic, As	....	Evaporation solids	3334
Strontium, Sr	....	Oxygen consuming capacity	3.02

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	14.8	Calc. bicarb., $Ca(HCO_3)_2$	818.3
Pot. chlor., KCl	395.5	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	.....	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	1874.7	Silica, SiO_2	160.2
Mag. sulph., $MgSO_4$	118.8	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	94.8	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	22.3	Pot. sulph., K_2SO_4	117.2
Total			3916.6

Properties of Reaction in Percent

Primary salinity	70.92	Primary alkalinity	....
Secondary salinity	7.12	Secondary alkalinity	21.42
Tertiary salinity	....	Tertiary alkalinity	.54

Radioactivity

Temperature, °C, 50.0. Temperature, °F, 122.0.
Curies Ra Emanation per liter x 10^{-10}, Gas, 6.63.
Mache Units per liter, Gas, 1.79.

NUMBER 161

COLD SPRING

Location—1¼ mi. below Pagosa Springs on E. bank of River.

Rate of Flow—10 gal. per min. Temperature—50° F.

Class of Water—Sodic, potassic, calcic, sulphated, muriated, saline, ferruginous, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	33.5	......
Sulphate	SO_4	1140.2	29.40
Bicarbonate	HCO_3	500.1	10.15
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	299.3	10.45
Iron	Fe	......	.22
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	7.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	232.7	14.35
Magnesium	Mg	30.6	3.12
Potassium	K	170	5.39
Sodium	Na	499.7	26.92
Lithium	Li	High trace	......
		2913.1	100.00
Oxygen in Fe_2O_3		2.1	
	Total	2911.0	

Concentration value	80.76	Excess carbon dioxide	180.30
Hydrogen sulphide, H_2S	7.74	Iron precipitated	1.36
Arsenic, As	....	Evaporation solids	2680
Strontium, Sr	....	Oxygen consuming capacity	1.70

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	High trace	Calc. bicarb., $Ca(HCO_3)_2$	650.2
Pot. chlor., KCl	324.2	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	239.2	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2So_4	1252.7	Silica, SiO_2	33.5
Mag. sulph., $MgSO_4$	151.4	Mang. oxide. Mn_3O_4	.....
Calc. sulph., $CaSO_4$	244.3	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	15.6		
Total			2911.1

Properties of Reaction in Percent

Primary salinity	64.62	Primary alkalinity	....
Secondary salinity	15.08	Secondary alkalinity	20.30
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 12.5. Temperature, °F, 54.6.

Curies Ra Emanation per liter x 10^{-10}, Water, 2.30.

Mache Units per liter, Water, 0.62.

NUMBER 162

BIG PAGOSA SPRING

Rate of Flow—600 to 800 gal. per min. Temperature—158° F.

Class of Water—Sodic, potassic, calcic, sulphated, saline, lithic, ferruginous, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	68.5	......
Sulphate	SO_4	1503.9	33.47
Bicarbonate	HCO_3	635.7	11.12
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	179.6	5.41
Iron	Fe	......	.44
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	16.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	Trace	......
Calcium	Ca	247.1	13.17
Magnesium	Mg	16.8	1.47
Potassium	K	370	10.10
Sodium	Na	525	24.40
Lithium	Li	2.7	.42
		3565.3	100.00
Oxygen in Fe_2O_3		4.8	
	Total......	3560.5	

Concentration value	93.60	Excess carbon dioxide	229.2
Hydrogen sulphide, H_2S	4.62	Iron precipitated	....
Arsenic, As	....	Evaporation solids	3327
Strontium, Sr	....		

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	16.6	Calc. bicarb., $Ca(HCO_3)_2$	812.0
Pot. chlor., KCl	348.4	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	.....	Calc. silicate, $CaSiO_3$	.....
Sod. sulphate, Na_2SO_4	1621.4	Silica, SiO_2	68.5
Mag. sulph., $MgSO_4$	83.2	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	157.3	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	35.7	Pot. sulph., K_2SO_4	417.4
Total			3560.5

Properties of Reaction in Percent

Primary salinity	69.84	Primary alkalinity	....
Secondary salinity	7.92	Secondary alkalinity	21.36
Tertiary salinity	....	Tertiary alkalinity	.88

Radioactivity

Temperature, °C, 65.0. Temperature, °F, 149.0.
Curies Ra Emanation per liter x 10^{-10}, Gas, 12.36.
Mache Units per liter, Gas, 3.34.

NUMBER 163

COLD SPRING

Location—Back of saw mill, Pagosa Springs.

Rate of Flow—3 to 4 gal. per min. Temperature—......

Class of Water—Sodic, potassic, calcic, bicarbonated, sulphated, saline, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	26.4	......
Sulphate	SO_4	995	30.49
Bicarbonate	HCO_3	648	15.61
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	94	3.90
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	259.1	19.03
Magnesium	Mg	45.9	5.56
Potassium	K	226	8.50
Sodium	Na	259	16.54
Lithium	Li	1.7	.37
	Total......	2555.1	100.00

Concentration value	68.00	Excess carbon dioxide	233.7
Hydrogen sulphide, H_2S	8.40	Iron precipitated	None
Arsenic, As	....	Evaporation solids	2328
Strontium, Sr	....	Oxygen consuming capacity	2.92

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	10.4	Calc. bicarb., $Ca(HCO_3)_2$	860.9
Pot. chlor., KCl	179.4	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	.....	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	799.9	Silica, SiO_2	26.4
Mag. sulph., $MgSO_4$	227.2	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	157.0	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	Trace	Pot. sulph., K_2SO_4	293.9
Total			2555.1

Properties of Reaction in Percent

Primary salinity	50.82	Primary alkalinity	....
Secondary salinity	17.96	Secondary alkalinity	31.22
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 164

SPRING IN SAW-MILL GROUNDS

Location—Pagosa Springs.

Rate of Flow—2 gal. per min. Temperature—58° F.

Class of Water—Sodic, potassic, calcic, sulphated, saline, lithic, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	39.2	......
Sulphate	SO_4	1310.5	29.92
Bicarbonate	HCO_3	823.5	14.80
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	171.0	5.28
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	247.5	13.53
Magnesium	Mg	30.2	2.73
Potassium	K	185	5.19
Sodium	Na	590	28.12
Lithium	Li	2.7	.43
	Total	3399.6	100.00

Concentration value	91.24	Excess carbon dioxide	296.9
Hydrogen sulphide, H_2S	15.96	Iron precipitated	None
Arsenic, As	....	Evaporation solids	3036
Strontium, Sr	....	Oxygen consuming capacity	2.34

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	16.4	Calc. bicarb., $Ca(HCO_3)_2$	1000.8
Pot. chlor., KCl	330.8	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	.....	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	1822.2	Silica, SiO_2	39.2
Mag. sulph., $MgSO_4$	80.4	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	84.2
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	Trace	Pot. sulph., K_2SO_4	25.6

Total 3399.6

Properties of Reaction in Percent

Primary salinity	67.48	Primary alkalinity	....
Secondary salinity	2.92	Secondary alkalinity	29.60
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 15.0. Temperature, °F, 59.1.
Curies Ra Emanation per liter x 10^{-10}, Water, None.
Mache Units per liter, Water, None.

NUMBER 165

GEYSER WARM SPRING

Class of Water—Sodic, potassic, bicarbonated, sulphated, alkaline-saline, lithic, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	98.8	......
Sulphate	SO_4	878.7	21.74
Bicarbonate	HCO_3	1005	19.56
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	259.9	8.70
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	156.9	9.30
Magnesium	Mg	13.0	1.27
Potassium	K	130	3.96
Sodium	Na	677	34.94
Lithium	Li	3.1	.53
	Total	3222.4	100.00

Concentration value	84.2	Excess carbon dioxide	362.4
Hydrogen sulphide, H_2S	1.23	Iron precipitated	None
Arsenic, As	....	Evaporation solids	2764
Strontium, Sr	....	Oxygen consuming capacity	0.97

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	18.7	Calc. bicarb., $Ca(HCO_3)_2$	634.4
Pot. chlor., KCl	247.9	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	208.4	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	1299.4	Silica, SiO_2	98.8
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	78.2
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	636.6
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			3222.4

Properties of Reaction in Percent

Primary salinity	60.88	Primary alkalinity	17.98
Secondary salinity	....	Secondary alkalinity	21.14
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Curies Ra Emanation per liter x 10^{-10}, Water, 0.83.
Mache Units per liter, Water, 0.22.
Permanent Activity, Grams Ra per liter x 10^{-10}, Trace.

NUMBER 166

STRONTIA SPRINGS

Location—Platte Canon, Colorado.

Rate of Flow—2½ gal. per min. Temperature—68° F.

Class of Water—Sodic, calcic, muriated, sulphated, saline, potassic.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	31.0	......
Sulphate	SO_4	730.3	7.02
Bicarbonate	HCO_3	19.08	.14
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	3289.5	42.84
Iron	Fe	......	.13
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	11.25	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	1349.2	31.09
Magnesium	Mg	Trace	......
Potassium	K	91.75	1.08
Sodium	Na	882.0	17.70
Lithium	Li	None	......
		6404.08	100.00
Oxygen in Fe_2O_3		3.38	
	Total	6400.70	

Concentration value	216.6	Excess carbon dioxide	6.88
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids (approx.)	6745
Strontium, Sr	Trace	Oxygen consuming capacity	13.60

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	.....	Calc. bicarb., $Ca(HCO_3)_2$	2.51
Pot. chlor., KCl	174.96	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	2241.8	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	.....	Silica, SiO_2	31.0
Mag. sulph., $MgSO_4$	Trace	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	2890.0	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	25.06	Calc. chlor., $CaCl_2$	1035.0
Total			6400.33

Properties of Reaction in Percent

Primary salinity	37.56	Primary alkalinity	....
Secondary salinity	62.16	Secondary alkalinity	.28
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 167

SILVER SPRING

Location—Plateau Creek, 14 mi. from DeBeque.

Rate of Flow—½ to ¾ gal. per min. Temperature—61° F.

Class of Water—Sodic, bicarbonated, alkaline, (carbondioxated, potassic).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	17.7	......
Sulphate	SO_4	7.1	.53
Bicarbonate	HCO_3	836.1	48.45
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	10.3	1.02
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	4.1	.71
Magnesium	Mg	3.5	1.02
Potassium	K	32.2	2.92
Sodium	Na	295	45.35
Lithium	Li	None	......
	Total	1205.8	100.00

Concentration value	28.30	Excess carbon dioxide	301.5
Hydrogen sulphide, H_2S	Trace	Iron precipitated	None
Arsenic, As	....	Evaporation solids	784
Strontium, Sr	....	Oxygen consuming capacity	1.51

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Pot. chlor., KCl	21.6	Calc. silicate, $CaSiO_3$	.....
Sod. chlor., NaCl	.....	Silica, SiO_2	17.7
Sod. sulph., Na_2SO_4	.....	Mang. oxide, Mn_3O_4	.....
Mag. sulph., $MgSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	21.1
Calc. sulph., $CaSO_4$	.....	Sod. bicarb., $NaHCO_3$	1077.5
Calc. carb., $CaCO_3$	.....	Pot. sulph., K_2SO_4	12.9
Ferrous bicarb., $Fe(HCO_3)_2$	.....	Pot. bicarb., $KHCO_3$	38.6
Calc. bicarb., $Ca(HCO_3)_2$	16.6		

Total 1206.0

Properties of Reaction in Percent

Primary salinity	3.10	Primary alkalinity	93.44
Secondary salinity	....	Secondary alkalinity	3.46
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 15.5. Temperature, °F, 60.0.
Curies Ra Emanation per liter x 10^{-10}, Water, 1.42.
Mache Units per liter, Water, 0.38.

NUMBER 168

SPRING AT HAINS RANCH

Location—¼ mi. below Atwell bridge, Plateau Creek.

Rate of Flow—½ to ¾ gal. per min. Temperature—64° F.

Class of Water—Sodic, bicarbonated, alkaline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	24.1	......
Sulphate	SO_4	15.4	1.68
Bicarbonate	HCO_3	536.6	46.27
Carbonate	CO_3	Trace	......
Phosphate	PO_4	None	......
Chloride	Cl	13.7	2.05
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	7.5	1.95
Magnesium	Mg	3.2	1.37
Potassium	K	20	2.68
Sodium	Na	192.1	44.00
Lithium	Li	None	......
	Total......	812.6	100.00

Concentration value	19.00	Excess carbon dioxide	193.5
Hydrogen sulphide, H_2S	None	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	575
Strontium, Sr	....	Oxygen consuming capacity	2.14

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	30.3
Pot. chlor., KCl	28.8	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	.....	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	13.9	Silicate, SiO_2	24.1
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	19.3
Calc. carb., $CaCO_3$	Trace	Sod. bicarb., $NaHCO_3$	685.3
Ferrous bicarb., $Fe(HCO_3)_2$	Trace	Pot. sulph., K_2SO_4	10.9
Total			812.7

Properties of Reaction in Percent

Primary salinity	7.46	Primary alkalinity	85.90
Secondary salinity	....	Secondary alkalinity	6.64
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 169

ALKALI SPRING

Location—Across creek from Hains Ranch.

Rate of Flow—50 gal. per min. Temperature—56° F.

Class of Water—Calcic, sodic, sulphated, saline, magnesic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	31.7	......
Sulphate	SO_4	1369	36.33
Bicarbonate	HCO_3	349.6	7.30
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	177.8	6.37
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	343.2	21.83
Magnesium	Mg	104.9	10.98
Potassium	K	45.7	1.49
Sodium	Na	283.5	15.70
Lithium	Li	None	......
	Total	2705.4	100.00

Concentration value	78.52	Excess carbon dioxide	126.1
Hydrogen sulphide, H_2S	None	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	2507
Strontium, Sr	....	Oxygen consuming capacity	4.29

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	464.5
Pot. chlor., KCl	87.2	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	224.7	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	602.6	Silica, SiO_2	31.7
Mag. sulph., $MgSO_4$	519.3	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	775.4	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	Trace		
Total			2705.4

Properties of Reaction in Percent

Primary salinity	34.38	Primary alkalinity	....
Secondary salinity	51.02	Secondary alkalinity	14.60
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 170

SULPHUR SPRINGS

Location—Plateau creek, 3 miles below Atwell bridge.

Rate of Flow—5 to 6 gal. per min. Temperature—58° F.

Class of Water—Sodic, bicarbonated, sulphated, alkaline, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	39.2	......
Sulphate	SO_4	103.5	10.06
Bicarbonate	HCO_3	511.6	39.05
Carbonate	CO_3	Trace	......
Phosphate	PO_4	None	......
Chloride	Cl	6.8	.89
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	9.7	2.24
Magnesium	Mg	2.1	.79
Potassium	K	24	2.84
Sodium	Na	217.7	44.13
Lithium	Li	None	......
	Total	914.6	100.00

Concentration value	21.46	Excess carbon dioxide	170.1
Hydrogen sulphide, H_2S	22.12	Iron precipitated	None
Arsenic, As	....	Evaporation solids	717
Strontium, Sr	....	Oxygen consuming capacity	1.95

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	39.2
Pot. chlor., KCl	14.4	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	.....	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	123.2	Silica, SiO_2	39.2
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	12.6
Calc. carb., $CaCO_3$	Trace	Sod. bicarb., $NaHCO_3$	649.4
Ferrous bicarb., $Fe(HCO_3)_2$	Trace	Pot. sulph., K_2SO_4	36.6
Total			914.6

Properties of Reaction in Percent

Primary salinity	21.90	Primary alkalinity	72.04
Secondary salinity	....	Secondary alkalinity	6.06
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 14.5. Temperature, °F, 58.1.
Curies Ra Emanation per liter x 10^{-10}, Water, None.
Mache Units per liter, Water, None.

NUMBER 171

SPRING ON SCOTT'S RANCH ON MORRISON CREEK

Location—15 mi. E. of Phippsburg, Colorado.

Rate of Flow—1½ to 2 gal. per min. Temperature—52° F.

