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IX. *Analysis of the Water of the Artesian Wells, Trafalgar Square,*
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The deep well-water of the London Basin has been analysed by Professor Graham.* The striking feature of this analysis is the discovery of the presence of phosphoric acid, and the absence of salts of potash.

The water which Professor Graham analysed, was taken from the deep well in the brewery of Messrs. Combe and Delafield, Long Acre. This well not descending so deep into the chalk as the Artesian wells in Trafalgar Square, we were induced to subject the water of the latter to an analysis in order to compare the results with those obtained by Professor Graham. The water on which we operated was taken in the beginning of October, 1847, from the shaft at the back of the National Gallery.

At a depth of about 109 feet, the water enters the shaft through a bore-hole, which passes the London clay and penetrates into the chalk. Thus the water rises from a depth of nearly 400 feet. The temperature of the water is 58° Fahr. (14·5° C.), its sp. gr. is 1000·95, the sp. gr. of distilled water being 1000.

The water is very soft, and very delicate test-papers show that it has an alkaline re-action.

* Memoirs of the Chemical Society, vol. II. p. 239.

A careful qualitative analysis of the water having pointed out the presence of potash, soda, magnesia, lime, sulphuric, silicic, carbonic, hydrochloric acids, and traces of phosphoric acid, as well as a small quantity of organic matter and ammonia, the following experimental numbers were obtained by quantitative analysis.

A. Determination of the total amount of fixed constituents :

Amount of water.	Fixed residue.	Per centage.
I. 1097,895 grms.	1,0929 grms.	0,09954
II. 1009,028 „	0,9965 „	0,09876

Mean 0,09915

B. Determination of sulphuric acid :

Amount of water.	Amount of sulphate of baryta.	Per centage of sulph. acid
I. 356,464 grms.	0,1657 grms.	0,01598
II. 326,303 „	0,1527 „	0,01607

Mean 0,016025

C. Determination of chlorine :

Amount of water.	Amount of chloride of silver.	Per centage of chlorine.
I. 208,481 grms.	0,1465 grms.	0,01738
II. 339,337 „	0,2390 „	0,01741

Mean 0,017395

D. Determination of silicic acid :

Amount of water.	Amount of silicic acid.	Per centage.
I. 547,155 grms.	0,0073 grms.	0,00133
II. 516,700 „	0,0067 „	0,00129

Mean 0,00131

E. Determination of lime :

Amount of water.	Amount of carbonate of lime.	Per centage of lime.
I. 547,155 grms.	0,0255 grms.	0,00261
II. 516,700 „	0,0242 „	0,00262

Mean 0,002615

F. Determination of magnesia :

Amount of water.	Amount of pyrophosphate of magnesia.	Per centage of magnesia.
I. 547,155 grms.	0,0237 grms.	0,00159
II. 516,700 „	0,0217 „	0,00153

Mean 0,00156

G. Determination of the alkalies :

Amount of water.	Amount of chlorides of potassium and sodium.	Per centage.
I. 245,307 grms.	0,2015 grms.	0,08206
II. 219,182 „	0,1920 „	0,08759
Amount of water.	Amount of potassiochloride of platinum.	Per centage of potash.
I. 245,307 grms.	0,1277 „	0,01008
II. 219,182 „	0,1255 „	0,01101
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		Mean 0,01055
Amount of water.	Amount of chloride of sodium.	Per centage of soda.
I. 245,307 grms.	0,16255 grms.	0,03467
II. 219,182 „	0,15380 „	0,03713
		<hr/>
		Mean 0,03590

H. Determination of carbonic acid :

The carbonic acid was determined by precipitating a known volume of water by a mixture of chloride of calcium and ammonia at the well. 2134,0254 cubic centimetres of water in this manner yielded 1,3397 grms. of precipitate, in which the carbonic acid was determined.

