ANNUAL REPORT

OF THE

GEOLOGICAL SURVEY

OF

ARKANSAS

FOR 1891

VOLUME I
THE MINERAL WATERS OF ARKANSAS

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OFFICE OF THE GEOLOGICAL SURVEY OF ARKANSAS,
LITTLE ROCK, ARK., Aug 1, 1892.

To His Excellency,
Hon. James P. Eagle,
Governor of Arkansas.

Sir:

I have the honor to submit herewith Volume I of my annual report for 1891, and to remain,

Your obedient servant,
JOHN C. BRANNER,
State Geologist.

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THE MINERAL WATERS OF ARKANSAS.

JOHN C. BRANNER, State Geologist.

CHAPTER I.

INTRODUCTION.

It has not been possible to collect and analyse the waters of all the mineral or reputed mineral springs of the state, and it must not therefore be understood that the analyses given herewith represent fully all our mineral waters. It has been necessary in doing this work to do, not what was most desirable, but what was expedient, and analyses have been undertaken only as the collection of the water samples became convenient during the course of geologic investigations which brought some member of the Survey near the springs. In only a few instances have special trips been made to collect samples of water. In a few cases persons interested in certain springs, the waters of which it was not otherwise convenient for the Survey to have collected, have paid the expenses of having some member of the Survey get the samples.

In cases of waters in which precipitates are formed after standing these precipitates have been used in the analyses and regarded as essential parts of the water.

The water analyses made by the Survey embrace:

I. Quantitative or mineral analyses for determining the mineral matter held in solution (Chapters II and III).

II. Qualitative analyses or tests (Chapter IV).

III. Sanitary analyses, made for determining the potability or fitness of waters for domestic use (Chapter V).

Besides the analyses made by the Survey there are here brought together nearly all the quantitative analyses known to have been made of Arkansas waters. The results are all reduced to grains per United States gallon in order to make them comparable with the Survey's results. In such cases the authority is mentioned and the name of the analyst is given if it is known.

Many qualitative analyses were made by Elderhorst and published in Owen's reports. A few of the more important of these are given in this volume, but most of them have been omitted, either on account of their lack of importance or because the locations of the springs are not given.

Method of making the analyses.—A complete mineral analysis consists essentially in the quantitative estimation of all the substances contained in the solid residue left on evaporation of a definite quantity of the water. An exception must, of course, be made of gases which would escape on evaporation, and which must therefore be determined in the natural water. For this reason the analyses of gas-bearing waters make no claim to be more than they are, for it has not been possible in all cases to make the gas determinations at the springs. The analyses of such waters must therefore be taken only for what they are worth.

The amount of total solid material in solution given separately after each table was determined by weighing the residue left on evaporating a definite quantity of water, and dried at about 212° Fahrenheit. Unless otherwise stated, the analyses given in this report have been made at the Survey's laboratory at Little Rock, by Dr. Richard N. Brackett, chemist of the Survey.

Statement of results.—The method of stating water analyses followed in this volume has not been adopted without due consideration of its objectionable features. Careful chemists naturally hesitate to give in detail the "hypothetical combination" of the substances found in a water analysis. Yet to give the simple elements as they are actually determined would not convey any idea to the mind of the average reader; for

this reason there are given both the materials found and the combinations in which these substances probably exist in the water. In this way the chemist can see just what has been determined, while in the "hypothetical combination" the average reader will get, or will think he gets, a clearer idea of the substances in the water.

Chemists would also prefer to have the results given in grams to the litre, the method commonly used nowadays. But while the value of uniformity in giving such analyses is realized, it is thought that it is, in this case, more important that the readers shall comprehend the statements, and it is believed that they will get a better idea on the whole from the method here followed, namely grains per U. S. gallon of 58,372.175 grains* or 231 cubic inches, than if grams to the litre were used. Moreover chemists always have the advantage of being able to convert the terms used in the report into those in use among chemists, while the general reader cannot be expected readily to make such conversions.

Each analysis is divided into two parts, the first giving the chemical compounds as they probably occur in the water, the second showing the constituent elements actually found by analysis, and from which the compounds are calculated. The column of percentages shows the percentage of each element or compound in the total amount contained in the water; care should be taken not to mistake these percentages for percentages of the water.

The common springs.—Arkansas is a well watered state. Besides the springs of which analyses are given in this report, hundreds of beautiful, free-flowing springs of excellent water gush from hillsides and valleys in all parts of the state. In the limestone region north of the Boston Mountains, such springs are especially abundant, large, and beautiful. They are not mineral waters, properly speaking, but they are more val-

*According to a recent determination by Prof. Wm. P. Mason of the Rensselaer Polytechnic Institute (J. Anal. Chem. IV, 121), the number of grains in the U. S. gallon is 58,334.946. The figure used in these analyses is the one in common use still, and is, for practical purposes, sufficiently accurate.

uable than if they were. Some of these springs are so big that they are utilized for driving mills, cotton gins and other machinery, and as their discharges are subject to little or no fluctuations throughout the year, they are free from the dangers of freshets and the risks of drouths. Such are Loster's Spring, six miles west, and "Big Spring," six miles northwest of Batesville; another on Mill Creek, Stone county; one at Marble City, Newton county; another on Rush Creek,* Marion county, and one at Silver Spring, Benton county. At Mammoth Spring, in Fulton county, one of the finest water powers in the country is furnished by an enormous clear water spring.

Besides these truly gigantic springs, no one who travels through north Arkansas can fail to be impressed by the great number of large and beautiful springs to be found at every town and village, to say nothing of those at almost every farm house. Especially worthy of mention are the springs at Big Flat, Lone Rock, Harrison, Bellefonte, Valley Springs, Western Grove, Yardell, Marble City, Francis Postoffice (Bear Creek Springs), Berryville, Whitener and Spring Valley.

Fortunately, the Survey has made an analysis of a type of these fine springs—that of Valley Springs, Boone county. That analysis shows the water to contain only 15 grains of mineral matter to the gallon, almost all of which is carbonate of lime.

There is also an abundance of springs whose waters are remarkable for their purity; such are the Crescent Spring at Eureka, Carroll county, and Elixir Spring at Elixir, Boone county. These springs contain less than six grains of mineral matter to the gallon. It should be noted in regard to these two springs in particular, and the same is no doubt true of many other springs in that part of the state, that their waters pass down through cherts, rocks that have but little easily soluble matter in them, and this is no doubt the reason of their great purity.

Running across north Arkansas from Batesville to the

*The big spring near Rush post-office is on the line of Rush Creek fault.

Indian Territory line, near Tolu post-office, in Washington county, is a formation spoken of in the Survey's reports as the Batesville sandstone; it is the coarse, yellowish brown sandstone on which and partly of which Batesville is built. Several other towns of north Arkansas are built on this same sandstone; namely, Marcella, Buck Horn, Mountain View, Big Flat, Marshall, St. Joe and Green Forest. The object in referring to this sandstone at this time is to call attention to it as a valuable water reservoir. The towns mentioned above get their water supply from wells dug in this Batesville sandstone; the water is soft, cool and abundant.

The use of mineral waters.—It is a popular belief that mineral waters are "nature's remedies," and that as they are good things the more one has of them the better. The analyses of our mineral waters show that some of them contain large quantities of Epsom salt, Glauber's salt, and common salt. Now no one would suppose for a moment that the habitual daily use by a healthy person of large quantities of these salts could be anything else than injurious. Epsom salt is Epsom salt, and its physiological effects are the same whether one takes it from a sparkling spring in the mountain or from the bottles of a drug store. Some of the mineral waters of the state are highly charged with such ingredients; every gallon of the Potash Sulphur water contains 33 grains of Glauber's salt; every gallon of the National Spring water at National, Logan county, contains 33 grains of Glauber's salt and 46 grains of Epsom salt; every gallon of the water from Howard's mineral well at Sharp's Cross Roads, Independence county, contains 160 grains of Glauber's salt and 115 grains of Epsom salt. Such waters should not be used without some reference to what they contain. It is not meant to imply that these and similar waters are dangerous, but simply that they have important medicinal properties, that they should be used as medicines with discrimination, and that those who have no need for such medicines should not use them. It should be remembered also that whether a water is a good or bad one for general use depends, not on the amount of matter it

holds in solution, but rather on the quality of that matter. The waters containing carbonate of lime and the chalybeate waters are generally good ones, but the habitual use of magnesian waters is injurious to most persons, in spite of the fact that they may be beneficial to the same persons at times when they stand in need of such remedies. And because one can advantageously drink large quantities of the waters of Eureka Springs, Elixir Springs and Hot Springs—waters containing but little mineral matter in solution—it must not be inferred that he can drink like quantities of strong magnesian waters with similar effects.

CHAPTER II.

The Waters of the Hot Springs.

The waters of the Hot Springs claim the place of first importance in any consideration of the medicinally valuable waters of the state. For a great many years these waters have been used by people from all parts of the country with results that merit the serious attention of everyone, and strike the ordinary observer as nothing short of marvelous.

The Geological Survey undertook the chemical analyses of the waters of the principal ones of these hot springs in October and November, 1890. Analyses were made of the springs popularly known as "Egg," "Rector," "Big Iron," "Ral," "Alum," "Old Hale," and "Magnesia"—the principal ones in use.

It is the custom to speak of a large number of the hot springs, variously estimated at from fifty to seventy; but while hot water does issue from the ground at as many or more points, it is hardly worth while to dignify each of these trickling streams with the name spring. Those mentioned below are the ones and about the only ones in common use.

The discharge of some of the springs was determined for the Survey by Mr. Howard D. Mitchell, City Engineer of Hot Springs, and the results of the measurements are given in connection with the analyses.

For the purpose of determining the effect of piping the hot waters one analysis was made of the water used at the Rockafellow bath-house, which receives its supply from the Egg spring, about 1800 feet away. The sample was drawn from the hydrant in bath room No. 1. With this exception, whenever it was possible, the water used in these analyses were collected directly from the spring. In the case of the Ral, the spring itself was not accessible, and the water was therefore

collected as near the source as possible, which was at the end of the 60-foot iron pipe through which the water enters the distributing tank.

The water of the Magnesia spring was collected from the stream flowing through the brick discharge pipe beneath the Magnesia bath-house. The stream is shallow and the water had to be filtered before it could be used.

In each case a little more than eight gallons of the water were concentrated by evaporation to about half a pint. This part of the work was done in a temporary laboratory, a room for which was kindly furnished the Survey by Mr. Albert Gaines, in the New Rector bath-house, adjoining the Arlington Hotel.* The samples were collected by the Survey, and the evaporation made between October 24 and November 10, 1890; the analyses were completed at the Survey's laboratory at Little Rock.

The temperature determinations were made nearly every day, from October 24 to November 10, at the points from which the water was taken. The thermometer used in taking temperatures was afterwards sent to the office of the Superintendent of the United States Coast and Geodetic Survey at Washington where its graduation was carefully corrected, and the corrections were applied to the recorded temperatures.

Dr. Brackett furnishes the following notes regarding the methods followed in making the analyses: All determinations were made in duplicate. The following substances were looked for beside those mentioned in the constituents found: arsenic, antimony, copper, lead, tin, cæsium, rubidium, thallium. Lithium was determined spectroscopically, no chemical determination being attempted. There was not enough bromine, iodine and aluminum for estimation.

The methods of Gooch and Whitfield used in their analyses of Yellowstone waters were followed in the main. All the

*The Survey is indebted to Hon. E. W. Rector of Hot Springs; to Hon. Frank M. Thompson, Superintendent of the Reservation, and to Mr. S. H. Stitt of the Arlington Hotel, for assistance kindly rendered in connection with the analyses of the Hot Springs waters.

waters are colorless, tasteless and odorless, and have neutral or faintly acid reaction; owing to the presence of free carbonic acid they are sparkling and pleasant to drink.

The carbonic acid is in every case calculated as that necessary to satisfy the elements left over after all the chlorine and sulphuric acid have been used up. In calculating the hypothetical combination all the chlorine has been given to the sodium; the sulphuric acid has been given to the iron, potassium, and sodium in the order mentioned; and the elements remaining have been calculated as carbonates. The silica has been left as such. The carbonic acid, free and for bicarbonates, represents the difference between the combined and the total carbonic acid. The analyses of waters from each individual spring are given below, while in the table at the end the results are grouped together for more ready comparison.

Origin of the high temperature of the water.—There is naturally much curiosity on the part of visitors to Hot Springs regarding the cause of the high temperature of the waters. In the Yellowstone National Park where hot waters abound, the activity of igneous agencies offers a ready answer to such questions, but in Arkansas, where nearly all the rocks to be seen are of sedimentary origin, there is no evidence of recent volcanic activity, and such an explanation of temperature is not therefore so readily accepted. Some of the theories advanced to explain the hot waters are interesting only as curiosities, and are not mentioned here as having any other value. For example, it has been suggested that the heat comes from coal burning beneath the surface of the ground. It is perhaps enough to say that the Coal Measures to which coal is confined in Arkansas lie far to the north of Hot Springs, and that the hot waters come up through Lower Silurian rocks which contain no coal.

Of the theory that the heat may be produced by chemical action it may be said that the water itself gives no evidence of its having received its temperature in this way, its chief constituent being carbonate of lime.

So far as the geology of the region is concerned, if there

were no hot waters in the vicinity none would have been anticipated on geologic ground alone. But the water being hot, it seems most probable that its heat is derived from coming in contact with masses of hot rocks, the cool edges of which may or may not be exposed at the surface.

In entertaining this view one must entirely set aside the possibility of any historically recent eruptions. The story told by one writer of his having seen a volcanic outburst and streams of molten rock near Hot Springs* seems to be altogether improbable, for there is no evidence whatever of any such recent eruptive action, and such an eruption could not have taken place without having left readily recognizable traces. There are eruptive rocks near Hot Springs, however, though they are inconspicuous and are seldom seen by the visitors, and they certainly were not erupted within the past hundred years.

General conclusions.—These analyses of the waters of the hot springs appear to warrant the following conclusions:

I. The waters of the hot springs are very pure. On an average the several spring waters contain 12.94 grains of material in solution to the gallon. Of this material nearly 60 per cent is carbonate of lime, over 21 per cent is silica, 9 per cent is carbonate of magnesia, while the remainder is chiefly chloride of sodium (common salt), sulphate of soda (Glauber's salt), and sulphate of potash.

II. There is but little difference in the composition of the waters of the various springs.

III. The positive therapeutic qualities of these waters are due to physical rather than to chemical properties.†

IV. The waters may be piped without much loss of heat and without seriously injuring their medicinal value.

One may sometimes hear of the electric and magnetic properties of the hot springs waters; it is scarcely necessary to say more on this subject than that such ideas have no basis in fact.

*New York Medical Repository, Vol. III., 1806, pp. 47-50.

†It is worthy of note that with the exception of the silica constituents there is but little difference in chemical composition between the waters of the hot springs and that of the Big Chalybeate spring near Hot Springs.

They spring solely from the general disposition of people to surround such phenomena with mysteries.

ALUM SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	2.47	22.01
Chloride of soda ($NaCl$)	.31	2.76
Carbonate of soda (Na_2CO_3)	.01	.09
Carbonate of magnesia ($MgCO_3$)	1.07	9.54
Carbonate of lime ($CaCO_3$)	6.66	59.36
Sulphate of soda (Na_2SO_4)	.43	3.83
Sulphate of potash (K_2SO_4)	.25	2.23
Sulphate of iron ($FeSO_4$)	.02	.18
Total	11.22	100.00

Found.

Silica (SiO_2)	2.47	22.01
Sodium (Na)	.27	2.41
Potassium (K)	.11	.98
Magnesium (Mg)	.30	2.67
Calcium (Ca)	2.66	23.71
Lithium (Li)	trace	trace
Iron (Fe)	.01	.09
Aluminum; manganese (Al; Mn)	traces	traces
Sulphuric acid (SO_4)	.44	3.92
Carbonic acid (CO_3)	4.77	42.51
Bromine; iodine (Br; I.)	traces	traces
Chlorine (Cl)	.19	1.69
Phosphoric acid (P_2O_5)	trace	trace
Total	11.22	100.00

Amount of water used for analysis, 8.25 United States gallons.

Temperature, 115.88° F.

Total solid material in solution dried at 230° to 239° F. (110° to 115° C.), 13.12 grains per U. S. gallon.

Carbonic acid (CO_2), free and for bicarbonates, 5.12 grains per U. S. gallon.

BIG IRON SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	2.64	20.19
Chloride of soda (NaCl)	.28	2.14
Carbonate of soda (Na_2CO_3)	.03	.23
Carbonate of magnesia ($MgCO_3$)	1.21	9.26
Cabonate of lime ($CaCO_3$)	81.3	62.20
Sulphate of soda (Na_2SO_4)	.37	2.83
Sulphate of potash (K_2SO_4)	.34	2 60
Sulphate of iron ($FeSO_4$)	.07	.54
Total	13.07	99.99

Found.

Silica (SiO_2)	2.64	20.19
Sodium (Na)	.24	1.84
Potassium (K)	.15	1.15
Magnesium (Mg)	.34	2.60
Calcium (Ca)	2.85	21.80
Lithium (Li)	trace	trace
Iron (Fe)	.03	.23
Aluminum; manganese (Al; Mn)	traces	traces
Sulphuric acid (SO_4)	.49	3.75
Carbonic acid (CO_3)	6.16	47.14
Bromine; iodine (Br.; I.)	traces	traces
Chlorine (Cl)	.17	1.30
Total	13.07	100.00

Amount of water used for analysis, 8.24 United States gallons.

Temperature, 146.48° F.

Total solid material in solution dried at 230° to 239° F. (110° to 115° C.), 12.94 grains per U. S. gallon.

Carbonic acid (CO_2), free and for bicarbonates, 3.63 grains per U. S. gallon.

Discharge of the spring from 240,000 to 250,000 gallons every 24 hours.

EGG SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon	Per cent. of total solids.
Silica (SiO_2)	2.65	21.85
Chloride of soda (NaCl)	.25	2.06
Carbonate of soda (Na_2CO_3)	.13	1.07
Carbonate of magnesia ($MgCO_3$)	1.17	9.65
Carbonate of lime ($CaCO_3$)	7.26	59.85
Sulphate of soda (Na_2SO_4)	.36	2.97
Sulphate of potash (K_2SO_4)	.25	2.06
Sulphate of iron ($FeSO_4$)	.06	.49
Total	12.13	100 00

Found.

Silica (SiO_2)	2.65	21.88
Sodium (Na)	.27	2.22
Potassium (K)	.11	.91
Magnesium (Mg)	.33	2.73
Calcium (Ca)	2.90	23.95
Lithium (Li)	trace	trace
Iron (Fe)	.02	.17
Aluminum; manganese (Al; Mn)	traces	traces
Sulphuric acid (SO_4)	.42	3.47
Carbonic acid (CO_3)	5.26	43.43
Bromine; iodine (Br; I)	traces	traces
Chlorine (Cl)	.15	1.24
Total	12.11	100.00

Amount of water used for analysis, 8.30 United States gallons.

Temperature, 144.68° F.

Total solid material in solution dried at 230° to 239° F. (110° to 115° C.), 13 12 grains per U. S. gallon.

Carbonic acid (CO_2), free and for bicarbonates, 4.17 grains per U. S. gallon.

MAGNESIA SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	2.62	22.30
Chloride of soda ($NaCl$)	.26	2.21
Carbonate of soda (Na_2CO_3)	.06	.51
Carbonate of magnesia ($MgCo_3$)	1.20	10.21
Carbonate of lime ($CaCO_3$)	6.85	58.30
Sulphate of soda (Na_2SO_4)	.41	3.49
Sulphate of potash (K_2SO_4)	.27	2.30
Sulphate of iron ($FeSO_4$)	.08	.68
Total	11.75	100.00

Found.

Silica (SiO_2)	2.62	22.32
Sodium (Na)	.26	2.21
Potassium (K)	.12	1.02
Magnesium (Mg)	.34	2.90
Calcium (Ca)	2.74	23.34
Lithium (Li)	trace	trace
Iron (Fe)	.03	.26
Aluminum; manganese (Al; Mn)	traces	traces
Sulphuric acid (SO_4)	.48	4.09
Carbonic acid (CO_3)	5.00	42.59
Bromine; iodine (Br; I)	traces	traces
Chlorine (Cl)	.15	1.28
Total	11.74	100.00

Amount of water used for analysis, 10.92 United States gallons.

Temperature, 124.88° F.

Total solid materials in solution dried at 230° to 239° F. (110° to 115° C.), 13.06 grains per U. S. gallon.

Carbonic acid (CO_2), free and for bicarbonates, 5.76 grains per U. S. gallon.

OLD HALE SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	2.59	22.06
Chloride of soda ($NaCl$)	.24	2.04
Carbonate of soda (Na_2CO_3)	.06	.51
Carbonate of magnesia ($MgCO_3$)	1.03	8.77
Carbonate of lime ($CaCO_3$)	7.14	60.82
Sulphate of soda (Na_2SO_4)	.42	3.58
Sulphate of Potash (K_2SO_4)	.19	1.62
Sulphate of iron ($FeSO_4$)	.07	.60
Total	11.74	100.00

Found.

Silica (SiO_2)	2.59	22.04
Sodium (Na)	.26	2.21
Potassium (K)	.09	.77
Magnesium (Mg)	.29	2.47
Calcium (Ca)	2.85	24.25
Lithium (Li)	trace	trace
Iron (Fe)	.02	.17
Aluminum, manganese (Al; Mn.)	traces	traces
Sulphuric acid (SO_4)	.44	3.74
Carbonic acid (CO_3)	5.06	43.06
Bromine; iodine (Br.; I.)	traces	traces
Chlorine (Cl)	.15	1.28
Total	11.75	100.00

Amount of water used for analysis, 8.12 United States gallons.

Temperature, 142.9° F.

Total solid material in solution dried at 230° to 239° F. (110° to 115° C.), 13.47 grains per U. S. gallon.

Carbonic acid (CO_2), free and for bicarbonates, 5.60 grains per U. S. gallon.

Discharge of the spring 52,205 gallons every 24 hours.

RAL SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	2.53	22.08
Chloride of soda (NaCl)	.29	2.53
Carbonate of soda (Na_2CO_3)	.02	.17
Carbonate of magnesia ($MgCO_3$)	1.12	9.77
Carbonate of lime ($CaCO_3$)	6.78	59.16
Sulphate of soda (Na_2SO_4)	.44	3.84
Sulphate of potash (K_2SO_4)	.26	2 27
Sulphate of iron ($FeSO_4$)	.02	.18
Total	11.46	100.00

Found.

Silica (SiO_2)	2.53	22.08
Sodium (Na)	.27	2.35
Potassium (K)	.11	.96
Magnesium (Mg)	.32	2.79
Calcium (Ca)	2.71	23.65
Lithium (Li)	trace	trace
Iron (Fe)	.01	0.9
Aluminum; manganese (Al; Mn)	traces	traces
Sulphuric acid (SO_4)	.45	3.93
Carbonic acid (CO_3)	4.88	42.58
Bromine, iodine (Br.; I.)	traces	traces
Chlorine (Cl)	.18	1.57
Total	11.46	100.00

Amount of water used for analysis, 8.23 United States gallons.

Temperature 139.28° F.

Total solid material in solution, dried at 230° to 239° F. (110° to 115° C.), 12.83 grains per U. S. gallon.

Carbonic acid (CO_2), free and for bicarbonates, 4.57 grains per U. S. gallon.

Discharge of the spring 18,000 gallons every 24 hours.

RECTOR SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	2.59	21.64
Chloride of sodium (NaCl)	.27	2.25
Carbonate of soda (Na_2CO_3)	.01	.08
Carbonate of magnesia ($MgCO_3$)	1.09	9.11
Carbonate of lime ($CaCO_3$)	7.28	60.82
Sulphate of soda (Na_2SO_4)	.45	3.76
Sulphate of potash (K_2SO_4)	.22	1.84
Sulphate of iron ($FeSO_4$)	.06	.50
Total	11.97	100.00

Found.

Silica (SiO_2)	2.59	21.64
Sodium (Na)	.26	2.17
Potassium (K)	.10	.84
Magnesium (Mg)	.31	2.59
Calcium (Ca)	2.91	24.31
Lithium (Li)	trace	trace
Iron (Fe)	.02	.17
Aluminum; manganese (Al; Mn)	traces	traces
Sulphuric acid (SO_4)	.47	3.92
Carbonic acid (CO_3)	5.15	43.02
Bromine; iodine (Br; I)	traces	traces
Chlorine (Cl)	.16	1.34
Total	11.97	100.00

Amount of water used for analysis, 8.06 United States gallons.

Temperature, 139.28° F.

Total solid material in solution, dried at 230° to 239° F. (110° to 115° C.), 12.07 grains per U. S. gallon.

Carbonic acid (CO_2), free and for bicarbonates, 4.07 grains per U. S. gallon.

ROCKAFELLOW BATH-HOUSE.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	2.56	22.03
Chloride of soda (NaCl)	.28	2.41
Carbonate of soda (Na_2CO_3)	.01	.09
Carbonate of magnesia ($MgCO_3$)	1.09	9.38
Carbonate of lime ($CaCO_3$)	6.97	59.98
Sulphate of soda (Na_2SO_4)	.42	3.61
Sulphate of potash (K_2SO_4)	.23	1.98
Sulphate of iron ($FeSO_4$)	.06	.52
Total	11.62	100 00

Found.

Silica (SiO_2)	2.56	22.03
Sodium (Na)	.25	2.15
Potassium (K)	.10	.86
Magnesium (Mg)	.31	2.67
Calcium (Ca)	2.79	24.01
Lithium (Li)	trace	trace
Iron (Fe)	.02	.17
Aluminum; manganese (Al; Mn)	traces	traces
Sulphuric acid (SO_4)	.45	3.87
Carbonic acid (CO_3)	4.97	42.77
Bromine; iodine (Br; I)	traces	traces
Chlorine (Cl)	.17	1.47
Phosphoric acid (P_2O_5)	trace	trace
Total	11.62	100.00

Water said to be supplied from the Egg spring.

