GEOLOGICAL SURVEY OF MISSOURI.

ARTHUR WINSLOW, STATE GEOLOGIST.

VOL. III.

A REPORT

ON THE

MINERAL WATERS OF MISSOURI

BY

PAUL SCHWEITZER, Assistant Geologist,

Embodying also the Notes and Results
of Analyses of

A. E. WOODWARD, Assistant Geologist.

FROM

Field and Laboratory Work conducted during the Years

1890 to 1892.

With 45 Illustrations and One Map.

PUBLISHED BY

THE GEOLOGICAL SURVEY.

JEFFERSON CITY.
DECEMBER, 1892.

Nixon-Jones Printing Co., 215 Pine St.

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LETTER OF TRANSMITTAL.

OFFICE OF THE GEOLOGICAL SURVEY,
JEFFERSON CITY, MISSOURI,
December 24, 1892.

To the President, Governor David R. Francis, and the members of the Board of Managers of the Bureau of Geology and Mines:

GENTLEMEN:

I have the honor to transmit, herewith, a Report on the Mineral Waters of the State, by Prof. Paul Schweitzer, assistant geologist.

The investigation of the mineral waters of the State was one of the first subjects to engage the attention of the present Survey. Missouri, although not in possession of many handsomely improved resorts whose waters are of such wide reputation as to attract many visitors from abroad, has yet a great number of mineral springs, many of them of undoubted medicinal value, which are patronized by citizens of the State. The majority of people are unable to avail themselves of the cures of the well known but distant resorts, and, hence, have recourse to what is provided at home. The investigation and the preparation of this report were, hence, undertaken principally for the following reasons: (1) To determine the composition and character of the waters and their values as compared with other waters which have acknowledged medicinal virtues. (2) To furnish an exact and full statement of the results reached, particularly for the use of physicians. (3) To supply certain suggestions for the guidance of the citizens of the State in the use of these waters. (4) To make the fact of the existence of these waters authoritatively and widely known with the object of interesting others in developments and improvements at the different localities.

As is stated in the preface following, the examination of the min eral waters was first begun under direction of Mr. A. E. Woodward, assistant geologist; after the latter's death it was continued and completed by Prof. Paul Schweitzer. The part thus contributed by Woodward is well-nigh the only product of his professional career which can stand as a memorial of his short but promising life. It is thought, therefore, that a short sketch of his life is appropriately introduced here.

Amos Erastus Woodward was appointed assistant geologist on the Missouri Geological Survey in December, 1889, and reported in Jefferson City early in January, 1890. The division of the Survey work assigned him was chemistry and mineralogy, and, as included within these subjects, he began at once an examination of the mineral waters of the State. He was the son of Erastus Woodward and was born in Charleston, Massachusetts, May 4, 1866. He subsequently moved to Somerville, Massachusetts, where he attended school and ultimately was graduated from the high school of that place. He entered the Massachusetts Institute of Technology in September, 1884, and was graduated from there in June, 1888, in the department of mining engineering. While a student in Boston he gave much attention to the geological side of his profession, and applied much of the spare time of his college terms and of his summer vacations to visits of points of interest in the vicinity. During the summer of 1888 he was attached, as assistant geologist, to a field party of the U. S. Geological Survey under the charge of Mr. C. W. Hayes, and was engaged in mapping the sedimentary rocks of northern Georgia and Alabama. Later he was assistant in the geological department of the Massachusetts Institute of Technology. During the summer of 1889 he held the position of chemist and assayer to one of the lead and silver smelting companies in Castle, Montana. It was soon after resigning this position that Mr. Woodward accepted the appointment on the Missouri Geological Survey. He continued with the Survey for a little over a year, resigning the 1st of April, 1891, to accept the position of chemist and metallurgist of the Cumberland Mining and Smelting Co. at Castle, Montana, at a great advance in salary; shortly before he was taken sick he was appointed superintendent of the reduction plant. This position be held up to the time of his death.

It is seldom that there is such unanimity of expression concerning the character and promise of a man as in the case of Woodward. His assistants and instructors in college, and his superior officers in the various positions which he held after graduation unite in expressions of esteem. "His record as a student was one of the best." "I also knew Mr. Woodward to be prompt, energetic and conscientious in his work." "He was my pupil at the Institute for three years, and a better student or a finer fellow I have rarely if ever seen." "All his work was done in the most prompt and thorough manner." "I found him an energetic worker and a careful, accurate, scientific observer." "Mr. Woodward was considered a most trustworthy and honorable man." These are quotations and extracts from some of the letters written by different professors and employers with whom he was associated, and in these expressions the writer cordially joins.

On coming to the Geological Survey, Mr. Woodward plunged into the work with all the ardor and energy natural to his temperament. The Survey was just then being organized and the burden of work was necessarily great upon all. In his department a laboratory had to be practically designed and equipped. He took hold of this work with great interest, providing all details with careful thought. He even went so far as to purchase out of his own pocket expensive instruments which were used by him in the interest of the Survey. During the delay incidental to such preparation, work necessarily accumulated and, after things were in working order, Mr. Woodward was at his desk or in the laboratory at all hours. By eight in the dark winter mornings his work would be started and often the midnight hour would find him still at it; it was an enthusiasm born of true love for his work. It was necessary, in order that too serious delay might not arise, that field work should be prosecuted during the winter of 1890, and several weeks were spent by Woodward in the field despite the inclement weather. After this, office and laboratory work were again pushed with the same ardor. The atmosphere of a laboratory is at no time conducive to the best of health and when to this is added overwork and a long continued spell of such a sedentary occupation, the effect upon one's constitution can readily be imagined.

During the late autumn of 1890 and the winter of 1891 evidence of nervous exhaustion was noticeable in the case of Woodward. It is true that he lightened his work considerably during that time, and, had he not been subjected to additional physical and mental strain, he would probably have soon regained his natural vigor. The new work which he took up, however, necessitated an entire change of climate; he removed to a high altitude, which is, in itself, injurious to some constitutions and, in addition, he was subjected to the mental strain of organizing and starting new work. About three weeks before his death he was taken down with mountain fever and was obliged to take to his bed. His sickness at first manifested only the usual symptoms that accompany this lingering illness; but gradually he got weaker and weaker under it. In previous years he had received medical treatment for heart trouble. This same derangement began again to reveal itself as his body grew weaker from the effects of this prolonged fever. During the last few days, to all appearances, the fever was beginning to leave him, but the new bodily trouble was increasing in its virulence. The attack of this second malady was more than his impaired strength could stand, and on September 18, 1891, shortly after noon, he quietly and peacefully passed away.

An incident which adds especial pathos to the circumstance of his death was the fact of his betrothal at the time to a young lady living in California. The day of his death was the day fixed for her to leave her home to be married in Helena, Montana. A dispatch announcing his death on that very day prevented the journey. We seek in vain to understand the purpose of this sudden ending. Sadly we recognize that in place of the fine shaft which this promising life might have reared for itself as a monument, we can only direct attention to this rough hewn and half completed column.

At the time of his resignation, Mr. Woodward's work covered but about half of the State. Part of his results had been published in Bulletins 1 and 3 of the Survey; but much remained unpublished and unwritten. Many of his notes were merely in note book form or were roughly written out on sheets of paper. Most of the samples of water collected by him, however, had been analyzed and the results calculated out. In the following report those descriptions which have been derived from Woodward's notes have been credited to him by Prof. Schweitzer by the addition of the initial (W.), and similarly with regard to the analyses. The photographs for almost all of the illustrations in this report were taken by Mr. Woodward during his trips into the field.

With this fragmentary material Prof. Schweitzer began his work and expanded it rapidly. The subject was, however, not a new one to him. During the many years that he has held the position of professor of chemistry at the State University he has had submitted to him for examination mineral waters from all parts of the State. He has thus had opportunity to become thoroughly familiar with all the different waters, and has been led to give the subject much thought and study. The necessary field work to supplement what had been done by Mr. Woodward, was conducted by Mr. J. D. Robertson during the summer of 1891. He visited a large number of localities in the central and southern portions of the State, made the necessary descriptive notes and collected most of the samples for analysis. He is duly credited with this work in the following report by addition of the initial (R.) after the heading of an analysis or description made by him. The analytical work on these samples was conducted by Prof. Schweitzer and, in addition, all of the results of Mr. Woodward's analyses were recalculated by the former. The plan of the following volume and the arrangement of the matter is almost entirely Prof. Schweitzer's and to him is due the credit of it. He is also the exclusive author of the three chapters of Part I. The vast amount of labor involved in all this analytical work and in the calculation of the results can only be imagined by one who has had experience in such work. I personally feel grateful to Prof. Schweitzer for the manner in which he has done this work, as well as for the readiness with which he has accepted suggestions and agreed to modifications, which seemed necessary from time to time.

The plates of this volume constitute a very prominent feature. They have been liberally introduced not so much, if at all, for their scientific value, as in order to convey a clear, graphic idea of the location and improvements of the various springs, facts which have much weight in determining the future of any resort.

For assistance in prosecuting this work the Survey is indebted to many citizens of the State, the names of all of whom space will not permit us to include; among these, however, we wish particularly to mention Mr. Leslie Marmaduke, of Sweet Springs; Mr. Henry Strother, of Marshall; Dr. J. H. Britts, of Clinton; Mr. T. O. Stump, of Monegaw; Mr. E. T. Keim, of Kansas City; Mr. F. C. Frost, of Plattsburg; Judge E. H. Norton, of Platte City; Capt. John Halstead, of West Plains; Mr. John Clark, of Warsaw; Mr. L. F. Jones, of Cassville; Mr. Kim. Winston and J. Mr. G. Martin, of Nevada.

The printing of this report, as well as of the preceding Vol. II, on the iron ores of the State, was done by the Nixon-Jones Printing Co. of St. Louis. The creditable manner in which they have done the work speaks for itself; but when it is understood that these two reports were both set up, printed and bound almost entirely within the period of a little over a month, the result is truly remarkable. With this unavoidable haste it was, however, impossible to prevent some imperfections creeping in and some mistakes escaping detection. To this cause must be attributed, in a large degree, such errors as may be observed, either in the facts stated or in the literary character of the report.

Very respectfully submitted,

ARTHUR WINSLOW,
State Geologist.

PREFACE.

It is proper to make certain statements in regard to the preparation of this report. Designed originally by the head of the Geological Survey and partly executed by its subordinate officers, it fell to the writer first to extend and complete the chemical work and later, after the untimely death of Mr. Woodward, to gather together the threads running through field notes and memoranda and weave them into a whole.

To prepare a REPORT ON THE MINERAL WATERS OF THE STATE, that would call attention to their variety and value without seeming a mere advertisement; that would give reliable information concerning their character without being too concise or too technical; that would be useful and acceptable to the people without giving up its scientific purpose of adding to our knowledge of the geologic history of the State, was the problem to be solved. No similar work existed to guide aim or execution and, while the subjects of science are doubtless not antagonistic to the demands of utility, yet each is pursued in so different a manner as to render equal justice a matter of exceeding difficulty.

In how far the task has been accomplished, how successfully scientific accuracy has been made to go side by side with practical usefulness, must be left to the decision of others.

May the work, which has been largely a labor of love, prove serviceable to the people and at least suggestive to the medical profession.

P. SCHWEITZER.

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PART I.

MINERAL WATERS.

A General Discussion of the Origin, Composition and Therapeutics of Mineral Waters.

THE MINERAL WATERS OF MISSOURI.

BY PAUL SCHWEITZER.

CHAPTER I.

THE ORIGIN OF MINERAL WATERS.

Introductory Remarks. — Muriatic and Alkaline Waters. — Sulphatic and Chalybeate Waters. — Sulphur Waters.

INTRODUCTORY REMARKS.

Definition of Mineral Water. The term "mineral" is usually applied to any natural inorganic body having a definite chemical composition. In this sense water itself is a mineral and to speak of a "mineral water" a tautology were it not that the term has, by common consent, assumed a very restricted meaning. According to this a mineral water is not a water that holds mineral matter in solution, for none but the purest distilled waters are free from this; but a water, either natural or artificial, that possesses medicinal virtues. As these virtues depend in most cases upon the presence within the water of certain chemical constituents, those waters which contain these are called mineral waters.

A mineral water to possess medicinal virtues.

The constituents of mineral waters are plainly derived from the body of the earth itself, either by a simple process of solution or by solution preceded or accompanied by chemical action. In discussing, then, the origin of mineral waters, the inquiry may advantageously follow these separate leads and begin with the simplest, that of mere solution.

Its constituents from the soil.

The Process of Formation. All atmospheric waters descending upon our globe, hasten to lower levels. They either form on its surface the various streams, creeks and rivers or penetrate to a greater or less depth the outer shell of the earth, whence they issue to be eventually reunited in the all-embracing ocean. During this passage the solvent power of the water is active and, in proportion as it meets readily soluble substances, becomes charged with them, to be called, as the case may be, a soft or a hard water, a water surcharged with mineral matter or a mineral water proper. All such come from the interior of the earth, though, not all, having this origin, are called mineral waters. Some one or more constituents with a distinct and noticeably curative effect upon the human body in ailment are required to give them this character; and, just as these constituents form the basis of the classification adopted, they likewise prove a guide in the present discussion. Muriatic and alkaline waters are the products of a simple process of solution; sulphatic and chalybeate, as also sulphur waters, those of a process of chemical action and solution combined. The former remove from the rocks, through which they force their way, what is ready formed and soluble, the latter are witnesses or agents in producing what they afterwards retain.

Solution and chemism active.

MURIATIC AND ALKALINE WATERS.

The muriatic waters, as detailed elsewhere, are solutions of mineral matter, that at one time was a portion of an ancient ocean; as this had changed during geologic times through evaporation, heat or mutual interchange of constituents, so the muriatic waters of to-day are varied and represent in their compositions the various conditions of these fossil oceans; quality of mineral matter, therefore, is what interests the geologist; quantity, is what constitutes its commercial or therapeutic value. This vast inland ocean, covering the interior of the north American continent for thousands of square miles, became encroached upon by the land forming to the east and west and north, with islands rising here and there out of its waters, until it was forced back to its present site. During such uprisings of the lands many small portions of the sea were cut off permanently or for a time to leave their mineral contents behind as witnesses of

Fossil oceans.

their former existence. These minerals are reached to-day by the percolating waters and re-appear once more in the form of springs or artesian wells, or when near enough to the surface, as licks or seeps such as are represented abundantly in Missouri.

Sulphuretted Hydrogen, its Occurrence and Source. There is one constituent, however, of these brines that requires special mention; hardly any one of them is entirely free from it, and yet its presence has not been deemed of sufficient importance to disturb either the classification followed or the present discussion; this is sulphuretted hydrogen, a gas contained in the muriatic waters of Missouri, in quantities all the way from a trace to a little more than a tenth of a grain per gallon. This latter quantity (more accurately 0.1549 grains) represents about eight cubic inches of the gas per gallon, or one cubic inch per pint. Muriatic waters from other States and from Europe contain, likewise, rarely more, while a number of alkaline waters with 100 grains or less of mineral matter to the gallon contain five and six, and sometimes ten times as much of this sulphur compound. It seems plain, then, that muriatic waters with 400 to 2,000 grains of saline constituents, and, at the best, only two tenths of a grain of sulphuretted hydrogen, must owe their therapeutic virtues chiefly to the former, while alkaline waters with only 50 to 150 grains of mineral matter and one to two grains of sulphuretted hydrogen owe theirs in all probability mainly to the latter. The two, therefore, belong to different classes of mineral waters and not to different groups of the same class, a view still further supported by the fact that the muriatic waters contain the hydrogen sulphide free, simply dissolved in the water and easily volatilized, so that when they are taken internally and have to be diluted on account of their strength, the sulphuretted hydrogen can scarcely be of any medicinal value. The alkaline waters on the other hand contain it in part at least, in combination and it is, therefore, more lasting and certainly much more effective therapeutically.

Condition and medicinal value of sulphuretted hydrogen.

The origin of the gas in the two cases is probably also different; in some instances it is certainly so. The muriatic waters receive it as the simple result of the action of organic matter in

Sulphuretted hydrogen produced by reduction.

the presence of carbonic acid upon calcium sulphate;[1] it is accidental, as it were, and therefore variable, as is shown by careful analyses made at different times of the waters of the same spring. In the alkaline waters volcanic action (heat) is more often the effective cause. Steam and metallic sulphides, often doubtless in the presence of carbonaceous matters, act upon each other under great pressure and with much energy. As a result of such action gases are evolved, one of which is hydrogen sulphide, which escape and are usually taken as the evidence of distinctly volcanic action. But it is plain that wherever such active forces are at play to-day they are merely the after tossings of the tremendous activities of former ages. No ocean or lagoon could exist for any length of time over an open volcanic hearth. The water would either conquer and close up the volcanic vents, rendering perhaps other and more distant openings necessary; or would be subdued, and by the rising of a crater-like orifice above its surface be crowded further and further back. In neither case could sulphuretted hydrogen, thus generated, find salt waters to impregnate; but, before escaping, the gas might easily meet waters in levels higher than those of the present saline deposits, which would absorb it, and in proportion to their distance from the seat of volcanic action, the waters would appear in the form of hot or cold sulphur springs. Such springs are usually alkaline and not represented in Missouri; the two typical sulphur waters described later derive their sulphuretted hydrogen like the brines from reduced sulphates.

Produced by volcanic agencies.

The Alkaline waters of Missouri furnish a second class of waters, purely the result of solution, though some such waters in other parts of the world may have a different origin. Their sources are shallow, generally in the immediately underlying limestones and sandstones, and in proportion as the latter are pure and contain but little soluble matter, these waters often constitute, from their absence of deleterious organic substances, admirable types of domestic potable waters. Their normal

Alkaline waters hold little mineral matter.

[1] This action is so well established that in bottling waters containing much carbonic acid and calcium sulphate great care must be exercised not to let fibers of straw or similar organic matters get into the bottles, since in such case sulphuretted hydrogen would be sure to make its appearance.

constituents are 10 to 20 grains of calcium carbonate with some sodium and magnesium carbonates and a little lithia and sodium chloride. Such waters are sometimes obtained by drilling to a greater or less depth, as is illustrated by various artesian wells in the western part of our State.

SULPHATIC AND CHALYBEATE WATERS.

The sulphatic and chalybeate waters originate otherwise, resulting generally from recent chemical decomposition. The extent of this decomposition, depending upon the quantity of water, the porosity of rock and other factors, determines naturally the strength of such mineral waters. This may vary in different seasons, and is influenced by rainfall, which explains what might otherwise seem mysterious in the different analyses of the same water.

Epsom and Glauber's Salts Springs. Dolomitic limestones and limestones containing gypsum produce the Epsom and Glauber's salts springs; magnesium sulphate and calcium carbonate result from their interaction, the former of which is very soluble and constitutes the main ingredient of the Epsom salts springs or wells. Such waters are nearly all obtained from wells or shafts, sometimes only ten or twenty feet deep; they contain in addition variable amounts of other sulphates but rarely chlorides or carbonates. If the limestones above mentioned are associated with marls rich in alkalies, or with other rocks containing alkaline carbonates or silicates, the conditions are given for the formation of Glauber's salt springs; these may be alkaline or neutral, as sodium carbonate or magnesian sulphate happen to be in excess. They are usually of a more varied composition than are the Epsom salts waters. In this way doubtless originated the water of the B. B. spring in Pike county and of the Lineville mineral well in Mercer county.

Epsom salts springs in dug wells.

Sulphatic Waters Containing Iron and Alumina. Still different is the manner of formation of members of the third group of the sulphatic waters, viz., those that contain variable yet considerable quantities of aluminium and iron sulphates. In these cases oxidation precedes decomposition (metathesis) and coincides, in a measure, with the process which evolves the waters of the third group of Chalybeates. The primary seat of production of all these waters are beds of pyritiferous shale so numerously represented in our State. These shales contain finely disseminated pyrite and carbonaceous matter, with clay and sometimes calcium carbonate consolidated into a solid and fine grained mass. Such shales are prone to change in the presence of oxygen and moisture, giving rise then to the formation of ferrous sulphate, and often to free sulphuric acid, which in turn acts upon the finely divided clay, thereby exchanging a portion of the iron for alumina and magnesia.

Formation of "alum waters."

A similar change occurs with many of the coals themselves, which are often highly charged with pyrite and other mineral matter distributed through their mass in seams, sometimes visible and sometimes not. The Carboniferous age that gave rise to these coals, had, in the interior of our continent, replaced the salt water ocean by vast stretches of low land through which mighty rivers forged their way to the sea. Luxuriant vegetation throve under the rays of a fervid sun. This was submerged from time to time, wholly or in part, by inundations, of which to-day yet furnishes illustrations, covering the vegetable matter with a layer of clay, repeated at intervals, till a catastrophy changed the course of events and started another era. Many of the coals thus formed contain from 30 to 40 per cent. of ash, a considerable portion of which is oxide of iron. This latter could at no time have been a constituent of plants; it existed then as it does now in the reddish colored clays, which yield it readily to acids. The first change in the formation of coal was the reduction in the presence of water and organic matter, of the sulphates naturally contained by all plants to sulphides; these, in return, reacted upon the iron in the clay and produced the variously constituted pyrites which now undergo oxidation again and are the real source of that class of mineral waters referred to.[1]

Formation of coal.

[1] In proof of the facts stated, the results of an investigation, made a number of years ago and published in the Catalogue for 1875 of the University of the State of Missouri, are here recapitulated; the details may be examined in the original paper.

COMPOSITION OF SUBSTANCES OPERATED UPON.

	ASH OF COAL. Per cent.	CLAY. Per cent.	LIMESTONE. Per cent.
Silica	14.3438	77.7061	0.3149
Ferric Oxide	75.8962	3.0772	0.1013
Manganic Oxide	0.9901	0.2314	......
Alumina	7.4578	10.2391	0.0946
Lime	0.3980	0.3788	55.3006
Magnesia	0.3881	0.2722	0.4000
Potassa	......	0.5750	......
Soda	......	1.5250	0.0025
Phosphoric Pentoxide	0.1404	0.0214	0.0021
Sulphur Trioxide	0.7126	......	......
Carbon Dioxide	......	0.6426	43.4505
Water	......	5.7363	......
Chlorine	......	......	0.0037
Total	100.3270	100.4051	99.6702

The coal itself, in addition to the ash constituents given, contained much sulphur in the form of sulphides, sulphuric acid and free sulphur.

On washing the coal with small quantities of water at a time and permitting oxidation in the intervals a solution was obtained which contained the following substances in grains per gallon:

SOLUTION FROM WASHING COAL.

Silica	0.4258	grains per gallon.
Alumina	8.3996	" "
Ferric Oxide	55.0412	" "
Ferrous Oxide	169.5829	" "
Lime	18.7974	" "
Magnesia	0.8374	" "
Sulphur Trioxide	322.9250	" "
Total	576.0093	grains.

United as follows:

Silica	0.4258	grains.
Aluminium Sulphate	28.1634	"
Ferric Sulphate	137.6031	"
Ferrous Sulphate	358.0083	"
Calcium Sulphate	45.6508	"
Magnesium Sulphate	2.5122	"
Sulphur Trioxide (free)	3.6457	"
Total	576.0093	grains.

On treating this liquid with clay and limestone separately, for two days, and then filtering off the solution and subjecting it to analysis the results calculated again in grains per gallon were as follows: —

SOLUTION AFTER TREATMENT WITH CLAY.

Silica	9.9459	grains
Alumina	15.2409	"
Ferric Oxide	0.4375	"
Ferrous Oxide	114.6422	"
Lime	44.1522	"
Magnesia	13.8826	"
Sulphur Trioxide	269.8486	"
Total	468.1499	grains.

United as follows:

Silica	9.9459	grains.
Aluminium Sulphate	50.7537	"
Ferric Sulphate	1.0937	"
Ferrous Sulphate	242.0224	"
Calcium Sulphate	107.2268	"
Magnesium Sulphate	41.6478	"
Sulphur Trioxide (free)	15.4595	"
Total	468.1499	grains.

SOLUTION AFTER TREATMENT WITH LIMESTONE.

Silica	1.8372	grains.
Alumina	7.5249	"
Ferric Oxide	....	"
Ferrous Oxide	127.0401	"
Lime	78.7202	"
Magnesia	1.4292	"
Sulphur Trioxide	240.1490	"
Total	456.7066	grains.
Carbon Dioxide	37.2492	"
	439.9558	grains.

United as follows:

Silica	1.8372	grains.
Aluminium Sulphate	25.0587	"
Ferrous Sulphate	203.8689	"
Calcium Sulphate	191.1776	"
Magnesium Sulphate	4.2876	"
Ferrous Bicarbonate	67.7258	"
Total	439.9558	grains.

Each of these solutions represents a fluid closely resembling a mineral water, and the last, by continued treatment, alternately perhaps with clay, will counterfeit the third group of Chalybeate waters to perfection.

Different, however, is the genesis of the first and second groups of chalybeate waters, as defined in a subsequent chapter of this report; the complete absence of calcium sulphate, not to mention other constituents, utterly precludes their connection with coals or shales. The waters of the first group, holding but very small quantities of mineral matter in solution, take their origin in sandstones, as do the waters in Cedar county, which are so remarkable alike for their large percentages of bicarbonate of iron and for their comparative freedom from other salts. These sandstones, forming often beds of considerable thickness, are porous, and organic matter reaches them continuously in the percolating waters. It is this organic matter which reduces their ferric and manganic oxides to forms which are subsequently dissolved as bicarbonates and, accompanied by minute quantities of alkaline and earthy salts, give rise to waters, that in the classification have been termed pure chalybeate waters. The second group of these waters carries a greater amount of saline matter, simply caused by a longer flow before issue through impure limestone beds often associated with sandstones, or by a direct generation of the waters in the ferruginous limestones themselves. Many of the chalybeate springs within the State furnish examples of this mode of formation, which will plainly appear in studying the geology of the counties in which they occur.

Pure chalybeate waters not connected with coal beds.

SULPHUR WATERS.

The sulphur waters, as already indicated, are alkaline and contain, besides free sulphuretted hydrogen gas, sulphides or sulphydrates and in some instances even thiosulphates. These latter are, doubtless, generated by oxidation of the former and are with a high degree of probability present in all waters, which exhibit a perceptible discharge of gas. This gas, bubbling up through the water at irregular but short intervals, or even in a continuous stream, consists by no means exclusively of sulphuretted hydrogen; mingled with it, and often in very considerable quantities, are carbon dioxide, nitrogen, oxygen and sometimes corburetted hydrogen readily recognized by its inflammability. The first three gases point plainly to a more or less close con-

Thiosulphates the product of oxidation.

Gases in sulphur waters.

nection of the water with atmospheric air and oxygen, thereby rendering the process of oxidation spoken of readily comprehensible.

When strongly alkaline such waters possess but a feeble odor, as all their hydrogen sulphide is in combination and often, in fact, increase the intensity of their odor by standing on account of the gradual decomposition through contact with air of their sulphides and sulphydrates.

As to the origin of the gas much might be said in speculation; many sulphur springs are thermal in their character, and those found in mountain districts greatly outnumber the ones in the plains. Exhalations of hydrogen sulphide together with sulphur and carbon dioxides characterize the regions of many and perhaps all active volcanoes; steam and metallic sulphides decompose each other readily with production of sulphuretted hydrogen gas. What, then, would be more inviting than to ascribe to all sulphur springs a volcanic origin! Heat from the bowels of the earth, whatever its cause, obeys promptly our imagination and enters into action; yet while such connection must, perhaps, be conceded in many cases there are others that demand a different explanation. The one most applicable in such is the reduction under pressure of the sulphates of the alkaline earths by organic matter and the subsequent decomposition of the sulphides, thus formed, by carbonic acid. Even then it seems difficult to deal without heat,[1] though pressure may take its place and effect all that heat would. In this manner are probably generated the two sulphur waters, so far come to our notice, as also the hydrogen sulphide of many of the brines within the borders of the State.

Whence the sulphuretted hydrogen?

Reduction of sulphates.

[1] T. Sterry Hunt, Chemical and Geological Essays, 1875, page 99.

CHAPTER II.

THE ANALYSIS AND COMPOSITION OF MINERAL WATERS.

Introductory Remarks.—The Collection of Samples.—The Analytic Work and the Calculation of Results.—The Unit Used for the Expression of Results.—The Classification of Mineral Waters.

INTRODUCTORY REMARKS.

The determination of the composition of the mineral matter held by a mineral water in solution might seem to be a comparatively easy matter. The methods for separating and determining silica, oxide of iron and alumina, lime, magnesia, alkalies, sulphuric, muriatic and carbonic acids are known in every detail and are quite exact in their results. Yet the experienced chemist holds the analysis of a mineral water a problem of no mean difficulty, partly on account of the relatively small quantity of solids dissolved, and partly on account of the necessity of bringing to bear upon each operation much knowledge and judgment in order to obtain results that can be relied upon. If, in addition, lithia, baryta or strontia, bromine, fluorine and phosphoric acid are to be looked for and brought into weighable forms, the difficulties are much increased, as every chemist who has given attention to the subject will concede. Yet, while skill and experience are necessary for a correct solution of the problem, it is not impossible to solve it, as is witnessed by the large number of analyses of mineral waters whose correctness is supported by indisputable evidence.

Analyzing a mineral water difficult.

Therapeutic Information Necessary. The mere determination of the constituents enumerated is, however, not enough; it is only the first step in ascertaining the character of a mineral water; for, while a knowledge of the amount of silica, lime, magnesia and other bodies in a water might satisfy chemist and geologist, it does not alone answer the main question for which mineral waters are analyzed at all. This question is the effect of such waters upon the human system; and though, in the first place, the proximate constituents searched for would, in a measure, account for these effects, the analysis of mineral waters, to-day, is made for the *purpose* of learning the probable effects which it will exert upon the system. In other words, the question is a medical rather than a geological one, and to answer it intelligibly to expert and layman the information derived from analysis must be put in a different form.

Action of mineral waters a medical question.

Popular Superstitions. It is true another question approaches us at the start, and that is whether the therapeutic effects of a mineral water may be inferred at all from a knowledge of the chemical composition and physiological properties of its components. Much has been said and written on this point, which was clouded, down to comparatively recent times, by a more or less openly avowed belief in a vital force, the existence of a mysterious power, active and present in all the operations of organic nature, a subtle spirit, potent but alike intangible as it was incomprehensible to reasoning intelligence. Remnants of this mischievous faith appear yet in many of the circulars printed and distributed by the owners and operators of mineral water resorts, and they find a fruitful soil in the minds of multitudes, still living under the influence of the inherited superstitions of long gone-by centuries, when disease was thought to be a separate individual existence, a real *Spiritus morbi*, in the bodies of man and beast.

To predict the effects of a mineral water from a knowledge of the properties of its components, is entirely possible, though not universally easy. Man's constitution, idiosyncrasies, physical and psychical inheritances, as well as the effects of his environment and life are so infinitely varied, that broad knowledge, long experience and ripe judgment alone will enable the medical practitioner to safely venture an opinion. To furnish the facts which make such opinion possible is the duty of the chemist, and the data which he furnishes form the most secure basis attainable.

How to judge the effects of a mineral water?

Proximate Constituents. The substances mentioned above by name, merely give an idea of the ultimate composition of the fixed residue of a mineral water. Oxides and anhydrides, it is true, appear in the schedule of analysis, not elements; yet they really represent only quantities of silicon, calcium, potassium, sulphur as sulphydride or as sulphate and nothing more, and some chemists indeed, tabulate their results in this manner. This, as already stated, suffices sometimes from a chemical point of view, but is entirely inadequate to reveal the medicinal character of the water; it would be like attempting to represent the nature of granite or gneiss by percentages of their ultimate constituents. Something more is demanded and is offered by most chemists in a table of calculated *proximate* constituents, which is usually introduced by the statement that the *ultimate* constituents, or the substances actually determined in a mineral water, are supposed to be united in the manner indicated, a statement which plainly seems to involve an element of uncertainty.

Constituents of a mineral water.

The reason for thus guardedly expressing an opinion is not far to seek; two soluble salts like magnesium sulphate and calcium chloride or sodium chloride may be mixed without apparently reacting on each other after dissolving; does the solution, however, yet contain the two substances we dissolved, or have bases and acids apportioned themselves differently, is a rather difficult question to answer. We know that by heating such a solution to boiling, or by cooling it below freezing, calcium sulphate on the one hand and sodium sulphate on the other are obtainable. We also know that the "law of maximum work" demands, in all probability, an altered arrangement of the constituents. Yet the latter law has so far received no exact expression, because certain factors, bearing upon it, are insufficiently known. When thoroughly known they will probably affirm the rule, now assumed, that, all things being equal, the strongest base goes to the strongest acid. The practical value of this latter and commonly adopted rule for calculating results is so plain as not to be lightly given up for a mere conformity with a theory, when the latter itself is yet somewhat uncertain.

Compatibility of constituents.

These introductory remarks are deemed in place here on account of the importance attached to the best ways of recording analyses of mineral waters, and of classifying the latter by some scientific system. It now remains to give the necessary information regarding the work done in preparation for this report, so that the product may receive fair and correct judgment.

THE COLLECTION OF SAMPLES.

For most of the waters examined one gallon was considered sufficient for analysis; this permitted the determination of carbon dioxide, sulphur trioxide, chlorine, silica, alumina, oxide of iron, lime, magnesia, potash and soda; if, besides, manganese was desired, another gallon of water was taken. For rarer substances, eight gallons at least were required. The bottles for holding the water were of half-gallon capacity, with common, or, better still, wine corks, driven into their necks with a "cork driver." They were packed, six in a box, and safely transported to their destination.

Amount of water taken for analysis.

In taking the samples from a well a gallon or two of the water was pumped or drawn up and the bottles first throughly washed with it; they were then filled as rapidly as possible, corked and labeled; from a spring, the rubbish from its mouth was removed and the water caught directly into the bottles, when that could be done, and, in every case, the water taken was watched to be clear and free from floating particles; whenever this condition was not directly attainable, the water was quickly filtered through a folded filter of good paper.

Manner of taking it.

The tests at the spring or well were few in number; lead paper for recognizing the presence of free hydrogen sulphide, blue and red litmus paper for ascertaining the reaction of the water, a good thermometer for taking its temperature and that of the air were deemed sufficient "apparatus" for this investigation. In addition, however, the flow of water was measured as accurately as circumstances permitted, and any points of interest or information that might subsequently prove of value, were noted down. The waters thus sampled and packed were sent to Jefferson City or Columbia for analysis.

Work at the spring.

THE ANALYTIC WORK AND THE CALCULATION OF RESULTS.

Outline of Method of Analysis pursued. It is not considered necessary to give here details of the analytic operations per-formed in the course of the work. These are found in any of the books that treat of the analysis of mineral waters and are supposed to be known. A few statements will explain what seems to be in need of explanation. Silica, ferric and aluminic oxides, lime and magnesia were determined in the same sample of water (400 to 1000 c. c.). The silica was, in every case, tested as to its purity, by volatilizing it with H Fl, and the residue, if insignificant, was neglected, or, if weighable, tested for sulphates by fusing it with sodium carbonate in a platinum dish, and accounting for it in the proper manner. In this way the barium sulphate reported in some waters in the Appendix was found. Oxides of iron and alumina were usually, and calcium oxalate was always, precipitated a second time; and magnesia, where it appeared necessary, was concentrated by evaporation and freed from oxalates and other salts of ammonia by ignition before precipitation. Iron, phosphoric acid, sulphuric acid and chlorine were determined each in a separate sample of water; chlorine volumetrically, and gravimetrically when present in sufficient quantity, as were likewise the other three bodies.

Determination of Constituents.

Alkalies (sodium and potassium) were determined in 200 c. c. to 1000 c. c. of water as chlorides, after considerable manipulation, and potash, when present, invariably as the double platinum salt.

Sulphuretted hydrogen and the total amount of carbon dioxide in these waters was rarely determined, as the requisite attention and preparation, in addition to the great task already set, could not be given to it. Further, it hardly promised a sufficient reward for the time, thought and care that would have been required to properly execute this work.

It might here be in place to say, that the salts of lithia, which appear in several analyses made by the author in the appendix, demanded in every case considerable quantities of water. Proof of their presence can now so easily be had, that the statement is ventured, that but few mineral waters within the State are devoid of lithia; it is a constituent of most of the limestones found here and is readily detected by the spectroscope in a solution, prepared by pouring small quantities of water at intervals over roughly pulverized lime rock.

Presence of lithia.

Calculation of results.

Given then the ultimate composition of the fixed residue of a mineral water and accepting the principle that the strongest bases combine with the strongest acids, the question of finding the real composition of the mineral matter, held in solution, is not yet a simple one. Other considerations in the chemist's mind affect the calculation of the results and deserve consideration here.

Silica and silicates.

Silica (SiO_2). Silica is a never failing constituent of every mineral water and is usually reported as such and not in combination. The hydrous silicates, which the percolating waters encounter in their passage through the rocks, are attacked, decomposed, dissolved, and as a result of the combined action of water, carbonic acid, oxygen — not to mention the presence, in many instances, of organic or inorganic acids — a small quantity of colloidal silica remains in solution; not more usually than from a fraction to one or two grains per gallon. Is the water alkaline, the case may be different; a larger amount of silica in conjunction with considerable sodium of potassium carbonate justifies the assumption of combination ; care must, however, be exercised in making sure that the silica is pure, free from sulphates of the alkaline earths that are apt to contaminate it, and that the water really contains carbonated alkalies. No neutral, or acid reacting water, not even a water containing but mere traces of alkaline carbonates, can be supposed to carry sodium or potassium silicate. Almost any limestone yields, on washing with water, a filtrate, which contains slight amounts of silica, sodium carbonate and sodium chloride, besides the ever present carbon dioxide, yet not in the proportion in which the two former might be expected to appear as the result of a dissolved silicate, for silica is the larger constituent of the two in solution. It is probable therefore, that waters containing silicates are rare and are found, perhaps, only among the hot springs of this and other countries.

Common salt and similar chlorides.

Alkaline Chlorides. These constituents are derived in every instance from deposits of ancient seas, or from fresh water deposits, that retained minute quantities of these substances, which only under very exceptional conditions are entirely absent from telluric waters. Chlorine is, therefore, united to the alkaline metals even when sulphates are present, and only in cases where its quantity is insufficient for the amount of these alkaline metals present do either sulphates or carbonates appear in the calculated results. This conclusion in all probability is correct, even considering the relative strength of the two acids; an addition of magnesium or calcium sulphate to a solution of common salt involves at the ordinary temperatures of our atmosphere and earth no change or division. For similar reasons, lithia whenever occurring in a water of neutral reaction, is calculated, as chloride or sulphate rather than as carbonate, even when it may seem more natural to assume it to have existed as carbonate in the rocks (*i. e.* limestones).

Chlorides of the Alkaline Earths. These compounds are calculated first, as magnesium and then as calcium chlorides; for, though calcium hydrate deprives the former readily of its acid, and proves thereby, apparently, the reverse order as preferable, the presence of even so feeble an acid as carbonic acid, not only arrests, but reverses this action.

Magnesium and calcium chlorides.

Sulphates. Sulphates, as already indicated, appear in the form of alkaline sulphates only when there is not enough chlorine present to neutralize the alkaline metals. More sulphuric acid goes to combine with magnesium and calcium in the order mentioned. Two cases may occur, the one in which calcium and magnesium is found with a less amount of sulphuric acid than will satisfy both, plus carbonic acid; the other similar to the first, excepting that the carbonate is replaced by chloride. The first conforms to the experimental result; calcium sulphate in solution decomposes magnesium carbonate and converts it and itself into magnesium sulphate and calcium carbonate; the second is less plain, for while moderately concentrated solutions of magnesium sulphate and calcium chloride would certainly react upon each other, more or highly dilute solutions, such as mineral waters are, retain larger amounts of calcium in solution than is possible through the solubility of calcium sulphate alone, a fact which probably weighs in favor of the view entertained.

Magnesium and calcium sulphates.

Other sulphates, in addition to those mentioned, could exist in a water only when, after providing alkalies and alkaline earths, sulphuric acid remains over. This occurs in some springs within the borders of the State, whose origin is traced to the oxidizing

Sulphate of iron and alumina occur in some waters.

effect of atmospheric agencies upon beds of shale or pyritiferous coals. In such cases both alumina and iron occur as sulphates, and when, even then, a surplus of sulphuric acid is left over, it becomes a matter of importance to know exactly the state of oxidation of the iron. If all is in the form of ferrous oxide, then sulphuric acid exists free; if more or less ferric oxide be present, then all the acid may be in combination. A glance at the third group of *sulphatic waters* in Chapter VII, as also at some waters in the Appendix, will illustrate the point, and it suffices here to say, that the existence of so large an amount of sulphuric acid as well as of ferric oxide is easily accounted for by the manner in which these waters originate. If the amount of alumina is small, it may not be worth while to calculate it as sulphate, but report it simply as dissolved (colloidal) alumina.

Ferrous Carbonate or Sulphate. These bodies in a water may offer a problem of increased difficulty to the conscientious chemist. Two cases may arise and the one is as simple as the other is complicated; if the iron on standing is *completely* precipitated from the water as ferric oxide, which, to be sure, in some cases takes a week, the conclusion is justified that it must have existed as a carbonate only. This will be the case in all so called pure chalybeate waters, that is those whose total quantity of mineral matter is small, and at the same time free from calcium sulphate. Boiling in an open vessel for half an hour accomplished the result quicker, and may be substituted for it as a perfectly reliable test for recognizing such waters; but to warrant the conclusion, attention should be paid to the fact, that the *whole* of the iron must have been precipitated so that none remain in solution, for partial precipitation, as is well known occurs also in the case of waters that carry the iron as sulphate. In the presence of considerable quantities of calcium sulphate the writer, in his experience, has often met with what, at the time, seemed puzzling and divergent results. A number of experiments were, therefore, undertaken to settle, if possible, the question at issue, and are here communicated. They lead, as will be seen, to the conclusion, that, when a water contains calcium sulphate, calcium carbonate being present or not, the iron which it may contain exists partly as carbonate and partly

Ferrous carbonate completely precipitated by standing.

as sulphate, and is not wholly precipitated from such water by either standing or boiling.

On the State of Combination in which Iron Exists in Chalybeate Waters.

(Substance of a paper written in 1875.)

In calculating the results of an analysis of a chalybeate water many difficulties are met with in the grouping of the bases and acids; this is especially the case when sulphates and chlorides of the alkaline earths are present, for then the question naturally comes up whether or no a part of the iron does not exist as sulphate or chloride. In all analyses so far come to my notice, sulphate of lime was a never failing constituent, and my experiments, I believe, fully prove its incompatibility w th carbonate of iron; a partial decomposition takes place, by which sulphate of iron and carbonate of lime are produced and the latter is precipitated, unless excess of carbonic acid and high pressure prevent it. No matter whether carbonate of iron in solution be brought into contact with sulphate of lime, or carbonate of lime be brought into contact with sulphate of iron, the result is always the same; the iron is divided between the carbonic and sulphuric acids, one-fourth of it uniting with the former and three-fourths with the latter. If chemists generally have calculated the iron as carbonate, whenever boiling or removal of carbonic acid by an air pump produced a precipitate, they have lost sight of the fact that only a portion of the iron is thus precipitated, while the larger part remains in solution; and this conversion or division of acids, of which I have spoken, takes place, not in consequence of elevated temperature, but at the moment of mixture.

A solution of ten grammes of green vitriol was placed in a bottle of three litres capacity, and lime water added until turmeric paper turned slightly brown, and a filtered part of the solution gave no precipitate with ammonia. The bottle was by this time nearly filled with liquid, which held a greenish, quickly subsiding precipitate of hydrated protoxide of iron in suspension; the whole was shaken up and carbonic acid was passed through for an hour, when most of the precipitated iron had redissolved. The clear limpid and colorless solution was then filtered off from the slight remaining precipitate and analyzed. It contained:

GRAMMES IN THE LITRE.

3.7948 gr. Sulphur Trioxide.
2.7942 gr. Ferrous Oxide.
1.0252 gr. Lime.

7.6142 gr.

In precipitating sulphate of iron with lime-water, gypsum is formed, which remains for some time dissolved in the liquid in larger quantity than is found to be the case, by experimenting upon the solid substance with distilled water. Carbonic acid does not affect the solubility, as proved by J. Davy, so that we may take all sulphuric acid found to have existed originally in combination with lime, as sulphate of lime or gypsum. This would require 2 6564 gr. of lime, while there are present only 1.0252 gr.; the difference, equal to 1.6312 gr. of lime, must have been precipitated, and can only have been precipitated as carbonate of lime. To precipitate however 1.6312 gr. of lime from its solution as sulphate would require 2.0972 gr. of protoxide of iron in the state of carbonate, and as all the iron present must have been originally carbonate, the difference, equal to 0.6970 gr. of FeO, must still exist as such in the solution. There might perhaps be an objection raised to carbonate of lime being precipitated in the presence of carbonic acid, while carbonate of iron is held in solution; but the former yields up its carbonic acid much more readily than the latter, as I found by placing both of them side by side under a bell jar, with caustic potash and potash and pyrogallic acid. Carbonate of lime separated completely in a few days; carbonate of iron had formed only a slight precipitate after a month, and yielded by boiling a copious precipitate of oxide.

The composition of the solution then was:

2.0972	FeO as Sulphate of Iron.
0.6970	FeO as Carbonate of Iron.
1.0252	CaO as Sulphate of Lime.
3.8194	

The proportion between the iron as sulphate to that as carbonate is exactly as 3:1; we might therefore expect that under the same or similar conditions one-fourth of the iron present would be precipitated by boiling. The experiment was made at the time with a portion of the same liquid, which was boiled three successive times, the precipitate being filtered off each time, dissolved in acid and reprecipitated and weighed. The second and third precipitate contained, or were altogether, basic salt, as sulphuric acid was found in them in larger proportion than was required for the lime that was mixed with them.

		Per cent.
First precipitate	0.7058 FeO =	25.26
Second precipitate	0.1613 FeO =	5.77
Third precipitate	0.0797 FeO =	2.85
Remained in solution	1.8474 FeO =	67.12
	2.7942	100.00

Another experiment was made by putting aside a part of the solution and filtering off the precipitate which had formed after the lapse of a month, and boiling then the filtrate:

		Per cent.
Precipitated by standing	0.7438 FeO =	26.62
Precipitated by boiling	0.1795 FeO =	6.42
Remained in solution	1.8709 FeO =	66.96
	2.7942	100.00

The results of these experiments, it seems to me, prove satisfactorily my proposition; namely, that carbonate of iron is decomposed by sulphate of lime; the reverse, however, is equally true and equally supported by facts. Carbonic acid gas was passed through lime water, which was kept cool by placing the bottle in snow, until much of the precipitate, which had formed at first, was redissolved. The fluid was then filtered, and with proper precaution — that is, exclusion of air — mixed with a small quantity of sulphate of protoxide of iron. The solution remained clear and colorless. It contained, by analysis, 1.4816 gr. of FeO to the litre. A portion of it was boiled, whereby a precipitate formed, which was filtered off and analyzed; it was perfectly free from sulphuric acid, proving the absence of all basic salt, and amounted to —

		Per cent.
Precipitated	0.3397 gr. FeO	= 23.93
In solution	1.1419 gr. FeO	= 76.07
	1.4816 gr.	100.00

It seems to me, then, that in calculating the results of an analysis of a chalybeate water, containing much gypsum, one-fourth of the iron present should only be counted as carbonate, and the rest as sulphate.

In calculating, then, the iron in a mineral water, the character of the latter should, in all cases, be ascertained, in order to represent truly its condition in the water; ferrous carbonate alone exists in all pure and saline chalybeate waters (first and second groups); ferrous carbonate *and* sulphate exists in all semi-chalybeate waters (third group) and ferrous sulphate, either alone or mixed with ferric sulphate, exists in all vitriolic waters (third group of sulphatic waters). If the calculations in the third group of chalybeate waters has not been made in correspondence with these ideas, it was because the inherent difficulties led to the acceptance of a departure from this rule by chemists generally, when expressing the results for every-day use.

Ferrous sulphate besides ferrous carbonate in semi-chalybeate waters.

Carbonates of Alkalies and of Alkaline Earth. These compounds are represented in the composition of a mineral water whenever a sufficiency of chlorine and of sulphuric acid is lacking; but not only this, since carbonates of the alkaline earths are insoluble, they must all appear as bicarbonates, in which condition they exist in all waters without the least doubt or uncertainty. Such representation is perfectly justifiable even when no complete determination of carbon dioxide has been made, since the amount of the latter exceeds in all cases that needed for the purpose of combination.

The question of calculation may then be dismissed with the following schematic arrangement showing the order and manner in which the various constituents of mineral waters have been combined:

SCHEDULE FOR CALCULATING PROXIMATE CONSTITUENTS.

1. SiO_2. (or silicate).
2. $Al_2\,O_3$. (or sulphate).
3. Li Cl.
4. Na Cl.
5. K Cl.
6. $Mg\,Cl_2$.
7. $Ca\,Cl_2$.
8. $Li_2\,SO_4$.
9. $Na_2\,SO_4$.
10. $K_2\,SO_4$.
11. $Mg\,SO_4$.
12. $Ca\,SO_4$.
13. $Fe\,SO_4$.
14. $Fe_2\,3SO_4$.
15. $Al_2\,3SO_4$.
16. $Fe\,H_2\,2\,CO_3$.*
17. Other bicarbonates.

THE UNIT USED FOR THE EXPRESSION OF RESULTS.

Units in Use. In expressing the results of the analysis of a mineral water much diversity of opinion prevails; grammes in a litre; parts in 1,000 or 100,000; grains in a pint or gallon are alike used for the purpose. This difference is, however, generally deplored; in fact to such an extent has the desire for uniformity made itself manifest, that the question has been taken up by the American Association for the Advancement of Science, but without, so far, meeting with a generally satisfactory solution. Grains per gallon in the United States and England, grammes per litre in France and parts per 1,000 or 100,000 in Germany are probably the preferred standards.

Parts in 1,000. Grammes per litre. Grains per gallon.

Controlling Principles. Which standard to select, depends altogether upon the view we take of the object of such an analysis. If it be simply to furnish a basis for the investigations of chemists or geologists regarding the chemical affinities of certain substances, or the manner, extent and origin of their solution, then grammes per litre or parts in 1,000 would probably be the most serviceable expression. It might almost seem superfluous to point out the difference existing between the two, if it was not for the fact that the writer, in looking over a considerable number of

Grains per gallon adopted.

* This symbol, though doubtless expressing the present views of chemists on the structure of chemical compounds, is open to objections. No bicarbonates of iron or of the alkaline earths have ever been obtained in solid form and, if existing at all, must be very unstable. It may be questioned, therefore, whether such bodies really exist, or whether they are not merely carbonates dissolved in carbonic acid; just as sulphates, even barium sulphate, dissolve in concentrated sulphuric acid. Besides, it is desirable to indicate in a chemical analysis of a mineral water the individual as well as the total amounts of mineral matter in solution, aside from any water, that may be in combination or not. I would suggest the use of the symbol: $M\,CO_3.\,CO_2$ or $M_2\,CO_3\;CO_2$ as may be required, as advantageous; it eliminates the water; it suggests the solution of insoluble carbonates; it distinguishes combined from semi-combined carbonic acid.

analyses of mineral waters in which parts per 1,000 and grains per gallon are given simultaneously, has found this difference to have been lost sight of. Grammes per litre would be parts per 1,000 only when the litre of mineral water weighed just 1,000 grammes, which can, of course, never happen. There is then no way of connecting parts per 1,000 with grammes per litre, unless the specific gravity of the water is known. This determination is often neglected, partly because it must be made at the springs before any of the gases have escaped, and partly, also, because it is considered of little importance. The expressions above criticised were evidently founded upon a determination of grammes per litre; from this was calculated grains per gallon and, by a *saltus*, grammes per litre became parts per 1,000.

Grammes per litre not parts per 1,000.

If the analysis, however, has a different object viz.: to enable the physician and educated layman to form an opinion, not alone of the character of the water, but of its strength — a kind of estimate of the quantity of active substance in a dose — then, for this country at least, grains per gallon or per pint is a comprehensible, and, in every way, practical mode of expression, that especially in a report, largely designed for the use of intelligent citizens, should be adopted and retained. In recognition, however, of the desire of easily comparing the waters here investigated, with those of foreign countries, grammes per litre of the immediate constituents and the specific gravity is recorded side by side with the old and yet vital standard of grains per gallon.

This is a unit of more general use.

THE CLASSIFICATION OF MINERAL WATERS.

The Need of Classification. As, in describing the unit of expression for recording the results of analyses of mineral waters, concessions were made to the side of utility, so likewise must the claims of utility have a voice in the selection of a proper classification. That a classification, — "a systematic arrangement of the facts or phenomena," — of the different waters is desirable goes without saying. A central thought, binding the individual members into groups and the groups into classes, and these again into a whole is not only evidence of

Classification must consider utility.

comprehensive knowledge, but also a light by which additional knowledge becomes attainable. Philosophy, therefore, as well as convenience, demands thought, system and arrangement.

Obstacles to Classification. Yet, it is plain that nature herself is a unit, a succession, an evolution without division, which means breaks, and that any classification must of necessity be artificial, a means to an end rather than the end itself. And what should this end be? An attempt at illustrating the geologic history of our earth, whose strata are broken through in every conceivable direction by telluric waters, that in part reach again to light and offer in their dissolved substances, a key which invites to use. Certainly, no mean or undesirable object. But the mineral waters are as varied as the earth's crust. The chemist has ascertained their compositions by the thousands as the physicist their temperatures and pressures, and yet new combinations appear with almost every new mineral water that is analyzed, that call for adjustment, alteration or improvement of the plan. Never, indeed, can we hope to reach that ideal success in our efforts to read nature (that perfection in our arrangement or classification, which properly locates and firmly connects *every* link in a chain of evidence), which results in perfect light where before there was darkness, in absolute certainty, where before was error. The futility of ultimate ideal success is, however, no argument against making the attempt at a useful compromise; a lofty ideal must be kept in mind and, if a true one, will encompass any plan, whose object is an orderly yet serviceable arrangement of facts. The discernment of unity in diversity is alone meritorious and will bear fruit.

Nature has no divisions.

Mineral waters of infinite variety.

Guiding Principles. In this report no classification of the mineral waters of the world is attempted, simply because Missouri does not possess types of all the waters found on our globe, a fact which justly restricts and simplifies our plans, as it has simplified and restricted our labors.

The utilitarian side of the proposed classifications is manifest in the direction of enlightening the masses rather than the few, for in that lies the very idea of utilitarianism: light for the many; knowledge comprehensible as it should be applicable, and applicable in enabling men to form a judgment as to the

A classification to be of use.

realization of hopes from the use of mineral waters upon the basis of statements, such as a report addressed to them as well as to the men of science may naturally be expected to furnish.

I have not attempted, here, to criticise the classifications of others; all, as it appears to me, possess merits and rest to a certain extent at least, upon a knowledge of the uses and effects of mineral waters upon the human body. These effects are referable to certain substances held in solution, and, when predominant, can be named without thereby either asserting or denying a modification in these effects by the presence of other bodies associated and dissolved with them. The names of classes then, in which the mineral waters are placed, are connotative and tell their own story; each class is subdivided into groups as may be necessary or desirable, the whole representing a plain, practical, and, as is thought, a scientific arrangement. By a slight addition, this classification could be made so complete as to embrace all mineral waters, including those not as yet represented in the State of Missouri.

SCHEDULE OF CLASSIFICATION.

CLASS I. MURIATIC WATERS.

Waters containing, as their main constituents, sodium chloride or common salt.

a. *First Group.*

Waters containing, besides sodium chloride, also calcium chloride, magnesium chloride, calcium sulphate (magnesium sulphate absent).

b. *Second Group.*

Waters containing besides sodium chloride, also magnesium chloride, calcium sulphate (calcium chloride absent).

c. *Third Group.*

Waters containing besides sodium chloride, also magnesium sulphate, calcium sulphate (calcium chloride and magnesium chloride absent).

CLASS II. ALKALINE WATERS.

Waters containing sodium carbonate or magnesium carbonate.

a. *First Group.*

Waters containing sodium carbonate with or without magnesium carbonate.

b. *Second Group.*

Waters containing magnesium carbonate only.

CLASS III. SULPHATIC WATERS.

Waters containing one or more sulphates as their main constituent.

a. *First Group.*

Waters containing sodium sulphate or Glauber's salt.

b. *Second Group.*

Waters containing magnesium sulphate or Epsom salts.

c. *Third Group.*

Waters containing ferrous sulphate, ferric sulphate, aluminum sulphate, either singly or together.

CLASS IV. CHALYBEATE WATERS.

Waters containing as their most efficient constituent some ferrous carbonate.

a. *First Group.*

(Pure Chalybeate waters.) Waters containing ferrous carbonate, magnesium carbonate, sodium carbonate (magnesium sulphate and calcium sulphate absent).

b. *Second Group.*

(Saline Chalybeate waters.) Waters containing ferrous carbonate magnesium carbonate, magnesium sulphate (sodium carbonate and calcium sulphate absent).

c. *Third Group.*

(Semi-Chalybeate waters.) Waters containing ferrous carbonate, magnesium carbonate, magnesium sulphate, calcium sulphate. (This latter, as explained previously, involves the existence of ferrous sulphate.)

CLASS V. SULPHUR WATERS.

This class might naturally be divided into three groups: waters containing sulphides only; waters containing sulphides and sulphydrates, and waters containing free sulphydric acid, sulphides and other thio-compounds. Since no determination of sulphur in this direction was attempted, the two waters, subsequently mentioned, are not grouped but simply placed within the class.

CHAPTER III.

THE THERAPEUTICS OF MINERAL WATERS.

The general uses of Ordinary Waters.—The use of Mineral Waters.

To enter here into a complete discussion of the medicinal value of mineral waters can neither be expected nor will it be attempted. Some general statements, however, seem not only desirable but appropriate, especially since the effects of mineral waters upon the human organism are more accurately observed and better comprehended by most people, than are those of any other medicinal agent. Yet in this, as in other popular conceptions which should be based upon an understanding of cause and effect, dissuasion and encouragement, denial and assent, are linked together.

General statements only attempted.

THE GENERAL USES OF ORDINARY WATERS.

Bathing and Drinking. Bathing and drinking are the two forms in which mineral waters may affect our system; but not only mineral waters, even the common potable waters of our homes will, under proper conditions, produce a marked effect which it may be well enough to recall and to understand. We usually bathe for purposes of cleanliness, and, as cleanliness is next to godliness, the habit should be encouraged, extended and practiced; physical well-being precedes moral and mental well-being and cannot prevail for any length of time where the habit of bathing is neglected. We evaporate daily an average of 20 to 30 ounces of water, with various saline and gaseous matters in solution from our skin; this is effected by a system of pores, distributed over the whole of our body, whose number is estimated at 7,000,000 and their combined length at 28 miles. A part of the solids, consisting of salts with mucus-like and epithelial matter remain behind and will, in time, effectually

Baths a necessity to physical and moral well-being.

prevent the very important normal action of the skin as a purifier of the system, unless attention be paid to keeping the pores open and free. So far, then, bathing is nothing but an act of domestic hygiene and, though practiced for thousands of years by all nations that have left their impress upon the development of mankind, its close connection and agreement with the modern spirit of medicine is only in these latter days observed and appreciated. To prevent disease is the higher and nobler mission of medicine, and a graver and more important politico-economic factor to a nation than to cure it, is well expressed by the inscription over some old baths, "*in balneis salus*," and might be inscribed with propriety over every public and private bath-house to-day.

Evaporation from body; pores.

To prevent disease rather than cure it the mission of medicine.

Hot and Cold Baths. A special medicinal function of the bath is to act by hot or cold water — in distinction to the temperate water used in ordinary bathing — upon the system; hot water to induce more abundant secretion through the skin, as well as to induce absorption of medicinal agents, held in solution; cold water to produce a shock with its subsequent salutary reaction; the former is temporarily weakening, though its final effects may result and often do result in the cure of diseases that through long standing have become chronic, difficult of treatment, well-nigh incurable and a burden to the person afflicted with them. Such cures, as a matter of course, take time and, like every truly medicinal measure, should be under the direct charge of an expert physician. The latter needs explanation as to the meaning of "shock." Our body is furnished on the outside with a net-work of capillary blood vessels, the distention or contraction of which induces a greater or smaller flow of blood through them; redness and paleness of the skin are respectively the visible signs of such conditions, which at the same time is accompanied by a greater or smaller transpiration of liquid, the perspiration of the body, and the sensation of more or less heat. A system of nerves, the vaso-motor system, regulates the distention or contraction of the capillaries and a sudden partial or complete immersion in cold water causes these nerves to make the capillaries to contract. Such contraction may extend to the inner organs of the body, producing spasms accompanied by

Effects of baths.

Vaso-motor system.

difficulty of breathing, the whole of which is called a shock. The immediate effect of such shock is a greater effort of the heart, stronger contractions, a fuller pulse which sends the blood to all parts of the body; this continues some time after the reaction sets in, by which the capillaries are nearly as much more extended as they had previously been contracted. As there is now less resistance to the flow of blood through the fine ramification of the arterial system, an actually greater quantity of blood passes through all parts of our body, including the brain. This produces a greater vitality, a feeling of increased strength, courage, joyousness and mental power, which, though in itself desirable, may further, by its powerful psychic reaction upon the body, result in permanent improvement to the whole system.

Reaction upon heart.

Digestive Action of Pure Water. In a similar manner, the beneficent action of water, even when free from medicinal agents, becomes apparent through the digestive tract. In such cases large quantities of hot (not warm) water result in increased activity of heart, lungs, skin and kidneys. This latter organ performs a most important function, which is to remove from the blood all those deleterious bodies, which naturally occur in it as the result of vital processes, besides those — mostly mineral substances — that have found their way into the circulation in a purely mechanical manner. An increased quantity of water, then, must stimulate the action of the kidneys, because blood possesses a normal degree of concentration, below or above which it can deviate but slightly, and such dilution increases its volume and at the same time its intra-arterial pressure. This stimulation, this greater activity of one organ, involves, however, in every case, better nutrition, and better nutrition means better and more blood for all the organs of the body, improvement, if not cure, of "old troubles," better health and greater strength and endurance.

Metabolic products removed by kidneys.

Influence of Surroundings. Thus it appears that water alone when properly administered, is a powerful agent for the restoration of health; more so yet, a mineral water, especially when used in conjunction with an enjoyable change of place and diet, two most important factors in its action.

Effect of environment.

"*Curæ vacuus hunc adeas locum*
ut morborum vacuus abire queas"

was the inscription above the baths of Antoninus at Rome: "Come to this place free from care that you may leave it free from disease." The psychic agency in the cure of disease is powerful and in no instance to be neglected; change of place, of surroundings, if possible of climate; a diet different from the one we have been accustomed to, though it may not be better; cheerful companions, exhilarating and reasonable recreations will often do wonders. Aided by the proper use of mineral waters a "cure," then is as pleasant in many instances as it is effective and to be recommended to and preferred by the afflicted to the pills and lotions, which to be sure must sometimes be swallowed, but which as a domestic remedy receive altogether more attention than they deserve.

