WETHERILL (C. M.)

REPORT

ON THE CHEMICAL ANALYSIS

OF THE

WHITE SULPHUR WATER

OF THE

ARTESIAN WELL OF LAFAYETTE, IND.

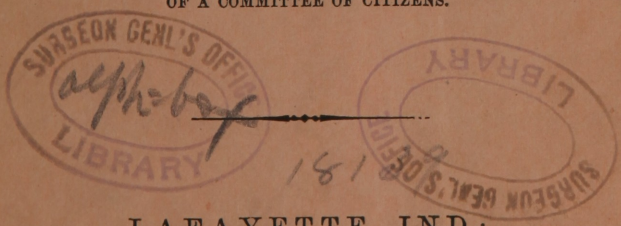
WITH REMARKS UPON THE

NATURE OF ARTESIAN WELLS.

BY

CHARLES M. WETHERILL, PH. D.; M. D.

PUBLISHED BY THE MAYOR AND COUNCIL OF LAFAYETTE, AT THE REQUEST OF A COMMITTEE OF CITIZENS.



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REPORT

UPON THE LAFAYETTE ARTESIAN WATER.

ON THE NATURE OF ARTESIAN WELLS.

Artesian Wells, though of ancient origin, have only in our day begun to attract universal notice. Their origin lies shrouded in the mists of past ages, and we are not sure even of the derivation of their name, "Artesian," which has arisen, it is said, from the province of France, Artois, where they were used at an early date. The northern departments of France and of Italy have employed such wells during a period of several centuries. In France, at Tours, Elbeuf, Rouen, etc., wells are in action that were bored many years ago, and at Lilliers, in the Pas de Calais, there is an Artesian Well which has poured forth its water incessantly for seven centuries.

The Chinese have, for some time past, practiced the art of Artesian Well boring.

Modern enterprise has successfully pierced, for water, the Egyptian desert, and is engaged in similar labors for our American plains. Our country possesses many Artesian Wells, of which that at St. Louis has attracted the most attention. It is, I believe, with one exception (in Italy) the deepest in the world; water having been reached at a depth of 2.250 feet.

Artesian Wells depend upon a simple principle of hydrostatics, and which obtains in all natural springs, viz.: that water always rises to the level of its source.

The meteoric water, which falls from the clouds as rain, or condenses upon the earth as dew, filters through the

porous drift and strata, until retained by an impervious bed of clay or rock, where it is collected in subterranean rivulets, sheets, or films. These underground lakes are frequently continuous over a vast area, and differ from superterraneous lakes, in having but few inches of depth, and with a surface, if we may so call it, not horizontal, but inclined at different angles to the vertical line, conforming thus to the dip of the strata. They occur most frequently at the junction of two contiguous formations.

Where the strata are inclined, it generally happens that a portion of the subterraneous sheet of water, remote from a given locality, stands on a higher level than the surface of the ground at the said locality. In such a case, if a natural fissure penetrates the intervening strata to the water, it will rise to the surface, and overflow as a natural spring. If, on the other hand, we bore a hole to the water, it will equally overflow as an Artesian Well. If the strata are horizontal at any place, the spring may have its "head" at a considerable distance where the strata are inclined. It will be seen from this, that Artesian Wells do not necessarily overflow. Their head may be so that the water rises within such distance from the surface as will enable it to be raised by a pump.

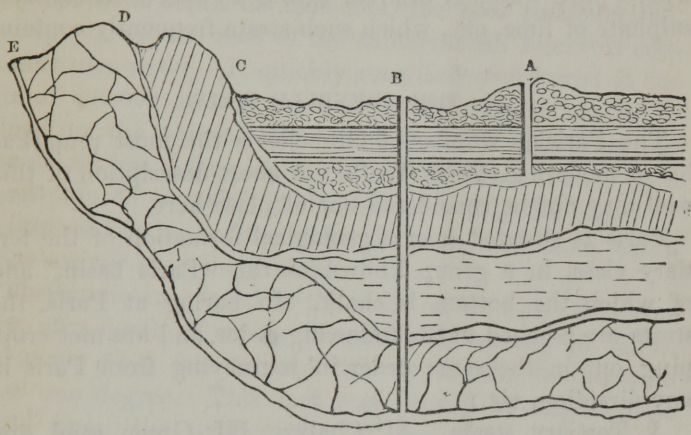
The advantage of these wells depends upon two facts: First. The supply of water is generally unfailing, depending, as it does, upon the meteoric water falling upon a large area of country. Dr. Ure notices, indeed, a sensible diminution in the London wells within the last few years; but attributes the loss to the vast amount of water raised from mines by steam-pumping engines.

Secondly. The water is frequently purer than the surface well water, especially where it filters through large beds of sand or gravel. It has been lately satisfactorily ascertained, that such filtration is capable of removing some of the salts dissolved from the strata first penetrated by the rain water.

Of course, in boring, several sheets of water are frequently reached; of which some are capable of rising to

the surface. At St. Ouen there are five of these veins at the following depths: at 118, 150, 169, 194, 218 feet. At Tours there are three at 312, 334½, and 410 feet. And at Dieppe, in boring for coal seven such sheets of water were reached.*

The following cut illustrates the principle of Artesian Wells.



This illustration represents a vertical section of the earth, at a given locality, exhibiting the geological formation of the region, and the subterraneous sheets of water.

Two sheets, having their heads at C and D, divide under the earth, at the contiguous strata, to form two films of water. The remaining sheet (E) is not so divided. If a well be bored at B, reaching this last mentioned sheet, five veins of water will be obtained; the first two, which have the same head, C, on the same level as B, will reach the surface without overflowing. The remaining three, having their heads at D and E, above the level of B, will overflow.

The water in the well at A, will not reach the surface, for A is above the level of C, the head of the two veins

* Dr. Ure.

of water reached. If the well A be deepened until it strike any of the three lower veins, the water thus obtained will overflow.

Primitive strata are unfavorable for Artesian Wells on account of their fewer connected fissures, and because, in such formations, filtering strata rarely overlie inferior ones.

Transition and secondary strata are equally unfavorable, where pure water is desired, owing to the common salt, sulphate of lime, etc., which such strata frequently contain.

THE GRENELLE WELL.

The Parisian wonder of Grenelle is the most remarkable of modern Artesian Wells. A short description of this well may not be considered out of place here.

