An Essay on Sulphurous Mineral Waters
by Murray Thomson
Section
A Thesis on Sulphurous Mineral Waters.

In the following thesis I purpose directing attention to Sulphurous Mineral Waters, their Chemistry, Therapeutics, and source of their Sulphuretted Hydrogen, describing more particularly those Scottish Sulphurous Springs which I have myself visited, and analyzed within the last twelve months, namely, the Strathfellow Spas, three in number, St. Bernard's mineral well, Edin.; and the two sulphurous springs at Moffat.

It is now well known that Sulphurous Springs along with other mineral waters, have from the earliest times been valued and prized for their curative power on some old cases and more especially on affections of the skin. An early notice of a Sulphurous Spring to which healing powers had been ascribed, re-
occurs in one of the Epistles of St. Paul, in which he says that he himself had been ordered by the prescription of Antony the Centurion to repair to the baths of Sulmarum, or Velin, which he calls the sulphureous waters, that were said, had the power 'to expel lingering diseases from the nerves.' Another notice of a sulphureous spring remarkable for the notoriety of the person for whose benefit it was prescribed, occurs in Josephus' Antiquities of the Jews, where he records that the physicians of Herod the Great during his last illness, sent him to bathe in the warm baths at Callirhoe, a place on the shores of the Dead Sea, and very likely the same place where Cestian, the traveler, discovered a hot sulphureous spring during his explorations of that remarkable sea, and its shores. These instances serve to show us that physicians of that time, well knew the powers of these waters, and placed great trust in them.

And in more modern times, when the light of chemistry has thrown on nature, was beginning to dawn upon mankind, these waters formed a frequent subject of investigation, and
and of many a special treatise, often perhaps written primarily to show forth the powers of the water as an adept in the science of chemistry, and secondarily to spread the praises of the particular water they wrote upon for its wonderful curative efficacy. And even in our own day, in the medical and chemical journals both at home and on the Continent, mineral waters still claim a large share of attention. It seems therefore, almost necessary, to make some apology for attempting "a new walk on such an old field", but this apology is, I think, abundantly given when I state that with the exception of one or two of the Altoff waters, none of the others I propose directing attention to in this treatise have been analysed within the last thirty years and during that time analytical chemistry has made such rapid progress, and has furnished us with so many important improved methods of investigation, it is for these reasons, therefore, that I feel justified in again directing attention to this subject, in the hope that by the application of more exact methods of analysis I may be enabled to exhibit not only their true chemical
constitution more accurately, but even to throw
light on their therapeutical actions, and on the source
of the Sulphuretted-Hydrogen gas, the charac-
teristic ingredient of sulphurous springs.
I will consider in the first place the chemistry
of each water in detail, and afterwards discuss
the sources of their Sulphuretted-Hydrogen gas,
and lastly their Therapeutics.

The General Plan of Analysis, which I
followed in every instance was nearly the same as
the very excellent one given by Fresenius,* and
it may save repetition afterwards if we commence
by stating in what this method consisted.
The Sulphuretted-Hydrogen gas was in all
cases determined during the visit to the spring.
This was done by means of pouring from a burette a
standard solution of Iodine in Iodide of Potas-
sium into a pint of the fresh drawn water, which
had previously added to it some solution of
starch, until a permanent blue color was obtain-
ed. The quantity of Iodine solution used being
then read off the burette, a simple calculation show-
ed the amount of Sulphuretted Hydrogen, the
water contained. The standard solution of
Sodium used was the same for all the waters, a considerable quantity having been made at first. The strength of it being the same measure or Felipe in the 1000 grains burette, equal to 10 grains of water, and contains free Sodium corresponding to .005 of a grain of Sulphurated Hydrogen. This solution was made as follows: if 17 the equivalent of Sulphurated Hydrogen require 126.08 of Sodium for saturation, then .005 will take .0372 of a grain, therefore each measure of the burette contains .0372 of Sodium, and 100 measures 3.72 grains, so that a burette full, equal to 7000 grains or 1000 of distilled water, had added to it 26.04 grains of pure Sodium, dried in vacuo over sulphuric acid, and to this there was added about a half ounce of Soda of Potassium, to promote solution of the Sodium. The increase in bulk of the solution from adding the Sodium, and Sodium was taken too small to be seen. Such a solution as this keeps for a great length of time, without change or decomposition, and I take this opportunity of adding my testimony to the ease and correctness, with which you can determine the amount both of free and combined Sulphurated Hydrogen.
by this process, and towards the further testing
the accuracy of the solution of Soda, which I
employed. While all its effects precipitated
the Sulphured Hydrogen in two parts of the
mineral water, by means of the old method, an
acid solution of arsenious acid, and the results
of the two determinations differed no more than
five hundredths of a grain of Sulphured Hydrogen
in the gallon of mineral water.