Curative effects of recreation.

THE USE OF MINERAL WATERS.

The Manner of Drinking. As to the manner of drinking a mineral water, much depends on time, circumstances and individuality. Quantity, it must be borne in mind, is an important factor, but a just measure of moderation is here likewise necessary. The time-honored custom of rising early and taking before breakfast one to four glasses of the water, amounting to not more than a quart in all, is to be recommended. The water should be taken slowly, glass by glass, allowing an interval of a few minutes between the first and second and between the third and fourth glasses, and from ten to twenty minutes between the second and third; this latter interval should be passed in walking and a walk of a half mile or a mile at the end is recommended. In the case of the stronger mineral waters this morning potion is sufficient and is preferable to taking the water at any other time of the day. Chalybeate and other less potent waters may be taken differently and in larger quantity. The time which experience has set for a "cure" with these latter waters, under ordinary conditions, should be reckoned at not less than four weeks; a shortening of this period by a greater daily consumption of water is unwise and sometimes even dangerous.

Drinking not bolting.

Exercise between drinks.

After this general statement the different classes of mineral waters may be passed in brief review as to their medicinal virtues, confining our remarks, however, to such observations only as will admit of easy and of general application.

1. *Muriatic Waters.* The use of muriatic waters, of which ocean water is perhaps the best known type, for purposes of bathing is as old as our race. The effect in general has already been sufficiently described, and is heightened by the powerful blow of the surf, wherever this is obtainable or called for; feeble constitutions neither desire or bear this well, however, and require still-water bathing, which is provided under about similar conditions to the ocean bath, by a number of watering places of the State. Several of these possess brines of the density of ocean waters—about 2,000 grains of mineral matter to the gallon—and are often near springs of different character, by which their usefulness is extended. The composition of the brines differ as a rule, from that of sea water. This is an advantage, rather than otherwise, when they, at the same time, are to be used for drinking. Only the feebler of these brines, however, are adapted for this latter purpose, and should be thus used with caution or after consultation with a physician. The bath, either alone or aided by the internal use of waters in diluted form, is invigorating, increases the action of the skin and becomes by absorption of some of the constituents a genuine tonic; scarcely any one using it will fail to derive benefit from it, provided only attention be paid to securing the proper reaction, so that the chill, incident to the bath, give place to warmth and glow of the skin. This, of course, requires a proper regulation of the length of time one should remain in the water, which may vary from 5 to 20 minutes, the simple rule being to leave the water before the second chill supervenes.

Action of surf an element in sea-bathing.

Need of preventing chill when bathing.

The temperature of the water for invalids should be between 85° F. and 90° F., and its strength between 900 to 1,800 grains of mineral matter per gallon. In fact, the former provides already a very acceptable salt water bath, with its usual concomitants of a sensation of moistness of the skin after rubbing it completely dry and a feeling of itching and burning, produced by adherence of the saline matter to the skin and its introduc-

Effect of baths upon skin.

tion into the pores. When the water is to be taken internally, it should invariably be taken in the morning in small quantity and, where necessary, diluted. It thus stimulates the mucous membranes, increases the flow of digestive fluids, aids the metamorphosis of albuminoid tissue, and, while apparently tending to reduce the body weight, increases the appetite. The resultant more perfect nutrition induces a general restorative action of the body, giving it better color, better blood, greater vigor and improved health. Though tempted to indicate the diseases which might be expected to be benefited by the muriatic and other waters to be here described, it is thought best to leave this to the members of the medical profession who are better able to perform this very important duty.

Water should be taken internally in the morning.

2. *Alkaline Waters.* The alkaline waters of Missouri are, in a measure, different from those of other States and of Europe; the abundant supply of gaseous carbonic acid which characterizes these latter to such advantage, is here reduced to a moderate, but yet perceptible quantity. If the cause which, in many of the foreign springs, is assigned to explain the presence of this gas, *i. e.*, connection with present or past volcanic action — be true, the relatively small amount in Missouri waters is the necessary consequence of their different origin. The percentage of mineral matter in them conforms, however, to that in similar waters elsewhere, being small and permitting many of them to be placed in the list of potable or domestic waters. Only a few are truly dietetic and still fewer really medicinal. These latter contain alkaline chlorides, sulphates, salts of magnesium and often lithia.

Little mineral matter in solution.

The alkaline waters, on direct contact or taken internally exert a marked effect upon all mucous membranes. Secretions are increased, rendered more fluid and, in the case of the respiratory passages, easier to raise; their use, therefore, is indicated in catarrh, either recent or chronic, provided only there remain a certain degree of irritation. It extends further to inflammation of all mucous membranes in general; catarrh of the stomach, intestines, especially when accompanied by chronic diarrhœa, and that form of dyspepsia which is connected with an excess of acid

Benefit derived from alkaline waters.

in the digestive tract. In all such cases a greater quantity of water than has previously been mentioned, must be consumed, thereby, at the same time, increasing the activity of the skin and kidneys; sight must not be lost of the fact, however, that long continued and large doses of alkaline water may impair digestion and exert a deleterious effect upon the blood corpuscles.

Lymph, blood and all secretions of mucous membranes contain sodium carbonate or bicarbonate as a never failing constituent. Without further theorizing as to its function, suffice it to state that it aids oxidation, and much of it in the blood may induce such rapid metamorphosis as to produce anæmia, for which reason the medicinal use of alkaline water has often to be followed by that of a chalybeate. As to effects and results of bathing nothing need be added to the statements made before.

Sodium carbonate aids oxidation in the system.

3. *Sulphatic Waters.* The four groups of sulphatic waters — Glauber's salt, Epsom salts, Alum and Vitriol waters —find each a representative in Missouri. The two last, from similarity of origin and character, as fully explained later on, have been placed in a single group. They demand here a separate treatment, as they are not in any case hygienic, but strictly medicinal, and have only in common their use in medicine, *i. e.*, in small doses, and their non-use for bathing.

Glauber's salt waters contain, as their main constituents, sodium sulphate with variable amounts of sodium chloride and alkaline and earthy carbonate. They should be taken in the morning in one or two doses of half a glass or a glass each, to be increased only by special direction. They are mildly laxative with a tendency to retard albuminous metamorphosis, while aiding the oxidation of fat, and are therefore conservative rather than constructive; but in cases of catarrh of the stomach and intestines, accompanied by loss of digestive power, relief or cure through the use of the waters encourages the formation of new tissues and results generally in an increase of body weight. Larger doses of the water, of course, prevent such effect by rapidly carrying the contents of the digestive tract through the body so as to prevent complete absorption; it is possible therefore to make a "cure" either restorative or reducing. The

Glauber's salt a laxative.

alkalinity of the water, as has already been pointed out in the case of the alkaline waters proper, exerts a salutary effect upon the liver, increases the flow of the bile and relieves or cures any existing catarrh of the gall ducts.

Epsom salts are diuretic.

Epsom salts waters contain magnesium sulphate as their chief constituent, with alkaline sulphates, but no chlorides or carbonates. In small amounts, taken just as the Glauber's salt waters are, they are laxative, giving the fæces a dark color. They are diuretic, and induce albuminous metabolism, as well as oxidation of fat; sodium chloride and urea appear in the urine in larger than normal quantities, and, though the appetite increases, the body weight diminishes, forbidding the use of these waters in fever, congestion of the stomach and all cases of enfeebled constitution. Strong and vigorous individuals, suffering from abdominal plethora, hemorrhoids, excessive fat formation and certain functional derangements of the liver and, perhaps, Bright's disease, are most benefited by them. Too long continued use, or rather abuse, produces catarrh of the mucous membranes of the intestines and should be discouraged.

Vitriolic waters contain variable, but considerable quantities of iron and aluminium sulphate; but, as they are powerfully active and their range of usefulness rather circumscribed, they should, in every case, come under the direct supervision of a medical adviser. The experiences gained with them at the two springs of this kind in the State, hereinafter referred to, may serve as a guide to their proper use.

Chalybeate waters numerous.

4. *Chalybeate Waters.* The Chalybeate waters derive their virtues from ferrous and manganous bicarbonates, either alone or in conjunction with earthy salts and, perhaps, ferrous sulphate. They are for number, extent and variety of composition the most remarkable of the spring waters of Missouri, and equal in many instances the most famous springs of the kind in Europe. As to their physiological function, but little can be said at present. That iron is a normal constituent of the red blood corpuscles; that it is contained in milk, urine, bile, the secretions of all mucous membranes and probably in other parts of the body, is well known. That salts of iron, absorbed by the stomach or injected into the blood, do not appear again immediately in

any secretion is equally well known. That ferrous bicarbonate, as also sulphate and chloride is, in advance of resorption, converted in the stomach or intestinal ducts into an iron albuminate is highly probable; but, as to the manner in which iron exercises its special functions, its modus operandi, as it were, we are yet ignorant and must be satisfied with the bare results of clinical experiences in its use, which are fortunately as striking as they are general. Its main effect, on which doubtless the whole of its efficacy hinges, is the fact, that the number of red blood corpuscles, fallen for any reason below a certain minimum, is increased by the introduction of iron into the blood. Plenty of blood corpuscles means plenty of good blood, and plenty of good blood means, other things being favorable, the normal performance of its functions by each organ, the overcoming of detrimental tendencies, the invigorating of the nervous system, the acquisition of strength, endurance and the power of enjoyment, or in a word, good health, courage and contentment.

Its effect on red blood corpuscles.

To attain this improvement of the blood larger doses of the water must be taken than previously stated. Four glasses, or a quart before breakfast in the morning, two glasses about 11 a. m., the same quantity at 4 p. m. and enough more after supper as will relieve thirst is probably a proper amount. Attention should be paid to its proper digestion, especially in the case of those waters that contain ferrous sulphate and considerable amounts of other salts (the members of the third group of the Chalybeate waters), in order to prevent nausea or other similar disturbances that would interfere with beneficial action. As a rule, it may be stated that the pure chalybeate waters, those of the first group can be taken with perfect freedom by the feeblest constitution, since they are all easily digestible and comparatively devoid of taste, and, in a manner, relished after short use.

Digestion of chalybeate waters.

All persons then, may expect to derive benefit from chalybeate waters whose constitutions are enfeebled by excesses, old age or disease. Anæmia, chronic, nervous and female diseases, impotency and the host of troubles incident to any or all of these may advantageously be treated with a "cure" with iron. Such patients must, however, be carefully watched or the "cure" altogether abandoned when their cases are complicated by functional lesions of heart or lungs.

4. *Sulphur Waters.* To attempt an explanation of the med-cinal effects of a sulphur water is difficult and apt to result in disappointment. That such waters are potent in their effects upon the skin, the mucous membranes in general, and those of the air passages in particular, as also upon the liver and the whole portal region is demonstrated in numerous cases. It is likewise known that the efficacy of such waters does not depend so much upon the free sulphuretted hydrogen, which they contain, as upon the sulphides and perhaps other sulphur compounds, from which after their entry into circulation sulphuretted hydrogen is evolved.

What organs acted upon.

The free gas inhaled or, in solution in water, taken into the stomach rapidly leaves the body without producing any apparent effect; while, when eliminated from sulphides that had entered into circulation, it manifests its presence by the appearance of a characteristic absorption band in the blood, as also by its quick and powerful effects upon the organism at large.

Free sulphuretted waters inert.

Waters, therefore, which contain soluble sulphides, a rather unstable and easily decomposable class of bodies, are of much greater therapeutic value than waters, merely rich in gas, though the gas be chiefly sulphuretted hydrogen. It is for this reason very important, in analyzing sulphur waters, to determine accurately the state of combination, in which the sulphur exists in them, and if this has been done in but few cases the omission is attributable to the troublesome necessity of conducting a part, at least, of the operations leading to an analysis, at the springs. It may be presumed, however, as highly probable that all waters containing sodium bicarbonate contains their sulphur wholly or in part in the form of sulphide, and all such become active and valuable therapeutic agents, whose chief effects center in their action upon the liver and portal region.

Alkaline sulphur waters contain sulphides.

The liver, as the organ which manufactures the bile, requires for this purpose the same elements that make red blood corpuscles. It is probable that these corpuscles, like all organisms possessing individual lives, grow old and decrepit in time, and in this state, having become useless and even deleterious to the body which harbors them, they furnish the material employed by the liver for this purpose. To remove them from circulation and to produce bile, itself actively engaged in the process of digestion, is the twofold office of the liver, and sulphur waters are a powerful auxiliary toward this end. The sulphur of those waters, powerless probably in the case of healthy red blood corpuscles, seizes upon and destroys the aged and effete ones, thereby producing or at least increasing the raw material, upon which the liver depends for action. The result is more and better bile; a reduction of an engorged and torpid liver to its natural condition; a better digestion and nutrition with a return of strength and vigor to the whole organism, or a renewal, as it were, of life with the disappearance of the gloom which so often engulfs the minds of this class of sufferers.

Effete blood corpuscles the source of bile.

Sulphur waters aid in the formation of bile.

It is to be remembered, however, that a cure by means of a sulphur water is destructive rather than constructive, and that a generous diet is, therefore, not only admissible but advisable; and further, that the cure should not be continued for too long a time.

Sulphur waters destructive, not constructive.

Besides the effects described, sulphur waters act directly upon skin and mucous membranes, taken internally or in the form of baths, or better yet, both results are reached, which, by their quickness and completeness of restoring health, are often surprising. In this effect some of the brines take a share, and deserve, along with the sulphur waters proper, a more generous attention on the part of the medical profession, than they seem to have so far received.

Alkaline sulpho-saline waters.

PART II.

THE MINERAL WATERS OF MISSOURI.

A systematic description and the results of analyses of the mineral waters of the State.

CHAPTER IV.

THE MINERAL WATERS OF THE STATE.

VALUE OF MISSOURI WATERS—LIST OF MINERAL WATER LOCALITIES.

Value of Missouri Waters. The abundance and value of the mineral waters of the State are striking; nearly every county possesses its springs, whose waters have acquired a local reputation. Many of these, indeed, possess virtues of a very high order, which, in time, must render them famous beyond the confines of the State, and destine them to become sources of relief for suffering mankind. A very considerable development of interest in these waters has actually taken place during the last ten years; health resorts with their accompaniments of modern hotels and modern comforts and pleasures can be found in half a dozen counties, the aggregate value of which reaches high up into the hundreds of thousands of dollars. These are, as it were, the pioneers in the establishment of true sanitaria. For such to be entirely successful many conditions must concur, which it is unnecessary to enumerate here beyond the fact that trained physicians, that is physicians who have given years of time and thought to the study of the effects upon their patients of the particular mineral water in question, so as to be able to advise with intelligence and knowledge, are a prerequisite to success; without these a watering place is liable to become a mere place for pleasure or, worse yet, for dissipation, and does not deserve the name of health resort.

Value of and investment in Missouri mineral waters.

The mineral waters of the State may be properly treated under five heads:—

1. Muriatic Waters.
2. Alkaline Waters.
3. Sulphatic Waters.
4. Chalybeate Waters.
5. Sulphur Waters.

Index of springs investigated and analyzed.

For easy reference the 83 waters collected and analyzed by the officers of the Survey during the years 1890 to 1892 are tabulated in the following list of localities, arranged alphabetically by counties. Additional analyses of waters from either the same or different springs, but made by chemists not connected with the present Survey, are placed in the Appendix and may be found by reference to the general index at the end of this volume. Of the 83 original analyses here recorded, 48 were made by Woodward and Robertson, and 35 by Schweitzer, and the results are marked respectively by (W.), (W. & R.), or (S.). The localities were visited and samples collected in a uniform manner by different individuals and the sources of the various descriptions are indicated in the same way by initial letters. Each water of the following list is referred to its class and group under which it is discussed in the following chapters.

LIST OF MINERAL WATER LOCALITIES OF THE STATE.[1]

EXAMINED, SAMPLED AND ANALYZED BY THE GEOLOGICAL SURVEY DURING THE YEARS 1890 TO 1892.

BARRY COUNTY.
- Panacea Spring.................... Alkaline Water....First Group.

BENTON COUNTY.
- Boling Spring......................Muriatic Water...Second Group.
- Clark Spring...................... " " ... " "

CAMDEN COUNTY.
- (a) Climax Spring..................Alkaline Water....First Group.

CASS COUNTY.
- (a) McLelland's Spring............Sulphur Water
- Elliott's Well...................... " "

CEDAR COUNTY.
- (a) Jericho Spring ....Chalybeate Water..First Group.
- (a) Park Spring (Eldorado Sp.)...... " " .. " "
- Main Spring (9 Wonders)........... " " ..Third Group.

CHARITON COUNTY.
- Deep Well (Brunswick)...... .....Muriatic Water....Second Group.

CLAY COUNTY.
- (a) Sulpho Saline Spring (Excelsior Sp.)..........................Muriatic Water....Third Group.

[1] An (a) in front of a name means that the water has been analyzed before and the results are found in the Appendix.

CLAY COUNTY — *Continued.*

(a) Roger's Spring.................Chalybeate Water..First Group.
(a) Reed's Spring.................. " " ..Second Group.
(a) Siloam Spring (Excelsior Sp.)... " " .. " "
(a) Regent Spring (Excelsior Sp.)... " " .. " "

CLINTON COUNTY.

Plattsburg Spring..................Alkaline Water....First Group.
Frost's Spring.....................Chalybeate Water..Second Group.

DAVIESS COUNTY.

Jamesport Mineral Well............Chalybeate Water..Third Group.

GENTRY COUNTY.

Siloam Spring......................Chalybeate Water..Second Group.

HENRY COUNTY.

Artesian Well (No. 1) (Clinton).....Muriatic Water....Second Group.
Windsor Spring....................Alkaline Water....First Group.
Water Works Well (Artesian Well No. 2.) (Clinton)..............Alkaline Water....Second Group.
Artesian Well (No. 3) (Clinton)..... " " .... " "
Sand Creek Spring.................Chalybeate Water..First Group.
Montrose Well..................... " " ..Third Group.

HOWARD COUNTY.

(a) Boonslick Spring...............Muriatic Water....First Group.
Glasgow Mineral Spring........... " " ... " "

HOWELL COUNTY.

Siloam Spring......................Chalybeate Water..First Group.
Cure-all or Dixon Spring...........Alkaline Water.... " "

JACKSON COUNTY.

Cusenbery Spring..................Alkaline Water....First Group.
Lithia Spring.......................Chalybeate Water.. " "
Greenwood Spring.................. " " .. " "

JEFFERSON COUNTY.

Sulphur Spring.....................Muriatic Water....First Group.
(a) Afton Spring................... " " .... " "
(a) Council Spring................. " " .... " "
(a) Montesano Spring............... " " .... " "

JOHNSON COUNTY.

Post Oak Sulphur Spring............Alkaline Water....First Group.
Pertle Spring.......................Chalybeate Water.. " "
Reed's Spring...................... " " .. " "
(a) Electric Spring................. " " ..Third Group.

LACLEDE COUNTY.

(a) Lebanon Magnetic Well...........Chalybeate Water..First Group.

LIVINGSTON COUNTY.

(a) Mooresville Mineral Well.......Chalybeate Water..Third Group.

MADISON COUNTY.

White Spring........................Chalybeate Water..First Group.

MERCER COUNTY.

Lineville Mineral Well.............Sulphatic Water.(Sodium Sulphate.)

MONROE COUNTY.

(a) Harris Well......................Chalybeate Water..Third Group.

MORGAN COUNTY.

(a) Alum Well (Versailles).........Sulphatic Water...Third Group.

MCDONALD COUNTY.

Galbraith Well.....................Alkaline Water....Second Group.

NODAWAY COUNTY.

(a) Burlington Junction Spring.....Chalybeate Water..First Group.

PERRY COUNTY.

Lithium Spring......................Chalybeate Water..First Group.

PETTIS COUNTY.

Crystal Spring (Lamonte)...........Sulphatic Water...Third Group.

PIKE COUNTY.

Elk Lick Spring.....................	Muriatic Water...	Second	Group.
Louisiana Well.....................	" " ...	"	"
(a) B. B. Spring.....................	Sulphatic Water (Magnesium Sulph.).		

PLATTE COUNTY.

(a) Crystal Spring..................Chalybeate Water..Second Group.

RALLS COUNTY.

Spalding Spring....................Muriatic Water....Second Group.

RANDOLPH COUNTY.

(a) Sulphur Spring (Randolph Sps.)..	Muriatic Water....	First	Group.
Salt Spring (Randolph Sps.)........	" "	"	"
Randolph Spa......................	Chalybeate Water..	"	"

SALINE COUNTY.

(a) Sweet Spring (Sweet Springs)...	Muriatic Water. ..	First	Group.
(a) Blue Lick Spring (Blue Lick)...	" "	"	"
Magnesia Spring (Blue Lick).......	" "	"	"
(a) Black Sulphur Spring (McAllister Sps.)........................	" "	"	"
(a) Akesion Spring (Sweet Sps.)....	" "	"	"
Salt Spring, near Akesion (Sweet Sps.)	" "	"	"
Black Sulphur Spring (Blue Lick)...	" "	"	"
Napton Spring......	" "	"	"
Gum Spring (Blue Lick).............	" "	"	"
Salt Spring (Blue Lick)............	" "	"	"
Red Sulphur Spring (Blue Lick)....	" "	"	"
Salt Spring (Great Salt Sps.).......	" "	"	"
Sulphur Spring (Great Salt Sps.)...	" "	"	"
White Sulphur Spring (Blue Lick)..	" "	Second	Group.

SALINE COUNTY — *Continued.*

Sweet Spring (Blue Lick)	Muriatic Water	Second Group.
Elk Lick Spring	" "	" "
Town Spring at Grand Pass	Alkaline Water	First Group.
Fresh Water Spring (Blue Lick)	" "	Third Group.

ST. CLAIR COUNTY.

"Old Black" (Monegaw Sps.)	Muriatic Water	Second Group.

ST. LOUIS.

Belcher Artesian Well	Muriatic Water	First Group.

VERNON COUNTY.

Nevada Artesian Well	Alkaline Water	Second Group.
Artesian Well (Fairhaven)	Chalybeate Water	Third Group.
(a) Main Spring "	" "	" "
(a) Life Well "	" "	" "

WORTH COUNTY.

(a) Denver (Fairview) Well	Chalybeate Water	Third Group.

CHAPTER V.

MURIATIC WATERS OR BRINES.

Waters containing as their main constituent sodium chloride or common salt.

A. FIRST GROUP OF MURIATIC WATERS. — B. SECOND GROUP OF MURIATIC WATERS. — C. THIRD GROUP OF MURIATIC WATERS.

Contents of mineral waters supplied by dried up oceans.

The muriatic waters, or brines, as indicated by their name, contain common salt as their main constituent and are in their origin related in some way to the ocean. From this body of water, during past geologic periods, portions were cut off by upheaval or subsidence, to exist for a time as inland salt water lakes. These dried up eventually, or were partly or wholly drained back again into the ocean by a subsequent geologic revolution, thus giving rise to the different brines, which are found in different parts of the State. All the brines analyzed indicate their ancient origin; for, while modern seas contain, besides the chlorides of the alkalies, only magnesium chloride and no calcium chloride or sulphate, these waters analyzed contain either both or at least one of them in considerable quantity. They are grouped in three divisions, beginning with the oldest, geologically speaking, and each group has its members arranged according to the quantity of total mineral matter which it contains:

Differences between modern and ancient oceans.

A. FIRST GROUP OF MURIATIC WATERS.

The waters of the First Group consist of those which contain, in addition to sodium chloride or common salt (Na Cl), magnesium chloride (Mg Cl_2), calcium chloride (Ca Cl_2), and calcium sulphate (Ca SO_4), but no magnesium sulphate (Mg SO_4).

The twenty-three waters under this group are arranged in the following pages, according to their total residues. A glance at the tables shows this to be likewise the order in which the quantity of magnesium chloride or calcium sulphate would place them. A common origin may probably be attributed to all of them, the presence or absence of calcium bicarbonate depending, doubtless, in a measure, on local conditions. But few of these waters can be considered mineral waters in the narrow sense of the word, *i. e.*, as waters to be taken internally for medicinal purposes. As substitutes for ocean baths, however, they deserve consideration, and, as some are found near mineral waters of different types, their values become enhanced. It is not the purpose of this publication to advocate one or the other of these waters; the tabulation is such as is calculated to enable the physician to select easily, for any given case, the proper water.

Medicinal use of these waters.

TABLE OF ANALYSES OF MISSOURI MURIATIC WATERS — FIRST GROUP.

Contents are expressed in grains per Gallon.

	1 Sweet Springs (W.), Sweet Sps., Saline Co.	2 Sulphur Spring (S.), Jefferson Co.	3 Elk Lick Spring (W.), Saline Co.	4 Sulphur Spring (W.), Randolph Co.	5 Afton Spring (S.), Jefferson Co.	6 Council Spring (S.). Jefferson Co.	7 Montesano Spring (S.), Jefferson Co.	8 Belcher Artesian Well (S.), St. Louis Co.	9 Blue Lick Spring (W.), B. L., Saline Co.	10 Magnesia Spring (S.), B. L., Saline Co.	11 Black Sulphur Spring (W.), McAlist. Sps., Saline Co.	12 Glasgow Mineral Spring (R.), Howard Co.
Silica	0 3095	0.8177	0.3972	......	0 8177	0.8177	0.8177	0 9346	0.5724	2.6869	0.2570	0.4439
Alumina..............	0.1285	....	0.1168	0.2513	....	....	....	....	0.0993	1.6005	0.0818	0.0175
Oxide of Iron.............	....	....	....	....	....	....	....	0.0584	....	....	....	....
Calcium Bicarbonate.......	25.0540	....	27.0537	20.0880	....	....	....	....	29.0967	57.0249	62.4735	....
Calcium Sulphate..........	8.7977	10 8829	20.6042	33.3900	33 0658	40.5727	37 7726	50.1847	39.3315	51.4845	40.3046	71.1345
Calcium Chloride.	11.0402	37.6935	4 5083	11.8400	27 3583	47.1653	53.9660	47.4941	32 5371	24 5517	44.5560	47.7500
Magnesium Chloride........	21 9738	12.8456	22.8198	29.2900	40.4379	38.2877	45.1743	46.0840	46.0841	55.7471	64.1319	81.9303
Potassium Chloride........	0 0463	....	....	5.2000	....	....	....	0 8680	....	21.7566	....	7.1569
Potassium Bromide........	....	2.2956	....	....	1.7348	1.9100	2 2897	3.0583	....	....	....	....
Sodium Chloride...........	98.7948	168.5675	176.7242	250.4436	265.8275	337.9619	356.9426	401.5730	410.8915	555.5167	636.7276	831.4624
Mineral Matter.............	166.1448	233.1320[1]	252.2242	350.5027	369.2595[1]	466.7211[1]	496.9863[1]	550.2551	558.6126	770.3699	848.5324	1048.6278
Specific Gravity...........	1.0023	1.0031	1.0033	1.0041	1.0043	1.0052	1.0058	1 0059	1.0071	1.0066	1.0064	1.0142

[1] See analysis in special description.

TABLE OF ANALYSES OF MISSOURI MURIATIC WATERS — FIRST GROUP.

Contents are expressed in Grains per Gallon.

	13 Salt Spring (W.), Randolph Co.	14 Akesion Spring (W.), Sweet Springs, Saline Co.	15 Salt Spring (W.), Near Akesion, Saline Co.	16 Black Sulphur Spring (W.), Bl. L., Saline Co.	17 Brine (S.), Boonslick, Howard Co.	18 Napton Spring (W.), Saline Co	19 Gum Spring (W.), Bl. L., Saline Co.	20 Salt Spring (S.), Bl. L., Saline Co.	21 Red Sulphur Spring (S.), Bl. L., Saline Co.	22 Salt Spring (W.), Great Salt Spring, Saline Co.	23 Sulphur Spring (W.), Great Salt Spring, Saline Co.
Silica	....	0.3154	0.2887	0.5432	1.0514	0.4731	0.4147	0.8761	3.6214	0 3914	0.5140
Alumina.	0.1869	0.1986	0.1082	0.0642	....	0.1810	....	....	4.7429	0 0993	0.1051
Calcium Bicarbonate	94.8024	52.2582	28.2202	73.6349	... ...	....	44.3015	64.9884	42 3161	23 0752	34.6128
Calcium Sulphate	43 0500	55.9339	56.8852	88 2849	115 2149	102.3255	112.5133	112.9999	107.0521	117.7563	119 9110
Calcium Chloride	51.8700	85 2176	107 9969	44 5570	62.6228	117 3459	102 3062	85.8861	57 8236	108.2547	126.6737
Magnesium Chloride	84.7100	89.5056	88.4039	89.5232	96.6767	83.7611	113.2681	116.1658	148.3683	103.0718	114.7525
Potassium Chloride	6 7300	5 3422	9 8030	....	....	9 9901	....	11 7988	14.5074	.. ...	... .
Sodium Chloride	777.2792	882 7786	892.2072	945.4912	977 0602	1039.0722	1280.5890	1289 1729	1292.1135	1388 1556	1423.7697
Mineral Matter	1053.6285	1171.5531	1183.8833	1242 0986	1252 6260	1353.1489	1653.3928	1681.8880	1708.1596	1750.8043	1821.3388
Specific Gravity	1.0106	1.0149	1 0150	1.0153	1.0168	1.0174	1.0206	1.0214	1.0212	1.0219	1.0227

It is deemed advisable, in discussing the waters of this group, to deviate from the order of the table, and to bring together the springs of one neighborhood. This plan is, in this instance, all the more proper, since these waters belong virtually only to two sections of the State, Saline county near the center with an outcropping in Randolph and Howard counties, and in Jefferson county and St. Louis in the east. The springs of Saline county are, therefore, described first.

Order of description of these springs.

THE SPRINGS OF SALINE COUNTY.

Saline county, situated in the west-central part of Missouri, and having the Missouri river for its northern and eastern boundary, has long been noted for the large number of salt springs within its limits, which facts suggested its name. The majority of these springs are very salty, and would, undoubtedly, be classed as "saline springs." In connection with the salt water many of them give off quantities of hydrogen sulphide gas, and are locally known as "sulphur" springs. The temperatures of all are nearly the same, and the flow remains constant, independent of rain-fall. They are all probably of deep-seated origin, and are not thermal. From the waters of many of the larger ones, salt was manufactured years ago by evaporation over fire. This work has now been abandoned, and the waters are at present used only as beverages, or for medicinal purposes. The location of the principal springs is shown quite accurately on the accompanying map of the State. Numerous springs exist which are not shown individually on the map; but, of these, many are closely associated with the larger springs, and all are small and do not differ in character from those to be described. Among those not described are: —

Brines often contain free sulphuretted hydrogen.

Formerly used for making of salt.

a. A spring at Arrow Rock, having a good flow, which was formerly a salt-sulphur water, but which is now reported by its owner to be very weak in saline matter.

b. A salt-sulphur spring near Miami, section 35, township 53 north, range 21 west, the property of A. J. Caseboat.

c. A sulphur spring near Shackleford (between Great Salt Springs and Marshall) in section 1, township 50 north, range 22 west, owned by James Prior, and reported to be a weak salt spring.

Some springs of strong flow and clear water also occur along the Missouri bluffs at Grand Pass, but they can hardly be classified as mineral springs. Some are slightly chalybeate and small quantities of oil have been found in connection with them; but the flow of oil has been very weak. Several years ago, on sinking a well at Malta Bend, in section 3, township 51 north, range 22 west, oil was struck; and gas has been reported from the vicinity of Elmwood, section 3, township 49 north, range 23 west. Oil found on some of the brines.

Most of the salt springs of this county are found in the vicinity of Salt-fork and Black-water branches of the Lamine river, and seem to be limited to the valleys of these streams. An important exception to this is the Elk Lick spring in the Lamine river valley itself.

SWEET SPRING AT SWEET SPRINGS (W.).

Location and Character. Sweet spring is decidedly the best known of Saline county's springs. It is in the southwestern

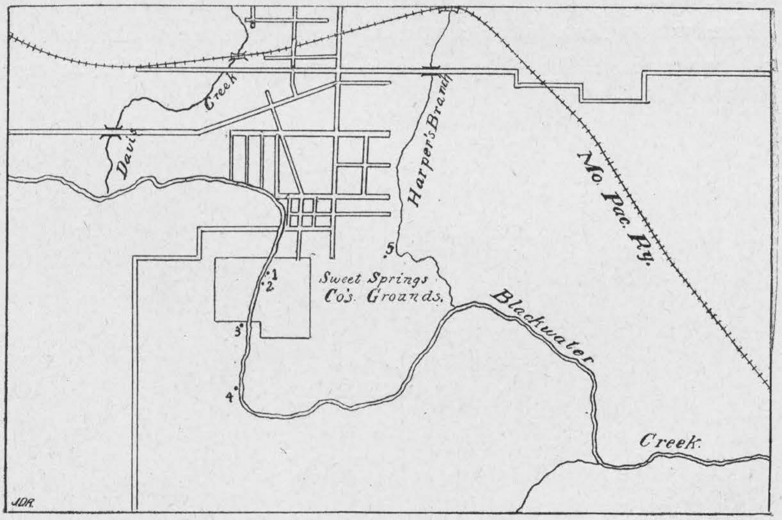


FIG. 1. Sketch map of Sweet Springs and vicinity.
1 is the Sweet spring;
2 are the Sulphur springs;
4 is the Alum spring;
5 is a fresh water spring.

corner of the county, in the northwest quarter of section 14, T. 48 N., 23 W., about one mile south of the railway station at Sweet Springs, on the Missouri Pacific railway.

Sweet spring itself (so called from its lacking any salty or strong mineral taste) issues from a bluff of limestone, some twenty-two feet above the low water mark of Black Water creek. This is the only locality in the county where the water can be seen emerging from the rock so that the exact horizon of its occurrence can be determined. It flows at the rate of 1,100 gallons per hour from a crevice in the limestone of about 50 square inches in area. A remarkable fact concerning this water, when compared with that of other similar springs in the county, is that although deep seated enough to exhibit great regularity of flow, temperatures, etc., it contains so small a proportion of mineral matter as to be hardly recognized by taste. This is, in all probability, owing to the fact that it does not reach the yet lower levels of saline deposits, which originate the other springs, but is confined entirely to the crevices of the limestone rock from which it issues, and is, therefore, destitute of sulphuretted hydrogen, instead of which it contains carbonic acid gas.

Flow and contents of this spring.

The water flows into a walled basin five feet in diameter and fourteen inches deep with a cemented porcelain bottom.

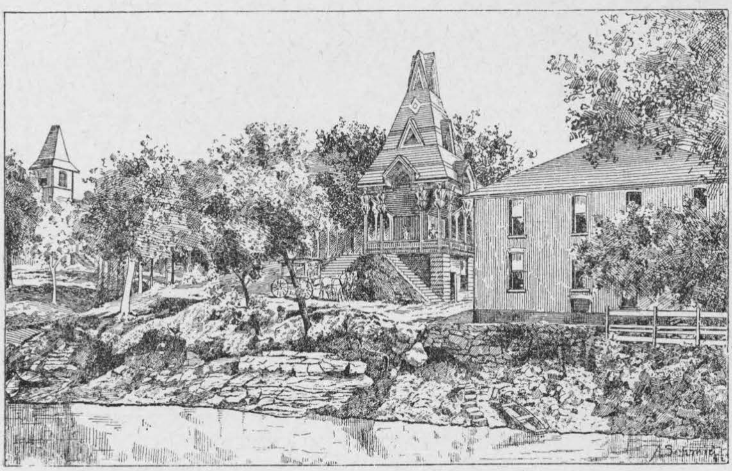


FIG. 2. View of Spring house at Sweet Springs.
From a photograph.

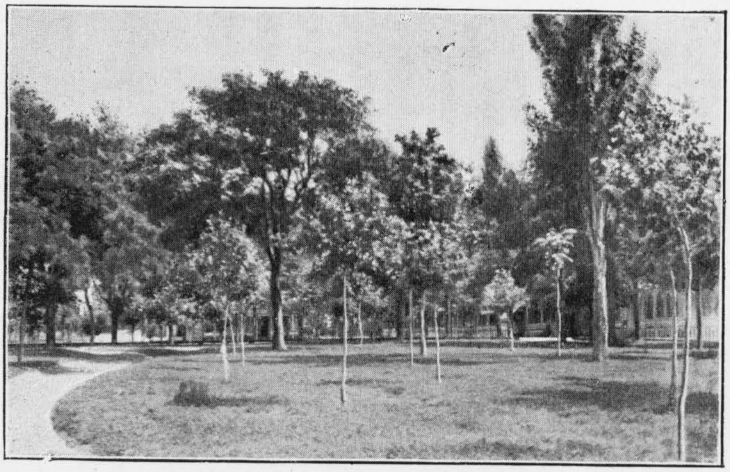


FIG. I.

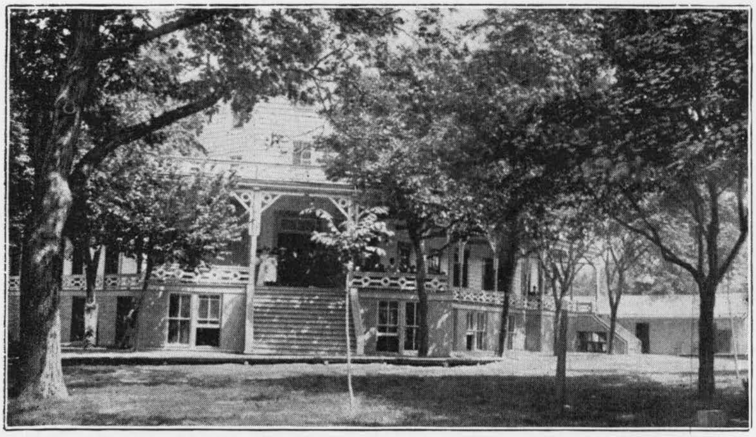


FIG. 2.

FIG. 1. VIEW OF GROUNDS AT SWEET SPRINGS.
FIG. 2. VIEW OF HOTEL AT SWEET SPRINGS.

Thence it is forced into the bottling house, where large quantities are bottled and shipped to various points in the State, and elsewhere. The temperature of the water in the basin was 53.3° F., that of the air being 41.5° F. About twenty feet below the level of the Sweet spring, a few feet above Black Water creek, is a sulphur spring. It has constant flow, but is covered by the Black Water in times of freshet. Collected in walled in porcelain basin.

Improvements and Uses. The property is a well patronized health resort, managed by a company under the name of the New Sweet Springs Company, owning a well appointed hotel of 130 rooms, valued at $50,000, with outbuildings, lecture hall, ball-room, pavilions and other improvements valued at a like sum. A number of private summer residences have been erected within the company's park and near the hotel, bringing the value of the whole plant to about $135,000. Value of improvements made. A season of about three months, during which conventions and other meetings take advantage of the facilities and diversions of the place, render the investment profitable. The water is shipped in barrels and bottles, either carbonated or plain, the capacity of the establishment being 1,500 quarts a day. The water is used both for drinking and bathing purposes, though, for the latter, Akesion water, to be described later, is, perhaps, preferable. A number of bath rooms with two large swimming pools near the hotel, each one five feet deep and thirty-two feet in diameter are constantly at the service of the guests. For the use of the water the direction gives advice which may be found in the printed circular, issued annually.

Results of analysis of Sweet Spring water (w.):

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	0.3095	0.0053
Alumina	(Al_2O_3)	0.1285	0.0022
Lime	(CaO)	17.8617	0.3058
Magnesia	(MgO)	9.2522	0.1584
Potassa	(K_2O)	0.0292	0.0005
Soda	(Na_2O)	52.3529	0.8963
Chlorine	(Cl)	83.4445	1.4286
Sulphur Tiroxide	(SO_3)	5.1751	0.0886
Carbon Dioxide	(CO_2)	13.6096	0.2330
Water in combination	(H_2O)	2.7838	0.0477
		184.9470	3.1664

		Grains in Gallon.	*Grams in Litre.*
Oxygen	(O)	18.8022	0.3219
Mineral matter		166.1448	2.8445
Fixed residue		156.5562	2.6803

Spec. Gravity = 1.0023

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0 3095
Alumina	(Al_2O_3)	0.1285
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	25.0540
Calcium Sulphate	($CaSO_4$)	8.7977
Calcium Chloride	($CaCl_2$)	11.0402
Magnesium Chloride	($MgCl_2$)	21.9738
Potassium Chloride	(KCl)	0.0463
Sodium Chloride	($NaCl$)	98.7948
Mineral matter		166.1448

Results of analysis of Akesion water (w.):

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	0.3154	0.0054
Alumina	(Al_2O_3)	0.1986	0.0034
Lime	(CaO)	84.0870	1.4396
Magnesia	(MgO)	37.6861	0.6452
Potassa	($K_2 O$)	3.3703	0.0577
Soda	(Na_2O)	467.7707	8.0084
Sulphur Trioxide	(SO_3)	32.9023	0.5633
Chlorine	(Cl)	659.6942	11.2942
Carbon Dioxide	(CO_2)	28.3872	0.4860
Water in combination	(H_2O)	5.8064	0.0994
		1320.2182	22.6026
Oxygen	(O)	148.6651	2.5452
Mineral matter		1171.5531	20.0574
Fixed residue		1151.5531	19.7150

Spec. Gravity = 1.0149

H_2S present.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.3154
Alumina	(Al_2O_3)	0.1986
Calcium Bicarbonate	($CaH_2 (CO_3)_2$)	52.2582
Calcium Sulphate	($CaSO_4$)	55.9339
Calcium Chloride	($CaCl_2$)	85.2176
Magnesium Choride	($MgCl_2$)	89.5086
Potassium Chloride	(KCl)	5.3422
Sodium Chloride	($NaCl$)	882.7786
Mineral matter		1171 5531

Results of analysis of Salt Spring water (w.):

		Grains in Gallon.	*Grams in Litre.*
Silica....................	(SiO_2)	0.2887	0.0049
Alumina....................	(Al_2O_3)	0.1082	0.0018
Lime....................	(CaO)	87.6505	1.5006
Magnesia....................	(MgO)	37.2224	0.6373
Potassa....................	(K_2O)	6.1846	0.1059
Soda....................	(Na_2O)	472.7913	8.0944
Sulphur Trioxide..........	(SO_3)	33.4442	0.5726
Chlorine....................	(Cl)	681.2416	11.6631
Carbon Dioxide...........	(CO_2)	15.3294	0.2624
Water in combination.	(H_2O)	3.1356	0.0537
		1337.3965	22.8967
Oxygen....................	(O)	153.5132	2.6282
Mineral matter...........		1183.8833	20.2685
Fixed residue.............		1173.0830	20.0836

Spec. Gravity = 1.0150

H_2S present.

United as follows:

		Grains in Gallon.
Silica....................	(SiO_2)	0.2887
Alumina....................	(Al_2O_3)	0.1082
Calcium Bicarbonate......	($CaH_2(CO_3)_2$)	28.2202
Calcium Sulphate..........	($CaSO_4$)	56.8852
Calcium Chloride..........	($CaCl_2$)	107.9969
Magnesium Chloride......	($MgCl_2$)	88.4039
Potassium Chloride........	(KCl)	9.8030
Sodium Chloride..........	($NaCl$)	892.2072
Mineral matter.............		1183.8833

The two last springs are likewise under the management of the parties owning the Sweet Springs property, and are situated on the north side of the Black Water in the northwest quarter of section 16, T. 48 N., 22 W. They are about three hundred feet apart, both flowing from the alluvial clays. They are both saline and sulphuretted and appear to flow from a common source. The medicinal properties of the two, it is claimed, however, are quite distinct, the Akesion water being bottled and shipped away, while the salt spring water (together with the Akesion) is pumped over four miles to the Sweet Springs ground, where it is used in the bath houses.

Medicinal properties of the two salt springs different.

Both springs deposit sulphur (white and flocculent) along their courses, and have each a flow of about 4000 gallons per hour. Their temperatures are as follows:[1]—

[1] See other analyses in the Appendix.

	Of Water.	*Of Air.*
Akesion	59.7° F.	35° F.
Salt Spring	58.8° F.	40° F.

THE MCALLISTER SPRINGS (W.).

Location. The McAllister springs are found in the northeast quarter of section 17, T. 48 N., 22 W., about five miles east of Sweet Springs and close to Black Water creek. The principal springs are three in number, known respectively as the Black Sulphur and White Sulphur, and Salt springs. The Black Sulphur and Salt springs occur near each other and are both saline and sulphuretted; the Salt spring water seems to contain more gas than the others. From the Salt spring is deposited a reddish white precipitate of sulphur, while the Black Sulphur is characterized by a black sediment composed of sulphur and organic matter mixed with clay and fine sand. A small amount of Black Sulphur water is bottled and shipped away; but most of it, mixed with the Salt spring water flows into the bath houses. The White Sulphur spring is a few hundred feet nearer the Black Water and is well protected from the weather. It is saline like the other two.

Precipitate from salt and black sulphur rings.

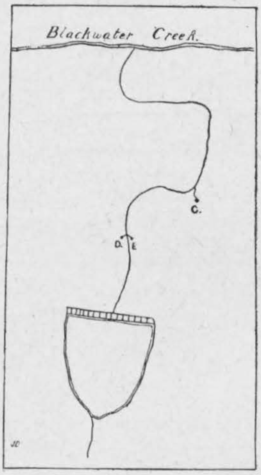


FIG. 3. Sketch at McAllister Springs.
C is the Sulphur spring.
D and F are the Salt springs.

				Of Water.	*Of Air.*
Temperature	Black Sulphur	Springs		57.7° F.	33° F.
"	White	"	"	52.° F.	33° F.
"	Salt	"	"	58.° F.	33° F.

Improvements and Uses. The property is owned by private parties but managed and under the direction of a resident physician. It contains a commodious hotel with thirty rooms, ball-room, billiard and bowling alley, and some private summer residences, valued at $25,000. The Black Sulphur water is shipped in barrels and jugs. It has been used for twenty years and longer, the management claiming it to be beneficial in "dyspepsia, skin diseases, blood poisoning, rheumatism, liver diseases and stomach troubles," of which proof is offered in a number of letters

Value of improvements made.

received from parties who have been benefited by its use. An earlier analysis of this water is given in the Appendix.

The spring has a flow of about twenty gallons per hour.

Results of analysis of Black Sulphur water (w.):

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	0.2570	0.0044
Alumina	(Al_2O_3)	0.0818	0.0014
Lime	(CaO)	60.6705	1.0387
Magnesia	(MgO)	27.0029	0.4623
Soda	(Na_2O)	337.4112	5.7766
Sulphur Trioxide	(SO_3)	23.7086	0.4059
Chlorine	(Cl)	462.8116	7.9235
Carbon Dioxide	(CO_2)	33.9362	0.5810
Water in combination	(H_2O)	6.9415	0.1188
		952.8413	16.3126
Oxygen	(O)	104.2910	1.7855
Mineral matter		848.5303	14.5271
Fixed residue		824.6207	14.1178

Spec. Gravity = 1.0064
H_2S present.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.2570
Alumina	(Al_2O_3)	0.0818
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	62.4735
Calcium Sulphate	($CaSO_4$)	40.3046
Calcium Chloride	($CaCl_2$)	44.5560
Magnesium Chloride	($MgCl_2$)	64.1319
Sodium Chloride	($NaCl$)	636.7276
Mineral matter		848.5324

ELK LICK SPRING (W.).

Location. On crossing the divide between Black Water creek and Lamine river, in the southeastern part of the county, we find the Elk Lick springs, situated on Heath's creek, in section 17, T. 48 N., 20 W.

Character. One principal spring here is surrounded by smaller ones. The spring is of remarkably clear, palatable water, charged with carbonic acid gas and slightly sulphuretted. It flows at a rate of between 100 and 200 gallons per hour and deposits a very small amount of sediment, mostly of a black color. These springs are occasionally resorted to by excursion parties; but they have little more than a local reputation.

Water palatable and rich in carbonic acid.

Improvements and Uses. The property consists of a hotel with thirty-four rooms, with accommodations for about fifty guests; two cottages, a dancing hall and bath houses, valued, in all, at \$25,000. It is owned by J. H. Rector, who keeps the place open for about four months during the year. The springs have been known for more than fifty years and are claimed by the proprietor to be effective in curing indigestion, scrofula and rheumatic affections. The water has been analyzed before, but no copy of the analysis was procurable.

Value and ownership of property.

	Of Water.	*Of Air.*
Temperature	56.2° F.	35.0° F.

Results of analysis of Elk Lick spring water (W. & R.):

Analysis.

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	0.3972	0.0068
Alumina	(Al_2O_3)	0.1168	0.0020
Lime	(CaO)	20.1105	0.3443
Magnesia	(MgO)	9.6084	0.1645
Soda	(Na_2O)	93.6487	1.6033
Sulphur Trioxide	(SO_3)	12.1259	0.2076
Chlorine	(Cl)	127.1761	2.1773
Carbon Dioxide	(Cl)	14.6958	0.2516
Water in combination	(H_2O)	3.0060	0.0515
		280.8354	4.8089
Oxygen	(O)	28.6618	0.4907
Mineral matter		252.2236	4.3182
Fixed residue		241.8697	4.1409

Spec. Gravity = 1.0033
Contains H_2S.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.3972
Alumina	(Al_2O_3)	0.1168
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	27.0537
Calcium Sulphate	($CaSO_4$)	20.6042
Calcium Chloride	($CaCl_2$)	4.5083
Magnesium Chloride	($MgCl_2$)	22.8198
Sodium Chloride	($NaCl$)	176.7242
ineral matter		252.2242

BLUE LICK SPRINGS (W. & S.).

Location and Character. Passing down Blackwater on Finney's creek, about one mile from its mouth, we find the group known as "Blue Lick Springs," located in the southeast quarter of section 21, T 49 N., 21 W. Here a number of sulpho-saline springs are scattered along Finney's creek from its junction with the Blackwater; but they culminate at Blue Lick where a number of such springs occur within a radius of a quarter of a mile. **Salt and fresh water springs occur together.** Fresh water springs are common and one, which when visited was flooded with water, is reported to be very bitter or "magnesian" when the surface water is low. As the fresh water springs are somewhat dependent on rainfall, are colder than the sulphur springs, and lack salt, they are probably surface springs and not connected with those from a deep-seated source.

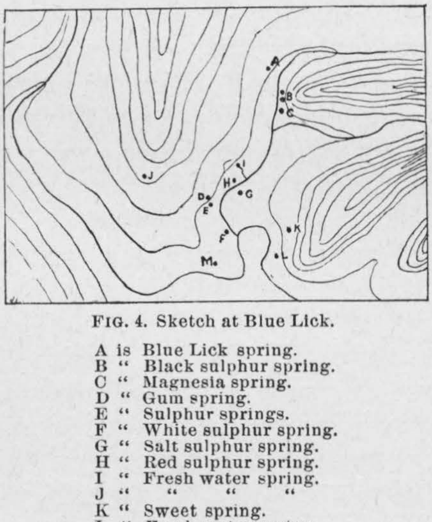


FIG. 4. Sketch at Blue Lick.

A is Blue Lick spring.
B " Black sulphur spring.
C " Magnesia spring.
D " Gum spring.
E " Sulphur springs.
F " White sulphur spring.
G " Salt sulphur spring.
H " Red sulphur spring.
I " Fresh water spring.
J " " " "
K " Sweet spring.
L " Fresh water spring.
M " Sulphur spring.

The "Blue Lick" spring is the highest of the group and is thus less affected by the floods of Blackwater creek. It is sulpho-saline in character and deposits sulphur. Its temperature is 54.7° F., that of the air being 40° F. **Temperature of water.**

At least four or five of the springs here used as beverages could be classed as "black sulphur" or better, as sulpho-saline springs. One of these has been protected by a tile sunk around it and is more generally used than the others of its class. Its temperature is 55.7° F., that of the air being 42° F.

The "Gum spring" is the largest of the group and is said to furnish, and apparently flows at a rate of about 3000 gallons of water per hour. Like the others, the water is sulpho-saline. **Flow of Gum spring.** It is allowed to flow into a large wooden basin forty feet square and four or five feet deep, which is used for bathing purposes. On the sides of this basin, sulphur is deposited in very considerable quantities. This sulphur is the so-called "white flocculent precipitate." It is the well-known accompaniment of sulphur springs and is derived from the oxidation of the sulphuretted hydrogen gas in the water, of which gas the sulphur remains in the form of a precipitate. The terms white, black and red sulphur apply to the pure or impure precipitates of sulphur in the springs. The water itself issues from a large "gum" and a great quantity of gas is continually escaping (probably carbonic acid gas). The water is used for bathing purposes entirely. The springs are much frequented during the summer months, and the waters of "Blue Lick" and Black Sulphur springs are also shipped to Marshall in small quantities.

So called white, black and red sulphur springs.

A short distance south of this group occurs a "sulphur" spring very slightly saline. It is neglected, however, and its true flow could not be seen.

Salt was made from the various springs here several years ago and the lines of ditches where the kettles were placed and the water evaporated can still be seen.

Salt once made from these springs.

On a subsequent visit to this locality (November 14, 1892) the clear, bright weather that had prevailed for a month past, was utilized to sample six additional springs, and to elucidate some points, which the previous investigation of these waters had failed to touch upon.

The first was the determination of the nature and quality of the sulphuretted hydrogen in the different muriatic or sulpho-saline waters. Toward this end the spring which at the time of the visit appeared to possess the strongest odor — the Red Sulphur spring — was selected and the gas, on taking the water from the spring, fixed by the addition of a solution of neutral cadmium chloride; subsequent determination gave

How sulphuretted hydrogen is held in these waters.

0.0102 grains of H_2S per litre, or
0.5957 grains per gallon.

Through the untreated water, which had been carefully bottled and sent to the laboratory, was passed, on the following day, a current of hydrogen gas which speedily volatilized the free sulphuretted hydrogen and rendered the water odorless; in this

No sulphides present.

condition it gave no longer the characteristic yellow precipitate with cadmium chloride. The statement, therefore, made in Chapter III. regarding the occurrence of this gas in our muriatic waters as free and accidental is borne out by the results of this test.

The second point was the determination of the whole of the carbonic acid gas in the waters, as they issue. The Red Sulphur and the Sweet springs were selected for trial and the carbonic acid gas determined at the time of sampling. Analysis showed in

Red Sulphur spring water 0.3935 grains of CO_2 per litre and in
Sweet spring water 0.5865 " " " " "

Amount of carbonic acid in some of these springs.

The first is the exact amount of carbonic acid gas necessary to keep the calcium carbonate in solution and the second exceeds it but slightly. The gas evolved by these springs, however, and especially the latter, plainly exceeds in volume that of the carbon dioxide found, and reveals the presence in the escaping gas of other gaseous bodies, which, in all probability, are nitrogen and marsh gas.

Composition of the "white precipitate."

A third point examined was the composition of the white flocculent precipitate so often noticed in and about the tanks into which these waters flow. None could be collected satisfactorily at the spot, but the water of the Salt spring, which on sampling was perfectly clear and limpid, separated after a few days standing enough of the substance for a qualitative test. It consisted mainly of white sulphur and silica with traces of alumina and calcium carbonate.

Temperature of waters and depth of origin.

The observation of the temperatures of these waters is of interest. On the morning when they were taken the air was cool and bracing, showing on a good thermometer 47.3° F. The waters, just as they issued from the ground, exhibited the following range of temperature:

	Grains of Mineral Matter per Gallon.	*Temperature.*
Fresh Water Spring	76.3932	not taken
White Sulphur Spring	245.4602	54.5° F
Sweet Spring	300.8429	54.4° F
Blue Lick Spring	558.6126	56.3° F
Magnesia Spring	770.3699	54.5° F
Black Sulphur Spring	1242.0986	not taken
Gum Spring	1653.3926	61.7° F
Salt Spring	1681.8886	62.6° F
Red Sulphur Spring	1708.1596	62.6° F

The temperature indicates depth from which water comes.

The highest temperature attaches to the water carrying the greatest quantity of mineral matter, and may perhaps be taken as an indication of the greatest relative depth reached by it; a higher temperature, a greater depth, an older geologic deposit appear, in these waters at least, to be connected, and may prove so in others. Careful simultaneous temperature determinations over larger areas might profitably be undertaken in similar cases by the investigators.

Water sold at Marshall.

Improvements and Uses. The property is owned in partnership and is operated by Henry Strother of Marshall, Mo. It has, as yet, no hotel, but several cottages, private residences, two bath houses, and some stores have been built to accommodate guests and visitors. The water of all the springs is used for drinking purposes excepting that of the Gum spring, which is used for bathing. It is sold to a moderate extent in bottles and barrels, though no regular bottling establishment has been kept in operation. A pamphlet descriptive of the waters has been published giving an analysis, which is printed in the Appendix, and in which the waters are claimed to be beneficial in kidney and bladder disease, dyspepsia, diseases of the bowels, cholera infantum, chronic diarrhœa, general debility, and for other troubles.

Analysis.

Results of analysis of water of Blue Lick Spring (w.):

	Grains in Gallon.	*Grams in Litre.*
Silica....................(SiO_2)	0.5724	0.0098
Alumina....................(Al_2O_3)	0.0993	0.0017
Lime....................(CaO)	42.6685	0.7305
Magnesia....................(MgO)	19.4038	0.3322
Soda....................(Na_2O)	218.6812	3.7439
Sulphur Trioxide.........(SO_3)	23.1362	0.3961
Chlorine....................(Cl)	303.3815	5.1940
Carbon Dioxide...........(CO_2)	15.8056	0.2706
Water in combination.....(H_2O)	3.2330	0 0553
	626.9815	10.7341
Oxygen....................(O)	68.3689	1.1705
Mineral matter............	658.6126	9.5636
Fixed residue.............	547.4768	9.3730

Spec. Gravity=1.0071
Contains H_2S.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.5724
Alumina	(Al_2O_3)	0.0993
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	29.0967
Calcium Sulphate	($CaSO_4$)	39.3315
Calcium Chloride	($CaCl_2$)	32.5371
Magnesia Chloride	($MgCl_2$)	46.0841
Sodium Chloride	($NaCl$)	410.8915
Mineral matter		558.6126

Analysis of Blue Lick water.

Results of analysis of Magnesia spring water (s.):

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	2.6869	0.0460
Alumina	(Al_2O_3)	1.6005	0.0274
Lime	(CaO)	53.2991	0.9125
Magnesia	(MgO)	23.4750	0.4019
Potassa	(K_2O)	13.7263	0.2350
Soda	(Ma_2O)	294.4039	5.0403
Chlorine	(Cl)	404.8806	6.9317
Sulphur Trioxide	(SO_3)	30.2856	0.5185
Carbon Dioxide	(CO_2)	30.9765	0.5303
Water in combination	(H_2O)	6.3361	0.1085
		861.6705	14.7521
Oxygen	(O)	91.3006	1.5631
Mineral matter		770.3699	13.1890
Fixed residue		748.5456	12.8154

Spec. Gravity = 1.0066

Li present

H_2 S absent.

Analysis of Magnesia Spring water.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	2.6869
Alumina	(Al_2O_3)	1.6005
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	57.0249
Calcium Sulphate	($CaSO_4$)	51.4855
Calcium Chloride	($CaCl_2$)	24.5517
Magnesium Chloride	($MgCl_2$)	55.7471
Potassium Chloride	(KCl)	21.7566
Sodium Chloride	($NaCl$)	555.5167
Mineral matter		770.3699

Results of analysis of Black Sulphur Spring (w.):

Analysis of Black Sulphur water.

		Grains in Gallon.	Grams in Litre.
Silica	(SiO_2)	0.5432	0.0093
Alumina	(Al_2O_3)	0.0642	0.0011
Lime	(CaO)	84.2856	1.4430
Magnesia	(MgO)	37 6919	0.6453
Soda	(Na_2O)	501.1461	8.5798
Sulphur Trioxide	(SO_3)	51.9323	0.8891
Chlorine	(Cl)	669.0164	11.4538
Carbon Dioxide	(CO_2)	39.9992	0.6848
Water in combination	(H_2O)	8.1817	0.1401
		1392.8606	23.8463
Oxygen	(O)	150.7620	2.5811
Mineral matter		1242.0986	21.2652
Fixed residue		1213.9173	20.7827

Spec. Gravity = 1.0153
H_2S present.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.5432
Alumina	(Al_2O_3)	0.0642
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	73.6349
Calcium Sulphate	($CaSO_4$)	88.2849
Calcium Chloride	($CaCl_2$)	44.5570
Magnesium Chloride	($MgCl_2$)	89.5232
Sodium Chloride	($NaCl$)	945.4912
Mineral matter		1242.0986

Results of analysis of water of Gum Spring (w.):

Analysis of Gum Spring water.

		Grains in Gallon.	Grams in Litre.
Silica	(SiO_2)	0.4147	0.0071
Lime	(CaO)	113.2570	1.9390
Magnesia	(MgO)	47.6918	0.8165
Soda	(Na_2O)	678.6074	11.6180
Sulphur Trioxide	(SO_3)	66.1843	1.1331
Chlorine	(Cl)	927.1945	15.8739
Carbon Dioxide	(CO_2)	24 0650	.4120
Water in combination	(HO)	4.9224	0.0842
		1862.3371	31.8838
Oxygen	(O)	208.9443	3.5772
Mineral matter		1653.3928	28.3066
Fixed residue		1636.4379	28.0164

Spec. Gravity = 1.0206
H_2S present.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.4147
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	44.3015
Calcium Sulphate	($CaSO_4$)	112.5133
Calcium Chloride	($CaCl_2$)	102.3062
Magnesium Chloride	($MgCl_2$)	112.2681
Sodium Chloride	($NaCl$)	1280.5890
Mineral matter		1653.3928

Analysis of Gum Spring water.

Results of analysis of Salt Spring water (s.):

		Grains in Gallon.	Grams in Litre.
Silica	(SiO_2)	0.8761	0.0150
Lime	(CaO)	112.3224	1.9230
Magnesia	(MgO)	48.9126	0.8374
Potassa	(K_2O)	7.4415	0.1274
Soda	(Na_2O)	683.1516	11.6958
Chlorine	(Cl)	929.7003	15.9168
Sulphur Trioxide	(SO_3)	66.4707	1.1380
Carbon Dioxide	(CO_2)	35.3030	0.6044
Water in combination	(H_2O)	7.2209	0.1236
		1891.3330	32.3814
Oxygen	(O)	209.5109	3.5869
Mineral matter		1681.8881	28.5475
Fixed residue		1657.0157	28.1219

Spec. Gravity = 1.0214.
Li present.
H_2S present.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.8761
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	64.9884
Calcium Sulphate	($CaSO_4$)	112.9999
Calcium Chloride	($CaCl_2$)	85.8861
Magnesium Chloride	($MgCl_2$)	116.1658
Potassium Chloride	(KCl)	11.7988
Sodium Chloride	($NaCl$)	1289.1729
Mineral matter		1681.8880

Analysis of Salt Spring water.

Results of analysis of Red Sulphur Spring (s.):

Analysis of Red Sulphur Spring water.