Paris is situated over a geological formation of the tertiary class, in a group known as the "Paris basin," and of which the bottom is chalk. In boring at Paris, the strata are reached in the following order, and are met cropping out in the same order in journeying from Paris in any direction, viz.:

I. Tertiary strata. II. Chalk. III. Green sand and clay. IV. Oolite and Jura limestone.

Wells had been already successfully bored in this basin at St. Ouen, St. Denis, etc., reaching the stratum of gravel immediately above the chalk. It was proposed, however, by the engineers of the Grenelle Well, to penetrate the chalk; for it was deemed probable, that, as at Rouen, water would be found in the green sand and clay beds immediately beneath it. The thickness of this chalk stratum could not be inferred from any geological data, which constituted one of the uncertainties of the work. The celebrated Arago thought that, if found there, the water would overflow, because in the Elbeuf Well it rises to thirty-six yards above the level of the ocean, and Grenelle is situated at thirty-four yards above the same level.

It was supposed that the water, if obtained where it was expected, would be very abundant, as the basin has an area

of filtering strata of about two hundred miles in diameter. With this opposition of probabilities and of uncertainties, the well was begun. Boring tools had not attained the same degree of excellence as at the present time, consequently the work was delayed for nearly two years by constant labor in extracting broken rods on three different occasions. At last, in February, 1841, after eight years' toil, and at a depth of 1806 feet, the rods suddenly fell, having pierced the roof of the subterranean reservoir containing the water. It quickly rose, and overflowed at the rate of 600.000 gallons per hour, which rate it has maintained to the present day. The water is the purest in Paris, and has a temperature of 81° F. It is carried by a stand-pipe to a reservoir situated at nearly the hight of the source of the spring, where it cools, and from which pipes convey it to the ground.

Thermometers placed in the wells of the Paris Observatory, at a depth of ninety feet, stand invariably at 53° F. For every $61\frac{2}{10}$ feet beyond this depth, the temperature rises one degree. This fact was proven by experiments made upon the temperature of the earth, at different depths, during the boring of the Grenelle Well, and is corroborated by observations in other wells and in mines.

Thus, at 30 y'ds, temperat. of the earth at Grenelle 53° F.

"	442	"	"	"	"	74°
"	550	"	"	"	"	79°
"	602	"	"	"	"	81°

It is noteworthy that the temperature of the Lafayette water corresponds to the depth of the well, by a calculation with the Grenelle data; for assuming 53° to be the invariable temperature at a depth of 90 feet, for the remaining 139 feet there would be a rise of $2° \frac{2}{10}$, corresponding to a temperature of $55° \frac{2}{10}$ for the water, and which agrees with the temperature actually found for the Lafayette water, viz., between 55° and 56°.

HISTORY OF THE LAFAYETTE WELL.

This well is situated in the northeast angle of the court-house square of the city of Lafayette, Tippecanoe Co., Ind.

The boring was undertaken at the instance of the County Commissioners, to furnish pure drinking water, to fill reservoirs for use in extinguishing fires, and to test the practicability of such wells in the county.

Mr. William S. M'Kay, an experienced Artesian Well digger, commenced the work on April 22, 1857, and carried it to a successful termination. On Feb. 18, 1858, at 20 minutes after 10 A. M., the vein of overflowing water was reached; and at 20 minutes after 4 P. M., was flowing abundantly from the top of the pipe. The depth of the well was 216 ft. 6 in. at this date.* It was increased to 229 ft. 3 in., which depth was reached, and the boring terminated by the middle of March. The depth was subsequently increased to 230 feet.

* The following notes of the succession of strata encountered, were furnished me by Mr. M'Kay.

TABLE of Strata encountered in the Lafayette Well.

	Feet.	Inches.	Remarks.
Clay	3		
Clay and gravel	9	6	Water.
Gravel and pebbles	1	6	
Fine gravel and sand	13		
Quicksand	1		
Gravel, clay and pebbles	2	6	
Dark gray clay	72		Marlite.
Sand and gravel	4		Water.
Clay and pebbles	1	3	
Sand and gravel	7	3	
Clay		6	
Sand and gravel	3		
Clay and pebbles	6	6	
Gravel and pebbles	5		
Boulders	40		Which much impeded the work.
Blue shale	2		To shale 170 ft.
Gray "	18		
Blue "	1	6	Iron pyrites in all the rock formation.
Gray "	7		Thickness of shale 28 ft. 6 in.
Limestone—Coralline	11	6	To coralline, 198 ft. 6 in.
Gray limestone with spar	20		Overflowing water.
Depth of well from original surface	230		

* Measured from the *original* surface of the ground.

Depth of overflowing vein 216 ft. 6 in., viz: in the gray limestone, 13 ft. 6 in. from the bottom of the well.

A cast-iron pipe of eight inches diameter cases the well from the surface to the first blue shale rock. This pipe was proved, by fragments of the iron raised to the surface, to be broken, probably at the bottom, in driving it through the forty foot bed of boulders; consequently a large leak of the mineral water into the water under the marlite, has always existed. This marlite water stood in the well at a distance of 36—38 feet from the top of the iron pipe, until the vein of mineral water was struck. Subsequent observation showed that this water of the marlite has communication with the Wabash river, at a lower level than the surface of the ground at the Artesian Well. We have some data for calculating the lowest extent of the leak by an experiment by Mr. M'Kay, who, in shutting it off imperfectly, obtained an increase of the mineral water, equal to 300 per cent. As the overflowing water at this time measured over 6000 gallons in 24 hours, its leak must have delivered 18000 gallons during the same time, which is equal to an expenditure of mineral water by leak and overflow together, of 1000 gallons per hour.

It was contemplated by the commissioners eventually, to tube off this leak; but the work upon the well was interrupted on the middle of March, to ascertain the value of the mineral water, and the action of the overflow. On the 19th of March, Mr. Henry C. Lawrence and myself found the flow of the spring, by an accurate method of measurement, to equal 6604 wine gallons in 24 hours. This rate speedily decreased, for on March 30th, it yielded 2641 gallons in the same time, and shortly after ceased to overflow. Mr. M'Kay then introduced the valved bucket and removed some packing hemp and tallow (the result of his former experiment,) from the well, when its overflow was reëstablished. Notwithstanding the frequent introduction of the bucket, the flow of water was gradually diminishing. On April 24th, it measured 4241 gallons,

and continued visibly to fail. By this time, the analysis had been completed, and the great value of the water ascertained. It was, however, deemed prudent before inviting the public to enjoy its benefits, to finish the well and obtain a constant stream of mineral water.