The Carbonic Acid existing as gas was deter-
mined by adding to measured quantities of the
waters, a clear ammoniacal solution of Chloride
of Barium, and afterwards separating and dry-
ing the precipitated carbonate, sulphate, or
which being weighed the Carbonic Acid was de-
termined by loss of the laboratory.

The indifferent gases, Oxygen, and Nitro-
gen, were not determined in any of the waters.

The other circumstances noticed at the
springs were, the temperature of the water, and
that of the surrounding air; the action of
the waters on red or blue litmus paper; the gen-
eral appearance of the water as it came from
the source; with the rate of supply, mode of
mode of collection.

After the waters had been transmitted to the laboratory, the first operation was to perform in each case, a careful qualitative analysis, but besides this I evaporated a certain quantity averaging about two parts for detection of minute constituents, and here I may remark that although in the quantity of the waters I used, I failed in detecting some of the minute constituents of mineral waters shown lately to be present in small quantity such as Ammonia, Jodide, and Fluorine, which have been shown to be present when 1000 grains or so of the solid residue of the mineral water was used for their detection; still, from the quantity I did employ for such purposes I have the guarantee that if any of the above substances are present they must be so in such minute quantity as to be, as far as least as medicinal action is concerned, removed from consideration altogether.

Jodide and Bromine were looked for, by digesting the residue of two parts of the water in strong alcohol, distilling off the spirit, dissolving the residue in water, and dividing the
solution into two parts, in one I tested for
iodine with chlorine-water and starch, in
the other for bromine with chlorine-water and
ether.

Bromine was tested for by Professor Geo.
Nelson's process, mixing the dry residue of 30
ounces of mineral water, with pure silica, and pure
sulphuric acid, and conducting the gaseous
fluoride of silicon that might be so produced
into water where it decomposes into hydrofluosilicic
acid, and silica which separates, but in no case did any separate, therefore I proceed
no further with the test.

The next step in the analysis was to take the
specific gravity of the water which was done in the
usual way by a 1000-Gr. bottle, and bringing the
content invariably to the temperature of 60.

The amount of solid matter was determined
on a quantity of 16 fluid ounces of the water, evaporat-
ing carefully, and drying the residue at a tem-
perature of about 300° Fahr., so as to ensure expul-
sion of all water of crystallisation. The weighing
being continued until no more loss was sustained.
On the same quantity, the organic matter was deter-
mined, by heating to dull redness, and again weighing till no more loss was detected. The ignited residue from these operations was reserved for determination of the alkalies. In the case of the Strathpeffer, and St. Bernard waters, where I did not expect a large quantity of alkalies, I boiled off the residue above mentioned, with 1 or 2 ounces more of the mineral water, so as to make up the quantity used in all, for the determination of the alkalies in these waters to one part and one half. The alkalies were determined in the usual way by precipitating the solution obtained, by exhausting the above residue with water, by solution of Barnta, removing excess of Barnta, by carbonate of ammonia, conversion of the alkalies into dry chlorides, and weighing them as such, and afterwards separating them by dichloride of platinum, in the usual way.

The estimation of the total lime, phosphates of lime, and iron, when these existed magnesia and sulphuric acid, was performed on a quantity of the water measuring three parts, which was evaporated to dryness in contact with an acid, re solution in dilute hydrochloric acid, separation of the silice so obtained by filtration, and washing.
and ignition of the filter in the ordinary manner. So the filtrate, from the silica, ammonium, and sulphuric of ammonium were added, and precipitate if any, carefully separated and determined, and afterwards this precipitate when it was not too minute was subjected to further examination, but generally the quantity was too small to warrant any further interference with any degree of correct analysis, as far as quantitative estimation was concerned. In those analyses in which the precipitate is given as phosphate of lime, it was white in color, insoluble in potash, and when treated with nitric acid, and nitrate of ammonia, it gave the reaction of phosphoric acid. But really the precipitate as may be seen in the analysis, was so trifling that it may have been with propriety passed over. In the filtrate from the precipitate produced by sulphuric of ammonium, the total lime and magnesium were successively determined by precipitating with oxalate of ammonia, and ammonium phosphate soda. The filtrate from the precipitated magnesium was acidulated with hydrochloric acid, and nitrate of Barium added to throw down the total sulphuric acid.
The analysis of the precipitate produced by boiling was performed in one and a half parts of the water which was well boiled for upwards of half an hour, collecting the precipitate as produced, on a weighed filter which was afterwards dried at 310° and weighed. The filter and its contents were then ignited, dissolved in dilute hydrochloric acid, evaporating to dryness to separate any silver that might have precipitated, but in none of the waters examined did I detect any. The precipitate on boiling usually consisted of carbonate of lime, with sometimes carbonate of magnesia with small quantities of phosphate of iron base.