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	3.6214	0.0620
Alumina	(Al_2O_3)	4.7429	0.0812
Lime	(CaO)	87.8836	1.5046
Magnesia	(MgO)	62.4753	1.0696
Potassa	(K_2O)	9.1529	0.1567
Soda	(Na_2O)	684.7754	11.7236
Chlorine	(Cl)	938.9757	16.0756
Sulphur Trioxide	(SO_3)	62.9718	1.0781
Carbon Dioxide	(CO_2)	22.9865	0.3935
Water in combination	(H_2O)	4.7018	0.0805
		1882.2873	32.2254
Oxygen	(O)	211.7420	3.6251
Mineral matter		1670.5453	28.6003
Fixed residue		1654.3503	28.4035

Spec. Gravity =1.0212
Li present.
H_2S present.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	3.6214
Alumina	(Al_2O_3)	4.7429
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	42.3161
Calcium Sulphate	($CaSO_4$)	107.0521
Calcium Chloride	($CaCl_2$)	57.8236
Magnesium Chloride	($MgCl_2$)	148.3683
Potassium Chloride	(KCl)	14.5074
Sodium Chloride	($NaCl$)	1292.1135
Mineral matter		1078.1596

THE CAMP CREEK GROUP OF SPRINGS (W.).

Location and Character. The first group met on the Salt Fork river occurs near Napton. The Camp creek group of sulpho-saline springs is located in the southeast quarter of section 28. The various springs flow immediately from alluvial clays, the underlying rock being, probably, limestone. The springs are a dozen or more in number, which, flowing together, constitute the "Salt branch" of Camp creek. They are all sulpho-saline. They are included in about five acres of ground, within which area they are reported to be constantly changing their

Water flows from alluvial clays.

position. Salt was made here quite extensively before the war, and the posts can still be seen where evaporation was carried on. Salt made from them formerly. In the northwest quarter of section 34 occurs a slightly saline sulphur spring, the water of which is reported to have medicinal properties.

East of Marshall, near the Salt Fork, occur two or three salt seeps which were formerly good sized springs; and about one and a half miles east of town, is a neglected bath-house, formerly supplied with water by a sulpho-saline spring. It is now entirely abandoned and the spring partially choked up.

On Cow creek, a tributary of the Salt Fork, in sections 24 and 25, T. 51 N., 21 W., a number of sulpho-saline springs are found belonging to J. Wall and Martin Zimmerman. They are sulphur springs slightly saline. Those occurring on Wall's land have a local reputation. From this point on, up the Salt Fork, the springs seem to disappear or to assume small proportions.

Results of analysis of Napton Spring water (w.):

Analysis.

	Grains in Gallon.	*Grams in Litre.*
Silica ....(SiO_2)	0.4731	0.0081
Alumina....................(Al_2O_3)	0.1810	0.0031
Lime ....(CaO)	101.3355	1.7349
Magnesia ....(MgO)	35.2679	0.6038
Soda ....(Na_2O)	550.6194	9.4268
Potassa....................(K_2O)	6.3025	0.1079
Sulphur Trioxide...........(SO_3)	60.1915	1.0305
Chlorine...................(Cl)	772.9629	13.2334
	1527.3338	26.1485
Oxygen.....................(O)	174.1903	2.9822
Fixed residue.............	1353.1435	23.1663

Spec. Gravity = 1.0174
Contains H_2S.

United as follows:

	Grains in Gallon.
Silica.............. ......(SiO_2)	0.4731
Alumina....................(Al_2O_3)	0.1810
Calcium Sulphate..........($CaSO_4$)	102.3255
Calcium, Chloride..........($CaCl_2$)	117.3459
Magnesium Chloride......($MgCl_2$)	83.7611
Potassium Chloride........(KCl)	9.9901
Sodium Chloride...........($NaCl$)	1039.0722
Mineral matter............	1353.1489

THE GREAT SALT SPRINGS (W.).

Location and Character. On traveling up the Salt branch, a small tributary of the Salt Fork, we find about eight and one-half miles west of Marshall, in sections 17 and 20, T. 50 N., 22 W., the group known as "The Great Salt Springs." It consists principally of two large springs, but there are numerous other smaller springs and seeps near these two. The largest and at present the most important is a sulpho-saline spring, now known as the "Sulphur Spring," in the southeast quarter of section 17, T. 50 N., 22 W., only a short distance south of the Chicago and Alton railway.

Numerous springs are found here.

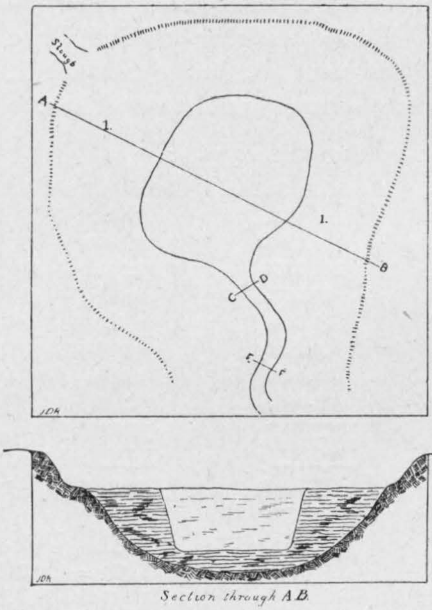


FIG. 5. Plain and section of the great Salt Spring.

It is found in a basin five feet below the general level of the alluvial plain. This basin is nearly circular, about 20 to 25 feet in diameter and 10 to 15 feet deep. The water flows at a rate of at least 10,000 gallons per hour; it is very salty and deposits sulphur for hundreds of feet along its course. This spring is undoubtedly the largest of any in the county, but the area of its basin is gradually being reduced by the wash from the farmed lands around it. Salt was made here formerly in considerable quantities.

Largest flow of any spring in county.

The other of these two large springs, situated in the northeast quarter of section 20, T. 50 N., 22 W., is a salty spring, with very little, if any, sulphuretted hydrogen present, distinguished as the "Salt Spring." In marked contrast to the Sulphur spring is this one, the flow of which cannot exceed 200 gallons per hour, although occupying a basin 25 feet in diameter and 7 feet deep. The temperature of the water of this spring was 36°

Shallow and deep springs.

F., that of the air being 20° F., while at the Sulphur spring the thermometer registered 57.2° F., with the air at 14.5° F.

Reported to have once contained sulphuretted hydrogen.

In Meek's report, made twenty years ago, the Salt spring was given a temperature of 59° F., with a flow at least half as strong as that of the Sulphur Spring, and was also stated to contain sulphuretted hydrogen in abundance. There can, thus, be little doubt but that this spring has changed in character, and this is probably accounted for by the choking of the spring with mud and slit in times of flood of the "Salt branch."

Valleys of Salt Fork and Blackwater creeks the seat of the springs.

The groups above described embrace the most important springs in the county and, as will have been noticed, they appear to be confined to the valleys of the Salt Fork and Blackwater creeks. Exceptions to this are, however, a sulpho-saline spring reported to be in the vicinity of Arrow Rock and one in the vicinity of Miami; but the writer was unable to visit them.

The constancy in temperature, the regularity of flow, the large quantity of salts in solution, all tend to indicate that the waters of these springs have a deep-seated source. From what depth and from what formation the water derives the various substances which it holds in solution is a problem which can only be solved after further observation in other counties and after a more comprehensive comparative study.

Results of the analysis of the water of Salt Spring (w.):

Analysis.

		Grains in Gallon.	*Grams in Litre.*
Silica....................	(SiO_2)	0.3914	0.0067
Alumina..................	(Al_2O_3)	0.0993	0.0017
Lime......................	(CaO)	114.5362	1.9609
Magnesia.................	(MgO)	43.3986	0.7430
Soda......................	(Na_2O)	735.6038	12.5938
Sulphur Trioxide.........	(SO_3)	69.2684	1.1859
Chlorine..................	(Cl)	988.6652	16.9263
Carbon Dioxide...........	(CO_2)	17.9668	0.3076
Water in combination....	(H_2O)	3.6750	0.0629
		1973.6047	33.7888
Oxygen...................	(O)	222.7991	3.8144
Mineral matter...........		1750.8056	29.9744
Fixed Residue............		1738.1472	29.7577

Spec. Gravity = 1.0219

H_2S present.

United as follows:

Analysis of Salt Spring water.

		Grains in Gallon.
Silica	(SiO_2)	0.3914
Alumina	(Al^2O_3)	0.0993
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	23.0752
Calcium Sulphate	($CaSO_4$)	117.7563
Calcium Chloride	($CaCl_2$)	108.2547
Magnesium Chloride	($MgCl_2$)	103.0718
Sodium Chloride	($NaCl$)	1388.1556
Mineral matter		1750.8043

Results of analysis of water of Sulphur Spring (w.):

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	0.5140	0.0088
Alumina	(Al_2O_3)	0.1051	0.0018
Lime	(CaO)	125.5932	2.1502
Magnesia	(MgO)	48.3168	0.8272
Soda	(Na_2O)	754.4762	12.9169
Sulphur Trioxide	(SO_3)	70.5359	1.2076
Chlorine	(Cl)	1030.7862	17.6474
Carbon Dioxide	(CO_2)	19.3452	0.3312
Water in combination	(H_2O)	3.9570	0.0677
		2053.6296	35.1588
Oxygen	(O)	232.2908	3.9769
Mineral matter		1821.3388	31.1819
Fixed residue		1807.7092	30.9486

Spec. Gravity = 1.0227

H_2S present.

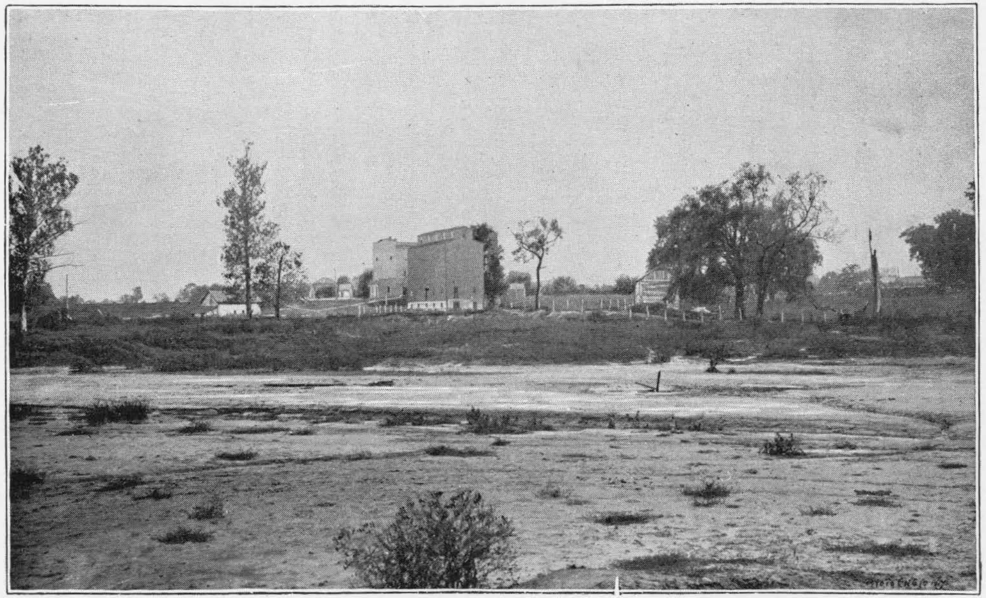
United as follows:

Analysis of Sulphur Spring water.

		Grains in Gallon.
Silica	(SiO_2)	0.5140
Alumina	(Al_2O_3)	0.1051
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	34.6128
Calcium Sulphate	($CaSO_4$)	119.9110
Calcium Chloride	($CaCl_2$)	126.6737
Magnesium Chloride	($MgCl_2$)	114.7525
Sodium Chloride	($NaCl$)	1423.7697
Mineral matter		1821.3388

THE SPRINGS OF HOWARD COUNTY.

Three sets of muriatic springs have been visited in this county. Fayette Salt springs, just a short distance south of Fayette, flows from the alluvium in the bed of a small "salt branch" as



VIEW OF FAYETTE SALT SPRINGS.

shown in the plate opposite this page; the spring area is about 50 feet in diameter and is entirely unimproved. The water is very salty to the taste and holds a fine mud suspended in it. Just a short distance from Fayette are found other similar waters which are unimproved and which do not seem to differ essentially from the other springs of the county or to be otherwise of sufficient importance to warrant special analysis of the waters. Water carries clay in suspension.

THE BOONSLICK SPRING (W.).

Character of Spring. This is a bored well, sunk for the purpose of obtaining a commercial brine, and abandoned after reaching 1008 feet. The water issues from a 3 inch pipe, sunk 400 feet into the rock, and seems to furnish an inexhaustible supply. The property is not improved, is situated eight miles from Estill, on the Missouri, Kansas & Texas railway, and is owned by W. W. Marshall of Boonston, Mo., in the same county. Fig. 1 of Plate III, gives a view of this spring. Depth and flow of spring.

Results of analysis of Boonslick Spring water (s.):

	Grains in Gallon.	*Grams in Litre.*
Silica (SiO_2)	1.0514	0.0180
Lime (CaO)	79.0345	1.3531
Magnesia (MgO)	40.7060	0.6969
Soda (Na_2O)	517.7579	8.8642
Sulphur Trioxide (SO_3)	67.7734	1.1603
Chlorine (Cl)	705.2248	12.0737
	1411.5480	24.1662
Oxygen (O)	158.9220	2.7208
Fixed residue	1252.6260	21.4454

Trace of Li.
Trace of Br.
Spec. Gravity = 1.0168
Contains H_2S.

Analysis.

United as follows:

	Grains in Gallon.
Silica (SiO_2)	1.0514
Calcium Sulphate ($CaSO_4$)	115.2149
Calcium Chloride ($CaCl_2$)	62.6228
Magnesium Chloride ($MgCl_2$)	96.6767
Sodium Chloride (NaCl)	977.0602
Mineral matter	1252.6260

THE GLASGOW MINERAL SPRING (W.).

Value of property.

This spring is owned and operated by Mr. R. S. McCampbell. It is situated in Glasgow, on Bear creek near the Chariton county line. It possesses a very weak flow. Near it is located a bath house with six rooms, in which hot and coald baths are procurable. The "Glasgow hotel" has 70 rooms and, with bath houses and private cottages, represents an investment of several thousand dollars. A circular is issued in which the water is recommended as beneficial in sciatica, mild paralysis, dyspepsia, etc.

Results of analysis of Glasgow Mineral spring (W. & R.):

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	0.4439	0.0076
Alumina	(Al_2O_3)	0.0175	0.0003
Lime	(CaO)	53.3809	0.9139
Magnesia	(MgO)	34.4970	0.5906
Potassa	(K_2O)	4.5151	0.0773
Soda	(Na_2O)	440.6041	7.5433
Sulphur Trioxide	(SO_3)	41.8438	0.7164
Chlorine	(Cl)	599 7481	10.2679
Carbon Dioxide	(CO_2)	8.7323	0.1495
		1183.7827	20.2668
Oxygen	(O)	135.1549	2.3139
Mineral matter		1048.6278	17.9529
Fixed residue		1039.8955	17.8034

Spec. Gravity = 1.0142
H_2S present.

United as follows:

Analysis.

		Grains in Gallon.
Silica	(SiO_2)	0.4439
Alumina	(Al_2O_3)	0.0175
Calcium Sulphate	($CaSO_4$)	71.1345
Calcium Chloride	($CaCl_2$)	47.7500
Magnesium Chloride	($MgCl_2$)	81.9303
Sodium Chloride	($NaCl$)	831.4624
Potassium Chloride	(KCl)	7.1569
Carbon Dioxide	(CO_2)	8.7323
Mineral matter		1048.6278

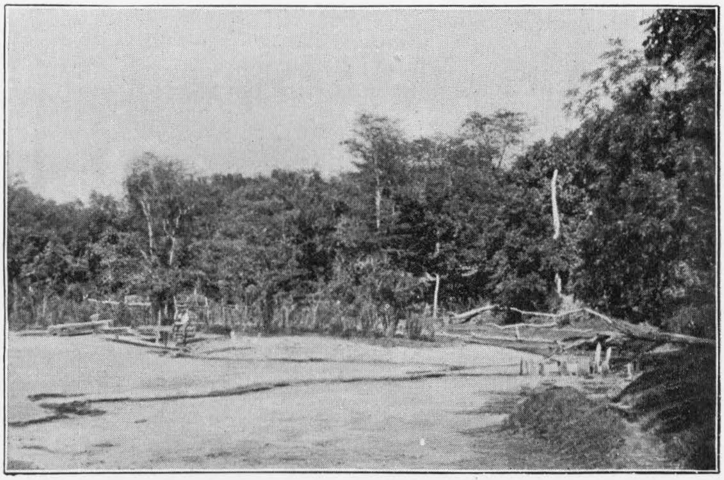


FIG. I.

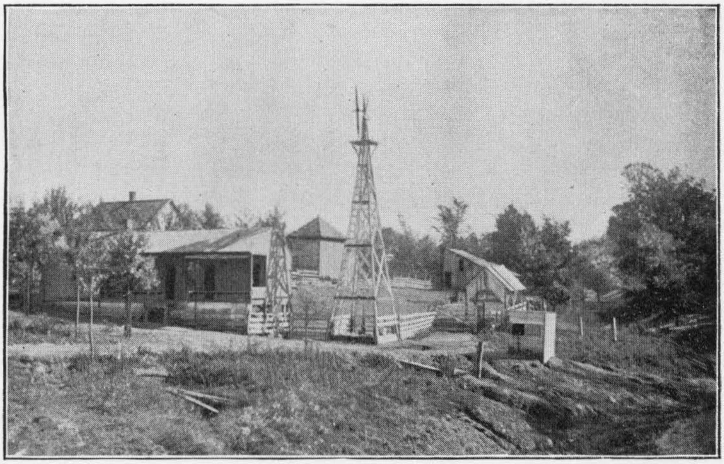


FIG. 2.

FIG. 1. VIEW OF BOONSLICK SPRING.
FIG. 2. VIEW OF GLASCOW MINERAL SPRING.

THE SPRINGS OF RANDOLPH COUNTY.

The prominent springs of Randolph county are situated close to the Randolph Springs station on the Wabash railway, and are three in number.

RANDOLPH SPRINGS (W.).

The Sulphur Spring is a free flowing four-inch well, 969 feet deep, and bored originally by parties now residing at Huntsville, for the purpose of obtaining petroleum; the water smells of sulphuretted hydrogen and, as it passes from a three-quarter inch pipe into a trough and away, it leaves all along its path a deposit of sulphur. The flow is at the rate of about 120 gallons per hour. The temperature of the water is 58° F., that of the air being 65° F. A partial analysis, made more than ten years ago, is printed in the Appendix.

Spring issues from a well, 969 feet deep.

The Salt Spring is a natural spring, the water of which is used for bathing exclusively, and is situated in the midst of a so-called " salt lick " of several acres in extent. A funnel-shaped opening about seven feet wide and ten feet deep has been dug out, from which the water is pumped into the bath houses. The temperature of the water is 57° F., the air being 62° F. Salt was made there fifty years ago.

Appearance of spring.

The Alum well was dug to obtain fresh water; but on reaching a depth of sixteen and one-half feet it became very astringent and it was decided to try its medicinal virtues. Pyrite observed in the clay shale excavated from the well here would account for the sulphates present. This shale is called " alum shale." The water in the well is about four feet deep. It is bottled in small quantities. The temperature is 57° F., the air being 66° F.

Iron sulphate probably derived from decomposed pyrite.

Improvements and Character of Waters. The three springs, with the property surrounding it, are owned by Horton brothers. Two hotels with an aggregate of forty-seven rooms, several private residences, bath houses and other improvements have been made and the resort is kept open for the accommodation of guests six to seven months in the year. The waters are claimed to be beneficial in dyspepsia, stomach and kidney troubles, and the alum water for sore eyes, piles and similar complaints. A few miles east from this locality a different class of waters is found which will receive attention under their proper headings.

Analysis of Sulphur Spring water.

Results of analysis of Sulphur Spring water (W. & R.):

		Grains in Gallon.	Grams in Litre.
Alumina	(Al_2O_3)	0.2511	0.0043
Lime	(CaO)	26.6876	0.4569
Magnesia	(MgO)	12.3420	0.2113
Potassa	(K_2O)	3.2827	0.0562
Soda	(Na_2O)	132.6666	2.2713
Chlorine	(Cl)	183.9156	3.1487
Sulphur Trioxide	(SO_3)	19.6608	0.3366
Carbon Dioxide	(CO_2)	10.9120	0.1868
Water in combination	(H_2O)	2.2320	0.0382
		391.9504	6.7103
Oxygen	(O)	41.4477	0.7096
Mineral matter		350.5027	6.0007
Fixed residue		342.8147	5.8691

SiO_2 not determined.
Spec. Gravity = 1.0041
H_2S present.

United as follows:

		Grains in Gallon.
Alumina	(A'_2O_3)	0.2513
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	20.0880
Calcium Sulphate	($CaSO_4$)	33.3900
Calcium Chloride	($CaCl_2$)	11.8400
Magnesium Chloride	($MgCl_2$)	29.2900
Potassium Chloride	(KCl)	5.2000
Sodium Chloride	($NaCl$)	250.4436
Mineral matter		350.5027

Analysis of Sulphur Spring water.

Results of analysis of Sulphur Spring water (W. & R.):

		Grains in Gallon.	Grams in Litre.
Alumina	(Al_2O_3)	0.1869	0.0032
Lime	(CaO)	76.4120	1.3082
Magnesia	(MgO)	35.5659	0.6089
Potassa	(K_2O)	4.2756	0.0732
Soda	(Na_2O)	412.1585	7.0563
Chlorine	(Cl)	572.2428	9.7970
Sulphur Trioxide	(SO_3)	24.7132	0.4231
Carbon Dioxide	(CO_2)	51.4976	0.8816
Water in combination	(H_2O)	10.5336	0.1803
		1187.5861	20.3318

FIG. I.

FIG. 2.

FIG. 1. HOTEL AT RANDOLPH SPRINGS.
FIG. 2. SPRING AND BATH HOUSES.

Oxygen..................	(O)	128.9576	2.2078
Mineral matter...........		1058.6285	18.1240
Fixed residue............		1022.3461	17.5029

Analysis of Sulphur Spring water.

SiO_2 not determined.
Spec. Gravity = 1.0106
Contains H_2S.

United as follows:

		Grains in Gallon.
Alumina................	(Al_2O_3)	0.1869
Calcium Bicarbonate......	($CaH_2(CO_3)_2$)	94.8024
Calcium Sulphate.........	($CaSO_4$)	43.0500
Calcium Chloride..........	($CaCl_2$)	51.8700
Magnesium Chloride......	($MgCl_2$)	84.7100
Potassium Chloride.......	(KCl)	6.7300
Sodium Chloride..........	($NaCl$)	777.2792
Mineral matter...........		1058.6285

THE SPRINGS OF JEFFERSON COUNTY.

The springs of the first group of muriatic waters in Jefferson county are situated some twenty to twenty-two miles south of St. Louis, on and near the Iron Mountain railway.

MONTESANO SPRINGS (R.).

Location and Improvements. At Montesano are a great number of springs which issue from low marshy ground. Their temperatures are uniformly between 57° and 59° F.; their flows are moderate, hardly amounting to more than 100 gallons in twenty-four hours for the most copious. A number of them are walled up, flush with the ground, forming a basin around each, three to four feet in diameter, with a like depth, from which the overflow runs off by a depression below the rim, a few inches wide. The walled up parts, as well as the rocks in the neighborhood, are covered with a whitish or pinkish coating of sulphur, while the surface of the water exhibits black and iridescent films, indicative, perhaps, of the existence of mineral hydrocarbons. Numerous black snails live in and out of the water, their shells often white from deposited sulphur; algæ thrive in abundance in the water courses, that carry away the overflow.

Temperature and flow of springs.

Algæ and snails live in water.

The valley, in which the springs occur, at the time of our visit, in April, was somewhat marshy. A hotel, built here some ten years ago, or longer, was burned down after a few years of existence and has not been rebuilt. In the early settlement of the district salt is said to have been made here by spontaneous evaporation of the waters in the shallow flats; no trace of the industry, however, is discernable at the present day. Three different samples were collected here, from what are known as the Montesano spring, the Council spring and the Afton spring.

Former improvements destroyed by fire.

All of these springs arise, or rather flow, from the Trenton limestone.

The general location of these springs may be seen in the adjoining diagram.

FIG. 6. Topographic sketch at Montesano Springs.

Cliff spring is situated at the base of a rather abrupt limestone cliff and is walled in: its flow is small and for that reason no sample was collected and no analysis was made of its water. Afton spring consists of two springs a few feet apart, both walled in and giving off an abundance of gas; the analysis refers to the upper one of the two. Council spring is the largest and the strongest of the springs of this tract, and contains the greatest amount of sulphuretted hydrogen. The others are all similar and differ only in flow and the

Much gas in water.

amount of gas which they give off. All these springs have been analyzed before and the results are given in the Appendix.

Results of analysis of Montesano Springs water (s.):

Analysis of Montesano Spring water.

		Grains in Gallon.	*Grams in Litre.*
Silica	(LiO_2)	0.8177	0.0140
Lime	(CaO)	42.7795	0.7324
Magnesia	(MgO)	19.0292	0.3258
Potassa	(K_2O)	0.9228	0.0158
Soda	(Na_2O)	188.4855	3.2269
Chlorine	(Cl)	284.8818	4.8773
Bromine	(Br)	1.5421	0.0264
Sulphur Trioxide	(SO_3)	22.2192	0.3804
		560.6778	9.5990
Oxygen	(O)	63.6915	1.0904
Fixed residue		496.9863	8.5086

Spec. Gravity = 1.0058
Contains H_2S.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.8177
Calcium Sulphate	($CaSo_4$)	37.7726
Calcium Chloride	($CaCl_2$)	53.9660
Magnesium Chloride	($MgCl_2$)	45.1743
Potassium Bromide	(KBr)	2.2897
Sodium Chloride	($NaCl$)	356.9426
Potassa neglected	(K_2O)	0.0234
Mineral matter		496.9863

Results of analysis of Council Spring water (s.):

Analysis of Council Spring water.

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	0.8177	0.0140
Lime	(CaO)	40.5015	0.6934
Magnesia	(MgO)	16.1212	0.2760
Potassa	(K_2O)	0.7593	0.0130
Soda	(Na_2O)	179.0909	3.0661
Chlorine	(Cl)	263.8718	4.5176
Bromine	(Br)	1.2850	0.0220
Sulphur Trioxide	(SO_3)	23.8663	0.4086
		526.3137	9.0107
Oxygen	(O)	59.5926	1.0202
Fixed residue		466.7211	7.9905

Spec. Gravity = 1.0052
Contains H_2S.

United as follows:

Analysis of Council Spring water.

	Grains in Gallon.
Silica.....................(SiO_2)	0.8177
Calcium Sulphate........($CaSo_4$)	40.5727
Calcium Chloride..........($CaCl_2$)	47.1653
Magnesium Chloride......($MgCl_2$)	38.2877
Potassium Bromide........(KBr)	1.9100
Sodium Chloride..........(NaCl)	337.9619
Potassa neglected..........(K_2O)	0.0058
Mineral matter............	466.7211

Results of analysis of Afton Spring water (s.):

	Grains in Gallon.	Grams in Litre.
Silica.....................(SiO_2)	0.8177	0.0140
Lime.....................(CaO)	27.4177	0.4614
Magnesia..................(MgO)	17.0265	0.2912
Potassa...................(K_2O)	0.7009	0.0120
Soda.....................(Na_2O)	140.8674	2.4117
Chlorine...................(Cl)	209.0344	3.5787
Bromine...................(Br)	1.1682	0.0200
Sulphur Trioxide ....(SO_3)	19.4505	0.3330
	416.4833	7.1220
Oxygen....................(O)	47.2238	0 8085
Fixed residue.............	369.2595	6.3135

Spec. Gravity = 1.0043
Contains H_2S.

United as follows:

Analysis of Afton Spring water.

	Grains in Gallon.
Silica.....................(SiO_2)	0.8177
Calcium Sulphate..........($CaSO_4$)	33.0658
Calcium Chloride..........($CaCl_2$)	27.3583
Magnesium Chloride.......($MgCl_2$)	40.4379
Potassium Bromide........(KBr)	1.7348
Sodium Chloride..........(NaCl)	265.8275
Potassa neglected.........(K_2O)	0.0175
Mineral matter...........	369.2595

SULPHUR SPRING (R.).

Location. This spring is situated one-half mile west of Sulphur Spring station, on the Iron Mountain railway. It issues, with a few smaller springs, from a low marshy ground, and is rudely walled up with limestone blocks to prevent filling up. The place is not improved, though excursion parties come down during the summer time, staying a day, and some visitors a couple of weeks, at the neighboring farm houses.

Results of analysis of Sulphur Spring water (s.):

Analysis of Sulphur Spring water.

		Grains in Gallon.	Grams in Litre.
Silica	(SiO_2)	0.8177	0.0140
Lime	(CaO)	23.5626	0.4034
Magnesia	(MgO)	5.4087	0.0926
Soda	(Na_2O)	89.3264	1.5293
Potassa	(K_2O)	0.9346	0.0160
Chlorine	(Cl)	136.0860	2.3298
Bromine	(Br)	1.5421	0.0264
Sulphur Trioxide	(SO_3)	6.4017	0.1096
		264.0798	4.5211
Oxygen	(O)	30.9478	0.5298
Fixed Residue		233.1320	3.9913

Spec. Gravity = 1.0031

Contains H_2S.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.8177
Calcium Sulphate	($CaSO_4$)	10.8829
Calcium Chloride	($CaCl_2$)	37.6935
Magnesium Chloride	($MgCl_2$)	12.8456
Potassium Bromide	(KBr)	2.2956
Sodium Chloride	($NaCl$)	168.5675
Potassa neglected	(K_2O)	0.0292
Mineral matter		233.1320

THE SPRINGS OF ST. LOUIS COUNTY.

THE BELCHER ARTESIAN WELL (R.).

Location and Character. This artesian well, which has quite a history, is situated in St. Louis on O'Fallon street below Main. The water flows from a $1\frac{1}{4}$ inch pipe in a continuous stream at the rate of about fifty gallons per hour; it is clear and sparkling, with a perceptible odor of sulphuretted hydrogen gas, which gives rise to a white precipitate of sulphur on the stones over which it flows. Its temperature at the time when the sample for analysis was collected was found to be 66° F., that of the air being 64° F.; but persons, claiming a knowledge

Flow of water and temperature.

of the spring, find it at times warmer. A large amount of this water is constantly used for home consumption as well as for shipping, its use being free to any one who may wish to take it. The water is introduced here from the similarity in composition and its proximity to the waters of Jefferson county. The results of an older analysis are given in the Appendix.

Water much used locally.

Results of analysis of water of Belcher artesian well (s.):

	Grains in Gallon.	Grams in Litre.
Silica .... (SiO_2)	0.9346	0.0160
Ferric Oxide .... (Fe_2O_3)	C.0584	0.0010
Lime .... (CaO)	44.6252	0.7640
Magnesia .... (MgO)	19.4038	0.3322
Potassa .... (K_2O)	1.7555	0.0301
Soda .... (Na_2O)	212.7993	3.6432
Chlorine .... (Cl)	308.9240	5.2894
Bromine .... (Br)	2.0560	0.0352
Sulphur Trioxide .... (SO_3)	29.5204	0.5054
	620.0772	10.6165
Oxygen .... (O)	69.8221	1.1954
Fixed residue	550.2551	9.4211

No organic matter.
No Li, no I.
Spec. Gravity = 1.0059
Contains H_2S.

United as follows:

	Grains in Gallon.
Silica .... (SiO_2)	0.9346
Ferric Oxide .... (Fe_2O_3)	0.0584
Calcium Sulphate .... ($CaSO_4$)	50.1847
Calcium Chloride .... ($CaCl_2$)	47.4941
Magnesium Chloride .... ($MgCl_2$)	46.0840
Potassium Bromide .... (KBr)	3.0583
Potassium Chloride .... (KCl)	0.8680
Sodium Chloride .... ($NaCl$)	401.5730
Mineral matter	550.2551

Analysis of Belcher water.

B. SECOND GROUP OF MURIATIC WATERS.

Waters containing, besides sodium chloride, magnesium chloride, and calcium sulphate; calcium chloride being absent.

The waters of the second group differ from those of the first group, as already indicated, by not containing calcium chloride. How this constituent of the ancient seas disappeared — whether by gradual solution and admixture of substances, which in time caused precipitation of the lime in an insoluble form, or by crystallization from a closed sea of the substances, now giving rise to these brines, and a mechanical removal of the yet liquid mother liquors—cannot be discussed here, but may find a satisfactory answer in the concluding volumes of the Survey. It must suffice to call attention to the fact, and to the use of these waters for bathing purposes. The order of description is, as in the first group, by quantities of mineral water, and any special water can thus be readily found. A moderate application for internal use of these waters is permissible, and may even be recommended in individual cases.

Calcium chloride disappeared from ancient seas.

These waters, as in the case of those of the first group, occur in two distinct sections of the State: the one near the western boundary and south of Saline county, in the counties of Benton, Henry and St. Clair; the other near the eastern boundary and north of St. Louis, in the counties of Pike and Ralls. They will be discussed by counties, as was done in the first group.

The two Saline county waters in this group are peculiar; occurring side by side with the other Blue Lick waters, which belong to group first, the assumption of assigning them to a higher geologic horizon seems forced; and yet the temperature determinations, given elsewhere, seem to indicate in their case a shallower local origin.

Springs close together may originate in different geological horizons.

TABLE OF ANALYSES OF MISSOURI MURIATIC WATERS — SECOND GROUP.

Contents are expressed in Grains per Gallon.

	1 Boling Spring (W.), Benton Co.	2 Clark's Spring (S.), Benton Co.	3 Artesian Well (W.), Clinton, Henry Co.	4 Old Black (W.), Monegaw Springs, St. Clair Co.	5 White Sulphur Spring (S.), Bl. L., Saline Co.	6 Sweet Spring (S.), Bl. L., Saline Co,	7 Elk Lick Spring (W.), Pike Co.	8 Louisiana Well (W. & R.), Pike Co.	9 Spalding Spring (W. & R.), Ralls Co.	10 Deep Well (S.), Brunswick, Chariton Co.
Silica	0 6.91	0.4089	0.6834	0.6483	3.7382	2.6869	0.2920	0.2862	0.3387	0 2920
Calcium Bicarbonate	19.7795	17 7524	16.7231	32.4645	41 7529	56 2169	26.2926	14.3856	12.5712	46.2982
Magnesium Bicarbonate	7.8157	6.6704	11.1125	7.0916	2.2866	4.1572	....	....	....	....
Calcium Sulphate	3.9918	7.3678	9.1254	3.1873	....	....	24.5200	71.4600	96.7200	107.9360
Magnesium Sulphate	....	....	....	....	12 5288	17 6046	16.9900	13 2700	0.3300	....
Magnesium Chloride	4.6945	5.8558	4.4639	9 4938	6 6969	5 8818	10.4200	27.5300	48 4300	75.6600
Potassium Chloride	1.5278	....	1 8518	2.7221	2.4833	1 8625	4.0700	7.0300	8.6600	....
Sodium Chloride	35.3679	56 2479	62.2853	111.4822	175 9326	212.4330	234.3612	411.7484	533.2613	698.8279
Mineral Matter	73.7963	94.3032	106 2454	167.0898	245 4602	300 8429	316.9696	545.7102	700.3112	929.0141
Specific Gravity	1.0005	1.0014	1.0009	1.0017	1.0033	1.0038	1.0040	1.0071	1.0091	1.0138

THE SPRINGS OF BENTON COUNTY.

Two springs in this county have been sampled and analyzed, *i. e.*, Boling spring and Clark's spring.

BOLING SPRING (W.).

Location. Boling spring is situated in the west central part of Benton county on the north side of the Osage river. It is in a remote part of the county in a rugged country, and the roads leading to it are in poor condition. Nevertheless it is made a resort by parties during the summer and has a local reputation. Its exact location is very near where Benton, Henry and St. Clair counties meet, or about section 30, T. 40 N., 23 W. The flow of water is strong, about 5000 gallons per hour. It contains a small amount of free hydrogen sulphide gas at the spring but not enough to show in analysis. The temperature of the water is 58° F., that of the air being 57° F. Boling spring.

Results of analysis of Boling Spring water (w.): Analysis.

	Grains in Gallon.	*Grams in Litre.*
Silica.................... (SiO_2)	0.6191	0.0106
Lime...................... (CaO)	8.4811	0.1452
Magnesia.................. (MgO)	4.1179	0.0705
Potassa................... (K_2O)	0.9638	0.0165
Soda...................... (Na_2O)	18.7379	0.3208
Sulphur Trioxide.......... (SO_3)	2.3481	0.0402
Chlorine.................. (Cl)	25.7076	0.4401
Carbon Dioxide............ (CO_2)	15.4552	0.2646
Water in combination...... (H_2O)	3.1613	0.0541
	79.5906	1.3626
Oxygen.................... (O)	5.7943	0.0992
Mineral matter............	73.7963	1.2634
Fixed residue.............	62.9074	1.0770

Spec. Gravity=1.0005

Trace of H_2S.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.6191
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	19.7795
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	7.8157
Calcium Sulphate	($CaSO_4$)	3.9918
Magnesium Chloride	($MgCl$)	4.6945
Potassium Chloride	(KCl)	1.5278
Sodium Chloride	($NaCl$)	35.3679
Mineral matter		73.7963

CLARK'S SPRING (R.)

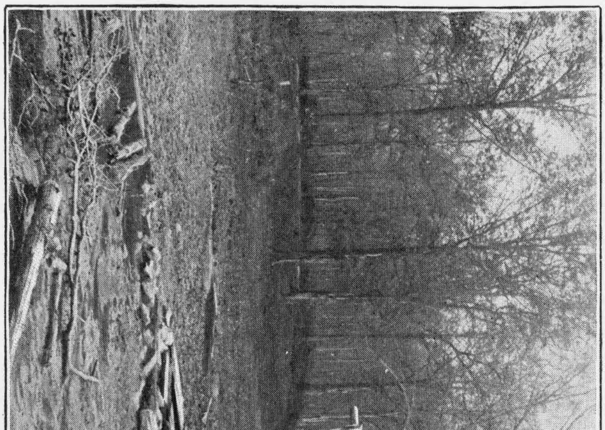
Clark's spring.

Location and Improvements. Clark's spring is situated about six miles west of Warsaw. It is one of a group of four, arranged in a line nearly northeast, the two extreme ones being about 200 yards apart. It is curbed to enclose the water, which flows at the rate of 500 gallons per hour. As none of the others are improved, the low, marshy ground in which they are situated, causes them to be overflowed in high water by a small stream near by, called "the branch," which, on retreating, leaves from four to six inches of mud behind. The ground is rendered thereby, in places, quite soft and insecure in spring and early summer; yet later on picnic parties resort to it, and families and visitors make stays there for their health, of several weeks' duration.

The property is owned by Clark Brothers, of Warsaw, Mo., but is undeveloped; the water is free to the use of any one who wishes it, and is claimed, by the owners, to be beneficial in stomach, kidney and blood diseases. It contains, like the previous spring, slight traces of sulphuretted hydrogen.

Results of analysis of Clark's spring water (s.):

		Grains in Gallon.	Grams in Litre.
Silica	(SiO_2)	0.4089	0.0070
Lime	(CaO)	9.1704	0.1570
Magnesia	(MgO)	4.2931	0.0735
Soda	(Na_2O)	29.8066	0.5103
Chlorine	(Cl)	38.5097	0.6593
Sulphur Trioxide	(SO_3)	4.3340	0.0742
Carbon Dioxide	(CO_2)	13.6638	0.2340
Water in combination	(H_2O)	2.7949	0.0478
		102.9814	1.7631



VIEW OF BOILING SPRING.

Oxygen..................(O)	8.6782	0.1486	Analysis.
Mineral matter...........	94.3032	1.6145	
Fixed residue............	84.6764	1.4497	

Spec. Gravity = 1.0014
Trace of Li, H_2S.
No K.

United as follows:

		Grains in Gallon.
Silica....................	(SiO_2)	0.4089
Calcium Bicarbonate......	($CaH_2(CO_3)_2$)	17.7524
Magnesium Bicarbonate...	($MgH_2(CO_3)_2$)	6.6704
Calcium Sulphate.........	($CaSO_4$)	7.3678
Magnesium Chloride......	($MgCl_2$)	5.8558
Sodium Chloride..........	(NaCl)	56.2479
Mineral matter............		94.3032

THE SPRINGS OF HENRY COUNTY.[1]

THE CLINTON ARTESIAN WELL (W.).

Depth and Flow of Water. During the summer of 1887, an eight-inch well was drilled south of Clinton (in N. W. $\frac{1}{4}$, of S. W. $\frac{1}{4}$, section 10, T. 41 north, 26 west). At the depth of 310 feet, the rate of flow of water from the well is reported to have been 75 gallons per minute, which increased to 200 gallons per minute at 425 feet; this water was termed "sulphur water." At the latter depth the diameter of the drill bit was decreased to $5\frac{5}{8}$ inches, and the drilling continued to 800 feet. The flow down to 425 feet was then separated from that at greater depths by a casing so that two distinct flows were obtained; one, from around the casing, of sulphur water, at 425 feet, at the rate of 200 gallons per minute; the other, through the casing, of fresh water, from 425 to 800 feet, at the same rate of 200 gallons per minute, thus making the combined flow about 400 gallons per minute. The casing is now removed and the waters mix in the well. The

Clinton Artesian Well.

[1] The springs of Henry County with the exception of the Clinton Artesian Well, belong to other classes and must be treated further on. It would doubtless have been more convenient, for some purposes, to treat them with the Artesian Well here; but the difference in composition prevented such arrangement and rendered the division necessary.

well is tubed above the surface of the ground to a height of, perhaps, ten feet. Through this the water rises and flows over into a sheet iron basin, escaping from this into the artificial pond by means of a trough, as is illustrated in the cut on the opposite page. The flow of the water through this trough was measured and found to be about 370 gallons per minute. Part of the water is, however, conveyed directly from the stand-pipe to the bath houses and, considering this, the present flow of the well may fairly be given as 400 gallons per minute. The well is reached by a line of horse cars from Clinton.

The flow of the well.

Improvements. An artificial lake receives the overflow from the well where boating and bathing are engaged in. Other improvements, in the way of bath houses and pavilions, have been made, and a large hotel has been erected for the accommodation of guests. The water is used extensively both for drinking and bathing, and for the latter purpose is furnished to the bath-rooms either hot or cold.

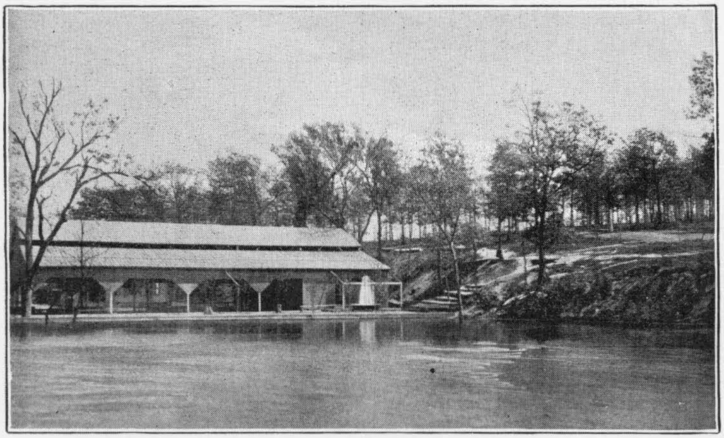
The sample for analysis was obtained by plunging the gallon bottle into the mouth of the stand pipe and allowing it to fill with the water. It was then immediately stoppered and sealed with melted paraffine. The analysis shows the water to be distinctly a saline water with a small percentage of carbonates present.

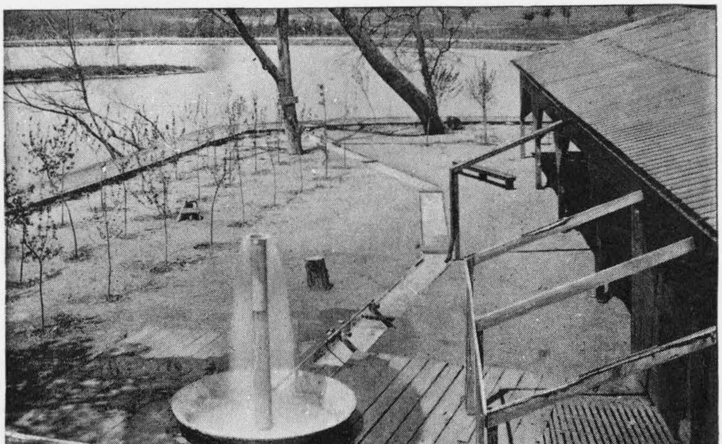
Results of analysis of water of Artesian Well No. 1 (w.):

Analysis.

	Grains in Gallon.	*Grams in Litre.*
Silica.................... (SiO_2)	0.6834	0.0117
Lime...................... (CaO)	9.5383	0.1633
Magnesia.................. (MgO)	4.9239	0.0843
Potassa................... (K_2O)	1.1682	0.0200
Soda...................... (Na_2O)	33.0016	0.5650
Sulphur Trioxide.......... (SO_3)	5.3679	0.0919
Chlorine.................. (Cl)	42.0202	0.7194
Carbon Dioxide............ (CO_2)	15.7822	0.2702
Water in combination...... (H_2O)	3.2281	0.0553
	115.7138	1.9811
Oxygen.................... (O)	9.4682	0.1621
Mineral matter..........	106.2456	1.8190
Fixed residue............	95.1264	1.6286

Spec. Gravity = 1.0009





VIEWS OF THE CLINTON ARTESIAN WELL AND LAKE.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.6834
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	16.7231
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	11.1125
Calcium Sulphate	($CaSO_4$)	9.1254
Magnesium Chloride	($MgCl_2$)	4.4639
Potassium Chlcride	(KCl)	1.8518
Sodium Chloride	($NaCl$)	62.2853
Mineral matter		106.2454

THE SPRINGS OF ST. CLAIR COUNTY.

St. Clair county, which lies directly south of Henry county, has the following springs, which have now or have had in the past a local reputation:—

1. *The Salt Creek Sulphur Spring.* This is an unimportant spring on Salt creek in the southwest quarter of the northwest quarter of section 27, T. 38 north, 26 west. It is reported to be a weak sulphur water and is probably of similar composition to the water of Monegaw spring (No. 7). **Springs not visited.**

2. An unimportant sulphur spring in section 6, T. 37 north, range 27 west, on the south side of the Osage river.

3. *The Iuka Spring.* Near Johnson post-office, in the south-west quarter of the south-west quarter of section 32, T. 39 north, range 27 west. This is said to be a "fresh water" spring, slightly chalybeate. It is now neglected, but considerable money has been spent on the spring and its surroundings. A former analysis is printed in the Appendix.

4. *The Taberville Spring.* This is a large fresh water spring at Taberville in lower half of northwest quarter section 3, T. 37 north, range 28 west. This is much resorted to during the summer.

5. *The Guller Spring.* This is reported to be a fresh water spring in section 34, T. 36 north, range 25 west.

6. On the west side of Little Monegaw creek, in the northeast quarter of the northeast quarter of section 14, T. 38 north, range 27 west, is an alkaline spring containing iron. The water flows from the limestone bluff. The yellow hydrate of iron is deposited around this spring, and for years past this has **Deposit of iron oxide from springs.**

given it a reputation as an "iron water" and has caused the spring to become a resort for such by visitors from Monegaw Springs. The water flows at the rate of about one hundred gallons per hour. The poor condition of the roads made the spring difficult of approach, and improvement in this respect would much increase its value to the frequenters of Monegaw Springs.

THE MONEGAW SPRINGS (W.).

Location and Character. These springs are situated on the north side of Little Monegaw creek in the southeast corner of the southwest quarter of the northwest quarter of section 30, Monegaw springs. T. 38 north, range 26 west, perhaps three quarters of a mile from the Osage river. On the north side of the creek the bluff

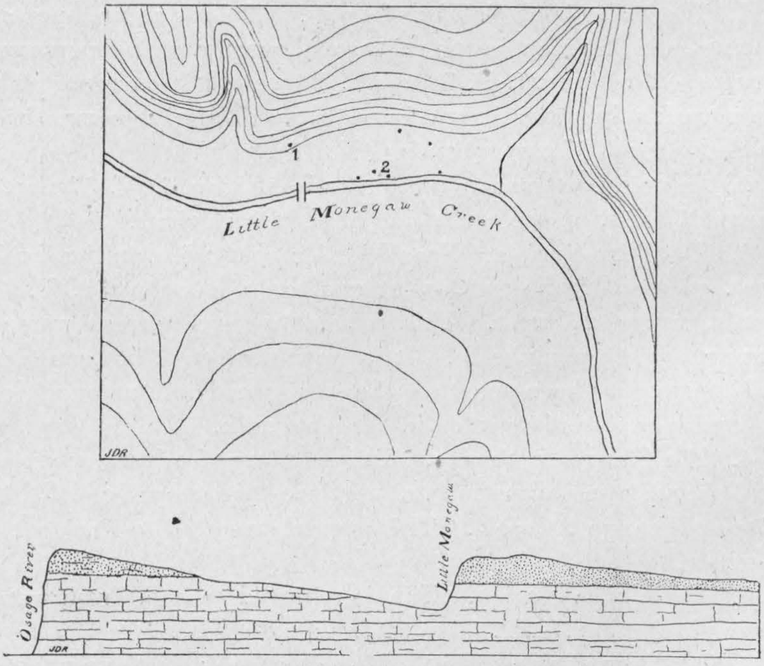
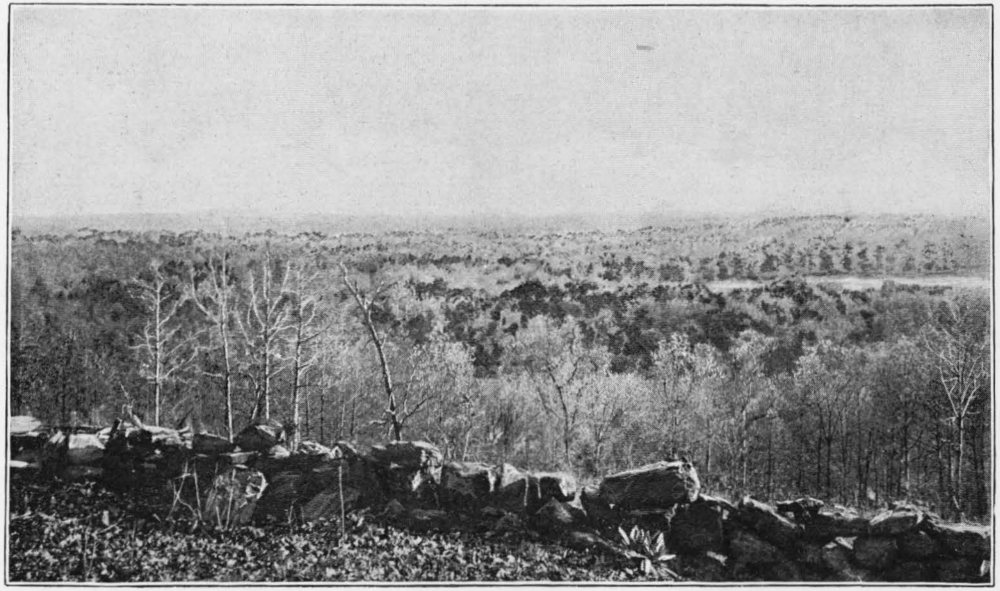


FIG. 7. Topographic sketch and cross-section at Monegaw Springs.
1 *White Sulphur spring;*
2 *Old Black spring.*

rises abruptly to a height of 150 feet above the level of the creek, and from the summit of this bluff there is a magnificent



VIEW OF MONEGAW CREEK AND OSAGE RIVER VALLEYS.

[From Monegaw Springs Hotel.]

view across the Osage valley. There are here about nine springs in all, situated in the very bed of Monegaw creek, so that at times of high water they are all flooded. The difficulty in obtaining water caused thereby could, however, be easily obviated by forcing the spring water to flow up through an iron pipe, as has been successfully done with one spring in the vicinity. The most important spring, and the largest, is termed "Old Black."

At the time of the writer's visit to Monegaw all of the springs were flooded, but a sample was obtained by carefully forcing a corked empty jug down into the spring water and, then, by pulling the cork out, the jug was filled while totally immersed. The analysis given was made of a sample from Old Black spring taken in this manner. The locality has many natural advantages for a summer resort, and it has been favorably known for a long time.

Method of obtaining sample of water.

Uses. Monegaw Springs is evidently destined to be the prominent mineral water resort of St. Clair county, and it is certainly admirably situated for such. It is reached either from Osceola or from Clinton in Henry county. The property is owned by I. O. Stump of Clinton, Mo., and H. Allton of Monegaw Springs. It possesses an hotel with twenty-seven rooms, built many years ago (in fact the springs have been known and used since the earliest history of the State) and a number of bath-rooms. The water is claimed to be beneficial in kidney, stomach and skin diseases and in bowel complaints.

Improvements at Monegaw Springs.

Rates of Flow. The flow of the Old Black spring, as nearly as could be determined from the reports of the owners, must be about 10,000 gallons per hour. The spring marked 1, has been piped to a depth of 14 feet by a 4-inch iron gas pipe, out of which the water escapes at a rate of about 4000 gallons per hour. The other springs of the group must furnish about 4000 gallons more. Thus, the total flow of the group is somewhere in the vicinity of 18,000 gallons per hour.

	Of Water.	*Of Air.*
Temperature of Old Black	61°F	59°F
" Spring 1	61°F	59°F

Results of analysis of Black Spring water (w.):

Analysis.

		Grains in Gallon.	Grams in Litre.
Silica	(SiO_2)	0.6483	0.0111
Lime	(CaO)	12.5347	0.2146
Magnesia	(MgO)	5.9403	0.1017
Potassa	(K_2O)	1.7173	0.0294
Soda	(Na_2O)	59.0760	1.0114
Sulphur Trioxide	(SO_3)	1.8749	0.0321
Chlorine	(Cl)	76.0441	1.3019
Carbon Dioxide	(CO_2)	21.9094	0.3750
Water in combination	(H_2O)	4.4815	0.0767
		184.2265	3.1539
Oxygen	(O)	17.1367	0.2934
Mineral matter		167.0898	2.8605
Fixed residue		151.6536	2.5963

Spec. Gravity = 1.0017

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.6483
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	32.4645
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	7.0916
Calcium Sulphate	($CaSO_4$)	3.1873
Magnesium Chloride	($MgCl_2$)	9.4938
Potassium Chloride	(KCl)	2.7221
Sodium Chloride	($NaCl$)	111.4822
Mineral matter		167.0898

THE SPRINGS OF SALINE COUNTY.

Blue Lick springs.

The occurrence and location of the springs of this county are given in detail in group first, so that mention need be made here only of the two springs from Blue Lick, properly coming under this heading. The third analysis, that of the Fresh Water spring, is appended as showing the existence of patches of saline deposits at no great depth below the surface, from which the waters percolating the limestone ridges dissolve more or less salt in their passage and, in this manner, change their character to a greater or less extent.

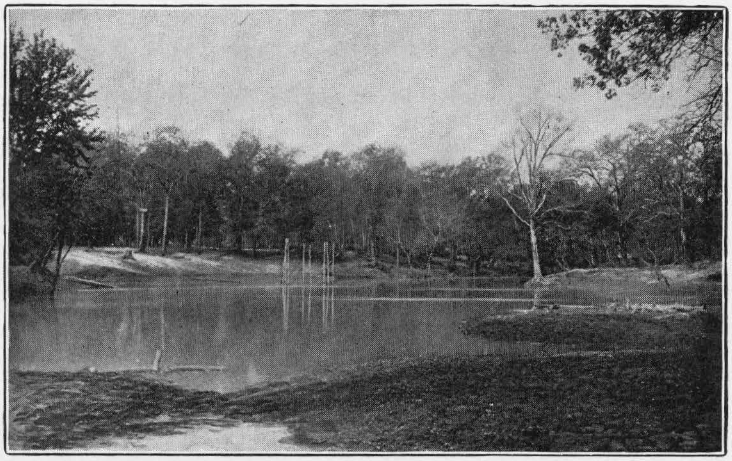


FIG. I.

FIG. 2.

FIG. 1. VIEW OF SPRING AND POOL AT MONEGAW SPRINGS.
FIG. 2. OLD HOTEL AT MONEGAW SPRINGS.

Results of analysis of White Sulphur Spring water (s.):

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	3.7382	0.0640
Ferric Oxide	(Fe_2O_3)	0.0409	0.0007
Lime	(CaO)	14.4331	0.2471
Magnesia	(MgO)	7.6225	0.1305
Potassa	(K_2O)	1.5667	0.0268
Soda	(Na_2O)	93.2292	1.5961
Chlorine	(Cl)	112.9508	1.9338
Sulphur Trioxide	(SO_3)	8.3526	0.1430
Carbon Dioxide	(CO_2)	24.0589	0.4119
Water in combination	(H_2O)	4.9210	0.0843
		270.9139	4.6382
Oxygen	(O)	25.4538	0.4358
Mineral matter		245.4600	4.2024
Fixed residue		228.5097	3.9122

Analysis.

Spec. Gravity = 1.0033
Li present.
H_2S trace.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	3.7382
Ferric Oxide	(Fe_2O_3)	0.0409
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	41.7529
Magnesium Bicarbonate	($MgH(CO_3)_2$)	2.2866
Magnesium Sulphate	($MgSO_4$)	12.5288
Magnesium Chloride	($MgCl_2$)	6.6969
Potassium Chloride	(KCl)	2.4833
Sodium Chloride	($NaCl$)	175.9326
Mineral matter		245.4602

Results of analysis of Sweet Spring water (s.):

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	2.6869	0.0460
Lime	(CaO)	19.4330	0.3327
Magnesia	(MgO)	9.1354	0.1564
Potassa	(K_2O)	1.1750	0.0201
Soda	(Na_2O)	112.5713	1.9273
Chlorine	(Cl)	134.1959	2.2975
Sulphur Trioxide	(SO_3)	11.7365	0.2008
Carbon Dioxide	(CO_2)	33.0102	0.5652
Water in combination	(H_2O)	6.8066	0.1165
		330.7508	5.6625

Analysis.

Oxygen....................(O)	29.9080	0.5120
Mineral matter......... ...	300.8428	5.1505
Fixed residue.............	277.5311	4.7514

Spec. Gravity = 1.0038
Li present.
H_2S absent.

United as follows:

	Grains in Gallon.
Silica......................(SiO_2)	2.6869
Calcium Bicarbonate......($CaH_2(CO_3)_2$)	56.2169
Magnesium Bicarbonate...($MgH_2(CO_3)_2$)	4.1572
Magnesinm Sulphate......($MgSO_4$)	17.6046
Magnesium Chloride......($MgCl_2$)	5.8818
Potassium Chloride.......(KCl)	1.8625
Sodium Chloride..........($NaCl$)	212.4330
Mineral matter	300.8429

Results of analysis of fresh water Spring water (s.):

Analysis.

	Grains in Gallon.	*Grams in Litre.*
Silica.... ....(SiO_2)	3.5046	0.0600
Lime....................(CaO)	12.7976	0.2191
Magnesia................(MgO)	3.0723	0.0526
Soda...... ....(Na_2O)	16.5387	0.2832
Chlorine.................(Cl)	18.7846	0.3216
Sulphur Tiroxide..........(SO_3)	1.7056	0.0292
Carbon Dioxide...........(CO_2)	20.1105	0.3443
Water in combination.....(H_2O)	4.1135	0.0704
	80.6274	1.3804
Oxygen...................(O)	4.2342	0.0725
Mineral matter...........	76.3932	1.3079
Fixed residue............	62.2245	1.0654

H_2S absent.
K, Li absent.

United as follows:

	Grains in Gallon.
Silica.................... (SiO_2)	3.5046
Calcium Bicarbonate......($CaH_2(CO_3)_2$)	37.0216
Magnesium Sulphate......($MgSO_4$)	4.6084
Sodium Sulphate..... ....(Na_2SO_4)	0.3008
Sodium Chloride.........($NaCl$)	30.9578
Mineral matter......	76.3932

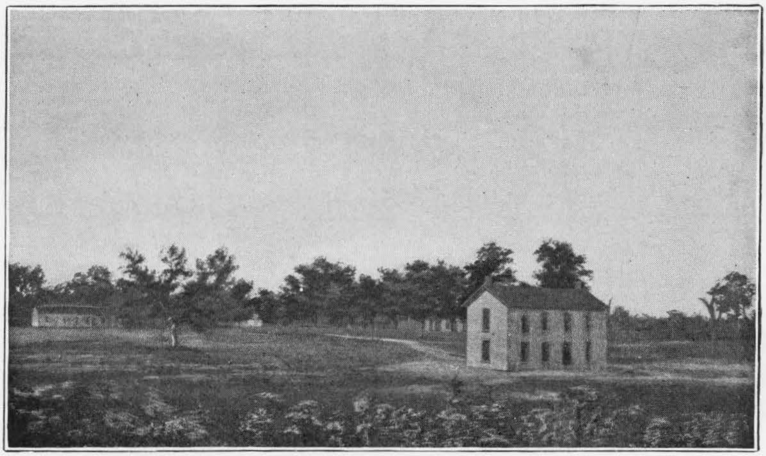


FIG. I.

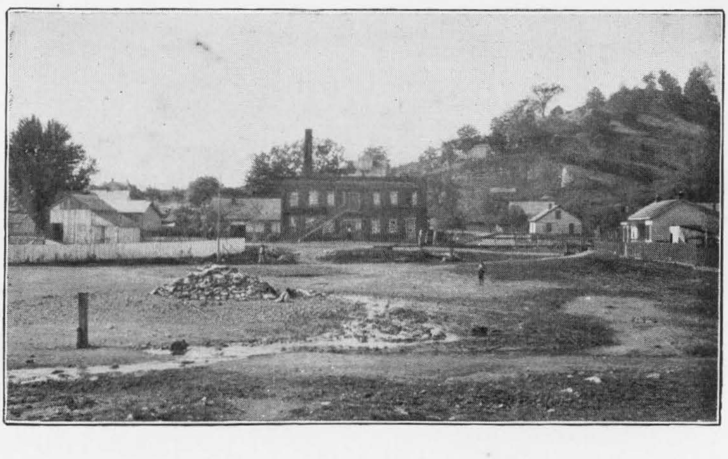


FIG. 2.

FIG. 1. VIEW OF ELK LICK SPRING HOUSE.
FIG. 2. VIEW OF THE LOUISIANA ARTESIAN WELL.

THE SPRINGS OF PIKE COUNTY.[1]

ELK LICK SPRINGS (W.).

Elk Lick spring is one of a number owned and operated by J. H. Rector, and is situated in section 13, T. 4 N., 5 W., about half a mile from Spencer creek; a small hotel and a few summer houses constitute the improvements, which are utilized during the summer months by visitors and guests. The water, like nearly all the waters of this group, contains a small amount of sulphuraetted hydrogen gas. The rate of flow is between 100 and 200 gallons per hour. The temperature of the water is 58° F., that of the air being 72° F. A stone building has been erected over the spring, which is represented in the adjoining Plate IX. The spring issues from the center of the floor of the building in a rectangular, stone-curbed basin, about 4 feet across and 5 feet deep. Elk Lick Springs.