This work was commenced May the 7th, but the commissioners were unfortunately advised to abandon their original intention of at once tubing off the leak, until the bore of the well was first enlarged, with a view to open perhaps, new crevices, or enlarge those already yielding mineral water. The hole in the rock was at this time $7\frac{1}{2}$ inches in diameter to the commencement of the coralline, which it penetrated for a few feet; for a few feet farther, it was smaller, then 4 inches for a distance of 21 feet, to the bottom of the well. It was proposed to enlarge to $7\frac{1}{2}$ inches, until a greater overflow was obtained, or the bottom of the well reached. During this reaming, the water suddenly receded from the surface, owing to an enlargement of the leak, by the removal of a fragment of the blue shale at the bottom of the cast-iron pipe. The work of enlarging was continued notwithstanding, until May 27th, when the well was placed by the commissioners, in the hands of Captain Rogers and myself, for the purpose of obtaining some experimental knowledge with regard to the mineral water. The report of these experiments has been published in the Lafayette "Daily Journal," of July 20th, and to it I would refer, for particulars.

We have proved that the original mineral water comes from the gray limestone. In my opinion, derived from certain experiments, and for reasons stated in the report, *all* the mineral water comes from this rock. Capt. Rogers does not concur in this opinion, for reasons which are also stated in our report. We agree in believing that a sufficient quantity of the mineral water has its origin in the gray limestone.

We have shown by the experiments, the cause of the temporary failure of the water, and from the knowledge

they have yielded, have been able to re-establish a permanent overflow. In fact, the water would never have been lost, if the simple expedient of tubing off the leak (which we performed) had been at first resorted to. The waste of 1000 gallons of mineral water per hour, in action since the middle of February, operated in lowering the head of water in the reservoir supplying the well; this accounts for the gradual decrease in the strength of flow. When the water was removed from view by the increase of the leak, this waste still operated in diminishing the head. We recovered the water by enlarging for nineteen inches the four inch hole to six inches, boring a truly cylindrical socket,* in which we forced a conical vulcanized rubber plug, made of a car spring and perforated by a wrought iron gas pipe, of 2½ inches bore, extending to the surface. The water fell outside of this pipe to the level of the marlite water, showing that the leak was completely shut off. The rains, springs, rivulets, etc., which operated once to fill the reservoir of the well, came again into action; the water soon overflowed, and the overflow increased. When the efflux of water at Lafayette equals the influx of the reservoir, a point of equilibrium will be reached, which will either remain constant, or be slightly disturbed spring and fall, after very wet seasons, or after drought, as is the case with many springs. That the head of water gradually increased, we proved by shutting off the overflow, and suffering the water to rise in a pipe on three different occasions. Every succeeding experiment showed a greater head.

The following table will show the gradual increase of the water as the reservoir filled, and consequently the head increased.

At two feet above the surface, a wine gallon of water was delivered through an inch tube, at the following rates:

---

* During the reaming, I discovered specimens of marine fossil shells (terebratula.)

July	6,	11-20 A. M.	in	44.3 seconds.	difference.
"	"	4 P. M.	"	26.6 "	17".7
"	7,	3-15 P. M.	"	25.6 "	1".0
"	8,	M.	"	22.6 "	3".0
"	9,	11-30 A. M.	"	21.3 "	1".3
"	10,	11-30 A. M.	"	20.6 "	0".7

The water was now delivered through a tube 4 inches higher, diminishing to that extent the head.

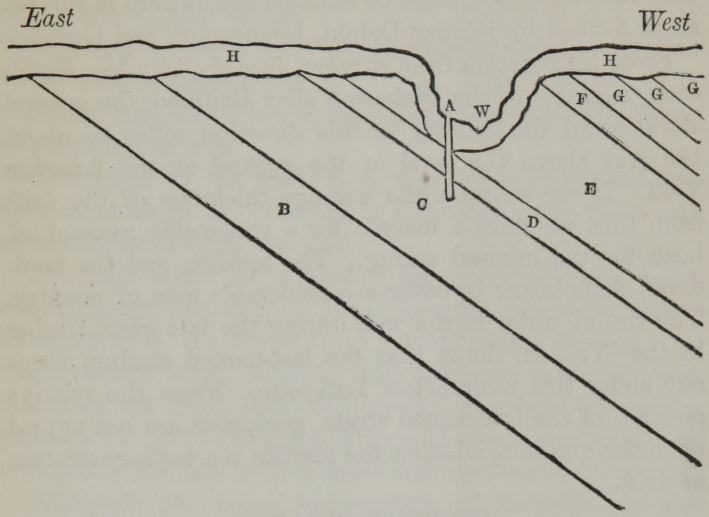
July	10,	5-30 P. M.	1 gal.	in 23.4 sec.	difference.
"	12,	8 A. M.	" "	21.6 "	1".8
"	13,	7 A. M.	" "	21.1 "	0".5
"	14,	" "	" "	20.3 "	0".8
"	16,	9 A. M.	" "	19.6 "	0".7
"	17,	7-30 A. M.	" "	19.4 "	0".2
"	19,	8-15 A. M.	" "	19.1 "	0".3
"	23,	11 A. M.	" "	18.4 "	0".7
"	30,	11 A. M.	" "	17.3 "	1".1
Aug.	6,	10-30 A. M.	" "	16.5 "	0".8
"	20,	10-30 A. M.	" "	16.2 "	0".3
Sept.	3,	11-30 A. M.	" "	15.8 "	0".4

The spring now, Sept. 3d, delivers one wine gallon of mineral water in 15.8 seconds, equal to a discharge of 5468 gallons in 24 hours, and sufficient, if the surplus water be *properly* saved, for all the purposes of a first-class watering place, where not only the internal use of the water is resorted to, but baths of every description employed. Successful as drinking the water has been, I must call attention to the fact, that the bath of this water will, in certain diseases, prove even more eminently efficacious.

The following section by Dr. Brown, State Geologist, illustrates the geological position of the well.

A denotes the Artesian Well at Lafayette. The depression is the valley of the Wabash river (W.) At this locality the stratum of clay sandstone has been denuded; not a trace was found in the boring.

B denotes the Blue Limestone (Lower Silurian), of 8000 feet thickness.



C, Gray Limestone (Upper Silurian), 6000 feet.

D, Delphi Slate (lingualis shale of Owen), varies from 25 to 100 feet. It is about 28 feet in thickness at Lafayette, and thins to the northwest.

E, Clay Sandstone (Devonian), about 500 feet.

F, Mountain Limestone, about 200 feet.

G G, Seams of Coal.

H H, Alluvium or drift.