Class of Water—Calcic, sodic, bicarbonated, alkaline, magnesic, ferruginous, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	104.7	......
Sulphate	SO_4	26.34	.85
Bicarbonate	HCO_3	1921.7	48.50
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	15	.65
Iron	Fe	......	.12
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	3.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	357.6	27.48
Magnesium	Mg	107	13.54
Potassium	K	9.35	.37
Sodium	Na	127.0	8.49
Lithium	Li	Trace	......
		2671.7	100.00
Oxygen in Fe_2O_3		.9	
	Total	2670.8	

Concentration value	64.94	Excess carbon dioxide	693
Hydrogen sulphide, H_2S	None	Iron precipitated	3.65
Arsenic, As	....	Evaporation solids	932(?)
Strontium, Sr	....	Oxygen consuming capacity	0.55

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	1446
Pot. chlor., KCl	17.8	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	10.72	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	38.95	Silica, SiO_2	104.7
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	643.8
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	402.5
Ferrous bicarb., $Fe(HCO_3)_2$	6.7		

Total 2671.2

Properties of Reaction in Percent

Primary salinity	3.00	Primary alkalinity	14.72
Secondary salinity	....	Secondary alkalinity	82.28
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 172

SPRING ON SMITH'S RANCH

Location—On Morrison Creek.

Rate of Flow— Temperature—52° F.

Class of Water—Calcic, sodic, bicarbonated, alkaline, magnesic, ferruginous, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	87.4	......
Sulphate	SO_4	24.18	.94
Bicarbonate	HCO_3	1573.07	48.35
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	13.36	.71
Iron	Fe	......	.15
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	3.25	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	284.8	26.65
Magnesium	Mg	91.54	14.11
Potassium	K	10.37	.49
Sodium	Na	105.37	8.60
Lithium	Li	Trace	......
		2193.34	100.00
Oxygen in Fe_2O_3		.98	
	Total	2192.36	

Concentration value	53.34	Excess carbon dioxide	567.3
Hydrogen sulphide, H_2S	None	Iron precipitated	2.23
Arsenic, As	....	Evaporation solids	949
Strontium, Sr	None	Oxygen consuming capacity	2.0

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	1151.6
Pot. chlor., KCl	19.78	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	6.53	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	35.76	Silica, SiO_2	87.4
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	550.8
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	333.2
Ferrous bicarb., $Fe(HCO_3)_2$	7.24		
Total			2192.31

Properties of Reaction in Percent

Primary salinity	3.30	Primary alkalinity	14.88
Secondary salinity	....	Secondary alkalinity	91.82
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 173

JONES MINERAL SPRING

Location—5 mi. E. of Phippsburg on Bear River.

Rate of Flow—40 gal. per min. Temperature—67° F.

Class of Water—Sodic, bicarbonated, alkaline, (ferruginous, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	14.8	......
Sulphate	SO_4	8.03	1.33
Bicarbonate	HCO_3	362.6	46.48
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	10.02	2.19
Iron	Fe	......	.78
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	4.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	16.07	6.25
Magnesium	Mg	7.86	5.08
Potassium	K	Trace	......
Sodium	Na	111.47	37.89
Lithium	Li	None	......
		534.85	100.00
Oxygen in Fe_2O_3		1.2	
	Total	533.65	

Concentration value	12.80	Excess carbon dioxide	130.7
Hydrogen sulphide, H_2S	None	Iron precipitated	6.69
Arsenic, As	....	Evaporation solids	334
Strontium, Sr	....	Oxygen consuming capacity	0.64

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	64.98
Pot. chlor., KCl	Trace	Iron and aluminum oxides, Fe_2O_3, Al_2O_2	.....
Sod. chlor., NaCl	16.52	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	11.86	Silica, SiO_2	14.8
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	None
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	47.3
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	369.3
Ferrous bicarb., $Fe(HCO_3)_2$	8.9		
Total			533.66

Properties of Reaction in Percent

Primary salinity	7.04	Primary alkalinity	68.74
Secondary salinity	....	Secondary alkalinity	22.66
Tertiary salinity	....	Tertiary alkalinity	1.56

NUMBER 174

LAUNDRY SPRING

Location—Poncha Springs.

Rate of Flow—3 to 4 gal. per min. Temperature—130° F.

Class of Water—Sodic, carbondioxated, sulphated, alkaline-saline.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	54.1	......
Sulphate	SO_4	207.4	22.69
Bicarbonate	HCO_3	223.1	19.22
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	54.7	8.09
Iron	Fe	......	.21
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	1.7	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	19.7	5.14
Magnesium	Mg	2.7	1.16
Potassium	K	16.5	2.23
Sodium	Na	180.5	41.26
Lithium	Li	None	......
		760.4	100.00
Oxygen in Fe_2O_3		0.5	
	Total	759.9	

Concentration value	19.04	Excess carbon dioxide	80.5
Hydrogen sulphide, H_2S	None	Strontium, Sr	Trace
Arsenic, As	....	Evaporation solids	700
Strontium, Sr	....	Oxygen consuming capacity	0.58

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	.....	Calc. bicarb., $Ca(HCO_3)_2$	79.7
Pot. chlor., KCl	31.5	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	65.5	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	306.7	Silica, SiO_2	54.1
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	16.3
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	202.3
Ferrous bicarb., $Fe(HCO_3)_2$	3.8		
Total			759.9

Properties of Reaction in Percent

Primary salinity	61.56	Primary alkalinity	25.42
Secondary salinity	....	Secondary alkalinity	13.02
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 175

WEST MOUND SPRING

Location—Poncha Springs.

Rate of Flow—½ to ¼ gal. per min. Temperature—151° F.

Class of Water—Sodic, bicarbonated, sulphated, alkaline-saline, ferruginous, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	81.2	......
Sulphate	SO_4	197.3	21.61
Bicarbonate	HCO_3	235.4	20.24
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	54.7	8.15
Iron	Fe	......	.47
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	3.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	20.4	5.31
Magnesium	Mg	3.3	1.42
Potassium	K	36.5	4.89
Sodium	Na	166.0	37.91
Lithium	Li	None	......
		798.3	100.00
Oxygen in Fe_2O_3		1.0	
	Total	797.3	

Concentration value	19.02	Excess carbon dioxide	84.9
Hydrogen sulphide, H_2S	None	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	671
Strontium, Sr	....	Oxygen consuming capacity	0.78

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	.....	Calc. bicarb., $Ca(HCO_3)_2$	82.5
Pot. chlor., KCl	69.6	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	35.6	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	291.8	Silica, SiO_2	81.2
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	19.9
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	208.9
Ferrous bicarb., $Fe(HCO_3)_2$	7.8		
Total			797.3

Properties of Reaction in Percent

Primary salinity	59.52	Primary alkalinity	26.08
Secondary salinity	....	Secondary alkalinity	13.46
Tertiary salinity	....	Tertiary alkalinity	.94

Radioactivity

Temperature, °C, 71.5. Temperature, °F, 160.7.
Curies Ra Emanation per liter x 10^{-10}, Water, 18.62; Gas, 760.0.
Mache Units per liter, Water, 5.03; Gas, 205.2.
Permanent Activity, Grams Ra per liter, x 10^{-10}, 0.091.

NUMBER 176

EAST MOUND SPRING

Location—Poncha Springs.

Rate of Flow—½ to 5 or 6 gal. per min. Temperature—154° F.

Class of Water—Sodic, ferruginous, bicarbonated, sulphated, alkaline-saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	80.3	......
Sulphate	SO_4	198.7	22.20
Bicarbonate	HCO_3	220.9	19.47
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	54.7	8.33
Iron	Fe	......	.59
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	4.2	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	17.7	4.72
Magnesium	Mg	2.3	1.02
Potassium	K	21.0	2.89
Sodium	Na	174.5	40.78
Lithium	Li	None	......
		774.3	100.0
Oxygen in Fe_2O_3		1.2	
	Total	773.1	

Concentration value	18.64	Excess carbon dioxide	79.7
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	691
Strontium, Sr	....	Oxygen consuming capacity	0.88

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	71.6
Pot. chlor., KCl	40.0	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	58.9	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	293.8	Silica, SiO_2	80.3
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	13.8
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	205.3
Ferrous bicarb., $Fe(HCO_3)_2$	9.4		
Total			773.1

Properties of Reaction in Percent

Primary salinity	61.06	Primary alkalinity	26.28
Secondary salinity	....	Secondary alkalinity	11.48
Tertiary salinity	....	Tertiary alkalinity	1.18

Radioactivity

Curies Ra Emanation per liter x 10^{-10}, Water, 13.58.

Mache Units per liter, Water, 3.67.

Permanent Activity, Grams Ra per liter, x 10^{-10}, 0.121.

NUMBER 177

GULCH SPRING

Location—Poncha Springs.

Rate of Flow—2 to 6 gal. per min. Temperature—146° F.

Class of Water—Sodic, potassic, sulphated, alkaline-saline, ferruginous, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	77.1	......
Sulphate	SO_4	215.5	23.17
Bicarbonate	HCO_3	221.3	18.81
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	54.7	8.02
Iron	Fe	......	.57
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	4.2	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	22.2	5.75
Magnesium	Mg	2.7	1.14
Potassium	K	43.2	5.70
Sodium	Na	163.7	36.84
Lithium	Li	None	......
		804.6	100.0
Oxygen in Fe_2O_3		1.2	
	Total	803.4	

Concentration value	19.32	Excess carbon dioxide	79.8
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	698
Strontium, Sr	....	Oxygen consuming capacity	0.78

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	89.8
Pot. chlor., KCl	82.4	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	25.6	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	318.7	Silica, SiO_2	77.1
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	16.3
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	184.1
Ferrous bicarb., $Fe(HCO_3)_2$	9.4		
Total			803.4

Properties of Reaction in Percent

Primary salinity	62.38	Primary alkalinity	22.70
Secondary salinity	....	Secondary alkalinity	13.78
Tertiary salinity	....	Tertiary alkalinity	1.14

Radioactivity

Temperature, °C, 64.5. Temperature, °F, 148.1.

Curies Ra Emanation per liter x 10^{-10}, Water, 263.9.

Mache Units per liter, Water, 71.25.

Permanent Activity, Grams Ra per liter, x 10^{-10}, 0.063.

NUMBER 178

COLD SPRING

Location—¾ mi. up Gulch from Poncha Springs.

Rate of Flow—2½ gal. per min. Temperature—48° F.

Class of Water—Calcic, ferruginous, bicarbonated, alkaline-saline.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	15.4	......
Sulphate	SO_4	25.7	8.41
Bicarbonate	HCO_3	143.5	37.02
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	10.3	4.57
Iron	Fe	......	.94
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	2.6	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	34.8	27.36
Magnesium	Mg	8.7	11.32
Potassium	K	4.0	1.57
Sodium	Na	12.8	8.81
Lithium	Li	None	......
		257.8	100.0
Oxygen in Fe_2O_3		0.8	
	Total	257.0	

Concentration value	6.36	Excess carbon dioxide	51.7
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	178
Strontium, Sr	....	Oxygen consuming capacity	0.78

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	.....	Calc. bicarb., $Ca(HCO_3)_2$	140.7
Pot. chlor., KCl	7.6	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	11.0	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	26.3	Silica, SiO_2	15.4
Mag. sulph., $MgSO_4$	9.9	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	40.3
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	5.8		
Total			257.0

Properties of Reaction in Percent

Primary salinity	20.76	Primary alkalinity	....
Secondary salinity	5.20	Secondary alkalinity	72.16
Tertiary salinity	....	Tertiary alkalinity	1.88

Radioactivity

Permanent Activity, Grams Ra per liter, x 10^{-10}, 0.186.

NUMBER 179

OLD BATH HOUSE SPRING

Location—Powderhorn.

Radioactivity

Temperature, °C, 33.5. Temperature, °F, 92.2.
Curies Ra Emanation per liter x 10^{-10}, Water, 8.31.
Mache Units per liter, Water, 2.24.

NUMBER 180

CABIN SPRING

Location—Powderhorn.
Rate of Flow—½ to 1 gal. per min. Temperature—79° F.
Class of Water—Sodic, bicarbonated, alkaline, potassic, ferruginous, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	77.5	......
Sulphate	SO_4	122.5	5.00
Bicarbonate	HCO_3	1188.7	38.20
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	123.1	6.80
Iron	Fe	......	.22
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	4.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	133.7	13.07
Magnesium	Mg	50.5	8.16
Potassium	K	77.5	3.88
Sodium	Na	289.5	24.67
Lithium	Li	Trace	......
		2067.5	100.0
Oxygen in Fe_2O_3		1.4	
	Total	2066.1	

Concentration value	51.02	Excess carbon dioxide	428.8
Hydrogen sulphide, H_2S	None	Iron precipitated	1.74
Strontium, Sr	....	Evaporation solids	1440
Arsenic, As	....	Oxygen consuming capacity	2.63

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	540.6
Pot. chlor., KCl	147.8	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	87.0	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	181.2	Silica, SiO_2	77.5
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	303.9
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	718.1
Ferrous bicarb., $Fe(HCO_3)_2$	10		
Total			2066.1

Properties of Reaction in Percent

Primary salinity	23.60	Primary alkalinity	33.50
Secondary salinity	....	Secondary alkalinity	42.90
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 181

DRINKING SPRING

Location—Powderhorn.

Rate of Flow—½ to 1 gal. per min. Temperature—60° F.

Class of Water—Sodic, calcic, bicarbonated, alkaline, potassic, (carbon-dioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	86.9	......
Sulphate	SO_4	131.1	5.14
Bicarbonate	HCO_3	1241.8	38.32
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	123.1	6.54
Iron	Fe	......	.13
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	2.6	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	141.9	13.30
Magnesium	Mg	50.0	7.77
Potassium	K	86.5	4.16
Sodium	Na	301	24.64
Lithium	Li	None	......
		2164.9	100.0
Oxygen in Fe_2O_3		.8	
	Total	2164.1	

Concentration value	53.12	Excess carbon dioxide	447.9
Hydrogen sulphide, H_2S	None	Iron precipitated	1.97
Arsenic, As	....	Evaporation solids	1446
Strontium, Sr	....	Oxygen consuming capacity	1.85

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	573.8
Pot. chlor., KCl	165	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	73.5	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	193.9	Silica, SiO_2	86.9
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	300.9
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	764.5
Ferrous bicarb., $Fe(HCO_3)_2$	5.6		
Total			2164.1

Properties of Reaction in Percent

Primary salinity	23.36	Primary alkalinity	34.24
Secondary salinity	....	Secondary alkalinity	42.40
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 182

NEW BATH HOUSE SPRING

Location—Powderhorn.

Rate of Flow—2 gal. per min. Temperature—92° to 114° F.

Class of Water—Sodic, calcic, bicarbonated, alkaline, ferruginous, carbondioxated.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	79.5	......
Sulphate	SO_4	131.9	5.66
Bicarbonate	HCO_3	1107.1	37.39
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	119.7	6.95
Iron	Fe	......	.19
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	3.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	133.3	13.70
Magnesium	Mg	48.7	8.24
Potassium	K	74.7	3.94
Sodium	Na	267.2	23.93
Lithium	Li	Trace	......
		1953.3	100.0
Oxygen in Fe_2O_3		1.1	
	Total	1952.2	

Concentration value	48.56	Excess carbon dioxide	394.8
Hydrogen sulphide, H_2S	None	Iron precipitated	1.89
Arsenic, As	....	Evaporation solids	1453
Strontium, Sr	....	Oxygen consuming capacity	1.40

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	539.0
Pot. chlor., KCl	142.4	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	85.7	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	195.1	Silica, SiO_2	79.5
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	293.0
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	622.0
Ferrous bicarb., $Fe(HCO_3)_2$	7.8		
Total			1952.2

Properties of Reaction in Percent

Primary salinity	25.22	Primary alkalinity	30.52
Secondary salinity	....	Secondary alkalinity	44.26
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 40.5. Temperature, °F, 104.9.
Curies Ra Emanation, per liter x 10^{-10}, Gas, 128.5.
Mache Units per liter, Gas, 34.7.

NUMBER 183

LOWER HOT SPRING

Location—Powderhorn.

Rate of Flow—12 gal. per min. Temperature—84° F.

