

## The Mineral Waters of Bath.

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MACKAY HERIOT, F.C.S.,

*Captain, Royal Marine Light Infantry.*

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THE thermal waters of Bath, which for ages have been celebrated for their medicinal properties, constitute my subject. To go into the history of these mineral springs would occupy too much time and be foreign to the purport of my paper ; but a few introductory remarks on their antiquity may not be out of place.

Legends tell us how Bladud, when wandering through the valley of the Avon, was cured of his leprosy by bathing in the mineral waters, and how, years afterwards, when he became a king, he revisited the scene of his cure, and, in gratitude for his restoration to health, built a beautiful city on the spot and erected baths that others might benefit from the waters. This was supposed to have happened about 1,500 years before the Christian era. According to Warner the earliest period of these baths being of any repute was A.D. 44 ; and the fact that Roman baths of great size and beauty were discovered during the last century would go far to prove this. The present enclosures round the chief springs are supposed to have been built by John de Villula, Bishop of Bath, about the year 1106, and, I am informed, that it was under the very house in which this bishop lived, and which was destroyed some time during the last century, that the remains of the Roman baths, before referred to, were discovered.

The mineral spring at the King's Bath, as analysed by me during the past month, contains as follows :—calcium, 403 parts

per million ; strontium, traces ; magnesium, 34 parts per million ; sodium, 144 parts ; potassium, 29 parts ; lithium, traces ; iron, 3.5 parts ; sulphuric acid, 962 parts ; carbonic acid, 62 (combined) parts ; chlorine, 280 parts ; silicic acid, 33 parts ; solid contents, 1,950 parts ; specific gravity, 1.002 parts ; (water, 1) ; temperature,  $113\frac{1}{2}^{\circ}$  Fahrenheit. The water for analysis was taken from the drinking fountain in the Grand Pump Room.

The geological formations through which the spring passes may be thus enumerated :—The coal measures, upper red sandstone and marls, lias and alluvial soil. Supposing these waters to pass through the coal measures, I think we may dismiss that as adding to their chemical constituents. We know the red sandstone and marls to be rich in gypsum and salt, and it may be here that a great proportion of the calcium, sulphuric acid, sodium, and chlorine are obtained. In passing through the lias the spring would take up the magnesium salts and more chlorine. The amount of iron present is possibly due to the decomposition of the iron pyrites, acted on by the bituminous deposits in the same strata. We may not be far wrong in ascribing the free nitrogen which bubbles up through the spring in such large quantities to the same source ; and if we put down the thermicity of the springs as due to the spontaneous ignition of the bituminous shales, I think we have completed a theory received as worthy of consideration by many people. This theory, in which I must own to having once believed, has, however, many fatal objections ; the decomposition of the iron pyrites and bituminous deposits in the lias, though possibly giving rise to great heat at times, would not account for the constant thermal heat of the mineral spring. I lay stress on the word constant, for, if we give any credit to the numerous pamphlets published on the Bath waters during the past century, we must believe that the variation in the temperature for that time has been very small. Again, suppose this decomposition to be the cause of the heat, should we not ere this have had optical evidence of the same ? for those deposits are not so deeply

placed, being above the red sandstone. Surely, had this been the case, cutting for coal or other deep excavations must have brought the truth to light. Another objection to the decomposition theory is the wonderful constancy of these thermal waters, which I am not aware that any one has ever noticed. You will, perhaps, be surprised when I prove to you that their composition has scarcely altered during the past seventy years. I had by me, for the purpose of completing this paper, the different analyses made by eminent chemists since the commencement of this century. The figures did not show much : thus, in the year 1806, Phillips found 14,000 parts of sulphate of soda; Scudamore, in 1820, found only 1,500; while Galloway, in 1848, discovered, 19,000; the same way with the other salts of soda, and lime, &c. It, however, occurred to me that, as the solid contents in each case were nearly similar, if I calculated the different salts of lime, soda, &c., into their elements, I might have something to work on. Thus I took the amount of carbonate of lime in each analysis, and calculated it into calcium and carbonic acid; the sulphate of lime into calcium and sulphuric acid; and the same way with the others. By doing this I arrived at a gross total of the different elements, and now I will show you the result.

ANALYSIS OF THE BATH MINERAL WATERS SINCE THE YEAR 1806.

Expressed in parts per Million or Milligrammes per Litre.

	Calcium.	Magnesium.	Sodium.	Potassium.	Iron.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Silicic Acid.	Solid Contents.
Phillips, in 1806	406	...	243	...	2.2	1011	67	275	28	2032
Scudamore, 1820	443	55	75	...	1.4	1006	45	271	27	1925
Wackler, 1829	404	48	174	19	2	1033	92	273	46	2092
Herapath, 1836	426	42	144	...	1.9	1100	70	209	25	2019
Noad, 1844	405	26	195	...	3.5	970	51	308	48	2006
Galloway, 1848	387	53	160	30	7.4	1029	87	265	43	2053
Heriot, 1873	377	47	129	40	6.1	869	86	280	30	1864
Heriot, 1876	403	34	144	29	3.5	962	62	280	33	1950

The above is drawn up in a tabular form for the purpose of showing how little variation has taken place in the mineral

springs of Bath during the past 70 years. We see then the constancy of these waters for the past 70 years; and this appears more wonderful since we know that during this time these springs have discharged over 100,000 tons of solid inorganic matter drawn from the source whence they come. The amount of insoluble débris, sand, &c., thrown up daily to the mouth of the spring, is not computed in this calculation. I will explain how I base my estimation of this enormous weight of solid matter. The springs give off daily about 7,500 hogsheads, weighing say 2,000 tons. The solid contents of these waters are, as nearly as possibly, two parts in 1,000 by weight, so that the 2,000 tons of water represent four tons of residue, equal to 1,460 tons for a year, and to 102,200 tons for 70 years. One would naturally imagine that the enormous mass of earth necessarily disintegrated to allow 100,000 tons of solid matter to be taken from it would have a great effect upon the springs; such, however, is not the case, it appears to have had no effect worth noticing, nor has the rainfall chemical influence of any consequence. Some time ago I undertook a series of experiments (since published in the *Proceedings of the Bath Field Club*) and found the variation in the amount of chlorine taken daily during the week from the Hetling Spring was only two parts per million; the other springs varied a little more. I could not discover that rain had any influence, though I tested the waters on many occasions after a long continued rainfall. I will endeavour to account for the constancy of their chemical composition. We are all aware of the great extent and thickness of the upper red sandstone formation, and water passing through it for a long distance, say a few miles, would naturally have the same composition at all times. The spring, in working its way to the surface, has in the course of ages coated the natural passages through which it rises with insoluble salts of iron, lime, and magnesia, forming for itself a crystalline tunnel impervious to outward influences as, for instance, rain water filtering through the alluvial soil. To see that such a thing is not impossible one

has only to notice the deposit on the drinking fountain in the Grand Pump Room. Having briefly noticed what, in my opinion, are the objections to the theory that the source of thermal heat emanates from the lias—a formation, comparatively speaking, close to the surface,—I will now close this paper by observing that from the constancy of the temperature, as well as that of the chemical composition of these waters, we are justified in saying that one point is tolerably well established, namely, that the source of heat, whatever that may be, can hardly be the result of chemical decomposition, which would be intermittent, or, at least, varying in intensity ; and that for a solution of this problem we must go to some of the older geological formations.

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