The dip of these rocks is, at this locality, about 25° to the south of west, at an angle of 50 feet to the mile. This westward dip is maintained until the Mississippi is crossed, when the dip is eastward. The strike of these strata, from information kindly furnished by Dr. Brown, shows that the well is situated upon the edge of a great geological basin, of which a crude idea may be gained, by tracing, upon a map of Indiana, the general strike of the Delphi slate by a curved line, joining Louisville, Ky., Lexington, Indiana, Elizabethtown, Indianapolis, Delphi and Crown Point, Ind.

As far as present geological knowledge goes, the reser-

voir of the Artesian Well lies beyond Delphi, for it comes from below the Delphi slate which crops out in that locality. This reservoir, then, must be situated somewhere in the triangle formed by joining Delphi, Logansport and Cocomo.

From information from surveys, furnished by Mr. Handcock, engineer of the Wabash Valley Railroad, the general elevation of the country in this direction must be about 100 feet above the level of the ground at the Artesian Well. If we subtract the average thickness of the drift from this, we have a margin for a reasonable amount of head for the mineral spring. The marlite, and the bouldered drift below it, cover a considerable area of country. The rise of water in the well during the late great freshet in the Wabash, shows that the last-named stratum crops out under this river below Lafayette. From the relative position of the last-named strata, geologists are not agreed upon the question, whether the marlite is a tertiary stratum or drift.

CHEMICAL ANALYSIS.

Application having been made to me for the analysis of the Artesian water, I found myself many miles away from my laboratory, and with but one piece of apparatus adapted to the work; viz: a very delicate Platner balance, capable of being loaded with 150 grains. Constructing a species of crucible of thin platinum foil which might be used with this balance, alone enabled the prosecution of the analysis to a successful termination.

Almost every reägent, and the larger weights and graduates, had to be specially made. It is, therefore, a duty, at this place, to render acknowledgment to Mr. Henry C. Lawrence, proprietor of the "City Drug-store," who not only tendered me the use of his laboratory and several pure chemicals for some of the experiments, but rendered intelligent and valuable assistance for others.

PHYSICAL CHARACTERS.

The Artesian water is of an extreme limpidity when taken freshly from the well. The deposit upon the peb-

bles over which it flows is *white*, entitling it to the name of a *white sulphur* water.

Standing in imperfectly closed vessels, a similar bluish-white deposit takes place.

Under certain conditions, the deposit contains black flakes of sulphuret of iron.

The smell of the water is strongly of sulphuretted hydrogen, so as to be perceived at a distance (with the wind) of two squares from the well.

The taste is similar to that of the celebrated Blue Lick water, though less strong. It is pleasantly brackish, resembling, in taste, the liquor from oysters freshly opened.

The temperature, noted at intervals since the water was first obtained (Feb. 18th) to July 6th, remained constantly between 55° and 56° Fahrenheit, my thermometer not being sufficiently delicate to give more definite results.

Although the mean temperature of Lafayette is unknown, I have no doubt, from other considerations, that the Artesian water is "Thermal;" for, firstly, the calculated temperature of the water, upon the Grenelle basis, renders this, in absence of contradictory facts, most probable; and, secondly, the temperature of the water is above that of the neighboring wells and springs.

In proof of the latter statement, the following table is submitted. It contains wells and springs situated at different points of the compass from the Artesian Well, and within a circle of two squares radius.

Temperature of the Wells and Springs of Lafayette, taken April 30, 1858.

	LOCALITY.	Depth. Feet.	Direction from Artesian Well.	TEMPERATURE.	
				Air.	Water.
Well ...	Mr. C. Taylor's dwelling	25	South	78° F.	51° F.
Well ...	Courthouse yard	16	S. East	"	51°
Well ...	Wilstach's Drug Store	16	North	"	48°
Spring ...	Two Squares from Artes. Well		North	81°	50°
Well ...	Mr. Benbridges' dwelling	20	S. East	80°	49°
Spring ...	Mess. Taylor & Co., lumber yard		N. West	"	50°
Well ...	Cellar of Mr. J. Mix' store	16	West	56°	49°
Well ...	Lahr's Hotel	16	East	80°	50°
Artesian Well,				80°	55-56°

THE DENSITY OF THE WATER

Is 1.00523 by a mean from the following six observations occurring in the course of the analysis:

No. 1,	density, ...	1.0051
No. 2,	"	1.0056
No. 3,	"	1.0058
No. 4,	"	1.0050
No. 5,	"	1.0049
No. 6,	"	1.0050

The ice from rain water, caught in a wooden cistern, was melted and used, in lieu of distilled water, for the density determinations, and for graduating my analytical measures.

CHEMICAL CHARACTERS, QUALITATIVE.

The water is faintly acid from sulphuretted hydrogen and carbonic acid, but becomes neutral after having been boiled, owing to the expulsion of these gases. It follows from this fact, that *all* of the sulphur is in the state of sulphuretted hydrogen dissolved in the water, and from the neutrality after boiling, that alkaline carbonates are absent. A particular experiment for the search of a trace of alkaline carbonates gave the same results.

Carbonic acid is contained, dissolved, in the water, and holding in solution the earthy carbonates. Nitrogen is the only remaining gas held in solution; although there may be *traces* of atmospheric air.

On boiling the water, the carbonates of lime, magnesia, and iron, held in solution by the carbonic acid, are thrown down, and by a slight concentration sulphate of lime is also precipitated.

In the boiled water, chlorides of sodium, calcium, and magnesia, were detected.

Crenic and apocrenic acids were in vain sought. A trace of organic matter was found dissolved in the water.

Mr. H. C. Lawrence kindly undertook the concentration of eleven and a half wine gallons of the Artesian water, which were boiled down to half a gallon; a concentration in the ratio of 23 to 1.

After filtering, I detected in the residue and in the mother liquid of this concentrated water, phosphate of lime, *hydrofluoric acid*, alumina, and a very faint trace of oxide of manganese. A small trace of iodine was discovered in the mother liquid, both by the starch test, and by chloride of palladium. With the starch test the characteristic blue tinge could not be developed by chlorine water, the excess of chlorine decolorizing the extremely minute quantity of iodide of starch; but was readily brought out by nitric acid. Bromine was sought by Fresenius' method. I was in doubt from the result of the experiment whether this element was present.

THE DATA FURNISHED BY THE QUANTITATIVE ANALYSIS.

The method of analysis employed was the usual one.

Residue left by evaporation, by weight in 1000 parts.

Experiment I, ...	7.280
" II, ...	7.221
Mean, ...	7.25

This corresponds to 53.443 grains in a wine pint.

Sulphuric Acid.

365.23 grammes gave sulphuric acid in two experiments:

I, ...	0.2054
II, ...	0.2051

The mean of which corresponds to 0.5621 of sulphuric acid in 1000 parts of the water.