The chlorine in the Southwark, and St. Bernard water was determined on a half part of the water precipitating by nitrate of silver, and collecting the chlorides of silver on a weighed filter, then drying on the water-bath, and weighing and calculating out the chlorine from the chlorides of silver so obtained. In the Wofford waters I pursued a different plan, as in them the chlorine is found in considerable quantity. I resorted to estimation a standard solution of nitrate of silver, of which one measure in the
1000 grains borettta corresponded to 0.1 of a grain of chlorine. This standard solution was prepared with great care, and from pure dry nitrate of silver, and, moreover, I confirmed the results obtained by it by collecting the precipitate of chloride of silver produced on a weighed filter paper, and the result came out about 0.20 in a gallon lower than the result from the direct use of the standard solution. This was in the lower Moffat water.

The sulfuretted hydrogen present as a sulfuretted gas was determined by boiling one part of the water till all the sulfuretted hydrogen gas was expelled, then testing again with the standard solution of silver, and noting the results.

The rule followed in the arrangement of the results was, first, to combine those constituents together which formed the most volatile compounds, and then to arrange what remained in the manner that seemed most consistent with the properties of the water, due regard being paid to the existence in the water of sulfuretted of the alkali metals, and carbonates of the earths.

This then, concludes what I have to say on the method of analysis made use of in detailed results.
Phil. burnt of London for 1772.
now about to be mentioned; and I now proceed to notice individually the springs in the order in which I visited them, and first.

The Strathpeffer Sulphurous Waters have now been pretty widely known for nearly a century; they were first brought into general notice by a Dr. Morrison of Abertlernish, who spoke very highly both of the climate and waters of Strathpeffer. A full-length portrait of this gentleman now hangs in the pump room to commemorate his services on behalf of the spa.

The first chemical examination that was made of these waters was by Dr. Donald Munro, Physician to St. George's Hospital, London, who read a paper before the Royal Society of London on the sulphurous springs of Castle Cock and Fairburn, near Dingwall. I cannot precisely make out whether these springs are the same as those now called Strathpeffer springs, but this however is not a point of much importance in our present task, because though the analysis made by Dr. Munro was no doubt a very able performance for his day, it is now too old and insufficient to be of any use whatever.
so that I shall merely mention the conclusion Dr. Muñro comes to, he says "the Castle Rod is one of the strongest sulphurous springs in Great Britain. It is impregnated in its natural state with a sulphurous vapour which evaporates when exposed to the air, and is completely dissipated by heat. It contains also a sulphurous matter dissolved in it, by some means hitherto unknown to us, for it neither contains an alkaline salt, nor lime the only two substances that can dissolve sulphur. It contains sulphur in suspension." He also remarks that the water contains no purging salt and that the gritty tasteless salt which does not effervesce, is deposited in large quantities from the water is selenite (sulphate of silver). The Fairburn water was he says very similar, only it contained no selenite, nor fixed sulphur, nor was it such a strong water. "Both waters," he adds, "are full of atolete, green."

These facts stated by Dr. Muñro, are wonderfully correct considering the imperfect state of chemistry in his time, and my own analysis as will be seen, confirms a number of them.
The next chemical examination these waters received was by Dr. Theo. Thomson, of Glasgow, who analyzed two of the springs, the upper and the lower well. The lower well is now divided into two distinct springs, the water received from each being received into separate reservoirs which are now called the weak well, and the strong one. Whether this was the case when Dr. Thomson visited the spa, I cannot now ascertain, and from the difference of his numbers from my own, with care, I tell which of the pump-room waters he examined, but I think it is evident that one or other of these waters has not been as yet analyzed by any one but myself.

Back to proceed with Dr. Thomson's account of these waters, he remarks that "it was a wet day in the month of June, 1830, in which he visited Southpuffer, that the thermometer was a little below 68°, at which time the upper well had a temperature of 39 1/4° Far. and the lower 39°." He then gives the following analyses of the upper and lower wells:

Specific Gravity of Upper Well 1.00198
do do Lower do 1.00091
In Imperial Gallon of the Upper Well, contains 26.167 - 
Cubic inches
Sulphate of Soda 67.770 grs.
Sulphate of Lime 39.457 "
Chloride of Sodium 23.728 "
Sulphate of Magnesia 6.242 "
136.194 "

Lower Well
Sulphuretted Hydrogen 15.639 c. c.
Sulphate of Soda 52.710 grs.
Sulphate of Lime 38.686 "
Chloride of Sodium 19.233 "
Sulphate of Magnesia 4.853 "
187.394 "

Since Dr. Thomson published his analysis of the Strathpeffer water in 1824, I am not aware of there being any later research on this subject.

My visit to the Strathpeffer springs was in the month of September last year, 1857, it also happened to be a wet day, for my visit like that of Dr. Thomson's, it had, however
been fine, dry weather for a few weeks previous, but I succeeded in securing my specimen of water from the pump-room well, at least before they were in any way affected by the back rain, but I am not however so fortunate with the upper well which is easier affected than the others.