Amount of water used for analysis, 8.12 United States gallons.

Temperature, 134.78° F.

Total solid material in solution, dried at 230° to 239° F. (100° to 115° C.), 13.70 grains per U. S. gallon.

Carbonic acid (CO_2), free and for bicarbonates, 3.81 grains per U. S. gallon.

AVERAGE OF SEVEN SPRINGS.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	2.58	21.72
Chloride of soda (NaCl)	.27	2.27
Carbonate of soda (Na_2CO_3)	.04	.34
Carbonate of magnesia ($MgCO_3$)	1.13	9.51
Carbonate of lime ($CaCO_3$)	7.15	60.19
Sulphate of soda (Na_2SO_4)	.41	3.45
Sulphate of potash (K_2SO_4)	.25	2.10
Sulphate of iron ($Fe SO_4$)	.05	.42
Total	11.88	100.00

RESUME OF ANALYSES OF THE WATERS OF THE HOT SPRINGS OF ARKANSAS.

(In grains per United States gallon.)

Constituents (Hypothetical Combination).	Rockafellow Bath-House.	Egg.	Rector.	Big Iron.	Ral.	Alum.	Old Hale.	Magnesia.	Average of seven springs.
Silica (SiO_2)	2 56	2.65	2 59	2 64	2.53	2.47	2 59	2 62	2 58
Chloride of soda (NaCl)	28	25	.27	.28	.29	.31	.24	.26	.27
Carbonate of soda (Na_2CO_3)	.01	.13	.01	.03	.02	.01	.06	06	.04
Carbonate of magnesia ($MgCO_3$)	1.09	1 17	1 09	1 21	1.12	1.07	1.03	1 20	1.13
Carbonate of lime ($CaCO_3$)	6 97	7.26	7 28	8 13	6 78	6.66	7.14	6 85	7.15
Sulphate of soda (Na_2SO_4)	.42	.36	.45	.37	.44	43	.42	.41	.41
Sulphate of potash (K_2SO_4)	.23	25	.22	.34	.26	.25	.19	.27	.25
Sulphate of iron ($FeSO_4$)	.06	.06	06	.07	.02	.02	.07	.08	.05
Total	11 62	12 13	11.97	13.07	11 46	11 22	11.73	11.75	11.88
Total solid material in solution dried at 230° to 239° F. (110°-115° C.)	13 70	13 12	12.07	12 94	12 83	13 12	13.47	13 06	12.94
Carbonic acid (CO_2), free and for bicarbonates	3 81	4 17	4.07	3 63	4 57	5.12	5.66	5 76	4.71
Temperature in degrees F.	134.78	144 68	139 28	146 48	139 28	115 88	142 90	124 88	136.19

Average temperature, 136.02° F.

Total solid material in solution, dried at 230°–239° F. (110°–115° C.), 13.03 grains per U. S. gallon.

Carbonic acid (CO_2), free and for bicarbonates, 4.60 grains per U. S. gallon.

To give some idea of the comparative amount of solids in solution in the hot springs waters the total solids of several of the well known waters of the state as determined by the Geological Survey are given below:

SOLIDS IN SOLUTION IN ARKANSAS SPRINGS.

	Grains per gallon.
Happy Hollow spring, Hot Springs	1.69
Elixir spring, Boone county	4.25
Gum spring, Mt. Nebo, Yell county	5.00
Crescent spring, Eureka Springs	5.36
Darling spring, Mt. Nebo, Yell county	5 89
Griffins spring, White county	7.32
Armstrong spring, White county	9.39
Big Chalybeate spring, near Hot Springs	12.08
Hot Springs (average of 7)	*12.94*
Mammoth spring, Fulton county	15.56
Blanco spring, Garland county	16.41
Mountain Valley, Garland county	16.52
Searcy sulphur spring, Searcy, White county	17.73
White sulphur water, Sulphur Springs, Benton county	22.59
Black sulphur spring, Heber, Cleburne county	30.87
Ellington gas well, Magazine, Logan county	31.13
Red sulphur spring, Heber, Cleburne county	34.63
Potash Sulphur spring, Garland county	51.89
Lithia spring, near Hope, Hempstead county	67.69
Barnwell's well, Batesville, Independence county	131.60
National spring, National, Logan county	151.23
Howard's well, Sharp's Cross Roads, Independence county	263.91
Arkansas River water at Little Rock (filtered)	7 to over 60

In order to add still more to our knowledge of the composition of the matter dissolved in the hot waters, analyses were made of the deposits formed by them. The old deposit or tufa was collected east of the Arlington hotel on Hot Springs Mountain, and represents a white seam in the dark colored tufa formed three years ago by the action of the hot springs.

The recent deposit is of the material formed in the vapor chamber of room No. 8 by the Big Iron spring in the Big Iron bath-house. This material differs from the hard, white, crystalline matter composing the seam in the older tufa, being soft and flaky; most of the material is of a brownish yellow color;

only the whitest portions of the specimen were taken for analysis.

Below are the analyses of the older tufa and of the deposit from the Big Iron bath-house For the sake of comparison there is placed beside them an analysis of the portion of the evaporate of the Big Iron spring water which is insoluble in hot distilled water.

TUFA DEPOSIT FROM BIG IRON SPRING.

Deposit formed in room No. 8, Big Iron Bath-house.

*Analysis of air-dried tufa.**

	I. Per cent.		II. Per cent.
Silica (SiO_2)	.21	Silica (SiO_2)	.21
Soda (Na_2O)	.34	Soda (Na_2O)	.34
Potash (K_2O)	trace	Potash (K_2O)	trace
Magnesia (MgO)	trace	Magnesia (MgO)	trace
Lime (CaO)	55.69	Carbonate of lime ($CaCO_3$)	99.43
Oxide of iron (Fe_2O_3)	.45	Oxide of iron (Fe_2O_3)	.45
Oxide of manganese (Mn_2O_3)	trace	Oxide of manganese (Mn_2O_3)	trace
Alumina (Al_2O_3)	trace (?)	Alumina (Al_2O_3)	trace (?)
Sulphuric acid (SO_3)	trace	Sulphuric acid (SO_3)	trace
Chlorine (Cl)	.07	Chlorine (Cl)	.07
Loss on ignition (CO_2 etc.)	43.71	Water at 135°C	.02
Water 135°C	.02		
Total	100.49	Total	100.52

*In column II the lime of column I has been calculated as carbonate and sulphate. In column II the total is higher than the total of column I. This is due to the fact that all the lime of column I was calculated as carbonate, though the carbonic acid (loss on ignition) 43.71 lacked .03 per cent. of being sufficient to satisfy all the lime.

TUFA.

Tufa in the rear (east) of Arlington Hotel.

Analysis of air-dried tufa.

I.	Per cent.	II.	Per cent.
Silica (SiO_2)	.16	Silica (SiO_2)	.16
Soda (Na_2O)	.27	Soda (Na_2O)	.27
Potash (K_2O)	trace	Potash (K_2O)	trace
Magnesia (MgO)	trace	Magnesia (MgO)	trace
Lime (CaO)	55.52	Carbonate of lime ($CaCO_3$)	98.93
Oxide of iron (Fe_2O_3)	.13	Oxide of iron (Fe_2O_3)	.13
Alumina (Al_2O_3)	trace	Alumina (Al_2O_3)	trace
Oxide of manganese (Mn_2O_3)	.00	Oxide of manganese (Mn_2O_3)	.00
Sulphuric acid (SO_3)	.16	Sulphate of lime ($CaSO_4$)	.27
Chlorine (Cl)	.02	Chlorine (Cl)	.02
Loss on ignition (CO_2 etc.)	43.76	Loss on ignition	.24
Water at 135°C	.12	Water at 135°C	.12
Total	100.14	Total	100.14

*In column II the lime of column I is calculated as carbonate and sulphate.

ANALYSES OF HOT SPRINGS DEPOSITS.

Constituents.	Tufa.	Big Iron Tufa.	*Portion of evaporate of the Big Iron spring insoluble in distilled water.
Silica (SiO_2)	.16	.21	24.76
Soda (Na_2O)	.27	.34	.00
Potash (K_2O)	trace	trace	.00
Magnesia (MgO)	trace	trace	2.58
Carbonate of magnesia ($MgCO_3$)	.00	.00	4 60
Carbonate of lime ($CaCO_3$)	98.93	99.43	67.76
Sulphate of lime ($CaSO_4$)	.27	trace	4.60
Oxide of iron (Fe_2O_3)	.13	.45	.30
Oxide of manganese (Mn_2O_3)	.00	trace	trace
Alumina (Al_2O_3)	trace	trace	trace
Chlorine (Cl)	.02	.07	.00
Loss on ignition	.24	.00	undt.
Water lost at 230°-239°F (110°-115°C)	.12	.02	undt.
Total	100.14	100.52	100 00

*This was thoroughly dried in the air, after having been previously dried at 212°–239° F. (100°–115° C.). The carbonic acid was not determined quantitatively. All the lime has been calculated as carbonate, and enough of the magnesia as carbonate to bring the analysis to a hundred.

The analyses show a close agreement between the composition of the old and recent deposits. The analysis of the insoluble portion of the evaporate (which was evaporated to dryness on a water bath before extracting with distilled water) shows the presence, as is usual in most hot waters, of a rather large quantity of silica, though the fact would not be suspected from the composition of the deposits. The absence of notable quantities of silica and magnesia in these deposits is of course due to the relatively easy solubility of these substances compared with that of carbonate of lime.

CHAPTER III.

Quantitative Mineral Analyses of Water.

Except those of the Hot Springs, which are given in the preceding chapter, analyses of all the springs and wells, which have been analyzed quantitatively, are given in this chapter. They are arranged in alphabetic order. In some cases, however, where there is a group, as in that of the Sugar Loaf Springs, they are all brought together under the head of "Sugar Loaf Springs." The springs about Mt. Nebo are grouped under the head of "Mt. Nebo Springs." The best and quickest way to find any analysis, however, will be to refer to the index at the end of the volume.

SEDIMENT IN ARKANSAS RIVER WATER.

	Per cent.
Silica (SiO_2)	69.53
Soda (Na_2O)	1.14
Potash (K_2O)	.66
Magnesium carbonate ($MgCO_3$)	3.51
Calcium carbonate ($CaCO_3$)	6.62
Iron oxide(Fe_2O_3)	4.46
Alumina (Al_2O_3)	11.65
Loss on ignition	2.95
Total	100.52
Water lost at 110°–115° C	3.31

Material dried at 110°–115° C.

Collected by assistant C. E. Taft, May 2, 1888, when the river stood at seventeen feet on the gauge.

Analysis by J. P. Smith.

ARKANSAS RIVER WATER, LOW STAGE.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids
Silica (SiO_2)	.85	1.83
Chloride of soda (NaCl) (common salt)	28.57	61.58
Chloride of potash (KCl)	.68	1.47
Carbonate of lime ($CaCO_3$)	8.47	18.26
Sulphate of soda (Na_2SO_4) (Glauber's salt)	2.72	5.86
Sulphate of magnesia ($MgSO_4$) (Epsom salt)	3.92	8.45
Sulphate of lime ($CaSO_4$)	.75	1.62
Sulphate of iron ($FeSO_4$)	.05	.11
Sulphate of alumina ($Al_2(SO_4)_3$)	.38	.82
Total	46.36	100 00

Found.

Silica (SiO_2)	.85	1.83
Sodium (Na)	12.14	26.15
Potassium (K)	.35	.75
Magnesium (Mg)	.78	1.68
Calcium (Ca)	3.56	7.68
Iron (Fe)	.02	.04
Aluminum (Al)	.06	.13
Sulphuric acid (SO_4)	5.90	12.73
Carbonic acid (CO_3)	5.08	10.96
Chlorine (Cl)	17.62	38.91
Total	46.36	100.00

The sample was taken from the hydrant in the Survey's laboratory at Little Rock, August 22, 1888, when the river marked 2.4 feet on the U. S. gauge. The water was slightly cloudy, but easily filtered clear.

Total solid material in solution, 72.23 grains per U. S. gallon.*

*If the water of crystallization be calculated for the salts given in the hypothetical combination and deducted from this amount, the total solid material in solution will be 46.46 grains per U. S. gallon.

ARKANSAS RIVER WATER, HIGH STAGE.

Hypothetical Combination.

Constituents.	Grains per U. S. Gallon.	Per cent. of total solids.
Silica (SiO_2)	.75	11.81
Chloride of soda (NaCl) (common salt)	1.96	30.87
Chloride of potash (KCl)	.44	6.93
Carbonate of soda (Na_2CO_3)	1.07	16.85
Carbonate of magnesia ($MgCO_3$)	.28	4.41
Carbonate of lime ($CaCO_3$)	1.13	17.80
Sulphate of magnesia ($MgSO_4$) (Epsom salt)	.14	2.20
Sulphate of iron ($FeSO_4$)	.43	6.77
Sulphate of alumina ($Al_2(SO_4)_3$)	.15	2.36
Total	6.35	100.00

Found.

Silica (SiO_2)	.75	11.83
Sodium (Na)	1.24	19.57
Potassium (K)	.23	3 63
Magnesium (Mg)	.11	1.73
Calcium (Ca)	.45	7.10
Iron (Fe)	.16	2.52
Aluminum (Al)	.02	32
Sulphuric acid (SO_4)	.51	8 04
Carbonic acid (CO_3)	1.48	23.34
Chlorine (Cl)	1.39	21.92
Total	6.35	100.00

The sample was taken from the hydrant in the Survey's laboratory at Little Rock, December 20, 1888, when the river marked nine feet on the gauge. The water was very muddy, and was filtered for analysis.

Total solid material in solution, 7.17 grains per U. S. gallon.

These two analyses of the Arkansas River water were made in order to find out its composition at both low and high water.

Determinations were made of the amounts of dissolved matter and of suspended matter in the Arkansas River water covering an entire year. The results of these observations are given in the chapter on river observations in another part of this report.

ARMSTRONG SPRING.

White County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	3.04	28.07
Chloride of soda (NaCl)	.90	8.31
Carbonate of soda (Na_2CO_3)	1.27	11.73
Carbonate of magnesia ($MgCO_3$)	1.12	10.34
Carbonate of lime ($CaCO_3$)	3.32	30.66
Sulphate of soda (Na_2SO_4)	.69	6.37
Sulphate of iron ($FeSO_4$)	.23	2.12
Sulphate of alumina ($Al_2(SO_4)_3$)	.26	2.40
Total	10.83	100.00

Found.

Silica (SiO_2)	3.04	28.07
Sodium (Na)	1.13	10.43
Potassium (K)	trace	trace
Magnesium (Mg)	.32	2.96
Calcium (Ca)	1.33	12.28
Lithium (Li)	trace	trace
Iron (Fe)	.08	.74
Aluminum (Al)	.04	.37
Sulphuric acid (SO_4)	.83	7.66
Carbonic acid (CO_3)	3.51	32.41
Chlorine (Cl)	.55	5.08
Total	10.83	100.00

Water collected by assistant J. H. Means, June 5, 1891.

Total solid material in solution, 9.39 grains per U. S. gallon.

Temperature of the air, 81.68° F.; of water, 61.88° F.

Armstrong spring is in White county, in township 8 N., 8 W., section 33, the southwest quarter; the water comes from arenaceous shale of the Barren Coal Measures, and is near the axis of the Searcy anticline. The spring is five feet deep; the water is drawn through a pipe from the bottom, and is clear, odorless and sparkling; it has a slightly chalybeate taste, and forms the usual yellow deposit at the end of the waste-pipe.

BIG CHALYBEATE SPRING.

Garland County.

Hypothetical combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.22	1.65
Chloride of soda (NaCl)	.20	1.50
Chloride of lithium (LiCl)	trace	trace
Carbonate of magnesia ($MgCO_3$)	1.12	8 39
Carbonate of lime ($CaCO_3$)	10.24	76.70
Carbonate of iron ($FeCO_3$)	.89	6.67
Sulphate of potash (K_2SO_4)	.66	4.94
Sulphate of magnesia ($MgSO_4$)	.02	.15
Total	13.35	100.00

Found.

Silica (SiO_2)	.22	1.64
Sodium (Na)	.08	.60
Potassium (K)	.18	1.34
Magnesium (Mg)	.24	1.79
Calcium (Ca)	4.10	30.55
Iron (Fe)	.43	3.20
Sulphuric acid (SO_4)	.55	4.10
Carbonic acid (CO_3)	7.50	55.89
Chlorine (Cl)	.12	.89
Total	13.42	100.00

Water collected by assistant H. E. Williams; analysis by A. E. Menke.

Total solid material in solution, 12.08 grains per U. S. gallon.

Temperature of air, 40.28° F.; water, 78.98°F.

The Big Chalybeate spring is in Garland county, township 2 S., 19 W., section 22, near the center of the northwest quarter of the southeast quarter. It comes from shales of Lower Silurian age, that underlie the novaculites of that region.

The spring is rectangular in shape, about 6 feet wide by 9 feet long and from 15 inches to 2 feet deep. The loose rocks in the bottom of the pool are covered with patches of flocculent, moss-like deposit, of pale greenish or reddish yellow color, adhering in places. The deposit in the stream flowing from the spring is light reddish yellow near the spring, changing to bright, slightly yellowish red farther away. It covers the rocks, leaves, and twigs over which the water flows.

There is a gas given off which rises to the surface frequently, causing a slight effervescence.

The discharge of the Big Chalybeate spring is 268,540 gallons every 24 hours (determined by H. D. Mitchell.)

BLALOCK SPRINGS.

Polk County.

Hypothetical Combination.

Constituents.	Grains per U. S. Galoln.	Per cent. of total solids.
Chloride of soda (NaCl)	2.07	11.17
Chloride of lithia (LiCl)	.35	1.90
Sulphate of soda (Na_2SO_4)	1.85	9.99
Sulphate of potash (K_2SO_4)	.37	2.00
Sulphate of magnesia ($MgSO_4$)	2.08	11.22
Sulphate of lime ($CaSO_4$)	8 36	45.05
Sulphate of iron ($Fe\ SO_4$)	.24	1.30
Organic matter	3.23	17.37
Total	18.54	100.00

Found.

Sodium (Na)	1.42	7.65
Potassium (K)	.17	.91
Magnesium (Mg)	.41	2.21
Calcium (Ca)	2 46	13.25
Lithium (Li)	.14	.74
Iron (Fe)	.09	.47
Sulphuric acid (SO_4)	9.18	49.46
Chlorine (Cl)	1.47	7 90
Organic matter	3.22	17.31
Total	18.56	100.00

Analysis by C. M. Riley.*

Total solid material in solution, 18.56 grains per U. S. gallon.

Sulphuretted hydrogen (H_2S), 6.94 grains per U. S. gallon.

*For comparison with other analyses the sulphuretted hydrogen, given as 17.83 cubic inches, has been calculated to grains per U. S. gallon; the constituent elements have been calculated from the hypothetical combination, and the percentages of total solid material in solution are given in a separate column.

Blalock springs are near the head of Saline Creek, in 4 S., 20 W., Section 19.

BLANCO SPRING.

Garland County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	1.29	7.93
Chloride of potash (KCl)	.06	.37
Chloride of magnesia ($MgCl_2$)	.51	3.13
Carbonate of soda (Na_2CO_3)	.53	3.26
Carbonate of potash (K_2CO_3)	.28	1.72
Carbonate of magnesia ($MgCO_3$)	1.16	7.13
Carbonate of lime ($CaCO_3$)	11.71	71.98
Sulphate of magnesia ($MgSO_4$)	.14	.86
Sulphate of lime ($CaSO_4$)	.52	3.20
Iron oxide (Fe_2O_3)	.03	.18
Alumina (Al_2O_3)	.04	.24
Total	16.27	100.00

Found.

Silica (SiO_2)	1.29	7.93
Sodium (Na)	.23	1.41
Potassium (K)	.19	1.17
Calcium (Ca)	4.84	29.73
Magnesium (Mg)	.49	3.10
Iron (Fe)	.02	.12
Aluminum (Al)	.02	.12
Sulphuric acid (SO_4)	.48	2.95
Carbonic acid (CO_3)	8.28	50.86
Chlorine (Cl)	.41	2.52
Oxygen (basic)	.03	.18
Total	16.28	100.00

Total solid material in solution, 16.41 grains per U. S. gallon.

Blanco spring is in township 2 S., 21 W., section 1, at the center of the northeast quarter, in rocks of the Lower Silurian formation.

BLANCO SPRING DEPOSIT.

The natural deposit made by the Blanco spring was analyzed with the following result:

Analysis of the deposit made by Blanco spring.

Silica (SiO_2)		4.81
Soda (Na_2O) } by difference		.71
Potash (K_2O) } by difference		.71
Magnesia (MgO)		.11
Lime (CaO)		50.61
Iron (ferric oxide) (Fe_2O_3)		.42
Alumina (Al_2O_3)		1.21
Phosphoric acid (P_2O_5)		.07
Loss on ignition		42.06
Total		100.00
Water lost at 230°–239° F. (110°–115° C.)		.78

Material dried at 230°–239° F. (110°–115° C.)

BON AIR (CHALYBEATE) SPRING.

Stone County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.70	17 24
Chloride of soda (NaCl)	.30	7.39
Carbonate of magnesia ($MgCO_3$)	.70	17.24
Carbonate of lime ($CaCO_3$)	1.08	26.60
Carbonate of iron ($FeCO_3$)	.91	22.42
Sulphate of lime ($CaSO_4$)	.37	9.11
Total	4.06	100 00

Found.

Silica (SiO_2)	.70	17.24
Sodium (Na)	.12	2.96
Magnesium (Mg)	.20	4.93
Calcium (Ca)	.54	13.30
Iron (Fe)	.44	10.84
Sulphuric acid (SO_4)	.26	6.40
Carbonic acid (CO_3)	1.62	39.90
Chlorine (Cl)	.18	4.44
Total	4.06	100.00

Water collected by assistant T. C. Hopkins, December 18, 1891.

Analysis by A. E. Menke.

Total solids in solution, 4.75 grains per U. S. gallon.

The Bon Air spring is on top of the Boston Mountains in the southeastern part of Stone county, in 13 N., 9 W., section 8, the northwest quarter. It is half a mile southeast of the public road from Mountain View to Bradford, seven miles from Marcella, the nearest post-office, at the foot of the mountain, and twenty miles from Batesville, the nearest railway station. The spring forms the waters of one of the small tributaries of Coon Creek, which flows into the Devil's Fork of Red River. It is 150 feet below the highest point of the mountain and 1200 feet above sea level.

There are three springs close together, only one of which is

used for its medicinal properties, and the water from which was analyzed. This one has a strong flow, throwing out a stream of remarkably clear water, large enough to fill a two-inch pipe. There is a heavy deposit of iron in the spout through which the water flows, and in a box or trough in which it collects, making it frequently necessary to clean out the sediment from the latter. There is a bank 20 feet or more in diameter apparently made up of deposit from this spring, the most of the deposit, however, being carried away in the rivulet that flows close by. A considerable deposit of iron is formed around what is apparently a small seep a few feet from the main spring, but which is reported to be a flowing stream when opened. Another spring, which apparently contains but little mineral matter, is situated in the bed of the rivulet, but is concealed by the brook in wet weather, and shows only in dry weather when the brook above it is dry. The main spring is affected but slightly by the rains, and a stream flows at all seasons.

The water flows from the base of a bed of yellow ferruginous sandstone from 25 to 30 feet thick that is close to the top of the mountain and near the base of the Coal Measures. No other rock was observed on the mountain near the spring.

Many claim to have been benefitted by the use of this water. It is visited in the summer season by many persons who come and camp for several weeks or months at a time. Two families reside permanently at the spring. One of the dwelling houses was built for a hotel and used for a time as such. The region about is but thinly settled.—[T. C. Hopkins.]

CRAB ORCHARD SALTS.

Hypothetical Combination.

Constituents.	Per cent.
Silica (SiO_2)	.13
Chloride of soda (NaCl) (common salt)	8.78
Chloride of potash (KCl)	1.83
Sulphate of potash (K_2SO_4)	.98
Sulphate of magnesia ($MgSO_4$) (Epsom salt)	47.17
Sulphate of iron ($FeSO_4$)	.30
Alumina (Al_2O_3)	trace(?)
Water (H_2O) lost at 200°C	38.09
Organic matter (by difference)	2.72
Total	100.00

Found.

Silica (SiO_2)	.13
Sodium (Na)	3.46
Potassium (K)	1.40
Magnesium (Mg)	9.43
Calcium (Ca)	.00
Iron (Fe)	.11
Aluminum (Al)	trace(?)
Sulphuric acid (SO_4)	38.47
Chlorine (Cl)	6.19
Water (H_2O) lost at 200°C	38.09
Organic matter (by difference)	2.72
Total	100.00

Bottle labeled "O. K. Crab Orchard Salts, bottled by Old Kentucky Medici Co. Office and headquarters, Louisville, Ky. 25 cents per bottle." The sample used was bought from the stock kept by one of the leading druggists at Little Rock.

This analysis of Kentucky Crab Orchard Salts, a medicine in common use in the South, was made for comparison with the constituents of some of the waters of this state. The analysis shows that the Crab Orchard Salts are a mixture of Epsom salt and a little common salt.

DIAMOND SPRING.

Benton County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.52	3.80
Chloride of soda (NaCl)	.01	.07
Carbonate of lime ($CaCO_3$)	13.12	95.96
Carbonate of iron ($FeCO_3$)	.02	.15
Sulphate of magnesia ($MgSO_4$)	.003	.02
Total	13.673	100.00

Found.