Chlorine.

Experiment I, per mille, . . .	3.7732
" II, " . . .	3.7882
Mean, ...	3.7807

Sodium.

The only alkali present is soda, which is in the state of chloride of sodium. No trace of potassa was discovered, although carefully sought.

Sodium per mille, by calculation (loss),	2.1782
" " " experiment .	2.1683
Difference, only, ...	0.0099

Peroxide of Iron.

Which exists in the water as the carbonate of the protoxide.

Ex. I, per mille,	0.008
Ex. II, "	0.009
Mean,	0.0085

Silica.

Per mille,	0.008

Lime.

After boiling the water,	per mille.
In the precipitate,	0.1149
In the solution,	0.4255
	0.5404
Total lime (without boiling the water),	0.5386
Difference,	0.0018

Magnesia.

After boiling the water,	per mille.
In the precipitate,	0.0039
In the solution,	0.2088
	0.2127
Total magnesia (without boiling),	0.2005
Difference,	0.0122

Sulphur.

This constituent was determined in water collected at two different times. It was precipitated at the well by the addition of chloride of arsenic to a known quantity of the Artesian water.

Sulphur in the water of March 25th.

By four experiments the sulphur in 365.23 grammes of the water is,

Ex. I,	0.0027
Ex. II,	0.0027
Ex. III,	0.0035
Ex. IV,	0.0039
Mean,	0.0032

Corresponding to 0.0034 grammes of sulphuretted hydrogen, which is equal to 0.0093 by weight of this gas per mille. This quantity corresponds to 6.3594 cubic centimeters of sulphuretted hydrogen, in 1000 grammes of the water, at the standard of barometric pressure, and at the temperature (55°) of the spring; or in other words to 0.1841 cubic inches of this gas in a wine pint.

Sulphur in the water of April 8th.

At this date the sulphur was again determined.

365.23 parts by weight of water gave sulphur:

Ex. I, ...	0.0048
Ex. II, ...	0.0052
Mean, ...	0.0050

Corresponding to 0.0053 sulphuretted hydrogen, or 0.0145 by weight per mille; or 9.9154 cubic centimeters in 1000 grammes of water; or 0.287 cubic inches in a wine pint. This is a larger quantity than in the water of March 25th.

FREE CARBONIC ACID.

The total amount of this gas was precipitated at the spring by the addition of chloride of calcium and ammonia; the carbonic acid being determined in the precipitate. After neutralizing, by calculation, the lime magnesia and protoxide of iron (which fall from the Artesian water on boiling) with the proper quantity of this carbonic acid, there remains free carbonic acid in 1000 grammes of the water, at 55° F., 0.0997 grammes = 52.683 cubic centimeters = 1.5253 cubic inches of this gas in a wine pint.

NITROGEN.

On passing the gases liberated by boiling the water through caustic potassa, there remains one which extinguishes a live coal instantly, and which I have estimated as pure nitrogen, although it may contain traces of oxygen.

In quantity, at the temperature of the spring, and at the standard of barometric pressure, it equals 21.28 cubic centimeters, in 1000 grammes of water, or 0.616 cubic inches in a wine pint.

CALCULATION OF RESULTS.

In analyzing a mineral water, the constituents are determined by decomposing the salts, and forming new compounds with their acids and bases. From the results, science, at present, affords no means of ascertaining what salts actually exist in the water. Within the last few years, much doubt has prevailed in regard to Berthollet's Laws, the only guide we have possessed, since 1804, as to the constitution of different salts in the same solvent.

It is owing to this want of knowledge that mineral waters have, in *no instance*, been exactly imitated artificially, although the essay has been made by the very first chemists of Europe.

It is probable that a portion of every acid is united with a part of every base; but as we have no means of determining the proportions of such union, chemists have agreed to adopt one and the same method of calculation, in order to be able to compare the analyses of different waters.

This method depends upon the following rules:

I. To regard the lime magnesia and oxide of iron, which are precipitated by boiling the water, as existing in the state of neutral carbonates, dissolved in an excess of carbonic acid, and which excess is calculated as free carbonic acid.

II. That the sulphuric acid first neutralizes the lime remaining in the water after boiling, then (if any acid be left over) potassa, soda, magnesia, etc., in their order.

Since, in the Lafayette water, by this rule, the sulphuric acid is insufficient to neutralize the whole of the lime, the only sulphate in the water is sulphate of lime, and the excess of lime is joined to a portion of the hydrochloric acid, forming chloride of calcium.

III. Iodine and bromine are regarded to be in the form of magnesia salts, and fluorine as fluoride of calcium.

The accuracy of an analysis is proven by the following checks:

1. The sum of the ingredients, separately determined,

must nearly equal the quantity of residue obtained by the evaporation experiments.

2. Duplicate determinations of the same ingredient must agree.

3. The total quantity of lime and magnesia, determined by one experiment, must agree with the sum of these ingredients as determined in the precipitate by boiling, and in the resulting solution by another experiment.

The following is the composition of the Lafayette water, calculated according to the foregoing principles:

COMPOSITION OF THE WHITE SULPHUR WATER

Of the Lafayette Artesian Well. *Water of March 25th*, 1858.

Temperature 55°–56° F. Density, 1.00523.

GASEOUS CONTENTS.

	In 1000 grammes. Grammes.	In 1000 grammes. Cub. centim.	In a wine pint. Cubic inches.
Sulphuretted hydrogen,	0.0093	6.3594	0.1841
Ditto water of April 8,	0.0145	9.9154	0.2870
Carbonic acid,	0.0997	52.683	1.5253
Nitrogen,		21.280	0.6160

SOLID INGREDIENTS.

	In 1000 parts by weight.	Grains in a wine pint.
Residue by evaporation, Pure water,	992.75	7274.446
Solid ingredients,	7.25	53.124
	1000.00	7327.570*

INGREDIENTS BY ANALYSIS.

Carbonate lime,	0.2052	1.503
Carbonate magnesia,	0.0069	0.050
Peroxide iron with alumina, Phosphate of lime, fluoride of calcium, And a faint trace of manganese,	0.0085†	0.062
Silica,	0.0080	0.058
Sulphate of lime,	0.9555	7.002
Chloride of calcium,	0.0635	0.465
Chloride of magnesium,	0.5059	3.707
Chloride of sodium,	5.5402	40.596
Trace of iodine and organic matter, Bromine doubtful,		
	7.2937	53.443

* This is the weight of a wine pint of the Artesian water; the weight of the same measure of pure water being 7291.11 grains.