I do not mean to discuss at any length, the situation and climate of Strathpeffer, suffice it to say that the village is part of the parish of Duddo, and lies at the top of Strath, or vale, well protected from the east and north winds by high hills. The Strath is very fertile and enjoys a very equable temperature both summer and winter. Dr. Morrison used to speak of the air as "the balsamic air of Strathpeffer"; besides, the whole valley, being at a considerable elevation renders the air pure and bracing.

Over the two lower wells a handsome pump-room has been erected, which however contains no pump as its name would imply, the water of both the springs being collected in stone cisterns, and lifted from them with jugs, by the well-keeper, for the supply of the visitors. The larger part of the building is appropriated to the
purpose of a reading-room, and promenade, so as to enable visitors during all states of the weath-
er, to take the necessary exercise, between the draughts of the mineral water. Behind this
promenade are two or three bath-rooms, fitted with every comfort, but these can only occasion-
ally be employed with the mineral water, as the spring is not abundant enough to yield wa-
ter for all the visitors to drink, and for baths also, so far however, as the supply for the drink
is concerned it seldom fails.

The Upper Hill is situated across the high road that goes through the village; it is cover-
ed in with a wooden building of a rougher kind. This spring also empties itself into a stone
reservoir; this reservoir where these waters are col-
lected, is incrusted with a thin, white layer, which
I found to be in every case sulphur with traces
of oxide of iron.

Geologic source of the Strathpeffer Springs. "These," says Mr. Mathew, "rise from a highly sul-
furated limestone rock, and that near this rock
there runs a vein of asphaltum, consisting of bitumen,
our oil, hydrogen gas, and charcoal, with oxide of
iron in the ashes. It resembles, he says, the asphalt from the Dead Sea. This vein is imbedded in quartz, and is one and a half to two inches in thickness.

I will now go on to state the individual analyses of each water, and first

The Strong Well in Pump House.

The water of this spring when lifted in quantity in a glass vessel, has an iron gray color, which proceeds from a small quantity of sulfur in fine powder suspended in it, and this color the well keeper informed me, the water invariably has. This suspended sulfur separates when the water stands for an hour or so, and immediately, if the water is boiled, I did not separate this suspended sulfur, and analyze it separately, but preferred to return the sediments of sulfur, in a state of suspension by a thorough agitation of the bottle, when about to measure out the quantity to be used in the different analytical processes, excepting the quantity of water used for determining the total solids r. which was allowed to settle, and then filtered through a weighed filter, and the suspended sulfur thus determined, I did this with
all the strontium carbonate, as they are all alike in having suspended sulphur in them.

This water has a strong colour of sulphuric acid hydrogen, a silver coin or a lead test-paper put in the water is turned dark brown immediately. An odour of gas is felt whenever you enter the pump-room door, and it is curious to notice that although the gas exerts its usual effect on all bright metallic articles, trying about, it does not seem strong enough to affect the lead and other colors which must have been used in painting the oil-portrait of D. Morrison, already alluded to, though it has now been exposed to its actions for thirty-four years. I should however remark that the sulphuric acid hydrogen is not allowed to accumulate, as the pump-room is well ventilated.

The water of the strong well has neither an acid nor an alkaline reaction, red and blue litmus papers exposed to its action for more than an hour, were entirely unaffected, when a thermometer was plunged in and let remain some time in the cistern, it indicated a temperature of 55° F., while the temperature of
the air on the day of my visit was 59° F. I suspect that I was unable to determine the carbonic acid gas in these waters, from having forgotten to supply myself with the necessary solution of Ammonia Chloride of Barium, and omission I was entirely unable to remedy at Strathpeffer. Still, that gas was present; however, there can be no doubt from the amount of carbonate of lime that exists in solution in the water.

The qualitative analysis of this water, showed the presence of bases—lime, magnesia, potash, soda, traces of iron.

Acids—sulphuric, carbonic, phosphoric, hydro-sulphuric, silicic, and sulphuric.

As this spring was so strongly sulphurous, I only used half a pint to determine the sulphuric acid hydrogen contained. This was twice done about three hours clamping between each trial, the first gave 7.8 grains of sulphuric acid hydrogen, the second 2.9 "... These correspond respectively to 4.459, and 4.604 grs. in a gallon, and the average of these two quantities, converted in
to cubic inches of the gas, corresponds to 11.84
The specific gravity of this water at 60°
was 1062.46.
The precipitate produced by boiling amounted to 15.54 gms in a gallon. It consisted of
Phosphatic 0.80
Carbonate of lime 14.88
Carbonate of magnesia Trace
Direct results of analysis calculated in an
imperial gallon of water.
Total solid matter by experiment 111.93 gms
Silica 2.14
Organic matter 1.82
 Lime 29.29
Magnesia 10.36
Potassium .928
Sodium 2.21
Sulphur partly in suspension, partly in the water, and partly from decomposed sulphur 4.67
Sulphuric acid 53.97
Sulphur in union with alkalies .68
Phosphatic of lime and magnesia .82
Oxygen in union with sodium .66
Carbonic acid in union with lime 6.55