Class of Water—Sodic, calcic, bicarbonated, alkaline, ferruginous, potassic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	76.7	......
Sulphate	SO_4	124.8	5.28
Bicarbonate	HCO_3	1136.9	37.85
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	119.7	6.87
Iron	Fe	......	.33
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	6.2	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	131.7	13.34
Magnesium	Mg	52.2	8.70
Potassium	K	70.7	3.68
Sodium	Na	271	23.95
Lithium	Li	Trace	......
		1989.9	100.0
Oxygen in Fe_2O_3		1.9	
Total		1988.0	

Concentration value	49.24	Excess carbon dioxide	410
Hydrogen sulphide, H_2S	None	Iron precipitated	1.14
Arsenic, As	....	Evaporation solids	1432
Strontium, Sr	....	Oxygen consuming capacity	1.46

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	532.5
Pot. chlor., KCl	134.8	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	91.7	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	181.5	Silica, SiO_2	76.7
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	314.1
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	639.9
Ferrous bicarb., $Fe(HCO_3)_2$	13.8		
Total			1988.0

Properties of Reaction in Percent

Primary salinity	24.30	Primary alkalinity	30.96
Secondary salinity	....	Secondary alkalinity	44.08
Tertiary salinity	....	Tertiary alkalinity	.66

Radioactivity

Temperature, °C, 26.4. Temperature, °F, 79.6.

Curies Ra Emanation per liter x 10^{-10}, Gas, 229.7.

Mache Units per liter, Gas, 62.0.

Permanent Activity, Grams Ra per liter, x 10^{-10}, Trace.

NUMBER 184

SHRECKER'S IRON SPRING

Location—Near mouth of Powderhorn Creek.

Rate of Flow—15 gal. per min. Temperature—55° F.

Class of Water—Sodic, calcic, ferruginous, bicarbonated, potassic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	17.8	......
Sulphate	SO_4	265.4	8.32
Bicarbonate	HCO_3	1384.8	34.16
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	177.8	7.52
Iron	Fe	......	.21
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	5.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	208.9	15.68
Magnesium	Mg	29.6	3.67
Potassium	K	97.0	3.73
Sodium	Na	408.5	26.71
Lithium	Li	Trace	......
		2595.3	100.0
Oxygen in Fe_2O_3		1.7	
	Total......	2593.6	

Concentration value	66.50	Excess carbon dioxide	499.4
Hydrogen sulphide, H_2S	None	Iron precipitated	3.18
Arsenic, As	....	Evaporation solids	1801
Strontium, Sr	....	Oxygen consuming capacity	1.07

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith chlor., $LiCl$	Trace	Calc. bicarb., $Ca(HCO_3)_2$	844.7
Pot. chlor., KCl	185.0	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	148.0	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	392.5	Silica, SiO_2	17.8
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	178.1
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	815.2
Ferrous bicarb., $Fe(HCO_3)_2$	12.3		
Total			2593.6

Properties of Reaction in Percent

Primary salinity	31.68	Primary alkalinity	29.20
Secondary salinity	....	Secondary alkalinity	39.12
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 9.9. Temperature, °F, 49.9.

Curies Ra Emanation per liter x 10^{-10}, Water, 41.1; Gas, 112.5.

Mache Units per liter, Water, 11.1; Gas, 30.38.

Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

NUMBER 185

SHRECKER'S SODA SPRING

Location—200 yds. below No. 161.

Rate of Flow—1½ to 2 gal. per min. Temperature—48° F.

Class of Water—Sodic, calcic, bicarbonated, alkaline-saline, ferruginous, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	12.0	......
Sulphate	SO_4	187.2	9.70
Bicarbonate	HCO_3	800.2	32.64
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	109.4	7.66
Iron	Fe	......	.27
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	4.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	114.2	14.17
Magnesium	Mg	19.6	4.00
Potassium	K	91.0	5.80
Sodium	Na	238.0	25.76
Lithium	Li	Trace	......
		1576.1	100.0
Oxygen in Fe_2O_3		1.3	
	Total	1574.8	

Concentration value	40.20	Excess carbon dioxide	288.5
Hydrogen sulphide, H_2S	None	Iron precipitated	3.33
Arsenic, As	....	Evaporation solids	1192
Strontium, Sr	....	Oxygen consuming capacity	6.72

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	461.8
Pot. chlor., KCl	173.5	Iron and aluminum oxides,	
Sod. chlor., NaCl	44.3	Fe_2O_3, Al_2O_3	.....
Sod. sulphate, Na_2SO_4	276.8	Calc. silicate, $CaSiO_3$	.....
Mag. sulph., $MgSO_4$	.....	Silica, SiO_2	12.0
Calc. sulph., $CaSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	117.9
Ferrous bicarb., $Fe(HCO_3)_2$	10.0	Sod. bicarb., $NaHCO_3$	478.5
Total			1574.8

Properties of Reaction in Percent

Primary salinity	34.72	Primary alkalinity	28.40
Secondary salinity	....	Secondary alkalinity	36.34
Tertiary salinity	....	Tertiary alkalinity	.54

NUMBER 186

NICHOLS SPRING

Location—On road between Cebolla and Powderhorn Creeks.

Rate of Flow—1 gal. per min. Temperature—48° F.

Class of Water—Sodic, calcic, bicarbonated, sulphated, alkaline-saline, ferruginous, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	12.3	......
Sulphate	SO_4	252.8	8.20
Bicarbonate	HCO_3	1358.2	34.60
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	164.2	7.20
Iron	Fe	......	.39
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	10.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	187.6	14.55
Magnesium	Mg	40.4	5.16
Potassium	K	62	2.47
Sodium	Na	405.7	27.43
Lithium	Li	Trace	......
		2493.2	100.0
Oxygen in Fe_2O_3		3.	
	Total	2490.2	

Concentration value	64.32	Excess carbon dioxide	489.7
Hydrogen sulphide, H_2S	None	Iron precipitated	3.18
Arsenic, As	....	Evaporation solids	1791
Strontium, Sr	....	Oxygen consuming capacity	1.07

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	Trace	Calc. bicarb., $Ca(HCO_3)_2$	758.6
Pot. chlor., KCl	118.2	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	178.1	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	373.8	Silica, SiO_2	12.3
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	243.1
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	783.8
Ferrous bicarb., $Fe(HCO_3)_2$	22.3		
Total			2490.2

Properties of Reaction in Percent

Primary salinity	30.80	Primary alkalinity	29.00
Secondary salinity	....	Secondary alkalinity	39.42
Tertiary salinity	....	Tertiary alkalinity	.78

Radioactivity

Temperature, °C, 10.3. Temperature, °F, 50.6.

Curies Ra Emanation per liter x 10^{-10}, Water, 79.25; Gas, 375.6.

Mache Units per liter, Water, 21.4; Gas, 101.41.

Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

Remarks—Contains Thorium Emanation.

NUMBER 187

PUEBLO LITHIA WATER

Location—Congress Hotel, Pueblo.

Rate of Flow— Temperature—75° F.

Class of Water—Sodic, ferruginous, sulphated, saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	12.4	......
Sulphate	SO_4	530.8	34.92
Bicarbonate	HCO_3	238.25	12.33
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	30.94	2.75
Iron	Fe	......	.19
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	2.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	74.05	11.66
Magnesium	Mg	17.97	4.67
Potassium	K	23.2	1.86
Sodium	Na	230	31.62
Lithium	Li	Trace	......
		1160.11	100.0
Oxygen in Fe_2O_3		0.75	
	Total	1159.36	

Concentration value	31.64	Excess carbon dioxide	85.92
Hydrogen sulphide, H_2S	None	Iron precipitated	2.58
Arsenic, As	....	Evaporation solids	1100
Strontium, Sr	....	Oxygen consuming capacity	1.35

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	Trace	Calc. bicarb., $Ca(HCO_3)_2$	299.43
Pot. chlor., KCl	44.24	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	16.32	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	690.5	Silica, SiO_2	12.4
Mag. sulph., $MgSO_4$	80.08	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	10.83
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	5.57		

Total 1159.37

Properties of Reaction in Percent

Primary salinity	66.96	Primary alkalinity	....
Secondary salinity	8.38	Secondary alkalinity	24.66
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 188

CLARK'S MAGNETIC MINERAL WATER

Location—Pueblo.

Class of Water—Sodic, ferruginous, sulphated, saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	17.4	......
Sulphate	SO_4	520	36.10
Bicarbonate	HCO_3	206.22	11.27
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	28.04	2.63
Iron	Fe	......	.20
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	2.25	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	49.16	8.17
Magnesium	Mg	25.07	6.87
Potassium	K	21.7	1.88
Sodium	Na	227	32.88
Lithium	Li	Trace	......
		1096.84	100.00
Oxygen in Fe_2O_3		.68	
	Total	1096.16	

Concentration value	30.00	Excess carbon dioxide	74.36
Hydrogen sulphide, H_2S	None	Iron precipitated	1.49
Arsenic, As	....	Evaporation solids	1053
Strontium, Sr	....	Oxygen consuming capacity	1.81

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	198.8
Pot. chlor., KCl	41.38	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	13.78	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	684.3	Silica, SiO_2	17.4
Mag. sulph., $MgSO_4$	71.68	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	63.78
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	5.01		
Total			1096.13

Properties of Reaction in Percent

Primary salinity	69.52	Primary alkalinity	....
Secondary salinity	7.94	Secondary alkalinity	22.54
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 189

ARTESIAN WELL

Location—Sisters' Hospital, Pueblo.

Class of Water—Sodic, bicarbonated, sulphated, alkaline-saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	11.1	......
Sulphate	SO_4	335.2	25.49
Bicarbonate	HCO_3	343.4	20.57
Silicate	SiO_3	......	1.35
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	25.04	2.59
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	2.6	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	13.07	2.41
Magnesium	Mg	10.92	3.28
Potassium	K	26.2	2.45
Sodium	Na	263.6	41.86
Lithium	Li	Trace	......
Oxygen to form SiO_2		2.94	......
	Total	1034.07	100.00

Concentration value	27.38	Excess carbon dioxide	123.8
Hydrogen sulphide, H_2S	None	Iron precipitated	1.88
Arsenic, As	....	Evaporation solids	793
Strontium, Sr	....	Oxygen consuming capacity	0.16

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	Trace	Calc. bicarb., $Ca(HCO_3)_2$	23.0
Pot. chlor., KCl	49.96	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	2.6
Sod. chlor., $NaCl$	2.11	Calc. silicate, $CaSiO_3$	21.42
Sod. sulph., Na_2SO_4	495.7	Silica, SiO_2	.....
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	65.71
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	373.54
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			1034.04

Properties of Reaction in Percent

Primary salinity	56.16	Primary alkalinity	32.46
Secondary salinity	....	Secondary alkalinity	11.38
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 24.0. Temperature, °F, 75.2.
Curies Ra Emanation per liter x 10^{-10}, Water, 2.05.
Mache Units per liter, Water, 0.55.

NUMBER 190

FERRIS ARTESIAN WELL

Location—Pueblo, Colorado.

Rate of Flow—Fills a 2 inch pipe. Temperature 79.7° F.

Class of Water—Sodic, calcic, sulphated, saline, ferruginous, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	11.8	......
Sulphate	SO_4	628.7	32.81
Bicarbonate	HCO_3	350.6	14.38
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	39.76	2.81
Iron	Fe	......	.23
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	3.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	202.18	25.26
Magnesium	Mg	34.19	7.05
Potassium	K	1.17	.08
Sodium	Na	159.6	17.38
Lithium	Li	Trace	......
		1431.50	100.00
Oxygen in Fe_2O_3		1.05	
	Total......	1430.45	

Concentration value	39.90	Excess carbon dioxide	126.4
Hydrogen sulphide, H_2S	0.97	Iron precipitated	2.0
Arsenic, As	....	Evaporation solids	1237
Strontium, Sr	....	Oxygen consuming capacity	0.36

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	458.7
Pot. chlor., KCl	2.23	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	63.8	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	415.5	Silica, SiO_2	11.8
Mag. sulph., $MgSO_4$	169.25	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	301.5	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	7.80		
Total			1430.48

Properties of Reaction in Percent

Primary salinity	34.92	Primary alkalinity	....
Secondary salinity	36.32	Secondary alkalinity	28.76
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 26.5. Temperature, °F, 79.7.

Curies Ra Emanation per liter x 10^{-10}, Water, Trace.

Mache Units per liter, Water, Trace.

Remarks—From pipe 90 ft. from well.

NUMBER 191

IRON SPRING

Location—¾ mi. N. of Rico by R. R.

Rate of Flow— Temperature—81.5° F.

Class of Water—Calcic, bicarbonated, sulphated, alkaline-saline, (carbon-dioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	90.3	......
Sulphate	SO_4	861.2	20.26
Bicarbonate	HCO_3	1410	26.14
Silicate	SiO_3	......	3.39
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	6.8	.21
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	701.4	39.55
Magnesium	Mg	72.3	6.73
Potassium	K	31.5	.92
Sodium	Na	57	2.80
Lithium	Li	Trace	......
Oxygen to form SiO_3		24	......
	Total	3254.5	100.00

Concentration value	88.5	Excess carbon dioxide	508.4
Hydrogen sulphide, H_2S	None	Iron precipitated	14.56
Arsenic, As	....	Evaporation solids	2706
Strontium, Sr	....	Oxygen consuming capacity	0.49

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	1873.3
Pot. chlor., KCl	14.3	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	.....	Calc. silicate, $CaSiO_3$	174.3
Sod. sulph., Na_2SO_4	176.4	Silica, SiO_2	.....
Mag. sulph., $MgSO_4$	357.9	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	604.8	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....	Pot. sulph., K_2SO_4	5.35
Total			3254.5

Properties of Reaction in Percent

Primary salinity	7.44	Primary alkalinity	....
Secondary salinity	33.50	Secondary alkalinity	59.06
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 27.5. Temperature, °F, 81.5.
Curies Ra Emanation per liter x 10^{-10}, Water, 2.54.
Mache Units per liter, Water, 0.69.

NUMBER 192

SPRING IN N. W. CORNER OF RICO

Rate of Flow— Temperature—52.4° F.

Class of Water—Calcic, bicarbonated, alkaline, ferruginous (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	10.3	......
Sulphate	SO_4	65	7.82
Bicarbonate	HCO_3	411.8	39.11
Silicate	SiO_3	......	1.97
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	6.8	1.10
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	13.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	144	41.54
Magnesium	Mg	11.1	5.27
Potassium	K	1.7	.23
Sodium	Na	11.5	2.96
Lithium	Li	None	......
Oxygen to form SiO_3		2.7	......
	Total	678.4	100.00

Concentration value	17.26	Excess carbon dioxide	148.5
Hydrogen sulphide, H_2S	None	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	447
Strontium, Sr	....	Oxygen consuming capacity	1.46

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Fe(HCO_3)_2$	547.1
Pot. chlor., KCl	3.2	Iron and aluminum oxides,	
Sod. chlor., NaCl	8.7	Fe_2O_3, Al_2O_3	13.5
Sod. sulph., Na_2SO_4	25.0	Calc. silicate, $CaSiO_3$	19.9
Mag. sulph., $MgSO_4$	54.9	Silica, SiO_2	.....
Calc. sulph., $CaSO_4$	6.1	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....	Sod. bicarb., $NaHCO_3$	.....
Total			678.4

Properties of Reaction in Percent

Primary salinity	6.38	Primary alkalinity	....
Secondary salinity	11.46	Secondary alkalinity	82.16
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 11.3. Temperature, °F, 52.4.
Curies Ra Emanation per liter x 10^{-10}, Gas, 4.97.
Mache Units per liter, Gas, 1.34.

NUMBER 193

SPRING 100 YDS. S. OF 192

Class of Water—Calcic, bicarbonated, alkaline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	16.0	......
Sulphate	SO_4	59.2	4.36
Bicarbonate	HCO_3	673.9	39.25
Silicate	SiO_3	......	1.88
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	45.1	4.51
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	248.1	43.93
Magnesium	Mg	15.2	4.44
Potassium	K	Trace	......
Sodium	Na	10.5	1.63
Lithium	Li	None	......
Oxygen to form SiO_3		4.2	......
	Total	1072.1	100.00

Concentration value	28.16	Excess carbon dioxide	243
Hydrogen sulphide, H_2S	None	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	716
Strontium, Sr	....	Oxygen consuming capacity	0.88

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	895.3
Pot. chlor., KCl	Trace	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	26.7	Calc. silicate, $CaSiO_3$	30.9
Sod. sulph., Na_2SO_4	.....	Silica, SiO_2	.....
Mag. sulph., $MgSO_4$	26.2	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	54.3	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....	Mag. chlor., $MgCl_2$	38.8
Total			1072.2

Properties of Reaction in Percent

Primary salinity	3.26	Primary alkalinity	....
Secondary salinity	14.48	Secondary alkalinity	82.26
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 194

SPRING 50 FT. FROM 193 IN OLD CREEK BED

Rate of Flow— Temperature—55.5° F.