Amount of precipitate.	Amount of carbonic acid.	Per centage in the precipitate.
I. 0,3656 grms.	0,117 grms.	32,002
II. 0,3679 „	0,118 „	32,070
		<hr/>
		Mean 32,036

The whole amount of precipitate accordingly contained 0,4297 grms. carbonic acid, representing a per centage of 0,02013 carbonic acid in the water.

I. Determination of the total amount of phosphoric acid :

A known quantity of water was evaporated to dryness, the residue obtained was fused in a platinum capsule, the fused mass digested with water, the solution filtered, and the phosphoric acid determined therein as pyrophosphate of magnesia.

Amount of water.	Amount of pyrophosphate of magnesia.	Per centage of phosphoric acid in the water.
1002,208 grms.	0,0037 grm.	0,000233

For the determination of the small amounts of phosphoric acid, in combination with lime, of organic matter existing in the water in

the different forms designated as apocrenic and crenic acids, and of extractive matter,

36,31712 kilogrammes of the water were evaporated to 306,923 grms. yielding a precipitate (*a*), insoluble in water, of . . . 2,899 „ the solution (*b*) along with the washings amounting to 569,306 „

K. Determination of the phosphoric acid in combination with lime :

Amount of precipitate (<i>a</i>).	Amount of pyrophosphate of magnesia.	Per centage of phosphoric acid in the water, combined with lime.
0,6925 grm.	0,0032 gm.	0,0000234

L. Determination of the organic matter :

0,6100 grm. of precipitate (*a*) was extracted with potash, the alkali was saturated with acetic acid, and acetate of copper added ; there was obtained, after standing for some time,

0,0189 grm. of a brown precipitate of apocrenate of copper, corresponding to 0,0001414 per cent of apocrenic acid in the water.

The filtrate from this precipitate, on boiling with excess of carbonate of ammonia, yielded :

0,0567 grm. of a greenish precipitate of crenate of copper, corresponding to 0,000196 per cent of crenic acid in the water.

For the determination of what is usually called extractive matter : 189,50 grms. of the solution (*b*) were evaporated with carbonate of soda, the residue obtained was dried, weighed and afterwards ignited ; it lost 0,1165 grm. corresponding to :

0,00096 per cent of extractive matter in the water.

From these analytical results, the following composition of the water is deduced :

	Grammes in 100 kilogrammes. (liter).	Grains in an imperial gallon. (70,000 grs.)
Carbonate of lime . . .	4,65000 . . .	3,255000
Phosphate of lime . . .	0,04863 . . .	0,034041
Carbonate of magnesia . .	3,22000 . . .	2,254000
Sulphate of potash . . .	19,53000 . . .	13,671000
Sulphate of soda . . .	12,49900 . . .	8,749300
Chloride of sodium . . .	28,65500 . . .	20,058500
Phosphate of soda . . .	0,41600 . . .	0,291000
Carbonate of soda . . .	25,78400 . . .	18,048800
Silicic acid . . .	1,31000 . . .	0,971000
Apocrenic acid . . .	0,14100 . . .	0,098700
Crenic acid . . .	0,19600 . . .	0,137200
Extractive matter . . .	0,96000 . . .	0,672000
	<hr/> 97,40963	<hr/> 68,240541

The amount of fixed residue obtained by direct experiment was :

in 100 kilogrammes	99,150 grammes ;
in an imperial gallon	69,405 grains.

According to the experiments detailed above, one liter of water contains 30,3864 cubic centimetres of free carbonic acid at the temperature 58,1° F. (14,5° C.) ; one imperial gallon contains, therefore, 8,4235 cubic inches.

In order to ascertain whether the water loses a portion of carbonic acid in being pumped up, a determination of this gas was made in some of the water, as it issued from the mouth of the force-pump in the works :

Water employed.	Precipitate obtained.	Per centage of carbonic acid in the water.
1067,012 cubic centimeters	0,2103 grm.	0,01971

After deducting the amount of carbonic acid in combination with lime, magnesia, and soda, from the per centage obtained above, we have remaining a quantity corresponding to 28,153 cubic centimeters in a liter, or 7,805 cubic inches in an imperial gallon at 14,5° C.