Silica (SiO_2)	.52	3.80
Sodium (Na)	.005	.04
Magnesium (Mg)	.006	.04
Calcium (Ca)	5.25	38.38
Iron (Fe)	.01	.07
Sulphuric acid (SO_4)	.002	.02
Carbonic acid (CO_3)	7.88	57.61
Chlorine (Cl)	.006	.04
Total	13.679	100.00

Water collected by assistant T. C. Hopkins.

Analysis by A. E. Menke.

Temperature of air, 29.3° F. (-1.5° C.) of water, 57.2°F. (14° C.)

Total solids in solution, 11.66 grains per U. S. gallon.

Diamond spring is one mile east of Rogers, in township 19 N., 29 W., section 7; it is a large, clear spring with sparkling water, emerging from the Boone chert. It furnishes the water supply for the town of Rogers, the water being forced by steam into a standpipe in the town. The water is also used in several fish ponds near the spring.

The Dove Park Springs.

The Dove Park Springs, formerly generally and still locally known as the "Brown Springs," are in Hot Spring county, in township 6 S., 18 W., section 35, the northeast quarter, about four miles east of Witherspoon, a station on the Iron Mountain Railway. They are on low ground close to the banks of White Oak Creek, and owing to the boggy nature of the region it would be difficult to determine their exact number. There are, however, not less than six flowing springs with numerous seeps, many of which might flow if opened.

A hill of sand covered with gravel, and about 50 feet high, extends in a general east and west direction along the south side of White Oak Creek south of the springs, forming a bluff on the creek bank a few hundred yards above the main group. At the base of this hill is a small exposure of yellow clay. The soil about the springs is of a clayey nature.

A considerable deposit of iron is formed around all the springs. The water has a pleasant taste and no odor. It is reported to act strongly on the liver and kidneys. There is no village about the springs, and but few houses, which during the summer season are often occupied by visitors; in November 1891, there was no one living there, the nearest resident being half a mile south.

Water for analysis was collected from these springs by assistant T. C. Hopkins.

DOVE PARK SPRING NO. I.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	3.26	29.66
Chloride of soda ($NaCl$)	1.37	12.47
Carbonate of magnesia ($MgCO_3$)	.59	5.37
Carbonate of lime ($CaCO_3$)	2.92	26.57
Carbonate of iron ($FeCO_3$)	.74	6.73
Sulphate of soda (Na_2SO_4)	1.91	17.38
Alumina (Al_2O_3)	.20	1.82
Total	10.99	100.00

Found.

Silica (SiO_2)	3.26	29.69
Sodium (Na)	1.16	10.56
Magnesium (Mg)	.17	1.55
Lime (CaO)	1.63	14.84
Iron (Fe)	.35	3.19
Alumina (Al_2O_3)	.20	1.82
Sulphuric acid (SO_4)	1.29	11.75
Carbonic acid (CO_3)	2.09	19.04
Chlorine (Cl)	.83	7.56
Total	10.98	100.00

Analysis by A. E. Menke.

Temperature of air, 70.88° F.; temperature of water 61.7° F.

Total solids in solution, 11.16 grains per U. S. gallon.

DOVE PARK SPRING NO. 2.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	3.60	39.47
Chloride of soda (NaCl)	.89	9.76
Carbonate of magnesia ($MgCO_3$)	.79	8.66
Carbonate of lime ($CaCO_3$)	1.97	21.60
Carbonate of iron ($FeCO_3$)	.69	7.57
Sulphate of soda (Na_2SO_4)	.96	10.53
Alumina (Al_2O_3)	.22	2.41
Total	9.12	100.00

Found.

Silica (SiO_2)	3.60	39.48
Sodium (Na)	.66	7.24
Magnesium (Mg)	.22	2.42
Lime (CaO)	1.10	12.05
Iron (Fe)	.35	3.86
Alumina (Al_2O_3)	.22	2.46
Sulphuric acid (SO_4)	.65	7.14
Carbonic acid (CO_3)	1.77	19.42
Chlorine (Cl)	.54	5.94
Total	9.11	100.00

Analysis by A. E. Menke.

Temperature of air, 70.88° F.; temperature of water, 63.5° F.

Total solids in solution, 9.25 grains per U. S. gallon.

DOVE PARK SPRING NO. 3.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	3.61	38.00
Chloride of soda (NaCl)	1.03	10.84
Carbonate of magnesia ($MgCO_3$)	.51	5.37
Carbonate of lime ($CaCO_3$)	1.97	20.74
Carbonate of iron ($FeCO_3$)	.88	9.26
Sulphate of soda (Na_2SO_4)	1.24	13.05
Alumina (Al_2O_3)	.26	2.74
Total	9.50	100.00

Found.

Silica (SiO_2)	3.61	38 01
Sodium (Na)	.80	8.43
Magnesium (Mg)	.15	1.59
Lime (CaO)	1.10	11.59
Iron (Fe)	.42	4.43
Alumina (Al_2O_3)	.26	2.75
Sulphuric acid (SO_4)	.84	8.86
Carbonic acid (CO_3)	1.69	17.80
Chlorine (Cl)	.62	6.54
Total	9.49	100.00

Analysis by A. E. Menke.

Temperature of air, 40.68° F.; temperature of water, 63.05° F.

Total solids in solution, 9.08 grains per U. S. gallon.

DOVE PARK SPRING NO. 4.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	3.59	44.82
Chloride of soda (NaCl)	.89	11.11
Carbonate of lime ($CaCO_3$)	.83	10.36
Carbonate of iron ($FeCO_3$)	.74	9.24
Sulphate of soda (Na_2SO_4)	1.84	22.97
Alumina (Al_2O_3)	.12	1.50
Total	8.01	100.00

Found.

Silica (SiO_2)	3.59	44.88
Sodium (Na)	.94	11.75
Lime (CaO)	.46	5.75
Iron (Fe)	.35	4.38
Alumina (Al_2O_3)	.12	1.50
Sulphuric acid (SO_4)	1.25	15.62
Carbonic acid (CO_3)	.75	9.37
Chlorine (Cl)	.54	6.75
Total	8.00	100.00

Analysis by A. E. Menke.

Temperature of air, 72.68° F.; temperature of water, 62.15° F.

Total solids in solution, 8.83 grains per U. S. gallon.

ELECTRIC SPRING.

Rogers, Benton County.

Constituents.	Grains per U. S. gallon.
Silica (SiO_2)	.552
Iron and alumina (Fe, Al)	.025
Chloride of soda (NaCl)	.174
Chloride of potash (KCl)	.008
Sulphate of potash (K_2SO_4)	.397
Sulphate of lime ($CaSO_4$)	.328
Bi-carbonate of lime ($CaCO_3, CO_2$)	20.488
Bi-carbonate of magnesia ($MgCO_3, CO_2$)	.488
Total	22.460

Temperature of the air, 90° F.; of the water, 55° F.

Analysis made in 1881 by Potter and Riggs of St. Louis, Mo.; copy kindly furnished by Prof. W. B. Potter.

"The water belongs to the calcic or lime class of waters with small quantities of the alkalies. There is no free gas in the water and the mineral matter is not sufficient to give a taste to it. In general character it is not unlike the Bethesda water of Waukesha, Missouri, and the Yellow Springs water of Ohio." [Potter and Riggs.]

The springs are a little over two hundred feet lower than the town of Rogers, and about a mile and a quarter distant from that town. A line for an electric railway has been surveyed from the town to the springs. There is one hotel on the hill near the springs, two hotels at the springs, and one other in the process of erection.

ELIXIR SPRING.

Boone County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	1.41	33.53
Chloride of soda (NaCl)	.26	6.18
Chloride of potash (KCl)	.01	.24
Carbonate of soda (Na_2CO_3)	.60	14.27
Carbonate of lime ($CaCO_3$)	1.92	45.66
Carbonate of iron ($FeCO_3$)	.001	.02
Sulphate of magnesia ($MgSO_4$)	.004	.10
Total	4.205	100.00

Found.

Silica (SiO_2)	1.41	32.46
Sodium (Na)	.36	8.29
Potassium (K)	.05	1.15
Magnesium (Mg)	.0008	.02
Calcium (Ca)	.77	17.72
Iron (Fe)	.0005	.01
Sulphuric acid (SO_4)	.0032	.07
Carbonic acid (CO_3)	1.59	36.60
Chlorine (Cl)	.16	3.68
Total	4.3445	100.00

Water collected by assistant T. C. Hopkins, February 7, 1892.
Analysis by A. E. Menke.
Temperature of air, 41.9° F.; of water, 55.4° F.
Total solids in solution, 4.25 grains per U. S. gallon.

Elixir springs are in 20 N., 19 W., section 36, near the head of one of the terminal ravines of upper Sugar Loaf Creek. There are two principal springs, one on each side of the ravine, and several minor ones in the immediate vicinity. They emerge near the top of the Silurian rocks from saccharoidal sandstone and siliceous limestone. The one on the east side of the ravine and below the post-office is at a lower level than the one on the west side opposite the post-office, the latter being about ten feet and the former ninety feet below the Carboniferous

rocks. The one on the west side of the ravine is the stronger spring and is the one from which the water was taken for analysis. The result of the analysis shows the water to contain less solid matter in solution than that of any of the springs of the north part of the state that have been analyzed. This is no doubt due in great measure to the fact that the water was taken for analysis shortly after heavy rains when the springs were swollen to twice their normal size.

At one time, it is reported, these springs were thronged with health and pleasure seekers, but they have now (1892) an air of desertion. There is a post-office, a store, a livery stable, a number of vacant houses and three or four occupied dwellings.

ESCULAPIA SPRINGS.

Benton County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Chloride of soda ($NaCl$)	.84	6.80
Chloride of potash (KCl)	.23	1.86
Carbonate of soda (Na_2CO_3)	6.29	50.93
Carbonate of lime ($CaCO_3$)	3.49	28.26
Sulphate of magnesia ($MgSO_4$)	.08	.65
Sulphate of iron ($FeSO_4$)	1.42	11.50
Total	12.35	100.00

Found.

Silica (SiO_2)	.75	5.72
Sodium (Na)	3.06	23.34
Potassium (K)	.11	.84
Magnesium (Mg)	.01	.08
Calcium (Ca)	1.40	10.68
Iron (Fe)	.40	3.05
Sulphuric acid (SO_4)	1.09	8.32
Carbonic acid (CO_3)	5.66	43.17
Chlorine (Cl)	.63	4.80
Total	13.11	100.00

Water collected by assistant T. C. Hopkins.

Analysis by A. E. Menke.

Temperature of air, 27.04° F.; of water, 52.7° F.

Total solid material in solution, 15.00 grains per U. S. gallon.

The Esculapia springs are in township 19 N., 29 W., section 16, the southeast quarter; they are noted for their medicinal properties. There are two of the springs, walled in with cut limestone. They occur in the Boone chert formation at the base of the Lower Carboniferous, in the bottom of a small ravine about 200 yards north of the road from Rogers to Van Winkle mill, and three miles from Rogers. A few years ago several houses were built near the springs, which were at the time the resort of a number of invalids. Title to the property being in dispute, the houses were abandoned and the springs are now

but rarely visited. Analysis of the water from the larger of the two springs is given above.

EUREKA SPRINGS.

Carroll County.

Of the numerous mineral springs in north Arkansas none are so well known or so much frequented as the Eureka springs, around which a town of several thousand inhabitants has grown up, and which are visited by people from all parts of the United States. The town is located at the terminus of the Eureka Springs Railway, in township 20 N., 26 W., sections 10 and 15, on the hills and slopes of the terminal ravines of one of the tributaries of Leatherwood Creek; most of the noted springs occur in the town, with some others immediately adjoining. The strongest flowing ones are Basin, Sycamore and the one near the middle of section 11, but they are all perennial. The one most patronized by invalids is the Basin spring, yet many of the others are much frequented.

BASIN SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.31	5.30
Chloride of soda ($NaCl$)	.19	3.25
Bi-carbonate of soda ($NaHCO_3$)	.15	2.56
Bi-carbonate of magnesia ($MgCO_3, CO_2$)	.47	8.03
Bi-carbonate of lime ($CaCO_3, CO_2$)	4.43	75.73
Sulphate of soda (Na_2SO_4)	.09	1.54
Sulphate of potash (K_2SO_4)	.13	2.22
Iron and alumina (Fe; Al)	.08	1.37
Total	5.85	100.00

Analysis by Potter and Riggs, St. Louis, Mo.

Free ammonia, 0.14 parts in a million; albumoid ammonia, 0.07 parts in a million.

Nearly all the springs are affected to some extent by heavy rains, after which the volume of water is increased, and for a

few hours the water contains sediment; at all other times they are noted for their clearness and purity. Their purity is shown in the following determinations of the total solids in solution, made by F. W. Clarke, chemist of the U. S. Geological Survey:

Total solids in solution in Eureka springs.

Name of spring.	Grains per U. S. gallon.	Total solids per million parts of water.
Crescent Spring	5.365	92.0
Dairy Spring	6.30	108.0
Basin Spring	6.97	119.6
Magnetic Spring	7.70	132.0

Prof. Clarke says: "These waters contain mainly carbonates of lime and magnesia, with small amounts of sulphates, chlorides and alkalies."

Two miles south of Eureka Springs, in Greenwood Hollow, are a number of small springs, similar in appearance to those in the town, at which a large sanitarium is now in process of erection, and an artificial lake being made.

FRISCO SPRING.

Benton County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.41	3.49
Chloride of soda (NaCl)	.86	7.52
Chloride of potash (KCl)	.14	1.22
Carbonate of lime ($CaCO_3$)	8.77	76.66
Carbonate of iron ($FeCO_3$)	.84	7.34
Sulphate of magnesia ($MgSO_4$)	.42	3.67
Total	11.44	100.00

Found.

Silica (SiO_2)	.41	3.58
Sodium (Na)	.34	2.29
Potassium (K)	.07	.61
Magnesium (Mg)	.08	.70
Calcium (Ca)	3.51	30.65
Iron (Fe)	.41	3.58
Sulphuric acid (SO_4)	.34	2.97
Carbonic acid (CO_3)	5.70	49.78
Chlorine (Cl)	.59	5.15
Total	11.45	100.00

Water collected by assistant T. C. Hopkins, March 18, 1892.
Analysis by A. E. Menke.
Temperature of air, 38.3° F.; of water, 53.6° F.
Total solids in solution, 10.41 grains per U. S. gallon.

The Frisco spring is in township 19 N., 29 W., section 33, the southwest quarter, and has a local reputation for great healing properties. It flows out of the chert formation of the Lower Carboniferous age at the head of a ravine 65 feet below the top of the hill and 340 feet above White River. A nice grove covers the top of the hill above the spring, from which a fine view may be obtained, overlooking the White River valley and the mountains to the northeast. Two families live at the spring, and there are three other houses occupied in the summer.

Grandma Chase's Springs.

Garland County.

Grandma Chase's springs are in Garland county, about six miles northeast of the city of Hot Springs.

The best known of the springs are the Red Chalybeate and the Dripping springs. These come from the north face of Cutter's Mountain and are on the south side of the middle fork of Gulpha Creek. The rocks of this region belong to the Lower Silurian age.

DRIPPING SPRINGS.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.81	6.12
Chloride of soda (NaCl)	.30	2.26
Chloride of potash (KCl)	.05	.38
Chloride of magnesia ($MgCl_2$)	.20	1.51
Carbonate of lime ($CaCO_3$)	10.90	82.33
Sulphate of magnesia ($MgSO_4$)	.59	4.46
Sulphate of lime ($CaSO_4$)	.19	1.43
Sulphate of iron ($FeSO_4$)	.20	1.51
Total	13.24	100.00

Found.

Silica (SiO_2)	.81	6.11
Sodium (Na)	.12	.90
Potassium (K)	.03	.23
Magnesium (Mg)	.17	1.28
Calcium (Ca)	4 42	33 36
Lithium (Li)	.00	.00
Iron (Fe)	.07	.53
Aluminum (Al)	trace	trace
Sulphuric acid (SO_4)	.73	5.51
Carbonic acid (CO_3)	6.54	49.36
Chlorine (Cl)	.36	2.72
Phosphoric acid (P_2O_5)	.00	.00
Total	13.25	100.00

Water collected by R. N. Brackett, November 3, 1889.
Temperature of water, 59.18° F.
Total solid material in solution, 13.003 grains per U. S. gallon.
Carbonic acid (CO_2), free and for bicarbonates, 3.33 grains per U. S. gallon.

These little springs issue almost at the foot of the north slope of Cutter's Mountain, on the west bank of the middle fork of Gulpha Creek, in township 2 S., 18 W., section 30, the northwest quarter of the northwest quarter.

The water is clear, tasteless and odorless, with a neutral reaction. No deposit of iron is made by the water.

The water for analysis was collected from what appeared to be the boldest of these springs, which is next to the last one going up the creek (east), and low down on the bank of the creek. The flow of this spring is intermittent. A stream of clear water about the size of an ordinary lead pencil flows from five to ten minutes at a time.

RED CHALYBEATE SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.72	24.74
Chloride of soda (NaCl)	.08	24.75
Chloride of potash (KCl)	.01	.34
Chloride of magnesia ($MgCl_2$)	.19	6.53
Carbonate of lime ($CaCO_3$)	.18	6.19
Sulphate of magnesia ($MgSO_4$)	.49	16.84
Sulphate of lime ($CaSO_4$)	.49	16.84
Sulphate of iron ($FeSO_4$)	.75	25.77
Total	2.91	100.00

Found.

Silica (SiO_2)	.72	24.87
Sodium (Na)	.03	1.04
Potassium (K)	.005	.17
Magnesium (Mg)	.14	4.84
Calcium (Ca)	.22	7.60
Lithium (Li)	good trace	good trace
Iron (Fe)	.27	7.33
Aluminum (Al)	trace	trace
Sulphuric acid (SO_4)	1.21	41.79
Carbonic acid (CO_3)	.11	3.80
Chlorine (Cl)	.19	6.56
Phosphoric acid (P_2O_5)	strong trace	strong trace
Total	2.89	100.00

Water collected by R. N. Brackett, November 3, 1889.

Amount of water used for analysis, 1½ gallons.

Temperature of water, 62.78° F.

Total solid material in solution, 3.02 grains per U. S. gallon.

Carbonic acid (CO_2), free and for bicarbonates, 6.34 grains per U. S. gallon.

Grandma Chase's Red Chalybeate spring is in township 2 S., 19 W., section 25, the northeast quarter of the northeast quarter, south of Mrs. Chase's house. The water collects in an old hollow stump, forming a copious deposit of reddish brown hydroxide of iron on the sides and at the bottom; it is clear, and has a very slight odor, but no sulphuretted hydrogen.

GRIFFIN SPRING.

White County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	1.54	21.78
Chloride of soda (NaCl)	.06	.85
Chloride of potash (KCl)	.01	.14
Chloride of magnesia ($MgCl_2$)	1.15	16.27
Carbonate of lime ($CaCO_3$)	1.82	25 74
Sulphate of magnesia ($MgSO_4$)	.22	3 11
Sulphate of lime ($CaSO_4$)	2.16	30.55
Sulphate of iron ($FeSO_4$)	.11	1.56
Total	7.07	100.00

Found.

Silica (SiO_2)	1.54	6.13
Sodium (Na)	.02	.08
Potassium (K)	.01	.04
Magnesium (Mg)	.33	1.32
Calcium (Ca)	1.36	5 42
Iron (Fe)	.04	.16
Sulphuric acid (SO_4)	1.77	7 04
Carbonic acid (CO_3)	19.14	76.23
Chlorine (Cl)	.90	3.58
Total	25.11	100.00

Water collected by assistant J. P. Smith, March 23, 1888.

Temperature of air, 50° F.; of water, 58° F.

Total solid material in solution, 7.33 grains per U. S. gallon.

Carbonic acid (CO_2), free and for bicarbonates, 18.05 grains per U. S. gallon.

Griffin Spring is in White county, in township 8 N., 17 W., section 28, the southwest quarter of the northeast quarter, about four miles north slightly west from the town of Searcy.

The water issues from rocks of the Barren Coal Measures and is strongly chalybeate.

A small hotel has been built for the accommodation of visitors but of late years very few health or pleasure seekers have visited the place.

Immediately north of the spring is an escarpment from 125

to 175 feet high with a bed of sandstone at the top, which has a low dip to the north, slightly west.

Happy Hollow Springs.

Garland county.

The Happy Hollow springs are in Happy Hollow in the city of Hot Springs, Garland county, about 600 yards northeast of the Arlington Hotel.

HAPPY HOLLOW SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.38	23.30
Chloride of soda (NaCl)	.22	13.51
Chloride of potash (KCl)	.04	2.45
Chloride of magnesia ($MgCl_2$)	.001	.05
Carbonate of magnesia ($MgCO_3$)	.09	5.51
Carbonate of lime ($CaCO_3$)	.77	47.23
Sulphate of magnesia ($MgSO_4$)	.09	5.51
Sulphate of alumina ($Al_2(SO_4)_3$)	.02	1.22
Sulphate of iron ($FeSO_4$)	.02	1.22
Total	1.63	100.00

Found.

Silica (SiO_2)	.38	23.00
Sodium (Na)	.09	5.43
Potassium (K)	.02	1.20
Magnesium (Mg)	.04	2.43
Calcium (Ca)	.31	18.77
Lithium (Li)	.00	.00
Iron (Fe)	.01	.54
Aluminum (Al)	.004	.20
Sulphuric acid (SO_4)	.11	6.65
Carbonic acid (CO_3) calculated	.53	32.10
Bromine and Iodine (Br, I)	.00	.00
Chlorine (Cl)	.16	9.68
Phosphoric acid (P_2O_5)	trace	trace
Manganese (Mn)	trace	trace
Titanium (Ti)	.00	.00
Total	1.654	100.00

Total solid material in solution, dried at 110°–115° C., 1.69 grains per U. S. gallon.
Free carbonic acid (CO_2), 4.54 grains per U. S. gallon.

The water is colorless, odorless and tasteless, with neutral reaction.

The following analysis* of Happy Hollow spring water, made by R. B. Riggs, of the U. S. Geological Survey, is added for comparison.

Hypothetical Combination.

Constituents.	Grains per U. S gallon.	Per cent. of total solids.
Silica (SiO_2)	.30	29.13
Chloride of sodium (NaCl)	.28	27.18
Carbonate of soda (Na_2CO_3)	.16	15.53
Carbonate of lime ($CaCO_3$)	.24	23.30
Alumina and iron sesquioxide (Al_2O_3 and Fe_2O_3)	.05	4.85
Total	1.03	99.99

Found.

Silica (SiO_2)	.30	29.13
Sodium and Potassium (Na, K)	.18	17.50
Calcium (Ca)	.10	9.71
Alumina and iron sesquioxide (Al_2O_3 and Fe_2O_3)	.05	4.84
Carbonic acid (CO_3)	.23	22.32
Chlorine (Cl)	.17	16.50
Total	1.03	100.00

Total solid material in solution, 1.04 grains per U. S. gallon (by analysis).
Carbonic acid (CO_2), free, 1.28 grains per U. S. gallon.

*The bicarbonates given by Mr. Riggs have been calculated as carbonates, and results changed from grammes per litre to grains per U. S. gallon.

HAPPY HOLLOW CHALYBEATE SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.86	28.17
Chloride of soda (NaCl)	.35	11.46
Chloride of potash (KCl)	.10	3 28
Carbonate of magnesia ($MgCO_3$)	.20	6.55
Carbonate of lime ($CaCO_3$)	.20	6.55
Sulphate of potash (K_2SO_4)	.003	.10
Sulphate of magnesia ($MgSO_4$)	.16	5.24
Sulphate of iron ($FeSO_4$)	1.01	33.08
Sulphate of alumina ($Al_2(SO_4)_3$)	.17	5.57
Total	3.05	100.00

Found.

Silica (SiO_2)	.86	28.10
Sodium (Na)	.14	4.58
Potassium (K)	.05	1 63
Magnesium (Mg)	.09	2.94
Calcium (Ca)	.08	2 61
Lithium (Li)	trace	trace
Iron (Fe)	.37	12.09
Aluminum (Al)	.03	.98
Manganese (Mn)	.00	.00
Sulphuric acid (SO_4)	.92	30.07
Carbonic acid (CO_3)	.26	8.50
Phosphoric acid (P_2O_5)	.00	.00
Chlorine (Cl)	.26	8.50
Bromine and iodine (Br and I)	.00	.00
Barium and strontium (Ba, Sr)	.00	.00
Titanic acid (TiO_2)	.00	.00
Total	3.06	100.00

A little less than seven gallons of the water was collected and concentrated for analysis.

The temperature of the air ranged from 50.9° to 74.3° F

Average temperature of the water, 64.58° F.

Total solid material in solution, 3.81 grains per U. S. gallon.

Carbonic acid (CO_2), free and for bicarbonates, 6.43 grains per U. S. gallon.

This spring is about 100 feet west of the Happy Hollow spring.

The water has a faint chalybeate taste and the sides of the pipe through which it flows and the bottom of the spring are

covered with a flocculent, yellowish-red precipitate of hydrated oxide of iron; the water is colorless and odorless.

Hominy Hill Springs.

Pulaski County.

There are two springs at Hominy Hill, in Pulaski county, township 1 N., 14 W., section 27, at General Garland's place. The water comes from shales of Lower Silurian age.

OLD OR UPPER SPRING.

Hypothetical Combination.

Constituents	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.71	10.95
Carbonate of soda (Na_2CO_3)	.80	12.32
Carbonate of potash (K_2CO_3)	.41	6.32
Carbonate of magnesia ($MgCO_3$)	.69	10.55
Carbonate of lime ($CaCO_3$)	3.54	54.62
Sulphate of lime ($CaSO_4$)	.34	5.24
Total	6.49	100.00
Carbonic acid (CO_2), free	1.61	

Found.