Class of Water—Calcic, bicarbonated, alkaline-saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	14.1	......
Sulphate	SO_4	82.1	5.93
Bicarbonate	HCO_3	686.4	39.10
Silicate	SiO_3	......	1.63
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	34.2	3.34
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide Aluminum oxide	Fe_2O_3 Al_2O_3	5.5	......
Manganese	Mn	None	......
Calcium	Ca	263.7	45.72
Magnesium	Mg	9.9	2.82
Potassium	K	9.1	.80
Sodium	Na	4.3	.66
Lithium	Li	None	......
Oxygen to form SiO_3		3.7	......
	Total	1113.0	100.00

Concentration value	28.78	Excess carbon dioxide	247.5
Hydrogen sulphide, H_2S	None	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	748
Strontium, Sr	....	Oxygen consuming capacity	1.75

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	911.9
Pot. chlor., KCl	17.4	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	5.5
Sod. chlor., NaCl	10.9	Calc. silicate, $CaSiO_3$	27.2
Sod. sulph., Na_2SO_4	.....	Silica, SiO_2	.....
Mag. sulph., $MgSO_4$	16.3	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	97.9	Mag. bicarb.. $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....	Mag. chlor., $MgCl_2$	25.9
Total			1113.0

Properties of Reaction in Percent

Primary salinity	2.92	Primary alkalinity	....
Secondary salinity	15.62	Secondary alkalinity	81.46
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 13.0. Temperature, °F, 55.5.
Curies Ra Emanation per liter x 10^{-10}, Gas, 1.90.
Mache Units per liter, Gas, 0.51.

NUMBER 195

SPRING 30 FT. S. E. OF 194

Class of Water—Calcic, bicarbonated, alkaline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	12.9	......
Sulphate	SO_4	56.4	4.70
Bicarbonate	HCO_3	636.4	42.00
Silicate	SiO_3	......	1.73
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	13.7	1.57
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	5.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	Trace	......
Calcium	Ca	203.0	40.75
Magnesium	Mg	21.6	7.16
Potassium	K	Trace	......
Sodium	Na	12	2.09
Lithium	Li	None	......
Oxygen to form SiO_3		3.4	......
	Total......	964.3	100.00

Concentration value	24.84	Excess carbon dioxide	213.2
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	644
Strontium, Sr	....	Oxygen consuming capacity.	0.88

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	785.5
Pot. chlor., KCl	Trace	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	5.0
Sod. chlor., NaCl	22.6	Calc. silicate, $CaSiO_3$	24.9
Sod. sulph., Na_2SO_4	9.6	Silica, SiO_2	.....
Mag. sulph., $MgSO_4$	62.5	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	54.2
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			964.3

Properties of Reaction in Percent

Primary salinity	12.54	Primary alkalinity	5.96
Secondary salinity	....	Secondary alkalinity	81.50
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 196

HOT SPRINGS 2 MI. SOUTH OF RIDGWAY

Rate of Flow—10 to 20 gal. per min. Temperature—126° F.

Class of Water—Sodic, calcic, sulphated, potassic, saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	57.5	......
Sulphate	SO_4	1287	39.13
Bicarbonate	HCO_3	277.6	6.65
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	102.6	4.22
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	274.1	19.98
Magnesium	Mg	20.6	2.48
Potassium	K	102.0	3.81
Sodium	Na	374.0	23.73
Lithium	Li	Trace	......
	Total	2495.4	100.00

Concentration value	68.5	Excess carbon dioxide	100.1
Hydrogen sulphide, H_2S	None	Iron precipitated	2.35
Arsenic, As	....	Evaporation solids	2283
Strontium, Sr	....	Oxygen consuming capacity	3.99

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	368.8
Pot. chlor., KCl	194.5	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	16.7	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	1134.7	Silica, SiO_2	57.5
Mag. sulph., $MgSO_4$	102.0	Mang. oxide, Mn_3O_4	....
Calc. sulph., $CaSO_4$	621.2	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	Trace		
Total			2495.4

Properties of Reaction in Percent

Primary salinity	55.08	Primary alkalinity	....
Secondary salinity	31.62	Secondary alkalinity	13.30
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 53.5. Temperature, °F, 128.3.
Curies Ra Emanation per liter x 10^{-10}, Water, 8.75; Gas, 36.2.
Mache Units per liter, Water, 2.36; Gas, 9.78.

NUMBER 197

SPRING

Location—1½ mi. S. W. Ridgway.

Class of Water—Calcic, magnesic, sulphated, saline, sodic.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	34.3	......
Sulphate	SO_4	326.6	32.48
Bicarbonate	HCO_3	94.7	7.40
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	75.2	10.12
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	77.7	18.48
Magnesium	Mg	47.0	18.48
Potassium	K	8.2	1.02
Sodium	Na	58	12.02
Lithium	Li	None	......
	Total	721.7	100.00

Concentration value	20.94	Excess carbon dioxide	34.2
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	750
Strontium, Sr	....	Oxygen consuming capacity.	0.85

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	125.8
Pot. chlor., KCl	15.6	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	111.8	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	43.8	Silica, SiO_2	34.3
Mag. sulph., $MgSO_4$	232.7	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	158.3	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			721.7

Properties of Reaction in Percent

Primary salinity	26.08	Primary alkalinity	....
Secondary salinity	59.12	Secondary alkalinity	14.80
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 198

RUSTIC LODGE—IRON SODA SPRING

Location—3½ miles W. of Rustic Lodge, Larimer Co.

Rate of Flow—1½ gal. per min. Temperature—40° F.

Class of Water—Sodic, calcic, bicarbonated, muriated, alkaline-saline, ferruginous, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	41.8	......
Sulphate	SO_4	169.4	6.34
Bicarbonate	HCO_3	917.7	27.02
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	328.3	16.64
Iron	Fe	......	.22
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	4.7	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	116.5	10.42
Magnesium	Mg	25.7	3.81
Potassium	K	17.5	.81
Sodium	Na	444.7	34.74
Lithium	Li	Trace	
		2066.3	100.00
Oxygen in Fe_2O_3		1.4	
	Total	2064.9	

Concentration value	55.66	Excess carbon dioxide	330.9
Hydrogen sulphide, H_2S	None	Iron precipitated	3.78
Arsenic, As	....	Evaporation solids	1638
Strontium, Sr	....	Oxygen consuming capacity	1.07

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor, LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	471.1
Pot. chlor., KCl	33.4	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	515.0	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	250.5	Silica, SiO_2	41.8
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	154.6
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	588.1
Ferrous bicarb., $Fe(HCO_3)_2$	10.4		
Total			2064.9

Properties of Reaction in Percent

Primary salinity	45.96	Primary alkalinity	25.14
Secondary salinity	....	Secondary alkalinity	28.90
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 199

BUBBLING SPRING

Location—Near Siloam.

Rate of Flow—2½ gal. per min. Temperature—73° F.

Class of Water—Sodic, bicarbonated, muriated, alkaline-saline, potassic, magnesic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	105.8	......
Sulphate	SO_4	157.6	2.77
Bicarbonate	HCO_3	2292.3	31.78
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	648.2	15.45
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	215.4	9.09
Magnesium	Mg	69.69	4.84
Potassium	K	107	2.32
Sodium	Na	918.2	33.75
Lithium	Li	Trace	......
	Total	4514.2	100.00

Concentration value	118.30	Excess carbon dioxide	826.6
Hydrogen sulphide, H_2S	None	Iron precipitated	1.87
Arsenic, As	....	Evaporation solids	3270
Strontium, Sr	....	Oxygen consuming capacity.	1.13

Hypothetical Combinations

Milligrams pėr liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	871.0
Pot. chlor., KCl	204.0	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	908.7	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	233.1	Silica, SiO_2	105.8
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	419.3
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1772.4
Ferrous bicarb., $Fe(HCO_3)_2$	Trace		
Total			4514.3

Properties of Reaction in Percent

Primary salinity	36.44	Primary alkalinity	35.70
Secondary salinity	....	Secondary alkalinity	27.86
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 22.5. Temperature, °F, 72.5.
Curies Ra Emanation per liter x 10^{-10}, Gas, 5.66.
Mache Units per liter, Gas, 1.53.

NUMBER 200

SPRING ACROSS CREEK FROM BUBBLING SPRING

Location—Siloam.

Rate of Flow— Temperature—69° F.

Class of Water—Sodic, bicarbonated, muriated, alkaline-saline, potassic, magnesic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	106.5	......
Sulphate	SO_4	163.0	2.88
Bicarbonate	HCO_3	2265.9	31.42
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	658.5	15.70
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	208.9	8.84
Magnesium	Mg	67.12	4.67
Potassium	K	107	2.32
Sodium	Na	930	34.17
Lithium	Li	Trace	......
	Total	4506.9	100.00

Concentration value	118.24	Excess carbon dioxide	817.1
Hydrogen sulphide, H_2S	None	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	3485
Strontium, Sr	....	Oxygen consuming capacity.	1.35

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	844.7
Pot. chlor., KCl	204.3	Iron and aluminum oxides,	
Sod. chlor., NaCl	925.6	Fe_2O_3, Al_2O_3	.....
Sod. sulph., Na_2SO_4	241.4	Calc. silicate, $CaSiO_3$	.....
Mag. sulph., $MgSO_4$	.....	Silica, SiO_2	106.5
Calc. sulph., $CaSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	403.9
Ferrous bicarb., $Fe(HCO_3)_2$	Trace	Sod. bicarb., $NaHCO_3$	1780.8
Total			4507.2

Properties of Reaction in Percent

Primary salinity	37.16	Primary alkalinity	35.82
Secondary salinity	....	Secondary alkalinity	27.02
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 14.0. Temperature, °F, 57.4.
Curies Ra Emanation per liter x 10^{-10}, Water, 1.03.
Mache Units per liter, Water, 0.29.
Permanent Activity, Grams Ra per liter, x 10^{-10}, Trace.

NUMBER 201

CLEAR SPRING

Location—100 yds. below Bubbling Spring, Siloam.

Rate of Flow—1 gal. per min. Temperature—60° F.

Class of Water—Sodic, calcic, bicarbonated, muriated, alkaline-saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	48.4	......
Sulphate	SO_4	96.1	2.97
Bicarbonate	HCO_3	1257.3	30.61
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	391.9	16.42
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	164.5	12.18
Magnesium	Mg	36.92	4.51
Potassium	K	5.7	.22
Sodium	Na	512.2	33.09
Lithium	Li	Trace	......
	Total	2513.02	100.00

Concentration value	67.32	Excess carbon dioxide	453.4
Hydrogen sulphide, H_2S	None	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	2080
Strontium, Sr	....	Oxygen consuming capacity	1.21

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	665.2
Pot. chlor., KCl	10.87	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	637.6	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	142.1	Silica, SiO_2	48.4
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	222.15
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	786.8
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			2513.12

Properties of Reaction in Percent

Primary salinity	38.78	Primary alkalinity	27.84
Secondary salinity	....	Secondary alkalinity	33.38
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 202

IRON SPRING

Location—Siloam.

Rate of Flow—¼ to ½ gal. per min. Temperature—64° F.

Class of Water—Sodic, calcic, bicarbonated, muriated, alkaline-saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	35.6	......
Sulphate	SO_4	12.01	.83
Bicarbonate	HCO_3	623.9	34.16
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	159.1	15.01
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide Aluminum oxide	Fe_2O_3 Al_2O_3	Trace	......
Manganese	Mn	None	......
Calcium	Ca	96.95	16.17
Magnesium	Mg	22.66	6.22
Potassium	K	19.5	1.64
Sodium	Na	178.6	25.97
Lithium	Li	Trace	......
	Total	1148.32	100.00

Concentration value	29.92	Excess carbon dioxide	225.0
Hydrogen sulphide, H_2S	None	Iron precipitated	1.03
Arsenic, As	....	Evaporation solids	955
Strontium, Sr	....	Oxygen consuming capacity	4.15

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	392.03
Pot. chlor., KCl	37.18	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	233.15	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	17.76	Silica, SiO_2	35.6
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	136.3
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	296.3
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			1148.32

Properties of Reaction in Percent

Primary salinity	31.68	Primary alkalinity	23.54
Secondary salinity	....	Secondary alkalinity	44.78
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 203

MOUND SPRING.

Location—50 yds. up hill from Iron Spring, Siloam.

Class of Water—Sodic, bicarbonated, muriated, alkaline-saline, potassic, magnesic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	103.9	......
Sulphate	SO_4	140.8	2.97
Bicarbonate	HCO_3	1945.1	32.17
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	521.5	14.86
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	177.2	8.92
Magnesium	Mg	63.03	5.24
Potassium	K	91.7	2.37
Sodium	Na	762.5	33.47
Lithium	Li	Trace	......
	Total	3805.73	100.00

Concentration value	99.10	Excess carbon dioxide	701.4
Hydrogen sulphide, H_2S	None	Iron precipitated	3.29
Arsenic, As	....	Evaporation solids	2900
Strontium, Sr	....	Oxygen consuming capacity.	0.23

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	716.5
Pot. chlor., KCl	174.9	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	722.65	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	208.2	Silica, SiO_2	103.9
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	379.3
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1500.4
Ferrous bicarb., $Fe(HCO_3)_2$	Trace		
Total			3805.85

Properties of Reaction in Percent

Primary salinity	35.66	Primary alkalinity	36.02
Secondary salinity	....	Secondary alkalinity	28.32
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 20.5. Temperature, °F, 69.0.

Curies Ra Emanation per liter x 10^{-10}, Water, 11.86.

Mache Units per liter, Water, 3.20.

Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

NUMBER 204

WATSON ARTESIAN WELL

Location—1 mile south and ½ mile east of Siloam post office.

Rate of Flow—200 gal. per min. Temperature—72° F.

Class of Water—Sodic, calcic, bicarbonated, sulphated, alkaline-saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	20.2	......
Sulphate	SO_4	340.9	10.32
Bicarbonate	HCO_3	1168.7	27.85
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	288.7	11.83
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	143.5	10.42
Magnesium	Mg	40.63	4.88
Potassium	K	37.0	1.38
Sodium	Na	527.1	33.32
Lithium	Li	Trace	......
	Total	2567.13	100.00

Concentration value	68.80	Excess carbon dioxide	421.4
Hydrogen sulphide, H_2S	None	Iron precipitated	0.52
Arsenic, As	....	Evaporation solids	2035
Strontium, Sr	....	Oxygen consuming capacity.	1.35

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	580.3
Pot. chlor., KCl	70.56	Iron and aluminum oxides,	
Sod. chlor., NaCl	420.6	Fe_2O_3, Al_2O_3	.....
Sod. sulph., Na_2SO_4	503.8	Calc. silicate, $CaSiO_3$	.....
Mag. sulph., $MgSO_4$	.....	Silica, SiO_2	20.2
Calc. sulph., $CaSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	244.5
Ferrous bicarb., $Fe(HCO_3)_2$	Trace	Sod. bicarb., $NaHCO_3$	727.2
Total			2567.16

Properties of Reaction in Percent

Primary salinity	44.30	Primary alkalinity	25.10
Secondary salinity	....	Secondary alkalinity	30.60
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 205

IRON SPRING

Location—4 miles up Mineral Creek.

Rate of Flow— Temperature—58° F.

Class of Water—Calcic, ferruginous, sulphated, saline, (silicious).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	38.2	......
Sulphate	SO_4	108.5	38.97
Bicarbonate	HCO_3	27.5	7.75
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	6.8	3.28
Iron	Fe	......	7.75
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	18	
Aluminum oxide	Al_2O_3		......
Manganese	Mn	None	......
Calcium	Ca	29.7	25.53
Magnesium	Mg	5.8	8.27
Potassium	K	7.5	3.28
Sodium	Na	6.9	5.17
Lithium	Li	None	......
		248.9	100.06
Oxygen in Fe_2O_3		5.4	
	Total	243.5	

Concentration value	5.80	Excess carbon dioxide	9.9
Hydrogen sulphide, H_2S	None	Iron precipitated	48.25
Arsenic, As	....	Evaporation solids	243
Strontium, Sr	....	Oxygen consuming capacity	2.63

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	.....	Calc. bicarb., $Ca(HCO_3)_2$	.....
Pot. chlor., KCl	14.3	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	.....	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	21.3	Silica, SiO_2	38.2
Mag. sulph., $MgSO_4$	28.7	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	100.9	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	40.1		
Total			243.5

Properties of Reaction in Percent

Primary salinity	16.90	Primary alkalinity	....
Secondary salinity	67.60	Secondary alkalinity	....
Tertiary salinity	....	Tertiary alkalinity	15.50

NUMBER 206

SOUTH FORK SPRING

Location—5 mi. up S. fork of Rio Grande.