Results of analysis of Elk Lick Spring water (W. & R.):

	Grains in Gallon.	*Grams in Litre.*
Silica (SiO_2)	0.2920	0.0050
Lime (CaO)	19.2344	0.3293
Magnesia (MgO)	9.9063	0.1696
Potassa (K_2O)	2.5700	0.0440
Soda (Na_2O)	124.1914	2.1262
Chlorine (Cl)	151.9244	2.6010
Sulphur Trioxide (SO_3)	25.8873	0.4432
Carbon Dioxide (CO_2)	14.2824	0.2446
Water in combination (H_2O)	2.9214	0.0500
	351.2096	6.0129
Oxygen (O)	34.2400	0.5862
Mineral matter	316.9696	5.4267
Fixed residue	306.9070	5.2544

Analysis.

Spec. Gravity = 1.0040
Trace of H_2S.

[1] Besides the two muriatic springs described here, a vitriolic water has been obtained from near Bowling Green, which is treated of subsequently. See also Appendix for additional analyses.

United as follows:

		Grains in Gallon.
Silica....................	(SiO_2)	0.2920
Calcium Bicarbonate......	($CaH_2(CO_3)_2$)	26.2926
Calcium Sulphate.........	($CaSO_4$)	24.5200
Magnesium Sulphate......	($MgSO_4$)	16.9900
Magnesium Chloride......	($MgCl$)	10.4200
Potassium Chloride.......	(KCl)	4.0938
Sodium Chloride..........	($NaCl$)	234.3612
Mineral matter...........		316.9696

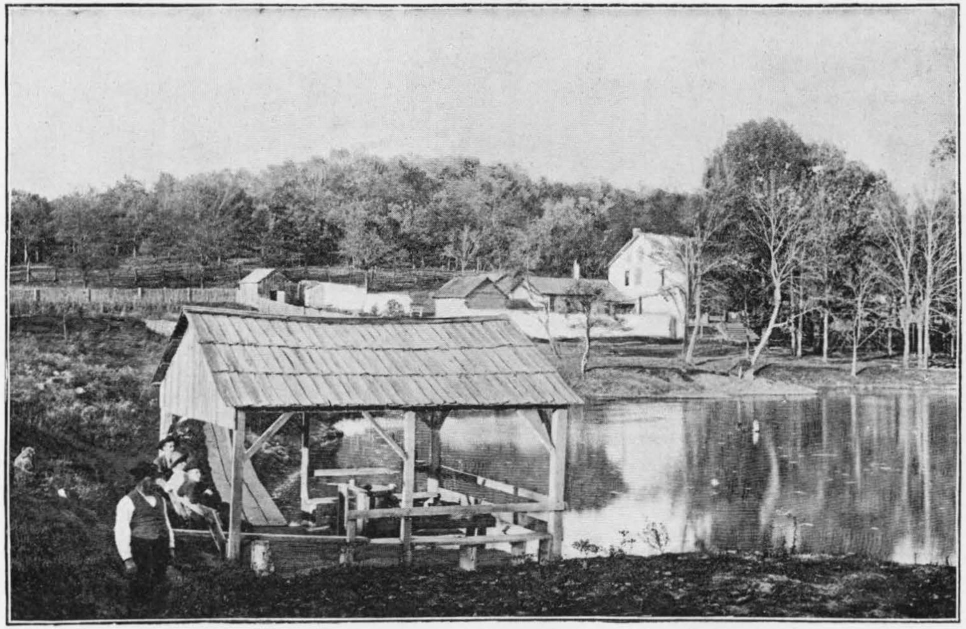
THE LOUISIANA ARTESIAN WELL (W.).

The Louisiana artesian well.

Location and Improvements. The Louisiana artesian well, also called "Therapeudor" is situated within the town limits of Louisiana, a flourishing city of about 6000 inhabitants on the west bank of the Mississippi river and eighty miles from St. Louis. The well is owned by the citizens in general; it is sunk to a depth of 1.275 feet, the bottom resting in sandstone, and is cased to depth of 910 feet. The strata passed through are given by Mr. W. H. Suda as follows: loose soil 90 feet; sandstone 90 to 650 feet; limestone 650 to 770 feet; sandstone 770 to 800 feet; undetermined 800 to 810 feet; sandstone 810 to 880 feet; undetermined 880 to 1275 feet. The flow of water is very abundant and appears inexhaustible, having now run four years since completion. A sanitarium, owned by Mr. J. J. Blackwell, has been established, furnishing, at a moderate expense, the usual comforts of a home with facilities for bathing and with experienced medical treatment. A pamphlet has been issued by the proprietor giving detailed information as to the virtues of the water, including an analysis made nearly four years ago, which is printed in the Appendix of this report.

The temperature of the water is 64.2° F., that of the air being 74° F.

A few miles below Louisiana two other salt springs are reported; also one about four miles northwest of that place and others of minor importance at other localities.



VIEW OF SPRING AND LAKE AT SPALDING SPRING.

Results of analysis of water of Louisiana well (W. & R.):

Analysis.

		Grains in Gallon.	Grams in Litre.
Silica	(SiO_2)	0.2862	0.0049
Lime	(CaO)	34.3451	0.5880
Magnesia	(MgO)	15.9868	0.2737
Potassa	(K_2O)	4.4626	0.0764
Soda	(Na_2O)	218.3716	3.7386
Chlorine	(Cl)	273.2537	4.6782
Sulphur Trioxide	(SO_3)	51.1730	0.8761
Carbon Dioxide	(CO_2)	7.8144	0.1338
Water in combination	(H_2O)	1.5984	0 0274
		607.2918	10.3971
Oxygen	(O)	61.5816	1.0543
Mineral matter		545.7102	9.3428
Fixed residue		540.2046	9.2485

Spec. Gravity = 1.0071

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.2862
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	14.3856
Calcium Sulphate	($CaSO_4$)	71.4600
Magnesium Sulphate	($MgSO_4$)	13.2700
Magnesium Chloride	($MgCl_2$)	27.5300
Potassium Chloride	(KCl)	7.0300
Sodium Chloride	($NaCl$)	411.7484
Mineral matter		545.7102

THE SPRINGS OF RALLS COUNTY.

SPALDING SPRING (W.).

Spalding well.

Location and Improvements. Spalding spring is the only one which has been sampled and analyzed by the Survey. This spring, or rather well, was sunk in 1823 by the State of Missouri, boring through rock some five feet below the surface to a depth of about 330 feet, for the purpose of obtaining brine for the manufacture of salt. It was leased to a company who made salt from it for some time, and is now owned and operated by Robert M. Spalding, of Spalding, Mo., a post-office some four miles from Rensalier station, on the Missouri, Kansas & Texas railway. The property consists of a hotel with twenty-four rooms and several cottages, kept open all the year round for the accommodation of guests and visitors. There is a large pool some twenty-five by fifty feet in extent for bathing. The value of the improvements is given at $6,000, and claims are made that the water is beneficial in stomach and kidney affections. The exact location of the springs, of which there are several, is in section 25 T., 56, N., 6 W. The flow is about 300 gallons per hour. The temperature of the water is 57° F., that of the air being 84° F.

Results of analysis of Spalding Spring water (W. & R.):

Analysis.

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	0.3387	0.0058
Lime	(CaO)	44.5084	0.7620
Magnesia	(MgO)	20.6537	0.3536
Potassa	(K_2O	5.5080	0.0943
Soda	(Na_2O)	283.0139	4.8453
Chlorine	(Cl)	364.6945	6.2437
Sulphur Trioxide	(SO_3)	57.5513	0.9853
Carbon Dioxide	(CO_2)	6.8288	0.1168
Water in combination	(H_2O)	1.3968	0.0239
		782.4941	13.4307
Oxygen	(O)	82.1829	1.4070
Mineral matter		700.3112	12.0237
Fixed residue		697.5000	11.9414

Spec. Gravity = 1.0091

United as follows:

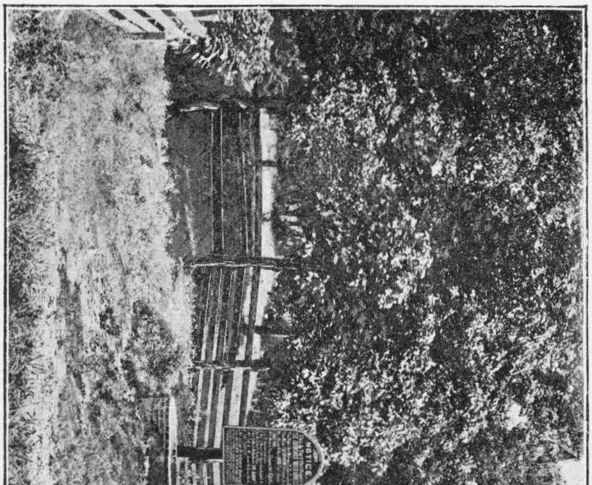
		Grains in Gallon.
Silica	(SiO_2)	0.3387
Calcium Bicarbonate	($CaH_2(CO_3)_2$	12.5712
Calcium Sulphate	($CaSO_4$)	96.7200
Magnesium Sulphate	($MgSO_4$)	0.3300
Magnesium Chloride	($MgCl_2$)	48.4300
Potassium Chloride	(KCl)	8.6600
Sodium Chloride	($NaCl$)	533.2613
Mineral matter		700.3112

THE SPRINGS OF CHARITON COUNTY.

THE BRUNSWICK WELL (A. W.).

The Brunswick well.

Location. The well is located in a small depression near the top of the ridge along which the town of Brunswick is built. Its location and immediate surroundings are well shown in the plate (XI.) opposite this page. The top of the well is about fifty



VIEWS OF BRUNSWICK MINERAL WELL.

feet above the river bottoms. The hole was drilled to a depth of 1505 feet, passing through about 130 feet of Coal Measure rocks and then into Lower Carboniferous and lower lying strata. It is cased to a depth of about 800 feet. The rate of flow, as roughly measured by the writer, was about 400 gallons per hour. Sulphuretted hydrogen gas is liberated.

Results of analysis of water of the deep well at Brunswick (s.):

		Grains in Gallon.	Grams in Litre.
Silica	(SiO_2)	0.2920	0.0050
Lime	(CaO)	60.4485	1.0349
Magnesia	(MgO)	731.8568	0.5454
Soda	(Na_2O)	370.3194	6.3400
Sulphur Trioxide	(SO_3)	63.4917	1.0870
Chlorine	(Cl)	480.6213	8.2284
Carbon Dioxide	(CO_2)	25.1496	0.4306
Water in combination	(H_2O)	5.1444	0.0881
		1037.3237	17.7594
Oxygen	(O)	108.3096	1.8543
Mineral matter		929.0141	15.9051
Fixed residue		911.2949	15.6017

Analysis.

Spec. Gravity = 1.0138
Trace of Li.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.2920
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	46.2982
Calcium Sulphate	($CaSO_4$)	107.9360
Magnesium Chloride	($MgCl_2$)	75.6600
Sodium Chloride	($NaCl_2$)	698.8279
Mineral matter		929.0141

C. THIRD GROUP OF MURIATIC WATERS.

Waters containing, besides sodium chloride ($Na\ Cl$), magnesium sulphate, ($Mg\ SO_2$) and calcium sulphate ($Ca\ SO_4$), calcium chloride ($Ca\ Cl_2$) and magnesium chloride ($Mg\ Cl_4$) being absent.

Origin and Distribution. The waters of this group differ by the absence of calcium chloride from the ancient, and by the absence of magnesium chloride from the present ocean waters.

In viewing the three groups of waters with reference to their location within the State, as we pass towards the west we seem to meet deposits purer in sodium chloride and freer from the accompanying salts, which so often detract from its value. This fact may offer an explanation as to their origin. An enclosed salt water sea of moderate extent, over southern and western

Origin of salt beds.

Kansas, deposited through evaporation, a fairly pure layer of sodium chloride, at present reached in Hutchinson and neighboring cities; an uplifting of the bottom of this sea forced the concentrated and now impure waters east and perhaps west. This process of elevation may have continued slowly and gradually, until either the whole had dried up or until the mother liquors had been poured out again into the ocean. This latter has probably been the case, or deposits of potash salts would exist in the States east of Missouri of which, so far, no indication has revealed itself. It is also possible, however, that the difference in composition of these brines may be owing to their formation during the different geological periods.

Only one water of this group and class occurs in the State.

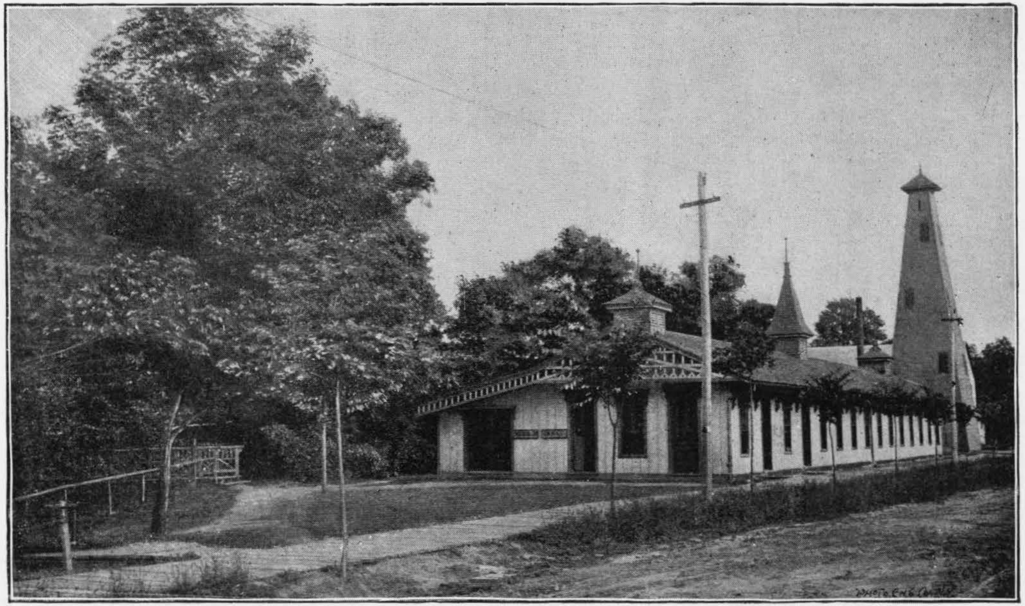
THE SPRINGS OF CLAY COUNTY.

EXCELSIOR SPRINGS (W.).

The springs of Clay county are mostly chalybeate, with one in the class of alkaline waters, and will be treated of further on. The analysis of the Sulpho-Saline spring at Excelsior Springs is, however, given here, as the only representative of the third group of muriatic waters. A full, illustrated description of this prominent resort will be given in chapter VIII, under the

Excelsior Springs.

head of chalybeate waters. Plate XII, opposite this page, shows the location of the Sulpho-Saline spring.



SULPHO-SALINE WELL AND BOWLING ALLEY AT EXCELSIOR SPRINGS.

Results of analysis of Sulpho-Saline Spring water (W. & R.):

	Grains in Gallon.	Grams in Litre.
Silica.................. ..(SiO_2)	0.5899	0.0101
Alumina..................(Al_2O_3)	2.2780	0.0390
Ferric Oxide.............(Fe_2O_3)	0.0584	0.0010
Lime......................(CaO)	19.5246	0.3343
Magnesia.................(MgO)	9.5500	0.1635
Potassa...................(K_2O)	2.9964	0.0513
Soda.......................(Na_2O)	205.5623	3.5193
Chlorine..................(Cl)	222.7173	3.8130
Sulphur Trioxide.......... (SO_3)	54.8879	0.9397
Carbon Dioxide...........(CO_2)	9.8048	0.1678
Water in combination.....(H_2O)	2.0055	0.0343
	529.9769	9.0733
Oxygen...................(O)	50.1976	0.8593
Mineral matter..........	479.7793	8.2140
Fixed residue.............	472.8714	8.0958

Analysis.

Spec. Gravity = 1.0065

United as follows:

	Grains in Gallon.
Silica.....................(SiO_2)	0.5899
Alumina..................(Al_2O_3)	2.2780
Ferrous Bicarbonate......($FeH_2(CO_3)_2$)	0.0921
Calcium Bicarbonate......($CaH_2(CO_3)_2$)	17.9658
Calcium Sulphate.........($CaSO_4$)	32.1800
Magnesium Sulphate......($MgSO_4$)	28.5500
Sodium Sulphate..........($NaSO_4$)	29.7400
Potassium Chloride........(KCl)	4.7300
Sodium Chloride..........(NaCl)	363.6535
Mineral matter...........	479.7798

CHAPTER VI.

ALKALINE WATERS.

Waters containing Sodium Carbonate or Magnesium Carbonate.

A. First Group of Alkaline Waters. — B. Second Group of Alkaline Waters.

Character and Origin. Of this class of waters twelve have been analyzed, which, for convenience sake, are placed in two groups, the one embracing the waters that contain sodium besides magnesium carbonate, the other those in which the former is absent. They evidently originated through atmospheric action upon feldspathic rocks or sandstones containing a part of such material in their make-ups; they consequently contain a considerable proportion of silica. Their total amounts of mineral matter are, however, small and depend, in all probability, upon the length of passage of the waters through the rocks before issuing above ground. In conformity with this view we find the first two or three springs of the first group, as well as the first spring of the second group, quite soft and deficient in mineral matter, while the rest of the waters of both groups hold each about an equal amount of mineral matter in solution. Allowance, however, must be made for the fact that, as the four waters of the second group are all free flowing artesian wells of more than 800 feet in depth, they strike, in all probability, outcroppings of the salt deposits mentioned in discussing the brines, with consequent increase of their mineral contents by dissolving this readily soluble salt. This is all the more probable since these four waters, as well as the brines, contain sulphuretted hydrogen gas. The absence of sodium carbonate in their case is, in my judgment, owing to the fact that these waters, on leaving the sandstone, do not come in contact with limestones, which invariably yield a certain amount of sodium carbonate. All the waters of this group belong to the western portion of the

Alkaline waters derived from feldspathic rocks.

State and, with one exception,—Clinton county—are found south of the river. They occur there, in a line from north to south, in the three border counties of Jackson, Vernon and McDonald; and in the next tier of counties from north to south of Johnson, Henry and Barry, leaving only Saline, Camden and Howell counties to the east of these. There seems to be hardly a doubt, that, in this whole section of the State, free flowing artesian wells, similar to those now flowing at Clinton, Nevada and Galbraith, could be obtained by boring.

Distribution of alkaline waters.

A. FIRST GROUP OF ALKALINE WATERS.

Waters containing both Sodium and Magnesium Carbonates.

The eight waters of this group are arranged in the order of the quantity of mineral matter contained in them; their therapeutic values may probably be measured by the amount of sodium and magnesium bicarbonate combined, and can easily be ascertained by the physician prescribing or by the patient using such waters.

TABLE OF ANALYSES OF MISSOURI ALKALINE WATERS — FIRST GROUP.

Results expressed in Grains per Gallon.

	Windsor Spring (W.), Henry Co. 1	Climax Spring (S.), Camden Co. 2	Electric Spring (S.), Dixon, Howell Co. 3	Panacea (S.), Barry Co. 4	Plattsburg Spring (W.), Clinton Co. 5	Town Spring (W.), Grand Pass, Saline Co. 6	Cusenbury Spring (W.), Kansas City. 7	Post Oak Sulphur Sp. (W.), Johnson Co. 8
Silica	0.7009	0.7009	0.5841	0.4673	1 5596	1 1215	1 0514	0.5783
Alumina	0.4205	....	....	....	1.3901	0.9111	3 2125	....
Calcium Bicarbonate	0.8800	8.4486	11 4902	21.9664	17.6256	14 4436	20.6482	11.3664
Magnesium Bicarbonate	0.8933	7.9949	8.9753	0.3836	3.9805	4.6297	3.0918	7.5630
Potassium Bicarbonate	....	....	....	....	....	1 3416	....	....
Sodium Bicarbonate	2.3267	0.0625	3.3654	3.1150	0 8400	4.8992	1 4191	2 8749
Potassium Sulphate	0.8063	....	....	....	....	1.3416	....	....
Sodium Sulphate	0 1049	....	....	....	0.2300	....	0.8700	3.3279
Potassium Chloride	0.1224	....	....	....	0 5790	....	0.4556	1.4190
Sodium Chloride	....	0.0088	0.0481	0.0481	0.5000	0 0491	0.0300	8.9535
Mineral Matter	6.2550	17.2197	24.4631	25 9805	26.7048	28.0309	30.7766	33.5797
Specific Gravity	1.0000	1.0002	1.0003	1.0002	1.0003	1.0002	1.0003	1.0001

THE WINDSOR MEDICAL SPRING.

THE SPRINGS OF HENRY COUNTY.

In addition to the analysis of the muriatic water of the artesian well already given in chapter V, three alkaline waters from this county have been analyzed, one belonging to the first and the other two to the second group of this class.

THE WINDSOR MEDICAL SPRING (W.).

Improvements and Character. This well is found in a grove one mile south of the town of Windsor, in the southeast quarter of the northeast quarter of section 14, T. 43 north, 24 west; it is excavated from a bed of sandstone. The amount of flow could not be determined, but the well furnishes water to a very large number of people during the summer months. A hotel of forty-two rooms has been built here, on elevated ground near the well. Other and more extensive improvements were contemplated but have not, as yet, been begun. **The Windsor medical spring.**

As a mineral water it is remarkable rather for the small amount of solids in solution than for its high mineralization. Among the constituents of the water the alkaline carbonates predominate in place of the carbonates of lime and magnesia. The water flows from ferruginous and micaceous sandstone. The temperature of the water is 47° F., that of the air being 74° F.

The property is owned by the city of Windsor and is operated by J. E. Ball of the same place; the water is claimed to be beneficial in kidney diseases and rheumatism and is used to a considerable extent.

Results of analysis of Windsor Spring water (w.):

	Grains in Gallon.	*Grams in Litre.*
Silica........................ (SiO_2)	0.7009	0.0120
Alumina .... (Al_2O_3)	0.4205	0.0072
Lime............................ (CaO)	0.3042	0.0052
Magnesia.................... (MgO)	0.2447	0.0042
Potassa .... (K_2O)	0.5128	0.0088
Soda......................... (Na_2O)	0.9103	0.0156
Sulphur Trioxide.......... (SO_3)	0.4298	0.0074
Chlorine...................... (Cl)	0.0584	0.0010
Carbon Dioxide............ (CO_2)	2.2434	0.0384
Water in combination..... (H_2O)	0.4432	0 0076
	6 2682	0.1074

Analysis.

Oxygen	(O)	0.0131	0.0002
Mineral matter		6.2551	0.1072
Fixed residue		4.6902	0.0804
			Spec. Gravity = 1.0000

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.7009
Alumina	(Al_2O_3)	0.4205
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	0.8800
Magnesium Bicarbonate	($MgH_2\ (CO_3)_2$)	0.8933
Sodium Bicarbonate	($NaHCO_3$)	2.3267
Potassium Sulphate	(K_2SO_4)	0.8063
Sodium Sulphate	(Na_2SO_4)	0.1049
Potassium Chloride	(KCl)	0.1224
Mineral matter		6.2550

THE SPRINGS OF CAMDEN COUNTY.

CLIMAX SPRING (R.).

Location. Only one spring in this county, the Climax Spring, has been investigated. It is situated in the extreme western edge of the county, about 30 miles from Warsaw, which is the nearest railroad point to it. It is accessible from there by wagon over very rough roads. The whole country, in fact, is as yet untouched by any railroad. Several springs are visible, but the

Climax Spring.

one which has given some celebrity to the place is in a cave and about fifty feet below the entrance to it. The pool has been explored some one hundred feet back, but is not known to terminate anywhere. Its water is fresh and nearly tasteless, not appearing in any way stagnant; persons claiming to be familiar with the locality assert

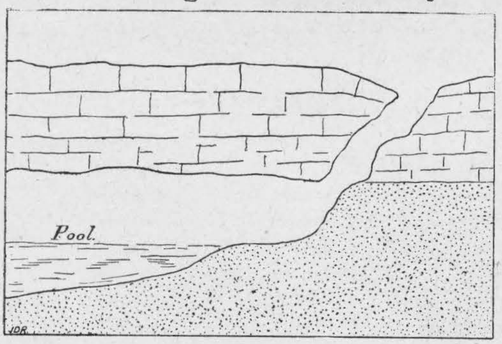


FIG. 8. Section through cave and pool at Climax Spring.

that the height of the water is not affected by rains in its immediate neighborhood, but increases when the rains extend to the head of the Niangua, some five miles away. A slight flow toward the west is recognized without difficulty. Other springs in the vicinity.

A spring near by, on the side of the hill, has a constant flow of a thousand gallons or so per hour, and forms the water supply for the town. A chalybeate spring, not walled in or improved, flows in the hotel yard. The property is owned by Indianapolis parties, who tried some time ago to make a summer resort of it by advertising and otherwise, but failed on account of the inaccessibility of the place.

Results of analysis of Climax spring water (s.):

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	0.7009	0.0120
Lime	(CaO)	2.9205	0.0600
Magnesia	(MgO)	2.1904	0.0375
Soda	(Na_2O)	0.0290	0.0005
Carbon Dioxide	(CO_2)	9.4412	0.1616
Chlorine	(Cl)	0.0070	trace
Water in combination	(H_2O)	1.9307	0.0330
		17.2197	0.3046
Oxygen	(O)	0.0040	0.0001
Mineral matter		17.2157	0.3045
Fixed residue		10.5644	0.1809

Analysis.

Trace of Mn.
Spec. gravity = 1.0002

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.7009
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	8.4486
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	7.9949
Sodium Bicarbonate	($NaHCO_3$)	0.0625
Sodium Chloride	($NaCl$)	0.0088
Mineral matter		17.2157

THE SPRINGS OF HOWELL COUNTY.

SILOAM SPRINGS (R.).

Location. This county possesses a number of springs of more or less reputation of which the best known are Siloam springs, situated in S. W. $\frac{1}{4}$, S. W. $\frac{1}{4}$ of section 32, T. 24 N., 10 W., about sixteen miles from West Plains. They are reached from the latter

Siloam springs.

place over a very rough road, especially after a season of rainy weather. The ground is covered with chert boulders and gravel dislodged from the limestone of the Ozark series, probably near the lower levels, though the great profusion of the chert in this part of the State makes it difficult to find contacts. The country is a succession of gently sloping hills with the chert cropping out at every bare spot. The springs, of which there are seven, are all on low ground, and were subject to overflows from surface waters; recent improvements have, however, remedied this. The water has a temperature of 58° F. The flow of water at each spring is moderate. The accompanying diagram shows their exact locations.

Sulphur Spring is the one sampled and analyzed. It has a flow of about 100 gallons per hour, a pleasant taste and a trace of sulphuretted hydrogen; being a chalybeate spring its analysis is given in Chapter VIII.

Keystone Spring is ferruginous with small flow and, at the time of visit, not fit for sampling.

Rheumatic Spring is provided with a spring house. The water contains no iron or sulphuretted hydrogen. The flow is about 50 gallons per hour.

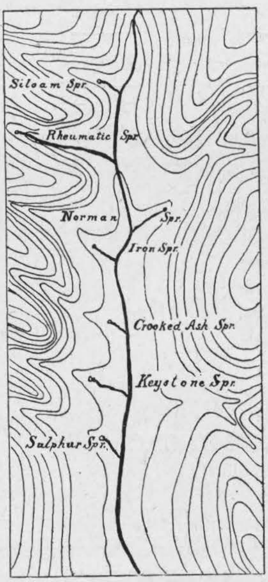


FIG. 9. Sketch of Siloam Springs, showing location of springs.

Iron Spring is not improved and has a very feeble flow.

Several varieties of Springs occur.

Norman Spring is a strongly ferruginous spring with a flow of 100 gallons an hour.

Siloam Spring is apparently a good lime magnesia spring with fairly strong flow.

Crooked Ash Spring is a strong chalybeate spring with a flow of 50 gallons per hour and a reputation for curing constipation.

The property including all of these springs is owned by Johnson & Keller, who are rapidly improving it. A bath house for hot and cold baths, with waiting and dressing rooms and two hotels have been erected at a combined cost of $40,000. The springs are to be walled in and protected against overflow and impurities. Descriptive circulars are printed, which may be obtained on application to John Johnson, the manager of the property, at Siloam Springs.

CURE-ALL, OR DIXON SPRINGS (R.).

Location and Character. At another locality, some fifteen miles south of West Plains, a second group of springs — Dixon Cure-all springs.
springs — is found. This was once a flourishing place but is now a deserted settlement, accessible from West Plains by roads and over a country in every way similar to that about Siloam Springs. An enclosure of about 200 feet square reveals five springs, though a larger number might be detected if the accumulated debris were removed. No difference in taste could be detected between them; which might, perhaps, be owing to overflow and admixture of the water of the creek; a distinction is, however, recognized by residents. The following figure shows the distribution of the different springs.

None of these springs were, at the time of visit, in condition to be sampled with any expectation of obtaining by analysis the composition of their waters as they actually issue from the ground; but by exercising much care, it is thought, a satisfactory sample of the Electric spring was obtained.

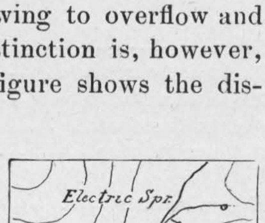


FIG. 10. Sketch showing location of springs at Dixon Springs.

Near the springs, prospectors have found from the surface to four feet below, some good calamine with blende, embedded in magnesian limestone. This limestone is here very compact, but on account of much earthy material in it, it weathers easily and then becomes soft.

Results of analysis of water of Electric spring near Dixon or Cure-all (s.):

Analysis.

		Grains in Gallon.	*Grams in Litre.*
Silica	($Si\ O_2$)	0.5841	0.0100
Lime	(CaO)	3.9719	0.0680
Magnesia	(MgO)	2.4590	0.0421
Soda	(Na_2O)	1.2675	0.0217
Chlorine	(Cl)	0.0292	0.0005
Carbon Dioxide	(CO_2)	13.4142	0.2296
Water in combination	(HO)	2.7438	0.0470
		24.4697	0.4189
Oxygen	(O)	0.0066	0.0001
Mineral matter		24.4631	0.4188
Fixed residue		15.0122	0.2570

Spec. Gravity = 1.0003
No Organic Matter.
No Li; no SO_3
Trace of K.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.5841
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	11.4902
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	8.9753
Sodium Bicarbonate	($NaHCO_3$)	3.3654
Sodium Chloride	($NaCl$)	0.0481
Mineral matter		24.4631

THE SPRINGS OF BARRY COUNTY.

A number of springs are known in Barry county with a local reputation attaching to each for the cure of certain diseases.

Large springs at Cassville.

Some ten miles east of Cassville, at Hailey, a number of similar springs of various names are found; some exist also in many of the caves, in which marble beds (Burlington limestone) abound. In Cassville itself three large springs emerge from the limestone beds, having a flow of from 500 to 1,000 gallons a minute. One of these springs supplies the town with drinking water.

VIEW OF DIXON SPRING AND POOL.

PANACEA SPRINGS (R.).

Location and Character. The best known of these springs perhaps, is the Panacea, situated about seven miles east of Cassville. It is one of two, issuing on different flanks of the divide out of the Lower Carboniferous limestone. Each of the two has about the same moderate flow 1½ gallons per minute with a temperature of 58° F., that of the air being 92° F. The water is claimed to be serviceable in rheumatism, kidney diseases, dyspepsia and bowel troubles. The springs, which have been known for thirteen years, are situated in S. ½, S. W. ¼, Section 29, T. 23 N., 26 W. and are not improved. Panacea spring.

Results of analysis of Panacea spring water (s.): Analysis.

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	0.4673	0.0080
Lime	(CaO)	7.5933	0.1300
Magnesia	(MgO)	0.1051	0.0018
Soda	(Na_2O)	1.1751	0.0201
Chlorine	(Cl)	0.0292	0.0005
Carbon Dioxide	(CO_2)	13.7954	0.2362
Water in combination	(H_2O)	2.8218	0 0483
		25.9872	0.4449
Oxygen	(O)	0.0066	0.0001
Mineral matter		25.9806	0.4448
Fixed residue		16.2611	0.2784

No Organic Matter.
No K; no Li; no SO_3
Spec. Gravity = 1.0002

United as follows.

		Grains in Gallon.
Silica	(SiO_2)	0.4673
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	21.9664
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	0.3836
Sodium Bicarbonate	($NgH_2(CO_3)_2$)	3.1150
Sodium Chloride	($NaCl$)	0.0481
Mineral matter		25.9805

THE SPRINGS OF CLINTON COUNTY.

The two springs of this county, that have been analyzed, belong the one to this group of Alkaline waters and the other to the second group of the Chalybeate waters. They are similar in composition, excepting that one contains a small quantity of bicarbonate of iron, while the other is free from it; this, however, may have been accidental as an analysis, made formerly and printed in the Appendix, reports a small amount of iron as present in the Plattsburg Spring.

THE PLATTSBURG SPRING (W.).

Location and Improvements. The spring is situated in the S. E. of the N. W. quarter of section 35, T. 55 N., 32 W., on Smith's Fork of the Platte river, about five feet above the level of the water in the creek. The spring has been tiled, and is protected by a substantial stone wall. A frame building twenty-five by fifty feet in size has been erected near it for bathing purposes and both hot and cold baths are furnished; the water for these is, however, derived from other springs in the ravine of presumably the same composition as that of the main spring. The flow of the spring sampled is only about fifty gallons per hour. The temperature of the water is 54° F., that of the air being 80° F. A hotel and several boarding houses accommodate guests and patients desirous of testing the qualities of the water, which is claimed to be efficacious in rheumatism, neuralgia, dyspepsia, bladder and kidney troubles. The property is owned by Funkhouser, Froman & Company of Plattsburg and is operated by Dr. Alston of the same place. Several thousand dollars having been spent in its development.

Water used for bathing.

Improvements.

Results of analysis of Plattsburg spring water (W. & R.):

	Grains in Gallon.	*Grams in Litre.*
Silica .... (SiO_2)	1.5596	0.0267
Alumina .... (Al_2O_3)	1.3901	0.0238
Lime .... (CaO)	6.0804	0.1041
Magnesia .... (MgO)	1.0864	0.0186
Potassa .... (K_2O)	0.3739	0.0046
Soda .... (Na_2O)	0.6775	0.0116
Chlorine .... (Cl)	0.5841	0.0100
Sulphur Trioxide .... (SO_3)	0.1285	0.0022
Carbon Dioxide..... ..... (CO_2)	12.4134	0.2126
Water in combination..... (H_2O)	2.5394	0.0435
	26.8333	0.4595

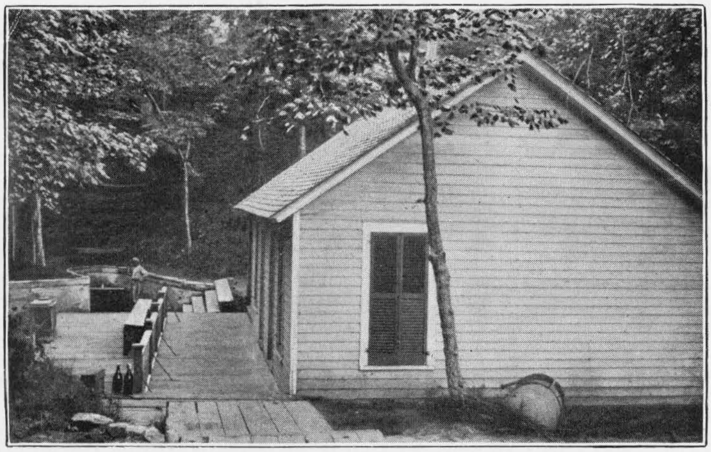


FIG. I.

FIG. 2.

THE PLATTSBURG MINERAL SPRING.

FIG. 1. VIEW OF SPRING HOUSE.

FIG. 2. VIEW OF HOTEL AND GROUNDS.

Oxygen....................(O)	0.1285	0.0022
Mineral matter............	26.7048	0.4573
Fixed residue.............	17.9587	0.3075
		Spec. Gravity = 1.0003

Analysis of the Plattsburg water.

United as follows:

	Grains in Gallon.
Silica....................(SiO_2)	1.5596
Alumina...................(Al_2O_3)	1.3901
Calcium Bicarbonate......($CaCO_3$)	17.6256
Magnesium Bicarbonate...($MgH_2)CO_3)_2$)	3.9805
Sodium Bicarbonate.......($NaH_2CO_3)_2$)	0.8400
Sodium Sulphate..........(Na_2SO_4)	0.2300
Potassium Chloride.......(KCl)	0.5790
Sodium Chloride..........(NaCl)	0.5000
Mineral matter......	26.7048

Peerless Spring, three miles from Plattsburg was at one time quite popular but is now altogether neglected.

Frost's Spring.

Frost's Spring, situated in the N. E. of the N. W. ¼, section 32, T. 55 N., 31 W. is placed among the chalybeate waters further on. It issues from a high ridge, about two miles from town, running northwesterly between Plattsburg and Lathrop, at a considerable height above water level. The bank whence it issues consists of drift twelve feet in thickness, nine feet of sand and three feet of gravel. The water is not used commercially.

THE SPRINGS OF SALINE COUNTY.

TOWN SPRING AT GRAND PASS (W.).

The only spring of this class is at Grand Pass, and supplies that town with water. It was visited during March, 1890, and sampled for analysis. The water from another similar spring a few yards away is used in the locomotives of the Mo. Pac. railway.

Results of analysis of Town spring water (w.):

Analysis of Grand Pass waters.

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	1.1215	0.0192
Alumina	(Al_2O_3)	0.9111	0.0156
Lime	(CaO)	4.9882	0.0854
Magnesia	(MgO)	1.2675	0.0217
Potassa	(K_2O)	1.0047	0.0172
Soda	(Na_2O)	1.8107	0.0310
Sulphur Trioxide	(SO_3)	0.2920	0.0050
Chlorine	(Cl)	0.0234	0.0004
Carbon Dioxide	(CO_2)	13.7964	0.2362
Water in combination	(H_2O)	2.8212	0.0483
		28.0367	0.4800
Oxygen	(O)	0.0058	0.0001
Mineral matter		28.0309	0.4799
Fixed residue		18.3115	0.3135

Spec. Gravity = 1.0002

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	1.1215
Alumina	(Al_2O_3)	0.9111
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	14.4436
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	4.6297
Potassium Bicarbonate	($KHCO_3$)	1.3416
Sodium Bicarbonate	($NaHCO_3$)	4.8992
Potassium Chloride	(K_2SO_4)	0.6351
Sodium Chloride	($NaCl$)	0.0491
Mineral matter		28.0309

THE SPRINGS OF JACKSON COUNTY.

Most of the waters are good for domestic use.

The springs of this county are quite numerous, though not especially remarkable for such constituents as give medicinal value to their waters. Some are Chalybeates and are treated under their proper heading; but most are Alkaline with but a moderate amount of mineral matter in solution, so that they are often fit for domestic use. Springs of such waters, each with a considerable flow, are found quite numerously in what is now Kansas City, and have acquired extended commercial use for ordinary household purposes as well as for the manufacture of carbonated beverages.

Bethsaida Spring is a fresh water spring located in Kansas City near the residence of Mr. E. T. Keim. It issues at the rate of 800 gallons per hour from a bank of loess. It is owned by the Winner Investment Company of Kansas City and is operated by Chas. B. Shattuck. The spring is protected from outside overflow by a properly constructed tank and its water is sold about the city for family and office use from tank wagons.

Water used in the city extensively.

Twin Springs, similar in character to the above, is owned and operated by P. Setzler & Sons, of 3506 Independence avenue, Kansas City. Only one of the springs is used commercially for manufacturing carbonated waters. It has a constant flow of about 650 gallons per hour, and has been known since the time of the early settlement of the county. The property, 50 by 125 feet, is valued at $10,000. A bottling establishment is erected upon it at a cost of between six and seven thousand dollars.

Union Spring is owned and operated by James Brodie, of 3251 East Sixth street. It is a dug well 23 feet deep, thirteen of which are cut into the solid rock. The water flows at the rate of about 1,000 gallons per hour. It, like the previous springs, is used for domestic purposes. Of like character are the "*Seven Springs*," the "*Diamond Springs*," the "*Scarritt Springs*" and the "*Washington or Reid Springs*."

The Tobener Gas Well is of a different character; it is owned by R. H. Tobener, of Kansas City, Mo. This is a bored well, 344 feet deep and touches at that depth saline deposits, which render the water salty in taste and impregnated, as many saline waters are, with iron. In boring, limestone, coal and sandstone were penetrated; but the nature of the material, in which the spring originates, is not known.

Young's Medical Well, like the preceding, belongs also to the muriatic waters, it is owned and operated by Dr. H. H. Young, of Kansas City, Mo., and is a bored well over 1,000 feet deep, passing, according to information furnished, through 5 feet of clay, 30 feet of slate and soapstone, 100 feet of limestone, then soapstone, sandstone and so on. The water is used medicinally to a considerable extent both for drinking and bathing and is claimed to be beneficial in rheumatism, old sores and as a blood purifier. The property is developed to a certain extent by the erection of bath houses and cottages for the accommodation of guests and is valued at a high figure.

Young's medical well.

THE CUSENBURY SPRING (W.).

The Cusenbury Spring.

Location and Properties. The Cusenbury spring, whose analysis follows, is situated near Independence, in N. E. $\frac{1}{4}$, S. W. $\frac{1}{4}$, Section 33, T. 50 N., 32 W. The water flows apparently from the surface of the limestone beds just beneath the clay above them. The rate of flow is considered to be 700 gallons per hour, but that observed at time of visit was only 150 gallons, though a large amount seeps away through the clay and soil. The temperature of the water was 54° F., that of the air being 77° F. The property is owned by J. D. Cusenbury of Independence, and was fitted formerly with bath houses with facilities for hot as well as cold baths. It is claimed to be serviceable in rheumatism, liver and kidney diseases, general debility and indigestion. The whole property, consisting of 162 acres, is held at a high price.

Analysis.

Results of analysis of Cusenbury spring water (w.):

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	1.0514	0.0180
Alumina	(Al_2O_3)	3.2125	0.0550
Lime	(CaO)	7.1260	0.1220
Magnesia	(MgO)	0.8459	0.0145
Potassa	(K_2O)	0.2862	0.0049
Soda	(Na_2O)	1.1507	0.0197
Chlorine	(Cl)	0 2336	0.0040
Sulphur Trioxide	(SO_3)	0.4848	0.0083
Carbon Dioxide	(CO_2)	13.6474	0.2336
Water in combination	(H_2O)	2.7897	0.0478
		30.8292	0.5278
Oxygen	(O)	0.0526	0.0009
Mineral matter		30.7766	0.5269
Fixed residue		21.1632	0.3623

Spec. Gravity = 1.0003

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	1.0514
Alumina	(Al_2O_3)	3.2125
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	20.6482
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	3.0918
Sodium Bicarbonate	($NaHCO_3$)	1.4191
Sodium Sulphate	(Na_2SO_4)	0.8700
Potassium Chloride	(KCl)	0.4556
Sodium Chloride	($NaCl$)	0.0300
Mineral matter		30.7766

FIG. 1.

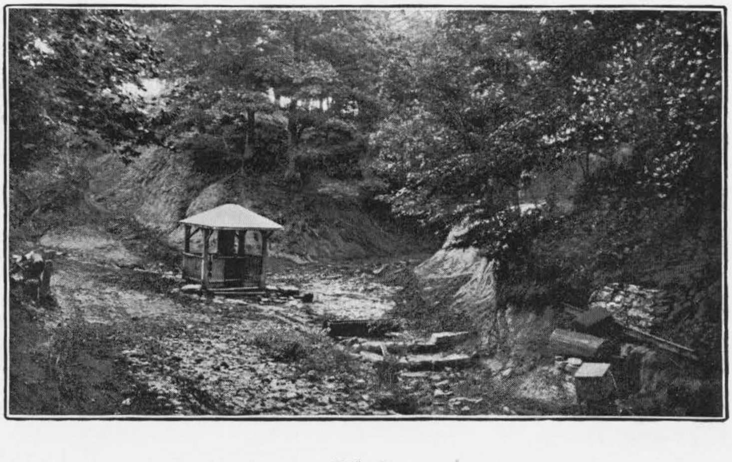


FIG. 2.

FIG. 1. THE YOUNG MEDICAL WELL AT KANSAS CITY.
FIG. 2. THE CUSENBURY SPRING.

THE SPRINGS OF JOHNSON COUNTY.

The most important springs of Johnson county are the ferro-alkaline springs, which will be described later under their proper heading. Sulphur springs exist and one which was visited and sampled is found on the Post Oak Creek branch of the Black water river in or near Section 11, T. 46 N., 26 W.; but most of the springs of this character are unimportant.

POST OAK SULPHUR SPRING (W.).

The Sulphur Spring north of Warrensburg is situated in the alluvial plane of Post Oak Creek. The flow is about 150 gallons per hour; it is very weak in mineral matter and weak in hydrogen sulphide. The temperature of the water is 56° F., that of the air being 59° F. Little attention is paid to it, but it is interesting as belonging to an entirely different class of waters from others in the neighborhood. Post Oak Sulphur Spring.

Results of analysis of Post Oak Sulphur spring water (w.):

	Grains in Gallon.	*Grams in Litre.*
Silica .... (SiO_2)	0.5783	0.0099
Lime........................ (CaO)	4.0069	0.0686
Magnesia.................... (MgO)	2.1028	0.0360
Potassa .... (K_2O)	0.7651	0.0131
Soda......................... (Na_2O)	7.2662	0.1244
Sulphur Trioxide.......... (SO_3)	1.8749	0.0321
Chlorine.................... (Cl)	6.2265	0.1066
Carbon Dioxide........... (CO_2)	12.1608	0.2082
Water in combination..... (H_2O)	2.5033	0.0429
	37.4848	0.6418
Oxygen...................... (O)	1.4018	0.0240
Mineral matter	36.0830	0.6178
Fixed residue............	27.4993	0.4708

Spec. Gravity = 1.0001 Analysis.
Trace of H_2S.

United as follows:

	Grains in Gallon.
Silica .... (SiO_2)	0.5783
Calcium Bicarbonate...... ($CaH_2(CO_3)_2$)	11.3664
Magnesium Bicarbonate... ($MgH_2(CO_3)_2$)	7.5630
Sodium Bicarbonate ...... ($NaHCO_3$)	2.8749
Sodium Sulphate......... (Na_2SO_4)	3.3279
Potassium Chloride .... (KCl)	1.4190
Sodium Chloride.......... ($NaCl$)	8.9535
Mineral matter...........	33.5797

B. SECOND GROUP OF ALKALINE WATERS.

Waters containing magnesium carbonate; sodium carbonate being absent.

Medicinal value of waters of this group.

Of the four waters of this group three contain appreciable quantities of sodium chloride, though lacking in sodium bicarbonate, and they contain larger amounts of magnesium bicarbonate than do the waters of the first group. Which of the two groups should be selected by the physician in individual cases would depend upon the nature of the disease under treatment, and upon the results, which experience has demonstrated to follow the use of the waters of each group. As already indicated, all the waters of this group are from deep bored wells, and may be assumed to be accessible in the whole western portion of the State, south of the Missouri river.

TABLE OF ANALYSES OF MISSOURI ALKALINE WATERS — SECOND GROUP.

Grains in Gallon.

	Galbraith Spring (S.), McDonald Co. 1	*Water Works Well* (S.), Clinton, Henry Co. 2	*Artesian Well* (S.), Nevada, Vernon Co. 3	*Artesian Well* (*No. 3*) (S.), Clinton, Henry Co. 4
Silica	0.5841	0.2336	0.8177	0.8177
Calcium Bicarbonate	6.9563	9.9844	13.7206	16.0778
Magnesium Bicarbonate	3.0508	12.8984	11.5124	15.6698
Sodium Bicarbonate	....	2.4050	....	....
Calcium Sulphate	0.6853	7.5764	4.3690	7.4968
Potassium Chloride	....	4.7292	....	2.0852
Sodium Chloride	1 8078	28.6482	45.5951	52.4010
Mineral Matter	14.0854	66.4752	76 0116	94.5483
Specific Gravity	1.0002	1.0006	1.0014	1.0019

THE SPRINGS OF McDONALD COUNTY.

McDonald county, in the southwestern corner of the State, is traversed by Elk river and numerous creeks. It possesses a number of free flowing springs of apparently pure or alkaline waters. Such springs are *the Twin Springs*, consisting of a group, six or seven in number, situated in section 19, T. 23 N., 32 W., one and a half miles from Splitlog. The aggregate rate of flow is about 300 gallons per hour from a bed of rock. The locality is unimproved and not readily accessible. Flow about 300 gallons per hour.

Indian Springs is another such group in section 6, T. 23 N., 31 W., some six miles west from Wade on the Splitlog railway. A hotel and private residences render this place quite convenient for a sojourn; the water is said to be beneficial in rheumatism and kidney diseases.

GALBRAITH SPRING (R.).

Location. Galbraith Spring is a well 804 feet deep penetrating limestone. It is piped to a depth of 400 feet. No knowledge of the strata, through which it passes was procurable. Its flow is very large, and its appearance clear and sparkling with a decided odor of sulphuretted hydrogen, but with only a slight taste. It is situated on the side of the railroad track on the Kansas City, Fort Smith and Southern railway, hardly more than ten feet away, and flows through a culvert beneath the track into the valley below. Seasons seem to have no effect upon the flow. Though at present unimproved, the owner of the property, Mr. Galbraith, intends to develop it. The proposal is to construct a branch road from Bentonville, Arkansas, to Pineville to connect with the Splitlog road at the latter place, and to establish a city here, — Oil Well City — the well having been bored for oil. Galbraith Spring.

A black, brittle, slaty shale crops out in the vicinity, resembling exceedingly that of the Coal Measures often found overlying a seam of coal; the marble beds rest uncomformably upon this, while underneath, and likewise unconformably, a yellowish limestone, somewhat like the Chouteau Limestone, is visible in which, at the time, no fossils could be found. Black shale crops out.

Results of analysis of Galbraith spring waters (s.):

Analysis.

		Grains in Gallon.	Grams in Litre.
Silica	(SiO_2)	0.5841	0.0100
Lime	(CaO)	2.6869	0.0460
Magnesia	(MgO)	1.1098	0.0190
Soda	(Na_2O)	0.9580	0.0164
Chlorine	(Cl)	1.0981	0.0188
Sulphur Trioxide	(SO_3)	0.4031	0.0069
Carbon Dioxide	(CO_2)	6.2202	0.1066
Water in combination	(H_2O)	1.2724	0.0218
		14.3326	0.2455
Oxygen	(O)	0.2472	0.0043
Mineral matter		14.0854	0.2412
Fixed residue		9.7029	0.1661

Trace of Mn. and Li.
Spec. Gravity = 1.0002

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.5841
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	6.9563
Magnesium Bicarbonate	($MgH_2CO_3)_2$)	4.0508
Calcium Sulphate	($CaSO_4$)	0.6853
Sodium Chloride	($NaCl$)	1.8089
Mineral matter		14.0854

THE WELLS OF HENRY COUNTY.

Two classes of waters have already been described in Henry County, *i. e.* "The Clinton Artesian Well" in Chapter V., under the head of Muriatic Waters, and the Windsor Medical Spring in the first group of this Chapter on Alkaline Waters. The two remaining wells belong to the second group of this class.

THE WATER-WORKS WELL NO. 2 (W.).

Comparison with water of Artesian Well. This well was drilled to a depth of 800 feet with a five inch drill. The present flow, owing to leakage and the form of the overflow pipe, could not be ascertained, but is certainly less than that of the adjoining "Artesian" well. The water supply of Clinton is derived entirely from this well, the overflow being collected in a reser-

Artesian well No. 2 supplies Clinton with water.

voir. The sample for analysis was taken, as before, by plunging the bottle into the stand pipe, and the bottle was sealed immediately with paraffine. Since the two wells are but a short distance apart and both were drilled to about the same depth, a correspondence between the analyses of these waters might be expected. A very considerable difference is found to exist, however. Thus, though both are characterized by a large percentage of sodium chloride the water of this well differs from the Artesian well water by containing larger amounts of carbonates and sulphates. These differences are produced, probably, by the mixing in the water-works well of a greater quantity of surface waters with the chloride water, thereby decreasing the amount of total solids and increasing at the same time the amount of alkaline constituents. The following table will show exactly the relations between the two wells:—

The two wells drilled to same depth, but differ in composition.

PERCENTAGE COMPARISON OF THE CLINTON ARTESIAN AND THE WATER-WORKS WELL.

Comparison of Artesian Wells Nos. 1 and 2.

	Clinton "Artesian."	"Water-Works Well."
Total Solids	1.6271 pts. per 1000	.9628 pts. per 1000
Free Hydrogen Sulphide	.0041 " " "	.0011 " " "
Free Carbonic Acid and acid combined as bicarbonate.	.1748 " " "	.1468 " " "
Potassium Chloride	1.94 % of solids.	8.40 % of solids.
Sodium Chloride	65.47 % " "	50.90 " " "
Calcium Chloride	.08 " " "	....
Magnesium Chloride	4.64 " " "	....
Calcium Sulphate	9.59 " " "	7.17 % " "
Magnesium Sulphate	....	2.52 % " "
Sodium Sulphate	....	3.59 % " "
Magnesium Carbonate	6.78 " " "	11.41 % " "
Calcium Carbonate	10.78 " " "	15.58 % " "
Chlorides present	72.13 " " "	59.30 % " "
Sulphates present	9.59 " " "	13.28 " " "
Carbonates present	17.56 " " "	26.99 " " "

Results of analyses of other well or spring waters directly comparable to these Clinton waters are not easy to find. The Fort Scott, Kansas, Artesian well water yielded 109.16 grains per gallon, the Clinton water works well 63.8, the Nevada Artesian 73, the Clinton Artesian No. 3, 90.8 grains per gallon.

Results of analysis of Water-Works well water (w.):

Analysis of water of Artesian Well No. 2.

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	0.2336	0.0040
Lime	(CaO)	6.5711	0.1125
Magnesia	(MgO)	3.5338	0.0605
Potassa	(K_2O)	2.9847	0.0511
Soda	(Na_2O)	16.0627	0.2750
Sulphur Trioxide	(SO_3)	4.4567	0.0763
Chlorine	(Cl)	19.6316	0.3361
Carbon Dioxide	(CO_2)	14.4388	0.2472
Water in combination	(H_2O)	2.9896	0.0512
		70.9026	1.2139
Oxygen	(O)	4.4274	0.0758
Mineral matter		66.4752	1.1381
Fixed residue		56.2662	0.9633

Spec. Gravity = 1.0006

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.2336
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	9.9844
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	12.8984
Sodium Bicarbonate	($NaHCO_3$)	2.4050
Calcium Sulphate	($CaSO_4$)	7.5764
Potassium Chloride	(KCl)	4.7292
Sodium Chloride	($NaCl$)	28.6482
Mineral matter		66.4752

THE CLINTON ARTESIAN WELL NO. 3 (R.).

Artesian well No. 3.

The Clinton Artesian Well No. 3, about a mile from the others (Nos. 1 and 2), is 913 feet deep. The temperature of the water is 64° F.; it flows at a rate of about 2,500 to 3,000 gallons per minute and is similar in character to the Water-Works well. It is located in the creek bottom about a mile northwest of them. No improvements were made here at the time of inspection, as the well was not drilled until the year 1891. Other springs in Henry county are few in number and for the most part alkaline, with bicarbonate of iron in some of them.

Results of analysis of water of Clinton Artesian well No. 3 (s.):

Analysis.

		Grains in Gallon.	Grams in Litre.
Silica	(SiO_2)	0.8177	0.0140
Lime	(CaO)	8.6447	0.1480
Magnesia	(MgO)	4.2931	0.0735
Potassa	(K_2O)	1.3142	0.0225
Soda	(Na_2O)	27.7681	0.4745
Chlorine	(Cl)	32.7972	0.5615
Sulphur Trioxide	(SO_3)	4.4099	0.0755
Carbon Dioxide	(CO_2)	18.1784	0.3112
Water in combination	(H_2O)	3.7183	0.0637
		101.9416	1.7444
Oxygen	(O)	7.3909	0.1265
Mineral matter		94.5507	1.6179
Fixed residue		81.7432	1.3936

Trace of Si.
No K_2S.
Spec. Gravity = 1.0019

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.8177
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	16.0778
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	15.6698
Calcium Sulphate	($CaSO_4$)	7.4968
Sodium Chloride	($NaCl$)	52.4010
Potassium Chloride	(KCl)	2.0852
Mineral matter		94.5483

THE SPRINGS OF VERNON COUNTY.

Springs of Vernon county nearly all chalybeate.

The springs of Vernon county, with the exception of the Artesian Well here described, are chalybeates and will be treated later in their proper class.

THE NEVADA WELL (R.).

Location and Improvements. The Artesian Well is situated about a mile and a half south of Nevada. It was bored by a company for oil, coal or anything, which might be struck, and has been sunk to a depth of 800 feet. At about 750 feet the present stream of water was met, flowing at the rate of 10,000 gallons per hour, and operations were carried but little further. The property has been developed and rendered attractive by the construction of a lake some seven or eight acres in extent from the surplus waters, in the midst of which a beautiful island with grand stand and boats invites and receives much patronage. On the grounds is maintained a restaurant and pavillon and the roads to Nevada are kept in good condition.

Well 800 ft. deep; attractive improvements.

Results of analysis of waters of Nevada Artesian well (s.):

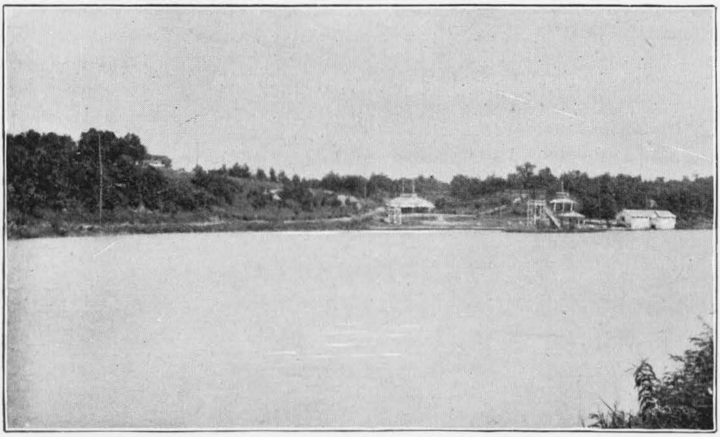
Analysis.

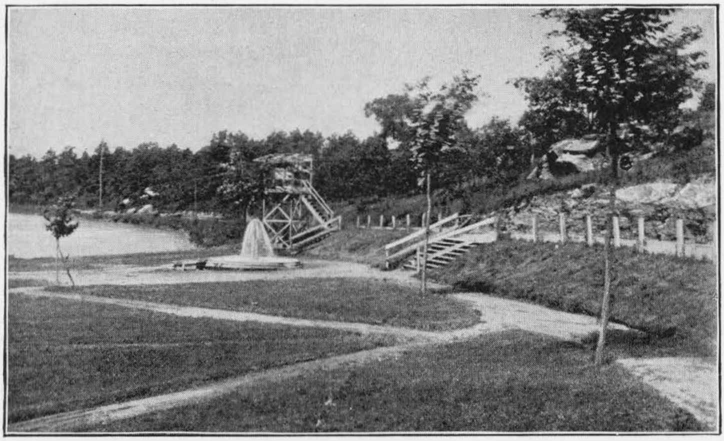
	Grains in Gallon.	*Grams in Litre.*
Silica....................(SiO_2)	0.8177	0.0140
Lime....................(CaO)	6.5419	0.1126
Magnesia................(MgO)	3.1541	0.0540
Soda....................(Na_2O)	24.1583	0.4136
Chlorine.................(Cl)	27.6688	0.4737
Sulphur Trioxide..........(SO_3)	2.5700	0.0440
Carbon Dioxide...........(CO_2)	14.3922	0.2464
Water in combination. ...(HO_2)	2.9438	0.0504
	82.2468	1.4081
Oxygen..................(O)	6.2352	0.1067
Mineral matter...........	76.0111	1.3014
Fixed residue............	65.8717	1.1278

Spec. Gravity = 1.0014
No Organic Matter.
No K; no Br.
Trace of Li.

United as follows:

	Grains in Gallon.
Silica....................(SiO_2)	0.8177
Calcium Bicarbonate......($CaH_2(CO_3)_2$)	13.7206
Magnesium Bicarbonate...($MgH_2(CO_3)_2$)	11.5124
Calcium Sulphate.........($CaSO_4$)	4.3690
Sodium Chloride..........($NaCl$)	45.5919
Mineral matter...........	76.0116





ARTESIAN MINERAL WELL AND LAKE AT NEVADA

CHAPTER VII.

SULPHATIC WATERS.

Waters containing one or more sulphates as their main constituents.

FIRST GROUP OF SULPHATIC WATERS. — SECOND GROUP OF SULPHATIC WATERS. — THIRD GROUP OF SULPHATIC WATERS.

Origin. Among sulphatic waters are placed all waters whose chief constituents are soluble sulphates. Four natural divisions or groups might, therefore, be expected to exist, viz.: Epsom salts waters, Glauber's salt waters, Alum waters and Vitriol waters; the two latter, from their mode of formation, often pass into one another.

Epsom salts and Glauber's salt are merely leached out from rock formations that contain these salts ready formed; a longer or shorter contact during the passage through these rocks would, as is proven in certain cases, render the water more or less strongly impregnated with them. Heavy rains affecting the copiousness of flow of springs reduce, then, invariably the quantity of mineral water, which the waters carry, and offer an explanation for differences in the analytical results of waters, collected and analyzed at different times. This is all the more observable with these special waters, since they originate at no great depth.

Epsom and Glauber's salts leached from rocks.

Alum and Vitriol waters, on the other hand, are primarily the products of chemical action upon pyritiferous coals or shales; atmospheric oxygen, moisture and carbonic acid, simultaneously or in turns, decompose the finely divided pyrite, giving rise to waters, that contain ferrous sulphate or vitriol, either alone or in conjunction with aluminium sulphate which is a product of secondary action of the former upon aluminous deposits, in the presence of oxygen. All such waters are free from chlorides and carbonates and many even contain free sulphuric acid,

Ferrous and aluminous sulphates from decomposed pyrite.

unless they pass, before reaching the surface, through beds of limestone. In such cases a variety of changes result, often entirely altering the character of the water. These are described elsewhere in this volume.

Attention called to differences in waters.

Uses. All waters of this class are truly medicinal and of great therapeutic value; their potency, however, demands absolutely the advice of a skillful physician in their use. In this connection it is proper to call the attention to the difference of action of the waters of the first two groups from those of the last two described in Chapter III of this Report. This difference is fundamental and must, in no case, be lost sight of. The four waters of this class are for convenience of comparison tabulated together in the following list.

TABLE OF ANALYSES OF MISSOURI SULPHATIC WATERS.

Results are expressed in grains per gallon.