112.29
Statement of the above as they combine with one another,

<table>
<thead>
<tr>
<th>Substance</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphate of Potassium</td>
<td>0.38</td>
</tr>
<tr>
<td>Sulphur</td>
<td></td>
</tr>
<tr>
<td>Potassium</td>
<td>0.92 - 1.30</td>
</tr>
<tr>
<td>Sulphate of Sodium</td>
<td>0.22</td>
</tr>
<tr>
<td>Sulphur</td>
<td></td>
</tr>
<tr>
<td>Sodium</td>
<td>0.31 - 0.53</td>
</tr>
<tr>
<td>Sulphate of Soda</td>
<td>3.30</td>
</tr>
<tr>
<td>Sulphuric acid</td>
<td></td>
</tr>
<tr>
<td>Soda</td>
<td>2.36 - 5.86</td>
</tr>
<tr>
<td>Sulphate of Magnesia</td>
<td>20.72</td>
</tr>
<tr>
<td>Sulphuric acid</td>
<td></td>
</tr>
<tr>
<td>Magnesia</td>
<td>10.36 - 31.08</td>
</tr>
<tr>
<td>Sulphate of Lime</td>
<td>29.95</td>
</tr>
<tr>
<td>Sulphuric acid</td>
<td></td>
</tr>
<tr>
<td>Lime</td>
<td>20.97 - 50.92</td>
</tr>
<tr>
<td>Carbonate of Lime</td>
<td>0.32 - 14.873*</td>
</tr>
<tr>
<td>Carbonic acid</td>
<td>6.55</td>
</tr>
<tr>
<td>Lime</td>
<td></td>
</tr>
<tr>
<td>Phosphates</td>
<td>0.30</td>
</tr>
<tr>
<td>Organic Matter</td>
<td>1.02</td>
</tr>
<tr>
<td>Sulphur in Suspension</td>
<td>4.07</td>
</tr>
<tr>
<td>Silica</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.14</td>
</tr>
<tr>
<td></td>
<td>112.29</td>
</tr>
</tbody>
</table>

* This represents the precipitate upon boiling.
The qualitative analysis showed the presence of:

Bases - lime, magnesia, soda,
Acids - sulphuric, phosphoric, carbonic, hydro-sulphuric, silicic, chlorine, and sulphur.
Statement of the saline, and other constituent

<table>
<thead>
<tr>
<th>Substance</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphuretted Hydrogen in grains</td>
<td>4.56</td>
</tr>
<tr>
<td>Sulphuretted Hydrogen in cubic inches</td>
<td>11.84</td>
</tr>
<tr>
<td>Sulphate of Lime</td>
<td>50.92</td>
</tr>
<tr>
<td>Carbonate of Lime</td>
<td>14.87</td>
</tr>
<tr>
<td>Phosphate of Lime and Magnesia</td>
<td>5.50</td>
</tr>
<tr>
<td>Sulphate of Magnesia</td>
<td>31.08</td>
</tr>
<tr>
<td>Carbonate of Magnesia</td>
<td>Trace</td>
</tr>
<tr>
<td>Sulphate of Soda</td>
<td>5.86</td>
</tr>
<tr>
<td>Sulphure of Sodium</td>
<td>53.3</td>
</tr>
<tr>
<td>Sulphure of Potassium</td>
<td>1.30</td>
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<tr>
<td>Organic Matter</td>
<td>1.02</td>
</tr>
<tr>
<td>Silica</td>
<td>2.14</td>
</tr>
<tr>
<td>Chlorine</td>
<td>Trace</td>
</tr>
<tr>
<td>Sulphur in suspension</td>
<td>4.07</td>
</tr>
<tr>
<td></td>
<td>112.29</td>
</tr>
</tbody>
</table>

Physical Relations

Temperature of the water of the well 55° F.
Specific gravity 56° 1002.46.

I should also add that this water, can retain, for a considerable time, a great deal of its sulph. hydro. gas. A sealed bottle placed 20 days after the water was collected, contained 2.88 pints of this gas, or nearly one half of what is contained at the spring.
The qualitative analysis showed the presence of bases - lime, magnesium, soda.
Acids - sulphuric, phosphoric, carbonic, hydro.
sulphuric, silicic, chlorine, and sulphur.
The Weak Well in the Pump Room.

Though this spring is called the weak well, it is only to distinguish it from its neighbour, for it is not by any means a weak one. I have already remarked that this as a distinct spring, has not as far as I am aware been analysed before.

The water of this spring is much clearer than the preceding one, though it too when allowed to stand deposited a distinct precipitate of sulphur.

A thermometer plunged into the cistern, indicated a temperature of 52°.

This water had no action on either red or blue titanic paper.

Specific Gravity 1.0069.