Rate of Flow—8 to 10 gal. per min. Temperature—66° F.

Class of Water—Sodic, bicarbonated, alkaline, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	50.8	......
Sulphate	SO_4	10.2	2.12
Bicarbonate	HCO_3	231.4	38.20
Carbonate	CO_3	Trace	......
Phosphate	PO_4	Trace	......
Chloride	Cl	34.2	9.68
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide Aluminum oxide	Fe_2O_3 Al_2O_3	1.2	......
Manganese	Mn	None	......
Calcium	Ca	3.6	1.81
Magnesium	Mg	2.6	2.12
Potassium	K	3	.71
Sodium	Na	103.5	45.36
Lithium	Li	None	......
	Total	440.5	100.00

Concentration value	9.92	Excess carbon dioxide	83.4
Hydrogen sulphide, H_2S	1.26	Iron precipitated	None
Arsenic, As	....	Evaporation solids	348
Strontium, Sr	....	Oxygen consuming capacity.	1.07

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	14.6
Pot. chlor., KCl	5.7	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	1.2
Sod. chlor., NaCl	51.9	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	15.1	Silica, SiO_2	50.8
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	-.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	15.6
Calc. carb., $CaCO_3$	Trace	Sod. bicarb., $NaHCO_3$	285.6
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			440.5

Properties of Reaction in Percent

Primary salinity	23.60	Primary alkalinity	68.54
Secondary salinity	....	Secondary alkalinity	7.86
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 20.0. Temperature, °F, 68.0.
Curies Ra Emanation per liter x 10^{-10}, Water, 2.64.
Mache Units per liter, Water, 0.71.

NUMBER 207

TILE SPRING, EASTERN

Rate of Flow—1½ gal. per min. Temperature—59° F.

Class of Water—Sodic, calcic, bicarbonated, sulphated, alkaline-saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	89	......
Sulphate	SO_4	1437	28.54
Bicarbonate	HCO_3	1046.8	16.37
Silicate	SiO_3	......	2.80
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	85.58	2.29
Iron	Fe	......	.10
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	4.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	......	......
Calcium	Ca	437.1	20.83
Magnesium	Mg	38.1	2.99
Potassium	K	65.25	1.59
Sodium	Na	591.9	24.49
Lithium	Li	None	......
Oxygen to form SiO_3		23.6	......
		3818.33	
Oxygen in Fe_2O_3		1.2	
	Total	3817.13	

Concentration value	104.90	Excess carbon dioxide	377.5
Hydrogen sulphide, H_2S	None	Iron precipitated	....
Arsenic, As	....	Evaporation solids	3253
Strontium, Sr	....	Oxygen consuming capacity	0.72

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	1382.6
Pot. chlor., KCl	124.5	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	43.4	Calc. silicate, $CaSiO_3$	171.8
Sod. sulph., Na_2SO_4	1775.2	Silica, SiO_2	.....
Mag. sulph., $MgSO_4$	188.6	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	122.0	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	8.9		
Total			3817.0

Properties of Reaction in Percent

Primary salinity	52.16	Primary alkalinity	38.34
Secondary salinity	9.50	Secondary alkalinity	....
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 14.5. Temperature, °F, 58.1.

Curies Ra Emanation per liter x 10^{-10}, Water, 305.5; Gas, 2725.0.

Mache Units per liter, Water, 82.5; Gas, 735.8.

Permanent Activity, Grams Ra per liter, x 10^{-10}, Trace.

NUMBER 208

SPRINGDALE TUNNEL SPRING

Class of Water—Sodic, calcic, bicarbonated, sulphated, alkaline-saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	89.7	......
Sulphate	SO_4	1541	28.25
Bicarbonate	HCO_3	1175.1	16.92
Silicate	SiO_3	......	2.62
Carbonate	CO_3	None	......
Phosphate	PO_4	......	......
Chloride	Cl	88.71	2.21
Iron	Fe	......	.09
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	4.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	......	......
Calcium	Ca	462.4	20.31
Magnesium	Mg	41.2	3.00
Potassium	K	60.34	1.35
Sodium	Na	660.6	25.25
Lithium	Li	None	......
Oxygen to form SiO_3		23.8	......
		4146.85	100.00
Oxygen in Fe_2O_3		1.2	
	Total	4145.65	

Concentration value	113.70	Excess carbon dioxide	423.8
Hydrogen sulphide, H_2S	None	Iron precipitated	....
Arsenic, As	....	Evaporation solids	3501
Strontium, Sr	....	Oxygen consuming capacity.	2.7

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	.....	Calc. bicarb., $Ca(HCO_3)_2$	1553.1
Pot. chlor., KCl	115	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	56.1	Calc. silicate, $CaSiO_3$	173.1
Sod. sulph., Na_2SO_4	1972.1	Silica, SiO_2	.....
Mag. sulph., $MgSO_4$	203.95	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	63.4	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	8.9		
Total			4145.65

Properties of Reaction in Percent

Primary salinity	53.20	Primary alkalinity	....
Secondary salinity	7.72	Secondary alkalinity	39.08
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 12.5. Temperature, °F, 54.6.
Curies Ra Emanation per liter x 10^{-10}, Water, 108.3.
Mache Units per liter, Water, 29.25.
Permanent Activity, Grams Ra per liter, x 10^{-10}, 0.28.

NUMBER 209

SPRINGDALE BATH SPRING

Class of Water—Sodic, calcic, ferruginous, bicarbonated, sulphated, alkaline-saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	91.9	......
Sulphate	SO_4	1576	28.36
Bicarbonate	HCO_3	1171.4	16.59
Silicate	SiO_3	......	2.63
Carbonate	CO_3	None	......
Phosphate	PO_4	......	......
Chloride	Cl	99.14	2.42
Iron	Fe	......	.20
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	9.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	......	......
Calcium	Ca	473.4	20.43
Magnesium	Mg	42.5	3.02
Potassium	K	79.3	1.75
Sodium	Na	655.3	24.60
Lithium	Li	None	......
Oxygen to form SiO_3		24.4	......
		4222.34	100.00
Oxygen in Fe_2O_3		2.7	
	Total	4219.64	

Concentration value	115.76	Hydrogen sulphide, H_2S	None
Excess carbon dioxide	422.5	Arsenic, As	....
Evaporation solids	3582	Strontium, Sr	....
Oxygen consuming capacity.	0.96	Iron precipitated	....

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	.....	Calc. bicarb., $Ca(HCO_3)_2$	1538.1
Pot. chlor., KCl	151.3	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	44.7	Calc. silicate, $CaSiO_3$	177.4
Sod. sulph., Na_2SO_4	1969.6	Silica, SiO_2	.....
Mag. sulph., $MgSO_4$	210.4	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	108.1	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	20		

Total 4219.6

Properties of Reaction in Percent

Primary salinity	52.70	Primary alkalinity	....
Secondary salinity	8.86	Secondary alkalinity	38.44
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 14.0. Temperature, °F, 57.4.

Curies Ra Emanation per liter x 10^{-10}, Water, 138.4.

Mache Units per liter, Water, 37.37.

Permanent Activity, Grams Ra per liter, x 10^{-10}, 0.283.

NUMBER 210

WELL SPRING, WESTERN

Rate of Flow—1½ gal. per min. Temperature—58° F.

Class of Water—Sodic, calcic, bicarbonated, sulphated, alkaline-saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	82.2	......
Sulphate	SO_4	1276	28.05
Bicarbonate	HCO_3	975.7	16.89
Silicate	SiO_3	......	2.88
Carbonate	CO_3	None	......
Phosphate	PO_4	......	......
Chloride	Cl	73	2.18
Iron	Fe	......	.19
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	7.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	......	......
Calcium	Ca	387.5	20.42
Magnesium	Mg	33.4	2.91
Potassium	K	34.7	.94
Sodium	Na	556	25.54
Lithium	Li	None	......
Oxygen to form SiO_3		21.8	......
		3447.3	100.00
Oxygen in Fe_2O_3		2.1	
	Total	3445.2	

Concentration value	94.68	Excess carbon dioxide	351.9
Hydrogen sulphide, H_2S	None	Iron precipitated	....
Arsenic, As	....	Evaporation solids	2958
Strontium, Sr	....	Oxygen consuming capacity.	0.91

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	.....	Calc. bicarb., $Ca(HCO_3)_2$	1282.1
Pot. chlor., KCl	67.3	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	66.6	Calc. silicate, $CaSiO_3$	158.7
Sod. sulph., Na_2SO_4	1636.3	Silica, SiO_2	.....
Mag. sulph., $MgSO_4$	165.3	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	53.3	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	15.6		
Total			3445.2

Properties of Reaction in Percent

Primary salinity	52.96	Primary alkalinity	....
Secondary salinity	7.50	Secondary alkalinity	39.54
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 15.5. Temperature, °F, 60.0.

Curies Ra Emanation per liter x 10^{-10}, Water, 97.03; Gas, 614.8.

Mache Units per liter, Water, 26.2; Gas, 166.0.

Permanent Activity, Grams Ra per liter, x 10^{-10}, 0.233.

NUMBER 211

MACALSO LITHIA AND MAGNESIA SPRING

Location—Steamboat Springs, Colo.

Class of Water—Sodic, bicarbonated, muriated, alkaline-saline, ferruginous, potassic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	84.8	......
Sulphate	SO_4	485.6	4.99
Bicarbonate	HCO_3	3252.8	26.28
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	1345.5	18.73
Iron	Fe	......	.07
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	5.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	112.76	2.77
Magnesium	Mg	31.9	1.29
Potassium	K	155	1.96
Sodium	Na	2047.5	43.91
Lithium	Li	Trace	......
		7521.36	100.00
Oxygen in Fe_2O_3		1.65	
	Total	7519.71	

Concentration value	202.8	Excess carbon dioxide	1173
Hydrogen sulphide, H_2S	Trace	Iron precipitated	6.81
Arsenic, As	....	Evaporation solids	6059
Strontium, Sr	None	Oxygen consuming capacity.	2.24

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	Trace	Calc. bicarb., $Ca(HCO_3)_2$	455.96
Pot. chlor., KCl	295.6	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	1986.6	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	718.11	Silica, SiO_2	84.8
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	191.96
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	3774.5
Ferrous bicarb., $Fe(HCO_3)_2$	12.25		
Total			7519.78

Properties of Reaction in Percent

Primary salinity	47.44	Primary alkalinity	44.30
Secondary salinity	....	Secondary alkalinity	8.26
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 24.0. Temperature, °F, 75.2.

Curies Ra Emanation per liter x 10^{-10}, Water, Trace; Gas, Trace, 10.9.

Mache Units per liter, Water, Trace; Gas, Trace, 1.79.

NUMBER 212

BATH HOUSE SPRING

Location—Steamboat Springs, Colorado.

Rate of Flow—250 to 300 gal. Temperature—104° F.

Class of Water—Sodic, muriated, carbonated, saline.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	47.6	......
Sulphate	SO_4	141.37	10.13
Bicarbonate	HCO_3	100.18	5.65
Silicate	SiO_3	......	1.34
Carbonate	CO_3	11.73	1.34
Phosphate	PO_4	Trace	......
Chloride	Cl	323.93	31.54
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	2.25	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	20.96	3.58
Magnesium	Mg	Trace	......
Potassium	K	16.37	1.45
Sodium	Na	299.9	44.97
Lithium	Li	None	......
Oxygen to form SiO_3		3.13	......
	Total	967.42	100.00

Concentration value	29.00	Excess carbon dioxide	36.13
Hydrogen sulphide, H_2S	Trace	Iron precipitated	None
Arsenic, As	....	Evaporation solids	884
Strontium, Sr	None	Oxygen consuming capacity	None

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	None	Calc. bicarb., $Ca(HCO_3)_2$	53.04
Pot. chlor., KCl	31.22	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	2.25
Sod. chlor., NaCl	509.6	Calc. silicate, $CaSiO_3$	22.76
Sod. sulph., Na_2SO_4	209.06	Silica, SiO_2	35.81
Mag. sulph., $MgSO_4$	Trace	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	82.98
Ferrous bicarb., $Fe(HCO_3)_2$	.....	Sod. carb., Na_2CO_3	20.72
Total			967.44

Properties of Reaction in Percent

Primary salinity	83.34	Primary alkalinity	9.50
Secondary salinity	....	Secondary alkalinity	7.16
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 39.5, 39.5; °F, 103.0.

Curies Ra Emanation per liter x 10^{-10}, Water, 1.2; Gas, 13.35, 7.9.

Mache Units per liter, Water, 0.21; Gas, 3.61, 1.31.

Remarks—Schlundt.

NUMBER 213

HERON SPRING

Location—Steamboat Springs, Colo.

Class of Water—Sodic, bicarbonated, muriated, alkaline-saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	18.1	......
Sulphate	SO_4	214.8	4.85
Bicarbonate	HCO_3	1760	31.20
Silicate	SiO_3	......	.66
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	435.8	13.29
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	5.0	
Aluminum oxide	Al_2O_3		......
Manganese	Mn	None	......
Calcium	Ca	176.43	9.52
Magnesium	Mg	55.27	4.93
Potassium	K	52.62	1.46
Sodium	Na	724.35	34.09
Lithium	Li	None	......
Oxygen to form SiO_3		4.80	......
	Total	3447.67	100.00

Concentration value	92.40	Excess carbon dioxide	634.64
Hydrogen sulphide, H_2S	None	Iron precipitated	1.41
Arsenic, As	....	Evaporation solids	2556
Strontium, Sr	None	Oxygen consuming capacity	None

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Fe(HCO_3)_2$	666.7
Pot. chlor., KCl	100.34	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	5.0
Sod. chlor., NaCl	639.8	Calc. silicate, $CaSiO_3$	34.93
Sod. sulph., Na_2SO_4	317.6	Silica, SiO_2	.....
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	-.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	332.6
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1350.7
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			3447.67

Properties of Reaction in Percent

Primary salinity	36.28	Primary alkalinity	34.82
Secondary salinity	....	Secondary alkalinity	28.90
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 24.0, 23.8. Temperature, °F, 75.2.

Curies Ra Emanation per liter x 10^{-10}, Water, 9.05, 14.3; Gas, 35.0, 51.5.

Mache Units per liter, Water, 2.44, 2.39; Gas, 9.45, 9.05.

Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

Remarks—Schlundt.

NUMBER 214

BUBBLING SPRING

Location—Steamboat Springs, Colorado.

Rate of Flow—65 to 70 gal. Temperature—75° F.

Class of Water—Sodic, bicarbonated, muriated, alkaline-saline, ferruginous, (sulphuretted, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	22.2	......
Sulphate	SO_4	551.9	5.81
Bicarbonate	HCO_3	3135.16	25.90
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	1285.7	18.29
Iron	Fe	......	.06
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	4.75	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	140.83	3.54
Magnesium	Mg	36.05	1.50
Potassium	K	22.0	.29
Sodium	Na	2034.75	44.61
Lithium	Li	None	......
		7233.34	100.00
Oxygen in Fe_2O_3		1.43	
	Total	7231.91	

Concentration value	198.3	Excess carbon dioxide	1130.5
Hydrogen sulphide, H_2S	14.71	Iron precipitated	None
Arsenic, As	....	Evaporation solids	5494
Strontium, Sr	None	Oxygen consuming capacity.	0.18

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	569.5
Pot. chlor., KCl	41.95	Iron and aluminum oxides,	
Sod. chlor., NaCl	2086.8	Fe_2O_3, Al_2O_3	.....
Sod. sulph., Na_2SO_4	816.15	Calc. silicate, $CaSiO_3$	.....
Mag. sulph., $MgSO_4$	.....	Silica, SiO_2	22.2
Calc. sulph., $CaSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	216.9
Ferrous bicarb., $Fe(HCO_3)_2$	10.58	Sod. bicarb.. $NaHCO_3$	3468.0
Total			7232.08

Properties of Reaction in Percent

Primary salinity	48.20	Primary alkalinity	41.60
Secondary salinity	....	Secondary alkalinity	10.20
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 23.5. Temperature, °F, 74.3.
Curies Ra Emanation per liter x 10^{-10}, Gas, 63.25.
Mache Units per liter, Gas, 17.08.