Silica (SiO_2)	.71	11.09
Sodium (Na)	.27	4.23
Potassium (K)	.23	3.60
Magnesium (Mg)	.20	3.13
Calcium (Ca)	1.51	23.57
Lithium (Li)	trace	trace
Iron and aluminum (Fe and Al)	traces	traces
Sulphuric acid (SO_4)	.24	3.76
Carbonic acid (CO_3)	3.25	50.62
Bromine and iodine (Br and I)	.00	.00
Chlorine (Cl)	trace	trace
Boric acid (B_2O_3)	.00	.00
Ammonium (NH_4)	.00	.00
Total	6.41	100.00
Carbonic acid (CO_2), free	1 61	

Total solid material in solution, 6.50 grains per U. S. gallon (by analysis).

NEW OR LOWER SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.58	13.55
Carbonate of soda (Na_2CO_3)	.48	11.22
Carbonate of potash (K_2CO_3)	.12	2.80
Carbonate of magnesia ($MgCO_3$)	.48	11.22
Carbonate of lime ($CaCO_3$)	1.92	44.86
Sulphate of lime ($CaSO_4$)	.70	16.35
Total	4.28	100.00
Carbonic acid (CO_2), free	.53	

Found.

Silica (SiO_2)	.58	13.52
Sodium (Na)	.21	4.90
Potassium (K)	.07	1.63
Magnesium (Mg)	.14	3.26
Calcium (Ca)	.98	22.83
Lithium (Li)	trace	trace
Iron (Fe)	trace	trace
Aluminum (Al)	.00	.00
Sulphuric acid (SO_4)	.49	11.42
Carbonic acid (CO_3)	1.82	42.42
Boric acid (B_2O_3)	.00	.00
Ammonium (NH_4)	.00	.00
Bromine and iodine (Br and I)	.00	.00
Chlorine (Cl)	trace	trace
Total	4 29	100.00
Carbonic acid (CO_2), free	.53	

Total solid material in solution, 4.30 grains per U. S. gallon.

The above analyses* of the two springs were made in the laboratory of the U. S. Geological Survey, by J. E. Whitfield.

*The bicarbonates in these analyses have been reduced to carbonates, and the results, which are expressed by Mr. Whitfield in grains to the liter, have been recalculated to grains per U. S. gallon in order to make these analyses comparable with with the others.

Howard's Mineral Wells.

Independence County.

Howard's Mineral Wells or "Crystal Wells" are near Sharp's Cross Roads, in Independence county, 14 N., 5 W., section 28, the southeast quarter of the northeast quarter, about 7 miles northeast of Batesville. The analyses given of these waters show them to be highly charged with mineral salts. Both the waters and the dry salts obtained by evaporation are shipped to various points for medicinal uses. There are two wells, each 41 feet deep, with 18 feet of water. Well No. 2 is about 30 feet south of well No. 1. They are in Lower Carboniferous rocks, in the formation known as the Fayetteville shale. The water is colorless, odorless, and has a saline taste.

WELL NO. 1.

Hypothetical Combination.

Contituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	3.02	1.31
Chloride of soda (NaCl)	7.48	3.24
Carbonate of lime ($CaCO_3$)	55.01	23 80
Sulphate of soda (Na_2SO_4)	8.63	3.73
Sulphate of potash (K_2SO_4)	4.30	1.86
Sulphate of magnesia ($MgSO_4$)	115.26	49.86
Sulphate of lime ($CaSO_4$)	37.14	16.07
Sulphate of iron ($FeSO_4$)	.30	.13
Total	231.14	100.00

Found.

Silica (SiO_2)	3.02	1.31
Sodium (Na)	5.74	2.48
Potassium (K)	1.93	.83
Magnesium (Mg)	23.04	9.97
Calcium (Ca)	32.93	14.25
Lithium (Li)	trace	trace
Iron (Fe)	.11	.05
Aluminum (Al)	trace	trace
Sulphuric acid (SO_4)	126.83	54.87
Carbonic acid (CO_3)	33.00	14.28
Phosphoric acid (P_2O_5)	.00	.00
Chlorine (Cl)	4 53	1.96
Total	231.13	100.00

Water collected by assistant J. H. Means, May 25, 1891.

Temperature of air, 70.88° F.; of water, 60.08° F.

Total solids in solution, 263.91 grains per U. S. gallon.

WELL NO. 2.

Hypothetical combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	1.77	1.82
Chloride of soda (NaCl)	3.12	3.20
Carbonate of lime ($CaCO_3$)	29.99	30.77
Sulphate of soda (Na_2SO_4)	3.88	3.98
Sulphate of potash (K_2SO_4)	1.64	1.68
Sulphate of magnesia ($MgSO_4$)	34.17	35.61
Sulphate of lime ($CaSO_4$)	22.11	22.69
Sulphate of iron ($FeSO_4$)	.24	.25
Total	97.46	100.00

Found.

Silica (SiO_2)	1.77	1.81
Sodium (Na)	2.49	2.55
Potassium (K)	.74	.76
Magnesium(Mg)	6.94	7.12
Calcium (Ca)	14.50	14.88
Lithium (Li)	trace	trace
Iron (Fe)	.09	.09
Aluminum (Al)	trace	trace
Sulphuric acid (SO_4)	47.06	48.28
Carbonic acid (CO_3)	21.99	22.57
Phosphoric acid (P_2O_5)	trace	trace
Chlorine (Cl)	1.89	1.94
Total	97.47	100.00

Water collected by assistant J. H. Means, May 25, 1891.

Temperature of air, 70.88° F.; of water, 59.18° F.

Total solid material in solution, 92.36 grains per U. S. gallon.

LINCOLN COUNTY WATER.

Hypothetical Combination.

Constituents.	Grains per U. S. Gallon.	Per cent. of total solids.
Silica (SiO_2)	2.50	22.42
Chloride of soda ($NaCl$)	1.70	15.25
Carbonate of soda (Na_2CO_3)	1.55	13.19
Carbonate of magnesia ($MgCO_3$)	1 20	10.76
Carbonate of lime ($CaCO_3$)	2.59	23.22
Sulphate of soda (Na_2SO_4)	.58	5.20
Sulphate of potash (K_2SO_4)	.08	.72
Sulphate of iron ($FeSO_4$)	.59	5.30
Sulphate of alumina ($Al_2(SO_4)_3$)	.36	3.23
Total	11.15	100.00

Found.

Silica (SiO_2)	2.50	22.38
Sodium (Na)	1.53	13.70
Potassium (K)	.04	.36
Magnesium (Mg)	.34	3.04
Calcium (Ca)	1.04	9.31
Lithium (Li)	trace	trace
Iron (Fe)	.22	1.97
Aluminum (Al)	.06	54
Sulphuric acid (SO_4)	1.12	10.03
Carbonic acid (CO_3)	3.29	29.45
Chlorine (Cl)	1.03	9.22
Total	11.17	100.00

Water for analysis collected by John C. Hendricks; received at the laboratory, May 14, 1891.

Total solid material in solution, 10.21 grains per U. S. gallon.

The water is from township 9 S., 7 W., section 20, in Lincoln county. The geologic formations of this region belong to the Tertiary period, but locally there are many deposits of later origin.

The water is clear, odorless and tasteless, with a neutral reaction. It forms a considerable precipitate of hydroxide of of iron and alumina. The residue, when burned, for the most part turns white, giving off slight fumes and the odor of burnt organic matter.

LITHIA SPRING.

Baxter County.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.*
Chloride of soda	4.000	16.25
Bi-carbonate of iron	1.100	4.47
Bi-carbonate of lithia	2.130	8 66
Sulphate of magnesia	.832	3.38
Sulphate of lime (sol.)	.320	1.30
Sulphate of alumina	9.873	40.10
Sulphate of zinc	5.112	20.77
Phosphate of soda	1.246	5.07
Total	24.613	100.00

The above analysis is reported to have been made by Drs. R. J. Leonard and B. F. Denton, of Louisville and St. Louis.

The spring is in township 19 N., 14 W., section 28, the northeast quarter of the northeast quarter. Dr. B. F. Denton, who kindly gives the information regarding the locality of the spring, reports its discharge as 4320 gallons per 24 hours.

*The per cents here given were calculated by the Geological Survey from the grains per U. S. gallon, as given by Leonard and Denton.

LITHIA SPRING.

Hempstead County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silicate of soda (Na_2SiO_3)	9.62	14.96
Silicate of potash (K_2SiO_3)	.02	.03
Chloride of soda (NaCl)	13.82	21.53
Chloride of magnesium ($MgCl_2$)	11.13	17.31
Carbonate of lime ($CaCO_3$)	8.02	12.48
Sulphate of magnesia ($MgSO_4$)	4.75	7.39
Sulphate of lime ($CaSO_4$)	4.05	6 30
Sulphate of iron ($FeSO_4$)	2.81	4.37
Sulphate of alumina ($Al_2(SO_4)_3$)	2.14	3.33
Organic matter	7.91	12.30
Total	64.27	100.00

Found.

Silica (SiO_2)	4.74	7.37
Sodium (Na)	9.08	14.12
Potassium (K)	.01	.02
Magnesium (Mg)	3.76	5.85
Calcium (Ca)	4.40	6 84
Lithium* (Li)	undt.	undt.
Iron (Fe)	1.03	1.63
Aluminum (Al)	.34	.53
Sulphuric acid (SO_4)	10.24	15.93
Carbonic acid (CO_3) calculated	4.81	7.48
Chlorine (Cl)	16.70	25.97
Oxygen (basic)	1.26	1.96
Organic matter	7.91	12.30
Total	64.28	100.00

Water collected by J. C. Branner, May 7, 1889.

Total solid material in solution, 67.69 grains per U. S. gallon.

This spring is five and a half miles south of Hope. The country is gently rolling; the rocks are of Tertiary age.

The water is clear but has a brownish yellow color and contains much organic matter. A slight sediment was formed in each bottle.

*The spectroscope shows a strong lithium line.

MAGAZINE SPRING—(ELLINGTON'S GAS WELL).

Logan County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	1.96	6.16
Chloride of soda (NaCl)	3.25	10.21
Chloride of potash (KCl)	.19	.60
Carbonate of soda (Na_2CO_3)	20.94	65.74
Carbonate of magnesia ($MgCO_3$)	.01	.03
Carbonate of lime ($CaCO_3$)	.70	2.20
Sulphate of potash (K_2SO_4)	.29	0.90
Sulphate of iron ($FeSO_4$)	.09	.28
Sulphate of alumina ($Al_2(SO_4)_3$)	.05	.16
Organic matter	4.37	13.72
	31.85	100.00
Carbonic acid (CO_2), free and for bicarbonates	9.59	
Total	41.44	

Found.

Silica (SiO_2)	1.96	4.73
Sodium (Na)	10.38	25.03
Potassium (K)	.23	.56
Magnesium (Mg)	.004	.01
Calcium (Ca)	.28	.68
Lithium (Li)	.00	.00
Iron (Fe)	.03	.07
Aluminum (Al)	.01	.03
Sulphuric acid (SO_4)	.26	.63
Carbonic acid (CO_3)	21.86	52.74
Chlorine (Cl)	2.06	4.97
Sulphuretted hydrogen (H_2S)	sl't trace	sl't trace
Organic matter	4.37	10.55
Total	41.44	100.00

Water for analysis collected by assistant J. P. Smith, June 3, 1889.

Temperature of the air, 62.78° F.; of water, 51.34° F.

Total solid material in solution, 31.13 grains per U. S. gallon.

Magazine spring (Ellington's gas well) is in Logan county, in township 6 N., 26 W., section 19, the northeast quarter, about 400 yards northeast of Capt. W. J. Ellington's house, and one mile east of Magazine.

The water is very clear and has a discharge of one gallon in two minutes. It comes from a black pyritiferous shale of the Coal Measures twelve feet beneath the surface of the ground. The reaction is neutral; lead paper gave no reaction for sulphuretted hydrogen, though bubbles of gas which may be ignited rise in the pipe. Heavy rains do not appear to alter the discharge or the clearness of the water.

MAMMOTH SPRING.

Fulton County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids
Silica (SiO_2)	.81	5.65
Carbonate of soda (Na_2CO_3)	.40	2.79
Carbonate of magnesia ($MgCO_3$)	5.45	37.99
Carbonate of lime ($CaCO_3$)	7.32	51.02
Sulphate of soda (Na_2SO_4)	.10	.70
Sulphate of potash (K_2SO_4)	.21	1.42
Alumina (Al_2O_3)	.06	.43
Total	14.35	100 00

Found.

Silica (SiO_2)	.81	5.65
Sodium (Na)	.21	1.46
Potassium (K)	.09	.63
Magnesium (Mg)	1.55	10.81
Calcium (Ca)	2.93	20.43
Iron (Fe)	trace	trace
Aluminum (Al)	.03	.21
Sulphuric acid (SO_4)	.19	1.33
Carbonic acid (CO_2)	8.51	59.34
Oxygen (basic)	.02	.14
Chlorine (Cl)	trace	trace
Total	14.34	100.00

Water collected for the Survey, by F. W. Gibb, July 23, 1887.

Temperature of the water 57.50° F.

Total solid material in solution, 15.56 grains per U. S. gallon.

Carbonic acid (CO_2), free, 1.67 grains pe U. S. gallon, determined by F. W. Gibb.

Mammoth spring, which derives its name from its enormous discharge of water, is just south of the north boundary line of the state, in township 21 N., 7 W., section 5. The spring flows from the south side of a low, rocky ridge and forms a large pool where it comes out of the rock. The water remains clear at all seasons, except after long continued rains, when it becomes clouded. Its temperature remains about constant throughout the year, not varying much from 60° F. The rocks in the vicinity are chiefly the silico-magnesian limestones of Lower Silurian age.

The variation in the discharge at different seasons of the year is said to be very slight. Gen. Dandridge McRae* gives the discharge as "9000 barrels a minute," and adds that "so large an amount of carbonic acid is held in solution that the surface of the wonderful fountain is in a continual state of effervescence."

*Products and Resources of Arkansas, Little Rock, 1885, p. 22.

MINERAL SPRING.

Howard County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	1.91	51.27
Chloride of soda (NaCl)	.29	7.79
Chloride of potash (KCl)	.01	.27
Carbonate of soda (Na_2CO_3)	1.02	27.38
Carbonate of lime ($CaCO_3$)	.47	12.62
Carbonate of iron ($FeCO_3$)	.02	.54
Sulphate of magnesia ($MgSO_4$)	.005	.13
Sulphuretted hydrogen (H_2S)	trace	trace
Total	3.725	100.00

Found.

Silica (SiO_2)	1.91	51.19
Sodium (Na)	.56	15.01
Potassium (K)	.006	.16
Magnesium (Mg)	.001	.02
Calcium (Ca)	.19	5.09
Iron (Fe)	.01	.27
Sulphuric acid (SO_4)	.004	.11
Carbonic acid (CO_3)	.87	23.32
Chlorine (Cl)	.18	4.72
Total	3.731	100.00

Water collected by assistant T. C. Hopkins, January 23, 1892.

Analysis by A. E. Menke.

Temperature of air, 43° F.; of water, 53° F.

Total solid material in solution, 4.66 grains per U. S. gallon.

Mineral spring is at a little village of the same name in Howard county, eight miles southwest of Nashville, the nearest railway point. The spring emerges from the base of a low gravel hill of Pleistocene age, on which the village is located. It is in the southwest part of the village, on the north bank of a little brook that flows to the southeast. The spring is curbed with a piece of sewer pipe, 20 to 30 inches in diameter, from which the water flows in a stream that half fills a circular opening an inch in diameter. There is a small deposit of

iron oxide around the mouth of the spring. The village of Mineral Spring contains a post office, drug store, two general stores, a church, a school-house and about 100 inhabitants. Several mineral springs at Nashville have a local reputation for medicinal properties.

MOUNTAIN SPRING.

Lonoke County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.46	9.33
Chloride of soda (NaCl)	.23	4.67
Carbonate of magnesia ($MgCO_3$)	.92	18.66
Carbonate of lime ($CaCO_3$)	.88	17.85
Carbonate of iron ($FeCO_3$)	1.94	39.35
Sulphate of lime ($CaSO_4$)	.50	10.14
Total	4.93	100.00

Found.

Silica (SiO_2)	.46	9.33
Sodium (Na)	.09	1.83
Magnesium (Mg)	.26	5.27
Calcium (Ca)	.50	10.14
Iron (Fe)	.94	19.07
Sulphuric acid (SO_4)	.35	7.10
Carbonic acid (CO_3)	2.19	44.42
Chlorine (Cl)	.14	2.84
Total	4.93	100.00

Water collected by assistant T. C. Hopkins.

Analysis by A. E. Menke.

Temperature of air, 44.78° F.; temperature of water, 59° F.

Total solids in solution, 4.16 grains per U. S. gallon.

Mountain spring is on the southeast point of a low ridge, five miles north of west from Austin, in 5 N., 10 W., section 33, in the northwest corner of Lonoke county.

There is a considerable deposit of iron in and around the spring. The water flows in a small stream from a crevice near the base of a ledge of yellow ferruginous sandstone of the

Barren Coal Measures. The ridge on which the spring is situated is mainly composed of sandstone, a small outcrop of black shale showing near the top of the hill and larger outcrops of shale along the road leading from the base of the hill east towards Austin.

The spring is about 60 feet below the top of the hill, 40 feet above the base of the hill, and 180 feet above Austin (barometric measurement).

There is a church 200 to 300 yards northeast of the spring. One family is living about a quarter of a mile northeast of the spring and another about half a mile south of it.

MOUNTAIN VALLEY SPRING.

Garland County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.91	5.51
Chloride of soda ($NaCl$)	.43	2.60
Carbonate of magnesia ($MgCO_3$)	1.90	11.50
Carbonate of lime ($CaCO_3$)	11.38	68.86
Sulphate of soda (Na_2SO_4)	.64	3.88
Sulphate of potash (K_2SO_4)	.06	.37
Sulphate of magnesia ($MgSO_4$)	.74	4.49
Sulphate of iron ($FeSO_4$)	.02	.12
Sulphate of alumina ($Al_2(SO_4)_3$)	.44	2.67
Total	16.52	100.00

Found.

Silica (SiO_2)	.91	5.51
Sodium (Na)	.38	2.30
Potassium (K)	.03	0.19
Magnesium (Mg)	.69	4.18
Calcium (Ca)	4.55	27.51
Iron (Fe)	.01	.06
Aluminum (Al)	.07	.43
Barium and strontium (Ba, Sr)	.00	00
Sulphuric acid (SO_4)	1.45	8.78
Carbonic acid (CO_3) calculated	8.18	49 46
Bromine, iodine, manganese, titanium, lithium (Br, I, Mn, Ti, Li)	.00	.00
Chlorine (Cl)	.26	1.58
Phosphoric acid (P_2O_5)	.00	.00
Total	16.53	100.00

The water for analysis was collected by assistant L. S. Griswold, from the largest and most used spring at Mountain Valley.

Mountain Valley is in township 1 S., 19 W., section 19, due north of Hot Springs, a distance, by the road, of twelve miles. The water comes from rocks of the Lower Silurian formation, on the south side of a considerable ridge.

It tastes of iron and forms an iron deposit in the spring; the reaction is neutral.

Mt. Nebo Springs.

Yell County.

Mt. Nebo, around which are the "Mt. Nebo springs," is in Yell county, in township 7 N., 21 W., sections 29 and 32. The following are the principal springs:

DARLING SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	1.04	19.25
Chloride of sodium (NaCl)	.49	9.16
Carbonate of soda (Na_2CO_3)	.69	12.90
Carbonate of potash (K_2CO_3)	.18	3.36
Carbonate of magnesia ($MgCO_3$)	.39	7.29
Carbonate of lime ($CaCO_3$)	1.07	20 00
Carbonate of iron ($FeCO_3$)	.20	3.74
Sulphate of iron ($FeSO_4$)	.99	18.51
Sulphate of alumina ($Al_2(SO_4)_3$)	.31	5.79
Total	5 35	100.00

Found.

Silica (SiO_2)	1.04	19.37
Sodium (Na)	.49	9.12
Potassium (K)	.11	2.05
Magnesium (Mg)	.11	2 05
Calcium (Ca)	.43	8.01
Iron (Fe)	.47	8.75
Alumina (Al)	.05	.93
Sulphuric acid (SO_4)	.88	16.39
Carbonic acid (CO_3) calculated	1.50	27.93
Chlorine (Cl)	.29	5.40
Total	5.37	100.00

Water collected by J. C. Branner, October 26, 1888.

Analysis by J. P. Smith.

Temperature of air, November 13, 1889, 59.1° F.; of water, 42° F.

Total solid material in solution, 5.89 grains per U. S. gallon.

Darling spring is about 175 feet below the bottom of the cap rock of Mt. Nebo, and seems to come from the black

shales. It is situated on the bench on the west side of the mountain.

When the sample for analysis was collected the water was quite clear, with the exception of a slight precipitate of oxide or hydroxide of iron; when it reached the Survey laboratory it had formed a heavy, dark colored precipitate of iron.

SOUTH DICKENS SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.52	7.43
Chloride of soda (NaCl)	.63	9 00
Carbonate of soda (Na_2CO_3)	1.66	23.71
Carbonate of magnesia ($MgCO_3$)	1.45	20.71
Carbonate of lime ($CaCO_3$)	1.89	27.00
Carbonate of iron ($FeCO_3$)	.17	2.43
Sulphate of lime ($CaSO_4$)	.68	9.71
Total	7.00	99.99

Found.

Silica (SiO_2)	.52	7.45
Sodium (Na)	.87	12.46
Magnesium (Mg)	.41	5.87
Calcium (Ca)	.95	13.61
Iron (Fe)	.03	1.15
Sulphuric acid (SO_4)	.48	6.88
Carbonic acid (CO_3)	3.46	49.57
Chlorine (Cl)	.21	3.01
Total	6.21	100.00

Water collected by assistant T. C. Hopkins.

Analysis by A. E. Menke.

Temperature of air, 57.2° F.; of water, 55.4° F.

Total solid material in solution, 8.75 grains per U. S. gallon.

NORTH DICKENS SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.46	6.17
Chloride of soda (NaCl)	.30	4.02
Carbonate of soda (Na_2CO_3)	2.10	28.15
Carbonate of magnesia ($MgCO_3$)	1.59	21.31
Carbonate of lime ($CaCO_3$)	2.04	27.35
Carbonate of iron ($Fe\ CO_3$)	.50	6.70
Sulphate of lime ($CaSO_4$)	.47	6.30
Total	7.46	100 00

Found.

Silica (SiO_2)	.46	6.17
Sodium (Na)	.72	9.66
Magnesium (Mg)	.45	6 12
Calcium (Ca)	.95	12.75
Iron (Fe)	.24	3.22
Sulphuric acid (SO_4)	.33	4.41
Carbonic acid (CO_3)	4.12	55.28
Chlorine (Cl)	.18	2.40
Total	7.45	100.00

Water collected by assistant T. C. Hopkins.

Analysis by A. E. Menke.

Temperature of air, 57.2° F.; of water, 55.4° F.

Total solid material in solution, 8.75 grains per U. S. gallon.

Dickens springs are named from a Mr. Dickens, who lived at the springs many years ago, and who is said to have been the first settler in that region. The springs are on the bench on the west side of Mt. Nebo, and about 100 yards south of the Gum spring. No improvements had been made at the springs at the time when the water for analysis was obtained (December 24, 1891). They flow from a mass of yellow ferruginous sandstone, the talus from the steep bluff above, the rocks of which belong to the Barren Coal Measures. They are two in number, the outlets being not more than two feet apart, so close, in fact, that in their present natural condition the waters from

both mingle in the same pool. Their close proximity to each other and the character of the rocks from which they flow would indicate that the two might be separate outlets of the same spring, but the one to the south gave a very perceptible odor of sulphur, which could not be noticed in the other one, and the waters of the two are said to have quite different effects on the system when taken internally. Many people in the neighborhood value the water from these springs for its curative properties more highly than that from any other on the mountain. The temperatures of the water in the two springs differ but little from each other, and differed but little from the atmosphere at the time the water was obtained (December 24, 1891).

	South spring.	*North spring.*
Temperature of the atmosphere.	57.2° F.	57.2° F.
Temperature of the spring	56.7° F.	55.4° F.

Water collected from these springs by assistant G. D. Harris, November 15, 1889, gave total solids, 7.77 grains per U. S. gallon.

GUM SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.64	14.71
Chloride of soda (NaCl)	.23	5.29
Carbonate of magnesia ($MgCO_3$)	.92	21 15
Carbonate of lime ($CaCO_3$)	1.21	27.81
Carbonate of iron ($FeCO_3$)	1.01	23.22
Sulphate of lime ($CaSO_4$)	.34	7.82
Total	4.35	100.00

Found.

Silica (SiO_2)	.64	14.71
Sodium (Na)	.09	2.07
Magnesium (Mg)	.26	5.98
Calcium (Ca)	.58	13.33
Iron (Fe)	.49	11.26
Sulphuric acid (SO_4)	.24	5.52
Carbonic acid CO_3)	1.91	43.91
Chlorine (Cl)	.14	3.22
Total	4.35	100.00

Water collected by assistant T. C. Hopkins, December 24, 1891.

Analysis by A. E. Menke.

Temperature of air, 46.4° F.; temperature of water, 58.1° F.

Total solid material in solution, 5.00 grains per U. S. gallon.

Gum spring is on the bench of Mt. Nebo, close to the foot of the cliff on the west side; it issues from a mass of debris at about the same geological level as the Dickens springs. The stream flowing from it is remarkably clear and cold, about half filling a 1-inch pipe. It is said to vary little, if any, in either volume or temperature during the year. The water is odorless and almost tasteless. There is a considerable deposit of iron about the outlet.