The precipitate, produced on boiling, amounted to 10.01 grains in a gallon. It consisted of

- Carbonate of Lime
- Carbonate of Magnesia
- Phosphates

The sulphurated hydrogen was twice determined, one result gave 1.65 grains, the second 1.60 grains in a gallon. The average converted into cubic inches gave 5.06 of that gas.
Direct results of analysis as contained in a gallon.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica</td>
<td>0.77</td>
</tr>
<tr>
<td>Organic Matter</td>
<td>2.66</td>
</tr>
<tr>
<td>Phosphate of Lime, and Magnesia</td>
<td>0.48</td>
</tr>
<tr>
<td>Lime</td>
<td>11.94</td>
</tr>
<tr>
<td>Magnesia</td>
<td>0.52</td>
</tr>
<tr>
<td>Sodium</td>
<td>3.06</td>
</tr>
<tr>
<td>Potassium</td>
<td>Trace</td>
</tr>
<tr>
<td>Sulphur in combination</td>
<td>0.32</td>
</tr>
<tr>
<td>Sulphur in suspension</td>
<td>5.67</td>
</tr>
<tr>
<td>Chlorine</td>
<td>2.80</td>
</tr>
<tr>
<td>Sulphuric acid</td>
<td>12.50</td>
</tr>
<tr>
<td>Carbonic acid</td>
<td>3.84</td>
</tr>
<tr>
<td>Oxygen in union with Sodium</td>
<td>44.59</td>
</tr>
</tbody>
</table>

Statement of the above as they combine with one another.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphate of Sodium</td>
<td>0.32</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0.66-0.78</td>
</tr>
<tr>
<td>Sodium</td>
<td>0.80-0.80</td>
</tr>
<tr>
<td>Chloride of Sodium</td>
<td>2.80</td>
</tr>
<tr>
<td>Chlorine</td>
<td>1.80-4.60</td>
</tr>
<tr>
<td>Sodium</td>
<td>0.80-0.80</td>
</tr>
<tr>
<td>Ingredient</td>
<td>Value</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>Sulphate of Soda</td>
<td>1.39</td>
</tr>
<tr>
<td>Sulphuric acid</td>
<td>1.08</td>
</tr>
<tr>
<td>Soda</td>
<td>2.47</td>
</tr>
<tr>
<td>Carbonate of Magnesia</td>
<td>0.57</td>
</tr>
<tr>
<td>Carbonic acid</td>
<td>0.52</td>
</tr>
<tr>
<td>Magnesia</td>
<td>1.09</td>
</tr>
<tr>
<td>Sulphate of Lime</td>
<td>11:11</td>
</tr>
<tr>
<td>Sulphuric acid</td>
<td>7.78</td>
</tr>
<tr>
<td>Lime</td>
<td>18.89</td>
</tr>
<tr>
<td>Carbonate of Lime</td>
<td>3.27</td>
</tr>
<tr>
<td>Carbonic acid</td>
<td>4.76</td>
</tr>
<tr>
<td>Lime</td>
<td>7.43</td>
</tr>
<tr>
<td>Phosphate of Lime and Magnesia</td>
<td>0.43</td>
</tr>
<tr>
<td>Organic Matter</td>
<td>2.66</td>
</tr>
<tr>
<td>Silica</td>
<td>77</td>
</tr>
<tr>
<td>Sulphur in suspension</td>
<td>65.47</td>
</tr>
<tr>
<td></td>
<td>44.59</td>
</tr>
</tbody>
</table>

Statement of the saline and other constituents in an imperial gallon:

- Sulphuric acid, hydrogen in grains: 1.62
- The same in cubic inches: 5.06

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphate of Lime</td>
<td>18.89</td>
</tr>
<tr>
<td>Carbonate of Lime</td>
<td>7.43</td>
</tr>
<tr>
<td>Phosphate of Lime and Magnesia</td>
<td>0.43</td>
</tr>
</tbody>
</table>
Carbonate of Magnesia:
1.09
Sulphate of Soda:
2.47
Sulphure of Sodium:
0.78
Chloride of Sodium:
5.60
Potass:
Traces
Organic Matter:
2.66
Silica:
0.77
Sulphur in suspension:
9.47

Physical Relations:
Temperature of the water at spring 52°
Specific gravity at 60° 1000.93.

This water after standing for 21 days in sealed bottles, contained only 0.35 of a grain of sulphuretted hydrogen in a gallon.

The Upper Well:

As has been already mentioned that it rained on the day I visited Strathfellow, and that I could not collect this water before it had been affected by the rain which very soon, as I was informed, makes a difference on this spring.

It is therefore probable that my analysis does not represent the normal constitution of the water.

The water in this spring resembles in general...
appearance the strong pump-room water, tho' the sediment is not so large, but the sediment has this peculiarity of containing minute black particles mixed with the sulphur; these were found afterwards to be pure sulphur of iron.