From these results, it is evident that a small quantity of carbonic acid is lost by the process of pumping.

To ascertain the amount of matter precipitated by boiling the water, known quantities were submitted to strong ebullition for some time, the precipitates formed were collected on tared filters, dried and weighed.

Water employed.	Precipitate formed.	Per centage.
439,608 grms.	0,0392 grm.	0,00892
357,393 „	0,0320 „	0,00895

Mean 0,008935

The mean quantity obtained corresponds to 6,2545 grains in an imperial gallon, or 0,08935 grammes in a liter.

The preceding analysis shows that the constituents of the water of the Artesian wells in Trafalgar Square are essentially the same as those of the water from the well in Messrs. Combe and Delafield's brewery. There is only one point in which the two waters materially differ in composition. The water which Professor Graham analysed, and which, as already mentioned, comes from a higher stratum, was found to contain no potash salts, whilst these were invariably present in the waters of Trafalgar Square. In order to preclude the possibility of error, the water which we employed for testing was collected at different periods.

Mr. Payen* found that the water of the Artesian well at Grenelle contains a considerable amount of sulphate of potash and chloride of potassium, so that it would appear that potash salts are characteristic of the waters from the deeper strata.

The water analysed by us did not contain a trace of iron.

The presence of phosphoric acid, first pointed out by Professor Graham in deep well-water, could be easily ascertained in the Trafalgar Square water by the method indicated by that chemist; in fact, on evaporating the water to dryness, and gently igniting the residue, the phosphoric acid, existing partly in combination with lime and partly with soda, is obtained altogether in the form of a soda salt, the solution of which deposits the yellow tribasic silver-salt on the addition of nitrate of silver.

The large amount of organic matter contained in the deep well-water is very remarkable, while the quantity observed in the water of a higher stratum seems to have been very trifling. It evidently arises from the remains of organized beings which have invariably been found in the chalk.

With reference to the quantities in which the different constituents are present, it will be observed, on comparison, that the total amount of fixed constituents is somewhat different (56,80 and 69,40), whilst very considerable deviations are perceptible in the quantities of the various constituents. The most striking difference is observed in the quantities of sulphate of soda contained in the two waters.

In conclusion, we give a tabular view for the comparison of the water analysed by Professor Graham and the Trafalgar Square water, to which we annex the results obtained by M. Payen from the analysis of the water of Grenelle.

	Wells at Messrs. Combe & Delafield.	Trafalgar Square wells.	Grenelle.
	Grains in an imperial gallon.		
Carbonate of lime	6,18	3,255000	4,7600
Phosphate of lime	0,19	0,034041	. .
Perphosphate of iron . . .	0,24	. . .	. .
Carbonate of magnesia . . .	1,08	2,254000	0,9940
Sulphate of potassa . . . .	. . . . .	13,671000	0,8600
Chloride of potassium . . . .	. . . . .	. . .	0,7630
Bicarbonate of potassa . . . .	. . . . .	. . .	2,0720
Sulphate of soda	24,25	8,749300	. .
Chloride of sodium	12,74	20,058500	. .

* Annales de Chimie et de Physique, 3ème sér. tom. i. p. 381.

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	Wells at Messrs. Combe & Delafield.	Trafalgar Square wells.	Grenelle.
	Grains in an imperial gallon.		
Phosphate of soda		0,291000	. .
Carbonate of soda	11,68	18,048800	. .
Silicic acid	0,44	0,971000	0,3990
Apocrenic acid		0,098700	. .
Crenic acid		0,137200	. .
Extractive matter		0,672000	. .
Yellow substance . . . . .		. . .	0,0014
Organic matter (nitrogenous) . .		. . .	0,0138
	56,80	68,240541	9,8632

The purity of the water of Grenelle is most remarkable, the amount of fixed constituents being only about $\frac{1}{7}$ th of that which is found in the London waters.

This analysis was conducted in the laboratory of the Royal College of Chemistry.