NATIONAL SPRING.

Logan County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	1.40	.97
Chloride of soda (NaCl)	11.79	8.16
Chloride of potash (KCl)	.56	.39
Carbonate of magnesia ($MgCO_3$)	18 89	13.07
Carbonate of lime ($CaCO_3$)	31.92	22.09
Sulphate of soda (Na_2SO_4)	33.01	22.84
Sulphate of magnesia ($MgSO_4$)	46.55	32.22
Sulphate of iron ($FeSO_4$)	.15	.11
Sulphate of Alumina ($Al_2(SO_4)_3$)	.22	.15
Total	144.49	100.00

Found.

Silica (SiO_2)	1.40	.95
Sodium (Na)	15 35	10.44
Potassium (K)	.29	.20
Magnesium (Mg)	14.70	10.00
Calcium (Ca)	12.77	8 69
Lithium (Li)	sli't trace	sli't trace
Iron (Fe)	.06	.04
Aluminum (Al)	.03	.02
Sulphuric acid (SO_4)	59.84	40.69
Carbonic acid (CO_3)	32.64	23.94
Chlorine (Cl)	7.41	5.03
Total	144.49	100.00

Water collected by assistant J. P. Smith, June 3, 1889.

Temperature of air 78.53° F.; of water, 61.43° F.

Total solid material in solution, 151.23 grains per U. S. gallon.

Carbonic acid (CO_2), free and for bicarbonates, 2.56 grains per U. S. gallon.

National spring is in the town of National, Logan county, in township 7 N., 27 W., section 8, the northwest quarter of the north east quarter, about twenty-five feet east of Spring street and 100 yards south of the Iron spring.

The flow of the spring is west. The water comes from Carboniferous shales that contain much iron pyrites (FeS_2), the sulphur of which goes to form the large per cent. of sulphuric

acid (SO_4). There is no odor of sulphuretted hydrogen and apparently no gas escaping.

Reaction on litmus paper neutral.

The spring is seven feet deep, the water is clear and forms no sediment of iron.

PINNACLE SPRING.

Faulkner County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.277	1.50
Carbonate of magnesia ($MgCO_3$)	2.007	10.85
Carbonate of lime ($CaCO_3$)	.277	1.50
Carbonate of iron ($FeCO_3$)	13.649	73.82
Sulphate of potash (K_2SO_4)	.184	1.00
Sulphate of magnesia ($MgSO_4$)	1 435	7.76
Sulphate of lime ($CaSO_4$)	.323	1.75
Organic matter	.338	1.82
Total	18.490	100.00

Analyzed in 1881, by Messrs. Wright and Merrill, of St. Louis, Missouri.
Carbonic acid gas, (cubic inches) 38.3.

Pinnacle spring is in 8 N., 13 W., near the southwest corner of section 16. The water forms a heavy deposit of iron.

The water issues from a crevice in a sandstone bluff, immediately west of Cadron Creek. The rock beds in this locality lie approximately flat. Cadron Creek cutting deep down through these flat beds makes the landscape very rugged and picturesque.

At one time a great many people visited the spring to get the benefit of its medicinal properties, and a hotel and several boarding houses were erected for their accommodation.

Of late years the number of visitors has steadily decreased, until in 1891 the place was scarcely heard of, except locally, as a pleasure or health resort. This decline is probably due to the distance of the place from the railway.

POTASH SULPHUR SPRINGS.

Garland County.

The Potash Sulphur springs are in township 3 S., 1 W., section 17, near the center of the northwest quarter, about seven miles southeast of the city of Hot Springs, and one mile north of Lawrence station on the Hot Springs Railroad.

Their nearness to the railway and to the city of Hot Springs, the hotel accommodations and the picturesque scenery make this a favored locality for health and pleasure seekers.

The springs, which have attained a wide and valuable reputation for their curative properties, are three in number and are all within a radius of twenty feet. Each spring is under cover; the water wells up in each through large sewer tiles which are imbedded in the rock, and from which the water is dipped. The water is used more for drinking than for bathing purposes, much of it being bottled and shipped to various points for medicinal uses. The springs flow from metamorphosed sedimentary rocks * but they are very near the line of contact between the sedimentary and the igneous rocks. To the east, north and west of the springs are high hills, those east and north being of sedimentary, and those to the west, of igneous origin.

*The geology of the country in the immediate vicinity of Potash Sulphur springs is described in the Annual Report of the Geological Survey of Arkansas, 1890, Volume II., by J. F. Williams, page 347.

WEST SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	1.90	3 66
Chloride of soda (NaCl) (common salt)	5.04	9 71
Carbonate of soda (Na_2CO_3)	10.45	20.14
Carbonate of Magnesia ($MgCO_3$)	trace	trace
Carbonate of lime ($CaCO_3$)	.49	.95
Carbonate of iron ($FeCO_3$)	.32	.62
Carbonate of manganese ($MnCO_3$)	trace	trace
Sulphate of soda (Na_2SO_4) (Glauber's salt)	32.80	63.22
Sulphate of potash (K_2SO_4)	.88	1.70
Sulphide of soda (Na_2S)	trace	trace
Alumina (Al_2O_3)	trace	trace
Total	51.88	100 00

Found.

Silica (SiO_2)	1.90	3.66
Sodium (Na)	17.16	33 08
Potassium (K)	.40	.77
Magnesium (Mg)	trace	trace
Calcium (Ca)	.19	.37
Iron (Fe)	.15	.29
Aluminum (Al)	trace	trace
Manganese (Mn)	trace	trace
Sulphuric acid (SO_4)	22.65	43.67
Carbonic acid (CO_3)	6.37	12.28
Chlorine (Cl)	3.05	5.88
Sulphuretted hydrogen (H_2S)	trace	trace
Total	51.87	100.00

Water collected by C. B. Gannaway, October, 1887.

Analysis by the Geological Survey, C. B. Gannaway analysist.

Temperature of the water, 64°F.

Total solids in solution, 51.89 grains per gallon.

Free carbonic acid, 2.56 grains per U. S. gallon.

Faint order of sulphuretted hydrogen.

The constituents originally reported, given by Mr. Gannaway as bicarbonates, have been calculated as carbonates, and the per cent. of total solid material in solution has been given, to make the analysis comparable with the others.

EAST SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	1.60	4.10
Chloride of soda (NaCl) (common salt)	1 91	4 90
Chloride of potash (KCl)	2.52	6.46
Carbonate of soda (Na_2CO_3)	15.00	38.44
Carbonate of lime ($CaCO_3$)	.46	1.18
Sulphate of soda (Na_2SO_4) (Glauber's salt)	17 42	44.64
Alumina (Al_2O_3)	.11	.28
Total	39.02	100 00

Found.

Silica (SiO_2)	1.60	4.12
Sodium (Na)	12.92	33.29
Potassium (K)	1.32	3.41
Magnesium (Mg)	.00	.00
Calcium (Ca)	.18	.46
Alumina (Al_2O_3)	.11	.28
Sulphuric acid (SO_4)	11.82	30.46
Carbonic acid (CO_3) (by difference)	8.50	21.90
Sulphuretted hydrogen (H_2S)	.00	.00
Chlorine (Cl)	2.36	6.08
Total	38.81	100.00

Analysis by Prof. F. W. Clarke, chemist of the U. S. Geological Survey. Quoted from Bulletin No. 55 of the U. S. Geological Survey, p. 92.

Total solids in solution, 39.04 grains per U. S. gallon.

In order to make this analysis comparable with the others, the amount of the constituents, which Prof. Clarke states in grammes to the liter, have been reduced to grains per U. S. gallon.

The fact that these springs are called "Potash Sulphur" has probably given rise to the impression that there must be large quantities of potassium in the waters. To settle this matter beyond question the chemist of the Survey was directed to take an additional sample of water from the "original" spring—the north spring on the east side of the stream—and to rede-

termine the alkalies and sulphuretted hydrogen. The sample was collected November 13, 1890; the results are given below, together with those obtained by Prof. Clarke for the same substances in the water of this spring.

Alkalies in Potash Sulphur water—East Spring.

Constituents.	Clarke.	Brackett.
	Grains per gallon.	Grains per gallon.
Sodium (Na).....	12.92	13.66
Potassium (K)....	1.32	3.51
Total.....	14.24	17.17
Sulphuretted hydrogen (H_2S).....		0 09

The difference between the amount of potassium found by Prof. Clarke and that found in the Survey laboratory is probably due to the small amount of water with which the former had to work.

The alkali results obtained in the analysis made by Mr. Gannaway cannot justly be put in this table because that analysis is of water of a different spring.

It is shown below that the Potash Sulphur waters vary in strength among themselves and with meteoric conditions, but it is plain that the sulphate of soda or Glauber's salt is the chief mineral constituent of the water, and it is probably to this that the water owes its therapeutic value.

In order to determine whether the amount of material in solution in these waters varies much or is influenced considerably by the rainfall, samples were taken at several different times and the total solids determined. The results are here brought together.

Potash Sulphur Springs.—Matter in solution at different times, in grains per U. S. gallon.

(Dried at 110°–115° C.)

Collector.	Date.	Previous rainfall.	West spring.	North spring.	South spring.	Determined by.
?	1886–87.....	?	.....	39.04	.....	Clarke.
Gannaway...	Oct., 1887...	Dry weather	51.87	.....	.....	Gannaway
Means	July 11, 1891.	?	31.02	66.00	49.68	Brackett.
Siebenthal...	Aug. 3, 1891.*	After week of heavy rain	24.66	47.41	50.03	Brackett.
Brackett	Aug. 18, 1891.	?	29.62	49.85	50.96	Brackett.
Newsom	Oct. 25, 1891.	After long drouth...	45 89	48.86	.....	Brackett.

These determinations of total solids point to the fact that the waters of these three springs vary among themselves in the amount of solids in solution, and that they are considerably affected by the rainfall. The southern spring on the east side seems to be the one least affected, and that on the west side the one most affected by rains and drouth.

*The following temperatures were determined by assistant C. E. Siebenthal, August 2 and 3, 1891, when he collected the samples reported upon above:

West spring.—(August 2, 5 p.m.)—Temperature of air, 84.20° F.; of water, 71.6° F.

South spring.—(August 2, 5 p.m.)—Temperature of air, 84.20° F.; of water, 72.05° F. (August 3, 3 p.m.)—Temperature of air, 83.75°F.; of water, 70.25° F.

North spring.—(August 2, 5 p.m.)—Temperature of air, 84.20° F.; of water, 69.80°F. (August 3, 3 p.m.)—Temperature of air, 83.75°F.; of water, 68° F.

SEARCY SULPHUR SPRING.

Searcy, White County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	1.36	7.61
Chloride of soda (NaCl)	2.89	16.21
Chloride of potash (KCl)	.46	2.67
Carbonate of soda (Na_2CO_3)	5.49	30.81
Carbonate of magnesia ($MgCO_3$)	1.19	6 77
Carbonate of lime ($CaCO_3$)	3.25	18.23
Sulphate of soda (Na_2SO_4)	2.99	16.77
Sulphate of iron ($FeSO_4$)	.04	.21
Sulphate of alumina ($Al_2(SO_4)_3$)	.13	.72
Total	17.80	100.00
Carbonic acid (CO_2), free	16.29	
	34.09	

Found.

Silica (SiO_2)	1.36	3.99
Sodium (Na)	4.56	13.38
Potassium (K)	.24	.71
Magnesium (Mg)	.34	1.01
Calcium (Ca)	1.30	3.83
Iron (Fe)	.01	.04
Aluminum (Al)	.02	.07
Sulphuric acid (SO_4)	2.16	6.35
Carbonic acid (CO_3)	22.12	64.83
Chlorine (Cl)	1.97	5.79
Sulphuretted hydrogen (H_2S)	trace	trace
Total	34.08	100.00

100.46 per cent. accounted for.

Water collected by assistant J. P. Smith, March 23, 1888.

Analysis by R. N. Brackett and J. P. Smith.

Temperature of air, 58° F.; of water, 59° F.

Total solid material in solution, 17.73 grains per U. S. gallon.

The water comes from rocks of the Barren Coal Measures.

Gas was bubbling up from the water when the collection was made; there was a strong odor of sulphuretted hydrogen, but lead paper showed only a slight reaction for it.

In order to ascertain whether the amount of mineral matter in solution varied much, water was collected again on the 11th of August, 1891, by R. N. Brackett, and the following determinations made:

Total solids, 18.72 grains per U. S. gallon.

Sulphuretted hydrogen, { 0.09 grains per U. S. gallon. / 0.22 cubic inches.

SILOAM SPRINGS.

Benton County, near Ewing House.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.81	9.99
Chloride of soda (NaCl)	.68	8 38
Carbonate of lime ($CaCO_3$)	5.17	63.75
Carbonate of iron ($FeCO_3$	.02	.24
Sulphate of soda (Na_2SO_4)	1.43	17.64
Total	8.11	100.00

Found.

Silica (SiO_2)	.81	9.97
Sodium (Na)	.73	8.99
Lime (CaO)	2.90	35.71
Iron (Fe)	.01	.12
Sulphuric acid (SO_4)	.97	11.94
Carbonic acid (CO_3)	2.29	28.20
Chlorine (Cl)	.41	5.07
Total	8.12	100.00

Water collected and analyzed by A. E. Menke.

Temperature of air, 41° F.; of water, 60.8° F.

Total solid material in solution, 7.41 grains per U. S. gallon.

The spring is in the chert formation near the base of the Lower Carboniferous.

Starne Springs.

Independence County.

Starne springs (chalybeate), named for J. W. Starne, who owns them, are in the southwest part of Independence county, in 12 N., 7 W. section 30, the northwest quarter, six miles southwest of Jamestown, and thirteen miles southwest of Batesville, the nearest railway point. The springs are on the southwest side of a small tributary of Copperas Creek, which flows into Salado Creek and thence into White River. There are possibly twenty or more springs in this vicinity, only four of which form any marked deposit about their outlet, and from only two of which could clear water be obtained. The springs are so close to the brook that its waters flow over them during freshets and fill them up with sediment, unless they are boxed high, as is the case with two above mentioned. The springs flow from a sandy soil formed by the disintegration of a yellow, ferruginous sandstone of the Barren Coal Measures. The same rock forms the low hills on each side of the spring, and the higher hills on each side of Grassy Creek to the northeast.

The springs are on the property of J. W. Starne, who lives at the springs. Several other families live in the immediate vicinity. Friendship church is less than a quarter of a mile southwest, and Bullard's steam sawmill a little over a quarter of a mile in the same direction.

The springs are much frequented by persons from Batesville and the surrounding region, who camp there for weeks at a time.

SPRING NO. I.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.70	13.41
Chloride of soda (NaCl)	.30	5.74
Carbonate of soda (Na_2CO_3)	.02	.38
Carbonate of Magnesia ($MgCO_3$)	1.28	24 52
Carbonate of lime ($CaCO_3$)	.72	13.78
Carbonate of iron ($FeCO_3$)	1.52	29.12
Sulphate of lime ($CaSO_4$)	.68	12.94
Total	5.22	100.00

Found.

Silica (SiO_2)	.70	13.46
Sodium (Na)	.12	2.31
Magnesium (Mg)	.36	6.92
Calcium (Ca)	.50	9 62
Iron (Fe)	.73	14.04
Sulphuric acid (SO_4)	.48	9.23
Carbonic acid (CO_3)	2.13	40.96
Chlorine (Cl)	.18	3.46
Total	5.20	100.00

Water collected by assistant T. C. Hopkins, December 18, 1891.

Analysis by A. E. Menke.

Total solids in solution, 6.30 grains per U. S. gallon.

SPRING NO. 2.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.35	5.87
Chloride of soda (NaCl)	.30	5.03
Carbonate of soda (Na_2CO_3)	.01	.17
Carbonate of magnesia ($MgCO_3$)	1.45	24.31
Carbonate of lime ($CaCO_3$)	1.92	32.25
Carbonate of iron ($FeCO_3$)	1.43	23.98
Sulphate of lime ($CaSO_4$)	.50	8.39
Total	5.96	100.00

Found.

Silica (SiO_2)	.35	5.88
Sodium (Na)	.12	2.02
Magnesium (Mg)	.41	6.89
Calcium (Ca)	.91	15.29
Iron (Fe)	.69	11.60
Sulphuric acid (SO_4)	.35	5.88
Carbonic acid (CO_3)	2.94	49.41
Chlorine (Cl)	.18	3.03
Total	5.95	100.00

Water collected by assistant T. C. Hopkins, December 18, 1891.
Analysis by A. E. Menke.
Total solids in solution, 4.16 grains per U. S. gallon.

Sugar Loaf Springs.

Sugar Loaf springs are at Heber, a town of 450 inhabitants, the county seat of Cleburne county, in township 10 N., 10 W., sections 14 and 23. The principal objection to Heber as a health resort is its distance from railway accommodations; Searcy, the nearest station, being about 30 miles away.

To the north of the town the country is somewhat rolling and broken, and is covered with a pine forest, while Round Mountain, rising abruptly to the south, makes the scenery very picturesque. The air is of the pure and bracing character found in mountainous and piney woods districts.

The prevailing dip of the rocks at the east end of the town, where the springs are located, is about 8° S. 45° E., dipping under Round Mountain. The rocks belong to the Barren Coal Measures and consist of sandstones and shales. The surface of the ground slopes at about the same angle as the strata to Sulphur Creek, a small stream running northeast between Heber and Round Mountain, and cutting off the southeast corner of section 14.

There is no exposure of rock where the springs issue, but a short distance north of them, exposures of a thin bedded sandstone are found, which dips as before stated.

The principal springs are six in number and are enclosed in a park containing about ten acres lying in section 14, the southwest portion of the southeast quarter of the southeast quarter. The water came up originally through a clayey soil, the depth of the rock beneath the surface ranging from 3 to 5 feet. At present, however, sewer tiles have been sunk around each spring and the water collects in these. All except the Eye spring are under cover. A small temporary bath-house has been built near the White Sulphur spring, and uses the water from it. The water from all except the Eye spring has been used more for drinking than for bathing purposes.

ARSENIC SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	1.43	10.82
Chloride of soda ($NaCl$)	1.88	14.22
Carbonate of soda (Na_2CO_3)	2.21	16.72
Carbonate of magnesia ($MgCO_3$)	1.30	9.83
Carbonate of lime ($CaCO_3$)	5.53	41.83
Sulphate of soda (Na_2SO_4)	.70	5.29
Sulphate of alumina ($Al_2(SO_4)_3$)	.14	1.06
Nitrate of lime ($Ca(NO_3)_2$)	.03	.23
Total	13.22	100.00

Found.

Silica (SiO_2)	1.43	11.27
Sodium (Na)	1.20	9 47
Magnesium (Mg)	.37	2 91
Lime (CaO)	3.10	24.45
Alumina (Al_2O_3)	.04	.32
Sulphuric acid (SO_4)	.57	4.49
Carbonic acid (CO_3)	4.81	37.94
Nitric acid (NO_3)	.02	.16
Chlorine (Cl)	1.14	8.99
Total	12.68	100.00

Water collected by assistant J. F. Newsom, October 30, 1891.
Analysis by A. E. Menke.
Temperature of air, 45.68° F.; temperature of water, 59° F.
Total solids in solution, 15.18 grains per U. S. gallon.
Free ammonia, 0.086 parts per million.
Albuminoid ammonia, 0.048 parts per million.

Arsenic spring is under the same roof with the White Sulphur and the Chalybeate spring; its distance from the former is about 15 feet; from the latter, about 10 feet. The water is not much used, and at the time of collection contained much foreign matter, such as leaves and twigs. The discharge is about one gallon in ten minutes. No gas escapes. A thin, white, mossy deposit is formed on the sides of the sewer tile through which the water flows. Reaction, neutral.

BLACK SULPHUR SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.93	3.59
Chloride of soda ($NaCl$)	.96	3 71
Carbonate of soda (Na_2CO_3)	14.65	56.59
Carbonate of magnesia ($MgCO_3$)	2.61	10.13
Carbonate of lime ($CaCO_3$)	3.95	15.27
Sulphate of soda (Na_2SO_4)	2.69	10 40
Sulphate of alumina ($Al_2(SO_4)_3$)	.07	.27
Nitrate of lime ($Ca(NO_3)_2$)	.01	.04
Total	25.87	100.00

Found.

Silica (SiO_2)	.93	3.60
Sodium (Na)	7.25	29 09
Magnesium (Mg)	.74	2.86
Lime (CaO)	2.21	8.55
Alumina (Al_2O_3)	.02	.08
Sulphuric acid (SO_4)	1 90	7.35
Carbonic acid (CO_3)	11.94	46.19
Nitric acid (NO_3)	.01	.04
Chlorine (Cl)	.58	2.24
Total	25.85	100.00

Water collected by assistant J. F. Newsom, October 30, 1891.
Analysis by A. E. Menke.
Temperature of air, 38.66°F.; temperature of water 61.7° F.
Total solids in solution, 30.87 grains per U. S. gallon.
Hydrogen sulphide gas, 0.02 grains per U. S. gallon.
Free ammonia, 0.01 parts per million.
Albuminoid ammonia, 0.01 parts per million.

Black Sulphur spring is near the north side of the park and is about 160 yards north slightly east of its nearest neighbor, the Eye spring.

The discharge of this spring is one gallon in three minutes. When the sample was taken a little inflammable gas was escaping. A heavy white ropy deposit, which waves to and fro in the water, is formed on the sides of the tile in which the wa-

ter collects. Objects on which the deposit collects are turned black. Reaction, neutral.

CHALYBEATE SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	1.16	9.94
Chloride of soda (NaCl)	1.13	9.68
Carbonate of soda (Na_2CO_3)	.81	6.94
Carbonate of magnesia ($MgCO_3$)	1.37	11.75
Carbonate of lime ($CaCO_3$)	6.09	52.18
Sulphate of soda (Na_2SO_4)	1.06	9.08
Sulphate of alumina ($Al_2(SO_4)_3$)	.04	.34
Nitrate of lime ($Ca(NO_3)_2$)	.01	.06
Total	11.67	100.00

Found.

Silica (SiO_2)	1.16	9.94
Sodium (Na)	1.09	9.34
Magnesium (Mg)	.39	3.34
Lime (CaO)	3.41	29.22
Alumina (Al_2O_3)	.01	.09
Sulphuric acid (SO_4)	.76	6.51
Carbonic acid (CO_3)	4.15	35.56
Nitric acid (NO_3)	.01	.09
Chlorine (Cl)	.69	5.91
Total	11.67	100.00

Water collected by assistant J. F. Newsom, October 30, 1891.
Analysis by A. E. Menke.
Temperature of air, 45.68° F.; of water, 56.30° F.
Total solids in solution, 13.76 grains per U. S. gallon.
Free ammonia, 0.01 parts per million.
Albuminoid ammonia, 0.01 parts per million.

The Chalybeate spring is 10 feet from the Arsenic and 31 feet from the White Sulphur spring. The discharge is about 1 gallon in 15 minutes. No gas was found escaping, and no deposit is formed. The reaction is neutral. The water from this spring is but little used.

EYE SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.96	3.72
Chloride of soda (NaCl)	1.16	4.49
Carbonate of soda (Na_2CO_3)	14 49	56.12
Carbonate of magnesia ($MgCO_3$)	2.39	9.26
Carbonate of lime ($CaCO_3$)	4 08	15.80
Sulphate of soda (Na_2SO_4)	2.67	10.34
Sulphate of alumina ($Al_2(SO_4)_3$)	.06	.23
Nitrate of lime ($Ca(NO_3)_2$)	.01	.04
Total	25.82	100.00

Found.

Silica (SiO_2)	.96	3 72
Sodium (Na)	7.54	29.20
Magnesium (Mg)	.68	2.64
Lime (CaO)	2.28	8.83
Alumina (Al_2O_3)	.02	.08
Sulphuric acid (SO_4)	1.87	7.25
Carbonic acid (CO_3)	11.75	45.51
Nitric acid (NO_3)	.01	.05
Chlorine (Cl)	.70	2.72
Total	25.81	100.00

Water collected by assistant J. F. Newsom, October 30, 1891.
Analysis by A. E. Menke.
Temperature of air, 45.68° F.; of water, 54.5° F.
Total solids in solution, 31.39 grains per U. S. gallon.
Hydrogen sulphide gas, 0.002 grains per U. S. gallon.
Free ammonia, 0.01 parts per million.
Albuminoid ammonia, 0.01 parts per million.

The Eye spring is about thirty-five feet north slightly east of the Red Sulphur. Its discharge is very weak—only one gallon in thirty minutes. No gas escapes from this spring, and no deposit is formed. The reaction is neutral. The water is used for bathing inflamed eyes and sores.

RED SULPHUR SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.75	3.00
Chloride of soda (NaCl)	6.45	25.80
Carbonate of soda (Na_2CO_3)	11.73	46.92
Carbonate of magnesia ($MgCO_3$)	.76	3.04
Carbonate of lime ($CaCO_3$)	3.44	13 76
Sulphate of soda (Na_2SO_4)	1 79	7.16
Sulphate of alumina ($Al_2(SO_4)_3$)	.07	.28
Nitrate of lime ($Ca(NO_3)_2$)	.01	.04
Total	25.00	100 00

Found.

Silica (SiO_2)	.75	3.00
Sodium (Na)	8.18	32.72
Magnesium (Mg)	.27	1.08
Lime (CaO)	1.93	7.72
Alumina (Al_2O_3)	.02	.08
Sulphuric acid (SO_4)	1.30	5.20
Carbonic acid (CO_3)	8.63	34.52
Nitric acid (NO_3)	.01	.04
Chlorine (Cl)	3 91	15.64
Total	25.00	100.00

Water collected by assistant J. F. Newsom, October 30, 1891.
Analysis by A. E. Menke.
Temperature of air, 45.68° F.; of water, 61.7° F.
Total solids in solution, 34.63 grains per U. S. gallon.
Free ammonia, 0.02 parts per million.
Albuminoid ammonia, 0.01 parts per million.