	1 *B. B. Spring* (W. & R.), Pike Co.	2 *Lineville Well* (W. & R.), Mercer Co.
Silica	0.6659	0.1168
Alumina	1.6647	0.2862
Calcium Bicarbonate	5.1516	....
Calcium Sulphate	75.6700	1.9000
Magnesium Sulphate	475.5900	3.1800
Potassium Sulphate	1.0600	....
Sodium Sulphate	7.2100	180.3000
Potassium Chloride	....	1.7400
Sodium Chloride	2.4500	15.0700
Mineral Matter	569.4622	202.5930
Specific Gravity	1.0068	1.0034

	3 *Crystal Spring* (S.), Lamonte, Pettis Co.	4 *Alum Well* (S.), Versailles, Morgan Co.
Silica	3.0957	2.6869
Ferrous Sulphate	7.8905	22.4177
Aluminium Sulphate	10.5561	89.8930
Calcium Sulphate	29.8600	38.2009
Magnesium Sulphate	9.8481	32.6454
Sodium Sulphate	6.0790	7.0901
Mineral Matter	67.3294	192.9340
Specific Gravity	1.0015	1.0031

A. FIRST GROUP (EPSOM SALTS WATERS).

Waters containing magnesium sulphate or Epsom salts.

THE SPRINGS OF PIKE COUNTY.

B. B. SPRING (W.).

B. B. Spring.

Location and Improvements. The only one of the springs of this class is the B. B. spring near Bowling Green; it is a truly Epsom salts water spring. It is situated in section 26 T. 53 N. 3 W., and is owned and operated by Wood and Fielder of Bowling Green. The first well dug was fourteen feet deep with a slaty rock at the bottom. It was dug originally for an ordinary well, but its water soon attracted attention for its mineral contents and was analyzed by the writer in 1887, when its nature was disclosed. The wells possess an abundant flow, though a pump is required to lift the water to the surface. It gains its salts in the usual manner in which magnesium sulphate springs in other countries gain theirs; they form in all cases a part of the solid rock, and incrustations of magnesium sulphate were found on the surface of a limestone bridge near the spring, the stone for which had been quarried in the neighborhood. The salt is readily dissolved and its quantity depends, in a measure, upon the rapidity with which the water flows in its course toward the surface through the crevices and cracks in the rock bed; the slower the flow, other things being equal, the stronger the water; the more copious the flow the less its strength. The mineral matter is, however, at all times very considerable and renders the water at all times truly medicinal. Three additional wells have been dug, with a less favorable result, however, as to the quality of the water. The property is fairly developed; a considerable trade in the water, either bottled or in kegs

Incrustations of magnesium sulphate.

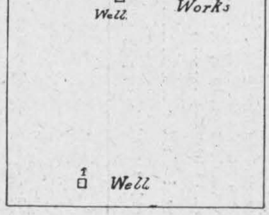


Fig. 11. Diagram of B. B. Springs, showing location of wells.

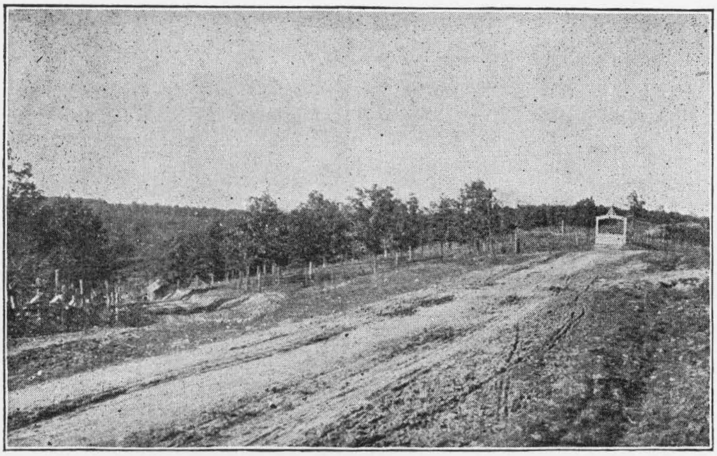


FIG. 1.

FIG. 2.

FIGS. 1—2. B. B. SPRINGS, BOWLING GREEN, PIKE CO.

and jugs, has sprung up and sales are reported over many States. The value of the property is placed at $8,000. The sketch opposite shows the location of the different wells and their depth. The sample of water for analyses was taken from the well numbered 3. The temperature of the water is 58° F., that of the air being 69° F. Improvements.

A pamphlet, giving information as to the water, is published by the owners and may be obtained from them by writing for it.

Results of analysis of B. B. spring water (W. & R.): Analysis.

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	0.6659	0.0114
Alumina	(Al_2O_3)	1.6647	0.0285
Lime	(CaO)	33.0250	0.5654
Magnesia	(MgO)	159.3600	2.7283
Potassa	(K_2O)	2.1320	0.0365
Soda	(NaO)	3.1483	0.0539
Chlorine	(Cl)	1.1682	0.0200
Sulphur Trioxide	(SO_3)	368.0998	6 3020
Carbon Dioxide	(CO_2)	1.3992	0.0240
		570.6631	9.7700
Oxygen	(O)	0.2978	0.0051
Fixed residue		570.3653	9.7649

Spec. Gravity = 1.0068

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.6659
Alumina	(Al_2O_3)	1.6647
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	5.1516
Calcium Sulphate	($CaSO_4$)	75.6700
Magnesium Sulphate	($MgSO_4$)	475.5900
Potassium Sulphate	(K_2SO_4)	1.0600
Sodium Sulphate	(Na_2SO_4)	7.2100
Sodium Chloride	($NaCl$)	2.4500
Mineral matter		569.4622

Baily Spring one mile northeast of Bowling Green, is likewise claimed to be a bitter water, but no visit was made to it. Of a different character are the Curryville and the Norton springs; the water of the former was analyzed some years ago and the results are given in the Appendix; the Norton spring is owned and operated by J. D. Kincaid, Bowling Green, Mo., who had a Baily and other springs.

qualitative analysis of it made by Dr. C. Luedeking of St. Louis. Neither of these two properties are improved.

B. SECOND GROUP (GLAUBER'S SALT WATERS).

Waters containing sodium sulphate or Glauber's salt.

THE SPRINGS OF MERCER COUNTY.

The only spring of the county that has been analyzed is, in its way, as remarkable as the B. B. spring of Pike county; the former owes its medical properties to the presence of Glauber's salt or sodium sulphate, while the latter contains Epsom salts or magnesium sulphate.

THE LINEVILLE MINERAL WELL (W.).

The Lineville mineral well.

Location and Improvements. The Lineville Mineral well, situated about three miles south of Lineville, Iowa, is drilled to a depth of 152 feet; it has a moderate flow of water, about fifty gallons per hour, and, according to the owner's statement, will lift it to nine feet above the surface, if a pipe be attached to the fixtures as they stand. The record kept of the drilling shows that Coal Measure limestones, shales, clays and two thin coal seams were passed through.

An hotel has been erected just above the well and the water is used both for drinking and bathing; it is operated by Mr. J. S. Pryor; but the owner, Mr. W. H. Alden lives in Iowa.

The temperature of the water is 52° F., that of the air being 71° F.

About twenty-four quarts of water are shipped away daily.

Results of analysis of Lineville well mineral water (W. & S.):

Analysis.

	Grains in Gallon.	Grams in Litre.
Silica .... (SiO_2)	0.1168	0.0020
Alumina.................. (Al_2O_3)	0.2862	0.0049
Lime..................... (CaO)	0.7827	0.0134
Magnesia.................. (MgO)	1.0572	0.0181
Potassa .... (K_2O)	1.1040	0.0189
Soda.................. (Na_2O)	82.5041	1.4125
Chlorine.................. (Cl)	9.9939	0.1711
Sulphur Trioxide......... (SO_3)	109.4369	1.8736
	205.2818	3.5145

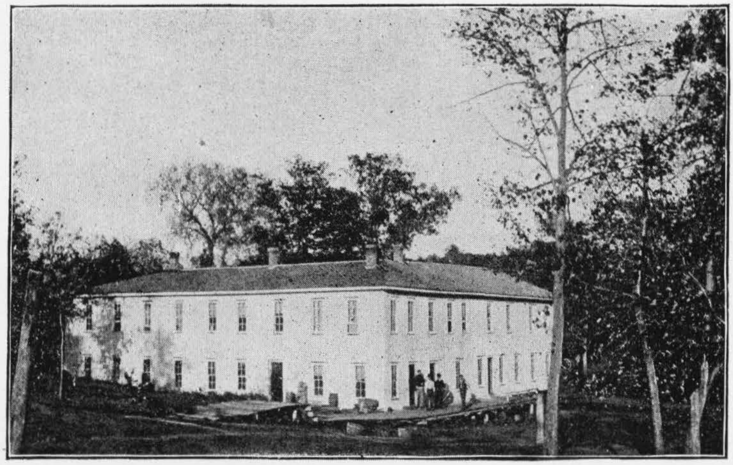


FIG. 1.

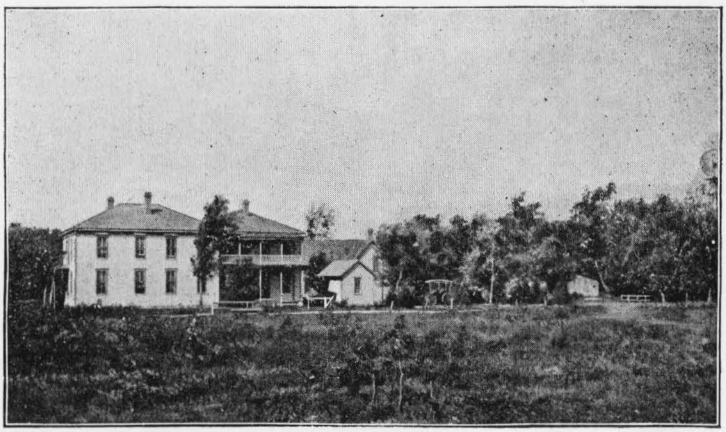


FIG. 2.

FIG. 1. LINEVILLE SPRING HOTEL, LINEVILLE, MERCER CO.

FIG. 2. HOTEL AT BURLINGTON JUNCTION MINERAL SPRINGS, NODAWAY CO.

Oxygen ....(O)	2.2488	0.0385
Fixed residue.............	2C3.0330	3.4760
		Spec. Gravity = 1.0034

Analysis.

United as follows:

	Grains in Gallon.
Silica ....(SiO_2)	0.1168
Alumina....................(Al_2O_3)	0.2862
Calcium Sulphate.........($CaSO_4$)	1.9000
Magnesium Sulphate......($MgSO_4$)	3.1800
Sodium Sulphate..........(Na_2SO_4)	180.3000
Potassium Sulphate.......(KCl)	1.7400
Sodium Chloride..........($NaCl$)	15.0700
Mineral matter...........	202.5930

C. THIRD GROUP (ALUM AND VITRIOL WATERS).

Waters containing ferrous sulphate, ferric sulphate and aluminium sulphate either alone or together.

It is deemed better to bring the two remaining waters of this class in a single group rather than to divide them; for, as already indicated, alum and vitriol waters readily pass into one another, and further, as the absence of potassium or sodium sulphate means likewise the absence of a true alum, the above heading seems preferable.

THE SPRINGS OF PETTIS COUNTY.

CRYSTAL SPRING (R.).

Crystal Spring, near Lamonte, is the only one of the springs of this county sampled and analyzed. Its claim for recognition as a mineral water of value dates from 1886, when an analysis, printed in the Appendix, was made of it. Few improvements have, however, been made in its immediate neighborhood, though the building of an hotel is contemplated. The water is used locally and is reported beneficial in stomach troubles and for strengthening enfeebled constitutions.

Few improvements made.

The spring is located about two miles south of the town on the Mo. Pac. Ry. in the ferruginous sandstone of the Coal Measures; its flow is about fifty gallons per hour and collects in a large trough built of sandstone; when fresh the water is clear though slightly colored, has a strong taste of iron and possesses a feeble odor of sulphuretted hydrogen; its temperature is 52° F. It deposits, on standing for a short time, a heavy precipitate of ferric hydroxide.

Water has a strong taste of iron.

Results of analysis of Crystal spring water (s.):

Analysis.

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	3.0957	0 0530
Ferric Oxide	(Fe_2O_3)	4.1529	0.0711
Alumina	(Al_2O_3)	3.1483	0.0539
Lime	(CaO)	12.2953	0.2105
Magnesia	(MgO)	3.2827	0.0562
Soda	(Na_2O)	2.6576	0.0455
Sulphur Teroxide	(SO_3)	39.1113	0.6696
Fixed residue		67.7438	1.1598

Spec. Gravity = 1.0015
Trace of Li.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	3.0957
Ferrous Sulphate	($FeSO_4$)	7.8905
Aluminum Sulphate	($Al_2(SO_4)_3$)	10.5561
Calcium Sulphate	($CaSO_4$)	29.8600
Magnesium Sulphate	($MgSO_4$)	9.8481
Sodium Sulphate	(Na_2SO_4)	6.0790
Mineral matter		67 3294
Oxygen		0.4153
Fixed residue		67.7447

Note: In this calculation 0.0009 grains of SO_3 are assumed more than found, rather than to have carbonate.

THE SPRINGS OF MORGAN COUNTY.

THE VERSAILLES MEDICAL SPRING (R.).

The Versailles Alum Well is situated at Versailles and is owned by the Versailles Medical Spring Company of Versailles, with offices at Kansas City, 701 New York Life Building. It was purchased in the fall of 1890, by the parties named who had the water analyzed and determined to develop the property; a pamphlet printed by them may be had on application, in which

Property to be developed.

the water is claimed to be beneficial in stomach trouble, blood diseases and the cure of old sores; a hand bottling establishment, just started, furnishes the means for shipping it to a distance.

The well is found three to four miles west of Versailles in a pocket of Coal Measure shales. An outcrop of seemingly good fire clay is seen on the hillside just above the mouth of the well. The water has a strong alum taste and is slightly yellowish in color, when fresh; on standing considerable ferric hydroxide separates out, which is probably derived from the leaching of the shales.

Iron probably derived from the leaching of shales.

Results of analysis of Alum well water (s.):

	Grains in Gallon.	Grams in Litre.
Silica....................(SiO_2)	2.6869	0.0460
Ferric Oxide..............(Fe_2O_3)	11.7988	0.2020
Alumina...................(Al_2O_3)	26.8102	0.4590
Lime......................(CaO)	15.7298	0.2693
Magnesia..................(MgO)	10.8818	0.1863
Soda......................(Na_2O)	3.0957	0.0530
Sulphur Trioxide..........(SO_3)	123.1108	2.1077
Fixed residue.............	194.1140	3.3233

Spec. Gravity = 1.0031
Some Li.
Traces of K, Cl.

United as follows:

Analysis

	Grains in Gallon.
Silica....................(SiO_2)	2.06869
Ferrous Sulphate..........($FeSO_4$)	22.4177
Aluminium Sulphate........($Al_2(SO_4)_3$)	89.8930
Calcium Sulphate..........($CaSO_4$)	33.2009
Magnesium Sulphate........($MgSO_4$)	32.6454
Sodium Sulphate...........($NaSO_4$)	7.0901
Mineral matter............	192.9340
Oxygen....................(O)	1.1799
Fixed residue.............	194.1139

CHAPTER VIII.

CHALYBEATE WATERS.

Waters containing, as their most efficient medicinal constituent, ferrous carbonate.

A. FIRST GROUP OF CHALYBEATE WATERS.—B. SECOND GROUP OF CHALYBEATE WATERS.—C. THIRD GROUP OF CHALYBEATE WATERS.

Character and Classification.—Chalybeate waters, as explained in a previous chapter, are waters that hold the iron in solution as bicarbonate. They are rich in carbonic acid and often contain lithia and other constituents that add to their value. On reaching the surface of the ground the excess or carbonic acid volatilizes and the oxygen of the air converts the ferrous into a ferric oxide. The latter is no longer soluble in the water, and in consequence is precipitated. The red and yellow deposits of ocher, found in some parts of the State, are derived in this manner. A like precipitation and in a much shorter time is effected by boiling. The degree to which this takes place furnished a basis for distinguishing two kinds of chalybeate waters; in the one the iron is completely precipitated by boiling and in the other the precipitation is only partial. The cause of this difference is the presence of calcium sulphate, which, as explained elsewhere, causes a part of the iron to remain in solution as sulphate. These two divisions of the waters of this class we have named True Chalybeate and Semi-Chalybeate Waters. The first of these is, for convenience, again sub-divided into two groups, the former containing sodium carbonate but no magnesium sulphate, the latter magnesium sulphate but no sodium carbonate. For medicinal effect more than one-half a grain of iron to the gallon should exist in such waters. To facilitate selection, the members of each group are arranged according to their amounts of bicarbonate of iron in solution.

Iron in these waters is deposited on standing.

Waters arranged according to the amount of bicarbonate of iron contained.

A. FIRST GROUP (PURE CHALYBEATE WATERS).

Waters containing ferrous carbonate, magnesium carbonate, and sodium carbonate, magnesium sulphate and calcium sulphate being absent.

This group embraces fourteen waters, from which boiling will precipitate every trace of iron; the last or strongest members of the group are of great intrinsic value and contain the ferrous bicarbonate in a condition of relative stability, so that much of it can be kept in solution for a number of days by simply guarding it against heat and too free access of air. The importance of this property for bottling and shipping the water is, of course, apparent and accounts for the development of some of the localities in which such springs are found. A yet better way for preserving the water is to carbonate and then bottle it, when it may be shipped long distances and kept for months without any deterioration whatever.

Iron kept in solution by carbonating.

TABLE OF ANALYSES OF MISSOURI CHALYBEATE WATERS — FIRST GROUP.

Results are expressed in grains per gallon.

	1 *Burlington Junction Spring* (W. & R.), Nodaway Co.	2 *Lithia Spring* (S.), Kansas City.	3 *Sand Creek Spring* (W.), Henry Co.	4 *Lithium Spring* (S.), Perry Co.	5 *Lebanon Magnetic Well* (S.), Laclede Co.	6 *Roger's Spring* (W. & R.), Liberty, Clay Co.	7 *White Spring* (S.), Madison Co.	8 *Sulphur Spring* (S.), Siloam Sps. Howell Co.	9 *Pertle Spring* (W.), Johnson Co.	10 *Reed's Spring* (W. & R.), Johnson Co.	11 *Jerico Spring* (S.), Cedar Co.
Silica	1.5829	1.5420	1.0748	1.6355	0.4089	2.5174	0.8761	0.8177	1.5069	0.9813	1.3434
Alumina	0.2686	0.0350	0.0934	....	....	0.9287	....	....	0.2570	0 1168	....
Ferrous Bicarbonate	0.1688	0.1910	0.2743	0.5197	0.5198	0.5328	0 6497	0.7808	1.1119	1.2274	1.5595
Calcium Bicarbonate	9.0968	23.8589	10.8479	26.6976	6.9278	17.3584	5.7448	12 3728	15.6604	6.7943	0.3379
Magnesium Bicarbonate	2 5898	5.9696	5.7564	13.6017	5.9269	3.7196	2.7714	9.1462	6.7583	1.5633	0.9165
Sodium Bicarbonate	0.3329	0.2689	....	0.7668	2.8073	0 3962	5.4034	4.9046	5.5508	1.3044	2.5027
Potassium Bicarbonate	....	....	2.6541	....	....	....	....	....	....	1.3611	....
Sodium Sulphate	1.9800	0.8400	....	1.3477	....	1.9400	....	....	4.5099	....	0 2176
Potassium Sulphate	....	....	2.5360	....	....	....	....	....	....	0.9170	....
Potassium Chloride	0.4600	0.4400	0.5798	....	....	0.5800	....	....	....	....	....
Sodium Chloride	1.2200	1.2926	....	19.5298	0.0962	0.4500	0.0288	0.0288	0.1408	0.9341	0.0288
Total mineral matter	17.9371	34.3680	23.8167	64.0988	16.6869	28.5687	15.4742	28 0509	35.4960	16.1997	6.9064
Specific Gravity	1.0003	1.0004	1.0000	1.0006	1.0002	1.0010	1.0004	1.0004	1.0004	1.0000	1.0001

TABLE OF ANALYSES OF MISSOURI CHALYBEATE WATERS — FIRST GROUP.

Results are expressed in grains per gallon.

	Greenwood (S.), Jackson Co. 12	*Park Spring* (S.), ElDorado Springs, Cedar Co. 13	*Randolph Spa* (W. & R.), Randolph Co. 14
Silica	....	2.2196	0.5491
Alumina	....	....	0.9404
Ferrous Bicarbonate	2.3395	3.3791	7.2427
Calcium Bicarbonate	2 5005	1.8586	33 3983
Magnesium Bicarbonate	0.4690	1.8549	9 7687
Sodium Bicarbonate	57.4211	....	1.9336
Sodium Sulphate	....	3.1414	0.3300
Potassium Chloride	....	....	0.6951
Sodium Chloride	....	0.4771	0.6100
Sodium Silicate	6 7678	....	....
Mineral Matter	69 4979	12.9307	55 4679
Specific Gravity	1.0012	1 0002	1 0009

THE SPRINGS OF NODAWAY COUNTY.

This county, situated in the northwestern corner of the State, possesses several chalybeate waters, a sample of one of which was collected and analyzed.

Arkoe springs at Arkoe, owned by Charles Sugles of Plattsburg, Mo., is not developed.

The Barnard Mineral Well, at Barnard station on the Kansas City, St. Joseph and Chicago and Burlington railway, in section 15, T. 62 N., 35 W., is a driven well 24 feet deep and appears to possess an abundant supply of water; it was analyzed some years ago, and advertised as far back as 1882 by a joint stock company as a health resort, but not possessing adequate improvements the undertaking failed, and the property is now owned by John R. Phipps of Barnard. This latter place, a village of some seven hundred inhabitants, possesses hotel ac-

The Barnard Mineral well.

commodations for prospective patients who may use the water free of charge.

THE BURLINGTON JUNCTION MINERAL SPRING (W).

Location and Improvements. The Burlington Junction Mineral spring, one and a half miles southwest of Burlington Junction on the Wabash railroad, is situated in the N. E. $\frac{1}{4}$ of section 20, T. 65 N., 37 W., and is owned and operated by Dr. S. Black of the same place. A 14-foot well, sunk into the clay, near the bed rock of a small stream, furnishes an abundance of water.[1] This was analyzed some years ago and was the cause of developing the property as an health resort. A pamphlet, printed by the proprietor, gives descriptions of the hotel accommodations, bathing facilities, diseases in which benefit is derived from the use of the water, and similar matters of interest to physicians and patients. The hotel will accommodate about thirty-five patients. The bath house has six rooms and is provided with hot and cold water.

Is a well 14 feet deep.

Results of analysis of water of Burlington spring (W. & R.):

Analysis.

		Grains in Gallon.	Grams in Litre.
Silica	(SiO_2)	1.5829	0.0271
Alumina	(Al_2O_3)	0.2686	0.0046
Ferric Oxide	(Fe_2O_3)	0.0759	0.0013
Lime	(CaO)	3.1366	0.0537
Magnesia	(MgO)	0.7067	0.0121
Potassa	(K_2O)	0.2862	0.0049
Soda	(Na_2O)	1.6180	0.0277
Chlorine	(Cl)	0.9346	0.0160
Sulphur Trioxide	(SO_3)	1.0981	0.0188
Carbon Dioxide	(CO_2)	6.7684	0.1158
Water in combination	(H_2O)	1.6809	0.0288
		18.1549	0.3108

[1] A rough estimate makes the inflow to the well between 400 and 500 gallons an hour.

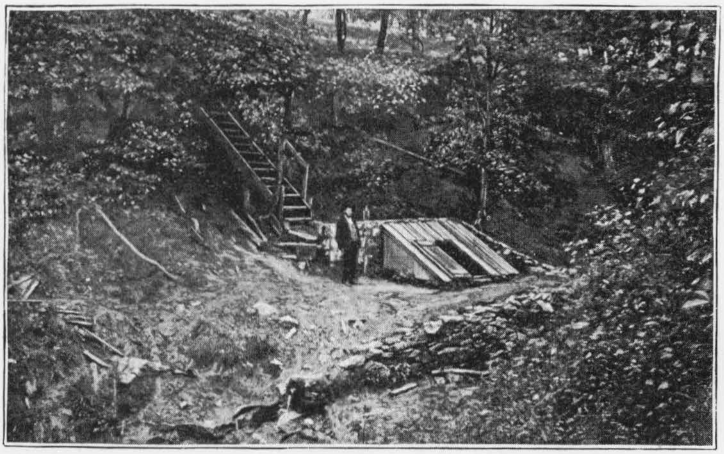


FIG. 1.

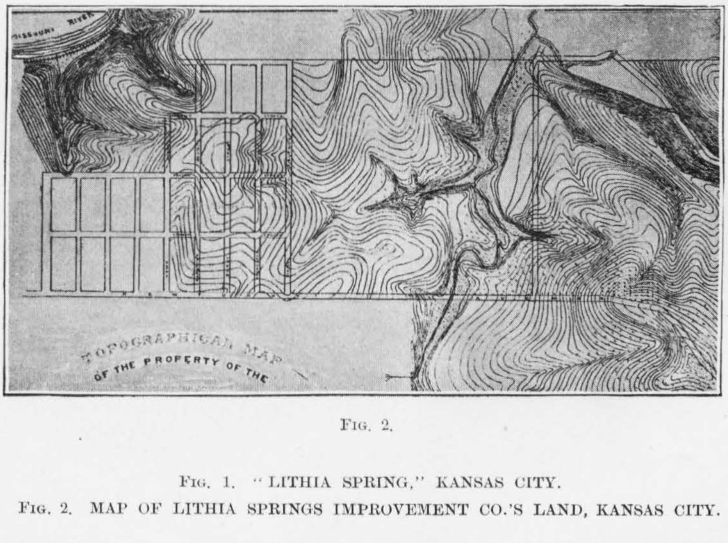


FIG. 2.

FIG. 1. "LITHIA SPRING," KANSAS CITY.
FIG. 2. MAP OF LITHIA SPRINGS IMPROVEMENT CO.'S LAND, KANSAS CITY.

Oxygen	(O)	0.2102	0.0036
Mineral matter		17.9447	0.3072
Fixed residue		12.8796	0.2205

Spec. Gravity = 1.0003

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	1.5829
Alumina	(Al_2O_3)	0.2686
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	0.1688
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	9.0968
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	2.5898
Sodium Bicarbonate	($NaHCO_3$)	0.3326
Sodium Sulphate	(Na_2SO_4)	1.9800
Potassium Chloride	(KCl)	0.4600
Sodium Chloride	(NaCl)	1.2201
Mineral matter		17.9371
Oxygen for Fe O		0.0076

THE SPRINGS OF JACKSON COUNTY.

Waters of two springs of this group have been analyzed from Jackson County, *i. e.*, Lithia spring and Greenwood spring.

LITHIA SPRING (W.).

Location. Lithia spring is situated six miles east of Kansas City on the property of the Lithia Springs Improvement company. The water flows from the side of a deep ravine into a walled limestone basin about seven feet square and eight feet deep, the over-flow pipe being so arranged as to keep the water constantly at a depth of four feet. The flow is about 250 gallons per hour, which, for waters of this class, is very abundant; the exact location of the spring is in the N. W $\frac{1}{4}$, N. E. $\frac{1}{4}$, section 32, T. 50 N., 32 W., nearly three hundred yards south of the Missouri river. The water is pumped to a large reservoir whence it can be readily distributed. The property is at present unimproved. The temperature of the water was 53° F., that of the air being 79° F.

The Lithia Spring flows 250 gallons per hour.

Results of analysis of water of Lithia spring (W. & R.):

		Grains in Gallon.	Grams in Litre.
Silica	(SiO_2)	1.5420	0.0264
Alumina	(Al_2O_3)	0.0350	0.0006
Ferric Oxide	(Fe_2O_3)	0.0934	0.0016
Lime	(CaO)	8.2475	0.1412
Magnesia	(MgO)	1.6355	0.0280
Potassa	(K_2O)	0.2745	0.0047
Soda	(Na_2O)	1.0981	0.0188
Chlorine	(Cl)	0.9346	0.0160
Sulphur Trioxide	(SO_3)	0.4848	0.0083
Carbon Dioxide	(CO_2)	16.7986	0.2966
Water in combination	(H_2O)	3.4435	0.0589
		34.5875	0.5956
Oxygen	(O)	0.2102	0.0036
Mineral matter		34.3773	0.5920
Fixed residue		22.5345	0.3848

Spec. Gravity = 1.0004

Analysis.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	1.5420
Alumina	(Al_2O_3)	0.0350
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	0.1910
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	23.8589
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	5.9696
Sodium Bicarbonate	($NaHCO_3$)	0.2689
Sodium Sulphate	(Na_2SO_4)	0.8400
Potassium Chloride	(KCl)	0.4400
Sodium Chloride	($NaCl$)	1.2226
Mineral matter		34.3680
Oxygen for Fe O		0.0093

GREENWOOD SPRING (R.).

Water flows from limestone and is sulphuretted.

Greenwood spring is located in Jackson county about thirty miles from Kansas City on the Missouri Pacific railway. The spring has a very weak flow, not sufficient for practical use, hence a pump was put in to increase the supply. The water is somewhat sulphuretted and not unpalatable. It has a distinct odor of H_2S when freshly drawn and is said to leave no sediment on standing. It flows from the Bethany Falls limestones.

The temperature of the water was 52° F. The property is owned by Eugene Ransom of Seymour, Texas, and was occupied at the time of inspection by Mr. S. Brown. A small spring house was built some seven years ago and a hotel was projected but never started. For the past few years but little interest has been taken in the spring, although the site is a very pretty one. A good site for a hotel.

Results of analysis of water of Greenwood spring (s.):

	Grains in Gallon.	*Grams in Litre.*
Silica .... (SiO_2)	3.3294	0.0570
Ferric Oxide.............. (Fe_2O_3)	1.0514	0.0180
Lime.......................... (CaO)	0.8644	0.0148
Magnesia.................. (MgO)	0.1285	0.0022
Soda .... (Na_2O)	24.6315	0.4217
Carbon Dioxide........... (CO_2)	32.8732	0.5628
Water in combination..... (H_2O)	6.7245	0.1151
Mineral matter............	69.6029	1.1916
Fixed residue.............	46.4418	0.7951

Spec. Gravity = 1.0012
Some Li.
Trace K.
Trace of H_2S. Analysis.

United as follows:

	Grains in Gallon.
Sodium Silicate........... (Na_2SiO_3)	6.7678
Ferrous Bicarbonate...... ($FeH_2(CO_3)_2$)	2.3395
Calcium Bicarbonate...... ($CaH_2(CO_3)_2$)	2 5005
Magnesium Bicarbonate... ($MgH_2(CO_3)_2$)	0.4690
Sodium Bicarbonate....... ($NaHCO_3$)	57.4211
Mineral matter............	69.4979
Oxygen for Fe O...............	0.1051

THE SPRINGS OF HENRY COUNTY.

The springs that should be mentioned here are three in number, of which two have been sampled and analyzed. The Sand Creek spring belongs properly to this group, while the Ford spring at Montrose belongs to the third group of chalybeate waters and will be described later.

The Jordan Artesian Well. Three miles southeast of Clinton, in the southwest quarter of section 19, T. 41 north, 25 west. This is a well of slightly chalybeate water, with a very weak Water slightly chalybeate.

flow. The water flows from the Carboniferous shales and sandstones of the region, and is probably related in composition to the other alkaline springs of the county. The water was formerly much used but is now entirely neglected, and the well is rapidly filling up.

Water flows from Carboniferous shales.

A weak "iron" spring is reported to be in or near section 2, township 40 north, 25 west, on Pretty Bob creek. This spring was not visited.

THE SAND CREEK SPRING (W.).

The Sand Creek spring is situated in the southwest quarter of the northwest quarter of section 28, T. 43 north, 25 west, on a branch of Sand creek, four miles north of Lewis station. It is found in a picturesque valley with sandstone bluffs on either side. There are here two springs emerging from the sandstone, but the one sampled is more important on account of its greater flow (perhaps between 50 and 100 gallons per hour). The iron contained in the water is rapidly oxidized, and is found in the spring and along its course as a brown sediment. It often forms on the surface of the spring as an iridescent scum, which has frequently been mistaken for oil. The flow is reported to be constant and the water is said never to freeze, even in the coldest weather.

Water emerges from sandstone.

Results of analysis of water of Sand Creek spring (w.):

Analysis.

	Grains in Gallon.	*Grams in Litre.*
Silica (SiO_2)	1.0748	0.0184
Alumina (Al_2O_3)	0.0934	0.0016
Ferric Oxide (Fe_2O_3)	0.1233	0.0021
Lime (CaO)	3.7499	0.0642
Magnesia (MgO)	1.5771	0.0270
Potassa (K_2O)	2.9789	0.0510
Sulphur Trioxide (SO_3)	1.1624	0.0199
Chlorine (Cl)	0.2862	0.0049
Carbon Dioxide (CO_2)	10.6656	0.1826
Water in combination (H_2O)	2.1816	0.0374
	23.8932	0.4091
Oxygen (O)	0.0642	0.0011
Mineral matter	23.8290	0.4080
Fixed residue	16.3146	0.2793

Spec. Gravity = 1.0000

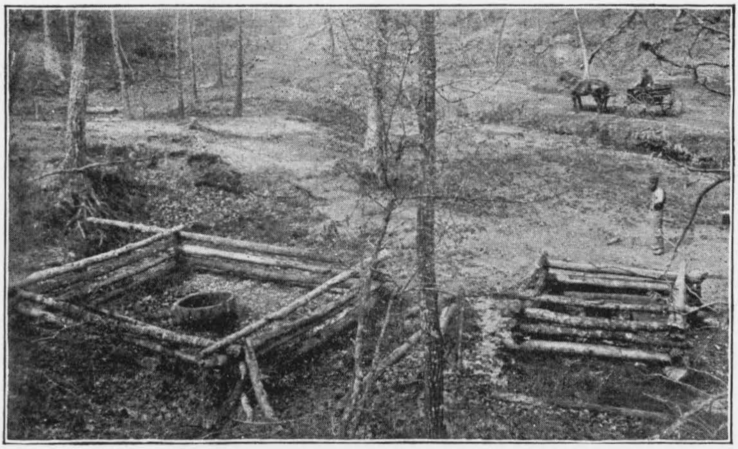


FIG. 1.

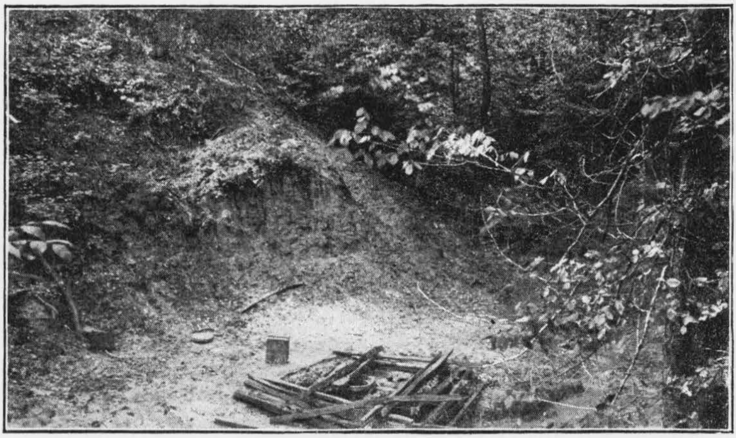


FIG. 2.

FIG. 1. CHALYBEATE SPRING, NORTH OF LEWIS STATION, HENRY CO.
FIG. 2. ROGERS' SPRING, WEST OF LIBERTY, CLAY CO.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	1.0748
Alumina	(Al_2O_3)	0.0934
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	0.2743
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	10.8479
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	5.7564
Potassium Bicarbonate	($KH(CO_3)$)	2.6541
Potassium Sulphate	(K_2SO_4)	2.5360
Potassium Chloride	(KCl)	0.5798
Mineral matter		23.8167
Oxygen for Fe O		0.0123

THE SPRINGS OF LACLEDE COUNTY.

THE LEBANON MAGNETIC WELL (S.).

Location and Source of Water. The Lebanon Magnetic well, the only one of the waters of this county analyzed, is located in Lebanon, the county seat of Laclede county, in southwestern Missouri, upon what is known as the plateau of the Ozarks. Its elevation above tidewater is 1280 feet, a fact sufficiently important to establish its advantages as a sanitarium as regards pure air and freedom from malaria, prevalent in the lower-lying country. It is distant from St. Louis 180 miles, and is reached by the main line of the St. Louis and San Francisco railway, only eight hours' run from St. Louis. Lebanon's location is singularly beautiful and advantageous, the site being high and sufficiently rolling to insure not only perfect surface drainage, but picturesqueness as well.

Location most healthful.

The well was drilled in the spring of 1887 by the citizens of the town, who struck a strong stream of water at a depth of 135 feet; wishing, however, if possible, to secure an artesian well the drilling was continued to a depth of 1000 feet. The present supply of water comes mainly from the rock beds at 750 feet below the surface; it is a clear sparkling water of the temperature of 60° F. It rises in the bore hole to a height of 700 feet and requires, consequently, a lifting of 300 feet to bring it to the surface. A pump, working continuously for fourteen hours a day, raises about sixty gallons per minute, a supply sufficient

The well is 1000 feet deep.

at present for the use of the town, and the large hotel, with bathrooms and bottling works, that have been erected since.

The Naming of the Well. As to the naming of the well the phenomena of magnetism were first observed while drilling through the quartz rocks, but thought to be incidental to the heavy steel and iron tools. Several months later it was discovered that iron pipes, which exhibited no unusual property while lying in the yard, became strongly magnetized when placed in the well or connected with those previously put down. This property is readily imparted to any substance susceptible of magnetic influence. An ordinary pocket-knife rubbed on the pipe will pick up a nail weighing eighty grains. A compass in the vicinity of the well is powerfully deflected and within a radius of three feet the north end of the needle points steadily to the well from all directions.

Phenomena of magnetism observed.

These observations, to be readily made at the well at any time, cannot be gainsaid; but a further statement, often made in connection with this as well as other "*magnetic wells*," viz.: that the water itself is magnetic and, by virtue of its magnetism, of special therapeutic value, has no foundation in fact. Water is a so-called diamagnetic body, *i. e.*, a body which is repelled by magnetism and, therefore, though perhaps not absolutely resistant to being magnetized, capable of taking up but an exceedingly small amount of it. A committee[1] appointed by the State Medical Society of Michigan to investigate the phenomena as claimed to exist in certain mineral waters of that State, reported as the result of a number of experiments made with pure waters and with water containing iron salts in solution, that water was not magnetic, was not susceptible of magnetism and could neither produce nor communicate it.

Water can not be magnetized readily.

It is a well-known fact, however, that an iron bar or tube held in a certain position, to be fixed for each place, becomes a magnet; it is further possible that a tube, sunk to a great depth, may reach rock formations that are magnetic and will communicate their magnetism to the tube. Such facts have been observed in

Iron tubes become magnetic under certain circumstances.

[1] It consisted of Dr. H. O. Hitchcock, Prof. S. C. Duffield and Prof. R. C. Kedzie, the latter of whom conducted the experiments.

THE GASCONADE HOTEL AT LEBANON.

a number of instances and are not remarkable, because not rare; but even a strong magnet, such as the iron tube of the Lebanon well doubtless is, cannot influence the water flowing through it, to either become magnetic itself or to exhibit by virtue of it any unusual properties; it is a matter of interest and will remain so, but not one of weight from a medical point of view.

Improvements. The property is owned by the Lebanon Light and Water company, of Lebanon, and is operated by R. C. Beaty, its business manager, of the same place. A large hotel has been erected at a cost of $100,000 in the usual summer hotel style, with verandas and pleasant nooks and corners, three stories in height, and altogether of striking appearance. Bath-houses for men and women, with sitting and dressing rooms, bowling alleys, billiard halls, an opera house and other attractions are provided. More than $200,000 may safely be estimated as having been spent on improvements incidental to developing the place as a health resort; pamphlets, descriptive of it, to be had on application to the manager.

Great improvements made in the last year.

Within the year past great improvements have been planned and carried out; a true sanitarium is to be built up, and a medical staff with Dr. Paquin as superintendent and physician-in-chief, has been appointed; the bathing facilities have been remodeled and enlarged, so that, in addition to the ordinary cold and hot baths, turkish, russian and electric, besides sea-salt baths, with or without massage treatment, and medicated vapor baths, are constantly accessible. In conformity with the idea the hotel is kept open all the year around, and with the many attractions surrounding it, and its first-class appointments throughout, has acquired an enviable reputation as a health resort.

Staff of physicians.

Uses. The water is claimed to be beneficial in rheumatism, heartburn, kidney and stomach diseases and similar disorders.

Results of analysis of water of Lebanon Magnetic well (s.):

Analysis.

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	0.4089	0.0070
Ferric Oxide	(Fe_2O_3)	0.2335	0.0040
Lime	(CaO)	2.3948	0.0410
Magnesia	(MgO)	1.6238	0.0278
Soda	(Na_2O)	1.0864	0.0186
Chlorine	(Cl)	0.0584	0.0009
Carbon Dioxide	(CO_2)	9.0637	0.1552
Water in combination	(H_2O)	1.8538	0.0317
		16.7233	0.2862
Oxygen	(O)	0.0131	0.0002
Mineral matter		16.7102	0.2860
Fixed residue		10.3246	0.1767

Spec. Gravity = 1.0002.
No organic matter.
No K, Li, SO_3.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.4089
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	0.5198
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	6.9278
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	5.9269
Sodium Bicarbonate	($NaHCO_3$)	2.8073
Sodium Chloride	(NaCl)	0.0962
Mineral matter		16.6869
Oxygen for Fe O		0.0233

THE SPRINGS OF CLAY COUNTY.

Most of these springs chalybeate.

The springs of Clay county are in the main chalybeate and of great value. Four of them were sampled and analyzed. Only one of these belongs, however, to this group of chalybeate waters; the other three fall within group two and will be described later. All of these springs are within easy reach of Kansas City and are destined in time to become prominent; in fact those at Excelsior Springs have already attained a very considerable reputation.

ROGERS' SPRING (W.).

Location. Rogers' spring is situated about seven miles west of Liberty on the Kansas City branch of the Hannibal and St.

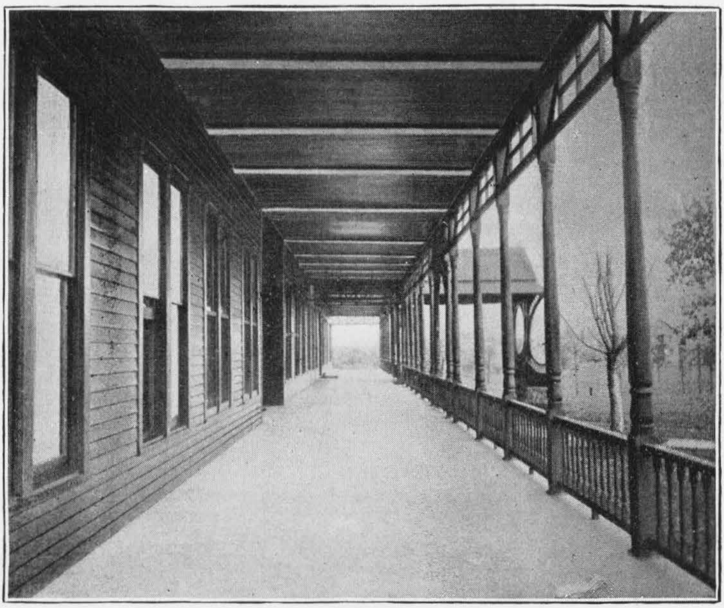


FIG. 1.

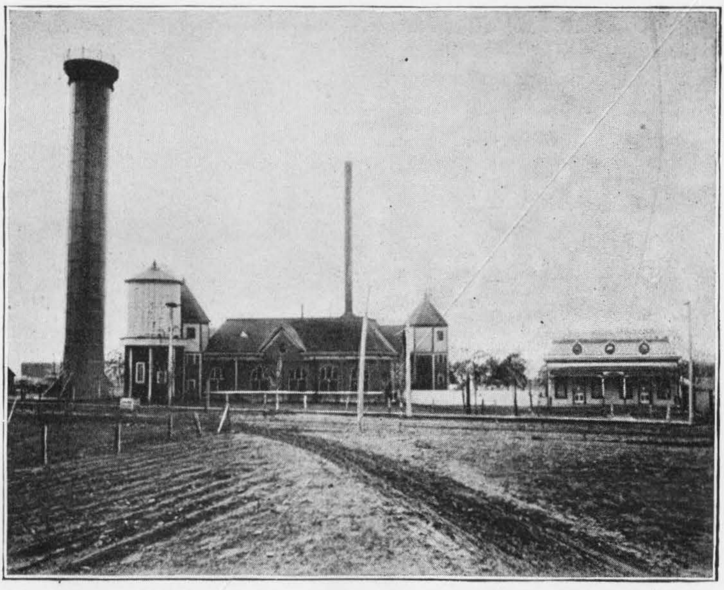


FIG. 2.

FIG. 1. VIEW ALONG VERANDA OF GASCONADE HOTEL.

FIG. 2. LEBANON MAGNETIC WELL AND WATER WORKS.

Joseph railway. It is near the bed of a small branch emptying into Big Shoal creek and is in times of high water, completely submerged. Attempts have been made, by the insertion of tiling, to direct the water into one channel, but the flow is yet scarcely greater than 300 gallons per hour. The temperature of the water was 52° F., that of the air being 58° F. The locality is resorted to as a picnic and barbecue ground. Spring in branch bottom.

Of similar character are the waters of the *Acme spring* near by, the *Shannon spring*, 13 miles north of Liberty and the *Schraeder spring* (especially rich in iron), near Barry station.

Results of analysis of waters of Rogers' spring (W. & R.): Analysis.

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	2.5174	0.0431
Alumina	(Al_2O_3)	0.9287	0.0159
Ferric Oxide	(Fe_2O_3)	0.2394	0.0041
Lime	(CaO)	6.0104	0.1029
Magnesia	(MgO)	1.0164	0.0174
Potassa	(K_2O)	0.3622	0.0062
Soda	(Na_2O)	1.2266	0.0210
Chlorine	(Cl)	0.7009	0.0120
Sulphur Trioxide	(SO_3)	1.0748	0.0184
Carbon Dioxide	(CO_2)	12.1818	0.2086
Water in combination	(H_2O)	2.4917	0.0426
		28.7503	0.4922
Oxygen	(O)	0.1577	0.0027
Mineral matter		28.5926	0.3895
Fixed residue		20.0100	0.3426

Spec. Gravity = 1.0010

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	2.5174
Alumina	(Al_2O_3)	0.9287
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	0.5328
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	17.3584
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	3.7196
Sodium Bicarbonate	($NaHCO_3$)	0.3962
Sodium Sulphate	(Na_2SO_4)	1.9400
Potassium Chloride	(KCl)	0.5800
Sodium Chloride	($NaCl$)	0.4500
Mineral matter		28.5687
Oxygen for Fe O		0.0239

THE SPRINGS OF MADISON COUNTY.

WHITE SPRING (R.).

Location and Improvements. There are a number of springs in this county, the best known of which is White spring, some six miles south of Fredericktown on the St. Louis & Iron Mountain railway. This water has been sampled and analyzed. It is situated in a beautiful valley, surrounded by rounded porphyry and granite hills. The flow is at the rate of about sixty gallons a minute into a walled reservoir, from which a wooden gutter leads into a flat marshy pasture. Its temperature was 52° F., that of the air being 72° F., it is devoid of taste but palatable and refreshing. No improvements surround the locality, and, though the remains of an artificial pond are visible and the grounds reveal the fact of their having once been taken care of, they are now much neglected; even the cottages round about are in a state of dilapidation and accommodation to visitors is often difficult to secure. A boarding house is usually opened during the summer, and numerous parties from the neighboring river counties spend a few days here at a time.

Location good but no improvements.

The water has a local reputation for curing dyspepsia, stomach troubles and malaria.

A new granite quarry has lately been opened in this locality, which exhibits, imbedded in the granite, small and large rounded pebbles of what appears to be diorite. A small spring near by is said to be very efficacious for curing malaria and kindred diseases, but is wholly unimproved.

Fredericktown well.

A spring or rather well, one mile east of Fredericktown, was at one time quite famous and the project of buying the ground on which it flows, and of converting it into a park, was entertained by the citizens of the town. Troubles regarding the title prevented, however, its being carried out.

Results of analysis of water of White spring (s.):

		Grains in Gallon.	*Grams in Litre.*
Silica	(Si_2O)	0.8761	0.0150
Ferric Oxide	(Fe_2O_3)	0.2920	0.0050
Lime	(CaO)	1.9859	0.0340
Magnesia	(MgO)	0.7593	0.0130
Soda	(Na_2O)	2.0093	0.0344
Chlorine	(Cl)	0.0175	0.0003
Carbon Dioxide	(CO_2)	7.9428	0.1360
Water in combination	(H_2O)	1.6246	0.0278
		15.5075	0.2655
Oxygen		0.0041	0.0001
Mineral matter		15.5034	0.2654
Fixed residue		9.9074	0.1696

Spec. Gravity = 1.0004
Trace of organic matter.
No K; no Li; no SO_3. Analysis of White Springs water.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.8761
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	0.6497
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	5.7448
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	2.7714
Sodium Bicarbonate	($NaHCO_3$)	5.4034
Sodium Chloride	($NaCl$)	0.0288
Mineral matter		15.4742
Oxygen for Fe O		0.0292

THE SPRINGS OF HOWELL COUNTY.

A description of the two mineral water localities investigated in this county has been given in Chapter VI, so that it is necessary here only to give the analysis of the water, belonging to this class and group.

Results of analysis of water of Sulphur spring at Siloam Springs (s.):

Analysis of Siloam Springs water.

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	0.8177	0.0140
Ferric Oxide	(Fe_2O_3	0.3505	0.0060
Lime	(CaO)	4.3807	0.0750
Magnesia	(MgO)	2.5058	0.0429
Soda	(Na_2O)	1.8574	0.0318
Chlorine	(Cl)	0.0175	0.0003
Carbon Dioxide	(CO_2)	15.0116	0.2570
Water in combination	(H_2O)	3.1505	0.0539
		28.0917	0.4809
Oxygen	(O)	0.0058	0.0001
Mineral matter		28.0859	0.4808
Fixed residue		17.4296	0.2984

Spec. Gravity= 1.0004
No organic matter.
No H_2S; no Li; no SO_3
Trace of K.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.8177
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	0.7808
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	12.3728
Magnesium Bicarbonate	($MgH_2(CO_3)$	9.1462
Sodium Bicarbonate	($NaHCO_3$)	4.9046
Sodium Chloride	($NaCl$)	0.0288
		28.0509
Oxygen for Fe O		0.0350

THE SPRINGS OF PERRY COUNTY.

LITHIUM SPRING (R.).

Perry county is without railroad communication and the springs can be reached by stage from St. Mary's or from Fredericktown, the latter trip a distance of 40 miles over a hilly country in which a shaly limestone crops out nearly all the way to the county seat and for ten miles beyond.

Location. Lithium, the site of the spring, is about nine miles north of Perryville and is a small town with a score or so of houses, situated in a high valley surrounded by higher hills and about seven miles distant from the river, of which a pleasing view may be had from the summit of the ridge road. The spring apparently issues from the surrounding limestone rocks and contains but little mineral matter. It is collected in a walled reservoir, eight feet square, and holding about 250 feet of water, from which the excess escapes in a feeble stream below the foundation, so as to render the measurement of the flow impossible. No other improvements have been made here nor are others in contemplation at present. Water issues from limestone.

Results of analysis of water of Lithium spring (s.):

Analysis.

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	1.6355	0.0280
Ferric Oxide	(Fe_2O_3)	0.2336	0.0040
Lime	(CaO)	9.2288	0.1580
Magnesia	(MgO)	3.7265	0.0638
Soda	(Na_2O)	11.2205	0.1921
Chlorine	(Cl)	11.8514	0.2029
Sulphur Trioxide	(SO_3)	0.7593	0.0130
Carbon Dioxide	(CO_2)	19.9684	0.3419
Water in combination	(H_2O)	8.1689	0.1399
		66.7929	1.1436
Oxygen	(O)	2.6707	0.0457
Mineral matter		64.1222	1.0979
Fixed residue		45.9691	0.7870

Spec. Gravity = 1.0006
No organic matter.
No K; no Li.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	1.6355
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	0.5197
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	26.6976
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	13.6017
Sodium Bicarbonate	($NaHCO_3$)	0.7668
Sodium Sulphate	(Na_2SO_4)	1.3477
Sodium Chloride	($NaCl$)	19.5298
Mineral matter		64.0988
Oxygen for Fe O		0.0234

THE SPRINGS OF JOHNSON COUNTY.

PERTLE SPRINGS (W.).

Location and Improvements. Besides the springs mentioned previously under different headings the most famous of Johnson county's springs is doubtless Pertle Spring. This spring is situated about one mile south of Warrensburg and is at present a very popular resort. The grounds about the spring have been improved by the construction of a spring house, hotel, summer houses and an artifical lake. The cut opposite this page gives a view of some of the surroundings. The water emerges from sandstone, but this is in close association with coal and limestone beds and thus one is led to expect the predominance of carbonates with some sulphates proved by the analysis, which shows it to be an alkaline water with quite a large proportion of iron carbonate. It is reached from Warrensburg by a dummy line.

The water is probably derived from Carboniferous shales.

The flow of water is about 187 gallons per hour, which might be increased even by a proper protection of the mouth of the spring. The property is owned and operated by James H. Christopher of Pertle Springs, who has spent about $50,000 in its improvements. A descriptive pamphlet is printed for general distribution. A number of private residences have been erected in the neighborhood of the springs.

Improvements.

Results of analysis of water of Pertle spring (w.):

Analysis.

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	1.5069	0.0258
Alumina	(Al_2O_3)	0.2570	0.0044
Ferric Oxide	(Fe_2O_3)	0.5023	0.0086
Lime	(CaO)	5.4146	0.0927
Magnesia	(MgO)	1.8516	0.0317
Soda	(Na_2O)	4.0887	0.0700
Sulphur Trioxide	(SO_3)	2.5408	0.0435
Chlorine	(Cl)	0.0759	0.0013
Carbon Dioxide	(CO_2)	16.0394	0.2746
Water in combination	(H_2O)	3.2807	0.0561
		35.5579	0.6087
Oxygen	(O)	0.0117	0.0002
Mineral matter		35.5462	0.6085
Fixed residue		24.2458	0.4151

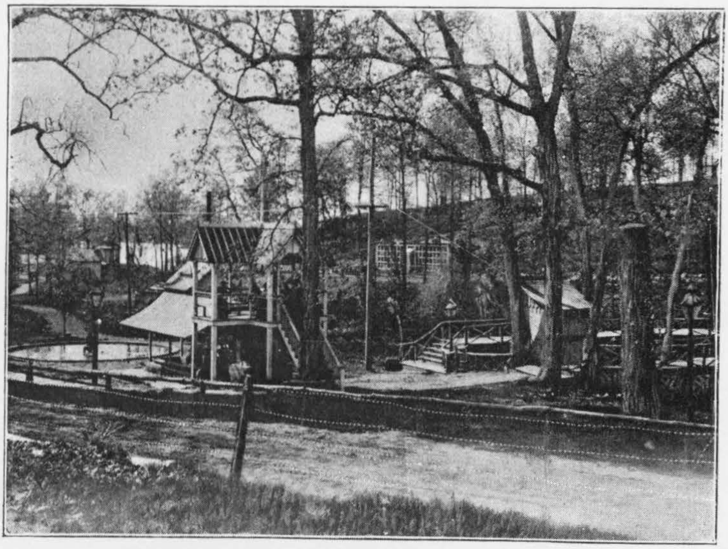


FIG. 1.

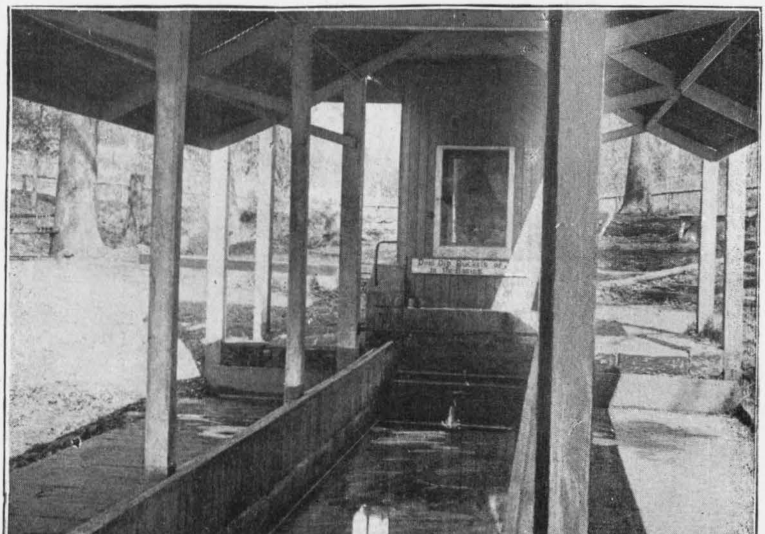


FIG. 2.

FIG. 1. PERTLE SPRING, NEAR WARRENSBURG.
FIG. 2. SPRING AT PERTLE SPRINGS, WARRENSBURG, JOHNSON CO.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	1.5069
Alumina	(Al_2O_3)	0.2570
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	1.1119
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	15.6604
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	6.7583
Sodium Bicarbonate	($NaHCO_3$)	5.5508
Sodium Sulphate	(Na_2SO_4)	4.5099
Sodium Chloride	($NaCl$)	0.1408
Mineral matter		35.4960
Oxygen for Fe O		0.0502

REED'S SPRING (W.).

Location and Character. A spring, the existence of which has been known for a long time, is found about eight miles south of Warrensburg in the northeast quarter section 29, T. 45 north, 26 west, on land of D. W. Reed, and known as *Reed's spring*. It is a ferro-alkaline spring, flowing at the rate of perhaps 200 gallons per hour, the water of which deposits yellow ferric hydrate. It is used to a small extent, locally, is unimproved, and is shown in the cut opposite this page.

Water ferro-alkaline.

Results of analysis of water of Reed's Spring (w.):

		Grains in Gallon.	Grams in Litre.
Silica	(SiO_2)	0.9813	0.0168
Alumina	(Al_2O_3)	0.1168	0.0020
Ferric Oxide	(Fe_2O_3)	0.5517	0.0094
Lime	(CaO)	2.3485	0.0402
Magnesia	(MgO)	0.4283	0.0073
Potassa	(K_2O)	1.6977	0.0291
Soda	(Na_2O)	0.5023	0.0086
Sulphur Trioxide	(SO_3)	0.4216	0.0072
Chlorine	(Cl)	0.4453	0.0076
Carbon Dioxide	(CO_2)	6.5266	0.1118
Water in combination	(H_2O)	1.3349	0.0229
		15.3552	0.2629
Oxygen	(O)	0.1003	0.0017
Mineral matter		15.2549	0.2612
Fixed residue		10.6567	0.1824

Spec. Gravity = 1.0000

United as follows:

Analysis.

		Grains in Gallon.
Silica	(SiO_2)	0.9813
Alumina	(Al_2O_3)	0.1168
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	1.2274
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	6.7943
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	1.5633
Potassium Bicarbonate	($KHCO_3$)	1.3044
Sodium Bicarbonate	($NaHCO_3$)	1.3611
Potassium Sulphate	(K_2SO_4)	0.9170
Sodium Chloride	($NaCl$)	0.9341
Mineral matter		15.1997
Oxygen for Fe O		0.0552

COLBURN OR ELECTRIC SPRING (W.).

Location and Improvements. This spring is situated in the northern part of the town of Warrensburg, in a small valley cut into the sandstone of the region. The spring and surrounding grounds are owned by Mr. G. W. Colburn. The spring itself has been improved and a hotel has been built on a neighboring hill. It is frequented as a health resort. The water of the spring flows at a rate of 253 gallons per hour and is, like the others, ferro-alkaline, deriving its carbonate of lime from the beds immediately adjoining the Warrensburg sandstone. It carries, for this class of springs, an exceptional amount of mineral matter in solution. It is placed here for convenience sake, though properly belonging to and tabulated with the waters of the third group. Fig. 2, of the plate opposite this page, is from a photograph of this spring.

Colburn or Electric Spring.

Results of analysis of water of Colburn or Electric spring (w.):

		Grains in Gallon.	Grams in Litre.
Silica	(SiO_2)	1.5645	0.0268
Alumina	(Al_2O_3)	0.4089	0.0070
Ferric Oxide	(Fe_2O_3)	0.0642	0.0011
Lime	(CaO)	11.5886	0.1984
Magnesia	(MgO)	2.9088	0.0498
Soda	(Na_2O)	3.1541	0.0540
Sulphur Trioxide	(SO_3)	7.1610	0.1226
Chlorine	(Cl)	0.0642	0.0011
Carbon Dioxide	(CO_2)	21.2028	0.3630
Water in combination	(H_2O)	4.3367	0.0743
		53.4538	0.8981

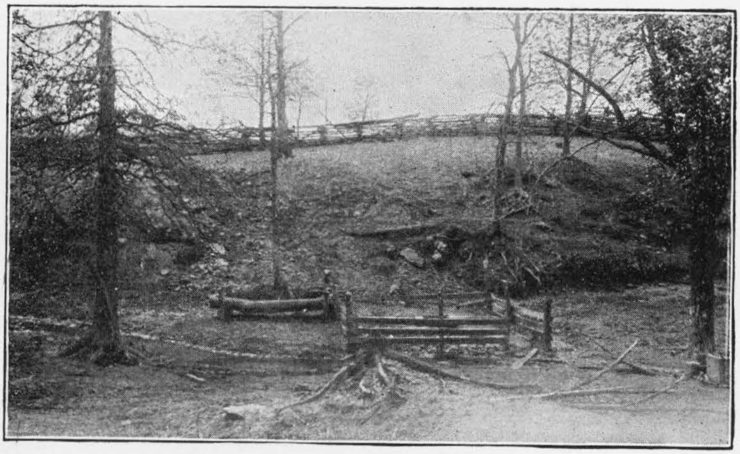


FIG. 1.

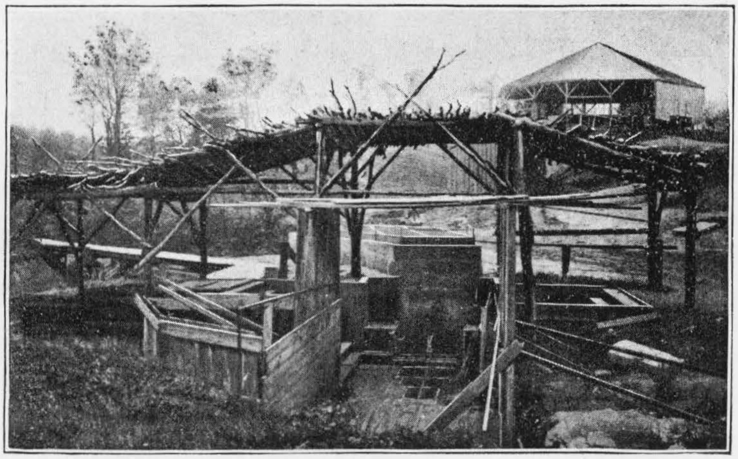


FIG. 2.