† Equivalent to carbonate of the protoxide of iron 0.0061 per mille.

COMPARISON OF THE LAFAYETTE WITH OTHER SULPHUR WATERS OF THE UNITED STATES.

Among the many sulphur springs of the United States, there are three groups which are remarkable for the numbers that visit them, or from other causes of publicity which they have received.

These are:

I. The Sharon and Avon Springs of New York, the latter of which are noted for their strength in sulphuretted hydrogen.

II. The Virginia Sulphur Springs, remarkable for their small content of the same gas, and of mineral ingredients. They are, as is well known, the most fashionable of all our sulphur springs, and the Greenbrier White Sulphur is considered the most efficient of the group.

III. The Blue Licks of Kentucky, noted for their strength in table-salt, and for the extent to which their water is bottled and distributed for use in our country, and especially in the Western States.

I have appended a table of the analyses of these important springs, enabling a comparison to be made with the Artesian water of Lafayette.

The numbers in the table denote grains in a wine pint for the solids, and cubic inches in the same measure for the gaseous constituents.

A glance at this table will show the great analogy existing between the Lafayette water and that of the Blue Lick. The former contains a less amount of salts, and is weaker in sulphuretted hydrogen. This gas is variable by my experiments, and equal in quantity to that of the celebrated White Sulphur Springs of Virginia, as shown by Dr. Rogers' analysis.

The Lafayette water contains the following comparative proportion of salts: as much carbonate of lime as the White Sulphur Springs of Virginia; as much sulphate of lime as the same spring, and as the Sharon Sulphur and Avon Lower Springs; as much chloride of magnesium as

TABULAR VIEW

OF THE PRINCIPAL SULPHUR WATERS OF THE UNITED STATES.

Expressed in Grains in the Wine Pint.

NAMES OF SPRINGS.	Temperat. F.	Density.	CARBONATES. Lime.	Magn.	Bic'b. Mag.	SULPHATES. Lime.	Mag.	Potass.	Soda.	CHLORIDES. Calc.	Mag.	Pot'm.	Sodium	IODIDE. Magnesium.	BROMIDE. Magnesium.	NAME OF ANALYST.
Sharon, New York, { Sulphur Spring						6.98	2. 65				0.15		0.14			Chilton.
Sharon, New York, { Magnesia Spring					3.81	9.50	2. 83				0.36*					L. Reed.
Avon, New York, { New Spring	50°	1.00356	3.37			0.44	1. 01		4.84				0.71			Hadley.
Avon, New York, { Middle Spring	51°		1.00			10.50	1. 25		2.00				2.30			Hadley.
Avon, New York, { Lower Spring	45°—47°	1.0018	3.58	....		7.17	6. 21		1.71	1.05						Chilton.
Avon, New York, { Sylvan Spring			3.35	2.0		10.05	1. 62				7.8		12.18	trace.		Chilton.
Virginia, ... Greenbrier White Sulphur, ...			1.15			7.744	5.588			0.204			0.180			Rogers.
Kentucky, ... Blue Lick	62°	1.007	2.957	0.017		4.25		1.117			4.049	0.174	64.107	0.005	0.030	Peters.
Indiana, ... Artesian Well, Lafayette, ...	55°—56°	1.00523	1.503	0.050		7.002				0.465	3.707		40.596	trace.	?	Wetherill.

NAMES OF SPRINGS.	Metallic Sulphurets.	Oxide Iron etc., etc.	Silica.	Organic Matter.	Loss.	Total Grains in a Wine Pint.	CUBIC INCHES OF GAS IN A WINE PINT. Sulphuretted Hydrogen.	Carbonic Acid.	Nitrogen.	Oxygen.	NAME OF ANALYST.
Sharon, New York, { Sulphur Spring	0.14†					10.06	1.00				Chilton.
Sharon, New York, { Magnesia Spring	0.06‡					16.57	0,41				L. Reed.
Avon, New York, { New Spring						10.37	3.91				Hadley.
Avon, New York, { Middle Spring						17.05	12.00	5.60			Hadley.
Avon, New York, { Lower Spring						19.72	1.32	0.50			Chilton.
Avon, New York, { Sylvan Spring				0.03		37.03	2.58	0.62	0.67		Chilton.
Virginia, ... Greenbrier White Sulphur, ...		trace.		trace.	0.41	15.276	0.175 to 0.343§	0.25	0.444	0.181	Rogers.
Kentucky, ... Blue Lick, ...		0.045	0.137	trace.	2.216	79.104	0.834	5.837			Peters.
Indiana, ... Artesian Well, Lafayette, ...		0.062	0.058	trace.		53.443	0.184 to 0.287	1.525	0.616		Wetherill.

* Chlorides of Magnesium and Sodium. † Sulphurets Calcium and Sodium. ‡ Sulphurets Calcium and Magnesium. § 0.032 by Dr. Hayes' Analysis.

the Blue Lick; more iron and less silica than the same spring.

It is curious that the common salt in the Lafayette water bears almost exactly the same ratio to the rest of the salts as in the Blue Lick water, as the following proportion, taken from the table, will show:

TOTAL SALTS.				COMMON SALT.		
Blue Lick.		Lafayette.		Blue Lick.		Lafayette.
79	:	53	: :	64	:	x=42

The common salt (x), in the Lafayette water, is, *by experiment*, nearly 41.

In round numbers, one and a half pints of the Lafayette water contain as much common salt as one pint of the Blue Lick.

Common salt is undoubtedly a beneficial ingredient in mineral waters, not only by increasing the aperient effect of the other salts, but *per se*. "When taken in larger quantities than usual with food, it is useful in some forms of dyspepsia, and by giving greater tone to the digestive organs in weakly children, may correct the disposition to generate worms."* Late experiments upon himself by Dr. W. Kaupp, of Germany, have shown its effect to increase the excretion of urea, in the proportion of 0.63 grains of urea for every 15.44 of salt above the usual quantity taken.

Common salt constitutes by far the greatest proportion of the total salts in the Blue Lick and Lafayette Artesian waters. Of the remaining salts let us, for the sake of a further comparison, subtract those existing in small quantities in both springs, viz.: silica, peroxide of iron, bromides, iodides, and potassa salts, the sum of which constitutes $2\frac{1}{5}$ grains in a pint of the Blue Lick, and a little over half a grain in the Lafayette water. There remain soluble salts of lime and magnesia.