The Red Sulphur spring is about 200 feet northeast of the White Sulphur. The discharge is 1152 gallons in 24 hours. When the sample was taken inflammable gas was escaping rapidly. The water forms a heavy, ropy deposit on the sides of the sewer tile, and in the small wooden trough that carries off the water.

WHITE SULPHUR SPRING.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	1.44	10.19
Chloride of soda (NaCl)	1.77	12.53
Carbonate of soda (Na_2CO_3)	1.02	7.22
Carbonate of magnesia ($MgCO_3$)	1.45	10.26
Carbonate of lime ($CaCO_3$)	7.09	50.17
Sulphate of soda (Na_2SO_4)	1.25	8.85
Sulphate of alumina ($Al_2(SO_4)_3$)	.10	.71
Nitrate of lime ($Ca(NO_3)_2$)	.01	.07
Total	14.13	100.00

Found.

Silica (SiO_2)	1.44	10.19
Sodium (Na)	1.92	13.59
Magnesium (Mg)	.41	2,90
Lime (CaO)	3.97	28.10
Alumina (Al_2O_3)	.03	.21
Sulphuric acid (SO_4)	.47	3.33
Carbonic acid (CO_3)	4.81	34.04
Nitric acid (NO_3)	.01	.07
Chlorine (Cl)	1.07	7.57
Total	14.13	100.00

Water collected by assistant J. F. Newsom, October 30, 1891.
Analysis by A. E. Menke.
Temperature of air, 45.68° F.; of water, 59.9° F.
Total solids in solution, 16.66 grains per U. S. gallon.
Free ammonia, 0.01 parts per million.
Albuminoid ammonia, 0.01 parts per million.

The White Sulphur spring is 13 feet from the Chalybeate, and 15 feet from the Arsenic spring. Its discharge is about 1440 gallons in 24 hours. No gas was escaping when the sample was collected, though it is said to escape sometimes. The reaction is neutral. The water forms a white, mossy deposit. A small pipe is arranged so that water for bathing purposes may be conveyed from this spring to the small bath house. The water is said to act as a purgative.

SULPHUR SPRING.

Newton County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.35	1.63
Chloride of soda (NaCl)	.02	.10
Chloride of potash (KCl)	.01	.05
Carbonate of soda (Na_2CO_3)	6.23	29.65
Carbonate of lime ($CaCO_3$)	7.72	36.73
Carbonate of iron ($FeCO_3$)	1.42	6.72
Sulphate of magnesia ($MgSO_4$)	4.80	22.83
Alumina (Al_2O_3)	.82	3 90
Total	21.02	100.00

Found.

Silica (SiO_2)	.35	1.63
Sodium (Na)	2.71	12.70
Magnesium (Mg)	.96	4.49
Potassium (K)	.01	.04
Calcium (Ca)	3.09	14.44
Iron (Fe)	.69	3.22
Alumina (Al_2O_3)	.82	3.83
Sulphuric acid (SO_4)	3.84	17.95
Carbonic acid (CO_3)	8.90	41.61
Chlorine (Cl)	.02	.09
Total	21.39*	100.00

Water collected by assistant T. C. Hopkins, Feb. 9, 1892.

Analyzed by A. E. Menke.

Temperature of air, 36.86° F.; of water, 50° F.

Total solids in solution, 22.91 grains per U. S. gallon.

Sulphur spring is in 17 N., 20 W., section 24, on the north side of Sulphur Mountain, two miles and a half from Watkins' post-office, and nearly nine miles from Harrison, the county seat. The spring is at the head of one of the tributaries of Crooked Creek. The water is slightly clouded, and gives a very perceptible odor and taste of sulphuretted hydrogen gas.

*This water contained sediment.

The shale in which the spring occurs is an aluminous, pyritiferous shale containing ferruginous, calcareous nodules. The overlying rocks are shales, shaly sandstones and impure limestone. The sulphuretted hydrogen gas (not shown in the analysis) and the sulphuric acid are probably due to the decomposition of the iron pyrites in the shale.

The spring is in Lower Carboniferous rocks and emerges near the top of the Marshall shale which at this point is 250 feet thick. It is 300 feet above Watkins' post-office and 500 feet above Harrison, both of which are on the Boone chert; it is probably not far from 500 feet above the base of the Lower Carboniferous series and about the same distance below the base of the Millstone Grit, which occurs on both ends of Sulphur Mountain.

Two other small springs of soft water, clear, odorless and tasteless, occur near Sulphur spring.

The property now belongs to Dr. Dodd, of Dodd City. No one was living at the springs in February, 1892, but the ruins of several cabins gave evidence of former residents. It is reported that a few years ago several hundred people, mostly health seekers, were encamped about the spring the greater part of the summer season.

On Fodder Stack Mountain two miles west of Sulphur spring is another spring, having a stronger sulphur odor and taste than the one on Sulphur Mountain. Both are in the same geologic level—the Marshall shale, of Lower Carboniferous age.

A sulphur spring with a local reputation as a health resort is on Lick Mountain, in 15 N., 19 W.

SULPHUR SPRING.

Benton County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	.72	3.17
Chloride of soda (NaCl)	9.34	41.13
Carbonate of magnesia ($MgCO_3$)	4.48	19.73
Carbonate of lime ($CaCO_3$)	6.51	28.66
Carbonate of iron ($FeCO_3$)	.12	.53
Sulphate of soda (Na_2SO_4)	1.33	5.86
Alumina (Al_2O_3)	.21	.92
Total	22.71	100.00

Found.

Silica (SiO_2)	.72	3.17
Sodium (Na)	4.10	18.05
Magnesium (Mg)	1.28	5.64
Lime (CaO)	3.64	16.03
Iron (Fe)	.06	.27
Alumina (Al_2O_3)	.22	.97
Sulphuric acid (SO_4)	.90	3.96
Carbonic acid (CO_3)	6.13	26.99
Chlorine (Cl)	5.66	24.92
Total	22.71	100.00

Collected by A. E. Menke, November 16, 1891.

Analysis by A. E. Menke.

Temperature of air, 28.4° F.; temperature of water, 61.7° F.

Sulphuretted hydrogen gas in solution, 0.0002 grains per U. S. gallon.

Total solids in solution, 22.59 grains per U. S. gallon.

TOM THUMB SPRING.

Newton County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	1.49	11.86
Chloride of soda (NaCl)	.14	1.12
Carbonate of soda (Na_2CO_3)	2.84	22.63
Carbonate of lime ($CaCO_3$)	7.53	60.00
Carbonate of iron ($FeCO_3$)	.19	1.32
Sulphate of magnesia ($MgSO_4$)	.36	2.87
Total	12.55	100.00

Found.

Silica (SiO_2)	1.49	12.31
Sodium (Na)	1.29	10.68
Magnesium (Mg)	.0004	.003
Calcium (Ca)	3 01	24.876
Iron (Fe)	.09	.74
Sulphuric acid (SO_4)	.0016	.013
Carbonic acid (CO_3)	6.13	50.65
Chlorine (Cl)	.09	.74
Total	12.102	100.00

Water collected by assistant T. C. Hopkins, February 11, 1892.

Analysis by A. E. Menke.

Temperature of air, 40.28° F.; of water, 56.3° F.

Total solids in solution, 15.00 grains per U. S. gallon.

Tom Thumb spring is in Newton county, in 17 N., 21 W., section 20, the southeast quarter of the southeast quarter. It is six miles from Marble City, the nearest town, fifteen miles from Harrison, the county seat, and fifty miles from Eureka Springs, the nearest railway station. It is on the west side of Gaither Cove, on a bench of Gaither Mountain, and 520 feet above the bottom of the cove. The location is beautiful and picturesque; the bench on which the spring is situated is from a few yards to a quarter of a mile in width and extends around the cove; from the bench to the bottom of the cove the

slope is steep and covered with forest; the bench is limited on the upper side by a perpendicular cliff of sandstone, which rises several hundred feet to the top of the mountain; on the bench, on top of the mountain, and in the cove, are a number of small farms. From the spring one overlooks the cove, and the Buffalo River valley, and is surrounded on all sides by mountains. The spring is in rocks of the Lower Carboniferous age, 520 feet above the Silurian rocks, which outcrop in the creek in the bottom of the cove. It is 190 feet above the Boone chert and either in or just above the Marshall shale. At the spring the surface is covered with debris and talus from the cliff, but below the spring the Marshall shale is exposed in a heavy bed. The high perpendicular cliff above the spring is of Millstone Grit, which forms a prominent wall around the cove. There is but one spring, which is not large, flowing seventy-five gallons per hour, but which is said to remain constant, uninfluenced by continued rains or drouth.

The water is clear, odorless, and has a slightly alkaline taste. The analysis given above shows it to contain much more solid matter in solution than the Eureka Springs water.

The spring first became noted for its medicinal properties in 1875 and 1876, when it was the resort of many people. At one time it is said that there were sixty houses at the place and over a thousand people living and camping there, most of whom claimed to derive great benefit from the use of the waters. There are now (March, 1892) but two families and a few vacant dwellings at the spring. The reason given for its abandonment is that building lots could not be bought. The property is owned by Mr. John M. Briscoe.

VALLEY SPRINGS.

Boone County.

Hypothetical Combination.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	1.25	7.90
Chloride of soda ($NaCl$)	.27	1.71
Carbonate of lime ($CaCO_3$)	13.89	87.75
Carbonate of iron ($FeCO_3$)	.14	.88
Sulphate of magnesia ($MgSO_4$)	.28	1.76
Total	15.83	100.00

Found.

Silica (SiO_2)	1.25	7.94
Sodium (Na)	.10	.63
Magnesium (Mg)	.06	.38
Calcium (Ca)	5.55	35.24
Iron (Fe)	.07	.44
Sulphuric acid (SO_4)	.23	1.46
Carbonic acid (CO_3)	8.33	52.89
Chlorine (Cl)	.16	1.02
Total	15.75	100.00

Water collected by assistant T. C. Hopkins, February 10, 1892.
Analysis by A. E. Menke.
Temperature of air, 53.15° F.; of water, 58.1° F.
Total solids in solution, 16.75 grains per U. S. gallon.

At Valley Springs, sometimes called "Double Springs," in 17 N., 19 W., section 3, are two large springs of clear cold water which flow from the chert bed, possibly near the bottom of it, near the base of the Lower Carboniferous beds. In dry weather they are the head of running water on Elm Branch, a tributary of Hog Creek. The analysis given above is of water taken from the eastern one of the two springs, the one to the rear of the post-office.

WATALULA SPRING.

Franklin County.

Partial Analysis.

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Silica (SiO_2)	1.29	58.64
Magnesium (Mg)	.28	12.73
Calcium (Ca)	.57	25.90
Iron sesquioxide (Fe_2O_3) / Alumina (Al_2O_3)	.06	2.73
Total	2.20	100.00

Water collected by assistant Arthur Winslow.

Total solid material in solution, 5.66 grains per U. S. gallon.

Watalula spring is north of Ozark, in township 11 N., 27 W.; it comes from rocks of Lower Carboniferous age.

The water forms a yellow sediment on standing.

CHAPTER IV.

QUALITATIVE TESTS AND NOTES OF MINERAL SPRINGS AND WELLS.

BAKER'S SULPHUR SPRING.

Howard County.

The following analysis of water from "Baker's Sulphur Spring," in township 5 S., 30 W., section 14, the southeast quarter, is quoted from Owen:*

> "Carbonate of alkali, which is probably in the state of
> Carbonate of soda,
> Chloride of sodium,
> A small quantity of free sulphuretted hydrogen,
> Traces of sulphate of soda and magnesia.

"When boiled down it exhibits strong alkaline properties. Its medical properties are a mild laxative, a diuretic, anti-scorbutic, slightly alterative, and strongly antacid. This spring rises from the slate at the base of a ridge of quartzose sandstone."

BARNWELL'S WELL.

Batesville, Independence County.

Qualitative Analysis.

Hypothetical Combination.

Silica (SiO_2) ..... trace
Chloride of soda (NaCl) ..... small quantity
Carbonate of soda (Na_2CO_3) ..... large quantity
Carbonate of magnesia ($MgCO_3$) ..... trace
Carbonate of lime ($CaCO_3$) ..... trace

Found.

Sodium (Na) / Carbonic acid (CO_3) ..... chief constituents
Calcium (Ca) / Alumina (Al_2O_3) / Chlorine (Cl) ..... traces

Water collected by B. F. Barnwell, October 31, 1891.

Analysis by A. E. Menke.

Total solids in solution, 131.6 grains per U. S. gallon.

*Second Report of a Geological Reconnoissance of Arkansas, 1860, p. 97.

Barnwell's well is in Block I, Wykoff's addition to West Batesville. The diameter of the drill hole is 5 inches. The well is 196 feet deep; the water comes to within 40 feet of the surface of the ground. The well is in rocks of the Lower Carboniferous formation, and was bored through strata as follows:

Earth	6 feet
Brown sandstone	20 "
Gray, hard sandstone	25 "
Soft, black shale	100 "
Harder, gritty shale	45 "
Total depth	196 "

A weak stream of water was struck at the top of the shale. A larger stream, and the one from which the well receives most of its supply, was struck at a depth of 193 feet.

BIG SPRING.

Phillips County.

The following analysis of the water of the "Big Spring," near Helena*, Phillips county, is quoted from Owen.†

"Carbonic acid	strong.
Lime	"
Magnesia	"
Iron	trace.

"Saturated with sulphuretted hydrogen, this water gave no indication, either in an acid or alkaline solution, of any metal except a trace of iron. Therefore, it is not likely to contain any mineral poison; and though strongly charged with bicarbonate of lime and magnesia, it is not probable that these ingredients are particularly injurious in water; except it be to those suffering from calculus."

BLACK SPRING.‡

Montgomery County.

"In the northern edge of the town of Black Spring the road

*For the geology of the region about Helena, see Annual Report of the Geological Survey of Arkansas for 1889, Vol. II, by R. E. Call, p. 43, *et seq.*

†Second Report of a Geological Reconnoissance of Arkansas, 1860, p. 412.

‡The notes here quoted on the spring at the town of Black Spring, Montgomery county, are taken from the Annual Report of the Geological Survey of Arkansas, 1888, Vol. I, by T. B. Comstock, p. 126.

crosses a little run in which the black shales are imperfectly exposed, the alluvial deposits of the ancient Caddo having obscured the rock formations. The rocks through this region, west of the line of the anticline, dip N., 27° W., 30° to 35°. The shales seem to lie near the base of the quartz-bearing division. The water which flows from these shales is agreeable to the taste, slightly charged with sulphur, and is diuretic. It is held in high esteem for its medical properties by the people of the neighborhood."

BLUE SPRING.

Carroll County.

Blue spring is eight miles northwest of Eureka Springs in 21 N., 27 W., section 26, the northeast quarter; it is named from its color. It throws out a strong stream of clear cold water from a rectangular opening in the magnesian limestone and forms a deep pool in which the water appears blue, probably on account of its great depth. The pool at the spring is thirty or forty feet in diameter; in the center and at the bottom of it is the rectangular opening, apparently about three by four feet. It is reported that an attempt was made to find the depth of the spring by lowering a blacksmith's anvil by means of a rope but that no bottom was found at 460 feet. Blind fish are reported to have been taken from the spring. It is about 100 yards from the river and twenty to thirty feet above it, and its situation inside of a long, sharp curve in White River suggests that a part of the river may escape at this point from a subterranean passage. In opposition to this view, however, it is reported that the water in the spring remains clear when that of the river is muddy. T. C. Hopkins, assistant of the Survey, states that at one time he found the spring clouded with sediment while the water in the river was quite clear. A citizen dwelling in the vicinity made the statement that the spring becomes turbid when there is a freshet in Osage Creek, a stream over twelve miles a way and on the opposite side of Kings River.

CABOT WELL WATER.

Lonoke County.

Analysis.

Constituents.	Grains per U. S. gallon.
Dissolved matter	676.81
Sulphuric acid (SO_4)	208.74
Chlorine (Cl)	102.05

The water contains in solution:

Chloride of soda (NaCl) (common salt) } mainly
Sulphate of magnesia ($MgSO_4$) (Epsom salt) }
Silica (SiO_2) }
Chloride of potash (KCl) }
Sulphate of lime ($CaSO_4$) } small quantities
Sulphate of potash (K_2SO_4) }
Sulphate of soda (Na_2SO_4) }

Organic matter—very little. Iron, copper, lead or nitrates—none.

Water collected by L. D. Stephens, from an open well at Cabot, Lonoke county August, 1889.

The water is milky in color, and deposits a voluminous, finely divided, dark colored sediment (clay). The taste is salty and disagreeable.

The town of Cabot is on the St. Louis, Iron Mountain and Southern Railway, in Lonoke county, township 4 N., 9 W., section 18, the west half; it is on rock of the Mesozoic formation very near the boundary line between this age and the Palæozoic.

The large per cent of common salt and Epsom salt shown by the analysis tends strongly toward the conclusion that this water comes from the same geologic horizon as the salt waters of Southwestern Arkansas.

CONWAY AND WILLIAMS' ARTESIAN WELL.

Saline Landing, Howard County.

Analysis.

Silica (SiO_2).
Chloride of soda (NaCl) } large quantity.
Carbonate of lime ($CaCO_3$) }
Carbonate or sulphate of potash (KCl or K_2SO_4)—trace, most probably K_2SO_4.
Sulphate of magnesia ($MgSO_4$)—the merest trace.

Water collected by J. C. Branner, December 20, 1891.

Analysis by A. E. Menke.

Total solids in solution, 90.41 grains per U. S. gallon.

This well is on Conway and Williams' farm, at Saline Landing, Howard county, in township 11 S., 28 W., section 35. The well is 466 feet deep and is bored in rocks of Cretaceous age. It passes through the following strata:

Soil and clay	25 feet.
Brown sand	1 "
White lime rock (chalk)	140 "
Blue marl and shale	290 "
Rock containing water (samples showed some iron pyrites)	8–10 "
Total	466 "

COX'S ALUM SPRING.*

Scott County.

"On the southwest quarter of section 5, 1 N., 28 W., the water flowing from the shales is highly charged with mineral ingredients. Much of it is highly concentrated and cannot well be drunk without dilution. It is similar in taste to the well water at Sloane's on the southeast quarter of section 31, 3 S., 25 W., referred to on page 126. Mr. Cox has a number of tanks or pans in which he first soaks and boils pieces of the rock, afterward evaporating to dryness the solution obtained. Some of the reddish powder, in all respects like that made by evaporating the water of Sloane's well in Montgomery county, was analyzed with the result stated on page 126. Some quarrying or digging has been done along the line of the fault which occurs at this place, and in the gorge of a stream which fol-

*The notes here quoted on Cox's Alum spring are taken from the Annual Report of the Geological Survey of Arkansas, 1888, Vol. 1, by T. B. Comstock, p. 168.

lows the fracture for some distance. At the head of the gorge, several natural and artificial pools collect strong alum water from crevices in the rocks."*

CRYSTAL SPRINGS.†

Montgomery County.

"In the black dolomite, near an anticlinal fold, a number of excellent chalybeate springs emerge along the sides of the stream. Some of them are quite small, but there are several of large dimensions. These springs are mostly clustered within a small area in the little town of Crystal Springs, which is admirably situated for a watering place. A few of the bowls of the springs are surrounded by evidence of former greater activity, and some have deposits which suggest that thermal waters once overflowed from them."

DALLAS TOWN SPRING.

Polk County.

The following analysis of the Dallas town spring water is quoted from Owen.‡

"The town spring at Dallas was tested at the fountain-head, and found to be a tolerably pure water, containing only traces of carbonates, chlorides, and sulphates of the alkalies and alkaline earths."

This is probably the spring that is now known as the "Bethesda spring," and is about a mile west of where the courthouse now (1891) stands.

DE SOTO SPRING.

Marion County.

De Soto spring (Sylva post-office) is in Marion county, in township 17 N., 15 W., section 20, the northwest quarter, near the head of one of the terminal ravines of Panther Creek. The

*See Sloane's Alum well, page 114.

†The notes here quoted on the springs at Crystal Springs, Montgomery county, are taken from the Annual Report of the Geological Survey of Arkansas, 1888, Vol. I, by T. B. Comstock, p. 106.

‡Second Report of a Geological Reconnoissance of Arkansas, 1860, p. 97.

spring emerges from the limestone at the base of the Lower Carboniferous rocks. Other springs, some of them larger, occur along the ravine at a lower level. A quarter of a mile below the water from all the springs flows over a perpendicular ledge of sandstone, in a stream several feet in width, forming a cataract thirty feet or more in height.

The De Soto spring was a few years ago the resort of large numbers of health-seekers. Two families reside permanently at the springs at present (1891) and others are there for a few months in the summer season. No analysis of the water has been made.—[T. C. Hopkins.]

GILLEN'S WHITE SULPHUR SPRING.

Garland County.

An analysis of water from Gillen's White Sulphur spring was made by Chauvenet and Blair, of St. Louis, Mo., the results of which are given below:

Constituents.

"Carbonates of iron, lime and magnesia; traces of organic matter and very small quantities of sulphuric acid and free carbonic acid.

"Chlorine is absent. Sulphuretted hydrogen cannot be detected even in traces. Exposed to the air, iron oxide in small amount is slowly deposited. Total residue on evaporation, sixteen grains to a gallon. Altogether similar in composition to 'Mountain Valley' water, near Hot Springs"

Gillen's White Sulphur spring is said to have good medicinal properties "in cases of dropsy, liver and stomach troubles, diseases of the kidney and bladder, and possess a fine tonic property."

The spring is in township 2 S., 19 W., section 26, near the center of the southeast quarter. It is three miles northeast of Hot Springs. The water comes from rocks of Lower Silurian age.

Near the spring the ground is comparatively level, but a half mile to the northwest, Indian Mountain rises to a height of 500 feet above the general level.

A good hotel has been built near the spring so that visitors may obtain first-class accommodations.

GRAY'S SPRING.

Howard County.

The following analysis of "Gray's Spring," Howard County, in township 5 S.,* 29 W., is quoted from Owen:†

"Temperature, 58° F., the air being 52° F. The main constituents of this water are:

"Carbonate of soda.
Sulphuret of sodium.
Chloride of sodium.
Traces of sulphate of soda.
Traces of sulphate of magnesia.

"Its medical properties will be found to be analogous to those of 'Baker's Spring.'"

INTERMITTENT SPRING.

Marion County.

At Bruno, in Marion County, in township 17 N., 17 W., section 3, is a spring that is intermittent in dry seasons. No regularity has been observed in the periods of flow. A bold stream flows from the spring for several hours, stops for a few hours or a half a day, and then suddenly begins again. In wet weather it flows continuously. It is in rocks of Lower Silurian age.—[T.C. Hopkins.]

JACKSON SPRING.

Marion County.

Jackson spring is in Marion county, in township 19 N., 16 W., on Lee's Mountain, about three miles northwest of Yellville: it has a local reputation as a health resort. The water flows from rocks of Silurian age.—[T. C. Hopkins.]

*In the text the township is given as 5 N., but the context shows that 5 S. is meant. This township was at that time a portion of Polk County.

†Second Report of a Geological Reconnoissance of Arkansas, 1860, p. 97.

JETT AND ORTON'S ARTESIAN WELL.

Little River County.

Qualitative Analysis.

Hypothetical Combination.

Silica (SiO_2)	small quantity.
Chloride of soda (NaCl)	chief constituent.
Chloride of potash (KCl)	traces.
Chloride of lithia (LiCl)	traces.
Chloride of lime ($CaCl_2$)	small quantity.
Chloride of magnesia ($MgCl_2$)	trace(?).
Carbonate of magnesia ($MgCO_3$)	very small quantity.
Carbonate of lime ($CaCO_3$)	small quantity.
Organic matter, nitrogen	large quantity, indicated by the free and albuminoid ammonia.

Sanitary Analysis.

Total solids, dried at 275° F. (135° C.)	298.66 grains per U. S. gallon.
Chlorine (Cl)	165 43 " " " "
Sulphuric acid (SO_4)	none.
Iron (Fe)	slight trace.
Free ammonia	13.19 parts per million.
Albuminoid ammonia	0.21 " " "

Water collected by R. H. Hale, July 27, 1891.

Conclusion.—This is not a potable water. The total solids are excessive.

The water is clear, deposits a slight reddish or reddish-yellow clayey sediment. Taste, strongly salty, faint odor; reaction neutral.

This water evidently comes from the salt beds of the Mesozoic formation, and must come from about the same horizon as the saline waters on the Ouachita River, near Arkadelphia.

The well is in 13 S., 27 W., section 27, on land owned by Jett and Orton in the flood plains of Red River. It is 146 feet in depth.

LONG SPRING.

Hempstead County.

Qualitative Analysis.

Magnesium (Mg)	chief constituents.
Hydrochloric acid (HCl)	chief constituents.
Sodium (Na)	small quantities.
Potassium (K)	small quantities.
Calcium (Ca)	small quantities.
Iron (Fe)	small quantities.
Sulphuric acid (SO_4)	very little.

The dissolved matter in the water, therefore, appears to be :

Chloride of magnesia ($MgCl_2$)	chiefly.
Sulphate of magnesia ($MgSO_4$)	chiefly.
Chloride of soda (NaCl)	in smaller qualtities.
Chloride of potash (KCl)	in smaller qualtities.
Chloride of lime ($CaCl_2$)	in smaller qualtities.
Sulphate of potash (K_2SO_4)	in smaller qualtities.
Sulphate of lime ($CaSO_4$)	in smaller qualtities.
Sulphate or oxide of iron	in smaller qualtities.