FIG. 1. CHALYBEATE SPRING NEAR WARRENSBURG.

FIG. 2. COLBURN'S OR "ELECTRIC SPRING," WARRENSBURG, JOHNSON CO.

Oxygen....................(O)	0.0145	0.0003
Mineral matter.....	52.4393	0.8978
Fixed residue............	37.5012	0.6420
		Spec. Gravity = 1.0002

United as follows:

Analysis.

	Grains in Gallon.
Silica.....................(SiO_2)	1.5645
Alumina..................(Al_2O_3)	0.4089
Ferrous Bicarbonate......($FeH_2(CO_3)_2$)	0.1428
Calcium Bicarbonate......($CaH_2(CO_3)_2$)	27.1180
Magnesium Bicarbonate...($MgH_2(CO_3)_2$)	10.6194
Calcium Sulphate.........($CaSO_4$)	5.3781
Sodium Sulphate..........(Na_2SO_4)	7.0954
Sodium Chloride..........($NaCl$)	0.1058
Mineral matter........ ...	52.4329
Oxygen for Fe O..........	0.0064

SPRINGS OF CEDAR COUNTY.

This county is situated in the southern part of the State and is as yet without any direct railroad communication. It possesses a number of springs, some of which are ferruginous and have justly been celebrated on account of the character of the waters, which, coming from a considerable depth out of the underlying sandstones, are alkaline, free from excess of mineral matter and easily digestible. Two centers of such chalybeate waters exist, one in the south eastern the other in the northwestern corner of the county.

JERICO SPRINGS (R.).

Location. Jerico spring also called "Fountain of Youth," near Jerico, in the southeastern part of the county is situated in section 9, township 33 N., 28 W. It was known and valued by the Indians, who resorted to it long after the country was settled. The water is recommended for rheumatism, kidney and stomach diseases and others. It issues on property belonging to the town but is managed by M. J. Straight, the owner of the bath houses erected near, who is known as the proprietor. Scant

An old Indian resort.

Strongly chalybeate.

accommodation and difficulty in reaching the place retard its development. This is a feebly flowing spring, a pump being erected to obtain the water supply at the bath houses, baths. are given both hot and cold, the warm baths being recommended. The water is a strongly chalybeate, and deposits a heavy mass of iron oxide on standing in the cold or on being heated.

Analysis.

Results of analysis of water of Jerico spring (s.):

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	1.3434	0.0230
Ferric Oxide	(Fe_2O_3)	0.7009	0.0120
Lime	(CaO)	0.1168	0.0020
Magnesia	(MgO)	0.2511	0.0043
Soda	(Na_2O)	1.0339	0.0177
Chlorine	(Cl)	0.0175	0.0003
Sulphur Trioxide	(SO_3)	0.1226	0.0021
Carbon Dioxide	(CO_2)	2.8935	0.0495
Water in combination	(H_2O)	0.5008	0.0086
		6.9805	0.1195
Oxygen	(O)	0.0039	0.0001
Mineral matter		6 9766	0.1194
Fixed residue		5.0291	0.0861

Spec. Gravity = 1.0001

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	1.3434
Ferrous Bicarbonate	$(FeH_2(CO_3)_2)$	1.5595
Calcium Bicarbonate	$(CaH_2(CO_3)_2)$	0.3379
Magnesium Bicarbonate	$(MgH_2(CO_3)_2)$	0.9165
Sodium Bicarbonate	$(NaH_2(CO_3)$	2.5027
Sodium Sulphate	(Na_2SO_4)	0.2176
Sodium Chloride	$(NaCl)$	0.2288
Mineral matter		6.9064
Oxygen for Fe O		0.0701

ELDORADO SPRINGS (S.).

A flourishing town.

Location. Eldorado Springs is a flourishing little town of 1,500 inhabitants, is situated in the extreme northwest corner of the county, twelve miles from Harwood, the nearest railroad station on the M., K. & T. railway, from whence it receives all its freight, and fourteen miles from Schell City, on the same railway, from whence the daily mail and most of the passengers arrive, and with which it is connected by telephone. From either of the two last named places the springs are accessible over a beautiful and picturesque country, by a not more than two and a half hours' pleasant drive. A stage line runs daily from Nevada, about twenty miles away through a very pretty country, and for the most part over good roads.

Located in a picturesque country.

Less than ten years ago this spot was a perfect wilderness. A remarkable cure was effected in 1881 by the use of waters issuing from a crevice in the rock at the bottom of a pretty valley, the renown of which spread so rapidly that a town was laid out forthwith and actually built within a very few years.

The Park Spring. A number of springs exist in this neighborhood, the most famous of which, and one which effected the above mentioned cure, is the Park spring, an everflowing spring yielding about 180 gallons per hour and belonging, together with a park three acres in extent, to the town. Its rights are jealously guarded.

The Park Spring.

Improvements. The whole property, though entirely free to the public, is nicely kept up and made attractive by flowers, music stand, pagoda and a large open hall for assembly or dancing. A number of hotels, the largest of which is the "Forest Grove" have been built in the past few years at an aggregate cost of $50,000. Several bathing establishments with hot and cold water facilities, a Casino hall and similiar attractions bring up the total of money spent to $80,000. Guests and patients are well taken care of and receive the comforts they have a right to expect. No bottling establishment exists yet on the grounds, though a very considerable trade is carried on from the sale of the water.[1] Pamphlets, descriptive of the place, are printed every year, and may be had on application to Mr. W. P. Cruce. Additional springs near by exist and are used along with the Park spring. Nearly all these springs were a few years ago carefully investigated and analyzed by the author.

Ho and grounds im-

[1] The sediment likewise is used commercially by incorporating it into a soap which is recommended for var!ous complaints.

Results of analysis of water of Park spring (s.):

Analysis.

		Grains in Gallon.	Grams in Litre.
Silica	(SiO_2)	2.2196	0.0380
Ferric Oxide	(Fe_2O_3)	1.5187	0.0260
Lime	(CaO)	0.6425	0.0110
Magnesia	(MgO)	0.5082	0.0087
Soda	(Na_2O)	1.6270	0.0278
Chlorine	(Cl)	0.2862	0.0049
Sulphur Trioxide	(SO_3)	1.7698	0.0303
Carbon Dioxide	(CO_2)	3.9091	0.0668
Water in combination	(H_2O)	0.6750	0.0116
		13.1471	0.2251
Oxygen	(O)	0.0645	0.0011
Mineral matter		13.0826	0.2240
Fixed residue		10.4576	0.1790

Spec. Gravity = 1.0002
Trace of organic matter.
Some Li; trace of Mn.
No K.

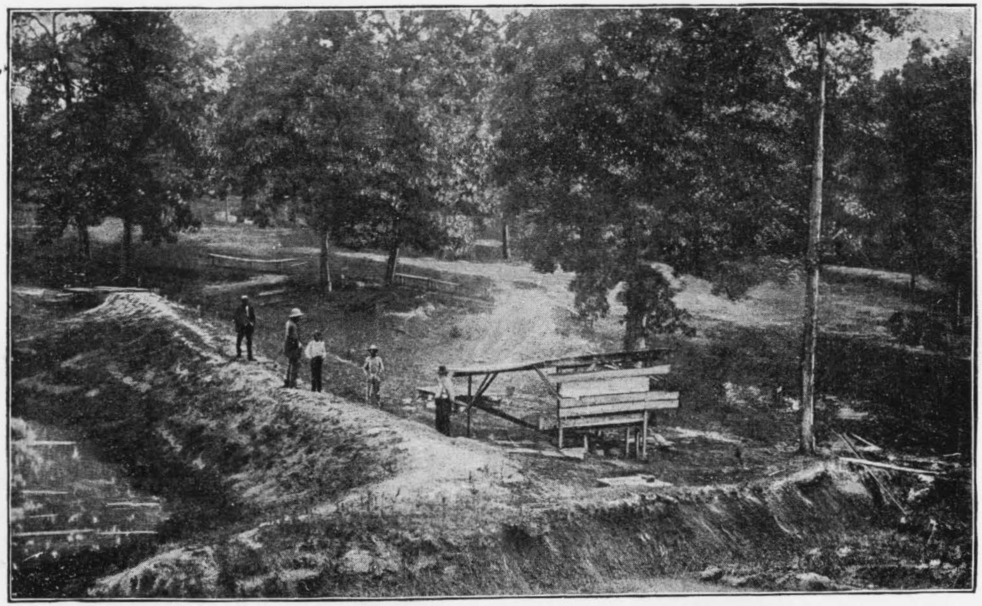
United as follows:

		Grains in Gallon.
Silica	(SiO_2)	2.2196
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	3.3791
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	1.8586
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	1.8549
Sodium Sulphate	(Na_2SO_4)	3.1414
Sodium Chloride	($NaCl$)	0.4771
Mineral matter		12.9307
Oxygen for Fe O		0.1519

MAIN SPRING (R.).

The "Nine Wonders."

Location. Main spring, near Eldorado Springs, is one of nine springs found at West Eldorado, a settlement about a mile from Eldorado Springs. All of these springs are enclosed within a handsomely walled-in basin, and are called "The Nine Wonders." A rival establishment to Eldorado Springs was started here, a park laid out and embellished, buildings erected, among which was a three story brick bank building completely fitted up but never occupied. The town can now only be considered a deserted village — though the springs possess



RANDOLPH WELL N. W. OF MOBERLY, RANDOLPH CO.

undoubted merit, and will in time develop the place. The spring properly belongs to the third group of chalybeate waters, and is placed here only for the purpose of having the waters of the county represented together.

Analysis of water from Main spring.

Results of analysis of water of Main spring (s.):

		Grains in Gallon.	Grams in Litre.
Silica	(SiO_2)	1.6355	0.0280
Ferric Oxide	(Fe_2O_3)	1.1683	0.0200
Lime	(CaO)	2.6284	0.0450
Magnesia	(MgO)	1 4310	0.0245
Soda	(Na_2O)	2.1670	0.0371
Chlorine	(Cl)	0.2044	0.0035
Sulphur Trioxide	(SO_3)	6.3784	0.1092
Carbon Dioxide	(CO_2)	4.4410	0.0760
Water in combination	(H_2O)	0.7679	0.0131
		20.8216	0.3564
Oxygen	(O)	0.0461	0.0008
Mineral matter		20.7755	0.3556
Fixed residue		17.7871	0.3045

Spec. Gravity = 1.0003
No organic matter.
Some K; some Li.

United as follows:

		Grains in Gallon.
Silica	(SiO)	1.6355
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	2.5993
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	5.0629
Calcium Sulphate	($CaSO_4$)	6.3832
Magnesium Sulphate	($MgSO_4$)	0.0868
Sodium Sulphate	(Na_2SO_4)	4.5541
Sodium Chioride	($NaCl$)	0.3369
Mineral matter		20.6587
Oxygen for Fe O		0.1168

THE SPRINGS OF RANDOLPH COUNTY.

RANDOLPH SPA (W.).

Location and Improvements.—Besides the muriatic springs of Randolph county, treated on previous pages, this county possesses chalybeate waters of much value; one of these has been sampled and analyzed. This is the Randolph spa, a well situated six miles north of Huntsville, in section 2, T. 54 N., 15 W., in one of the most beautiful and picturesque portions of Randolph

Water flows from the drift

county. The water flows at a moderate rate out of the gravelly drift of the region and is protected by an embankment against overflow from the outside. The flow seems to depend in a measure, upon the condition of the seasons, and had almost entirely stopped during the month of August of this year. The property is owned and operated by W. A. Skinner, of Huntsville, who has improved it by the erection of an hotel or boarding house, kept open during the six summer months, and in other ways. The water is recommended, on the strength of testimonials, for rheumatism, indigestion and kidney trouble; a pamphlet descriptive of its advantages may be had on application to the owner.

Results of analysis of water of Randolph spa (W. & R.):

Analysis.

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	0.5491	0.0094
Alumina	(Al_2O_3)	0.9404	0.0161
Ferric Oxide	(Fe_2O_3)	3.2651	0.0559
Lime	(CaO)	11.5302	0.1974
Magnesia	(MgO)	2.6693	0.0457
Potassa	(K_2O)	0.4381	0.0075
Soda	(Na_2O)	1.1799	0.0202
Chlorine	(Cl)	0.7009	0.0120
Sulphur Trioxide	(SO_3)	0.1810	0.0031
Carbon Dioxide	(CO_2)	28.6250	0.4900
Water in combination	(H_2O)	5.8731	0.1006
		55.9521	0.9579
Oxygen	(O)	0.1577	0.0027
Mineral matter		55.7944	0.9552
Fixed residue		35.6088	0.6096

Sp Gravity = 1.0009

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.5491
Alumina	(Al_2O_3)	0.9404
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	7.2427
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	33.3983
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	9.7687
Sodium Bicarbonate	($NaHCO_3$)	1.9336
Sodium Sulphate	(Na_2SO_4)	0.3300
Potassium Chloride	(KCl)	0.6951
Sodium Chloride	($NaCl$)	0.6100
Mineral matter		55.4679
Oxygen for Fe O		0.3265

B. SECOND GROUP (SALINE CHALYBEATE WATERS).

Waters containing ferrous carbonate, magnesium carbonate and magnesium sulphate; sodium carbonate and calcium sulphate being absent.

This group has been made chiefly for purposes of convenience in the selection of waters for use; what has been said as to the value of the waters of the first group applies to these waters also and no additional statement is necesssary, as their only difference from the waters of the first group is the absence of sodium carbonate.

Waters grouped for convenience.

TABLE OF ANALYSES OF MISSOURI CHALYBEATE WATERS — SECOND GROUP.

Results are expressed in grains per gallon.

	1 *Frost's Spring* (W. & R.), Clinton Co.	2 *Reed's Spring* (W. & R.), Liberty, Clay Co.	3 *Crystal Spring* (W. & R.), Platte Co.	4 *Siloam Spring* (W. & R.), Gentry Co.	5 *Siloam Spring* (W. & R.), Excelsior Spring, Clay Co.	6 *Regent Spring* (W. & R.), Excelsior Spring, Clay Co.
Silica	1.5011	1.1681	1.7406	1.1916	1.5245	1.1156
Alumina	0.1810	0.3400	1.1624	0.0175	0.0526	0.2978
Ferrous Bicarbonate	0.0921	0.8271	0.6752	0.7204	2.1175	3.4376
Manganous Bicarbonate	....	....	....	....	0.3836	0.9821
Calcium Bicarbonate	23.5557	15.4386	17.1008	8.9953	23.1066	28.8676
Magnesium Bicarbonate	4.3627	2.0166	1.4600	5.4922	2.2769	3.7542
Magnesium Sulphate	4.7400	0.3300	2.1400	1.4900	0.2500	0.3500
Sodium Sulphate	2.8200	0.9100	1.3000	1.2300	1.1700	....
Magnesium Chloride	....	....	....	....	....	0.4200
Potassium Chloride	....	0.4700	0.5900	0.2920	0.3400	0.6700
Sodium Chloride	1.1600	0.9700	1.0800	2.0800	0.9000	2.2300
Total Mineral Matter	38.4126	22.4704	27.2490	21.5091	32.2017	42.1274
Specific Gravity	1.0007	1.0005	1.0004	1.0011	1.0008	1.0007

Analyses.

THE SPRINGS OF CLINTON COUNTY.

FROST'S SPRING (W.).

Water flows from the drift.

Location. To the list of springs of this county heretofore mentioned, must now be added Frost's spring, situated in N. E., N. W. $\frac{1}{4}$, section 32, T. 55 N., 31 W., about two miles from Plattsburg. It issues at a considerable distance above water level from the side of a high ridge, running between Plattsburg and Lathrop in a northerly direction into Iowa. It flows out of the drift of that section of country, at an apparent rate of 300 or 400 gallons per hour and is at present unimproved; the temperature of the water was 62° F., the air being 78° F.

Results of analysis of Frost's spring water (W. & R.):

	Grains in Gallon.	*Grams in Litre.*
Silica.... .... (SiO_2)	1.5011	0.0257
Alumina.................. (Al_2O_3)	0.1810	0.0031
Ferric Oxide............. (Fe_2O_3)	0.0409	0.0007
Lime..................... (CaO)	8.1248	0.1391
Magnesia................. (MgO)	2.8446	0.0484
Soda..................... (Na_2O)	1.8399	0.0315
Chlorine................. (Cl)	0.7009	0.0120
Sulphur Trioxide.......... (SO_3)	4.7312	0.0810
Carbon Dioxide........... (CO_2)	15.4438	0.2650
Water in combination...... (H_2O)	3.1662	0.0542
	38.5744	0.6607
Oxygen................... (O)	0.1577	0.0027
Mineral matter............	38 4167	0.6580
Fixed residue.............	27.5286	C.4713

Spec. Gravity = 1.0007

Analysis.

United as follows:

	Grains in Gallon.
Silica.................... (SiO_2)	1.5011
Alumina.................. (Al_2O_3)	0.1810
Ferrous Bicarbonate...... ($FeH_2(CO_3)_2$)	0.0921
Calcium Bicarbonate...... ($CaH_2(CO_3)_2$)	23.5557
Magnesium Bicarbonate... ($MgH_2(CO_3)_2$)	4.3627
Magnesium Sulphate...... ($MgSO_4$)	4.7400
Sodium Sulphate.......... (Na_2SO_4)	2.8200
Sodium Chloride.......... (NaCl)	1.1600
Mineral matter............	38.4126
Oxygen for Fe O..........	0.0041

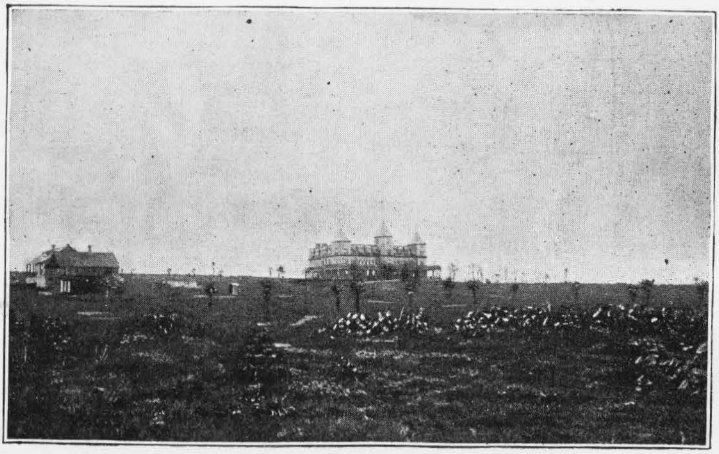


FIG. 1.

FIG. 2.

FIG. 1. HOTEL "THE WINNER," AT REED'S SPRINGS, NEAR LIBERTY, CLAY CO.
FIG. 2. HAUPTQUELLE AT REED'S SPRINGS, LIBERTY, CLAY CO.

THE SPRINGS OF CLAY COUNTY.

The remaining three springs of Clay county referred to in Chap. V., as having been analyzed, are all included in this second group of mineral waters and are described in the following pages.

REED'S SPRINGS (W.).

Location. Reed's springs are one mile south of Liberty. There are six springs in number, the principal one being known as "Hauptquelle" or "Schweitzer spring." It issues from the bottom of a small ravine at a moderate rate of flow, 150 gallons per hour or less; the temperature of the water was 58° F., air being at 62° F. The others, at times, give out entirely, which happened to be the case during the writer's visit; the place is a picnic resort in summer and accommodates camping parties. A hotel and pavillion has been built and other improvements have been made during recent years. The figures of the plate opposite this page illustrate these.

Water issues from bottom of a small ravine.

Results of analysis of the Reed's spring water (W. & R.):

	Grains in Gallon.	Grams in Litre.
Silica ....(SiO_2)	1.1682	0.0200
Alumina..................(Al_2O_3)	0.3400	0.0058
Ferric Oxide............(Fe_2O_3)	0.5432	0.0093
Lime.......................(CaO)	5.3270	0.0912
Magnesia.................(MgO)	0.6659	0.0114
Potassa...................(K_2O)	0.2978	0.0051
Soda........................(Na_2O)	0.9111	0.0156
Chlorine..................(Cl)	0.8177	0.0140
Sulphur Trioxide.........(SO_3)	0.7301	0.0125
Carbon Dioxide..........(CO_2)	9.8604	0.1688
Water in combination.....(H_2O)	2.0476	0.0350
	22.7090	0.3887
Oxygen ....(O)	0.1843	0.0031
Mineral matter............	22.5247	0.3856
Fixed residue............	15.5469	0.2662

Analysis.

Spec. Gravity= 1.0005.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	1.1681
Alumina	(Al_2O_3)	0.3400
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	0.8271
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	15.4386
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	2.0166
Magnesium Sulphate	($MgSO_4$)	0.3300
Sodium Sulphate	($NaSO_4$)	0.9100
Potassium Chloride	(KCl)	0.4700
Sodium Chloride	($NaCl$)	0.9700
Mineral matter		22.4704
Oxygen for Fe O		0.0543

EXCELSIOR SPRINGS (S.).

Location and Improvements. These well known springs are situated in a town of the same name, which has been built solely on account of the water, discovered in the summer of 1880. It possesses a sewerage system, is lighted by electricty and abounds in hotels and boarding houses, whose guests are welcome to a free use of the water.

Handsome **hotel.**

The Elms, with a capacity of five hundred guests, is a beautiful and commodious hotel, kept open all the year, and equipped with modern conveniences. Incandescent lights, automatic communicators and steam heaters are in each room ; open fire places in the public and also in some sleeping rooms ; furnishing and table very good.

Other extensive improvements have been made.

The baths connected with the hotel comprise turkish, russian, electric and hot and cold salt water tub baths, all in charge of skilled attendants. Amusements, such as bowling, billiards, tennis, hunting and fishing may be had, as also driving in the Elms park surrounding the hotel, which embraces some forty acres, and is pleasantly laid out in lawns, walks and drives. Facing the park is a musical hall, erected at a cost of $30,000 and arranged for balls, musicals and literary entertainments.

Over six hundred thousand dollars have been expended by the Excelsior Springs company in the endeavor to make the place a desirable resort for invalids and pleasure seekers. The whole is under the charge and operated by Mr. Chas. Fish, manager of the company, of whom descriptive pamphlets may be

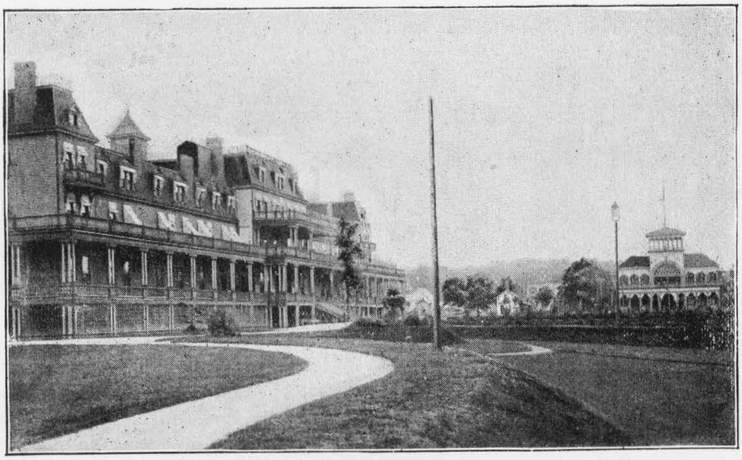


FIG. 1.

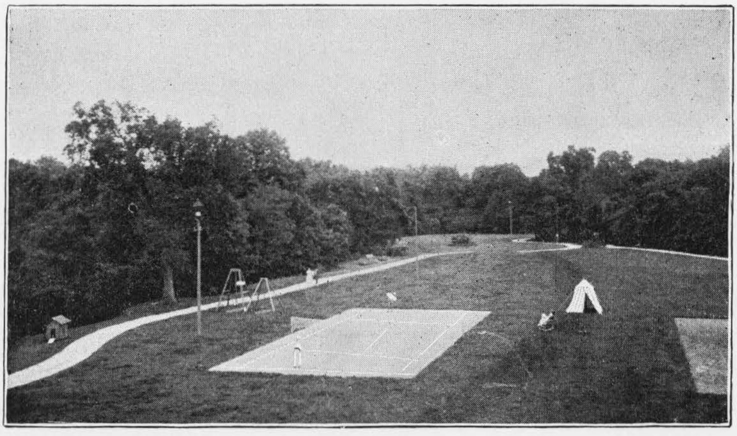


FIG. 2.

FIG. 1. THE "ELMS HOTEL" AND OPERA HOUSE, AT EXCELSIOR SPRINGS, CLAY CO.
FIG. 2. PROMENADE AND TENNIS COURT, EXCELSIOR SPRINGS.

obtained. The two plates opposite this and the next page illustrate the improvements and attractions of this resort.

The waters collected and analyzed are those of the Siloam well, the Regent spring and the Sulpho-Saline well, the latter already discussed under a different class.

The Siloam Well (W.) is situated about a mile from Regent spring and is ten feet deep, the bottom being about three feet above the river level. A protecting wall, fifteen feet high, with a wooden platform surmounted by a pagoda encloses it. Its flow is about 150 gallons per hour and its temperature 59° F., the air being at 74°F. A well 10 ft. deep.

Results of analysis of the Siloam well water (W. & R.):

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	1.5245	0.0261
Alumina	(Al_2O_3)	0.0526	0.0009
Ferric Oxide	(Fe_2O_3)	0.8878	0.0152
Manganic Oxide	(Mn_2O_3)	0.1710	0.0021
Lime	(CaO)	8.0664	0.1381
Magnesia	(MgO)	0.7009	0.0120
Potassa	(K_2O)	0.2161	0.0037
Soda	(Na_2O)	0.9813	0.0168
Chlorine	(Cl)	0.7009	0.0120
Sulphur Trioxide	(SO_3)	0.8235	0.0141
Carbon Dioxide	(CO_2)	15.2188	0.2622
Water in combination	(H_2O)	3.1215	0.0534
		32.4653	0.5566
Oxygen	(O)	0.1577	0.0027
Mineral matter		32.3076	0.5539
Fixed residue		21.5767	0.3694

Spec. Gravity = 1.0008

United as follows: Analysis.

		Grains in Gallon.
Silica	(SiO_2)	1.5245
Alumina	(Al_2O_3)	0.0526
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	2.1127
Manganous Bicarbonate	($MnH_2(C_3)_2$)	0.3836
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	23.1066
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	2.2769
Magnesium Sulphate	($MgSO_4$)	0.2500
Sodium Sulphate	(Na_2SO_4)	1.1700
Potassium Chloride	(KCl)	0.3400
Sodium Chloride	($NaCl$)	0.9000
Mineral matter		32.2017
Oxygen for FeO		0.1059

Regent Spring. ("Ferro-Manganese Spring.") (w.) This, perhaps the most famous chalybeate spring in the State, is situated in the Fishing River valley.

Location and Improvements. It is completely protected from overflow by a circular limestone wall, three feet thick, set in Portland cement. The inside diameter of this wall is forty feet and its height twenty feet, The cement base or floor of this structure is about ten feet above the level of the creek at low water. Four springs occur here, the main one being the Regent. This is of such a depth that the bottom is about level with the surface of the water in the creek. It collects in a circular well, five feet in diameter, and was sampled directly at its place of issue. For use, the water is pumped at present to the top of the twenty foot wall, where a flooring has been laid, on which stands a pagoda. Large quantities of it are shipped, and, to prevent the decomposition and precipitation of the iron and manganese bicarbonates (a danger with every true chalybeate water, which must be prevented to preserve its medicinal value), a block tin pipe takes it directly from the bottom of the spring to the bottling house, where it is carbonated and bottled, and in this manner rendered secure against change and deterioration. The flow of water of this spring is about 200 to 400 gallons per hour, though no measurements could be made, and its temperature 62.5 F,, the air being at 71 degree F.

Four springs in an enclosure of 40 ft. in diameter.

Water is carbonated before bottling.

The Sulpho-Saline well, already discussed under the third group of Chapter V., is situated near the hotel and furnishes bathing houses and visitors with a genuine "saline water."

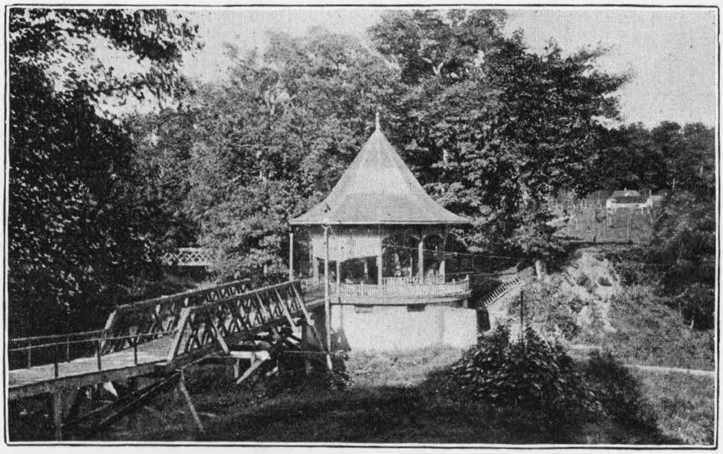


FIG. 1.

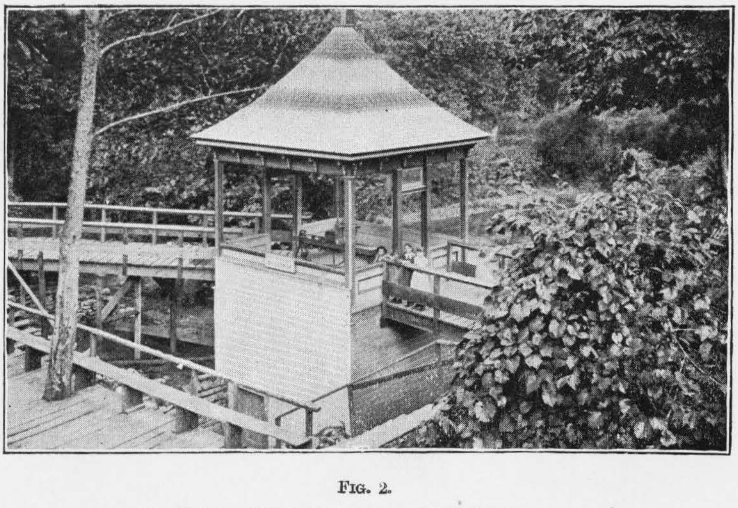


FIG. 2.

FIG. 1. THE "FERRO MANGANESE" SPRING, EXCELSIOR SPRINGS, CLAY CO.
FIG. 2. SILOAM WELL AT EXCELSIOR SPRINGS.

Results of analysis of the Regent spring water (W. & R.):

	Grains in Gallon.	Grams in Litre.
Silica .... (SiO_2)	0.1156	0.0191
Alumina.................... (Al_2O_3)	0.2978	0.0051
Ferric Oxide.............. (Fe_2O_3)	1.5596	0.0267
Manganic Oxide........... (Mn_2O_3)	0.4379	0.0075
Lime...................... (CaO)	9.9647	0.1706
Magnesia.................. (MgO)	1.3200	0.0226
Potassa.................... (K_2O)	0.4206	0.0072
Soda .... (Na_2O)	1.1740	0.0201
Chlorine.................. (Cl)	1.9859	0.0340
Sulphur Trioxide.......... (SO_3)	0.2278	0.0039
Carbon Dioxide........... (CO_2)	20.1522	0.3450
Water in combination..... (H_2O)	4.1209	0.0706
	42,7770	0.7324
Oxygen.................... (O)	0.4498	0.0077
Mineral matter............	42.3272	0.7247
Fixed residue.............	281302	0.4816

Spec. Gravity = 1.0007

United as follows: Analysis.

	Grains in Gallon.
Silica .... (SiO_2)	1.1156
Alumina.................... (Al_2O_3)	0.2978
Ferrous Bicarbonate...... ($FeH_2(CO_3)_2$)	3.4376
Manganous Bicarbonate... ($MnH_2(CO_3)_2$)	0.9821
Calcium Bicarbonate...... ($CaH_2(CO_3)_2$)	28.8676
Magnesium Bicarbonate... ($MgH_2(CO_3)_2$)	3.7542
Magnesium Sulphate...... ($MgSO_4$)	0.3500
Magnesium Chloride...... ($MgCl_2$)	0.4200
Potassium Chloride... ... (KCl)	0.6700
Sodium Chloride.......... ($NaCl$)	2.2300
Mineral matter...........	42.1274
Oxygen.................... (O)	0.1998

THE SPRINGS OF PLATTE COUNTY.

CRYSTAL SPRING (W.).

Location. The only spring of the county which has been sampled and analyzed is Crystal Spring, one of four springs situated about six miles from the Council Bluffs railway, in N. E. $\frac{1}{4}$, section 3, T. 51 N., R. 34 W. It has a flow of about 100 gallons per hour, and is owned and operated by M. C. Park, of Parkville, who reports a number of private houses erected there for the accommodation of boarders, and who recommends the water for rheumatism, constipation, sore eyes, etc. The temperature of the water was 62° F., that of the air being 69° F.

Glacial drift covers the surface.

The whole region is drift-covered; pieces of granite-pudding stone, mixed with other pebbles, sand and clay, rest on the sandstone shale of this region. The springs in question flow from the sandstone direct, with others, probably of a different character, in a neighboring gulch.

Analysis.

Results of analysis of the Crystal spring water (W. & R.):

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	1.7406	0.0298
Alumina	(Al_2O_3)	1.1624	0.0199
Ferric Oxide	(Fe_2O_3)	0.2978	0.0051
Lime	(CaO)	5.9052	0.1011
Magnesia	(MgO)	1.1098	0.0190
Potassa	(K_2O)	0.3739	0.0064
Soda	(Na_2O)	1.1448	0.0196
Chlorine	(Cl)	0.9346	0.0160
Sulphur Trioxide	(SO_3)	2.1554	0.0369
Carbon Dioxide	(CO_3)	10.5136	0.1800
Water in combination	(H_2O)	2.1509	0.0368
		27.4890	0.4706
Oxygen	(O)	0.2102	0.0036
Mineral matter		27.2788	0.4670
Fixed residue		19.8711	0.3402

Spec. Gravity = 1.0004

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	1.7406
Alumina	(Al_2O_3)	1.1624
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	0.6752
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	17.1008
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	1.4600
Magnesium Sulphate	($MgSO_4$)	2.1400
Sodium Sulphate	(Na_2SO_4)	1.3000
Potassium Chloride	(KCl)	0.5900
Sodium Chloride	($NaCl$)	1.0800
Mineral matter		27.2490
Oxygen for FeO		0.0298

FIG. 1.

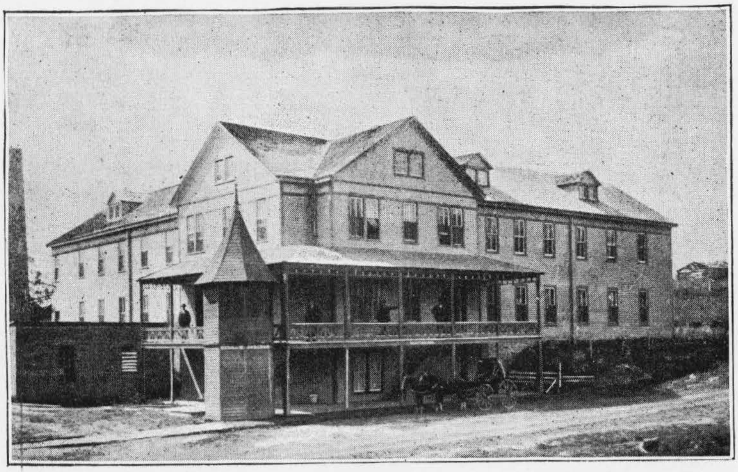


FIG. 2.

FIG. 1. THE "CRYSTAL" SPRINGS, FORMERLY SILOAM SPRINGS, AT CRYSTAL SPRING P. O., PLATTE CO.

FIG. 2. THE "SANITARIUM," AT SILOAM SPRINGS, GENTRY CO.

THE SPRINGS OF GENTRY COUNTY.

SILOAM SPRING (W.).

Location. Only one spring or well, Siloam spring, of this county was sampled and analyzed. It is located in N. W. ¼, section 10, T. 64 N., 30 W., near Gara Post Office, about twelve miles north of Albany, on the Chicago & Quincy railway. The well is 18 feet deep and has but a feeble flow, so that in very dry weather it gives out, and large numbers of people cannot be supplied by it. A good hotel of about one hundred rooms, and costing $20,000, has been erected near by. It is owned and managed as a sanitarium by Dr. J. J. Steinriede, who will, on application, send pamphlet to intending visitors. The waters are recommended by him for rheumatism, dyspepsia, general debility, etc. Its temperature was 56.5°F., the air being at 83° F.

Cost of improvements.

Claims for it.

Results of analysis of the Siloam spring water (w.):

Analysis.

	Grains in Gallon.	*Grams in Litre.*
Silica (SiO_2)	1.1916	0.0204
Alumina (Al_2O_3)	0.0175	0.0003
Ferric Oxide (Fe_2O_3)	0.3270	0.0056
Lime (CaO)	3.0915	0.0531
Magnesia (MgO)	1.9976	0.0344
Potassa (K_2O)	0.1869	0.0032
Soda (Na_2O)	1.6413	0.0281
Chlorine (Cl)	1.4018	0.0240
Sulphur Trioxide (SO_3)	1.6822	0.0288
Carbon Dioxide (CO_2)	8.5716	0.1464
Water in combination (H_2O)	1.7482	0.0410
	21.8572	0.3854
Oxygen (O)	0.3154	0.0054
Mineral matter	22.5418	0.3797
Fixed residue	15.5978	0.2655

Spec. Gravity = 1.0011

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	1.1916
Alumina	(Al_2O_3)	0.0175
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	0.7204
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	8.9953
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	5.4923
Magnesium Sulphate	($MgSO_4$)	1.4900
Sodium Sulphate	(Na_2SO_4)	1.2300
Potassium Chloride	(KCl)	0.2920
Sodium Chloride	($NaCl$)	2.0800
Mineral matter		21.5091
Oxygen for Fe O		0.0327

C. THIRD GROUP (SEMI-CHALYBEATE WATERS).

Waters containing ferrous carbonate, magnesium carbonate, magnesium sulphate, and some calcium sulphate. This latter, as explained previously, involves the existence of ferrous sulphate.

The reason for placing these waters in a group by themselves has already been sufficiently indicated; they possess therapeutic value like those of the two previous groups, but are stronger, more difficult of digestion and require more care in their use, on account of the calcium sulphate, which they contain.

TABLE OF ANALYSES OF MISSOURI CHALYBEATE WATERS — THIRD GROUP.

The results are expressed in grains per gallon.

	1 *Mooresville Spring* (W. & R.), Livingston Co.	2 *Electric Spring* (W.), Johnson Co.	3 *Denver Spring* (W. & R.), Worth Co.	4 *Artesian Well* (S.), Fairhaven, Vernon Co.	5 *Jamesport Well* (W. & R.), Daviess Co.	6 *Main Spring* (S.), Fairhaven, Vernon Co.	7 *Life Well* (S.), Fairhaven, Vernon Co.	8 *Main Spring* (S.), 9 Wonders—El Dorado, Cedar Co.	9 *Harris Well* (W. & R.), Monroe Co.	10 *Montrose Well* (W.), Henry Co.
Silica	1.5596	1.5645	1.6005	1.6939	1.4602	1 6939	1.8107	1.6355	1.9976	0.5140
Alumina	0 3095	0.4089	0 7184	....	0.0526	....	....	....	....	....
Ferrous Bicarbonate	0.0767	0.1428	0.1855	0.4418	1.1958	1.8193	2.0794	2.5993	3 3913	5.2265
Calcium Bicarbonate	35.5844	27.1180	45.9705	9.6144	32.7891	0.1701	....	....	79.4289	23.9161
Magnesium Bicarbonate	....	10.6194	....	19.4817	....	13.0860	32.2742	5.0629	....	....
Calcium Sulphate	27.8800	5.3781	17.4500	24.1861	1.6800	11.9143	47.5616	6.3832	24.2800	66.6243
Magnesium Sulphate	7.1600	....	9.8000	....	6.7700	....	....	0.0868	28.3100	20.3892
Sodium Sulphate	1.5100	7.0954	1.1700	11.4177	2.5000	8.8347	13.5628	4.5541	9.0200	19.5128
Potassium Sulphate	....	....	....	....	0.2000	....	....	....	....	1.8516
Potassium Chloride	0.8700	....	0.5400	....	....	....	....	....	2.4500	....
Sodium Chloride	2.4000	0.1058	2.8600	0.0481	0.3700	0.0288	0 0769	0.3369	0.7700	0.1580
Total Mineral Matter	77.3502	52.4329	80 2949	66.8837	47.0177	37.5471	97.3656	20.6587	149.6478	138.1925
Specific Gravity	1.0013	1.0002	1.0014	1.0009	1.0009	1.0008	1.0012	1.0003	1.0009	1.0002

THE SPRINGS OF LIVINGSTON COUNTY.

Two springs are noticed in this county, Moss's Mineral spring N. W. of Chillicothe in Section 31, T. 59 W., 24 W. which is of little importance and was not sampled, and Mooresville Mineral spring, near Mooresville.

THE MOORESVILLE MINERAL SPRING (W.).

Location. This spring is owned J. J. Lawson. Several springs were originally known to exist here but became clogged up by degrees and ceased to flow. Wells from seven to nine feet in depth were then dug to recover the water. These wells penetrate the shale and are worked with pumps; the property is leased to Dr. Y. Fisk, of Mooresville, on the Hannibal & St. Joseph railway, who owns the hotel of sixteen rooms close by, a bath house and improvements of the grounds representing an expenditure of several thousand dollars. Well No. 1 is the one analyzed and had a temperature of 61° F., the air being at 72° F.

Value of improvements and temperature of water.

Results of analysis of Mooresville spring water (W. & R.):

Analysis.

	Grains in Gallon.	*Grams in Litre.*
Silica.................... (SiO_2)	1.5596	0.0267
Aiumina.................. (Al_2O_3)	0.3095	0.0053
Ferric Oxide............ (Fe_2O_3)	0.0350	0.0006
Lime...................... (CaO)	23.7671	0.4069
Magnesia................ (MgO)	2.3831	0.0408
Potassa.................. (K_2O)	0.5432	0.0093
Soda...................... (Na_2O)	1.9275	0.0330
Chlorine.................. (Cl)	1.8691	0.0320
Sulphur Trioxide. .... (SO_3)	21.9797	0.3763
Carbon Dioxide.......... (CO_2)	19.4274	0.3326
Water in combination..... (H_2O)	3.9731	0.0680
	77.7743	1.3315
Oxygen.................. (O)	0.4206	0.0072
Mineral matter...........	77.3537	1.3243
Fixed residue............	63.6654	1.0900

Sp. Gr. = 1.0013

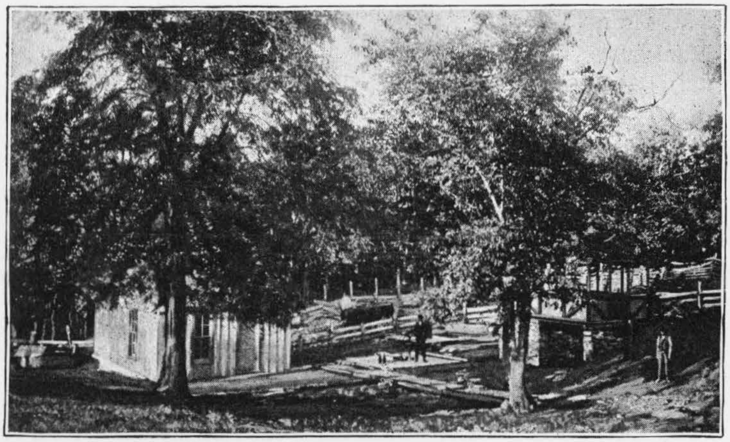


FIG. 1.

FIG 2.

FIG. 1. MOORESVILLE MINERAL SPRINGS, LIVINGSTON CO.
FIG. 2. HOTEL AT MOORESVILLE MINERAL SPRINGS.

United as follows:

		Grains to Gallon.
Silica	(SiO_2)	1.5596
Alumina	(Al_2O_3)	0.3095
Ferrous Bicarbonate	$(FeH_2(CO_3)_2)$	0.0767
Calcium Bicarbonate	$(CaH_2(CO_3)_2)$	35.5844
Calcium Sulphate	$(CaSO_4)$	27.8800
Magnesium Sulphate	$(MgSO_4)$	7.1600
Sodium Sulphate	(Na_2SO_4)	1.5100
Potassium Chloride	(KCl)	0.8700
Sodium Chloride	$(NaCl)$	2.4000
Mineral matter		77.3502
Oxygen for FeO		0.0035

THE SPRINGS OF WORTH COUNTY.

THE FAIRVIEW MINERAL SPRING (W.).

The old Fairview Mineral spring is situated at Denver, in the southeastern portion of the county, just north of Gara in Gentry county. It is a well rather than a spring, about fifteen feet deep, completely bricked, but subject to overflow from the neighboring creek in times of high water. A small three story brick hotel with eight bath rooms in the basement constitute the improvements. Its temperature was 58° F, that of the air being 83° F.

Value of improvements and temperature of water.

Results of analysis of the Fairview Mineral spring water (W. & R.):

		Grains in Gallon.	Grams in Litre.
Silica	(SiO_2)	1.6005	0.0274
Alumina	(Al_2O_3)	0.7184	0.0123
Ferric Oxide	(Fe_2O_3)	0.0818	0.0014
Lime	(CaO)	22.9084	0.3922
Magnesia	(MgO)	3.2651	0.0559
Potassa	(K_2O)	0.3387	C.0058
Soda	(Na_2O)	2 0209	0.0346
Chlorine	(Cl)	1.9859	0.0340
Sulphur Trioxide	(SO_3)	17.4062	0.2980
Carbon Dioxide	(CO_2)	24.8364	0.4252
Water in combination	(H_2O)	5.5906	0.0957
		80.7529	1.3825

Oxygen....................(O)	0.4498	0.0077
Mineral matter............	80.3031	1.3748
Fixed residue.............	62.2943	1.0665
		Spec. Gravity = 1.0014

Analysis of Fairview water.

United as follows:

	Grains in Gallon.
Silica.....................(SiO_2)	1.6005
Alumina...................(Al_2O_3)	0.7184
Ferrous Bicarbonate......($FeH_2(CO_3)_2$)	0.1855
Calcium Bicarbonate......($CaH_2(CO_3)_2$)	45.9705
Calcium Sulphate.........($CaSO_4$)	17.4500
Magnesium Sulphate......($MgSO_4$)	9.8000
Sodium Sulphate..........(Na_2SO_4)	1.1700
Potassium Chloride........(KCl)	0.5400
Sodium Chloride..........($NaCl$)	2.8600
Mineral matter............	80.2949
Oxygen for FeO...........	0.0082

THE SPRINGS OF VERNON COUNTY.

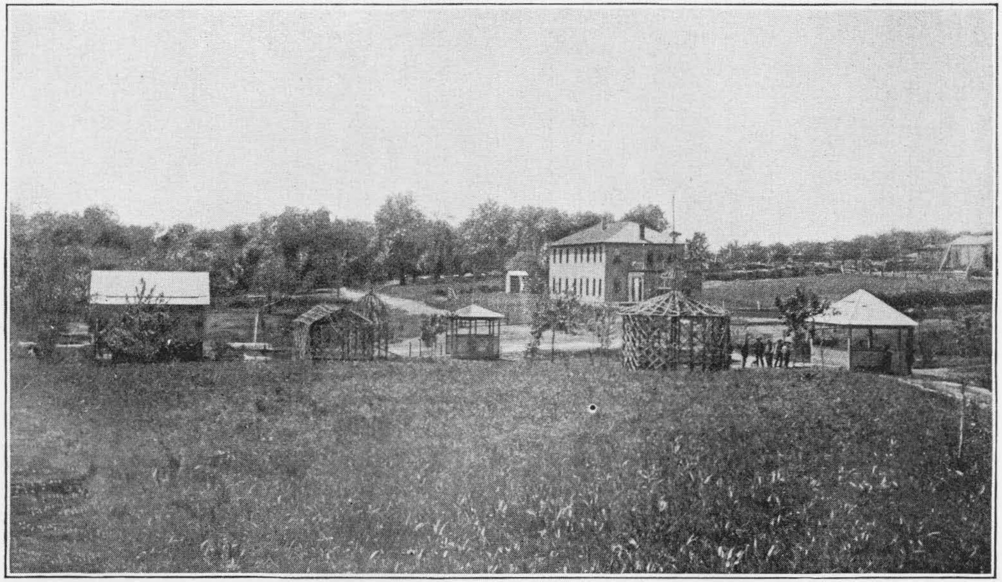
FAIRHAVEN SPRINGS (R).

Location and Character. The artesian well at Nevada has been noticed in a previous chapter. Here three additional analyses are given of springs at Fairhaven, about two and a half miles northwest of Harwood, on the Missouri, Kansas & Texas railway. This locality was formerly known as Connely Springs, and is situated in the W. ¼ of S. W. ¼, Section 18, T. 37 N., 29 W. Several springs, all more or less of the same character, issue, the main spring, flowing about 100 gallons per hour, being the one generally used by visitors and patients. It and the Life well are said to have a marked effect on the kidneys and to cure rheumatism. An artesian well was sunk to a depth of 138 feet and yields a water similar to that of the springs.

Benefits claimed for the waters.

Improvements. The property is controlled by the Fairhaven Town company, of Fairhaven and Nevada, who have built an hotel with 24 rooms, bath houses, some private residences, and have improved the grounds, spending on it in all, some $10,000. They expect to sink a second artesian well, if need be, one thou-

Value of improvements.



FAIRHAVEN MINERAL SPRINGS, VERNON CO.

sand feet deep, to obtain an abundant supply of water for lake, domestic and other purposes. It is the intention to build up here a sanitarium and summer resort; a circular may be obtained by writing the company.

A sanitarium to be built.

Results or analysis of the Artesian well water (s.):

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	1.6939	0.0290
Ferric Oxide	(Fe_2O_3)	0.1986	0.0034
Lime	(CaO)	13.2825	0.2274
Magnesia	(MgO)	5.3971	0.0924
Soda	(Na_2O)	5.0107	0.0850
Chlorine	(Cl)	0.0292	0.0005
Sulphur Trioxide	(SO_3)	20.6596	0.3537
Carbon Dioxide	(CO_2)	17.0962	0.2928
Water in combination	(H_2O)	3.5424	0.0606
		66.9102	1.1448
Oxygen	(O)	0.0066	0.0001
Mineral matter		66.9036	1.1447
Fixed residue		54.8131	0.9377

Spec. Gravity = 1.0007
No organic matter.
No K.
Trace of Li.

United as follows:

Analysis.

		Grains in Gallon.
Silica	(SiO_2)	1.6939
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	0.4418
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	9.6144
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	19.4817
Calcium Sulphate	($CaSO_4$)	24.1861
Sodium Sulphate	(Na_2SO_4)	11.4177
Sodium Chloride	($NaCl$)	0.0481
Mineral matter		66.8837
Oxygen for FeO		0.0199

Results of analysis of the Main spring water (s.):

Analysis of Main spring water.

		Grains in Gallon.	Grams in Litre.
Silica	(SiO_2)	1.6939	0.0290
Ferric Oxide	(Fe_2O_3)	0.8177	0.0140
Lime	(CaO)	4.9648	0.0850
Magnesia	(MgO)	3.8316	0.0656
Soda	(Na_2O)	3.8726	0.0663
Chlorine	(Cl)	0.0175	0.0003
Sulphur Trioxide	(SO_3)	11.9857	0.2052
Carbon Dioxide	(CO_2)	8.5218	0.1460
Water in combination	(H_2O)	1.9272	0.0330
		37.6328	0.6444
Oxygen	(O)	0.0039	0.0001
Mineral matter		37.6289	0.6443
Fixed residue		31.4408	0.5383

Spec. Gravity = 1.0008
No organic matter.
No K.
Traces of Li Mn.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	1.6939
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	1.8193
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	0.1701
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	13.0860
Calcium Sulphate	($CaSO_4$)	11.9143
Sodium Sulphate	(Na_2SO_4)	8.8347
Sodium Chloride	($NaCl$)	0.0288
Mineral matter		37.5471
Oxygen for FeO		0.0818

Results of analysis of the Life well water (s.):

Analysis of Life well water.

		Grains in Gallon.	Grams in Litre
Silica	(SiO_2)	1.8107	0.0310
Ferric Oxide	(F_2O_3)	0.9346	0.0160
Lime	(CaO)	19.5848	0.3353
Magnesia	(MgO)	9.1237	0.1562
Soda	(Na_2O)	6.9625	0.1192
Chlorine	(Cl)	0.0467	0.0008
Sulphur Trioxide	(SO_3)	35.6184	0.6098
Carbon Dioxide	(CO_2)	20.0722	0.3436
Water in combination	(H_2O)	4.3160	0.0739
		97.4696	1.6858

Oxygen..................(O)	0.0105	0.0002
Mineral matter............	97.4591	1.6856
Fixed residue............	83.1070	1.4399

Spec. Gravity = 1.0012
No organic matter.
Trace of Mn.

United as follows:

Analysis of Life well water.

	Grains in Gallon.
Silica.............. ......(SiO_2)	1.8107
Ferrous Bicarbonate......($FeH_2(CO_3)_2$)	2.0794
Magnesium Bicarbonate...($MgH_2(CO_3)_2$)	32.2742
Calcium Sulphate..........($CaSO_4$)	47.5616
Sodium Sulphate..........(Na_2SO_4)	13.5628
Sodium Chloride..........(NaCl)	0.0769
Mineral matter............	97.3656
Oxygen for Fe O...........	0.0935

THE SPRINGS OF DAVIESS COUNTY.

JAMESPORT MINERAL SPRINGS (W.).

Location. The only water of this county analyzed is that of the Jamesport Mineral springs in N. W. $\frac{1}{4}$ of S. E. $\frac{1}{4}$, Section 27, T. 60, Range 26 W., near Jamesport, on the Chicago, Rock Island & Pacific railway. They are owned by E. Martin, and operated by J. A. Kintner, both of the latter place. Four wells exist all in a space of 100 feet square, sunk about 27 feet deep in the drift. The flow of water to each is moderate; it is a question whether dry weather or large use would not exhaust them. A bath house, shown in Fig. 1 of the opposite plate, has been built for the use of patients, the town itself furnishing sufficient hotel accommodations for them. The temperature of the water was 56° F. (No. 1), and 55° F. (No. 2), the air being at 64° F.

Flow of water.

Accommodation offered.

Results of analysis of the Jamesport well water (W. & R.):

Analysis.

		Grains in Gallon.	Grams in Litre
Silica	(SiO_2)	1.4602	0.0250
Alumina	(Al_2O_3)	0.0526	0.0009
Ferric Oxide	(Fe_2O_3)	0.5374	0.0092
Lime	(CaO)	12.0149	0.2057
Magnesia	(MgO)	2.2605	0.0387
Potassa	(K_2O)	0.3446	0.0059
Soda	(Na_2O)	1.0923	0.0187
Chlorine	(Cl)	0.1752	0.0030
Sulphur Trioxide	(SO_3)	6.9975	0.1198
Carbon Dioxide	(CO_2)	18.4112	0.3152
Water in combination	(H_2O)	3.7659	0.0645
		47.1123	0.8066
Oxygen	(O)	0.0409	0.0007
Mineral matter		47.0714	0.8059
Fixed residue		34.0999	0.5838

Spec. Gravity = 1.0009

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	1.4602
Alumina	(Al_2O_3)	0.0526
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	1.1958
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	32.7891
Calcium Sulphate	($CaSO_4$)	1.6800
Magnesium Sulphate	($MgSO_4$)	6.7700
Potassium Sulphate	(K_2SO_4)	0.2000
Sodium Sulphate	(Na_2SO_4)	2.5000
Sodium Chloride	($NaCl$)	0.3700
Mineral matter		47.0177
Oxygen for Fe O		0.0537

THE SPRINGS OF MONROE COUNTY.

THE HARRIS WELL (W.).

Location. The Harris well or "Fountain of Youth" is situated in section 17, T. 53 N., 12 W., near Middle Grove, some six miles south of Evansville, on the Missouri Pacific railway. It is one of four wells sunk some twenty feet deep into sandstone or sand. It is the property of T. T. Harris, who has erected a bath-house for the use of patients, and has otherwise improved the

One of four wells in sandstone.

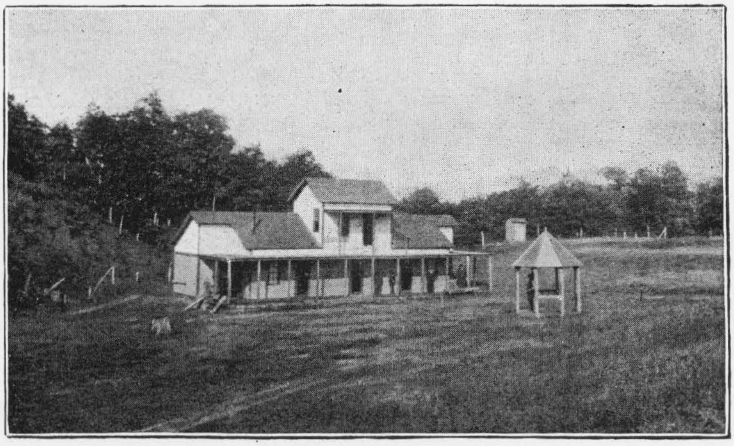


FIG. 1.

FIG. 2.

FIG. 1. JAMESPORT MINERAL WELL, JAMESPORT, DAVIES CO.
FIG. 2. HARRIS MINERAL WELL, MONROE CO.

spot, and Fig. 2 of Plate XXXV. gives some idea of the location. Boarding may be had at a short distance from the wells. Printed circulars inviting invalids to try the waters, are distributed on application. The water has a temperature of 58° F., the air being at 52° F. Accommodations offered.

Results of the analysis of the Harris well water (W. & R.):

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	1.9976	0.0342
Ferric Oxide	(Fe_2O_3)	1.4602	0.0250
Lime	(CaO)	37.4758	0.6416
Magnesia	(MgO)	9.4682	0.1621
Potassa	(K_2O)	1.5421	0.0264
Soda	(Na_2O)	4.3515	0.0745
Chlorine	(Cl)	1.6355	0.0280
Sulphur Trioxide	(SO_3)	38.2819	0.6554
Carbon Dioxide	(CO_2)	44.7878	0.7668
Water in combination	(H_2O)	9.1612	0.1568
		150.1618	2.5708
Oxygen	(O)	0.3680	0.0063
Mineral matter		149.7938	2.5645
Fixed residue		118.2387	2.0243

Spec. Gravity = 1.0009

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	1.9976
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	3.3913
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	79.4289
Calcium Sulphate	($CaSO_4$)	24.2800
Magnesium Sulphate	($MgSO_4$)	28.3100
Sodium Sulphate	(Na_2SO_4)	9.0200
Potassium Chloride	(KCl)	2.4500
Sodium Chloride	($NaCl$)	0.7700
Mineral matter		149.6478
Oxygen for FeO		0.1460

THE SPRINGS OF HENRY COUNTY.

THE FORD SPRING (W.).

Location. This well (probably supplied by a spring) is situated in the town of Montrose at the corner of Seventh street and Missouri avenue. The well is about twenty-five feet deep and

Rich in sulphates of alkaline earths.

the water is obtained by pumping. It has been improved to some extent and is used a great deal by people living in the vicinity. The water is remarkable as containing a large amount of the sulphates of the alkalies and alkaline earths in solution, which are probably derived from the oxidizing pyrite in the shales below.

Results of the analysis of the Montrose well water (w.):

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	0.5140	0.0088
Ferric Oxide	(Fe_2O_3)	2.3490	0.0402
Lime	(CaO	35.7008	0.6112
Magnesia	(MgO)	6.7964	0.1164
Potassa	(K_2O)	1.1000	0.0188
Soda	(Na_2O)	8.5197	0.1459
Sulphur Trioxide	(SO_3)	64.6280	1.1064
Chlorine	(Cl)	0.0752	0.0013
Carbon Dioxide	(CO_2)	15.5754	0.2666
Water in combination	(H_2O)	3.1858	0.0545
		138.4443	2.3701
Oxygen	(O)	0.0169	0.0003
Mineral matter		138.4274	2.3698
Fixed residue		127.4539	2.1820

Spec. Gravity = 1.0002

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.5140
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	5.2265
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	23.9161
Calcium Sulphate	($CaSO_4$)	66.6243
Magnesium Sulphate	($MgSO_4$)	20.3892
Potassium Sulphate	(K_2SO_4)	1.8516
Sodium Sulphate	(Na_2SO_4)	19.5128
Potassium Chloride	(KCl)	0.1580
Mineral matter		138.1925
Oxygen for Fe O		0.2349

CHAPTER IX.

SULPHUR WATERS.

Waters containing, as their remedial agent, sulphur in the form of sulphide or sulphydrate: often also free sulphuretted hydrogen gas.

CHARACTER AND CLASSIFICATION.

The reasons for excluding from this class of waters those which contain sulphuretted hydrogen in the free state merely, have been given in a previous chapter. All brines or sulpho-saline waters in which small quantities of this gas occur, are therefore discussed elsewhere and may be examined in Chapter V. The free gas, though obtrusive enough in one way, is comparatively without effect on the system, while sulphides, sulphydrates and doubtless also thio-sulphates are potent and their action quickly discernible. The number of waters, coming within the limits of this definition, is small. They must all contain carbonates and perhaps alkaline carbonates so as to properly bind the hydrogen sulphide. A greater or smaller amount of alkali would determine the existence of sulphur as sulphide or sulphydrade, and in conformity with this fact the suggestion has been made elsewhere, to divide the waters of this class into three groups; those containing sulphides (strongly alkaline waters); those containing sulphydrates (feebly alkaline or neutral waters) and those containing either of these two substances and thio-sulphates in addition. Only two waters of this class, both coming from the western part of the State, Cass county, have been examined, though attention is called here to their resemblance to the Greenwood water from the southern edge of Jackson county. No classification of the two is attempted.

Sulphides and sulphydrates act strongly upon the system.

Division into three groups.

THE SPRINGS OF CASS COUNTY.

The two springs investigated by the Survey are found in the southwestern corner of Cass county, which is the middle of the western tier of counties, being the seventh from either north or south. They are remarkable for their large contents of alkaline carbonates and have clearly a common origin; their location is readily accessible from Kansas City by the K. C., N. & Ft. S. railway, and their reputation is spreading.

Rich in alkaline carbonates.

M'LELLAND'S SPRING (HOVEY).