By reference to the table, it will be seen that two

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* U. S. Dispensatory by Wood and Bache.

springs contain less sulphate of lime than the Lafayette Artesian; three a larger, and three the same quantity of this salt. The remaining lime salt is chloride of calcium, existing in the Lafayette water in the proportion of nearly half a grain to the pint, and absent from the Blue Lick water. This ingredient is considered "tonic and deobstruent, promoting the secretion of urine, perspiration, and mucus." The remaining salt is the chloride of magnesium, existing (within $\frac{1}{5}$ of a grain in a pint) in the same proportion in the Blue Lick and Lafayette waters, and bearing a somewhat greater proportion to the rest of the salts in the latter spring. Some regard the soluble magnesia salts of mineral waters as the measure of their aperient effect.

There are yet two salts existing in both waters, and held in solution by carbonic acid. These are carbonate of lime, in the Lafayette water of half the quantity, and carbonate of magnesia of one-third the quantity as in the Blue Lick spring.

It will be seen from these remarks, that there is a remarkable resemblance between the two waters, and it is to be expected that they will produce precisely the same medicinal effect.

THE MEDICINAL EFFECT OF SULPHUR WATERS.

As Dr. Bell truly says, "no visitor at a sulphur spring can gorge himself with the waters for experiment or amusement, with impunity. In fact, few remedies are as diffusive in their action on the animal frame, or as searching and alterative on the tissues, as the sulphureous." A person in health or only slightly ailing, may use the waters in moderation without injury, or even with benefit, but the invalid should observe extreme caution, and if at all possible, take such waters only under the direction of a physician.

For those desirous of becoming familiar with the analysis, nature, medicinal effects, and use of the chief mineral springs of our country, I would refer to an excellent manual by Dr.

John Bell, entitled "The Mineral and Thermal Springs of the United States and Canada."*

The employment of a mineral water is twofold; by drinking, and by the bath. The latter use is too much restricted in our country. In Europe it is considered the most efficient means of employing the water, and especially sulphur water, which fact the European name, "*Baths*," applied to watering-places, distinctly shows.

It is to be hoped that the proper attention will be bestowed on this point for the Lafayette water. It would be well to prescribe and to afford facilities, not only for the bath of any desired temperature,† but for the shower douche and vapor-bath. "In cases of chronic cutaneous diseases, and of chronic rheumatism, and where a revulsive action is required for the relief of internal organs, the bath acts marvelously, and with few exceptions the temperature must be raised to the tepid or warm degree."

With regard to the internal use, the advice of the physician, and experience are the best monitors as to the quantity to be taken. The rule, in all cases, is to begin with moderation, and for delicate stomachs to abstain at least an hour before a meal. Before breakfast, at the spring, with gentle exercise in the intervals of drinking, the water produces the most beneficial effects; and, as a general rule, *invalids* should abstain after dinner, or at least after tea. In respect to the medicinal effects of sulphur waters, the greatest benefit is to be anticipated in chronic cases. With regard to the diseases themselves, the water proves beneficial in those which are connected with a derangement of secreting organs. This covers a very wide field,

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* I have taken the liberty of making extracts from this work in the following pages.

† 1 The cold bath 33°—60° F.
2 " cool " 60°—70°
3 " temperate " 75°—85°
4 " tepid " 85°—92°
5 " warm " 92°—98°
6 " hot " 98°—112°

Bell on Baths and Watery Regimen.

but we are warranted in the belief, by conclusions from a large number of cases on both continents. In fact so confident of the efficiency of mineral waters are the Germans, that the technical name in their language for a course of the waters is a "*cure.*"

The action of sulphur waters upon the liver resembles that of mercurial medicines in its effect. The benefit to be derived from them in cutaneous diseases is well known. They have been successfully employed in chronic rheumatism, in some forms of dyspepsia, in scrofula, in bronchitis and in *mitigation* for asthma, chronic pneumonia, congestion, and consumption. With respect to the latter disease, the greatest caution is to be used in employing sulphur waters; benefit is only to be *hoped for* in the *incipient stage*, and even then when *unaccompanied by fever.* In the contrary case, and in confirmed consumption, sulphur waters only hasten the progress of the disease. These waters are useful in some diseases of the urinary and genital organs, and especially so in some ailments peculiar to the female sex.

They remove the effect of intemperance, but their triumph, according to the French authors, is in the treatment of wounds, and especially of gunshot wounds.

The immediate effect of the internal use of sulphur waters depends upon the degree to which they are digested, hence for some stomachs, especially at the commencement of a course, the water must be warmed to the degree that it can be borne and retained. "According as they are more or less digested, sulphur waters will produce either increase of appetite, or the reverse state; either constipation or diarrhea. When they do not immediately act as a purgative, they quicken the pulse, give rise to a feeling of internal heat, and to sleeplessness and restlessness, a state of excitement, compared by Borden to that produced by coffee, and which may be carried to the extent of a slight intoxication. Their operation is terminated by a copious sweat, and sometimes by an exanthematous eruption, or copious discharges of urine, which serve as crises in most chronic diseases. * * * It is not uncommon for per-

sons, after drinking a mineral water, or using a warm, and still more, a hot bath, for a few days, to complain of fullness of the head or headache, lassitude, disordered digestion, with white tongue and some degree of fever, accompanied by eruptions on the skin. This is a state which the German writers call "Bathstorm" or "Crisis," and others "Saturation." It will generally disappear by increased discharges from the bowels, or by a copious sweat, sometimes by diuresis; it is regarded by these writers as salutary, and by not a few, as an evidence of the curative powers exerted by the mineral or balneatory medication."*

These effects have been produced upon several of the citizens of Lafayette, by the use of the Artesian water, and to the uneasiness of some who were not aware that this is a frequent method by which mineral waters exert their salutary influence upon the system. Having learned that one of our physicians, Thomas Chesnut, M. D., is engaged in studying carefully the curative power of the water, in order to publish its practical effects, I thought that a short abstract of his labors would afford a proper companion to the result of mine. In answer to my inquiry, I received the following communication.

LAFAYETTE, APRIL 20, 1858.

DEAR SIR:—

In compliance with your request I can with ingenuousness of purpose assure you that I entertain a very favorable opinion of the remedial virtues of the Artesian water, believing it to be possessed of valuable medicinal properties.

I have based this opinion upon my own observation, as well as upon reported results, making due allowance for exaggeration and the imaginary cures that are always attributed to newly-discovered remedial agents.