The temperature of this water was 56°. When allowed to act on litmus paper, the blue one was very slightly reddened.

The sulphuretted hydrogen was twice determined, the first trial gave 1.04, the second 1.05 grains in a gallon; average of the two 1.045, this converted into cubic inches gave 2.73 as the result.

The qualitative analysis showed the presence of bases: lime, magnesia, potash, soda.
Acids: sulphuric, carbonic, hydro-sulphuric, silicic, chloric, and sulphuric.

The specific gravity was at 60° 1.001 ± 0.

The precipitate produced by boiling amounted to 0.763 grains in a gallon. It consisted of
Carbonate of lime
Carbonate of magnesia
Direct results of analyses as contained in a gallon.

<table>
<thead>
<tr>
<th>Element</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicon</td>
<td>3.06</td>
</tr>
<tr>
<td>Organic Matter</td>
<td>2.35</td>
</tr>
<tr>
<td>Lime</td>
<td>13.14</td>
</tr>
<tr>
<td>Magnesia</td>
<td>13.91</td>
</tr>
<tr>
<td>Potassium</td>
<td>0.64</td>
</tr>
<tr>
<td>Sodium</td>
<td>15.07</td>
</tr>
<tr>
<td>Sulphur in combination</td>
<td>0.32</td>
</tr>
<tr>
<td>Sulphur in suspension</td>
<td>1.84</td>
</tr>
<tr>
<td>Chlorine</td>
<td>2.74</td>
</tr>
<tr>
<td>Sulphuric acid</td>
<td>45.46</td>
</tr>
<tr>
<td>Carbonic acid</td>
<td>3.68</td>
</tr>
<tr>
<td>Oxygen in union with Sodium Potassium</td>
<td>1.11</td>
</tr>
<tr>
<td>Sulphur of Iron</td>
<td>1.08</td>
</tr>
</tbody>
</table>

Amount of solid matter by experiment: 94.40 grs.

Statement of the above as they combined with one another:

<table>
<thead>
<tr>
<th>Element</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphur of Potassium</td>
<td>0.25</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0.64</td>
</tr>
<tr>
<td>Potassium</td>
<td>0.89</td>
</tr>
</tbody>
</table>
Sulphur of Soda 0.05
Sulphur 0.07 - 0.12
Chloride of Soda 2.76
Chlorine 1.80 - 4.54
Sulphate of Soda 5.66
Sulphuric Acid 4.31 - 9.87
Sulphate of Magnesia 2.612
Sulphuric acid 13.56 - 39.16
Carbonate of Magnesia 0.93
Carbonic acid 0.86 - 1.78
Sulphate of Lime 15.78
Sulphuric acid 9.65 - 23.43
Carbonate of Lime 2.76
Carbonic acid 3.49 - 6.21
Organic Matter 2.35
Silica 6.86
Sulphur in suspension 1.84
Proto-sulphur of Iron 1.08

Total 94.38
Statement of the saline and other consti-
tuents in an imperial gallon.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphuric acid</td>
<td>23.43</td>
</tr>
<tr>
<td>Carbonate of Magnesia</td>
<td>6.24</td>
</tr>
<tr>
<td>Sulphate of Magnesia</td>
<td>39.18</td>
</tr>
<tr>
<td>Carbonate of Magnesia</td>
<td>1.78</td>
</tr>
<tr>
<td>Sulphate of Soda</td>
<td>9.87</td>
</tr>
<tr>
<td>Sulphate of Potassium</td>
<td>0.12</td>
</tr>
<tr>
<td>Chloride of Potassium</td>
<td>41.64</td>
</tr>
<tr>
<td>Sulphate of Potassium</td>
<td>0.89</td>
</tr>
<tr>
<td>Silica</td>
<td>3.06</td>
</tr>
<tr>
<td>Organic Matter</td>
<td>2.35</td>
</tr>
<tr>
<td>Sulphur in suspension</td>
<td>1.84</td>
</tr>
</tbody>
</table>
| Proto-sulphate of Iron | 1.08     

Physical Relations

Temperature 53°. Specific gravity 1001.00

These then are the analyses of the Strath-
Hesper waters, and it will be seen at a glance that
the numbers differ widely from those of D. Thom-
sons. These differences may arise from the follo-


ing causes, first natural differences in the constitution of the water at different times. Dr. Thomson says, in reference to this, that he took the specific gravity of the spring in 1828, four years after his first trial, and gave them

Upper Well 1.0022
Lower 1.0015

They therefore, vary with the weather.

2. Different methods of analysis, and arrangement of results.

3. Difficulty of identifying the different springs analysed by Dr. Thomson, and myself.


This well is well known to every inhabitant of Edinburgh, as it is situated on the south side of the Water of Leith, between the Dean Bridge and Stockbridge.

"This water," says Dr. Gardner, "arises from the shales, slate clays, and sandstone of the coal formation."