Location. This spring or rather well is located in S. E. $\frac{1}{4}$, N. W. $\frac{1}{4}$, Sec. 22, T. 43 N., 33 W., about five miles N. E. of Drexel on the above mentioned railway, and was dug and drilled in the fall of 1882. After reaching a depth of 17 feet from the surface the hardness of the rocks — compact blue limestone — compelled the employment of a drill, and a nine inch hole was sunk to a total depth of 75 feet; a strong stream of water, with an estimated flow of about five gallons a minute, came in from the north, when the drill had descended 45 feet and was the only seam of water that was struck. The property was bought in 1885 by M. A. McLelland, of the post-office of that name, who put a water-tight galvanized iron pipe from the surface to the drill hole, and carefully filled in the old dug portion with brick laid in hydraulic cement and sand, so as to exclude all surface water. Neither season nor rain seem to influence the flow of water, which rises within 25 feet of the surface, or 20 feet above its inlet, as demonstrated by steady use.

Flow of water and depth of vein.

The water is lifted by means of a tubular galvanized iron bucket, is strongly impregnated with sulphuretted hydrogen and has a temperature of 55° F. (the sample was taken on October 5, 1892). It is used to a considerable extent by local patients and is also shipped to a distance, the largest amount sent in one day having been 140 gallons. It is recommended by the owner for Bright's disease, dropsy, dyspepsia, eczema and skin diseases in general and in all disorders of the liver.

Beneficial in certain diseases.

A white sulphur spring, which had existed in a dry branch south of the present well, dried up when the latter was sunk and was in all probability tapped, as its point of issue is on a level with the stand of water in the well.

Results of analysis of the water of McLelland well (s.) :—

Analysis.

		Grains in Gallon.	Grams in Litre.
Silica	(SiO_2)	0.7009	0.0120
Lime	(CaO)	0.3505	0.0060
Magnesia	(MgO)	0.1694	0.0029
Soda	(Na_2O)	45.9043	0.7859
Sulphur Trioxide	(SO_3)	4.2697	0.0731
Chlorine	(Cl)	5.4613	0.0935
Carbon Dioxide	(CO_2)	54.479	0.9327
Water in combination	(H_2O)	10.4588	0.1791
Hydrogen Sulphide	(H_2S)	0.0526	0.0009
		121.8465	2.0861
Oxygen		1.2558	0.0215
Mineral matter		120.5907	2.0646
Fixed residue		82.8953	1.4192

Spec. Gravity = 1.00

Trace of iron present and a larger amount of sulphuretted hydrogen than here given.

United as follows:

		Grains in Gallon.
Silica	(SiO_2)	0.7009
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	1.0119
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	0.6196
Sodium Bicarbonate	($NaHCO_3$)	191.5590
Sodium Sulphate	(Na_2SO_4)	7.5758
Sodium Chloride	($NaCl$)	9.0009
Sodium Sulphide	(Na_2S)	0.1226
Mineral matter		120.5907

ELLIOTT'S WELL (HOVEY).

Location. This well is situated in Drexel and is the property of W. R. Elliott of the same place. Like the McLelland well it was dug 20 feet into very hard limestone and then continued by a drill 44 feet farther, the last 4 feet in black slate or shale, through which the water issues slowly. It is not as yet protected against the inflow of water from nearer the surface. The water is lifted by means of a pump. At the time of visit its temperature

Condition and flow of spring.

was 58° F. Another drilled well in Drexel furnishes, from apparently the same stratum, a weak sulphur water, all of which waters are remarkable for their softness in washing, which is sufficiently explained by the large amounts of alkaline carbonates, which they contain in solution.

A weak sulphur water.

Results of analysis of the water of Elliott's well (s.):

		Grains in Gallon.	*Grams in Litre.*
Silica	(SiO_2)	0.6425	0.0110
Ferrous Oxide	(FeO)	0.2103	0.0036
Lime	(CaO)	0.8177	0.0140
Magnesia	(MgO)	0.6367	0.0109
Soda	(Na_2O)	37.8614	0.6482
Sulphur Trioxide	(SO_3)	3.5922	0.0615
Chlorine	(Cl)	6.0279	0.1032
Carbon Dioxide	(CO_2)	44.5785	0.7632
Water in combination	(H_2O)	9.1176	0.1561
Hydrogen Sulphide	(H_2S)	0.2628	0.0045
		103.7476	1.7762
Oxygen		1.5011	0.0257
Mineral matter		102.2465	1.7505
Fixed residue		70.8392	1.2128

Spec. Gravity = 1.0

A larger amount of sulphuretted hydrogen than here given present in water.

United as follows:

Analysis.

		Grains in Gallon.
Silica	(SiO_2)	0.6425
Ferrous Bicarbonate	($FeH_2(CO_3)_2$)	9.5199
Calcium Bicarbonate	($CaH_2(CO_3)_2$)	2.3656
Magnesium Bicarbonate	($MgH_2(CO_3)_2$)	2.3246
Sodium Bicarbonate	($NaH_2CO_3)_2$)	79.4587
Sodium Sulphate	(Na_2SO_4)	6.3784
Sodium Chloride	($NaCl$)	9.9297
Sodium Sulphide	(Na_2S)	0.6016
Mineral matter		102.0255
Oxygen for Fe O		0.0210

CHAPTER X.

EUROPEAN AND MISSOURI MINERAL WATERS COMPARED.

INTRODUCTORY REMARKS.

At the close of this investigation into the character and present development of the mineral waters of Missouri it becomes desirable for comparative purposes to cast a glance over the mineral waters of other places. A consideration of the composition, natural advantages and improvements incident to utilizing to the fullest extent the curative properties of the waters, as well as the kind of environment that had been called into existence by the expenditure of money under the guidance of knowledge and taste, seemed to promise, not only interesting information, but hints and suggestions for the proper realization of enterprises, into which citizens of Missouri have put more than a million of dollars already.

Environment of springs.

To this end a selection from the exceedingly large number of European mineral waters has been made and the points, that should determine this selection, were carefully considered. The object, evidently, was not merely to select for comparison a mineral water, whose composition was more or less closely allied to our own; such selection would have been devoid of value and imparted no lesson. Waters had to be chosen, similar, of course, in composition to our own; but they had to possess reputations far beyond the confines of their immediate localities; they had to have been under the close personal observation of diverse skillful physicians for a score of years; they had to have acquired a fame as effective remedial agents in certain specific diseases; they had to offer in the construction of their bath-buildings all that modern science could suggest for the relief of suffering or the restoration of health, and finally, they had, in the surroundings or environment, to afford that degree of comfort and repose, which sick or well derive from the proper satis-

Springs of reputation chosen for comparison.

faction of their physical and spiritual wants. Such conditions are found nowhere in so great perfection as in Europe.

It was plain, that *famous* mineral water resorts had to be chosen; not so much for any similarity in the composition of their waters with our own, but to serve as examples after which to fashion our own sanitaria of the future. Many mineral waters of Missouri are of great therapeutic value; they compare well with some renowned mineral waters of Europe, and the expectation of seeing their virtues spread rests upon a solid foundation of facts. Much, however, which so conspicuously characterizes European baths, is yet lacking, and the hope is cherished that the following pages may serve as hints to remedy this want.

Many Missouri waters of great therapeutic value.

For the proper comparison of analytical results each analysis was converted into the terms used in this report. In many instances where numerous analyses, made at different times and by different chemists, existed, those of most recent date were preferred; and, finally, all values for recalculation were chosen from *Handbuch der Balneotherapie* by Dr. H. Helfft, Berlin, "1882," with the remark, however, that while some were expressed in grams per litre, others were expressed in parts per thousand; this, as explained elsewhere, may introduce a slight error which, while unavoidable, is devoid of practical import, and does not alter the reliability of the figures given. The statements concerning the diseases benefited by the waters were taken from the same work. The historical notes are from Osann; the descriptions from various sources.

Health resorts should keep records of the weather.

One word in addition to hints which the following descriptions may give, as to what health resorts, striving to be sanitaria, should undertake to do: 1. *To keep weather records, embracing daily observations of temperature, sunshine, humidity of the atmosphere, velocity and direction of winds and barometric pressure; 2. To provide good working systems of ventilation and sewerage; 3. To secure an ample supply of pure and wholesome waters.*

To facilitate ready comparison between the waters described in this chapter and Missouri waters, the same classification is introduced and the classes will be considered in the same order, beginning with the Muriatic Waters.

MURIATIC WATERS.

The muriatic waters represent an endless variety in the composition and strength of their constituents and find an abundant use both for drinking, when not too strong, and for bathing. The characteristics, however, of a watering place whose reputation rests solely upon the presence of brines, is not sufficiently pronounced to impart by its description a useful lesson; none are therefore mentioned except the Harrowgate waters at the end of this chapter, which are rich in free sulphuretted hydrogen.

Few muriatic springs of prominence.

ALKALINE WATERS.

Two representative alkaline waters, one from France, and the other from Germany, and each probably the most famous of the mineral waters of the country in which it occurs, have been selected for comparison. It is true, both are, in a measure, thermal waters, but, as the object of these pages is partly to suggest to persons in control of Missouri mineral water resorts what really renders many of the European sanitaria so important and conspicuous, famous watering places had to receive the preference over those, whose closer resemblance in the composition of their springs to our own was joined to obscurity. Prudence spurred by hope and emulation is productive of fruits, but should always be restrained by the weight of facts and conditions. *Sapienti sat.*

VICHY IN FRANCE.

Vichy, a town of about 6,000 inhabitants is, situated in the Department of l'Allier on the right side of the stream of the same name and distant from Lyons in the south of France, about 150 miles. The volcanic mountains of the Auvergne, which for a hundred years have yielded to geology such stores of interesting knowledge, take their rise here and are the seat of the waters that make Vichy's fame. Its importance as a watering-place or sanitarium dates back little more than a hundred years. Within this time a new quarter of the town has been built, consisting of villas, hotels, halls and the various public buildings necessary to

Waters derived from volcanic rocks.

the proper and comfortable use of a mineral water, all of which exhibit a high degree of elegance and taste.

Vichy is situated 733 feet above sea level in a charming valley surrounded on all sides by wooded hills of moderate height. Thirteen springs of a nearly uniform composition, arise here at no great distance from each other with temperatures ranging from 112° F., rendering its waters thermal, to 61° F., the temperature of an ordinary cold spring. The combined flow of these is abundant so that during a season of four months besides the considerable amounts of water consumed by drinking, 3,000 baths are furnished daily and a large quantity of the waters, reaching to hundreds of thousands of bottles a year, is sold abroad.

Flow from the springs is very large.

The waters of the thirteen springs, as already indicated, have nearly the same composition, so that the analysis of the "*Grande Grille*," though a thermal spring, represents fairly well the composition of the cold springs. It was chosen as being the most famous of the number and the one with which a "cure" is usually finished. A purely alkaline water without admixture of other differently acting salts, it may be consumed in considerable quantities, up to ten glasses a day and even more, and proves, with a proper regime in diet, quickly efficacious. Wine and acids, must of course, be avoided as counteracting the effect of the water in rendering the urine and probably other secretions of the body, alkaline. This alkalinity manifests itself very quickly; a glass or two of the water swallowed in the morning, or a bath taken in it imparts in half an hour an alkaline reaction to the urine, which it retains for eight or ten hours afterwards.

Water may be consumed in large quantities.

The indications for Vichy are chronic catarrh of the stomach, dyspepsia, catarrh of the intestines, gall ducts and urinary organs, gall stones, stones in the bladder, liver diseases, gout and diabetes; contra-indications are all inflammatory tendencies and organic lesions of the heart, lung or liver.

EMS IN PRUSSIA (PROVINCE NASSAU).

Ems is situated at the junction of the foothills of the Westerwald and Taunus mountains in a bend of the river Lahn about ten miles from Koblenz and possesses an elevation of 291 feet above sea level. On account of its position mornings and nights are cool and damp, and sudden changes of temperature not infrequent, so that persons with tendency to catarrh of the mucous membrane have to exercise great caution. The place, stretching along both sides of the river, has numerous large and elegant hotels, attractive private residences and substantial and appropriate public buildings, which, in most part, with the majority of the springs belong to and are controlled by the Government.

Changes in temperature frequent.

The composition of the waters of the nine springs, known to exist, is much alike, though their temperatures differ, and is quite similar to that of the Vichy waters, excepting that a greater amount of sodium chloride or common salt is carried by the German waters. The *Kraenchen*, as perhaps the most famous of the nine springs, has been selected for representation, though possessing a temperature of 95° F.

Indications for Ems are catarrh of the mucous membrane of the respiratory passages, of the digestive tracts and of the urinary organs; hyperæmia of the liver with torpor of the gall bladder, and certain forms of female diseases; contra-indications are a tendency to active congestions of the mucous membranes, phthisis of the lungs and excessively enfeebled constitution.

RESULTS OF ANALYSES OF FOREIGN ALKALINE WATERS.

Results expressed in grains per gallon.

Analyses.

	Vichy. Grande Grille. *Bouquet.*	Ems. Kraenchen. *Fresenius.*
Silica	4.0887	2.9030
Ferrous Bicarbonate	0.2598	0.1299
Calcium Bicarbonate	28.5186	14.2068
Magnesium Bicarbonate	20.1867	13.7912
Potassium Bicarbonate	22.5937	......
Sodium Bicarbonate	319.4420	129.4646
Potassium Sulphate	......	2.1495
Sodium Sulphate	16.9973	1.9567
Sodium Chloride	7.8269	57.4228
Sodium Phosphate	7.5923	0.2044
Sodium Arsenite	0.1752	0 5958[1]
Mineral matter	427.6822	222.8247

[1] Sum of eight substances instead of Sodium Arsenite.

COMPARISON WITH MISSOURI ALKALINE WATERS.

By Arthur Winslow.

On comparing the results of the analyses of the two foreign waters just given, with those occurring in Missouri of the same class, we find that the total mineral matter in the latter is very much less, the maximum amount being 94.05 grains to the gallon, whereas the Vichy water has over 400 grains. The amounts of important constituents are hence correspondingly less. Sodium bicarbonate is the principal constituent of these foreign waters, while in the Missouri waters it is present in an entirely insignificant quantity. The amounts of calcium and magnesium bicarbonates in the Missouri waters are more nearly comparable and the same may be said with regard to the sodium chloride. The amount of sodium sulphate corresponds more nearly to that contained in the Ems water. Indeed, with the exception of the fact of the small amount of sodium sulphate contained in the Clinton Water Works well water, it is similar to the Ems water; but, of course, the elimination of over 100 grains of this salt is an important consideration and affects its medicinal value very considerably.

Mineral matter in Missouri waters less than in European.

In order to bring the amounts of mineral matter in Missouri waters up to those of these foreign waters, a great concentration would have to be made; for instance, in the case of the Cusenbury spring water, the constituents would have to be multiplied over seven times, and, in the case of the Clinton Water Works water, over three times.

Concentration of Missouri waters for purpose of comparison.

The results of such concentration are expressed in the following table, and, as is there to be seen, the waters are not dissimilar to that of Ems.

CUSENBURY SPRING, KANSAS CITY.

The amounts of all constituents present are multiplied by the factor 7.24.

	Grains in Gallon.
Silica	7.6111
Alumina	23.2585
Calcium Bicarbonate	149.4929
Magnesium Bicarbonate	22.2846
Sodium Bicarbonate	10.3370
Sodium Sulphate	6.2988
Potassium Chloride	3.2985
Sodium Chloride	0.2182
Total	222.7996

CLINTON WATER WORKS WELL.

Factor of multiplication is 3.35.

	Grains in Gallon.
Silica	0.7826
Calcium Bicarbonate	33.4487
Magnesium Bicarbonate	43.2096
Sodium Bicarbonate	8.0568
Calcium Sulphate	25.3809
Potassium Chloride	15.8628
Sodium Chloride	95 9605
Total	222.3019

Analysis.

SULPHATIC WATERS.

The waters chosen to illustrate this class are placed, as was done in the case of Missouri waters, in two divisions; to the first belong the waters of Karlsbad, Marienbad and Friedrichshalle and to the second the waters of Alexisbad and Muskau. The two latter, representing the vitriol and alum waters, though doubtless possessing each its own individual merits, are of inferior importance compared to the others, and are adduced only for the sake of completeness. This is especially striking in the case of Karlsbad, which is visited annually by over 30,000 persons in search of health and, in a less degree only, by Marienbad and Friedrichshalle, whose waters, bottled and sold in immense quantities, reach in this way perhaps an even larger number of persons.

Karlsbad is visited by many people.

The waters of Karlsbad and Marienbad are much alike; the former are thermal, and somewhat weaker than the latter, and permit freer use; yet both are potent on account of the sodium sulphate or Glauber's salt, which they carry, the action of which upon the system is to a certain extent modified and accentuated by the presence of sodium and other bicarbonates. The fame of these waters as very specific against many forms of liver disease, more specifically mentioned in the description of Karlsbad, is world-wide. The Karlsbad salt, manufactured and sold over a large part of our globe, is an important source of revenue to the town; its composition, as ascertained by chemical analysis, warrants the belief that a similar industry might, with a reasonable promise of success, be inaugurated in Missouri.

Karlsbad salt is sold widely.

The Friedrichshalle water is the type of European bitter waters, which differ from our own in always containing a certain quantity of sodium sulphate besides their main ingredient: Epsom salts or magnesium sulphate. Industrially their importance lies throughout in the sale of their bottled waters, in which practice Missouri might profitably follow. Even at Epsom in England, very favorably situated in Surrey, about eighty miles from London, and the very place which has given name to the group of waters carrying magnesium sulphate as their chief constituent, little water is consumed on the spot; but a considerable trade has arisen and is yet carried on in the sale of the salts, which are derived from the waters by evaporation. The vitriolic and alum waters, though used both internally and for bathing, are much more limited in their use and should in reality be considered medicinal rather than therapeutic agents.

Epsom salts waters usually bottled.

Alum waters generally medicinal.

KARLSBAD (OR CARLSBAD) IN BOHEMIA.

The waters of Karlsbad, though perhaps not properly coming within the scope of waters to be mentioned here, as they are thermal, are yet so remarkable in many ways and offer in their composition so instructive a basis for comparison with the waters of our own State, that discussion of them is deemed perfectly justifiable.

Karlsbad, in the western edge of the old kingdom of Bohemia and situated 1123 feet above sea level, in a narrow valley enclosed by granite hills famous for their beautiful pine and beech forests, is a city of a few thousand inhabitants known for centuries for its products in tin and steel, offered for sale and readily bought in central Germany. Its present and past importance, however, is owing chiefly to its mineral waters, which bring during the summer months a vast number of invalids and patients to their shrines, to receive improved or, may be, restored health from their systematic use.

At present as many as 30,000 persons come to Karlsbad each season for a longer or shorter sojourn. The place has become a sanitarium as perhaps none other on the globe; waters, diversions, parks, promenades, splendid and impressive halls in

A grand sanitarium.

public places, with a diet strictly guarded by hotel or private house, converge all toward the great end of rendering a cure at Karlsbad effective.

Numerous learned and experienced physicians are at the call of the seeker after health, free from any unseemly desire for patients, independent to advise removal if indications are against the expected improvement, reasonable in their charges even in grave cases.

A well equipped staff of physicians in attendance.

All of the springs arise from a fault in the granite making a cleft, that is partly filled with deposited material — the so-called *sprudelstein* or *sprudelschale*. The temperatures of the waters are not all alike, but vary in the eighteen springs known to exist from 165.8° F., possessed by the "Sprudel," whose analyisis is given, to 83.7° F., possessed by the coldest. A difference in depth is supposed to account for this range, and the Sprudel's origin is placed about 7,000 feet below the surface.

The composition of the various springs is nearly the same, and cures are usually begun with the cooler, taking about two glasses of water per day and increasing the quantity gradually until five to eight glasses of the hottest, the Sprudel, are taken in the morning and two glasses of it in the afternoon. The selection of the spring, mainly as to its temperature, and the amount and mode of taking the water is determined in each case by the physician, who also prescribes regarding vapor or mud baths as an adjuvant.

The indications for Karlsbad are broad and are, in part, as follows: chronic catarrh of the stomach, dyspepsia, chronic catarrh of the intestines whether accompanied by diarrhœa or habitual constipation, catarrh of the gall ducts, hyperæmia of the liver, hæmorrhoids, fatty degeneration, diabetes, scrofula, gout and rheumatism, especially when caused by high living, and many others. Contra indications are high graded poverty of blood, great feebleness, inflammatory tendencies especially of respiratory organs, consumption, excitability of the vascular system with tendency to congestions, severe diseases of the heart and aneurisms.

Karlsbad waters of good effect in many complaints.

In many of these diseases, benefited by the use of Karlsbad waters, Karlsbad salt is found equally beneficial; it is obtained by boiling down the waters of any one of the springs and is in reality nothing but sodium sulphate or Glauber's salt, which as a substitute will doubtless prove of value in such cases.

MARIENBAD IN BOHEMIA.

Springs issue from the granite

Marienbad, about twenty-five miles southeast of Karlsbad, is the cold counterpart of the latter. A number of springs, of which six have been analyzed, issue from the granite of the Koenigswarth mountains in a picturesque valley, transformed in recent years by the art of man from primeval wildness to pleasing and park-like serenity. Situated 1,912 feet above sea level and 789 feet higher than Karlsbad, though protected by the neighboring mountains and especially in the north against cold winds and sudden changes of temperature, Marienbad yet possesses a more invigorating climate and demands, on account of the greater potency of its waters, a stronger constitution to insure a successful cure than does Karlsbad. Indications for the use of its waters are, with the proviso just mentioned, about the same as for Karlsbad, and so also are the counter-indications, though in a still higher degree.

Founded in the twelfth century.

These springs have been locally known for hundreds of years without, however, receiving any attention on the part of their owners, the Præmonstrateuse Abbey at Tepl, founded in 1193. At the beginning of this century the growing fame of Karlsbad invited to efforts in the same direction. Parks and roads were laid out, houses, hotels and halls were built and facilities provided for cold and hot bath ; the century old deposit, left behind by the escaping waters, mixed with fine earth and organic matter, was utilized for curative purposes in the form of mud baths, and is extensively used to-day as a most important factor in a "cure" at Marienbad. The *Krentzbrunnen*, whose analysis is given, is the most important of the various springs at the place and is the one whose waters are bottled and sold at the rate of 600,000 quarts a year.

FRIEDRICHSHALLE IN SAXE MEININGEN.

Friedrichshalle is situated about fifteen miles from Coburg and possesses two springs — one natural and weaker, the other artesian and stronger — the waters of which are mixed to produce a liquid of 1.0220 specific gravity, which is known and sold as "Natural Friedrichshalle Bitter Water." Until quite recently no facilities for the use of the waters existed at their source, but large quantities are bottled and sold over the whole of Europe. The considerable amount of common salt, which it contains, is supposed to render it better adapted for a "cure," than any other bitter water known. Its chief use, however, is as an adjuvant in connection with the use of other mineral waters, and for acting upon the bowels, without producing much impression upon the system. The effects of magnesium sulphate, its chief constituent, are sufficiently set forth in Chapter III, to which reference may be made for further information.

Water extensively bottled and sold.

ALEXISBAD AND MUSKAU.

Alexisbad in the Harz mountains is situated 1,200 feet above sea level in a valley with charming surroundings. It possesses two springs, of which the *Selkebrunnen*, whose analysis is given, serves mainly for bathing and then has often to be diluted in the beginning with soft water.

Muskau in Prussia possesses also two springs mainly used for bathing, and has, like Alexisbad, facilities for many kinds of baths, such as mineral, mud, steam, pine leaf and others, and enjoys with the former a moderate reputation in the cure of diseases of the stomach, intestines, chronic diarrhœa, female diseases and diseases arising from general debility; the dose of water for internal use is small, beginning with about half a pint a day, which may have to be diluted, and increasing it gradually up to a quart.

Facilities for bathing good.

RESULTS OF ANALYSES OF FOREIGN SULPHATIC WATERS.

Results expressed in grains per gallon.

First and Second Groups.

Analyses.

	Karlsbad Sprudel. *Mauthner & Ludwig.*	Marienbad Krentzbrunnen. *Ragsky & Lerch.*	Friedrichshalle Nat. Bitter Water. *Liebig.*
Silica	4.1763	4.7946	......
Ferrous Bicarbonate	0.2599	3.1451	......
Manganous Bicarbonate	0.0131	0.2660	......
Calcium Bicarbonate	30.4111	49.1584	1.3909
Magnesium Bicarbonate	16.9025	44.0517	52.7662
Sodium Bicarbonate	153.2112	108.7791	......
Potassium Bicarbonate	......	0.4755	......
Lithium Bicarbonate	1.3164	......	......
Potassium Sulphate	10.8759	3.0490	11.6169
Sodium Sulphate	140.4935	291.6469	353.7310
Sodium Chloride	60.8515	99.3612	464.7100
Sodium Fluoride	0.2978	......	......
Magnesium Bromide	......	......	6.6587
Other substances	0.3214 [1]	0.4498 [2]	......
Carbonic Acid, free	11.0862	......	7.2019
Calcium Sulphate	......	......	78.6491
Magnesium Sulphate	......	......	300.8232
Magnesium Chloride	......	......	230.0770
Mineral matter	430.2168	605.1773	1507.6249

Third Group.

Analyses.

	Alexisbad Selkebrunnen. *Pasch.*	Muskau Badequelle. *Duflos.*
Silica	1.1390	3.7674
Alumina	......	9.9133
Ferrous Bicarbonate	......	32.7043
Ferrous Sulphate	3.2885	43.9535
Manganous Sulphate	1.4660	1.2208
Calcium Sulphate	6.0104	121.9309
Magnesium Sulphate	3.5104	8.1832
Potassium Sulphate	......	0.9872
Sodium Sulphate	1.3259	6.6061
Sodium Chloride	......	24.9236
Ferrous Chloride	6.1155	......
Magnesium Chloride	0.7126	......
Organic matter	4.5268	2.9731
Mineral matter	28.0951	257.1634

[1] Four other substances.

[2] Three other substances.

COMPARISON WITH MISSOURI SULPHATIC WATERS.

By Arthur Winslow.

In no Missouri water is the total amount of mineral matter so high as in the Marienbad and Friedrichshalle waters cited in the preceding table; but, on the other hand, many Missouri sulphatic waters have a higher percentage of mineral matter than others of this table.

From the Karlsbad and Marienbad waters, the Missouri waters differ in containing less calcium bicarbonate, no magnesium bicarbonate and no sodium bicarbonate, while the latter is in these foreign waters, as in the alkaline waters previously described, an important constituent. In addition, the analyses of Missouri waters show no lithium bicarbonate,[1] which is represented in the Karlsbad water, and less potassium sulphate. On the other hand, sodium sulphate and sodium chloride, which are both important constituents of these two foreign waters, are well represented in the Missouri Lineville well water.

Missouri waters contain less calcium and magnesium salts.

From the Friedrichshalle water, our waters differ by containing no magnesium bicarbonate, less potassium sulphate, less sodium sulphate and sodium chloride and no magnesium chloride or magnesium bromide. On the other hand, they contain more calcium bicarbonate, and calcium and magnesium sulphates are fully as well represented in our B. B. spring water.

Alexisbad water has less mineral matter than the Missouri Crystal spring water in Pettis county, and the latter lacks only the ferrous chloride and manganous sulphate to contain almost the same mineral matter as the former. The Crystal spring water has, however, noticeably large quantities of alumina and calcium sulphate.

Crystal Spring similar to the Alexisbad water.

CHALYBEATE WATERS, FIRST GROUP.

The waters selected as representatives of the first group of chalybeate waters are those of Spa in Belgium and of Schwalbach in Germany. They are pure chalybeate waters of great fame and may fairly serve as types, with which to compare

[1] The determination of small quantities of lithium salts in mineral waters is expensive and difficult and requires the use of very large quantities of water. Attempt has therefore not been made to determine its presence in many Missouri waters.

similar waters in our own State. They are, like pure chalybeate waters in general, easily digestible and may be consumed in considerable quantities. The effects of such waters are described in Chapter III, to which reference is here made to save repetition in these special cases.

Waters used both for drinking and bathing.

The waters are used internally and externally, for drinking and bathing, and baths are prescribed with long immersions, which may be taken as a hint to managers of mineral water resorts in Missouri. Walks, promenades, diversions, comforts and undoubted benefits derived from a cure are necessary to give reputation to a watering-place and this, in turn, creates a demand for the sale of water abroad. Nearly all celebrated "baths" of Europe have the advantage over ours in point of time and money spent in their development; but the latter can make up for the former, and a much greater success for our native resorts may be predicted in all cases, where quality of water, judicial expenditure of money, certain natural advantages and a liberal management go hand in hand.

SPA IN BELGIUM.

Spa, an old and renowned watering-place, is situated in a picturesque valley of the Ardennes mountains, 1,000 feet above sea level and is distant thirty miles from either Aix-la-Chapelle or Liege. Well wooded hills surround it on all sides, especially in the north, which cut off the moist sea winds from the east and render thereby the air dry and invigorating. Here many thousands of visitors congregate during the season, attracted partly by the fame of the waters and partly by the pleasures and diversions abundantly provided. Attractive promenades, well kept mountain paths, good hotels and a palatial bath buildings, offering baths and douches in every conceivable variety, have rendered the place the most famous, perhaps, of the chalybeate water resorts of Europe. Its waters, to the extent of several hundred thousand quarts a year, find a ready and constantly growing market not only in Belgium but in other parts of Europe.

Good hotels and bath houses are found here.

Like the waters of our own State, belonging to this class and group, those of Spa are easily digested and are taken by even feeble persons up to four and six glasses a day without discomfort, and with certain realization of expected benefit. Of the sixteen springs known to exist in the neighborhood, but one, the Pouhon Spa, is found in Spa itself, and as it is the one commonly used by patients in their cures, as also the one whose waters are bottled, its analysis has been selected and is given here. **Sixteen springs found here.**

SCHWALBACH IN PRUSSIA (PROVINCE NASSAU).

Schwalbach near Wiesbaden is situated 900 feet above sea level at the foot of the Taunus mountains, which stretch their outrunners, well wooded heights and fertile valleys, close to the place itself. Its name in reality is Langen-Schwalbach, *i. e.* consisting of but one long and continuous street. Its climate, though invigorating, is not one adapted to feeble constitutions, and persons with rheumatic tendencies had best avoid it. The mean monthly temperature of the air for 1880 was recorded as follows: —

May	52° F.	August	60.7° F.
June	58.3° F.	September	49.1° F.
July	65.3° F.		

This is a temperature which in the United States would in all probability be considered too low for a successful watering cure. Eight springs of a uniform character and differing only slightly in the relative quantities of iron, which they contain, are found here close together. The *Stahlbrunnen* (steel spring, *vulgo* iron water), the one whose analysis is given, is usually selected for drinking, up to eight glasses a day, and facilities for bathing in either fresh or mineral water, hot, cold or medicated are provided in great elegance. The number of guests coming here every year is quite large and the arrangements for taking care of them are systematic and comfortable. The property belongs mainly to and is managed by the Government. **The Stahlbrunnen water mainly used for drinking.**

RESULTS OF ANALYSES OF FOREIGN CHALYBEATE WATERS, FIRST GROUP.

Results expressed in grains per gallon:

Analyses.

	Spa (Belgium) Pouhon Spring, *Struve.*	Schwalbach Stahlbrunnen. *Fresenius.*
Silica	3.6389	1.8691
Alumina	0.1577[1]	......
Ferrous Bicarbonate	4.5675	5.4454
Manganous Bicarbonate	0.6498	1.1957
Calcium Bicarbonate	13.1159	14.5419
Magnesium Bicarbonate	16.2496	14.1376
Sodium Bicarbonate	9.5595	1.3475
Potassium Sulphate	0.5724	0.2161
Sodium Sulphate	0.2745	0.4615
Potassium Chloride	......	0.3914
Sodium Chloride	3.2768	......
Mineral matter	52.0626	39.7062

COMPARISON WITH MISSOURI CHALYBEATE WATERS OF FIRST GROUP.

By Arthur Winslow.

The total amount of mineral matter in half of the Missouri waters of the class and group cited, is nearly as high as that of the two waters whose analyses are given above, and, in three Missouri waters, the amounts exceed that of the Spa water.

Missouri waters, further, differ from both of these foreign waters in that, with the exception of Randolph Spa, they contain less ferrous bicarbonate, though several waters have noticeable quantities of this mineral. The analyses also show no manganous bicarbonate,[2] but this is in comparatively small amounts in two of the European waters, and is, hence, not a very important consideration. The amount of calcium bicarbonate is greater in many of the Missouri waters, and the amount of magnesium bicarbonate is equaled by some of ours. In the case of the Greenwood spring water, the amount of sodium bicarbonate exceeds that in the Spa water, and, in the case of most such Missouri waters, is greater than that of the Schwalbach

Manganese salts absent in Missouri waters.

[1] Reported as basic calcium and aluminium phosphate.

[2] It is probable that a more exhaustive analysis of very large quantities of Missouri waters would reveal the presence of at least small quantities of manganese in many.

waters. Our Pertle Springs and Randolph Spa waters perhaps combine the requirements best in that they contain considerable amount of ferrous, calcium, magnesium and sodium bicarbonates.

Missouri waters that approach European waters in composition.

CHALYBEATE WATERS, SECOND GROUP.

For the chalybeate waters of the second group, *i. e.*, those which contain besides bicarbonates considerable amounts of salts but no calcium sulphate, two springs from sub-alpine regions have been selected: one from Mont d'Or in France and the other from St. Moritz in Switzerland. Both are comparable to our own waters in every essential feature, yet contain, like the waters of the first group, sodium bicarbonate, which in Missouri waters is lacking. This, however, does not impair the value of the selection, as the waters of the two groups are about alike in their effects upon the system, and the division was made chiefly for the sake of convenience in choosing the proper water for cures.

Springs all at a great elevation.

The great elevation at which both of these waters occur and the necessarily rugged climate, to which visiting invalids are exposed, might seem to inveigh against a visit to these places. Art, however, has in these days sufficiently overcome the hardships of travel to render the objection to undertaking this trip and to sojourn in so cold and, at times, moist climate, nugatory. Besides, the hundreds of thousands of dollars spent upon the development of such places, bears testimony to the benefits derived from their use by persons in need of the treatment afforded by them.

MONT D'OR IN FRANCE.

The valley of the Mont d'Or, also called the valley of the Dordogne, is situated 3,222 feet above sea level in one of the most picturesque parts of the volcanic Auvergne. It is the seat of seven springs, of which only one is cold; they are fairly alike in the composition of their waters, very abundant in flow and rich in bicarbonate of iron. Extensive foundation walls with fragments of marble columns found there evidence Roman occupancy of the place. Its development, however, dates only

Evidences of Roman occupancy.

from 1817, when a magnificent building, with all possible facilities and comforts in the use of the waters, was erected, the cost of which surpasses $500,000. Since then numerous hotels and private residences have been built to accommodate the thousands of visitors which annually come here.

Climate subject to rapid changes.

The climate of the valley is invigorating but subject to rapid changes and, on the whole, rather cold; the season lasts from the middle of June to the middle of September and demands at all times warm clothing. In spite of its shortness, however, it is remunerative to the place, as large numbers of persons take a "cure" here, drinking, bathing or inhaling the atomized waters in rooms especially constructed for this purpose, from which much benefit is supposed to be derived in affections of the mucous membrane of the air passages.

ST. MORITZ IN SWITZERLAND (CANTON GRAUBUENDTEN — UPPER ENGADIN).

The Upper-Engadin valley is formed by the Berner and Rhætian Alps and stretches for nearly 200 miles with a total slope of 630 feet from southwest to northeast. Its upper end, which has an elevation of 5,890 feet above sea level, receives the river Inn, which traverses the whole length and carries the surplus waters of the beautiful mountain lakes, that adorn it, to the Danube and the Black Sea.

The highest watering-place in Europe.

About midways a rocky ledge pushes across the valley, near which, and at an elevation of 5,570 feet, St. Moritz is situated, the highest watering-place in Europe, and for centuries famous for its chalybeate waters. Mountain peaks three and four thousand feet higher than the valley surround it on all sides, rendering the climate quite alpine in character and not adapted to feeble constitutions. Its great height, however, implies also a greatly reduced atmospheric pressure and, as the air is generally dry, evaporation is rapid and considerable quantities of water can be consumed without discomfort; but the season is short and warm clothing always in place. The water of the Paracelsus spring collects in a polished basin of red granite with a flow of about sixty gallons an hour and is rich in gas, which escapes in a continuous current.

The *Alte Quelle* (Old spring), whose analysis is given, is close to the Paracelsus spring and has the same composition as the latter. A sanitarium has been erected near them, where exercise may be taken under cover. This, especially after a cold bath, becomes absolutely necessary and in fact is a part of the cure. Hot baths, however, are preferred and are taken in covered bath tubs to prevent inhalation of the carbonic acid, which escapes from the water in large quantities. Medical advice and a proper and generous diet are demanded here in every case.

Exercise necessary after a cold bath.

RESULTS OF ANALYSES OF FOREIGN CHALYBEATE WATERS, SECOND GROUP.

Results expressed in grains per gallon.

Analyses

	Mont d'Or Pavilion Spring. *Bertrand.*	St. Moritz Alte Quelle. *Huseman.*
Silica	2.0910	2.3481
Alumina	3.4170	......
Ferrous Bicarbonate	1.1242	2.3915
Manganous Bicarbonate	......	0.3768
Calcium Bicarbonate	25.6142	90.7003
Magnesium Bicarbonate	9.2741	14.9704
Sodium Bicarbonate	36.3011	19.9593
Potassium Sulphate	....	0.8411
Sodium Sulphate	5.7184	17.9553
Sodium Chloride	16.2380	2.5583
Lithium Chloride	....	0.0467
Other substances	....	0.4556[1]
Mineral matter	99.7780	172.6034

COMPARISON WITH MISSOURI CHALYBEATE WATERS OF THE SECOND GROUP.

By Arthur Winslow.

The total mineral matter in Missouri chalybeate waters of this group is less than in the two waters above given. More specifically, there is a somewhat smaller amount of silica present, and there is less ferrous bicarbonate excepting in the Regent and

[1] Sum of seven substances determined.

Siloam spring waters at Excelsior Springs. Still, the amount in the Mont d'Or water is small. Calcium bicarbonate is nearly as great in quite a number of Missouri waters and is seen to be greater in some than the amount contained in the Mont d'Or water; but is always less than that in the St. Moritz water. Manganous bicarbonate is present in the waters at Excelsior Springs. The amount of magnesium bicarbonate is less, sodium bicarbonate is absent, sodium sulphate is in small quantity; but the amount of sodium chloride is, at least generally, equal to that contained in the St. Moritz water.

Excelsior Springs water similar to the St. Moritz water.

CHALYBEATE WATERS, THIRD GROUP.

The two waters of the third group selected, one alpine with thermal waters, the other a common, cold spring, contain large quantities of sulphates, and are difficult of digestion. Their efficacy, however, is pronounced and of a very high order. Their use demands at the outset a sufficient strength of constitution to tolerate them, whether taken internally or in the form of baths. The latter are administered by immersion of from four to five hours. In such cases the waters must, of course, be heated, and, when taken in tubs, kept heated to avoid chilling, which would speedily destroy whatever benefits might otherwise accrue. No specific mention of the diseases, calling for the use of chalybeate waters, has been made, as their general effect is sufficiently described in previous pages.

Baths of long duration taken.

LEUK, SWITZERLAND (CANTON WALLIS.)

The baths of Leuk in the upper Rhone valley, 4,356 feet above sea level, are situated in a narrow valley or gorge, 16 miles long and two miles wide. This valley is open only on the south, where a torrent, fed by the neighboring glaciers, finds its way out and tumbles its waters into the river Rhone below. All other sides are enclosed by mountains, four, five and six thousand feet higher than the baths, the Gemmi rising almost perpendicularly over their very threshold to a height of 2,750 feet. A magnificent panorama of alpine scenery with its incidental rugged and changeable climate, however, distinguishes the loca-

The site one of great beauty.

tion' in which Cardinal Mathias Schinner had, in 1501, a commodious and substantial bath house erected, since which time the fame of the waters perhaps dates. The present buildings are, however, comparatively modern, and numerous well appointed hotels and private residences have been built.

More than 20 springs, with a large combined flow, occur here. Nearly all of these are thermal, having amidst these huge masses of bare rock and ice, which must feed them, a temperature of about 100° F. Their composition is much alike, excepting in the character of the gas which escapes from them, and in which the proportions of oxygen, nitrogen and carbonic acid vary. Thus the gas of the Lorenz spring, whose analysis is given compared with that which escapes from the ground near where the waters issue, exhibits the following proportions:— More than twenty springs found here.

	Lorenz Spring.	Ground Near Source.
Carbon Dioxide	16	1.0
Oxygen	8	0.5
Nitrogen	76	98.5

The waters are used both for drinking and bathing, two to eight glasses a day for the former and a variable time for the latter.

The waters are diuretic, increase the secretions and excretions, especially of mucous membrane and skin, and are taken under medical advice.

PYRMONT IN GERMANY.

Pyrmont, in the old dukedom of Waldeck, is situated about 35 miles from Hanover at an elevation of 400 feet above sea level.

During the sixteenth and seventeenth century the fame of Pyrmont's springs was at its height. Springs were famous in the sixteenth and seventeenth centuries.

The large number of chalybeate springs, each possessing a copious flow of water, and the occurrence near by of valuable brines, used in connection with the former in cures have, in a manner, maintained Pyrmont's reputation as a watering place. Hotels, parks, public buildings and sanitaria with their incidental concomitants of concerts, theaters and other diversions, attract yet many thousands of visitors.

Diseases benefited by these waters.

Poverty of blood, enfeebled constitution, nervous disorders, rheumatism, gout, scrofula, skin diseases and chronic catarrh of respiratory and digestive organs, along with the whole circle of chronic female diseases, are indications for Pyrmont.

RESULTS OF ANALYSES OF FOREIGN CHALYBEATE WATERS, THIRD GROUP.

Results expressed in grains per gallon.

Analyses.

	Leuk (Loeshe les bains.) Lorenz Spring, *Morin.*	Pyrmont. Hauptquelle, *Fresenius.*
Silica	2.0209	1.8574
Ferrous Bicarbonate	1.0982	5.0036
Manganous Bicarbonate	......	0.4073
Calcium Bicarbonate	0.5137	68.7866
Magnesium Bicarbonate	1.1125	5.3435
Calcium Sulphate	77.9306	46.3133
Magnesium Sulphate	17.2718	26.4772
Potassium Sulphate	2.1846	0.9638
Sodium Sulphate	2.9147	2.4474
Sodium Chloride	0.3914	9.2814
Lithium Chloride	......	0.0584
Other substances	0.2803[1]	0.3680[2]
Mineral matter	105.7187	167.3039

COMPARISON WITH MISSOURI CHALYBEATE WATERS OF THE THIRD GROUP.

By Arthur Winslow.

Missouri waters compare favorably with those of Europe.

Comparing the above two results of analyses with those of Missouri waters of the same class and group, we find that the total amounts of mineral matter in the latter are fully equal to those above given. The amounts of silica present are about the same; in ferrous bicarbonate they are equal and the amounts of calcium bicarbonate, calcium, magnesium and sodium sulphates are in close agreement. Generally speaking several of our waters compare favorably with these foreign waters, especially the waters of the Harris well in Monroe county and the Montrose well in Henry county.

[1] Strontium Sulphate.

[2] Sum of eight substances determined.

SULPHUR WATERS.

The two waters of this class selected for purposes of illustration are doubtless true sulphur waters though devoid of sodium carbonate in solution; their sulphur is combined as calcium sulphydrate, which constituent is specifically mentioned by the analyst of the Nenndorf water, and may be surmised from the statements given in the case of the waters of Aix les Bains. Both waters are rich in gases, of which considerable use is made in the "cures," and are very effective in their action upon skin, liver and chronic constitutional and syphilitic troubles. The Nenndorf water is cold, while that of Aix les Bains, with a temperature of 110° F., is thermal and is, in some way, connected with volcanic processes far remote from its occurrence.

Sulphur waters very effectual in chronic troubles.

The analysis of the Harrowgate water is given, mainly to exhibit the composition of a water properly belonging to the brines and containing, as many do, free sulphuretted hydrogen gas. Of such waters Missouri possesses many examples and the attention given to such by some members of the medical profession abroad may, perhaps, encourage their owners here to attempt a further and more intelligent development with the hope of receiving a reasonable return for money and thought spent upon improvements.

NENNDORF IN GERMANY.

Nenndorf is situated in a pleasant valley a few miles from Hanover about 200 feet above sea level. It possesses three sulphur springs, which seem to have been known to Agricola, but whose growth into the present watering-place dates from the beginning of this century. The climate is moderately warm, though moist, and several thousand visitors take the cure here during the season, for whose accommodation six buildings, managed by fiscal officers, besides hotels and private residences, afford sufficient room.

Climate warm and moist.

The waters, which are rich in sulphates, including calcium sulphate, and contain, according to Bunsen's analysis, calcium sulphydrate, are difficult of digestion and are taken either alone or mixed with warm milk or whey. made of goat's milk. When taken alone they are apt to produce discomfort or constipation, which is remedied by the admixture of Karlsbad salt in solution. The arrangements for bathing are very complete and embrace, besides the usual tub baths in undiluted cold or hot mineral water, all forms of douche, russian, romish, irish, gas and mud baths.

Bathing facilities

In a different part of the bath-building, three roomy and well appointed saloons are found, each with the necessary mechanical appliances to impregnate the air with gases, different in amount for each, for purposes of inhalation. For mud baths material is used, which is carefully prepared and exposed to the action of the mineral water during the winter months.

The diseases benefited by the Nenndorf waters are gout, rheumatism, swelling of the joints, paralysis, caries, necrosis, atonic boils, chronic eczema, hemorrhoids, chronic catarrh of the pharnyx, throat and bronchial tubes and certain female diseases. In some of these diseases the occurrence near by of muriatic waters is found quite serviceable.

AIX LES BAINS IN FRANCE (SAVOY).

Romans had extensive baths here.

The town, also called Aix en Savoie and formerly a possession of Italy, has 4000 inhabitants and is situated about 800 feet above sea level in the delightful valley of Chambéry. The climate is mild and yet tonic and, as the waters are thermal, having a temperature of 110° F., it is not strange that the Romans should have built here extensive and splendid baths. Upon their remains Victor Amadeus III erected in 1783 the present substantial and roomy bath building, known as the Royal House, whose present arrangements for bathing are in every respect models of their kind and include all possible varieties of water and steam baths.

Chronic rheumatism and gout, anchylosis, paralysis and the various forms of inveterate constitutional diseases, also syphilis, are successfully treated here.

HARROWGATE IN ENGLAND.

These springs, perhaps the most renowned of England's sulphur springs, are situated in Yorkshire about sixteen miles from

Leeds and are extensively patronized during the season. Facilities and comforts for the proper use of the waters are of an high order and many thousands of visitors take advantage of them. As indicated by the analysis the water is really a muriatic water containing free sulphuretted hydrogen and should rightly be placed under that class. It is given here, partly to exhibit the composition of a foreign muriatic water and partly to illustrate the use that might be made of similar waters in Missouri. This is properly a muriatic water.

RESULTS OF ANALYSES OF FOREIGN SULPHUR WATERS.

Results expressed in grains per gallon.

	Nenndorf. Trinkquelle. *Bunsen.*	Aix les Bains. Sulphur Spring. *Willm.*
Silica	1.1682	2.7979
Ferrous Bicarbonate	....	0.0714
Calcium Bicarbonate	40.0247	17.9194
Magnesium Bicarbonate	....	0.4997
Aluminum Sulphate	....	0.4733
Calcium Sulphate	59.2861	5.4204
Magnesium Sulphate	16.8805	4.2931
Potassium Sulphate	2.4532	......
Sodium Sulphate	21.4949	1.9100
Magnesium Chloride	13.4927	......
Sodium Chloride	....	1.7523
Calcium Phosphate	....	0.3855
Calcium Sulphydrate	4.0303	......
Mineral matter	158.8306	35.5230

Analyses.

The gases escaping from either water are mainly carbon dioxide with sulphuretted hydrogen and nitrogen.

	Harrowgate Old Sulphur Well. *West.*
Sodium Bicarbonate	12.80
Magnesium Chloride	29.20
Calcium Chloride	65.75
Sodium Chloride	752.00
Mineral matter	859.75

COMPARISON WITH MISSOURI SULPHUR WATERS.

By Arthur Winslow.

The total amount of mineral matter in Missouri sulphur waters compares favorably with the foregoing, but they differ considerably in the ingredients contained. Thus, there is in Missouri waters much less calcium bicarbonate, no calcium sulphate and no magnesium sulphate, which are all prominent constituents in the foreign waters. Further, there is no magnesium chloride and the amount of sodium sulphate, though exceeding that contained in the Aix les Bains water, is less than that in the Nenndorf water. On the other hand, Missouri waters contain large amounts of sodium bicarbonate which are absent in the European sulphur waters, though an important constituent of the European alkaline and sulphatic waters already described.

Missouri waters differ somewhat from these.

Concerning the Harrowgate water which stands, as a representative of the muriatic class of waters, many Missouri waters exceed it in total amounts of mineral matter contained, and the amounts of magnesium calcium and sodium chlorides contained are equal to and exceed the amounts in the former in many cases; especially is this so with the members of the first group tabulated on pages 48 and 49 of the preceding report. Sodium bicarbonate is, however, absent in our waters, but, as this is not a very important constituent in the Harrowgate waters, its absence does not affect the question very much.

APPENDIX A.

RELATION BETWEEN GRAMS PER LITRE AND GRAINS PER GALLON.

In view of the desirability of easily converting grams per litre into grains per gallon and *vice versa*, an operation, which the writer had to perform a thousand times, he constructed and used the following table: —

REDUCTION OF GRAMS IN LITRE TO GRAINS IN U. S. GALLON.

1	gram	per	litre	= 58.41	grains	per	gallon.
2	"	"	"	= 116.82	"	"	"
3	"	"	"	= 175.23	"	"	"
4	"	"	"	= 233.64	"	"	"
5	"	"	"	= 292.05	"	"	"
6	"	"	"	= 350.46	"	"	"
7	"	"	"	= 408.87	"	"	"
8	"	"	"	= 467.28	"	"	"
9	"	"	"	= 525.69	"	"	"

The use of the table is plain enough; if for instance the weight of any substance per litre is found to be 1.2039 grams, the number of grains per gallon is found by addition, thus:

58.4100
11.6820
0.1752
0.0526

70.3198 grains per gallon.

In a similar way the reduction of grains per gallon to grams per litre is found by subtraction, thus:

70.3198 grains per gallon.
58.41 = 1.2039 grams per litre.

11.9098
11.6820

.2278
.1752

.0526
.0526

The relation of gallon to litre with their weights of water in grains and grams, which has been taken as 1: 58.41, requires some explanation.

The Century Dictionary, under the title "Gallon," states that the U. S. gallon (established by English law anterior to the formation of our government and adopted at the time with the whole body of English law) contains 231 cubic inches, and is equal to a cylinder seven inches in diameter and six inches high, and is taken as the volume of 8.3389 pounds avoirdupois of water at its greatest density, weighed in air at a pressure of the barometer of 30 inches and a temperature of 62° F. It is equal to 3.7853 litres.

These statements permit the following deductions in connection with the values published by the OFFICE OF STANDARD WEIGHTS AND MEASURES, T. C. Mendenhall, superintendent, Washington, D. C., January, 1890.

1 kilogram =15432.36 grains.
1 cubic inch = 16.387 cubic centimetres.
1 gallon =3.78544 litres.

1. 3.7853 litres (Century value) of water at its greatest density at 15432.36 grams per kilogram makes:

1 U. S gallon = 58416.1123 grains.

2. 3.78544 litres (Coast Survey value) of water at its greatest density at 15432.36 grains per kilogram makes:

1 U. S. gallon = 58418.2728 grains.

3. 231 cubic inches at 16.387 cubic centimetres of water at its greatest density at 15432.36 grains per kilogram makes:

1 U. S. gallon = 58418.6092 grains.

4. The volume of a cylinder seven inches in diameter and six inches high (πr^2h) is 230.9068 cubic inches; using this as the value in No. 3 we find:

1 U. S. gallon = 58394.0548 grains.

5. The cubic foot of water at its greatest density is given as 1000 ounces; this would be for the gallon of 231 cubic inches 133.6805 ounces at 437.5 grains, or

1 U. S. gallon = 58485.2428 grains.

6. 8.3389 avoirdupois pounds of water at its greatest density at 7000 grains per pound makes:

1 U. S. gallon = 58372.3 grains.

In view of these differences in the weight of the same volume of water, each one of which seems to rest upon an equally secure basis, and further in view of the fact that the litre flask, as made and sold by dealers in chemical apparatus, is intended to discharge 1 kilogram of water at 15.5° C, the values, commonly employed in such calculations, viz.: 3.785 litres to the gallon, and 15.432 grains to the gram are employed; they make one gram per litre equal to 58.410120 grains per gallon, the value adopted. The printed table renders it a comparatively easy matter to convert any analysis of a mineral water from one expression to the other, and may be found useful in the comparison of other Missouri mineral waters.

APPENDIX B.

ADDITIONAL ANALYSES OF MISSOURI MINERAL WATERS.

In order to enlarge the picture of the distribution of the mineral waters of the State, as well as to give all information accessible at the present time regarding their composition, printed or published analyses from various sources are here reproduced. Many of these are results of the author's own work upon samples only in part taken by himself and mainly furnished him by parties interested in the waters. Completeness was aimed at and is believed to have been attained so far as such a thing is possible. No analysis was rejected unless it bore upon its face the stamp of doubtfulness, as when, for example, among the constituents, appeared "arsenicum" coupled with a statement of the anti-malarial efficacy of the latter. The responsibility for the correctness of the analyses rests with the analysts, whose names are given, whereas the value of results depends not only upon the correctness of the analysis but also upon the source of the sample and the manner in which it was collected; yet the results are thought to be reliable, and are serviceable when comparing double sets of figures, as a basis for the explanation of differences in the composition of mineral waters as exhibited in analyses made at different times either by the same or by different chemists. It must be borne in mind, however, that in many instances the analysis was made of water, not taken by the chemist but by the party who desired the analysis made. The results in such cases often admit of but one conclusion, as in the case of the Climax spring in Camden county.

A recalculation was in some instances necessary to facilitate comparison of results, all of which are given for the sake of brevity in the form of composition, not of contents, of the mineral waters. The total number of analyses here recorded, is 103, of which 62 were made by the author, and 41 by others. They are tabulated by counties, as are the results of the Geological Survey, so that one table may supplement the other. The descriptions here are, however, further given alphabetically by counties, irrespective of the class to which any water belongs. In the analyses here following the symbol for bicarbonates is taken as $(MH_2CO_3CO_2)$.

LIST OF THE MINERAL SPRINGS OF THE STATE, INVESTIGATED AND ANALYZED BY CHEMISTS NOT CONNECTED WITH THE GEOLOGICAL SURVEY.[1]

ADAIR COUNTY.

New Baden springs; Chalybeate (Schweitzer).

BARTON COUNTY.

Artesian well near Lamar; Sulphatic (S.).

Alum well near Milford; Sulphatic (Chauvenet).

(a) In front of name of spring means that it has been analyzed by Survey and can be found elsewhere.

BOONE COUNTY.

University chalybeate spring; Chalybeate (S.).
Bratton spring; Sulphatic (S.).
Artesian well, near Columbia, No. 1; Alkaline (S.).
Artesian well, near Columbia, No. 2; Alkaline (S.).
College Farm spring (S.).
Harris spring (S.).
University well (S.).

CALLAWAY COUNTY.

Fulton Asylum well; Alkaline (S.).

CAMDEN COUNTY.

(a) Climax spring (Wiley).

CASS COUNTY.

(a) McLelland spring; Sulphur water (Hamilton).

CARROLL COUNTY.

Artesian well near Carrollton; Alkaline (S.).

CEDAR COUNTY.

(a) Park spring (S.).
(a) South Forest Grove well (S.).
Cruce's well (S.).
Field's mineral well (S.).
East side Bath House springs; Nos. 1, 2, 3, at Eldorado Springs (S.).
(a) Fountain of Youth springs, near Jerico (S.).
Alum springs (S.).

CHARITON COUNTY.

Salisbury Artesian well; Muriatic (S.).

CLAY COUNTY.

(a) Reed's springs Nos. 1 and 2, and Nos. 1, 2, 3, 4 (S.).
(a) Roger's Climax spring (S.).
Evan's spring; Chalybeate (S.).
Schræder's springs No. 1 and 2 (S.).
(a) Regent spring at Excelsior Springs (Mason).
(a) Siloam spring (Mason).
(a) Sulpho-saline spring (Mason).

CLINTON COUNTY.

(a) Plattsburg mineral spring (Wright & Merrill).

COOPER COUNTY.

Chouteau spring; Muriatic (Litton).
Harriman's Sulphur spring (Litton).

DAVIESS COUNTY.

(a) Jamesport mineral well (S.).

HENRY COUNTY.

Jordan's spring; Chalybeate (S.)
Ford's spring (S.).
Baum Bros. spring (S.).

HOWARD COUNTY.

(a) Boon's Lick spring (Chauvenet).
Burkhart's spring; Muriatic (Chauvenet).
Lewis spring; Muriatic (Chauvenet).

JACKSON COUNTY.

Young's medicinal well; Muriatic (Hamilton).

Magneso-saline mineral spring; Muriatic (Hamilton & Hunter).

JEFFERSON COUNTY.

(a) Council spring at Montesano (Potter & Riggs).

(a) Afton spring at Montesano (Potter & Riggs).

Pearl spring at Montesano (Potter & Riggs).

Thorn spring at Montesano (Potter & Riggs).

(a) Montesano spring at Montesano (Potter & Riggs).

Casco spring at Montesano (Potter & Riggs).

JOHNSON COUNTY.

(a) Electric or Colburn spring (S.).

KNOX COUNTY.

Landreth's well; Chalybeate (S.).

LACLEDE COUNTY.

(a) Lebanon magnetic well (Clarke).

LAWRENCE COUNTY.

Paris chalybeate spring (Litton).

Paris chalybeate spring (same) (Williams).

LEWIS COUNTY.

La Grange mineral spring (S.).

Wyaconda mineral spring (S.).

LINCOLN COUNTY.

Crenshaw spring; Chalybeate (S.).

LIVINGSTON COUNTY.

(a) Moresville mineral spring (Wright & Merrill).

MACON COUNTY.

Patton spring (Wright & Merrill).

MARION COUNTY.

Palmyra Artesian well; Muriatic (S.).

Oakwood Artesian well; Muriatic (Chauvenet & Bro.).

MERCER COUNTY.

Bowsher mineral spring; Chalybeate (S.).

MILLER COUNTY.

Aurora spring.

MONROE COUNTY.

Bowman mineral springs Nos. 1, 2; Chalybeate (S.).

(a) Harris' well (S.).

Ragland mineral springs; Chalybeate (S.).

MONTGOMERY COUNTY.

Farthing mineral springs; Sulphatic (S.).

MORGAN COUNTY.

(a) Versailles Medical spring (Vaughan).

NODAWAY COUNTY.

(a) Burlington Junction mineral spring (Wright & Merrill).

Barnard mineral water (Wright & Merrill).

PETTIS COUNTY.

Teague or Crystal spring; Sulphatic (S.).

PIKE COUNTY.
(a) B. B. spring (S.).
Crow springs Nos. 1, 2, 3; Alkaline (S.).
Stevens spring; Alkaline (S.).
PLATTE COUNTY.
(a) Crystal spring (Holton.).
PHELPS COUNTY.
Kenklesha springs; Alkaline (Riley).
PUTNAM COUNTY.
Bray mineral well (S.).
RANDOLPH COUNTY.
(a) Salt spring (S.).
Randolph Spa (Skinner's well) (S.).
Rucker's well; Chalybeate (S.).
Hammett's well; Chalybeate (S).
Given well; Chalybeate (S.).
SALINE COUNTY.
(a) Sweet spring (Williams).
(a) Akesion spring (William.)
(a) Blue Lick spring (Riley).
(a) Black Sulphur spring near McAllister (Chauvenet)
Marshall artesian well (S.).
ST. CLAIR COUNTY.
Excelsior Spring; Chalybeate (S.).
ST. LOUIS CITY AND COUNTY.
(a) Belcher artesian well (Litton).
Benton spring; (Hillebrand & Howard).
VERNON COUNTY.
Ellis' well; Muriatic (Chauvenet).
(a) Main spring; Connely springs (Fair Haven) (S.).
(a) Life Well; Connely springs (Fair Haven) (S.).
WORTH COUNTY.
(a) Fairview mineral spring (Lord & Stoutenburg.)

ADAIR COUNTY.

New Baden springs, near Kirksville; analyzed October, 1881, by P. Schweitzer.

CHALYBEATE WATER, SECOND GROUP.

Silica	1.5420	grains.
Alumina	0.2161	"
Ferrous Bicarbonate	0.3116	"
Manganous Bicarbonate	0.1057	"
Calcium Bicarbonate	20.0498	"
Magnesium Bicarbonate	2.3644	"
Calcium Sulphate	28.0630	"
Potassium Sulphate	1.2276	"
Sodium Sulphate	7.4784	"
Sodium Chloride	0.0529	"
Calcium Phosphate	0.0409	"
Carbon Dioxide Gas (free)	12.7574	"
Mineral matter	74.2071	grains.
Fixed residue	54.2775	grains.

The free carbon dioxide gas amounts to 25.50 cubic inches.

BARTON COUNTY.

Artesian well, near Lamar; analyzed August, 1887, by P. S.

The well is 1040 feet deep, the water rising to within 155 feet of the surface; the water for analysis was taken from about 225 feet below the surface.

SULPHUR WATER.

Silica	0.4673	grains.
Calcium Bicarbonate	9.4022	"
Magnesium Bicarbonate	7.9811	"
Potassium Bicarbonate	2.1940	"
Sodium Bicarbonate	11.6724	"
Lithium Bicarbonate	1.1945	"
Carbon Dioxide Gas (free)	3.7699	"
Hydrogen Sulphide Gas	1.2186	"
Mineral matter	37.9000	grains.
Fixed residue	22.9025	grains,

Alum well, near Milford, analyzed by R. Chauvenet, no date.

SULPHATIC WATER.

Calcium Sulphate	43.44	grains.
Magnesium Sulphate	66.66	"
Sodium Sulphate	63.81	"
Mineral matter	173.91	grains.

BOONE COUNTY.

University chalybeate spring; analyzed October, 1873, by P. S.

CHALYBEATE WATER, THIRD GROUP.

Silica	1.4582	grains.
Alumina	0.7872	"
Ferrous Bicarbonate	5.5051	"
Calcium Bicarbonate	14.5270	"
Calcium Sulphate	95.7773	"
Magnesium Sulphate	31.3419	"
Sodium Sulphate	16.2237	"
Carbon Dioxide gas (free)	15.5166	"
Organic matter	0.0730	"
Mineral matter	181.2100	grains.
Fixed residue	158.1538	grains

Bratton spring, near Stephens station; analyzed in 1874 by P. S.

SULPHATIC WATER, THIRD GROUP.