NUMBER 215

HOT SPRING

Location—8 mi. N. of Steamboat Springs.

Rate of Flow—30 to 35 gal. per min. 12 to 15 gal. per min.
80 to 100 gal. per min. Temperature—148° F.

Class of Water—Sodic, muriated, carbonated, alkaline-saline.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	88.4	......
Sulphate	SO_4	43.51	5.91
Bicarbonate	HCO_3	140.7	14.93
Silicate	SiO_3	......	3.12
Carbonate	CO_3	4.69	.97
Phosphate	PO_4	None	......
Chloride	Cl	136.92	25.07
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	2.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	7.58	2.40
Magnesium	Mg	None	......
Potassium	K	11.14	1.82
Sodium	Na	162.2	45.78
Lithium	Li	None	......
Oxygen to form SiO_3		3.88	......
	Total	601.52	100.00

Concentration value	15.40	Excess carbon dioxide	50.74
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	552
Strontium, Sr	None	Oxygen consuming capacity	0.47

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Iron and aluminum oxides,	
Pot. chlor., KCl	21.24	Fe_2O_3, Al_2O_3	2.5
Sod. chlor., NaCl	209.1	Calc. silicate, $CaSiO_3$	22.01
Sod. sulph., Na_2SO_4	64.34	Silica, SiO_2	73.76
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	193.74
Ferrous bicarb., $Fe(HCO_3)_2$	.....	Sod. carb., Na_2CO_3	8.29
Calc. bicarb., $Ca(HCO_3)_2$	.....	Sod. silicate, Na_2SiO_3	6.57
Total			601.55

Properties of Reaction in Percent

Primary salinity	61.96	Primary alkalinity	....
Secondary salinity	....	Secondary alkalinity	33.24
Tertiary salinity	....	Tertiary alkalinity	4.80

NUMBER 216

STEAMBOAT SPRING

Location—Steamboat Springs, Colorado.

Class of Water—Sodic, bicarbonated, muriated, alkaline-saline, potassic, (sulphuretted, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	23.2	......
Sulphate	SO_4	599.6	5.95
Bicarbonate	HCO_3	3184.2	24.87
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	1427.7	19.18
Iron	Fe	......	.09
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	7.25	
Aluminum oxide	Al_2O_3		......
Manganese	Mn	None	......
Calcium	Ca	121.4	2.92
Magnesium	Mg	28.78	1.11
Potassium	K	162.5	1.98
Sodium	Na	2120	43.90
Lithium	Li	Trace	......
		7674.63	100.00
Oxygen in Fe_2O_3		2.18	
	Total......	7672.45	

Concentration value	210.00	Excess carbon dioxide	1148.2
Hydrogen sulphide, H_2S	17.52	Iron precipitated	3.65
Arsenic, As	....	Evaporation solids	5870
Strontium, Sr	None	Oxygen consuming capacity.	3.88

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	490.9
Pot. chlor., KCl	309.9	Iron and aluminum oxides,	
Sod. chlor., NaCl	2110.9	Fe_2O_3, Al_2O_3	.....
Sod. sulph., Na_2SO_4	886.7	Calc. silicate, $CaSiO_3$	.....
Mag. sulph., $MgSO_4$	.....	Silica, SiO_2	23.2
Calc. sulph., $CaSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	173.2
Ferrous bicarb., $Fe(HCO_3)_2$	16.15	Sod. bicarb., $NaHCO_3$	3661.7
Total			7672.45

Properties of Reaction in Percent

Primary salinity	50.26	Primary alkalinity	41.50
Secondary salinity	....	Secondary alkalinity	8.24
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Curies Ra Emanation per liter x 10^{-10}, Gas, 2.39.
Mache Units per liter, Gas, 0.65.

NUMBER 217

CRAWFORD SPRING

Location—Steamboat Springs, Colo.

Class of Water—Sodic, bicarbonated, muriated, alkaline-saline, (carbon-dioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	29.9	......
Sulphate	SO_4	546.3	5.59
Bicarbonate	HCO_3	3267.1	26.27
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	1310.8	18.14
Iron	Fe	......	.03
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	2.75	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	130.66	3.20
Magnesium	Mg	35.83	1.45
Potassium	K	124.5	1.57
Sodium	Na	2051	43.75
Lithium	Li	Trace	......
		7498.84	100.00
Oxygen in Fe_2O_3		.83	
	Total	7498.01	

Concentration value	203.8	Excess carbon dioxide	1178.7
Hydrogen sulphide, H_2S	19.37	Iron precipitated	0.59
Arsenic, As	....	Evaporation solids	5869
Strontium, Sr	None	Oxygen consuming capacity	13.99

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	528.4
Pot. chlor., KCl	237.4	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	1974.8	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	807.9	Silica, SiO_2	29.9
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	215.6
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	3697.7
Ferrous bicarb., $Fe(HCO_3)_2$	6.1		
Total			7497.8

Properties of Reaction in Percent

Primary salinity	47.46	Primary alkalinity	43.18
Secondary salinity	....	Secondary alkalinity	9.36
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 218

SODA SPRINGS

Location—Steamboat Springs, Colorado.

Rate of Flow— Temperature—59° F.

Class of Water—Sodic, bicarbonated, muriated, alkaline-saline, magnesic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	22.7	......
Sulphate	SO_4	229.6	5.18
Bicarbonate	HCO_3	1736	30.84
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	457.5	13.98
Iron	Fe	......	.06
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	2.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	192.93	10.43
Magnesium	Mg	54.40	4.84
Potassium	K	73	2.03
Sodium	Na	692.5	32.64
Lithium	Li	None	......
		3461.13	100.00
Oxygen in Fe_2O_3		.75	
	Total	3460.48	

Concentration value	92.26	Excess carbon dioxide	624.6
Hydrogen sulphide, H_2S	None	Iron precipitated	2.11
Arsenic, As	....	Evaporation solids	2274
Strontium, Sr	None	Oxygen consuming capacity	3.31

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	780.1
Pot. chlor., KCl	139.2	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	645.1	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	339.5	Silica, SiO_2	22.7
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	327.3
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	1201.0
Ferrous bicarb., $Fe(HCO_3)_2$	5.57		
Total			3460.47

Properties of Reaction in Percent

Primary salinity	38.32	Primary alkalinity	31.02
Secondary salinity	....	Secondary alkalinity	30.66
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 15.0, 14.8. Temperature, °F, 59.1.

Curies Ra·Emanation per liter x 10^{-10}, Water, 13.58, 2.55; Gas, 60.30, 20.5.

Mache Units per liter, Water, 3.67, 0.43; Gas, 16.28, 3.46.

Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

Remarks—Schlundt.

NUMBER 219

MAGNESIUM SPRING

Location—Steamboat Springs, Colorado.

Class of Water—Sodic, bicarbonated, muriated, sulphated, alkaline-saline, potassic, ferruginous, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	32.0	......
Sulphate	SO_4	505.0	6.20
Bicarbonate	HCO_3	2623.2	25.38
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	1107.0	18.42
Iron	Fe	......	.08
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	5.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	93.52	2.75
Magnesium	Mg	25.12	1.22
Potassium	K	100.6	1.52
Sodium	Na	1731.6	44.43
Lithium	Li	Trace	......
		6223.5	100.00
Oxygen in Fe_2O_3		1.6	
	Total	6221.9	

Concentration value	169.48	Excess carbon dioxide	945.9
Hydrogen sulphide, H_2S	24.19	Iron precipitated	1.06
Arsenic, As	....	Evaporation solids	5114
Strontium, Sr	None	Oxygen consuming capacity.	1.73

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	378.2
Pot. chlor., KCl	191.8	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	1674.6	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	746.8	Silica, SiO_2	32.0
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	151.6
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	3035.2
Ferrous bicarb., $Fe(HCO_3)_2$	12.2		
Total			6222.4

Properties of Reaction in Percent

Primary salinity	49.24	Primary alkalinity	42.66
Secondary salinity	....	Secondary alkalinity	8.10
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 220

MOFFAT SPRING

Location—Steamboat Springs, Colorado.

Class of Water—Sodic, bicarbonated, muriated, sulphated, alkaline-saline, potassic, ferruginous, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	25.3	......
Sulphate	SO_4	591.7	5.83
Bicarbonate	HCO_3	3263.6	25.24
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	1421	18.93
Iron	Fe	......	.05
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	3.75	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	111.7	2.64
Magnesium	Mg	31.79	1.24
Potassium	K	124.0	1.50
Sodium	Na	2172.0	44.57
Lithium	Li	Trace	......
		7744.84	100.00
Oxygen in Fe_2O_3		1.1	
	Total	7743.74	

Concentration value	211.84	Excess carbon dioxide	1177
Hydrogen sulphide, H_2S	16.30	Iron precipitated	0.94
Arsenic, As	....	Evaporation solids	5896
Strontium, Sr	None	Oxygen consuming capacity.	1.73

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	451.7
Pot. chlor., KCl	236.4	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	2157.4	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	875.0	Silica, SiO_2	25.3
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	191.3
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	3798.3
Ferrous bicarb., $Fe(HCO_3)_2$	8.3		
Total			7743.7

Properties of Reaction in Percent

Primary salinity	49.52	Primary alkalinity	42.62
Secondary salinity	....	Secondary alkalinity	7.86
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 221

SECOND SPRING

Location—Above Steamboat Spring, Steamboat Springs.

Rate of Flow—15 gal. Temperature—80° F.

Class of Water—Sodic, bicarbonated, muriated, sulphated, alkaline-saline, potassic, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	24.6	......
Sulphate	SO_4	583.8	5.61
Bicarbonate	HCO_3	3388.2	25.67
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	1436	18.72
Iron	Fe	......	.04
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	3.25	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	116.0	2.67
Magnesium	Mg	32.11	1.22
Potassium	K	157.5	1.86
Sodium	Na	2200	44.21
Lithium	Li	Trace	......
		7941.46	100.00
Oxygen in Fe_2O_3		0.98	
	Total	7940.48	

Concentration value	216.36	Excess carbon dioxide	1221.8
Hydrogen sulphide, H_2S	24.54	Iron precipitated	0.83
Arsenic, As	....	Evaporation solids	6183
Strontium, Sr	None	Oxygen consuming capacity.	2.55

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	469.1
Pot. chlor., KCl	300.3	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	2132.0	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	863.3	Silica, SiO_2	24.6
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	193.2
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	3951.0
Ferrous bicarb., $Fe(HCO_3)_2$	7.24		
Total			7940.74

Properties of Reaction in Percent

Primary salinity	48.66	Primary alkalinity	43.48
Secondary salinity	....	Secondary alkalinity	7.86
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 222

RUMBLING SPRING

Location—Steamboat Springs.

Rate of Flow— Temperature—77° F.

Class of Water—Sodic, bicarbonated, muriated, sulphated, alkaline-saline, ferruginous, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	29.2	......
Sulphate	SO_4	569.9	5.90
Bicarbonate	HCO_3	2991.6	24.39
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	1406	19.71
Iron	Fe	......	.05
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	4.25	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	109	2.71
Magnesium	Mg	26.76	1.09
Potassium	K	35.0	.45
Sodium	Na	2114	45.70
Lithium	Li	Trace	......
		7285.7	100.00
Oxygen in Fe_2O_3		1.3	
	Total	7284.4	

Concentration value	201.12	Excess carbon dioxide	1078.8
Hydrogen sulphide, H_2S	27.91	Iron precipitated	0.83
Arsenic, As	....	Evaporation solids	5881
Strontium, Sr	None	Oxygen consuming capacity	0.27

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	Trace	Calc. bicarb., $Ca(HCO_3)_2$	440.8
Pot. chlor., KCl	66.7	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	2265.7	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	842.8	Silica, SiO_2	29.2
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	161.0
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	3469.0
Ferrous bicarb., $Fe(HCO_3)_2$	9.5		
Total			7284.7

Properties of Reaction in Percent

Primary salinity	51.22	Primary alkalinity	41.08
Secondary salinity	....	Secondary alkalinity	7.70
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 24.5. Temperature, °F, 76.1.
Curies Ra Emanation per liter x 10^{-10}, Gas, 3.29.
Mache Units per liter, Gas, 0.89.

NUMBER 223

STEAMBOAT NAVAJO SPRING

Radioactivity

Temperature, °C, 13.5, 13.0. Temperature, °F, 56.3

Curies Ra Emanation per liter x 10^{-10}, Water, 1.64, 1.9.

Mache Units per liter, Water, 0.44, 0.32.

Remarks—Schlundt.

NUMBER 224

STEAMBOAT, LITTLE STEAMBOAT

Location—35 yds. S. W. of Cave Spring Hill Side.

Radioactivity

Curies Ra Emanation per liter x 10^{-10}, Gas, 25.58.

Mache Units per liter, Gas, 6.91.

NUMBER 225

ARTESIAN WELL

Location—Swallows, Colo.

Class of Water—Sodic, ferruginous, bicarbonated, alkaline, magnesic, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	13	......
Sulphate	SO_4	102.3	4.62
Bicarbonate	HCO_3	1064.5	38.02
Carbonate	CO_3	None	......
Phosphate	PO_4	......	......
Chloride	Cl	120	17.36
Iron	Fe	......	.26
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	4.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	......	......
Calcium	Ca	34.4	3.72
Magnesium	Mg	66.85	11.97
Potassium	K	46.1	2.57
Sodium	Na	332.5	31.48
Lithium	Li	None	......
		1784.15	100.00
Oxygen in Fe_2O_3		1.35	
	Total	1782.8	

Concentration value	45.90	Excess carbon dioxide	383.9
Hydrogen sulphide, H_2S	None	Iron precipitated	....
Arsenic, As	....	Evaporation solids	1289
Strontium, Sr	....	Oxygen consuming capacity.	11.33

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	None	Calc. bicarb., $Ca(HCO_3)_2$	139.1
Pot. chlor., KCl	87.9	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	128.9	Calc. silicate, $CaSiO_3$	.....
Sod. sulphate, Na_2SO_4	151.3	Silica, SiO_2	13
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	402.3
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	850.3
Ferrous bicarb., $Fe(HCO_3)_2$	10		
Total			1782.8

Properties of Reaction in Percent

Primary salinity	23.96	Primary alkalinity	44.14
Secondary salinity	....	Secondary alkalinity	31.38
Tertiary salinity	....	Tertiary alkalinity	.52

Radioactivity

Temperature, °C, 21.0. Temperature, °F, 69.9.
Curies Ra Emanation per liter x 10^{-10}, Water, 2.62.
Mache Units per liter, Water, 0.71.

NUMBER 227

IRON SPRING

Location—¾ mi. S. of Symons, Colo.

Rate of Flow—1 gal. per min. Temperature—59° F.

Class of Water—Calcic, magnesic, sulphated, saline, (ferruginous, carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	8.0	......
Sulphate	SO_4	850.3	38.72
Bicarbonate	HCO_3	264.7	9.47
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	29.46	1.81
Iron	Fe	......	.33
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	6.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	264.56	28.85
Magnesium	Mg	75.91	13.64
Potassium	K	6.0	.33
Sodium	Na	71.9	6.85
Lithium	Li	None	......
		1576.83	100.00
Oxygen in Fe_2O_3		1.8	
	Total......	1575.03	

Concentration value	45.74	Excess carbon dioxide	95.45
Hydrogen sulphide, H_2S	None	Iron precipitated	15.03
Arsenic, As	....	Evaporation solids	1162
Strontium, Sr	....	Oxygen consuming capacity	0.55

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	339.5
Pot. chlor., KCl	11.44	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	39.60	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	173.94	Silica, SiO_2	8.0
Mag. sulph., $MgSO_4$	375.8	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	613.4	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	13.36		
Total			1575.54

Properties of Reaction in Percent

Primary salinity	14.36	Primary alkalinity	....
Secondary salinity	66.70	Secondary alkalinity	18.28
Tertiary salinity	....	Tertiary alkalinity	.66

NUMBER 228

IRON SPRING

Location—At stone house in Symons.

