

### XXXIX.—*Analysis of the Water from the Dropping Well at Knaresborough, in Yorkshire.*

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THE history of Knaresborough dates from before the Norman Conquest, and the remarkable petrifying qualities of this spring must have attracted attention at a very early period. Its character was well known in 1534, for Leland thus describes it (*Leland's Itinerary*):—

“A little above March Bridge, but on the farther ripe of Nidde as I cam, is a Welle of a wonderful nature, caullid Dropping Welle, for out of the great Rokkes by it, distilleth water continually ynto it. This water is so could, and of such a nature, that what thing soever faullith oute of the Rokkes ynto this pitte, or ys caste in or growith about the Rokke and is touched of this water, growith ynto stone; or else some sand, or other fine ground that is about the Rokkes, cummith doune with the continuall dropping of the Springs in the Rokkes, and clevith on such things as it taketh, and so clevith aboute it and giveth it by continuance the shape of a stone. There was ons, as I hard say, a conduct of stone made to convey water from this welle over Nidde to the priory of Knaresborough; but this was decayed afore the dissolution of the house.”

It would, therefore, appear that some time prior to 1534, the water was used for drinking purposes.

From 1626 up to as late as 1838, it had a considerable reputation as a spa water, and numerous references as to its medicinal qualities are to be found in the works of Short, Elliott, Walker, and Hunter.

Dr. Short, in 1734, found it “to be twenty-four grains in a pint heavier than common water, on exhaling eighteen pints it left seventeen scruples of sediment.”\*

In 1783, Dr. Walker states, “the petrefying spring at Knaresborough contains a considerable quantity of *selenitical*, and a smaller quantity of *calcareous* earth.”†

This water was analysed in 1830, by Mr. W. West, of Leeds. His numbers were‡

\* *The Natural, Experimental, and Medicinal History of the Mineral Waters of Derbyshire, Lincolnshire, and Yorkshire.* By Thomas Short, M.D., of Sheffield. London, 1734.

† *An Essay on the Waters of Harrogate and Thorp Arch in Yorkshire.* By Joshua Walker, M.D. London, 1784.

‡ *The Waters of Harrogate and its Vicinity.* By Adam Hunter, M.D. London, 1830; also, *On Mineral Springs and other Waters of Yorkshire.* By W. West. *British Association Report*, 1844.

<i>Saline Contents in grains per Imperial Gallon :—</i>		<i>Gases yielded by the Water in Cubic Inches per Imperial Gallon :—</i>	
Carbonate of lime . . . . .	23	Carbonic acid . . . . .	7
Sulphate of lime . . . . .	132	Azote . . . . .	8
Sulphate of magnesia . . . .	11	Oxygen . . . . .	1
Carbonate of soda . . . . .	6		—
Iron . . . . .	trace	Total . . . . .	16
Solid contents on evaporation . . . . . } 172		Sp. gr. of water = 1·0032.	

So far as I am aware, no analysis has been made since 1830, and it seemed very desirable that a more complete examination should be made of this curious water. The investigation was commenced in 1894, and extended over the following year, various samples of the water having been taken from time to time.

The strata on which Knaresborough is built is mostly magnesium limestone. The Dropping Well is situated in the Long Walk, on the south-west bank of the river Nidd, where the water rises in the steep declivity of a hill, at the foot of a limestone rock, and flows in a small stream for about 24 yds. It is then caused to spread over the surface of a large rock, some 30 ft. high and 32 ft. long, over which it trickles. The upper part of this rock projects considerably over the base, and it is to this projection that the articles to be petrified are hung.

The water for analysis was collected immediately as it issues from the ground; at this point it is very clear and free from suspended particles. The flow is about 20 gallons a minute, and the temperature very constant, two readings giving

August . . . . .	Temp. of air, 15·5° C. ;	temp. of water, 9·7° C.
December . . . . .	„ 2·0° C. ;	„ 9·0° C.