The diseases in which the sulphurous class of mineral waters are supposed to exhibit their curative powers to the best advantage, as is well known to you, are in the chronic

* Bell on Mineral Waters.

forms of dyspepsia and bronchitis, with a languid circulation and depressed and exhausted state of the vital powers, in which a majority, if not all, of the important secreting organs and tissues of the abdominal and thoracic cavities are, if not structurally, at least functionally deranged. These waters holding, as they do, in intimate combination, saline and gaseous substances, appear to possess the remedial constituents necessary to effect a complete transmutation in the functions of all the organs and tissues involved in the above diseases; by exciting the circulation to a healthy standard; subduing the morbid action of the gastro-intestinal and bronchial mucous membranes; quickening and invigorating the digestive, nutritive, and respiratory functions; until by their renovating and alterative effects, every derangement is corrected; every vice overcome, and the invalid restored to energy, activity, and the luxury of health.

But, happily for the invalids of several other classes of chronic affections, the healing virtues of these waters are not alone confined to those who are suffering from derangement of the mucous surfaces of the digestive and respiratory organs. In the treatment of chlorosis, and the chronic forms of rheumatism, gout, scrofula, and affections of the skin and urinary organs, with the various and multiform diseases of the brain and nervous system, they have for centuries past been regarded by the most distinguished therapeutists as among the most valuable of our remedial agents.

From the numerous evidences which I have obtained, from observation and inquiry, of the beneficial effects of the Artesian water in the treatment of many of the diseases just enumerated, I have been induced to believe that it is possessed of the therapeutical properties peculiar to the most celebrated saline sulphur waters; and may be prescribed, not only with safety, but advantage, in all those diseases for which the experience of the Profession has proved them to be so eminently efficacious.

I look forward with confidence to the result of patient

clinical observation for establishing the correctness of this position.

Yours, very respectfully,

THOMAS CHESNUT.

CHARLES M. WETHERILL, Ph.D., M.D.

THE ADVANTAGES OF LAFAYETTE AS A WATERING PLACE.

I shall conclude this report with a few remarks upon the advantages of this locality for a watering place.

Lafayette is situated in the valley of the Wabash, which river is, during high water, navigable to this point. The city is regularly laid out. It contains a population of twelve thousand inhabitants. It is inclosed in the great net-work of the completed and projected railways of the West, and is readily accessible by rail from the great centers, St. Louis, Chicago, Cleveland, Toledo, Indianapolis, Cincinnati, and Louisville. The railroads centering at Lafayette are the Lafayette and Indianapolis, New Albany and Salem, and the Wabash Valley Railroad. The Wabash and Erie Canal, the longest in the United States, connecting lake Erie with the Ohio, passes Lafayette, enabling the transportation of freights at a low rate.

Travelers from the East may reach this city via Cincinnati and Indianapolis, or via Toledo and Fort Wayne; and from the West, direct from St. Louis, via Wabash Valley Railroad. Tourists to the great chain of lakes, to the Upper Mississippi, or to the country west and north of St. Louis, will find Lafayette directly upon their route, or can reach it by a slight detour.

On their arrival at Lafayette, visitors will find an agreeable and hospitable society; a variety of hotels and stores to accommodate their wants, and above all a healthful climate for the well, and good physicians for the sick. This city enjoys peculiar advantages over those watering places which are visited only during the summer season, in that its waters may be taken at all seasons of the year.

I have noticed in the neighborhood of this city, springs coating the surrounding ground with a thick deposit of oxide of iron, and I doubt not that if properly opened,

several fine chalybeate waters would result. One of these springs is situated upon the shore of Burnett's Creek, on the Tippecanoe battle-ground. I have seen many highly prized chalybeate waters which do not present as strong indications of iron as this one. The temperature was 53°, that of the air being 84°. It strikes a dark color with extract of galls, has, as said before, a strong taste of iron; is light and agreeable to the stomach, and coats the stones over which it flows with a strong ochreous deposit. It stands in a barrel at a foot above the ground, but the greatest flow of the spring passes under the barrel. Probably a proper stand-pipe would enable it to be raised to the top of the bank. At a short distance up the said creek, there is another spring of a similar character. I desire to direct particular attention to these iron springs, as there is an opportunity through them, not only of realizing a handsome fortune, but of greatly benefiting the advantages of Lafayette, as a watering-place. Many invalids who visit a sulphur spring ignorantly, find to their sorrow that they have undertaken the risk and expense of the journey for a water not suited to their case. It is well for them, if, as at the White Sulphur of Virginia, they can find a chalybeate spring which is adapted to their disease. Many such will doubtless visit the Artesian water, and will, in like manner, need to use the Battle-ground spring. It would be difficult to find a place better adapted for a hotel for summer resort, than at the Tippecanoe Battle-ground. A place of much interest; yearly visited by many; with beautiful surrounding scenery; fine opportunity for baths, both with the mineral water and with the water of Burnett's Creek, accessibility from Lafayette, etc., are advantages which greatly lessen the risk of the undertaking. It would supply a want much needed here, viz.: a pleasant place where parents could afford a few weeks change of scene and air, in the summer time to their children, at a small outlay. A battle-ground train would enable Lafayette to be reached every morning in time for business, and left in the evening at the close of the day's labors.

The business and agricultural opportunities of Lafayette are in some directions excellent. This fact might induce some, whose means do not permit a lengthened visit at other watering-places, to locate permanently in or near Lafayette, and while engaging in their mercantile, or agricultural pursuits, enjoy the benefit to their health, to be derived from the use of the mineral waters.

Finally, objects of interest and amusement are not wanting for the valetudinarian.

The Grand Prairie, extending from the northern portions of Minnesota far into the Southern States, and from Indiana to the Rocky Mountains, has its eastern edge distant about six miles from this city.

The battle-ground of Tippecanoe, celebrated in Harrison's two campaigns, the military and the presidential, lies at a distance of seven miles to the north. It is accessible in fifteen minutes by railway, and also, by a pleasant carriage drive.

Nearer the city, the hills and river bank offer many a pleasant walk, and the woods afford agreeable and shady rides and drives.

The sportsman will find here opportunity for spending many pleasant weeks. Success in fishing and shooting is, in the immediate neighborhood of the city, sufficient, and at a few hours ride by carriage or by rail, more than abundant. Among the finny tribe, we have bass, salmon, pike, perch, large catfish; and for game, wild geese, ducks, and crane, snipe, a few woodcock, deer, wild turkeys, pheasants, quail, and last, though not least, an abundance of grouse on the prairie, and which are in season at the very time the mineral spring would be most frequented, viz.: from August 1st.

In conclusion, I would recommend those seeking health or relaxation from business, to pay the Lafayette White Sulphur water a visit, confident that much benefit and many returns would be the result.

CHARLES M. WETHERILL.

Lafayette, Ind. *August* 19, 1858.