Rate of Flow—½ to ¾ gal. per min. Temperature—59° F.

Class of Water—Sodic, calcic, magnesic, saline, ferruginous.

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	11.5	......
Sulphate	SO_4	781.7	39.79
Bicarbonate	HCO_3	207.1	8.28
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	28.04	1.93
Iron	Fe	......	.10
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	1.75	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	160.62	19.60
Magnesium	Mg	67.52	13.57
Potassium	K	16.0	1.00
Sodium	Na	148.2	15.73
Lithium	Li	Trace	......
		1422.43	100.00
Oxygen in Fe_2O_3		0.53	
	Total	1421.9	

Concentration value	40.90	Excess carbon dioxide	74.81
Hydrogen sulphide, H_2S	None	Iron precipitated	3.42
Arsenic, As	....	Evaporation solids	1475
Strontium, Sr	....	Oxygen consuming capacity.	1.58

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., $LiCl$	Trace	Calc. bicarb., $Ca(HCO_3)_2$	271.6
Pot. chlor., KCl	30.5	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., $NaCl$	22.3	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	430.6	Silica, SiO_2	11.5
Mag. sulph., $MgSO_4$	334.2	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	317.3	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	3.9		
Total			1421.9

Properties of Reaction in Percent

Primary salinity	33.46	Primary alkalinity	....
Secondary salinity	49.98	Secondary alkalinity	16.56
Tertiary salinity	....	Tertiary alkalinity	....

NUMBER 229

WARM SPRING

Location—¾ mi. N. of Trimble.

Rate of Flow—50 to 60 gal. per min. Temperature—90° F.

Class of Water—Calcic, sodic, sulphated, saline, lithic, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	97.0	......
Sulphate	SO_4	1312	25.85
Bicarbonate	HCO_3	1121	......
Silicate	SiO_3	......	17.38
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	254	6.77
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	9.7	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	557.9	26.30
Magnesium	Mg	41.9	3.24
Potassium	K	165	3.98
Sodium	Na	395.5	16.26
Lithium	Li	1.6	.22
	Total	3955.6	100.00

Concentration value	105.74	Excess carbon dioxide	404.2
Hydrogen sulphide, H_2S	None	Iron precipitated	Trace
Arsenic, As	....	Evaporation solids	3450
Strontium, Sr	....	Oxygen consuming capacity	3.80

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	7.6	Calc. bicarb., $Ca(HCO_3)_2$	1489.3
Pot. chlor., KCl	314.6	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	9.7
Sod. chlor., NaCl	162.2	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	1024.5	Silica, SiO_2	97.0
Mag. sulph., $MgSO_4$	207.4	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	643.3	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			3955.6

Properties of Reaction in Percent

Primary salinity	40.92	Primary alkalinity	....
Secondary salinity	24.32	Secondary alkalinity	34.76
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 30.5. Temperature, °F, 86.9.

Curies Ra Emanation per liter x 10^{-10}, Water, 3.75.

Mache Units per liter, Water, 1.01.

NUMBER 230

TRIMBLE SPRING

Rate of Flow—150 to 200 gal. per min. Temperature—124° F.

Class of Water—Calcic, bicarbonated, sulphated, alkaline-saline, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	28.3	......
Sulphate	SO_4	611.6	30.50
Bicarbonate	HCO_3	498.2	19.50
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	None	......
Iron	Fe	......	.21
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	3.7	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	331.8	39.62
Magnesium	Mg	28.1	5.52
Potassium	K	12.5	.77
Sodium	Na	37.2	3.88
Lithium	Li	Trace	......
		1551.4	100.00
Oxygen in Fe_2O_3		1.2	
	Total	1550.2	

Concentration value	41.80	Excess carbon dioxide	179.6
Hydrogen sulphide, H_2S	None	Iron precipitated	2.76
Arsenic, As	....	Evaporation solids	1407
Strontium, Sr	....	Oxygen consuming capacity	40.5

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	654.3
Pot. chlor., KCl	.....	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	.....		
Sod. sulph., Na_2SO_4	114.9	Calc. silicate, $CaSiO_3$	.....
Mag. sulph., $MgSO_4$	139.1	Silica, SiO_2	28.3
Calc. sulph., $CaSO_4$	577.5	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	8.2	Sod. bicarb., $NaHCO_3$	.....
		Pot. sulph., K_2SO_4	27.9

Total 1550.2

Properties of Reaction in Percent

Primary salinity	9.30	Primary alkalinity	.....
Secondary salinity	51.70	Secondary alkalinity	39.00
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 49.5. Temperature, °F, 121.1.
Curies Ra Emanation per liter x 10^{-10}, Water, 5.14; Gas, 10.11.
Mache Units per liter, Water, 1.39; Gas, 2.73.

NUMBER 231

TRIMBLE

Location—N. Spring of Group near Hotel.

Radioactivity

Temperature, °C, 49.5. Temperature, °F, 121.1.
Curies Ra Emanation per liter x 10^{-10}, Gas, 12.03.
Mache Units per liter, Gas, 3.25.

NUMBER 232

BIG SULPHUR SPRING

Location—3½ mi. W. Thomasville.
Rate of Flow— Temperature—44° F.
Class of Water—Calcic, sulphated, saline, ferruginous, (sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	17.2	......
Sulphate	SO_4	1452	45.21
Bicarbonate	HCO_3	178.3	4.36
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	10.3	.43
Iron	Fe	......	.21
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	5.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	562.5	41.97
Magnesium	Mg	51.6	6.33
Potassium	K	Trace	......
Sodium	Na	23	1.49
Lithium	Li	None	......
		2300.4	100.00
Oxygen in Fe_2O_3		1.7	
	Total	2298.7	

Concentration value	66.90	Excess carbon dioxide	64.3
Hydrogen sulphide, H_2S	2.43	Iron precipitated	None
Arsenic, As	....	Evaporation solids	2290
Strontium, Sr	....	Oxygen consuming capacity.	0.68

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	225.6
Pot. chlor., KCl	Trace	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	17.0	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	50.3	Silica, SiO_2	17.2
Mag. sulph., $MgSO_4$	255.4	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	1720.9	Mag. bicarb., $Mg(HCO_3)_2$	.....
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	12.3		
Total			2298.7

Properties of Reaction in Percent

Primary salinity	15.64	Primary alkalinity	....
Secondary salinity	75.64	Secondary alkalinity	8.72
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 6.7. Temperature, °F, 44.0.
Curies Ra Emanation per liter x 10^{-10}, Water, 0.78.
Mache Units per liter, Water, 0.21.

NUMBER 233

SPRING

Rate of Flow— Temperature, 50° F.

Location—¼ mi. E. of No. 232, Thomasville.

Class of Water—Calcic, sulphated, saline, ferruginous, magnesic, (sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	14.8	......
Sulphate	SO_4	1405	45.60
Bicarbonate	HCO_3	160.4	4.10
Carbonate	CO_3	None	......
Phosphate	PO_4	None	......
Chloride	Cl	6.8	.30
Iron	Fe	......	.37
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	9.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	488.2	37.99
Magnesium	Mg	79.7	10.22
Potassium	K	Trace	......
Sodium	Na	20.9	1.42
Lithium	Li	None	......
		2185.3	100.00
Oxygen in Fe_2O_3		2.9	
	Total	2182.4	

Concentration value	64.16	Excess carbon dioxide	54
Hydrogen sulphide, H_2S	4.13	Iron precipitated	None
Arsenic, As	....	Evaporation solids	2181
Strontium, Sr	....	Oxygen consuming capacity	0.39

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	193.7
Pot. chlor., KCl	Trace	Iron and aluminum oxides,	
Sod. chlor., NaCl	11.2	Fe_2O_3, Al_2O_3	.....
Sod. sulph., Na_2SO_4	51.0	Calc. silicate, $CaSiO_3$	.....
Mag. sulph., $MgSO_4$	394.5	Silica, SiO_2	14.8
Calc. sulph., $CaSO_4$	1496.0	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	21.2	Sod. bicarb., $NaHCO_3$	.....

Total 2182.4

Properties of Reaction in Percent

Primary salinity	2.84	Primary alkalinity	....
Secondary salinity	88.96	Secondary alkalinity	7.46
Tertiary salinity	....	Tertiary alkalinity	.74

Radioactivity

Temperature, °C, 10.0. Temperature, °F, 50.0.
Curies Ra Emanation per liter x 10^{-10}, Water, 0.68.
Mache Units per liter, Water, 0.18.

NUMBER 234

BOILING SPRING

Location—Wagon Wheel Gap.

Rate of Flow—50 gal. per min. Temperature—132° F.

Class of Water—Sodic, potassic, bicarbonated, alkaline-saline, lithic, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	94.5	......
Sulphate	SO_4	210.0	7.20
Bicarbonate	HCO_3	1048	28.32
Silicate	SiO_3	......	4.96
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	205.2	9.52
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	Trace	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	67.9	5.58
Magnesium	Mg	17.6	2.41
Potassium	K	276.0	11.63
Sodium	Na	419.5	30.05
Lithium	Li	1.4	.33
Oxygen to form SiO_3		24.1	......
	Total	2364.2	100.00

Concentration value	60.70	Excess carbon dioxide	377.9
Hydrogen sulphide, H_2S	2.53	Iron precipitated	None
Arsenic, As	....	Evaporation solids	1796
Strontium, Sr	....	Oxygen consuming capacity.	1.75

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	8.3	Calc. bicarb., $Ca(HCO_3)_2$	30.8
Pot. chlor., KCl	416.9	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	.....		
Sod. sulph., Na_2SO_4	206.3	Calc. silicate, $CaSiO_3$	175.1
Mag. sulph., $MgSO_4$	.....	Silica, SiO_2	3.8
Calc. sulph., $CaSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. carb., $CaCO_3$	.....	Mag. bicarb., $Mg(HCO_3)_2$	105.9
Ferrous bicarb., $Fe(HCO_3)_2$	Trace	Sod. bicarb., $NaHCO_3$	1289.2
		Pot. sulph., K_2SO_4	127.9
Total			2364.2

Properties of Reaction in Percent

Primary salinity	33.44	Primary alkalinity	50.58
Secondary salinity	....	Secondary alkalinity	15.98
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 52.0. Temperature, °F, 125.7.
Curies Ra Emanation per liter x 10^{-10}, Gas, 15.76.
Mache Units per liter, Gas, 4.26.

NUMBER 235

HOT SALINE SPRING

Location—Wagon Wheel Gap.

Rate of Flow—6 to 8 gal. per min. Temperature—121° F.

Class of Water—Sodic, bicarbonated, muriated, alkaline-saline, lithic, ferruginous, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	75.2	......
Sulphate	SO_4	146.7	6.08
Bicarbonate	HCO_3	994.0	32.42
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	205.2	11.50
Iron	Fe	......	.60
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	12.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	72.6	7.20
Magnesium	Mg	18.9	3.08
Potassium	K	35.0	1.79
Sodium	Na	427.0	36.93
Lithium	Li	1.4	.40
		1988.0	100.00
Oxygen in Fe_2O_3		3.6	
	Total	1984.4	

Concentration value	50.28	Excess carbon dioxide	358.5
Hydrogen sulphide, H_2S	0.42	Iron precipitated	None
Arsenic, As	....	Evaporation solids	1497
Strontium, Sr	....	Oxygen consuming capacity.	1.75

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	8.3	Calc. bicarb., $Ca(HCO_3)_2$	293.6
Pot. chlor., KCl	66.7	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	274.6	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	216.9	Silica, SiO_2	75.2
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	113.7
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	908.7
Ferrous bicarb., $Fe(HCO_3)_2$	26.7		
Total			1984.4

Properties of Reaction in Percent

Primary salinity	35.16	Primary alkalinity	43.08
Secondary salinity	....	Secondary alkalinity	20.56
Tertiary salinity	....	Tertiary alkalinity	1.20

Radioactivity

Temperature, °C, 42.5. Temperature, 118.5.

Curies Ra Emanation per liter x 10^{-10}, Water, 2.28; Gas, 136.6.

Mache Units per liter, Water, 0.62; Gas, 36.88.

NUMBER 236

SPRING ACROSS FROM HOT SULPHUR SPRING

Location—Wagon Wheel Gap.

Rate of Flow—8 to 10 gal. per min. Temperature—125° F.

Class of Water—Sodic, ferruginous, bicarbonated, muriated, alkaline-saline, (carbondioxated, sulphuretted).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	87.7	......
Sulphate	SO_4	172.8	6.92
Bicarbonate	HCO_3	1014.1	31.96
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	205.2	11.12
Iron	Fe	......	.48
Aluminum	Al	......	......
Iron oxide Aluminum oxide	Fe_2O_3 Al_2O_3	10.0	......
Manganese	Mn	None	......
Calcium	Ca	72.2	6.92
Magnesium	Mg	17.6	2.79
Potassium	K	20	.98
Sodium	Na	464.5	38.83
Lithium	Li	Trace	......
		2064.1	100.00
Oxygen in Fe_2O_3		3.0	
	Total	2061.1	

Concentration value	52.00	Excess carbon dioxide	365.6
Hydrogen sulphide, H_2S	1.26	Iron precipitated	None
Arsenic, As	....	Evaporation solids	1601
Strontium, Sr	....	Oxygen consuming capacity	2.83

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Trace	Calc. bicarb., $Ca(HCO_3)_2$	292.0
Pot. chlor., KCl	38.1	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	308.5	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	255.5	Silica, SiO_2	87.7
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	105.9
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	951.1
Ferrous bicarb., $Fe(HCO_3)_2$	22.3		
Total			2061.1

Properties of Reaction in Percent

Primary salinity	36.08	Primary alkalinity	43.54
Secondary salinity	....	Secondary alkalinity	19.42
Tertiary salinity	....	Tertiary alkalinity	.96

Radioactivity

Temperature, °C, 39.5. Temperature, °F, 103.0.

Curies Ra Emanation per liter x 10^{-10}, Gas, 19.97.

Mache Units per liter, Gas, 5.39.

NUMBER 238

WAUNITA HOT SPRINGS

Location—Lower Spring ½ mi. from P. O. Garage Spring on S. Creek Bank.

Rate of Flow—10 to 15 gal. per min. Temperature—142° F.

Class of Water—Sodic, sulphated, alkaline-saline, (sulphuretted, siliceous).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	85.7	......
Sulphate	SO_4	179.2	24.84
Bicarbonate	HCO_3	174.7	18.98
Silicate	SiO_3	......	2.32
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	20.5	3.86
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	4.0	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	12.2	4.05
Magnesium	Mg	2.6	1.39
Potassium	K	15.0	2.52
Sodium	Na	145.5	42.04
Lithium	Li	None	......
Oxygen to form SiO_3		2.8	......
	Total	642.2	100.00

Concentration value	15.06	Excess carbon dioxide	63.0
Hydrogen sulphide, H_2S	0.40	Iron precipitated	None
Arsenic, As	....	Evaporation solids	556
Strontium, Sr	....	Oxygen consuming capacity	0.97

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	20.9
Pot. chlor., KCl	28.6	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	4.0
Sod. chlor., NaCl	11.4	Calc. silicate, $CaSiO_3$	20.3
Sod. sulph., Na_2SO_4	265.0	Silica, SiO_2	75.2
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	15.6
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	201.2
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			642.2

Properties of Reaction in Percent

Primary salinity	57.40	Primary alkalinity	31.72
Secondary salinity	....	Secondary alkalinity	10.88
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 64.0. Temperature, °F, 147.2.

Curies Ra Emanation per liter x 10^{-10}, Water, 10.69; Gas, 562.0.

Mache Units per liter, Water, 2.89; Gas, 151.7.

Permanent Activity, Grams Ra per liter, x 10^{-10}, None.

NUMBER 237

WAGON WHEEL GAP

Location—Small Spring beside boiling spring.

Radioactivity

Temperature, °C, 52.0. Temperature, °F, 125.7.
Curies Ra Emanation per liter x 10^{-10}, Gas, 111.8.
Mache Units per liter, Gas, 30.20.

NUMBER 239

HOTEL NO. 2 IN LOWER GROUP

Location—Waunita.

Radioactivity

Temperature, °C, 70.0. Temperature, °F, 158.0.
Curies Ra Emanation per liter x 10^{-10}, Water, 19.80; Gas, 956.8.
Mache Units per liter, Water, 5.35; Gas, 258.35.
Permanent Activity, Grams Ra per liter, x 10^{-10}, Trace.