The specific gravity = 1·0024 at 15·5°; it was taken by means of a Sprengel tube, the capacity of which had been very carefully determined. In each case the determination was made the same day as that on which the water was collected.

*Analysis.*—The general course adopted was that recommended by Fresenius; the numbers given are the means of at least two, and in some cases three or more concordant results. For the estimation of substances present in minute quantity, 25 litres were evaporated, but no traces of bromine, iodine, fluorine, or lithium could be detected.

Strontium was separated by the Rose-Stromeyer process, which has been carefully examined by Fresenius (Abstracts, 1893, ii, 301), who finds it to give very perfect results. The method was checked by making up mixtures of calcium and strontium sulphates in proportions similar to those found in the well water, the results

obtained show that the process is trustworthy. In each estimation, the separated strontium sulphate was subjected to spectroscopic examination, but contained only the merest trace of admixed calcium sulphate.\*

In estimating the gases dissolved in the water, the apparatus devised by Sidney Harvey was employed (*Analyst*, 1894, **19**, pp. 121, 122, 123); by means of this apparatus, the water may be collected at the source in the bulb in which it is afterwards boiled, thus reducing contact with the atmosphere to a minimum.

The atomic weights used are those given in Clowes and Coleman's *Quantitative Analysis*, 1894.

In the first table, the quantities of the different constituents are given in grams per litre under I, and in grains per gallon under II. In III the acids and bases are combined together, and the results stated in grains per gallon; and Table IV gives the gases dissolved in the water.

*Constituents per Litre and per Gallon.*

	I. In grams per litre.	II. In grains per gallon.
CO <sub>2</sub> .....	0·1614	11·298
SiO <sub>2</sub> .....	0·0107	0·749
SO <sub>4</sub> .....	1·3524	94·668
Cl .....	0·0270	1·890
Fe.....	0·0011	0·077
Mn.....	0·0006	0·042
Ca .....	0·6330	44·310
Sr .....	0·0046	0·322
Mg .....	0·0491	3·437
Na .....	0·0156	1·092
K.....	0·0035	0·245
NH <sub>3</sub> .....	0·00002	0·0014
Al.....	trace	trace
P <sub>2</sub> O <sub>5</sub> .....	trace	trace
HNO <sub>2</sub> .....	none	none
HNO <sub>3</sub> .....	none	none

In combining the various acids and bases, a deviation from the usual course has been adopted, the sulphuric acid being first combined with the magnesium in preference to the calcium, as practically the whole of the magnesium was found in the boiled water, and none in the sediment thrown down on boiling.

\* For the occurrence of strontium sulphate at Knaresborough the following may be consulted: *Trans. Geological Society*, 1817, **4**, 445; *Edinburgh Phil. Journal* Jan. 1825, **12**, 178, 179.

III. *Dissolved Saline Constituents in grains per gallon:—*

Calcium sulphate....	114·373
Calcium carbonate...	25·480
Calcium silicate ....	1·442
Strontium sulphate ..	0·672
Magnesium sulphate .	17·003
Ferrous carbonate ...	0·154
Manganous carbonate	0·084
Sodium chloride ....	2·765
Potassium chloride...	0·462
Alumina .....	trace
Phosphoric acid. ....	„

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162·435

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Fixed residue by eva-  
poration dried at } 162·324  
170—180° .....

Sp. gr. at 15·5°..... 1·0024

IV. *Gases dissolved by the Water in cubic inches per gallon, and measured at 15·5° and 760 mm.*

Carbon dioxide.....	4·74
Oxygen .....	1·29
Nitrogen* .....	5·02
Total .....	11·05

\* Not examined for argon.

It should be stated that all the reagents used in the analysis were not only of the highest degree of purity obtainable, but were carefully tested, the impurities estimated, and (as measured quantities were used throughout) allowed for in the final results.

It is intended to make the analysis of the deposit or sinter the subject of a future paper.

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