Water collected by Hon. J. D. Conway, Washington, Hempstead county.

Analysis by Brackett and Smith.

Temperature of air, 85° F.; of water, 58° F.

Total solids in solution, dried on water bath, 4.33 grains per U. S. gallon.

Total solid material after ignition, 3.58 grains per U. S. gallon. Upon ignition the solids burn brown and finally white, giving off white fumes with no decided odor.

The water is clear, odorless and tasteless. A slight yellowish sediment (iron hydroxide) is formed by the water.

Long spring is in township 9 S., 24 W., section 19.

MERIWETHER'S WELL.

Cleveland County.

The following analysis of well water from Judge J. M. Meriwether's place, in township 10 S., 10 W., section 8, is taken from Owen.*

" Bicarbonate of lime, remarkably strong.
Bicarbonate of magnesia, remarkably strong.
Sulphate of alumina, strong.
Sulphate of magnesia, strong.
Sulphate of soda, strong.
Chloride of sodium, strong.
Iron, a trace.

"The water is acid to test-paper, and when evaporated to dryness, leaves a large residuum. It is so strongly charged

*Second Report of a Geological Reconnoissance of Arkansas, 1860, p. 412.

with mineral matter that it is entirely unsuited for domestic use. Even cattle and other stock would probably be greatly injured, if suffered habitually to drink this water."

MINERAL SPRINGS.

Clark County.

Mineral springs, Clark county, are two miles northeast of Antoine post-office, a quarter of a mile south of the military road, on the Amity-Okolona road, six miles north of Okolona, the nearest railway point. Seven springs issue near each other, and one larger spring a short distance away. These springs are well tiled, and the large one has a cover. The water issues from a dark colored, sandy deposit, with streaks of black shale or clay, all of which are probably of Cretaceous age. These beds dip to the south at an angle of 45°. The place is used as a local summer resort and camping place. An open Methodist chapel, a dozen or more summer cottages, and frames for a number of tents, have been built at this locality.

POISON SPRING.

Carroll County.

A spring, known locally as "Poison spring," which is said to cause sickness to persons or animals using the water, is in Carroll county, on the Dry Fork of King's River, in township 18 N., 24 W., section 29. The water comes from rocks near the base of the Lower Carboniferous series.—[T. C. Hopkins.]

ROGERS SPRINGS.

Benton County.

The most noted medicinal springs in the eastern part of Benton county are those near Rogers, in 19 N., 29 W., section 6, where a dozen springs occur in one quarter-section. The ones most noted for their healing properties are those known as the Electric springs,* a name given to three small springs, or one spring with three outlets. Mossy spring has a reputation as a blood purifier. The Bath Rock spring is named from the nat-

*For analysis of the Electric spring see Chapter III.

ural cavity, shaped somewhat like a bath-tub, cut in the limestone. There are two springs which are slightly chalybeate, all the others being clear, odorless and tasteless. The springs are all in the Boone chert formation and its accompanying limestones.—[T. C. Hopkins.]

THE SANITARY WELL.

Logan County.

Near National spring (see page 75) is a well, known as the "Sanitary well," the water from which was formerly evaporated and the residue sold as a medicine. The wrapper used on these packages has the following regarding the character of this substance:

"It is not a panacea, but it is warranted to cure diseases of the liver and kidneys, chronic diarrhœa, hemorrhoids, dyspepsia, headache, rheumatism, cancer, ulcers, burns and all cutaneous diseases, when directions are correctly followed. It is unequaled as a worm exterminator."

The constituents as given on the wrapper are:

Silicate of iron.
Chloride of soda.
Chloride of magnesia.
Carbonate of magnesia.
Carbonate of lime.
Bicarbonate of iron.
Sulphate of soda.
Sulphate of potash.
Sulphate of magnesia.
Alumina.

SCOTT COUNTY WATERS.

The two following analyses of waters from Scott county are quoted from Owen:*

"About 275 feet below the top of the Chalybeate Hill, a strong chalybeate water issues from the ferruginous sandstones in the southern slope of that hill, and considerable iron ore is strewed along the hillside. The water is a saline chalybeate, possessing strong deoxidizing powers. It is situated near the line between sections 16 and 21, Township 3, North Range, 30 West, probably towards the southwest corner of 16. This

*Second Report of a Geological Reconnoissance of Arkansas, 1860, pp. 88, 89.

would be a most valuable mineral water for invalids requiring a pure tonic with a slight alterative influence combined.

"The spring water rising from the shales of the Millstone Grit, in the Poteau valley, at Dr. James H. Smith's, was also tested qualitatively, and found to contain principally chloride of sodium, a trace of bicarbonate of lime, and a trace of bicarbonate of magnesia.

"The west branch of the Poteau river was also tested,* and found to contain less chlorides, and more carbonates of the alkaline earths."

SEVIER COUNTY WATER.

The following analysis of water from a salt well in Sevier county is quoted from Owen.† The well is said to be in 10 S., 29 W., section 22, on a live-oak flat.

"Chloride of sodium.
Bicarbonate of lime.
Bicarbonate of magnesia.
Bicarbonate of alkali.
Chloride of magnesia.
Trace of sulphates.

"It is said that, at one time, with thirty-two kettles of thirty-five gallons each, twenty bushels of salt were made daily for three months, and that it afforded a dry, white salt."

SILVER SPRING.

Benton County.

Silver spring, in township 19 N., 29 W., section 28, is one of the largest and most beautiful springs in north Arkansas. It emerges from the base of a bluff near the bottom of the Boone chert formation, in a crystal stream two or three feet deep and from six to ten feet across. The water is utilized to run a flour mill, distillery and saw mill a short distance below the spring.

Another large spring is in township 19 N., 29 W., section 35, on the road from Rogers to Eureka Springs by way of Prairie Creek; it flows from Silurian rocks; still another in

*No note is made of the physical conditions of the water, or the stage of the river when the water was collected.

†Second Report of a Geological Reconnoissance of Arkansas, 1860, p. 116.

township 19 N., 27 W., section 17, on the east prong of Little Clifty Creek, emerges from the base of the Boone chert. [T. C. Hopkins.]

SLOANE'S ALUM WELL.*

Hot Spring County.

"On the southeast quarter of section 31, 3 S., 25 W., at Mr. Sloane's house, there is a deep well, opened in the black shale, the water from which cannot be regularly used because of its strong taste. When the supply is plentiful, as it was August 11, 1887, it is slightly astringent, and has the taste of a rather sour chalybeate water; but in a dry period the solution becomes highly concentrated and unsuitable for drinking purposes. Half a gallon of water, taken at the time of its greatest strength, and evaporated, produced a reddish brown powder, perhaps two ounces or more in weight. A qualitative analysis of this sample shows:

"Iron (ferrous), Magnesium
Sulphuric acid, Potassium,
Aluminum—a very slight trace.

"The line of the Blue Mountain uplift passes near this locality, and the topography at Mr. Sloane's, and between there and Black Spring, suggests that the fracture may run directly through his farm. The altitude at Mr. Sloane's is greater than at the town, and the beds of shale which supply the water are probably higher in the geologic scale than those at Black Spring. If this water should prove, medicinally or otherwise, economically valuable, it is probable that an abundance of it can be found at slight depths by boring under the guidance of a competent geologist."

SPRINGFIELD TOWN SPRING.

Conway County.

The following analysis from Owen† is of spring water from

*The notes here quoted on Sloane's Alum Well were taken from the Annual Report of the Geological Survey of Arkansas, 1888, Vol. I, by T. B. Comstock, p. 126.

†First Report of a Geological Reconnoissance of Arkansas, 1858, p. 236.

the town of Springfield, which was at that that time (1858) the county seat of Conway county:

"Carbonic acid;
Bi-carbonate of lime;
Bi-carbonate of magnesia;
Bi-carbonate of the protoxide of iron (strong).

"Another chalybeate spring of the same character occurs at Peach Orchard gap, in section 20, township 6 north, range 10 west, in the edge of White county, and belongs to Mr. Elliott."

STATE SALT SPRING.

Franklin County.

The following analysis of water from a spring in Franklin county, given by Owen as the "State Salt Spring," is quoted from him.*

"Chloride of sodium (common salt).
Bi-carbonate of lime.
Bi-carbonate of magnesia.
Bi-carbonate of the protoxide of iron.
Sulphates, a trace."

The "State Salt Spring" is on Mulberry River, in township 11 N., 28 W., section 30 (?). It is a saline water and flows from rocks of the Coal Measures.

STONEWALL SPRING.

Marion County.

Stonewall spring is in Marion county, in township 19 N., 15 W.; it has a local reputation as a health resort. The water flows from rocks of Silurian age.—[T. C. Hopkins.]

SULPHUR SPRING.

Yell County.

Just south of Spring Mountain, in Yell county, is a group of five springs, commonly known as the Sulphur springs. They are in 6 N., 22 W., section 10, southeast quarter of the northwest quarter. These springs are all highly charged with sulphuretted hydrogen. The place has been more or less used as a health resort. There is a hotel at the locality and a few cottages,

*First Report of a Geological Reconnoissance of Arkansas, 1858, p. 229.

which are occupied by visitors during the summer months. In addition to the sulphur waters a pipe was formerly used to bring chalybeate water from the mountain to the north. These springs are said to belong to the New York Mercantile Trust Company of New York and St. Louis.

There are also two chalybeate springs on the south side of Chickalah Mountain, 6 N., 22 W., section 28.—[J. H. Means.]

WASHINGTON COUNTY SPRINGS *

"As in all limestone countries, springs are abundant throughout Washington county. The largest issue from the Boone chert and cherty limestone, while many of value are found gushing from the Archimedes and Pentremital limestones. The following, in the immediate vicinity of Fayetteville, were gauged by Prof. J. Whitham, of the Engineering Department of the Arkansas Industrial University, upon the dates given. Within the corporate limits of Fayetteville are three springs of more than ordinary magnitude. Cato's Spring (also known as Harrison's Spring, Big Spring and Spout Spring), is situated in a ravine at the foot of East Mountain. Here the water issues from the Pentremital limestone. May 21, 1887, its measured flow was at the rate of 12,067 gallons in twenty-four hours.

"Lewis' Spring is near the line of the St. Louis and San Francisco Railway, south of the depot, between Dixon and Spring streets. This spring issues from rocks that immediately overlie the Archimedes limestone. It does not flow from the edge of eroded strata, like the preceding, but is rather a welling up of water. May 23, 1887, its flow was at the rate of 26,221 gallons in twenty-four hours.

"William's Spring is in an east-west ravine that extends through the northern part of Fayetteville, and, in its general character, resembles Lewis' Spring, but probably differs in its geologic position, inasmuch as the sandstones near at hand are

*The notes here quoted on Washington county springs are those of Dr. F. W. Simonds, published in the Annual Report of the Geological Survey, 1888, Vol. IV, p. 21.

very much disturbed, being completely turned on edge. May 28, 1887, it discharged 8607 gallons in twenty-four hours.

"The largest spring examined is situated in 17 N., 30 W., the southwest quarter of the southwest quarter of section 15, and is widely known as Johnson's Spring, or The Big Spring. It wells up from the cherty limestone, and covers an area of perhaps an eighth of an acre. August 2, 1888, its measured capacity was 2,345,967 gallons in twenty-four hours. The flow from this and two smaller springs is utilized for power at Johnson's mill. On this date the mill flume was also gauged showing a flow of 2,562,491 gallons in twenty-four hours. This locality may, in the future, be very valuable from an economic standpoint, as a source of water supply for the city of Fayetteville.

"In 16 N., 30 W., not far from the center of section 2, a fine flowing spring issues from what appears to be the opening of a cavern in the Pentremital limestone.

"At Elm Springs, in 18 N., 31 W., near the center of section 25, clear, sparkling water gushes from the cherty limestone, forming many springs along the bank of a small branch, locally called Brush Creek, a tributary of the Osage. Several houses of the village are supplied with water from them, and with the necessary improvements these springs could be made a resort of some importance. In 17 N., 28 W., near the northwest corner of the southwest quarter of the northeast quarter of section 7, in the bed of Brush Creek (not to be confounded with that above mentioned), a short distance above its union with White River, there is a very large spring, called Blue Water Spring. It issues from the cherty limestone.

"Mention should likewise be made of the large, flowing spring in 17 N., 32 W., near the center of section 36. It issues from the same limestone, at or very near its point of contact with the Eureka shale. The water, as it flows from the rock, seems to be accompanied by a current of air.

"At the residence of Col. J. P. Neal, at Prairie Grove, there is another beautiful spring, flowing from the same formation. In the neighborhood of Boonsboro, too, there are numerous

fine springs gushing from the Archimedes limestone, and the same is true on the south side of the Boston Mountains, in the vicinity of Morrow's school house, on Cove Creek.

"Occasionally, as might be expected, the sandstone formations furnish water. Water issuing from the shale is, as a rule, rather inferior for drinking purposes, owing to the salts carried in solution."

WASHINGTON WELL WATER.

Hempstead County.

The following analysis of water from a well "on Lowry's lot, on the north edge of the town of Washington," Hempstead county is quoted from Owen.*

"Protoxide of iron, partly held in solution by carbonic acid and partly by an organic acid.
Chloride of sodium.
Traces of sulphate of soda and magnesia.
Bicarbonate of lime.
Bicarbonate of magnesia.
Carbonate of alkali."

WATERS' SPRINGS.

Garland County.

Waters springs are in Garland county, four miles southeast of the city of Hot Springs, on land owned by W. W. Waters, in township 3 S., 18 W., section 7, the southeast quarter of the southwest quarter.

The samples for analysis were collected by W. W. Waters and C. N. Rix, June, 1891.

SPRING NO. 1.

The chief constituent of the water is carbonate of lime.

There are present besides: Sulphate of lime, carbonates and sulphates of magnesia, iron and alkalies, chlorides of the alkalies (sodium and potassium), organic matter; silica and free carbonic acid.

The iron and organic matter are in small quantities.

Discharge of spring from 270 to 535 gallons per hour.

Total solid material in solution, 11.54 grains per U. S. gallon.

The water is tasteless, odorless, and has a neutral reaction.

*Second Report of a Geological Reconnoissance of Arkansas, 1860, p. 117.

SPRING NO. 2.

The chief constituent is carbonate of iron.

There are present besides: Carbonates of lime and magnesia; chlorides of the alkalies (sodium and potassium); small quantity of organic matter; silica; free carbonic acid.

Discharge from 70 to 130 gallons per hour.

Total solid material in solution, 2.5 grains per U. S. gallon.

This is a weak chalybeate water; it is odorless and has a neutral reaction.

SPRING NO. 3.

The chief constituent is carbonate of lime.

There are present besides: Carbonates of magnesia and iron; chlorides of the alkalies (sodium and potassium); small quantity of organic matter; silica; trace of iron; lithium—none.

Discharge from 70 to 130 gallons per hour.

Total solid material in solution, 1.81 grains per U. S. gallon.

This is a good, pure water, being free from sulphates in any quantity.

WINONA SPRINGS.

Carroll County.

Winona springs have a local reputation as a health resort. They are in township 19 N., 25 W., section 6, six miles southeast of Eureka Springs, the nearest railway station. There are several small but constant springs, one of which seems to have been a resort for invalids. They resemble the Eureka springs in size, clearness of the water, and the rocks from which they flow, being either on or close to the top of the Silurian rocks. Near the springs are a post-office, store, school-house and two dwelling houses.—[T. C. Hopkins.]

YELL COUNTY WATER.

The following is quoted from Owen*

"On Section 28 or 29, Township 5,† Range 21 W., is a remarkable chalybeate spring, at an elevation of three hundred and seventy feet above Danville, and distant about two and a half miles from that place. From the large quantity of carbonate of the protoxyd of iron present it has a most powerful deoxidizing effect, instantly blackening nitrate of silver with-

*Second Report of a Geological Reconnoissance of Arkansas, 1860, p. 81.

†Township 5 N. is intended here, though in the text it has been omitted.

out even the addition of ammonia. Its temperature was found to be 62°, the temperature of the air being 79° F. It is a saline chalybeate, containing as its principal ingredients:

"Bi-carbonate of the protoxyd of iron.
Bi-carbonate of lime.
Bi-carbonate of magnesia.
Sulphate of soda.
Chloride of sodium?

"This mineral water not only blackens nitrate of silver, but also chloride of gold and tincture of campeche."

CHAPTER V.

Sanitary Water Analysis.

BY RICHARD N. BRACKETT, PH. D., CHEMIST.

Nature of the Analysis.—The kind of analysis of potable water, which is generally suitable for sanitary purposes, comprises determinations of total solids, chlorine, free ammonia and albuminoid ammonia, and whether or not the water contains more than the least trace of lead, copper, nitrites or nitrates.* Having made such a sanitary analysis of water, and knowing its previous history, one is in position to judge of its fitness for domestic use. The necessity of knowing the source and recent history of a water cannot be too strongly emphasized, for a constituent occurring in a water from one source, which alone would indicate the impurity of the water, or be a valuable aid in judging of its purity, might not raise any suspicion of impurity, if present in a water from another source and surrounded by different conditions.

With reference to this point Dr. Charles Smart† says: "The information furnished cannot be too full. With respect to wells, the depth of the well and of its contained water should be given, together with all particulars concerning drainage into it. The proximity of large trees is a point which should invariably be noted. * * * River samples should have mentioned with regard to them the exact point from which they were derived and the distance of this below such sources of impurity as are constituted by sewage inflow and manufactory refuse. The stage of the water is also important, as the turbidity which increases with a rise in the water level adds correspondingly to the impurity."

Total solids.—By solids or total solids is meant the residue

*Wanklyn, Water Analysis, 1884, p. 67.
†Report of the National Board of Health, 1880, p. 449.

remaining after evaporating the water. This residue is for the most part inorganic or mineral matter. Sodium chloride or common salt, and carbonates and sulphates of the alkalies, of lime and of magnesia are the mineral constituents most common in potable waters. Besides these the residue frequently contains a considerable amount of silica and a little organic matter. When the quantity of total solids is small the nature of the mineral matter need not be taken into account, so long as no poisonous substances are present. If a water contains less than 17.5* grains of total solids to the U. S. gallon it may be pronounced wholesome so far as inorganic constituents are concerned. If on the other hand as much as 58 grains to the U. S. gallon be found, the water may be condemned as unfit for use, without regard to the nature of the salts composing the residue. The limit of total solids as given by Wanklyn† is 25 to 33 grains to the U. S. gallon. Taking the limits of total solids allowable as 33 to 58 grains, when the amount of residue lies between these extremes, the decision in regard to potability must depend on the nature of the constituents. A water containing common salt and carbonates of the alkalies, of lime and of magnesia with very little sulphates, is less objectionable than one with a large quantity of sulphates and very little salt and carbonates.

Chlorine.—Chlorine occurs in waters usually in combination with sodium as common salt, but also as potassium and magnesium chlorides and sometimes combined with other metals. On account of the intimate and universal association of sodium chloride (common salt) with animal life, a knowledge of the amount of chlorine‡ present is, under certain conditions, of considerable value in determining the organic purity of water. In regions where there is a considerable amount of common salt, chlorine as a factor in the determination of the amount of the organic purity of water loses a part or all of its significance. The determination of chlorine is of most importance

*Report of the National Board of Health. 1880, p. 452.

†Water Analysis, 1884, p. 22.

‡Report of the National Board of Health, 1880, p. 480.

in shallow wells and underground cisterns. "In deep wells and springs the chlorine is valueless as a part of the organic analysis,"* for in these cases it has probably been long in the soil in the form of common salt and other chlorides, and has no organic matter accompanying it.

From four to eight grains of chlorine to the U. S. gallon will not injure water for domestic purposes, but are only a reason for suspicion under certain circumstances.†

Free Ammonia.—By free ammonia is meant that which is liberated by simply boiling water. This ammonia is present in water either as such or in the form of easily decomposed ammonium salts as the chloride and carbonate. When water is boiled the free ammonia is carried off with the water vapor, and this vapor may be condensed, collected, and the ammonia in it estimated.

"The estimation of ammonia is undertaken chiefly because this compound is often derived from animal matters just beginning to decompose, and its presence, therefore, gives an indication of the recent, and probably present, existence of animal pollution."‡

Ammonia is found in all rain and surface waters, but is usually absent or occurs in small proportion in unpolluted waters, in deep wells and springs. "That which occurs in the rain is derived from the atmosphere, where, in combination with nitrous acid, it is known to be formed by the union of elementary atmospheric nitrogen by electric discharge in the presence of moisture."‖ The amount of ammonia contained in rain water may, in the region of cities reach as much as 2.1 parts per million, but in the country the average is 0.03 part per million.§

The proportion of ammonia in shallow wells varies with the efficiency with which the water is filtered on its way to the

*Report of the National Board of Health, 1880, p. 480.

†Wanklyn, Water Analysis, 1884, p. 67.

‡Frankland, Water Analysis, 1880, p. 26.

‖Report of the National Board of Health, 1880, p. 463.

§Frankland, Water Analysis, 1880, p. 26.

reservoir. The presence of ammonia in considerable quantity indicates very recent contamination with animal matter.

In the case of deep wells* a large quantity of free ammonia does not necessarily indicate recent contamination with organic matter. When a large quantity of ammonia is found and cannot be traced to surface inflow, there seems to be no doubt that it is formed by the reduction of nitrates, which have been formed by oxidation from organic matter containing nitrogen. As both of these processes, oxidation and reduction, require some time, the ammonia found does not indicate recent contamination of the water. The consideration of such a case as this makes plain the necessity of knowing the source and surroundings of a water in judging of its purity from a chemical analysis.

As to the relation between the amount of free ammonia found and the purity of water Dr. Smart† says: "Ammonia in river waters has no sanitary value, as it depends on the rain fall. Well and spring waters should contain but a trace, certainly not over 0.02 part per million. * * * Where ammonia is over 0.02 part per million there is generally some contamination, the origin of which must be ascertained."

Albuminoid ammonia.—If water, from which the free ammonia has been removed, be treated with certain chemical reagents and boiled, the condensed water vapor will usually be found to contain ammonia. This ammonia is formed by the decomposition of organic matter containing nitrogen, and is called albuminoid ammonia or organic ammonia. Under certain conditions the amount of albuminoid ammonia found in water serves as a measure of its organic purity.

‡Ordinarily, if a water contains 0.05 part per million or less of albuminoid ammonia, it may be pronounced pure in this respect. When the amount of albuminoid ammonia found lies

*Report of the National Board of Health, 1880, p. 463.

†Report of the National Board of Health, 1888, p. 467.

‡In regard to the amount of albuminoid ammonia consistent with the organic purity of water, see Wanklyn, Water Analysis, 1884, p. 68; and Report of the National Board of Health, 1880, pp. 469, 471.

between 0.05 and 0.2 parts per million, the recent history of the water must be known in order to judge of its purity. Rain water fresh from the clouds is said to contain rarely less than 0.1 and may contain 0.46 part per million. Instances are given of river samples collected where there was no chance for sewage contamination, none of which contained less than 0.14 part per million of albuminoid ammonia. If as much as 0.15 part per million be found in a well water, that fact alone is sufficient to condemn the water. For stored rain water the limit is fixed at 0.2 part per million, because with much more than this amount warm weather will develop a taint in the water appreciable by the senses.

Nitrates and nitrites.—Nitrates and nitrites, like ammonia, in the small quantity in which they occur in waters, though harmless in themselves, are sometimes of value in judging of the purity of water. They are formed by oxidation from organic matter containing nitrogen, in many cases, probably under the influence of a special organism or nitric ferment. Taken alone they indicate past and more or less remote contamination, which is less remote in the case of nitrates and nitrites than of nitrates alone, since nitrites are an intermediate stage in the formation of nitrates. Their presence is of greater significance in surface waters and in shallow wells than in deep wells *

An attempt has been made above to set forth as briefly as possible what constitutes a sanitary water analysis, and its value in determining the fitness or unfitness of a water for domestic uses. The methods used are essentially those described by Wanklyn† in his book on water analysis. In no case was a quantitative determination of nitrites made, but merely a qualitative test for their presence.

To these determinations were added observations of the clearness, taste and odor of the water, together with its reaction toward litmus paper, whether acid, alkaline or neutral. In

*Report of the National Board of Health, 1880, p. 471.

†Wanklyn, Water Analysis, 1884.

every case the reaction was neutral, no substance with acid or alkaline properties being present.

The amounts of free ammonia and albuminoid ammonia are expressed in parts per million. All other results of the analyses of waters are given in grains to the United States gallon of 58,372.175 grains.

Such a sanitary analysis as that described above was made of the following waters:

I.—Little Rock water supply:

1. Wells and cisterns.
2. Arkansas River water.

II.—Fort Smith water supply.

III.—Hot Springs water supply.

IV.—Miscellaneous:

1. Water from Fulton, Hempstead county.
2. Water from T. W. McConnell's spring, Pulaski county.

LITTLE ROCK WATER SUPPLY.

Wells and cisterns.—In examining the well waters of Little Rock care was taken, under the direction of the State Geologist, to obtain water from wells penetrating the different geologic formations underlying the city. In most cases the water was collected at two stages, namely, after a dry season (November, 1887), when the wells were low, and after a wet season (July, 1888), when they were full. In collecting the water every precaution was taken to get representative samples, and the determinations were made as soon as possible after the water was collected.

For convenience of reference the results are given in the form of tables. The data of collection and of the determinations are given in the tables. In no instance was any poisonous substance found.

Water from 427 East Twenty-second Street, Little Rock.

Odor and taste, bad; reaction, neutral; water, a little cloudy and with a slight scum of iron oxide on the surface.

Total solids, 14.16 grains per U. S. gallon.

On ignition the yellowish brown residue turned black, gave off slight fumes, with strong odor of burnt organic matter. The black burns off leaving dark iron oxide.