NUMBER 240

HOTEL NO. 3 IN LOWER GROUP

Radioactivity

Temperature, °C, 68.5. Temperature, °F, 155.3.
Curies Ra Emanation per liter x 10^{-10}, Water, 19.54; Gas, 1155.0.
Mache Units per liter, Water, 5.29; Gas, 311.8.

NUMBER 241

HOTEL NO. 4 IN LOWER GROUP

Location—Waunita.

Radioactivity

Temperature, °C, 70.0. Temperature, °F, 158.0.
Curies Ra Emanation per liter x 10^{-10}, Water, 21.51; Gas, 1280.0.
Mache Units per liter, Water, 5.81; Gas, 345.6.
Permanent Activity, Grams Ra per liter, x 10^{-10}, Trace.

NUMBER 242

HOTEL NO. 5 IN LOWER GROUP

Location—Waunita.

Radioactivity

Temperature, °C, 71.0. Temperature, °F, 159.8.
Curies Ra Emanation per liter x 10^{-10}, Water, 27.94; Gas, 1147.0.
Mache Units per liter, Water, 7.54; Gas, 309.7.

NUMBER 243

HOTEL NO. 6, LOWER GROUP

Location—Waunita.

Radioactivity

Temperature, °C, 59.5. Temperature, °F, 139.1.
Curies Ra Emanation per liter x 10^{-10}, Water, 12.66; Gas, 690.9.
Mache Units per liter, Water, 3.42; Gas, 186.5.

NUMBER 244

HOTEL NO. 7, LOWER GROUP

Location—Waunita.

Radioactivity

Temperature, °C, 43.0. Temperature, °F, 109.4.
Curies Ra Emanation per liter x 10^{-10}, Water, 16.56.
Mache Units per liter, Water, 4.47.

NUMBER 245

WAUNITA HOT SPRINGS

Location—Lower Spring, S. bank of creek.

Rate of Flow—10 gal. per min. Temperature—158° F.

Class of Water—Sodic, sulphated, alkaline-saline (sulphuretted, siliceous).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	85.7	......
Sulphate	SO_4	181.9	25.54
Bicarbonate	HCO_3	174.7	19.28
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	27.4	5.18
Iron	Fe	......	.40
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	2.5	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	5.4	1.82
Magnesium	Mg	3.7	2.02
Potassium	K	2.5	.40
Sodium	Na	154.6	45.36
Lithium	Li	None	......
		638.4	100.00
Oxygen in Fe_2O_3		0.7	
	Total	637.7	

Concentration value	14.84	Excess carbon dioxide	62.9
Hydrogen sulphide, H_2S	0.40	Iron precipitated	None
Arsenic, As	....	Evaporation solids	559
Strontium, Sr	....	Oxygen consuming capacity.	0.58

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	21.8
Pot. chlor., KCl	4.8	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	.....
Sod. chlor., NaCl	41.4	Calc. silicate, $CaSiO_3$	.....
Sod. sulph., Na_2SO_4	269.0	Silica, SiO_2	85.7
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	22.3
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	187.1
Ferrous bicarb., $Fe(HCO_3)_2$	5.6		
Total			637.7

Properties of Reaction in Percent

Primary salinity	61.44	Primary alkalinity	30.08
Secondary salinity	....	Secondary alkalinity	7.68
Tertiary salinity	....	Tertiary alkalinity	.80

Radioactivity

Temperature, °C, 64.0. Temperature, °,F 147.2.

Curies Ra Emanation per liter x 10^{-10}, Water, 28.57; Gas, 687.5.

Mache Units per liter, Water, 7.71; Gas, 185.6.

Permanent Activity, Grams Ra per liter, x 10^{-10}, 0.083.

NUMBER 246

WAUNITA HOT SPRING

Location—Lower Spring, N. side of creek.

Rate of Flow—8 gal. per min. Temperature—160° F.

Class of Water—Sodic, sulphated, alkaline-saline (sulphuretted, siliceous).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	85.1	......
Sulphate	SO_4	185.0	26.24
Bicarbonate	HCO_3	174.7	19.55
Silicate	SiO_3	......	.27
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	20.5	3.94
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	4.7	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	8.9	3.00
Magnesium	Mg	2.9	1.64
Potassium	K	3.5	.61
Sodium	Na	151.0	44.75
Lithium	Li	None	......
Oxygen to form SiO_3		0.4	......
	Total	636.7	100.00

Concentration value	14.68	Excess carbon dioxide	63.0
Hydrogen sulphide, H_2S	0.40	Iron precipitated	None
Arsenic, As	....	Evaporation solids	556
Strontium, Sr	....	Oxygen consuming capacity.	2.78

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	32.4
Pot. chlor., KCl	6.7	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	4.7
Sod. chlor., NaCl	28.5	Calc. silicate, $CaSiO_3$	2.6
Sod. sulph., Na_2SO_4	273.6	Silica, SiO_2	83.8
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	17.4
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	187.0
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			636.7

Properties of Reaction in Percent

Primary salinity	60.36	Primary alkalinity	30.36
Secondary salinity	....	Secondary alkalinity	9.28
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 68.0. Temperature, °F, 154.4.

Curies Ra Emanation per liter x 10^{-10}, Water, 18.66; Gas, 1243.5.

Mache Units per liter, Water, 5.04; Gas, 335.5.

NUMBER 247

HOTEL NO. 10 IN LOWER GROUP

Location—Waunita.

Radioactivity

Temperature, °C, 66.3. Temperature, °F, 151.3.
Curies Ra Emanation per liter x 10^{-10}, Water, 12.62; Gas, 555.0.
Mache Units per liter, Water, 3.41; Gas, 149.85.

Number 248

HOTEL NO. 11 IN LOWER GROUP

Location—Waunita.

Radioactivity

Temperature, °C, 5.5. Temperature, °F, 42.0.
Curies Ra Emanation per liter x 10^{-10}, Water, 13.85.
Maché Units per liter, Water, 3.74.
Permanent Activity, Grams Ra per liter, x 10^{-10}, 0.085.

NUMBER 249

HOTEL NO. 12 IN LOWER GROUP

Location—Waunita.

Radioactivity

Temperature, °C, 72.0. Temperature, °F, 161.6.
Curies Ra Emanation per liter x 10^{-10}, Water, 1.18.
Mache Units per liter, Water, 0.32.

NUMBER 250

WAUNITA

Location—Large oval pool near Hotel.

Radioactivity

Curies Ra Emanation per liter x 10^{-10}, Gas, 36.2.
Mache Units per liter, Gas, 9.77

NUMBER 251

WELLSVILLE SPRING

Location—Near Salida.

Rate of Flow—8 gal. per min. Temperature—165° F.

Class of Water—Sodic, sulphated, alkaline-saline, ferruginous, (sulphuretted, siliceous).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	10.5	......
Sulphate	SO_4	181.6	25.38
Bicarbonate	HCO_3	162.2	17.80
Silicate	SiO_3	......	2.94
Carbonate	CO_3	Trace	......
Phosphate	PO_4	Trace	......
Chloride	Cl	20.5	3.88
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	9.7	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	12.2	4.08
Magnesium	Mg	2.7	1.47
Potassium	K	3.5	.60
Sodium	Na	150.5	43.85
Lithium	Li	Faint trace	......
Oxygen to form SiO_3		3.6	......
	Total	657.0	100.00

Concentration value	14.94	Excess carbon dioxide	58.5
Hydrogen sulphide, H_2S	2.83	Iron precipitated	None
Arsenic, As	....	Evaporation solids	608
Strontium, Sr	....	Oxygen consuming capacity	0.78

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	Faint trace	Calc. bicarb., $Ca(HCO_3)_2$	13.3
Pot. chlor., KCl	6.7	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	9.7
Sod. chlor., NaCl	28.5	Calc. silicate, $CaSiO_3$	25.8
Sod. sulph., Na_2SO_4	268.6	Silica, SiO_2	97.2
Mag. sulph., $MgSO_4$	.....	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	16.2
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	191.0
Ferrous bicarb., $Fe(HCO_3)_2$	.....		

Total 657.0

Properties of Reaction in Percent

Primary salinity	58.52	Primary alkalinity	30.38
Secondary salinity	....	Secondary alkalinity	11.10
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 55.5. Temperature, °F, 131.9.
Curies Ra Emanation per liter x 10^{-10}, Gas, 58.3.
Mache Units per liter, Gas, 15.74.

NUMBER 252

WELLSVILLE

Rate of Flow—150 to 200 gal. per min. Temperature—94° F.

Class of Water—Calcic, sodic, alkaline-saline, magnesic, ferruginous, (carbondioxated).

Constituents	Formula	Milligrams per liter Approximately parts per million	Reacting value percentage
Silica	SiO_2	34.7	......
Sulphate	SO_4	66.9	8.02
Bicarbonate	HCO_3	312.0	29.29
Silicate	SiO_3	......	2.80
Carbonate	CO_3	None	......
Phosphate	PO_4	Trace	......
Chloride	Cl	61.6	9.89
Iron	Fe	......	......
Aluminum	Al	......	......
Iron oxide	Fe_2O_3	6.2	......
Aluminum oxide	Al_2O_3		
Manganese	Mn	None	......
Calcium	Ca	82.2	23.46
Magnesium	Mg	26.8	12.65
Potassium	K	18.5	2.69
Sodium	Na	45.0	11.20
Lithium	Li	None	......
Oxygen to form SiO_3		3.9	......
	Total	657.8	100.00

Concentration value	17.48	Excess carbon dioxide	112.5
Hydrogen sulphide, H_2S	None	Iron precipitated	None
Arsenic, As	....	Evaporation solids	481
Strontium, Sr	....	Oxygen consuming capacity	0.68

Hypothetical Combinations

Milligrams per liter, approximately parts per million

Lith. chlor., LiCl	.....	Calc. bicarb., $Ca(HCO_3)_2$	292.6
Pot. chlor., KCl	35.3	Iron and aluminum oxides, Fe_2O_3, Al_2O_3	6.2
Sod. chlor., NaCl	73.9	Calc. silicate, $CaSiO_3$	28.5
Sod. sulph., Na_2SO_4	49.1	Silica, SiO_2	19.9
Mag. sulph., $MgSO_4$	42.2	Mang. oxide, Mn_3O_4	.....
Calc. sulph., $CaSO_4$	.....	Mag. bicarb., $Mg(HCO_3)_2$	110.1
Calc. carb., $CaCO_3$	.....	Sod. bicarb., $NaHCO_3$	.....
Ferrous bicarb., $Fe(HCO_3)_2$	.....		
Total			657.8

Properties of Reaction in Percent

Primary salinity	27.78	Primary alkalinity	....
Secondary salinity	8.04	Secondary alkalinity	64.18
Tertiary salinity	....	Tertiary alkalinity	....

Radioactivity

Temperature, °C, 35.5. Temperature, °F, 95.9.
Curies Ra Emanation per liter x 10^{-10}, Water, 4.40.
Mache Units per liter, Water, 1.19.

Number 253

RESERVOIR SPRING

Location—Yousse Radium Springs.

Radioactivity

Curies Ra Emanation per liter x 10^{-10}, Water, 5.84.

Mache Units per liter, Water, 1.58.

Permanent Activity Grams Ra. per liter x 10^{-10}, None.

Remarks—Rockwood, Colorado School of Mines, has found for No. 253 a permanent activity of 2.015×10^{-10} grams Ra per liter.

Number 254

PALMER SPRING

Location—Yousse Radium Springs.

Radioactivity

Curies Ra Emanation per liter x 10^{-10}, Water, 13.63.

Mache Units per liter, Water, 3.68.

Permanent Activity, Grams Ra per liter x 10^{-10}, None.

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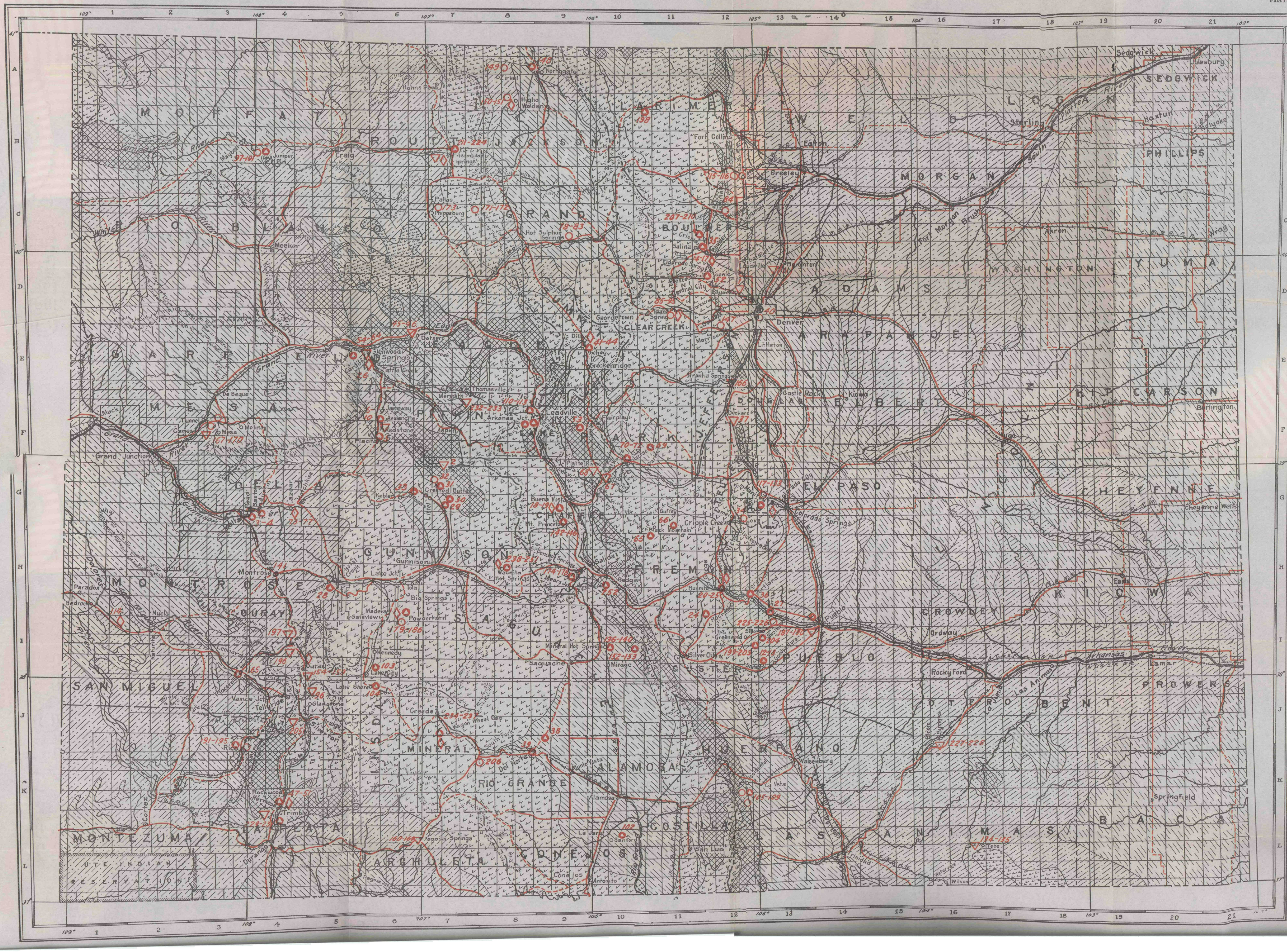
COLORADO STATE GEOLOGICAL SURVEY
R. D. GEORGE, STATE GEOLOGIST
BOULDER, COLORADO

MINERAL SPRINGS OF COLORADO

PLATE I



LEGEND

▨ TERTIARY & QUATERNARY

▨ CRETACEOUS

▨ TRIASSIC & JURASSIC

▩ CARBONIFEROUS

▨ CAMBRIAN, ORDOVICIAN, & SILURIAN

▨ PRE-CAMBRIAN

Railroads

Improved State Highways

Unimproved State Highways

MINERAL SPRINGS:

Alkaline ○

Alkaline-Saline ●

Saline ▽

Not analyzed, but tested for radio activity ◇

STATUTE MILES
0 10 20 30 40

Drawn by C. L. Mohr
July 1920