Silica	2.5300	grains.
Ferrous Bicarbonate	2.6300	"
Ferrous Sulphate	36.7400	"
Aluminium Sulphate	52.4500	"
Calcium Sulphate	64.1900	"
Magnesium Sulphate	15.7300	"
Sodium Chloride	1.3100	"
Carbon Dioxide Gas (free)	11.9500	"
Mineral water	187.5300	grains.

Artesian wells, two in number, sunk to a depth of 570 feet and 700 feet respectively, and distant from each other about 100 yards situated a mile north of Columbia on the farm of C. E. Moore. The water rises in each to within 20 feet of the surface, and was analyzed, the first in February, 1882, and the second in May, 1883, by P. S.

ALKALINE WATER, THIRD GROUP.

	No. 1.	No. 2.
Silica	0.2044 grains.	0.5286 grains.
Alumina	0.7184 "	0.5958 "
Calcium Bicarbonate	10.3998 "	10.0949 "
Magnesium Bicarbonate	8.4483 "	7.3149 "
Calcium Sulphate	2.8597 "	2.9690 "
Sodium Chloride	1.3091 "	1.3854 "
Carbon Dioxide Gas (free)	4.7986 "	5.7642 "
Mineral matter	28.7383 grains.	28.6528 grains.
Fixed residue	17.8579 grains.	17.2896 grains.

To complete the picture of the composition of spring waters, originating in the Encrinital limestones of this section, three additional analyses are given: No. 1 of a spring on the College Farm at the base of a high hill, about a mile from Columbia; No. 2 of a spring on the farm of the late John W. Harris, about eight miles south of Columbia; No. 3 of a well in the University campus; the analyses were made in 1880 by P. S.

	No. 1.	No. 2.	No. 3.
Silica	0.7059 grains.	1.8347 grains.	1.4057 grains.
Alumina	0.3112 "	1.8258 "	0.0058 "
Calcium Bicarbonate	23.3892 "	20.9887 "	5.0240 "
Magnesium Bicarbonate	2.1286 "	3.7331 "	4.6906 "
Calcium Sulphate	0.2700 "	...... "	34.1231 "
Sodium Chloride	2.5883 "	7.1162 "	2.7937 "
Mineral matter	29.3932 grains.	35.5112 grains.	48.0429 grains.
Fixed residue	21.5148 grains.	27.8116 grains.	44.8767 grains.

CALLAWAY COUNTY.

Deep well, in yard of Asylum No. 1, near Fulton, analyzed August, 1886, by P. S.

ALKALINE WATER.

Silica	0.5023 grains.
Ferrous Bicarbonate	0.1297 "
Calcium Bicarbonate	13.6530 "
Magnesium Bicarbonate	9.2707 "
Potassium Bicarbonate	1.7520 "
Sodium Bicarbonate	3.4054 "
Sodium Sulphate	3.7115 "
Lithium Chloride	1.2805 "
Mineral matter	33.7051 grains.
Fixed residue	24.4756 grains.

CAMDEN COUNTY.

Climax spring, analyzed in 1882 by H. W. Wiley, and recalculated by P. S. The analysis is so entirely different from the one made by the officers of the Survey from water collected by them personally, that the surmise of a mistake in the vessels in which the water was sent, or an addition of chemicals to the water before sending, is justifiable.

Alumina and Ferric Oxide	5.0800	grains.
Magnesium Bicarbonate	4.3312	"
Calcium Sulphate	4.6019	"
Magnesium Sulphate	1.3395	"
Sodium Chloride	33.6169	"
Calcium Bromide	11.0182	"
Potassium Bromide	3.6615	"
Sodium Bromide	3.5070	"
Carbon Dioxide Gas (free)	0.9423	"
Loss	3.0200	"
Mineral matter	71.1185	grains.

CARROLL COUNTY.

Artesian well, near Carrollton, supplying the town with water; analyzed January, 1885, by P. S.

ALKALINE WATER, FIRST GROUP.

Silica	4.5618	grains.
Alumina	0.9243	"
Ferrous Bicarbonate	0.0093	"
Calcium Bicarbonate	16.0662	"
Magnesium Bicarbonate	5.3936	"
Sodium Bicarbonate	1.4712	"
Mineral matter	28.4264	grains.
Fixed Residue	21.2269	grains.

CASS COUNTY.

McLelland spring, near Drexel; analyzed October, 1892, by C. C. Hamilton, partly recalculated.

SULPHUR WATER.

Silica	0.9480	grains.
Ferric Oxide	1.7710	"
Calcium Bicarbonate	1.8317	"
Magnesium Bicarbonate	0.4526	"
Sodium Bicarbonate	39.0693	"
Potassium Sulphate	1.6100	"
Sodium Sulphate	5.5310	"
Sodium Sulphydrate	0.4280	"
Mineral matter	51.6409	grains.
Sulphuretted Hydrogen	0.3820	grains.
Free Carbonic Acid Gas	5.3044	"

CEDAR COUNTY.

A number of waters from springs in the Eldorado Springs district were collected and analyzed by P. S.

CHALYBEATE WATER, FIRST AND SECOND GROUPS.

	Park Springs. Analyzed August, 1886.	South Forest Grove Well. Analyzed August, 1886.
Silica	2.2897 grains.	2.3427 grains.
Alumina	0.2394 "	0.1163 "
Ferrous Bicarbonate	3.3878 "	2.9623 "
Manganous Bicarbonate	0.0085 "	0.0267 "
Magnesium Bicarbonate	1.3949 "	0.0560 "
Calcium Sulphate	0.9454 "	0.6601 "
Magnesium Sulphate	0.0241 "	...... "
Potassium Sulphate	0.3891 "	0.3459 "
Sodium Sulphate	1.4715 "	1.3378 "
Lithium Sulphate	0.3894 "	0.3102 "
Calcium Sulphate	0.0037 "	0.0050 "
Lithium Chloride	0.1957 "	0.2237 "
Carbon Dioxide Gas (free)	6.8056 "	7.1213 "
Mineral matter	17.5448 grains.	15.5084 grains.
Fixed residue	8.3917 grains.	6.7229 grains.

	Cruce's Well. Analyzed December, 1885.	Field's Mineral Well. Analyzed December, 1885.
Silica	1.9976 grains.	5.0757 grains.
Alumina	0.2336 "	0.2512 "
Ferrous Bicarbonate	4.6728 "	4.9064 "
Calcium Bicarbonate	1.0656 "	0.2618 "
Calcium Sulphate	3.4478 "	0.1498 "
Magnesium Sulphate	3.7848 "	...... "
Sodium Sulphate	3.6785 "	0.6315 "
Sodium Chloride	0.0224 "	0.3088 "
Lithium Chloride	0.1654 "	0.0413 "
Carbon Dioxide Gas (free)	10.0203 "	7.4196 "
Mineral matter	29.0888 grains.	20.1299 grains.
Fixed residue	16.1729 grains.	9.5563 grains.

East Side Bath House spring No. 1, analyzed August, 1886.

Silica	2.4286 grains.
Alumina	0.1945 "
Ferrous Bicarbonate	7.2538 "
Manganous Bicarbonate	0.0495 "
Calcium Bicarbonate	7.7526 "
Magnesium Bicarbonate	7.5699 "
Calcium Sulphate	0.6686 "
Potassium Sulphate	0.4865 "
Sodium Sulphate	2.9431 "
Lithium Sulphate	0.4858 "
Calcium Phosphate	0.0076 "
Lithium Chloride	0.2866 "
Carbon Dioxide Gas (free)	2.4322 "
Mineral matter	32.5593 grains.
Fixed residue	21.1395 grains.

East Side Bath House springs Nos. 2 and 3; partial analyses, August, 1886.

	No. 2.	No. 3.
Silica	3.4137 grains.	2.1064 grains.
Ferrous Bicarbonate	9.1380 "	1.9598 "
Calcium Sulphate	0.8937 "	2.8511 "
Magnesium Sulphate	1.4895 "	1.7172 "
Sulphur Trioxide for other bases	1.8866 "	0.7002 "
Undetermined	1.2871 "	0.5212 "
Mineral matter	18.1086 grains.	9.8559 grains.
Fixed residue	13.0827 grains.	8.7780 grains.

Spring at Jerico; analyzed July, 1884.

Silica	1.3201 grains.
Ferrous Bicarbonate	0.4089 "
Calcium Bicarbonate	0.2129 "
Magnesium Bicarbonate	0.5046 "
Calcium Phosphate	0.2234 "
Sodium Phosphate	0.1922 "
Lithium Phosphate	0.9955 "
Sodium Sulphate	0.1036 "
Sodium Chloride	0.1058 "
Carbon Dioxide Gas (free)	2.5108 "
Organic matter	1.9100 "
Mineral matter	8.4878 grains.
Fixed residue	3.6037 grains.

Alum spring, near Eldorado Springs, analyzed March, 1887.

SULPHATIC WATER, THIRD GROUP.

Silica	2.2821 grains.
Ferrous Sulphate	67.7464 "
Aluminum Sulphate	13.5133 "
Calcium Sulphate	4.4824 "
Magnesium Sulphate	7.5522 "
Potassium Sulphate	0.3611 "
Sodium Sulphate	2.7809 "
Lithium Sulphate	0.9794 "
Sulphur Trioxide (free)	6.1159 "
Carbon Dioxide (free)	7.4312 "
Mineral matter	113.8249 grains.

Contains traces of organic matter, of manganese and of chlorine.

CHARITON COUNTY.

Bored well, near Salisbury; analyzed October, 1890, by P. S.

MURIATIC WATER.

Silica	1.0237 grains.
Ferrous Bicarbonate	0.9155 "
Manganous Bicarbonate	0.2285 "
Magnesium Bicarbonate	19.3037 "
Calcium Sulphate	66.6692 "
Magnesium Sulphate	18.1188 "
Magnesium Chloride	14.3334 "
Sodium Chloride	384.5022 "
Sodium Bromide	0.8022 "
Lithium Chloride	0.2876 "
Mineral matter	506.1848 grains.

CLAY COUNTY.

Reed springs near Liberty were personally investigated, sampled and analyzed in September, 1881, by P. S.

CHALYBEATE WATER, FIRST GROUP.

	No. 1.	No. 2.
Silica	2.7745 grains.	2.8270 grains.
Alumina	0.2979 "	0.1402 "
Ferrous Bicarbonate	3.2943 "	3.2943 "
Manganous Bicarbonate	0.1051 "	0.0935 "
Calcium Bicarbonate	13.9834 "	8.0966 "
Magnesium Bicarbonate	0.0935 "	0.2044 "
Magnesium Sulphate	0.3037 "	...... "
Potassium Sulphate	1.2909 "	1.1974 "
Sodium Sulphate	0.6542 "	0.6016 "
Calcium Phosphate	0.0584 "	0.1100 "
Sodium Chloride	0.6659 "	0.7243 "
Carbon Dioxide	2.8621 "	2.8504 "
Mineral matter	26.3839 grains.	20.1397 grains.
Fixed residue	17.3537 grains.	12.8910 grains.

Four additional waters (*Reed springs*) of the same character were analyzed in June, 1889, by P. S. Nos. 1 and 2 are probably the same as given above and represent the changes which springs coming from no great depth exhibit in different seasons.

	No. 1.	No. 2.
Silica	1.5187 grains.	1.5479 grains.
Ferrous Bicarbonate	3.5047 "	2.0118 "
Manganous Bicarbonate	0.0854 "	trace "
Calcium Bicarbonate	8.5094 "	10.6598 "
Magnesium Bicarbonate	1.1399 "	1.6262 "
Potassium Sulphate	0.8941 "	0.8552 "
Lithium Sulphate	0.4251 "	0.6451 "
Calcium Phosphate	0.0480 "	0.0568 "
Sodium Chloride	0.5680 "	0.5284 "
Carbon Dioxide Gas (free)	5.9704 "	6.5541 "
Mineral matter	22.6637 grains.	24.4853 grains.
Fixed residue	11.7246 grains.	13.0085 grains.

	No. 3.	No. 4.
Silica	1.4135 grains.	0.9346 grains.
Ferrous Bicarbonate	1.9469 "	0.4802 "
Calcium Bicarbonate	9.8401 "	11.1631 "
Magnesium Bicarbonate	1.4205 "	0.7072 "
Potassium Sulphate	0.8885 "	0.9037 "
Lithium Sulphate	0.5991 "	0.3747 "
Calcium Phosphate	0.0524 "	0.0480 "
Sodium Chloride	0.5321 "	0.5703 "
Carbon Dioxide Gas (free)	6.0456 "	5.6208 "
Mineral matter	22.7387 grains.	20.8026 grains.
Fixed residue	12.1273 grains.	11.3026 grains.

Evans' spring, near Harlem, analyzed April, 1882, and *Rogers' Climax spring*, near Liberty, analyzed February, 1887, both by P. S.

CHALYBEATE WATER, FIRST GROUP.

	Evans' Spring.		Roger's Climax Spring.	
Silica	2.6168	grains.	2.8037	grains.
Alumina	0.6367	"	......	"
Ferrous Bicarbonate	2.9076	"	2.6609	"
Manganous Bicarbonate	......	"	0.1933	"
Calcium Bicarbonate	6.6220	"	15.0197	"
Magnesium Bicarbonate	2.1868	"	3.1776	"
Sodium Bicarbonate	......	"	1.8588	"
Potassium Sulphate	0.8819	"	......	"
Sodium Sulphate	0.8035	"	0.6221	"
Calcium Phosphate	0.5014	"	......	"
Potassium Phosphate	0.3531	"	0.0699	"
Sodium Chloride	0.9721	"	0.2531	"
Lithium Chloride	.....	"	0.2357	"
Carbon Dioxide Gas (free)	1.8691	"	5.9874	"
Mineral matter	20.3510	grains.	32.8822	grains.
Fixed residue	14.9072	grains.	19.0974	grains.

Schrœder's springs, near Barry, five miles north of Kansas City, analyzed October, 1887, by P. S.

CHALYBEATE WATER, FIRST GROUP.

	No. 1.		No. 2.	
Silica	2.4065	grains.	1.8762	grains
Ferrous Bicarbonate	5.2482	"	4.2182	"
Manganous Bicarbonate	0.4927	"	0.4971	"
Calcium Bicarbonate	14.4005	"	12.7797	"
Magnesium Bicarbonate	1.6262	"	2.8310	"
Lithium Bicarbonate	0.4842	"	0.4763	"
Calcium Sulphate	2.7412	"	2.7688	"
Sodium Sulphate	1.0673	"	0.9647	"
Carbon Dioxide Gas (free)	4.0256	"	3.8523	"
Mineral matter	32.4924	grains.	30.2643	grains.
Fixed residue	20.1123	grains.	18.7612	grains.

Excelsior springs — Regent, Siloam and Sulpho-saline: — analyzed in April, 1890, by W. P. Mason.

CHALYBEATE WATERS, FIRST AND SECOND GROUPS.

	Regent.		Siloam.	
Silica	0.6998	grains.	1.6777	grains.
Alumina	0.1224	"	0.3890	"
Ferrous Bicarbonate	3.7694	"	2.5388	"
Manganous Bicarbonate	0.7586	"	0.2268	"
Calcium Bicarbonate	30.4361	"	19.1318	"
Magnesium Bicarbonate	4.8609	"	2.1309	"
Sodium Bicarbonate	0.4867	"	......	"
Calcium Sulphate	......	"	1.3028	"
Potassium Sulphate	0.2834	"	0.1929	"
Magnesium Chloride	......	"	0.7540	"
Potassium Chloride	0.1633	"	......	"
Sodium Chloride	1.0264	"	0.9949	"
Mineral matter	42.6070	grains.	27.3396	grains.

The bicarbonates in the foregoing two analyses have been recalculated from the analyst's values.

Sulpho-saline spring, muriatic water, as the name indicates.

Silica	0.6409	grains.
Calcium Sulphate	84.0018	"
Magnesium Sulphate	0.8239	"
Potassium Sulphate	1.8626	"
Magnesium Chloride	23.2688	"
Sodium Chloride	605.4393	"
Sodium Iodide	trace	"
Magnesium Carbonate	9.4912	"
Sodium Hydrosulphide	0.4292	"
Mineral matter	725.9577	grains.

CLINTON COUNTY.

Plattsburg Mineral springs; analyzed by Wright & Merrill; no date.

Silica	0.70	grains.
Alumina	0.25	"
Ferrous Carbonate	0.83	"
Calcium Carbonate	4.53	"
Magnesium Carbonate	0.53	"
Sodium Carbonate	1.06	"
Calcium Sulphate	1.63	"
Organic matter	3.97	"
Mineral matter	13.50	grains.

COOPER COUNTY.

Chouteau springs, ten miles from Boonville, and *Harriman's Sulphur spring;* analyzed by A. Litton, the former in 1853, the latter no date; taken from Bulletin No. 32, U. S. Geological Survey, and recalculated on the assumption that the figures given are grams per litre.

MURIATIC WATERS.

	Chouteau Springs.		Harriman's Sulphur Spring.	
Silica	0.4673	grains.	0.5841	grains.
Ferrous Bicarbonate	0.7251	"	0.4834	"
Calcium Bicarbonate	14.5511	"	10.2614	"
Magnesium Bicarbonate	3.2058	"	4.8952	"
Calcium Sulphate	38.8426	"	92.8719	"
Calcium Chloride	33.0601	"	77.4517	"
Magnesium Chloride	37.8497	"	81.9492	"
Potassium Chloride	4.9648	"	0.8177	"
Sodium Chloride	387.3751	"	920.3664	"
Carbon Dioxide Gas (free)	5.0582	"	12.4552	"
Mineral matter	526.0998	grains.	1202.1362	grains.
Fixed residue	520.1528	grains.	1197.0523	grains.

DAVIESS COUNTY.

Jamesport "Mineral spring;" analyzed in April, 1887, by P. S.

CHALYBEATE WATER, THIRD GROUP.

Silica	1.3726	grains.
Ferrous Bicarbonate	0.7789	"
Calcium Bicarbonate	31.5813	"
Magnesium Bicarbonate	10.1680	"
Calcium Sulphate	10.6437	"
Potassium Sulphate	0.5734	"
Sodium Sulphate	6.0155	"
Carbon Dioxide Gas (free)	11.7097	"
Mineral matter	72.8431	grains.
Fixed residue	47.5599	grains.

Jordan's spring, near Clinton, analyzed October, 1882, by P. S.

CHALYBEATE WATER, THIRD GROUP.

Silica	1 0572	grains.
Alumina	0.0292	"
Ferrous Bicarbonate	0.3618	"
Manganous Bicarbonate	0.0276	"
Magnesium Bicarbonate	0.6056	"
Calcium Sulphate	66.3729	"
Magnesium Sulphate	32.4527	"
Potassium Sulphate	5.1572	"
Sodium Sulphate	18.0512	"
Sodium Chloride	6.7310	"
Lithium Chloride	0.0172	"
Carbon Dioxide Gas (free)	23.8126	"
Mineral matter	154.8762	grains.
Fixed residue	130.6912	grains.

Ford's spring and Bowen Brothers' spring, both situated near Montrose and analyzed in October, 1886, by P. S.

CHALYBEATE WATER, THIRD GROUP.

	Ford's Spring.		Bowen Bros. Spring.	
Silica	0.6717	grains	1.7406	grains
Alumina	0.4823	"	0.3314	"
Ferrous Bicarbonate	3.2444	"	3.3791	"
Manganous Bicarbonate	0.2938	"	0.0918	"
Calcium Bicarbonate	14.6463	"	6.9531	"
Calcium Sulphate	60.1576	"	28.1020	"
Magnesium Sulphate	21.5883	"	12.2835	"
Potassium Sulphate	1.8274	"	0.1512	"
Sodium Sulphate	24.4945	"	17.3643	"
Lithium Sulphate	1.9697	"	0.6600	"
Lithium Chloride	0.1329	"	0.1188	"
Carbon Dioxide Gas (free)	1.8125	"	4.2965	"
Mineral matter	131.3214	grains.	75.4723	grains.
		"		"
Fixed residue	123.0866	grains.	67.1414	grains.

HOWARD COUNTY.

Boonslick, near Boonesborough, *Burkhart's spring*, two miles west of Franklin, and *Lewis spring* one and one-half miles from Glasgow; analyzed by R. Chauvenet; no date.

MURIATIC WATERS.

	Boone's Lick.	Burkhart's Spring.
Calcium Sulphate	119.27 grains.	135.08 grains.
Calcium Chloride	81.47 "	93.74 "
Magnesium Chloride	...... "	116.89 "
Sodium Chloride	972.29 "	1082.48 "
Mineral matter	1173.03 grains.	1428.19 grains.

	Lewis' Spring.
Calcium Carbonate	23.71 grains.
Magnesium Carbonate	73.12 "
Calcium Sulphate	122.91 "
Calcium Chloride	37.29 "
Sodium Chloride	951.30 "
Mineral matter	1208.33 grains.

JACKSON COUNTY.

"*Young's Medicinal well*," an artesian well at the corner of Twenty-fifth and Vine streets, Kansas City, analyzed about 1890, by C. C. Hamilton, and "*Magneso-Saline Mineral springs*," also an artesian well near Kensington and Cincinnati avenues, Kansas City, analyzed August, 1891, by C. C. Hamilton and R. R. Hunter.

MURIATIC WATER.

	Young's Med. Well.	Magneso-Saline Min. Springs,
Silica	4.0830 grains.	1.200 grains.
Alumina	...... "	0.648 "
Ferric Oxide	...... "	2.754 "
Ferrous Carbonate	5.8796 "	...... "
Calcium Carbonate	52.5778 "	25.980 "
Magnesium Carbonate	15.6989 "	9.234 "
Sodium Carbonate	8.4260 "	15.288 "
Calcium Sulphate	4.5322 "	...... "
Magnesium Sulphate	...... "	0.750 "
Calcium Chloride	...... "	14.400 "
Potassium Chloride	...... "	35.560 "
Sodium Chloride	1470.8124 "	1231.356 "
Carbon Dioxide Gas (free)	21.9984 "	17.160 "
Mineral matter	1584.0083 grains.	1374.330 grains.

JOHNSON COUNTY.

Electric or Colburn spring; analyzed February, 1887, by P. S.

CHALYBEATE WATER.

Silica	1.7815 grains.
Ferrous Bicarbonate	0.2595 "
Calcium Bicarbonate	35.0408 "
Magnesium Bicarbonate	2.4304 "
Magnesium Sulphate	8.4106 "
Potassium Sulphate	0.2221 "
Sodium Sulphate	4.8921 "
Lithium Chloride	0.3637 "
Carbon Dioxide Gas (free)	7.2231 "
Mineral matter	60.6238 grains.
Fixed residue	41.7157 grains.

JEFFERSON COUNTY.

Montesano springs, analyzed by Potter and Riggs; no date.

MURIATIC WATER.

	Council Spring.		Afton Spring.	
Silica	0.770	grains.	0.710	grains.
Alumina and Ferric Oxide	0.460	"	0.540	"
Calcium Bicarbonate	39.720	"	......	"
Calcium Carbonate	......	"	48.100	"
Magnesium Bicarbonate	3.770	"	......	"
Magnesium Carbonate	......	"	5.540	"
Calcium Sulphate	31.910	"	38.980	"
Magnesium Chloride	30.990	"	35.490	"
Potassium Chloride	11.680	"	13.050	"
Sodium Chloride	272.150	"	337.570	"
Magnesium Bromide	0.347	"	0.147	"
Sodium Bisulphide	1.947	"	......	"
Sodium Sulphide	......	"	1.560	"
Mineral matter	393.771	grains.	481.687	grains.

	Pearl Spring.		Thorn Spring.	
Silica	1.250	grains.	0.840	grains.
Alumina and Ferric Oxide	0.370	"	0.380	"
Calcium Bicarbonate	57.920	"	62.440	"
Calcium Sulphate	38.490	"	34.560	"
Calcium Chloride	3.380	"	7.220	"
Magnesium Chloride	46.230	"	47.500	"
Potassium Chloride	13.870	"	15.280	"
Sodium Chloride	362.520	"	365.520	"
Magnesium Bromide	0.879	"	0.409	"
Magnesium Iodide	0.024	"	0.112	"
Sodium Bisulphide	1.644	"	1.736	"
Suspended matter	4.360	"	......	"
Mineral matter	530.937	grains.	535.997	grains.

	Montesano Spring.		Casco Spring.	
Silica	0.510	grains.	0.670	grains.
Alumina and Ferric Oxide	0.870	"	0.750	"
Calcium Carbonate	71.450	"	69.970	"
Magnesium Carbonate	14.050	"	15.500	"
Calcium Sulphate	32.370	"	33.930	"
Magnesium Chloride	35.910	"	34.410	"
Potassium Chloride	16.370	"	16.990	"
Sodium Chloride	365.110	"	368.210	"
Magnesium Iodide	0.852	"	......	"
Magnesium Bromide	.....	"	0.107	"
Sodium Hyposulphite	0.747	"	0.649	"
Sodium Sulphide	0.339	"	0.432	"
Mineral matter	538.578	grains.	541.618	grains.

KNOX COUNTY.

Landreth's well, near Knox City; analyzed June, 1884, by P. S.

CHALYBEATE WATER, THIRD GROUP.

Silica	0.9508 grains.
Alumina	0.6697 "
Ferrous Bicarbonate	2.3919 "
Calcium Bicarbonate	32.6502 "
Calcium Sulphate	18.4061 "
Magnesium Sulphate	23.5369 "
Potassium Sulphate	0.4724 "
Sodium Sulphate	30.8562 "
Sodium Chloride	1.1721 "
Carbon Dioxide Gas (free)	7.5586 "
Mineral matter	118.6649 grains.
Fixed residue	99.8183 grains.

LACLEDE COUNTY.

Lebanon Magnetic well; analyzed June, 1888, by F. W. Clarke; recalculated.

ALKALINE WATER.

Silica	0.654 grains.
Alumina	0.187 "
Ferrous Bicarbonate	trace "
Calcium Bicarbonate	6.826 "
Magnesium Bicarbonate	4.705 "
Sodium Bicarbonate	2.404 "
Magnesium Sulphate	0.350 "
Sodium Chloride	trace "
Mineral matter	15.126 grains.
Fixed residue	10.718 grains.

LAWRENCE COUNTY.

"*Paris Chalybeate spring*," twelve miles N. E. of Mount Vernon; analyzed by C. P. Williams, about 1876, while acting State Geologist.

CHALYBEATE WATER, THIRD GROUP.

Silica	1.3996 grains.
Alumina	0.0239 "
Ferrous Bicarbonate	0.4957 "
Manganous Bicarbonate	0.0521 "
Calcium Bicarbonate	14.8018 "
Calcium Sulphate	0.7807 "
Magnesium Sulphate	4.2619 "
Sodium Sulphate	1.9053 "
Sodium Chloride	0.3133 "
Organic matter	1.0964 "
Mineral matter	25.1307 grains.
Fixed residue	20.4475 grains.

An older analysis of the same spring, made by A. Litton; no date; recalculated in grains per gallon by P. S. is as follows:—

Silica	0.7593	grains.
Ferrous Bicarbonate	0.4673	"
Calcium Bicarbonate	25.2331	"
Magnesium Bicarbonate	2.1028	"
Calcium Sulphate	20.7355	"
Magnesium Sulphate	2.1612	"
Potassium Sulphate	2.1612	"
Sodium Sulphate	3.7966	"
Magnesium Chloride	1.3434	"
Carbon Dioxide Gas (free)	5.3986	"
Mineral matter	64.1590	grains.
Fixed residue	50.0705	grains.

LEWIS COUNTY.

Mineral spring, near La Grange; analyzed in March, 1889, by P. S.

MURIATIC WATER.

Silica	2.3656	grains.
Ferrous Bicarbonate	0.2444	"
Calcium Sulphate	58.2464	"
Magnesium Sulphate	25.7063	"
Sodium Chloride	286.8340	"
Carbonic Acid (free)	15.1866	"
Mineral matter	388.5833	grains.
Fixed residue	373.262	grains.

Wyaconda Artesian well, near La Grange, 840 feet deep, free flowing and claimed to discharge 60 gallons of water a minute; analysis taken from printed card, giving no date nor name of chemist; partly recalculated.

Silica	2.861	grains.
Alumina	0.093	"
Calcium Bicarbonate	51.604	"
Magnesium Bicarbonate	31.287	"
Sodium Bicarbonate	0.209	"
Potassium Bicarbonate	8.173	"
Sodium Sulphate	9.223	"
Sodium Chloride	320.607	"
Mineral matter	424.057	grains.

LINCOLN COUNTY.

Crenshaw springs, near Winfield; analyzed in February, 1888, by P. S.

CHALYBEATE, THIRD CLASS.

Silica	0.6483	grains.
Alumina	0.2104	"
Ferrous Bicarbonate	0.4210	"
Calcium Bicarbonate	6.5265	"
Magnesium Bicarbonate	16.0367	"
Calcium Sulphate	18.9575	"
Potassium Sulphate	0.9807	"
Sodium Sulphate	3.0749	"
Sodium Chloride	92.4030	"
Lithium Sulphate	4.7952	"
Carbon Dioxide Gas (free)	3.6224	"
Mineral matter	147.6766	grains.
Fixed residue	136.2489	grains.

LIVINGSTON COUNTY.

Mooresville Mineral springs; analyzed in 1881 by Wright and Merrill.

Silica	0.61	grains.
Ferrous Bicarbonate	5.07	"
Calcium Bicarbonate	17.61	"
Aluminium Sulphate	5.20	"
Calcium Sulphate	4.66	"
Magnesium Sulphate	1.40	"
Potassium Chloride	2.45	"
Sodium Chloride	2.15	"
Organic matter	2.15	"
Loss	0.22	"
Mineral matter	41.52	grains.

MACON COUNTY.

Patton spring, near Macon, on S. F. & N. E. railway, in 36, 58, 13, analyzed in August, 1881, by Wright & Merrill; partly recalculated.

Silica	1.88	grains.
Ferrous Bicarbonate	1.74	"
Calcium Bicarbonate	18.22	"
Magnesium Bicarbonate	3.63	"
Calcium Sulphate	2.46	"
Magnesium Sulphate	13.67	"
Sodium Sulphate	12.01	"
Sodium Chloride	0.95	"
Apocrenic Acid	0.13	"
Organic and volatile matter	3.14	"
Mineral matter	57.83	grains.

MARION COUNTY.

Oakwood Artesian well, at Oakwood, near Hannibal; analyzed by R. Chauvent & Bros.; no date.

Calcium Sulphate	125.89	grains.
Magnesium Sulphate	72.21	"
Sodium Sulphate	77.26	"
Sodium Chloride	712.28	"
Mineral matter	987.64	grains.

Trace of Sulphuretted Hydrogen.

Artesian well, at Palmyra, hole 1683 feet deep; flow of water reported to have begun at 700 feet; analyzed October, 1887, by P. S.

MURIATIC WATER.

Silica	1.1098	grains.
Calcium Sulphate	67.4325	"
Calcium Chloride	28.3920	"
Magnesium Chloride	53.4778	"
Sodium Chloride	525.0307	"
Lithium Chloride	0.3181	"
Sodium Bromide	0.3008	"
Mineral matter	676.0617	grains.

MERCER COUNTY.

Bowsher Mineral spring, near Princeton; analyzed September, 1881, by P. S.

CHALYBEATE WATER, SECOND GROUP.

Silica	4.7896 grains.
Alumina	0.6484 "
Ferrous Bicarbonate	4.7639 "
Manganous Bicarbonate	0.0655 "
Calcium Bicarbonate	5.5980 "
Magnesium Bicarbonate	0.9089 "
Magnesium Sulphate	0.2286 "
Potassium Sulphate	0.7445 "
Sodium Sulphate	0.2208 "
Calcium Phosphate	0.0245 "
Sodium Chloride	1.0973 "
Carbon Dioxide Gas (free)	3.0541 "
Mineral matter	22.1441 grains.
Fixed residue	14.4116 grains.

MILLER COUNTY.

Aurora springs, given in U. S. Bulletin of the Geological Survey No. 32, without name of analyst.

CHALYBEATE WATER.

Ferrous Carbonate	5.130 grains,
Ferrous Oxide	0.933 "
Calcium Sulphate	2.427 "
Magnesium Sulphate	6.949 "
Sodium Chloride	4.009 "
Lithia	1.430 "
Mineral matter	20.878 grains.

MONROE COUNTY.

Four springs analyzed in June and July, 1886, by P. S.: *Bowman Mineral springs*, No. 1 and 2 and *Fountain of Health* or *Harris well*, near Middle Grove, and *Ragland Mineral springs*, near Madison.

CHALYBEATE WATER, THIRD GROUP.

Bowman Mineral springs.

	No. 1.	No. 2.
Silica	0.7009 grains.	1.3221 grains.
Alumina	0.1226 "	0.0820 "
Ferrous Bicarbonate	1.0644 "	6.0345 "
Manganous Bicarbonate	...... "	9.2088 "
Calcium Bicarbonate	30.8623 "	...... "
Barium Sulphate	...... "	2.5884 "
Calcium Sulphate	56.8861 "	100.1479 "
Magnesium Sulphate	85.3188 "	63.9063 "
Potassium Sulphate	0.2379 "	0.1351 "
Sodium Sulphate	35.6651 "	19.5250 "
Lithium Chloride	3.3609 "	0.0152 "
Carbon Dioxide Gas (free)	21.7767 "	...... "
Lithium Chloride	0.3985 "	...... "
Mineral matter	236.3942 grains.	202.9653 grains.

	Fountain of Health.	Ragland Mineral Spring.
Silica	2.4532 grains.	1.1565 grains.
Alumina	0.0422 "	0.0615 "
Ferrous Bicarbonate	3.3746 "	7.6322 "
Manganous Bicarbonate	0.1494 "	..... "
Calcium Bicarbonate	1.2320 "	22.1840 "
Barium Sulphate	...... "	2.4649 "
Calcium Sulphate	96.0769 "	61.2520 "
Magnesium Sulphate	29.8065 "	80.0802 "
Potassium Sulphate	0.8700 "	0.2162 "
Sodium Sulphate	4.4460 "	13.3911 "
Lithium Sulphate	...... "	3.6138 "
Lithium Chloride	1.0908 "	0.5174 "
Carbon Dioxide Gas (free)	15.9991 "	23.6756 "
Mineral matter	155.5407 grains.	216.2454 grains.
Fixed residue	137.2259 grains.	181.5936 grains.

MONTGOMERY COUNTY.

Farthing Mineral spring, near Middletown; analyzed April, 1887, by P. S.

SULPHATIC WATER, THIRD GROUP.

Silica	2.8037 grains.
Ferrous Sulphate	5.9419 "
Aluminum Sulphate	4.8007 "
Calcium Sulphate	28.3137 "
Magnesium Sulphate	7.7976 "
Potassium Sulphate	1.5589 "
Sodium Sulphate	29.5165 "
Lithium Chloride	0.5701 "
Sulphur Trioxide (free)	8.6407 "
Mineral matter	89.9438 grains.

MORGAN COUNTY.

Versailles Medical spring, situated near Versailles; analyzed by V. C. Vaughan; no date.

SULPHATIC WATER, THIRD GROUP.

Sodium Silicate	12.32 grains.
Ferric Oxide	37.25 "
Aluminium and Potassium Sulphate	157.70 "
Calcium Sulphate	20.98 "
Sodium Chloride	4.88 "
Mineral matter	233.13 grains.

NODAWAY COUNTY.

Burlington Junction Mineral springs and *Barnard Mineral water*, both analyzed by Wright and Merrill; no date.

CHALYBEATE WATER, SECOND GROUP.

	Burlington Junction Mineral Springs.	Barnard Mineral Water.
Silica	0.169 grains.	0.77 grains.
Alumina	0.231 "	0.41 "
Ferrous Carbonate	2.161 "	2.31 "
Calcium Carbonate	7.721 "	2.04 "
Magnesium Carbonate	0.988 "	1.00 "
Calcium Sulphate	0.386 "	2.65 "
Magnesium Chloride	0.660 "	.... "
Sodium Chloride	0.185 "	1.41 "
Organic, etc., matter	1.914 "	0.45 "
Mineral matter	14.415 grains.	11.05 grains.

PETTIS COUNTY.

Teague spring, near Lamonte; analyzed in November, 1886, by P. S.

SULPHATIC WATER, THIRD GROUP.

Silica	2.6576	grains.
Ferrous Bicarbonate	1.6340	"
Manganous Bicarbonate	0.4773	"
Ferrous Sulphate	8.7687	"
Aluminium Sulphate	17.3910	"
Calcium Sulphate	26.8952	"
Magnesium Sulphate	7.2546	"
Potassium Sulphate	0.1969	"
Sodium Sulphate	6.8627	"
Lithium Sulphate	0.2930	"
Lithium Chloride	0.1198	"
Carbon Dioxide Gas (free)	4.0410	"
Mineral matter	77.5918	grains.
Fixed residue	71.3881	grains.

PIKE COUNTY.

B. B. spring, near Bowling Green; analyzed December, 1886, by P. S.

SULPHATIC WATER, SECOND GROUP.

Silica	2.6576	grains.
Aluminum Sulphate	18.3114	"
Calcium Sulphate	80.1749	"
Magnesium Sulphate	669.4662	"
Sodium Sulphate	61.0431	"
Lithium Chloride	0.2898	"
Mineral matter	831.9430	grains.

Crow springs, Nos. 1, 2, 3, situated near Curryville, and analyzed by P. S., the first in April, the other two in August, 1887, all three chalybeates of the first group.

Stevens spring, near Bowling Green; analyzed in March, 1888, by P. S., and belonging to the class of alkaline waters.

	Crow Springs. No. 1.		Crow Springs. No. 2.	
Silica	2.0735	grains.	2.2132	grains.
Ferrous Bicarbonate	0.5191	"	0.3162	"
Calcium Bicarbonate	21.2528	"	21.2454	"
Magnesium Bicarbonate	13.7005	"	12.2131	"
Sodium Bicarbonate	3.0097	"	9.6160	"
Sodium Sulphate	8.6155	"	7.3968	"
Carbon Dioxide Gas (free)	13.7104	"	7.0091	"
Mineral matter	62.8815	grains.	60.0098	grains.
Fixed residue	36.7993	grains.	39.3162	grains.

	Crow Springs. No. 3.		Stevens' Spring.	
Silica	2.4216	grains.	0.8352	grains.
Alumina	......	"	0.2203	"
Ferrous Bicarbonate	0.3162	"	0.0295	"
Calcium Bicarbonate	22.7654	"	17.3026	"
Magnesium Bicarbonate	13.5725	"	10.8595	"
Sodium Bicarbonate	11.0079	"	......	"
Potassium Bicarbonate	......	"	0.3876	"
Sodium Sulphate	6.7169	"	4.3544	"
Lithium Chloride	......	"	0.8181	"
Carbon Dioxide Gas (free)	6.4458	"	7.3279	"
Mineral matter	63.2463	grains.	42.1351	grains.
Fixed residue	41.7760	grains.	25.6775	grains.

PLATTE COUNTY.

Crystal spring (No. 1); analyzed in 1887 by F. A. Holton; recalculated by P. S.

CHALYBEATE WATER, FIRST GROUP.

Silica	2.72	grains.
Ferrous Bicarbonate	5.43	"
Calcium Bicarbonate	15.79	"
Magnesium Bicarbonate	5.89	"
Calcium Sulphate.	2.24	"
Potassium Sulphate	0.47	"
Sodium Sulphate	2.18	"
Sodium Chloride	0.89	"
Mineral matter	35.61	grains.
Fixed residue	26.88	grains.

PHELPS COUNTY.

Kenklesha spring, near Rolla; analyzed in 1888 by C. M. Riley; recalculated by P. S.

SULPHATIC WATER.

Silica	0.9835	grains.
Alumina	0.7473	"
Ferrous Bicarbonate	0.0269	"
Calcium Bicarbonate	36.4594	"
Magnesium Bicarbonate	5.7777	"
Sodium Bicarbonate.	3.3009	"
Magnesium Sulphate	24.8486	"
Potassium Sulphate	0.5114	"
Sodium Sulphate	31.8427	"
Sodium Chloride	10.5851	"
Organic matter	0.1037	"
Mineral matter	115.1872	grains.
Fixed residue	100.9822	grains.

PUTNAM COUNTY.

Bray Mineral well, situated near Newton; analyzed October, 1888, by P. S.

Silica	1.1682	grains.
Ferrous Bicarbonate	0.1695	"
Calcium Bicarbonate	41.4548	"
Calcium Sulphate	60.3865	"
Magnesium Sulphate	31.0158	"
Potassium Sulphate	2.2213	"
Sodium Sulphate	6.3021	"
Sodium Chloride	1.0579	"
Lithium Sulphate	0.7700	"
Carbon Dioxide Gas (free).	7.1765	"
Mineral matter	151.7226	grains.
Fixed residue	138.9627	grains.

RANDOLPH COUNTY.

Salt spring, at Randolph Medical Springs; partially analyzed in March, 1881, by P. S.

MURIATIC WATER, FIRST GROUP.

Silica	2.2662	grains.
Aluminum Sulphate	30.1534	"
Aluminum Chloride	17.8082	"
Calcium Chloride	40.0929	"
Magnesium Chloride	11.9541	"
Sodium Chloride	237.8828	"
Mineral matter	340.1576	grains.

Four mineral wells, analyzed by P. S., and belonging to the third group of Chalybeate waters as follows: *Skinner well*, analyzed in May, 1887; *Rucker well*, analyzed in October, 1887; *Hammett's well*, analyzed in November, 1890, — all near Huntsville; and *Given well*, analyzed in August, 1887, and situated near Moberly.

	Skinner Well.	
Silica	1.0397	grains.
Ferrous Bicarbonate	13.3380	"
Manganous Bicarbonate	0.6857	"
Calcium Bicarbonate	24.9176	"
Magnesium Bicarbonate	6.6538	"
Sodium Bicarbonate	2.7224	"
Carbon Dioxide Gas (free)	9.7409	"
Mineral matter	59.0981	grains.
Fixed residue	31.4376	grains.

	Hammett's Well.		Rucker's Well.	
Silica	2.4392	grains.	4.3398	grains.
Ferrous Bicarbonate	5.7124	"	8.0149	"
Manganous Bicarbonate	0.2628	"	0.1308	"
Magnesium Bicarbonate	24.5206	"	......	"
Ferrous Sulphate	......	"	4.7416	"
Calcium Sulphate	112.2056	"	101.2690	"
Magnesium Sulphate	37.9548	"	62.0664	"
Sodium Sulphate	18.4868	"	8.0823	"
Lithium Sulphate	0.7788	"	0.8566	"
Sodium Chloride	......	"	0.5486	"
Carbon Dioxide Gas (free)	......	"	12.3273	"
Mineral matter	202.3610	grains.	202.3273	grains.
Fixed residue	190.6440	grains.	185.5684	grains.

Given well (several miles east of Moberly).

Silica	1.2072	grains.
Alumina	0.3061	"
Ferrous Bicarbonate	2.6818	"
Calcium Bicarbonate	55.8609	"
Barium Sulphate	2.2100	"
Calcium Sulphate	64.8245	"
Magnesium Sulphate	68.7951	"
Potassium Sulphate	0.4546	"
Sodium Sulphate	20.8444	"
Lithium Sulphate	3.0877	"
Carbon Dioxide Gas (free)	6.9980	"
Mineral matter	227.2703	grains.
Fixed residue	201.7287	grains.

Other springs from near this neighborhood were partially analyzed with nearly the same result as in the *Given Well.*

SALINE COUNTY.

Sweet spring and *Akesion*, near Sweet Springs, were analyzed about 1875 by C. P. Williams.

MURIATIC WATER.

	Sweet Spring.		Akesion.	
Silica	0.5132	grains.	1.0847	grains.
Alumina	0.1668	"	0.0892	"
Ferrous Carbonate	0.2668	"	0.5666	"
Magnesium Carbonate	0.1991	"	0.0019	"
Calcium Carbonate	40.2509	"	9.5631	"
Calcium Phosphate	......	"	0.2427	"
Barium Sulphate	......	"	8.1505	"
Calcium Sulphate	9.4591	"	57 9338	"
Calcium Chloride	14.7213	"	74.7909	"
Magnesium Chloride	22.2912	"	87.3184	"
Potassium Chloride	3.3980	"	28.5639	"
Sodium Chloride	89.9177	"	756.1140	"
Lithium Chloride	0.0476	"	0.2939	"
Magnesium Bromide	0.1180	"	0.1311	"
Organic matter	4.0130	"	3.0470	"
Magnesium Nitrate	......	"	0.1780	"
Ammonium Nitrate	......	"	1.1789	"
Sodium Sulphide	......	"	2.6087	"
Total solids	155.0093	grains.	1052.9469	grains.

Blue Lick spring; analyzed by C. M. Riley; no date.

Silica	8.1662	grains.
Alumina	10.2325	"
Calcium Carbonate	57.8386	"
Magnesium Sulphate	26.1319	"
Magnesium Chloride	10.9365	"
Sodium Chloride	493.8795	"
Potassium Chloride	0.6434	"
Organic matter	2.4782	"
Total solids	610.3068	grains.

Black Sulphur springs, near McAllister springs; analyzed by R. Chauvenet. no date.

Silica	0.3	grains.
Ferrous Bicarbonate	0.6	"
Calcium Bicarbonate	72.0	"
Magnesium Bicarbonate	36.5	"
Calcium Sulphate	48.5	"
Sodium Sulphate	0.7	"
Calcium Chloride	54.6	"
Magnesium Chloride	34.2	"
Potassium Chloride	0.9	"
Sodium Chloride	772.4	"
Mineral matter	1020.7	grains.

Artesian well near Marshall, furnishing the town with drinking water; analyzed in March, 1889, by P. S.

Silica	1.1390	grains.
Ferrous Bicarbonate	0.3796	"
Manganous Bicarbonate	0.1898	"
Calcium Bicarbonate	5.5341	"
Magnesium Bicarbonate	3.1776	"
Calcium Sulphate	11.2285	"
Potassium Chloride	0.7724	"
Sodium Chloride	3.6240	"
Mineral matter	26.0450	grains.
Fixed residue	22.9551	grains.

ST. CLAIR COUNTY.

Excelsior springs, near Appleton City; analyzed in November, 1886, by P. S.

CHALYBEATE, THIRD GROUP.

Silica	1.9275	grains.
Alumina	0.0584	"
Ferrous Bicarbonate	1.0513	"
Calcium Bicarbonate	42.4091	"
Calcium Sulphate	80.4795	"
Magnesium Sulphate	23.6559	"
Potassium Sulphate	0.5742	"
Sodium Sulphate	12.4413	"
Lithium Sulphate	0.7139	"
Lithium Chloride	0.1317	"
Carbon Dioxide Gas (free)	0.8558	"
Mineral matter	164.2986	grains.
Fixed residue	150.7620	grains.

ST. LOUIS CITY AND COUNTY.

Belcher Artesian well; analyzed by A. Litton; no date.

Silica	0.14	grains.
Ferrous Carbonate	0.52	"
Calcium Carbonate	10.63	"
Magnesium Carbonate	1.02	"
Calcium Sulphate	45.67	"
Calcium Chloride	27.58	"
Magnesium Chloride	38.34	"
Potassium Chloride	9.01	"
Sodium Chloride	350.61	"
Total residue	483.52	grains.

Spring, near Benton, St. Louis County; analyzed by W. F. Hillebrand and E. S. Howard and recalculated by P. S.

ALKALINE, SECOND GROUP.

Silica	1.5421	grains.
Alumina and Ferric Oxide	0.1518	"
Calcium Bicarbonate	19.1351	"
Magnesium Bicarbonate	3.9602	"
Calcium Sulphate	0.0409	"
Potassium Sulphate	0.1635	"
Sodium Sulphate	1.4193	"
Sodium Chloride	1.0572	"
Calcium Nitrate	1.3551	"
Mineral matter	23.8252	grains.
Fixed residue	21.6175	grains.

VERNON COUNTY.

Ellis' well, near Nevada; analyzed by R. Chauvenet; no date.

MURIATIC WATER, FIRST GROUP.

Calcium Carbonate	6.80	grains.
Magnesium Carbonate	7.76	"
Calcium Sulphate	5.85	"
Calcium Chloride	9.91	"
Magnesium Chloride	8.62	"
Sodium Chloride	30.19	"
Total residue	69.13	grains.

Connely springs, now Fair Haven springs; analyzed in March, 1888, by P. S.

CHALYBEATES, THIRD GROUP.

	Main Spring.		Well.	
Silica	1.2103	grains.	2.0151	grains.
Alumina	0.0432	"	0.0876	"
Ferrous Bicarbonate	3.0173	"	2.5960	"
Calcium Bicarbonate	11.1140	"	18.3842	"
Calcium Sulphate	6.8007	"	19.6324	"
Magnesium Sulphate	11.1711	"	28.2294	"
Potassium Sulphate	0.2269	"	0.5990	"
Sodium Sulphate	3.8647	"	6.9704	"
Lithium Sulphate	0.3747	"	0.7341	"
Carbon Dioxide Gas (free)	13.6214	"	12.3214	"
Mineral matter	51.4443	grains	91.5696	grains.
Fixed residue	32.7675	grains.	72.2030	grains.

WORTH COUNTY.

Fairview Mineral spring, near Denver; analyzed by Lord and Stoutenburg; no date.

Ferrous Bicarbonate	18.73	grains.
Calcium Bicarbonate	14.88	"
Magnesium Bicarbonate	16.98	"
Calcium Sulphate	11.60	"
Sodium Chloride	2.64	"
Carbon Dioxide Gas (free)	4.56	"
Mineral matter	69.39	grains.
Fixed residue	44.15	grains

APPENDIX C.

A BIBLIOGRAPHY OF MINERAL WATERS.

Chronologically Arranged.

It was originally intended to have prepared, for publication with this volume, a complete bibliography of mineral water. On looking over the ground, however, the number of monographs on a score of mineral waters and on the mineral waters of certain districts, as also the published papers and analyses in the various scientific journals, was found to be so large as altogether to exceed the compass of this report. The following list is therefore restricted to titles of special works mainly taken from *Osann, Darstellung der bekannten Heilquellen, Berlin, 1829–43.* Search for additional titles to complete the list and bring it down to the present time was made difficult on account of the complete destruction by fire on January 6, 1891, of the library of the State University. The list, as given, is printed in the belief that it will prove of some service and a basis, at least, upon which to build the complete bibliography of the future.—P. S.

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GENERAL INDEX.

LIST OF ERRATA.

On page 74, twelfth line from bottom, for Sulphur Spring read Salt Spring.

On page 151, nineteenth line from bottom, for "this page" read the next page.

On page 211, eleventh line from the bottom, drop H_2 from symbol of bicarbonates.

On page 237, thirteenth line from top, for Jan. 6, 1891, read Jan. 9, 1892.

On page 246, twenty-sixth line from top, for bill read bile.

On page 250, third line from top, for Buller read Quelle.

PUBLICATIONS OF THE

GEOLOGICAL SURVEY OF MISSOURI.

SURVEY OF 1853 TO 1862.

G. C. SWALLOW, STATE GEOLOGIST.

The First and Second Annual Reports of the Geological Survey of Missouri, by G. C. Swallow, State Geologist, Jefferson City. 1855. Parts I and II, 208 and 240 pp., 69 illustrations and 5 small county maps. **Edition exhausted.**

CONTENTS: First Annual Report—Administrative—pp. 19-22. Second Annual Report: Introduction, pp. 25 to 58. Part I, Chapter I: Geology of Missouri, pp. 59 to 136, by G. C. Swallow. Chapter II: Economical Geology, Soils, pp. 137 to 170. Chapter III: Special Report on Marion county, pp. 171 to 185. Chapter IV: Special Report on Cooper county, pp. 186 to 204. Chapter V: Geology of the Southwest, pp. 204 to 207. All preceding by G. C. Swallow.

Part II: Report on Lead Mines and Mining of Southeast Missouri, in the counties of Franklin, Jefferson, Washington, St. Francois and Madison, pp. 1 to 94, by A. Litton. Special report on Moniteau county, pp. 95 to 119, by F. B Meek. Description of the formations along the Hannibal & St. Joseph Railroad, with a catalogue of fossils collected, pp. 121 to 136, by F. Hawn. Geological Section on the Mississippi river, pp. 139 to 157; Special report on Franklin county, with map, pp. 157 to 169; Special report on St. Louis county, with map, pp. 169 to 184; Paleontology, including a description of 48 new species of fossils, with three plates of same, pp. 185 to 208, all by B. F. Shumard. Appendix, 31 pp., containing a list of publications previously made relating to the Geology of Missouri; a paper on the use of fossils, a catalogue of the fossils of Missouri and of her trees and shrubs, and a glossary of geological and other scientific terms.

The Third Report of Progress was transmitted in December, 1856, and is of 4 pages. It recites briefly what work has been done during the years 1855 and 1856. **Edition exhausted.**

The Fourth Report of Progress was made in December, 1858, and is of 14 pages. This describes, in greater detail, the operations of the Survey during the years 1857 and 1858, and gives, in tabular form, a statement of progress to date. **Edition exhausted.**

The Fifth Report of Progress of December 30, 1860, is of 13 pages and is a similar statement of operations during the years 1859 and 1860, with a brief reference to the results reached concerning the coal, lead and iron deposits and the soils of the State. In this report the product of the Survey to that time is given in tabular form. **Edition exhausted.**

SURVEY OF 1870 TO 1874.

A. D. HAGAR, RAPHAEL PUMPELLY AND G. C. BROADHEAD, STATE GEOLOGISTS.

Annual Report of the State Geologist of the State of Missouri (Albert D. Hagar, Nov. 30, 1870), 23 pp., no illustrations. The progress of the Survey is described and the principal minerals and building stones are briefly noticed. **Edition exhausted.**

Edition exhausted.

Report of the Geological Survey of the State of Missouri, 1855–1871. By G. C. Broadhead, F. B. Meek and B. F. Shumard, Jefferson City. 1873. pp. 323 and iv. 29 illustrations, 9 small county maps.

CONTENTS: It contains chapters on Maries, Osage, Warren, Shelby, Macon and Randolph counties by G. C. Broadhead; on Miller, Morgan and Saline counties by F. B. Meek; on Ozark, Douglas, Wright, Laclede, Pulaski, Phelps, Crawford, Cape Girardeau, Perry, ste. Genevieve, Jefferson any Clark counties by B. F. Shumard.

Edition exhausted.

Preliminary Report on the Iron Ores and Coal Fields from the field work of 1872, with 190 illustrations in the text, and an Atlas. 1873. pp. xvi, 214 and 441. Atlas accompanying, 22x28 inches, with 14 large sheets. Jefferson City. 1874.

CONTENTS: Part I, Chapter I.— Notes on the Geology of Pilot Knob and its vicinity, by R. Pumpelly, pp. 3 to 28. Chapter II: Analysis of Ores, Fuels and Pig Irons, pp. 29 to 44. Chapters III, IV, V and VI, constitute a partial report on the Iron Ores of Missouri, by Dr. Schmidt, pp. 45 to 214.

Part II, Chapters I, II, III, IV, V and VI, contain general matter relating to the Coal Fields, by G. C. Broadhead, pp. 1 to 213. Chapters VII and VIII are on the geology of Lincoln county, by Wm. B. Potter, pp. 215 to 289. Chapters IX to XV, are reports by G. C. Broadhead on Livingston, Clay, Platte, Buchanan, Holt, Atchison and Nodaway counties, pp. 290 to 402. Appendices, A, B and C contain, respectively, the results of some tests of strength of building materials, a note relating to Missouri rocks which admit of a fine polish, and a list of Coal Measure fossils, pp. 403 to 420.

Edition exhausted.

Report of the Geological Survey of the State of Missouri, including field work of 1873–1874, with 91 illustrations and one Atlas, 13x15 inches, containing 15 sheets. Garland C. Broadhead, State Geologist, Jefferson City, Mo. 1874. pp. 734; L. 4, 56.

CONTENTS: Chapters I and II contain an historical introduction and a brief description of the General Geology of the State, pp. 5 to 34. Chapters III, IV and V treat, in a general way, of Caves and Water Supply, and of Soils and Timber, and the last Chapter contains a brief list of the Minerals of the State, pp. 35 to 56. Chapter VI contains remarks on the Southwest Coal Field, and is accompanied by a general section, pp. 56 to 61. Chapters VII to XXI, inclusive, are reports on Cedar, Jasper, Barton, Vernon, Bates, Howard, Sullivan, Adair, Linn, Putnam, Schuyler, Andrew, Daviess, Cole and Madison counties, pp. 62 to 379, all the preceding by G. C. Broadhead. Chapters XXII to XXVIII constitute a report on the Lead Region of Southwest Missouri, in which the general characteristics of the region and its ores are given, together with a description of a number of its deposits, pp. 381 to 502, by Dr. A. Schmidt. Chapters XXIX to XXXII treat similarly of the Lead Deposits of Central Missouri, pp. 503 to 577, also by Dr. Schmidt. Chapter XXXIII contains rules for the development of Iron Ore Deposits and Notes on the Metallurgical Properties of Missouri Iron Ores, pp. 578 to 600, by A. Schmidt. Chapter XXXIV is on the Lead Region of Southeast Missouri, pp. 601 to 637, by J. R. Gage. Chapter XXXV is on the Iron Ore of the same region, pp. 638 to 671, by P. N. Moore. Appendices A, B, C and D are brief papers on the "History of Lead Mining in Missouri," on "Lead Mines in Upper Louisiana," on "Metallic Statistics," and on "Mineral Springs of Missouri." Appendix E contains results of analyses of ores, fuels and minerals, pp. 672 to 734.

SURVEY OF 1876 TO 1879.

CHAS. P. WILLIAMS, ACTING STATE GEOLOGIST.

Edition exhausted.

Industrial Report on Lead, Zinc and Iron, together with notes on Shannon county and its copper deposits, by Chas. P. Williams, Ph. D., Acting State Geologist, Jefferson City. 1877. pp. 183 and xvi, 11 illustrations.

GEOLOGICAL SURVEY OF MISSOURI.

SURVEY OF 1889 TO DATE.

ARTHUR WINSLOW, STATE GEOLOGIST.

SUBJECT REPORTS.

Vol. I.—**A Preliminary Report on the Coal Deposits** of Missouri from field work prosecuted during the years 1890 and 1891. With 131 illustrations, by Arthur Winslow, State Geologist. Published by the Geological Survey. Jefferson City. Nov. 1891. 8vo., cloth, 227 pp. **Postage 15 cts.**

CONTENTS: Chapter I: The Coal Measures, their distribution, topography, lithology and stratigraphy; the process of deposition, pp. 18 to 32. Chapter II: The Coal Beds, their distribution and character; the conditions restricting distribution and availability, pp. 33 to 41. Chapter IV: The Coal Industry, the coal production and market; the uses and adaptabilities of the coals; the available coal tonnage and the value of coal and coal lands, pp. 42 to 51. Chapter V: A systematic description, by counties, of coal beds now operated, including 57 counties, pp. 52 to 172. Appendix A: Notes on Coal Mining in thin coal beds, pp. 173 to 186. Appendix B: List of the Coal Operators of Missouri, pp. 187 to 199.

A Report on the Iron Ores of Missouri from field work prosecuted during the years 1891 and 1892. With 62 Illustrations and one Map, by Frank L. Nason, Assistant-Geologist. Published by the Geological Survey, Jefferson City. December, 1892. 8vo., cloth. 366 pp. **Postage 23 cts.**

CONTENTS: Part I: A general discussion and description. Chapter I, Introduction: The Ores of Iron, pp. 1 to 11. Chapter II: The Iron Ores of Missouri, pp. 12 to 15. Chapter III: The Specular Ores of the Porphyry Region, pp. 16 to 69. Chapter IV: The Red Hematites of Missouri, pp. 70 to 84. Chapter V: The General Geology of the Ozark Uplift, pp. 85 to 115. Chapter VI: The Specular Ores of the Sandstone Region, pp. 116 to 157. Chapter VII: The Limonite Ores, pp. 158 to 209. Part II: The Iron Ore Localities. Chapter VIII: Introduction to Part II, pp. 213 to 217. Chapter IX: The Specular Ores in Sandstone, pp. 218 to 232. Chapter X: The Limonites, pp. 232 to 278. Chapter XI: The Red Hematites, pp. 279 to 281. Appendix A: The Iron Deposits of Northeastern Arkansas, pp. 283 to 301. Appendix B: Historical and Statistical Sketch of the Iron Industry of Missouri, pp. 303 to 334.

AREA OF SHEET REPORTS.

No. 1.—**A Report on the Higginsville Sheet,** Lafayette county, accompanied by a Geologic and Topographic Map and a Sheet of Sections. From field work prosecuted during the years 1890 and 1891. By Arthur Winslow, State Geologist. Published by the Geological Survey. Jefferson City. April, 1892. Folio, 22 pp. **Postage 12 cts.**

CONTENTS: Introduction, including Area, Railways, Towns, Industries. Physiography, including Topography, Hydrography, Soils, Forestry. Geology, including Stratigraphic, Structural and Economic Geology, the latter embracing Coal, Building Stones, Clays and Shales.

BULLETINS.

BULLETIN No. 1.

CONTENTS: Administrative Report, by Arthur Winslow, State Geologist, 13 pp.; The Coal Beds of Lafayette county, by Arthur Winslow, State Geologist, 8 pp.; The Building Stones and Clays, of Iron, St. Francois and Madison counties, by G. E. Ladd, Assistant Geologist, 15 pp.; A Preliminary Catalogue of the Fossils occurring in Missouri, by Hamback, paleontologist, 15 pp., 8vo. Paper, 85 pp., 2 cuts. Jefferson City. April, 1890. **Edition exhausted.**

BULLETIN No. 2.

CONTENTS: A Bibliography of the Geology of Missouri, by F. A. Sampson, 8vo. Paper. 158 and xviii pp. 810 titles. Table of Contents, author and subject indexes. Jefferson City. December, 1890. **Postage 6 cts.**

BULLETIN No. 3.

Postage 5 cts.

CONTENTS: The Clay, Stone, Lime and Sand Industries of St. Louis City and county, by G. E. Ladd, Assistant Geologist. 80 pp. The Mineral Waters of Henry, St. Clair, Johnson and Benton counties, by A. E. Woodward, Assistant Geologist. 8vo. Paper. 101 pp. 4 cuts. 2 maps. Jefferson City. December, 1890.

BULLETIN No. 4.

Postage 4 cts.

CONTENTS: A Description of the Lower Carboniferous Crinoids from Missouri, by S. A. Miller. 8vo. Paper. 40 pp. 5 plates. Jefferson City. February, 1891.

BULLETIN No. 5.

Postage 5 cts.

CONTENTS: The Age and Origin of the Crystalline Rocks of Missouri, by Erasmus Haworth. 42 pp. Notes on the Clays and Building Stones of Certain Western Central Counties Tributary to Kansas City, by G. E. Ladd, Assistant Geologist. Jefferson City. July, 1891. 86 pp. Paper.

BIENNIAL REPORTS—ADMINISTRATIVE.

Edition exhausted.

Biennial Report of the State Geologist, transmitted by the Bureau of Geology and Mines to the Thirty-sixth General Assembly. Small 8vo. Paper. 53 pp. 2 small diagrams. Consists of an historical sketch of the progress of geological work in the State, and of a report of the progress. Jefferson City. December, 1890.