The residue from the evaporation of the water effervesces with acids, and gives odor somewhat like acetic acid; reacts for sulphuric acid; strongly for iron, and slightly for manganese.

The water itself turned brown on evaporation, and gave on analysis:

Iron	strong reaction
Sulphuric acid	none
Chlorine	strong reaction

Loss on ignition, 6.33 grains per U. S. gallon, and is largely organic matter.

It is not a good, potable water, as it contains too much iron and organic matter.

SANITARY ANALYSES OF LITTLE ROCK WELL WATERS.

Number.	Locality.	Surroundings of the well.	Collected.	Analyzed.	Grains per U. S. gallon. Total solids.	Chlorine.
1	206 Center street.	22 ft. to surface of water (Sept. 27, 1888); cow lot 20, and privy about 40, ft. west of well; drainage from west towards well; walled with loose rock to 3 ft. of top, then cemented brick to top; covered but not kept clean around mouth.	Nov. 15, 1887.	November 16.	.....	4.43
			Nov. 16, 1887.	November 16.	23.57	.....
			July 17, 1888.	July 17.	40.61	7.77
2	506 State street.	About 16 ft. deep; walled with loose rock about half way to top: overflows in wet weather; fitted with iron pipe and pump.	Nov. 17, 1887.	November 18.	10.08	1.83
			Nov. 19, 1887.	November 21.	....	.....
			July 5, 1888.	July 5.	30.99	4.17
3	504 Center street.	About 16 ft. deep; walled with loose rock; privy 20 ft. away and well kept; stable 60 ft. and wagon yard 100 ft. away; drainage carefully attended to.	Nov. 17, 1887.	November 18.	36.15	8.49
			Nov. 19, 1887.	November 21.	.....	.....
			July 27, 1888.	July 27.	55.89	8.73
4	521 West Third st.		Nov. 15, 1887.	November 15.	25.53	3.06
			Nov. 16, 1887.	November 16.	.....	.....
			July 17, 1888.	July 17.	28.49	4.96
5	Capitol Park.	Said to be 25 or 30 ft. deep and walled with brick; covered; fitted with iron pipe and pump; large trees within 6, 10 and 20 ft.	Nov. 14, 1887.	November 15.	30.11	7.36
			Nov. 16, 1887.	November 17.	.....	.....
			July 11, 1888.	July 12.	36.36	8.67
6	"Old red mill," north end of Spring st.	18 ft. deep; fitted with wooden pipe and pump; on bluff above the river; no source of contamination near.	Nov. 16, 1887.	November 16.	.....	4.73
			Nov. 17, 1887.	November 17.	19.08	.....
			July 17, 1888.	July 17.	14.37	2.42
7	Peabody School, 5th, between Gaines and State streets.	18 ft. deep; covered; large trees near; sewer pipe runs within 10 ft., but not thought to leak; lot formerly a graveyard.	Nov. 21, 1887.	November 22.	35.44	9.66
			July 27, 1888.	July 27.	34.69	8.05
8	Fort Steele School, State, between 12th and 13th streets.	30 ft. to surface of water (Sept. 25, 1888); on top of a hill; covered; walled up with brick to the top.	Nov. 21, 1887.	November 23.	5.66	1.36
			July 3, 1888.	July 3.	9.58	1.57
			July 3, 1888.	July 7.	9 16	1.63
			July 11.	July 11.	.....	1.57
9	Scott Street School, Scott, bet. 14th and 15th streets.	26 ft. to surface of water (Sept. 27, 1888); on top of a hill; covered; walled with brick to the top.	Nov. 21, 1887.	November 23.	16.92	4.02
			July 26, 1888.	July 26.	13.37	2.76

Parts per million. Free ammonia.	Albuminoid ammonia.	Character of the residue.	Conclusions.	Remarks.
0.12	0.04	Contains no carbonates, but chlorides and sulphates of the alkalies and magnesia.	Fair in dry weather.	Water slightly cloudy and deposited a yellowish, clayey sediment; odorless; tasteless.
0.11	0.08			
0.01	0.14		Not good in wet weather.	Water clear, tasteless and odorless; no nitrites.
0.02	0.07	Contains chlorides, sulphates and carbonates; very hygroscopic.	Good in dry weather.	Water clear, tasteless and odorless. Clouds slightly on boiling A small quantity gave a reaction for sulphuric acid.
0.02	0.06			
0.03	0.23		Unwholesome in wet weather.	Water clear, tasteless and odorless; reacts for nitrites.
0.02	0.09	Contains carbonates, chlorides and sulphates.	Fair in dry weather.	Water clear, tasteless and odorless; on boiling clouds and deposits carbonate of lime.
0.00	0.07			
0.05	0.16	Contains chlorides and sulphates, but no carbonates; very hygroscopic.	Passably good in wet weather.	Water clear, tasteless and odorless; no nitrites; water said to have a sweetish taste at times.
0.18	0.05	Contains very much carbonates, with a little chlorides and sulphates.	Good in dry weather.	Water clear, tasteless and odorless; clouds on boiling, depositing carbonate of lime.
0.14	0.03			
0.02	0.16	Contains no carbonates, but chlorides and sulphates; very hygroscopic.	Doubtful in wet weather.	Water clear, tasteless and odorless; no nitrites.
0.14	0.01	Contains chiefly sulphates and chlorides.	Good at all seasons.	Water clear, tasteless and odorless; turns slightly dark on evaporation, due to iron from pipe.
0.00	0.01			
0.03	0.01			Water clear, tasteless and odorless; a trace of nitrites.
0.10	0.09	Hygroscopic and contains chlorides, sulphates and carbonates.	Good at all seasons.	Water clear, tasteless and odorless; no nitrites.
0.12	0 03			
0.03	0.09			
0.05	0.06	Very hygroscopic, contains no carbonates, but chlorides, sulphates and silica.	Passably good at all seasons.	Water clear, tasteless and odorless; no nitrites.
0.04	0.10			
0.00	0.02	Contains sulphates, chlorides and carbonates.	Good in dry weather; doubtful in wet weather.	Water a little cloudy and deposits a yellowish, clayey sediment; tasteless and odorless; no nitrites.
0.15	0.14			
0.03	0.13			Trace of nitrites; no iron, nor any of sulphide group.
0.07	0.18			
0.00	0 03	Slightly hygroscopic; contains chlorides, sulphates, silica and no carbonates.	Good in dry weather.	Water clear, tasteless and odorless.
0.19	0.18		Bad in wet weather.	Water slightly cloudy and deposits a yellowish, clayey sediment; a trace of nitrites.

SANITARY ANALYSES OF LITTLE ROCK WELL WATERS.—*Continued.*

Number.	Locality.	Surroundings of the well.	Collected.	Analyzed.	Grains per U. S. gallon. Total solids.	Grains per U. S. gallon. Chlorine.	Parts per million. Free ammonia.	Parts per million. Albuminoid ammonia.	Character of the residue.	Conclusions.	Remarks.
10	Sherman St. School, 7th, bet. Sherman and Ferry streets.	17 ft. to surface of water (Sept. 27, 1888); covered; walled with loose rock; surroundings good.	Nov. 23, 1887.	November 24.	12.16	1.98	0.01	0.07	Hygroscopic; contains sulphates and chlorides, but no carbonates.	Good at all seasons.	Water cloudy and deposits a small yellowish, clayey sediment; odorless and tasteless.
			July 26, 1888.	July 26.	6.54	0.73	0.10	0.09			Water clear, tasteless and odorless; no nitrites.
11	Opposite Forrest Grove School, 5th st., near Ferry st.	15 ft. to surface of water (Sept. 27, 1888); well never dry; walled with loose rock; foul privy south of well; drainage from south towards well; large trees 20 ft. away on one side and privy the same distance on the other side.	Nov. 23, 1887.	November 25.	13.33	2.55	0.02	0.05	Very hygroscopic and contains sulphates and chlorides but no carbonates.	Good in dry weather.	Water cloudy and deposits a small yellowish, clayey sediment; tasteless and odorless; no nitrites. Well fills rapidly during local rains. Water used three days per week in dry weather by children of Forrest Grove school. Water clear; no nitrites, nitrates, iron, lead or copper.
			July 26, 1888.	July 26.	28.49	5.35	0.03	0.13		Very doubtful in wet weather.	
12	Cistern at the State House.	Underground; carefully cemented; water collected from roof of the Capitol and filtered through sand and charcoal.	July 27.	July 27.	36.86	0.79	0.02	0.10	Residue consists chiefly of sulphates, but contains also chlorides and carbonates of the alkalies and magnesia.	Free from organic impurities; large amount of total solids probably from the roof, which is covered with a tar preparation.	Water clear, tasteless and odorless; no nitrites.
13	Northeast corner of Spring and 11th sts.	About 18 ft. deep; 6½ ft. to surface of water (Sept. 25, 1888); almost fills during local rains; in a hollow; graveyard on hill near by; drainage towards well from all directions.	July 28, 1888.	July 28.	32.22	4.74	0.02	0.26	Quite hygroscopic and contains sulphates and chlorides with silica, but no carbonates.	Unfit for drinking.	Water clear, tasteless and odorless; no nitrites.
14	Northeast corner of Wolfe and 9th sts. (S. N. Marshall)	On top of Capitol Hill; surroundings good.	July 28, 1888.	July 28.	18.58	1.81	0.02	0.10	Quite hygroscopic and contains sulphates and chlorides but no carbonates.	Very good water.	Water clear, tasteless and odorless; no nitrites.
15	St. John's College.	50 ft. deep; in an orchard, but no large trees within 20 feet.	July 30, 1888.	July 31.	7.96	1.01	0.03	0.06	Contains sulphates and chlorides but no carbonates.	Very good water.	Water clear, tasteless and odorless; no nitrites.
16	Arkansas School for Blind.	50 ft. south of the school; 22 ft. deep; drainage away from well; fitted with wooden pump and pipe.	July 30, 1888.	July 31.	8.99	1.23	0.02	0.09	Contains sulphates and chlorides but no carbonates.	Very good water.	Water clear, tasteless and odorless; no nitrites.
17	Southeast corner of Scott and 10th sts.	24 ft. to surface of water (Sept. 27, 1888); uncovered; peach tree grows by and overhangs the well; not walled; fills during local rains; privy and stable about 20 ft. away.	July 30, 1888.	July 31.	23.75	3.99	0.12	0.20	Hygroscopic. Contains sulphates and chlorides but no carbonates.	Unfit for drinking.	Water cloudy; filtered for determination of total solids, but not for other determinations; no nitrates; contains nitrites.
18	Ark. Female College, cor. 7th and Rock sts.	26 ft. deep; 3 ft. of water; walled with brick; surroundings good.	Sept. 3, 1888.	September 3.	12.36	2.02	0.05	0.09	Contains sulphates and chlorides; turns brown on ignition; brown color permanent (iron oxide).	Very good water.	Water clear, tasteless and odorless; reacts for nitrites.
19	Insane Asylum supply, west of street car line.	Comes up through quicksand.	July 28, 1888.	July 28.	6.12	1.04	0.02	0.05	Not hygroscopic. Contains chiefly silica and chlorides with a little sulphates and no carbonates.	Excellent water.	Water clear, tasteless and odorless; no nitrites.
20	Southwest corner of Scott and 5th sts.		Aug. 12, 1888.	August 12.	27.33	4.85	.....	.....	Very hygroscopic. Some of it yellow, turns brown on ignition; disso ves in HCl with yellow color; gives reaction for iron, contains chlorides and nitrates, but no carbonates or sulphates.		Water clear, reaction neutral, nitrites strong, showing recent organic contamination. No iron, lead or copper.

Water from 2201 Rock Street.

Water collected from a well at 2201 Rock Street by A. A. Leslie.

Water clear, forming yellowish sediment of hydroxide of iron, odor faint and slightly disagreeable, taste slightly salty, reaction neutral.

A partial sanitary analysis gave :

	Grains per U. S. gallon.
Total solids, dried at 135°C	111.78
Chlorine (Cl)	39 28
Sulphuric acid (SO_3)	8.55

A qualitative analysis showed also :

Hypothetical Combination.

Silica (SiO_2)	small quantity.
Chloride of soda (NaCl)	chief constituent.
Chloride of potash (KCl)	trace probably.
Chloride of lime ($CaCl_2$)	small quantities.
Carbonate of lime ($CaCO_3$)	
Sulphate of magnesia ($MgSO_4$)	considerable.
Sulphate or carbonate of iron ($FeSO_4$ or $FeCO_3$)	
Organic matter	small quantity.

Found.

Calcium (Ca)	considerable quantities.
Magnesium (Mg)	
Sodium (Na)	chief metallic constituent.
Potassium (K)	traces.
Lithium (Li)	
Silica (SiO_2)	small quantities.
Carbonic acid (CO_3)	

Conclusions in regard to the well waters examined.—In general it may be said that there is little or no doubt but that in wet weather the filtering capacity of the soil is overtaxed. Many wells, both in wet and dry weather, contain rather large amounts of total solids, but in no case is the amount large enough to condemn the water on this account alone. The chlorine content is also somewhat high, but most of this is in the form of common salt which does the water no serious injury.

Arkansas River water.—In the following table are given the results of sanitary analyses of the water at different stages of the river. The collections were made in November, 1887, and July, 1888.

SANITARY ANALYSES OF THE ARKANSAS RIVER WATER.

Where obtained.	Stage of river.	Collected.	Analyzed.	Grains per U. S. gallon.		Parts per million.		Remarks.
				Total solids.	Chlorine.	Free ammonia.	Albuminoid ammonia.	
1200 feet west of the Iron Mountain bridge.	1.2 feet.	Nov. 12, 1887.	November 14.	35.83	10.07	0.24	0.13	The water was filtered for analysis; tasteless and odorless
		Nov. 12, 1887.	November 17.	.....	.....	0.21	0.14	
Snag boat north of Capitol; surface water.	1.1 feet.	Nov. 21, 1887.	November 22.	42.29	12.17	0.05	0.09	Clouds quickly on boiling.
	4.3 feet.	July 27, 1888.	July 27.	18.84	4.89	0.09	0.13	The salts in solution are for the most part carbonates and chlorides of the alkalies and lime with some sulphates, the chief constituents being carbonate of lime and common salt. No nitrites, nitrates, iron, lead or copper. See mineral analyses of Arkansas River water, this volume, p. 25.

Analysis by Wait.—About the year 1882 an analysis of the water furnished to the city of Little Rock by the Home Water Company, was made by Prof. C. E. Wait, now (1892) professor of chemistry in the University of Tennessee. At that time the water was sometimes pumped from the river, and sometimes from large wells on the north side of the river.

Prof. Wait has kindly furnished the Geological Survey with a copy of his analysis. The following is that of the water when the pumps were drawing from the river; it is given here so that it may be compared with the large number of analyses of river water made by this Survey:

Constituents.	Grains per U. S. gallon.	Per cent. of total solids.
Chlorine (Cl)	1.49	11.54
Mineral matter	10.90	84 43
Suspended matter	.52	4.03
Total	12.91	100.00

Free ammonia	0.24 parts per million
Albuminoid ammonia	0.14 " " "
Oxygen consumed	0.61 " " "

So far as organic matter is concerned the Arkansas River water is as good as the average river water where there is no danger of contamination from large cities or factories. The only objection to its use as a drinking water, after the removal of matter suspended in it, would be the large amount of matter in solution at certain seasons, *e. g.*, in August, 1888, when the total solids amounted to 60.809 grains per U. S. gallon. However, it never remains in this condition for any great length of time.

Odor of the Arkansas River water.—In view of a belief sometimes expressed that an odor develops in the river water on standing, some experiments were undertaken by the Survey to test the question. The water was collected from the hydrant in the Geological Survey's laboratory.

Four experiments were made as follows:

1. On filtered water, collected January 9, 1889. } Stage of river, 8.9 feet.
2. On unfiltered water, collected January 10, 1889.
3. On boiled filtered water, collected January 10, 1889. } Stage of river, 11.6 feet.
4. On boiled unfiltered water, collected January 10, 1889.

Each of the specimens of water was exposed to the air in a clean beaker glass covered with filter paper to keep out dust. Tests were made from time to time, but in none of the specimens was an odor noticed even after standing for several weeks.

The conclusion is, therefore, that when an odor is developed in the water on standing, it is due to the vessel in which the water is contained and not to the water itself.

FORT SMITH WATER SUPPLY.

The water sent to the Survey was a sample of Poteau River water collected from a hydrant on Garrison avenue, Fort Smith, by Dr. J. C. Eberle, August 30, 1888, p. m.

The water was muddy and the suspended matter settled very slowly. A bottle of the water which was kept in this laboratory retained a yellow color, and remained cloudy for several weeks. An attempt was made to filter the water for analysis, but it was still turbid and had a yellowish color when the organic matter was determined. By repeated filtering through a heavy plaited German filter paper and asbestos, enough of the water, slightly opalescent, was obtained for the estimation of the total solids.

Water received September 1, a. m.; analyzed September 1, p. m. Reaction, neutral. The following are the results of the analysis:

Total solids	5.75 grains per U. S. gallon.
Chlorine	0.48 " " "
Free ammonia	0.58 parts per million.
Albuminoid ammonia	0 34 " " "
Nitrites	present.

The residue had a dark color and blackened on ignition with a slight evolution of white fumes; finally burned white. As

represented by the sample sent to the Survey, the water is not fit for domestic use, both on account of the suspended matter and organic matter. The amount of free ammonia may be put down as having little or no significance, but 0.34 part per million of albuminoid ammonia is high for even a river water.

The indications are that the source of organic contamination is entirely of vegetable origin. It must be remembered that the water, when the sample was collected, was in an unusually bad condition. Dr. Eberle writes: "On account of recent continued rains the water is not as clear as usual." It is evident that the people of Fort Smith have at hand a water, which, with proper settling and filtering, can be made as good as that of the average city supply.

HOT SPRINGS WATER SUPPLY.

A sample of the Hot Springs city water was collected for analysis, November 12, 1890 from the hydrant in Eisele & Hogaboom's drug store, Central avenue, Hot Springs, by the chemist of the Survey.

The water was slightly cloudy, as a result of heavy rains for several days. Reaction, neutral. A little of the water gave a slight reaction for chlorine, but no reaction for sulphates, lead or barium, and a very slight reaction for iron.

The unfiltered water gave :

Total solids	2.39 grains per U. S. gallon.
Chlorine	0.38 " " " "
Free ammonia	0.042 parts per million.
Albuminoid ammonia	0.092 " " "
Total ammonia	0.134 parts per million.
Total ammonia by a separate determination	0.140 parts per million.

The residue when ignited turned from yellow to dark brown and black; the black color is permanent and is due to iron oxide. A scarcely perceptible odor and no fumes were noticed on ignition.

The residue before ignition does not show the presence of carbonates. A qualitative analysis of the residue showed the presence of iron, sodium, with a little potassium, sulphuric acid, silica and lime. Hence the salts of solution are probably

sulphate of iron, and chloride and sulphate of sodium, potassium and lime.

The water is quite pure, and free from organic or inorganic contamination.

Bases.	*Acids.*	
Iron. Sodium.	Hydrochloric.	main constituents.
Potassium Calcium.	Sulphuric	smaller quantities.
	Carbonic	none found.

MISCELLANEOUS.

Water from Fulton, Hempstead County.—This sample of well water was sent to the Survey by John Wilson, Jr. The water had been used by school children and there was much sickness in the school.

The water contained a slight sediment and was filtered for analysis.

The following are the results of the analysis :

Total solids	536.70 grains per U. S. gallon.
Chlorine	64.24 " " " " "
Sulphuric acid (anhydride)	22.31 " " " " "
Free ammonia	0.220 parts per million.
Albuminoid ammonia	0.156 " " "

Absence of notable quantities of lead, copper or iron.

A partial qualitative analysis of the water showed the presence of chlorides and sulphates of magnesia, lime and soda.

The salts in solutions are mainly :

Sulphate of magnesia (Epsom salt).
Sulphate of lime (gypsum).
Sulphate of soda (Glauber's salt).
Chloride of sodium (common salt).

The amount of total solids alone is sufficient to render the water unfit for drinking purposes.

The principal salts being chloride of soda, and sulphates of soda, magnesia and lime, indicates that this water comes from the Mesozoic salt beds of the same horizon as the salt waters east of Arkadelphia and the salt wells further west. See analysis on page 113.

This water deserves a complete mineral analysis, as it may prove to be a mineral water of some value.

Water from Pulaski County.—A specimen of water labelled: "T. W. McConnell's spring, the north end of the east half of the southwest quarter of the northwest quarter of section 7, 1 N., 12 W. Collected by T. W. McConnell, May 29, 1890"

The water was cloudy and had a yellowish color; tasteless and odorless; reaction, neutral. There was a considerable quantity of brownish yellow sediment in the bottle, which consisted largely of iron oxide and organic matter.

A little of the water decanted from the sediment gave:

Total solids.....10.90 grains per U. S. gallon.

The residue when ignited turned black, gave off slight fumes with a faint odor of burnt organic matter, and finally burned to a yellowish brown color due to iron oxide.

The loss on ignition amounted to 8.16 grains per U. S. gallon, much of which was due to organic matter.

A qualitative analysis showed the presence of a considerable quantity of iron and lime, with a little chlorine, sodium, and no sulphuric acid.

The salts in solution are probably:

Carbonate of iron.
Carbonate of lime (limestone).
Chloride of sodium (common salt).

So far as inorganic constituents are concerned this is a good, potable water, but appears to contain a rather large quantity of organic matter. Judging from the small amount of common salt present, the organic matter is of vegetable origin, and this is probably a safe drinking water.

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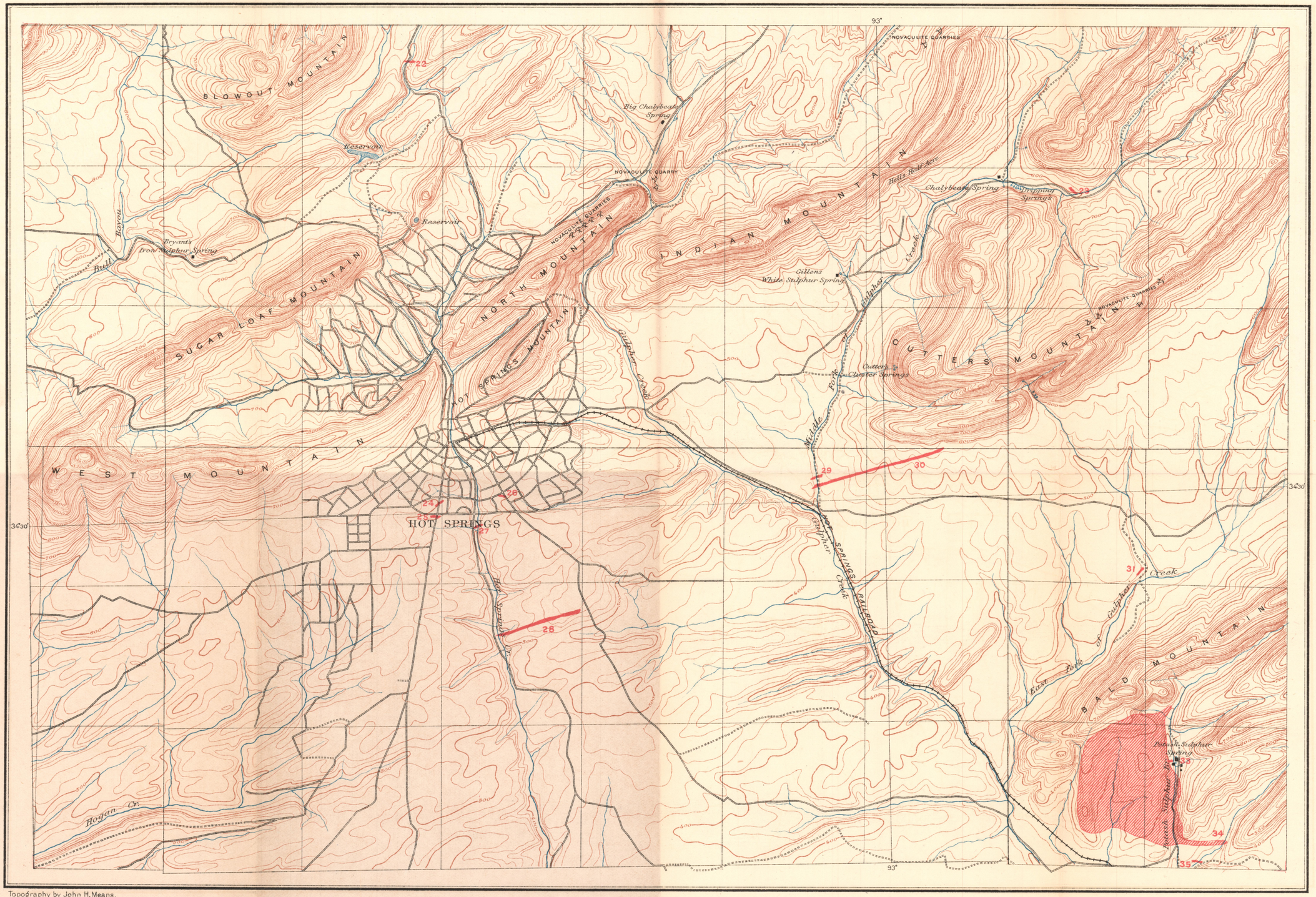

Topography by John H. Means.
Surveyed in 1890-91.

Scale 1:40 000

0 ½ 1 2 3 4 Miles

Contour Interval 20 feet — Datum is mean Sea level.

Igneous rocks (See An. Rep. 1890, Vol. II)

Topographic Map of the Region about Hot Springs and Potash Sulphur Springs.

To accompany Vol. I. of the Annual Report of the Geological Survey of Arkansas for 1891

JULIUS BIEN & CO. LITH. N.Y.