In the year 1791 there was erected over this well, a handsome temple-like structure, with a
station to the goddess Hygeia, in the centre.

There is a comfortable pump-room below, where a well-keeper is in daily attendance.

The water was analysed by Mr. W. S. Kemp, of Bolton, and his analysis is framed and hung in the pump-room. The following is a copy:

"This water contains sulphates and bicarbonates of lime, and magnesia, with muriates or chlorides of these earths, also the hydro-sulphates of lime and magnesia and a trace of free sulphuretted hydrogen. It closely resembles the Narrow-gate waters in its leading properties."

The water is brought up for the supply of the visitor by a hand-pump; there seems to be an abundant supply of the water, the well-keeper says he never saw it dry. The water is very clear and sparkling, tasty and smells distinctly of sulphuretted hydrogen, but very much less so than the weakest of the Strathpuffer waters.

When allowed to act on blue litmus paper for some time, it turns it distinctly red. The amount of carbonic acid gas contained in a
The qualitative analysis showed the presence of bases - lime, magnesia, soda, traces of iron. Acids - silicic, carbonic, hydro-sulphuric, sulphuric, chlorine, and phosphoric.
gallon is 12.37 yds.

The amount of sulphuric acid in a gallon was 0.169. As a grain, or 28.8 of a cubic inch. It was twice estimated but the same result was given in both.

The specific gravity was 1000.64.

The temperature of the water was 97°. The temperature of the air on the day of the 18th July (1858) was 83°, with side wind for equal distance.

The precipitate produced on boiling amounted to 23.666 grains in a gallon. It consisted of Carbonate of Lime 22.12
Carbonate of Magnesia .52
Phosphates 1.00

Direct Results of analysis calculated in an imperial gallon.

The amount of solid matter got by experiments was 29.27 21.6.

Silica 1.30
Organic Matter traces
Lime 12.38
Magnesium 2.45
Sodiuim 2.66
Chlorine 4.08
Sulphuric acid 6.57
Carbonic acid in combination 10.81
Phosphates, with a trace of Mud of Iron 1.00
Oxygen in union with Magnesium 41.77
Statement of the above, as they combined with one another
Chloride of Sodium
Chlorine 3.07
Sodium 2.66 5.73
Sulphate of Magnesiam
Sulphuric acid 6.57
Magnesiam 3.28 9.85
Carbonate of Magnesiam
Carbonic acid 0.27
Magnesiam 0.25 0.52
Chloride of Magnesiam
Chlorine 1.01
Magnesiam 0.34 1.35
Carbonate of Linn
Carbonic acid 9.74
Linn 12.38 22.12
Phosphates of Linn, and Magnesiam and Iron 1.00
Silica 41.77
Statement of the saline and other constituents in an imperial gallon:

<table>
<thead>
<tr>
<th>Substance</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphuretted Hydrogen in grains</td>
<td>0.14</td>
</tr>
<tr>
<td>The same in cubic inches</td>
<td>0.28</td>
</tr>
<tr>
<td>Carbonic acid, in grains</td>
<td>12.32</td>
</tr>
<tr>
<td>The same in cubic inches</td>
<td>24.64</td>
</tr>
</tbody>
</table>

Solid matter in a gallon is 22.76 by experiment:

<table>
<thead>
<tr>
<th>Substance</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbonate of Lime</td>
<td>22.12</td>
</tr>
<tr>
<td>Sulphate of Magnesia</td>
<td>9.83</td>
</tr>
<tr>
<td>Carbonate of Magnesia</td>
<td>6.32</td>
</tr>
<tr>
<td>Chloride of Magnesia</td>
<td>1.35</td>
</tr>
<tr>
<td>Chloride of Sodium</td>
<td>5.73</td>
</tr>
<tr>
<td>Phosphate and trace of Chlorides</td>
<td>1.80</td>
</tr>
<tr>
<td>Silica</td>
<td>1.80</td>
</tr>
<tr>
<td>Organic Matter</td>
<td>Trace</td>
</tr>
</tbody>
</table>

Physical Relations:

Temperature of water at spring 47°.
Specific gravity at 60°: 1.056.4.

This water, then, is a very weak sulphurous spring, with just about the amount of solid matter necessary to give it the name of a mineral water. It does not follow that this water was ever quantitatively analyzed before.
The Moffat Sulphurous Spas.

This is one of the most frequented watering places in all Scotland. But independent of its mineral wells, of which there are both sulphurous and chalk springs, Moffat enjoys a very mild and genial climate, protected as it is from the north and east winds by the high range of the Lead hills, and therefore the exposure is principally to the south-west, so that even the breezy sea breezes from the Solway Firth may not be without their influence in tempering the climate. Dr Smith and Munro inform me that bronchitic affecting, and some forms of asthma are very much improved by even a short residence at Moffat.

The sulphurous springs of which there are two, issue from the same rock within a few feet of one another, and are situated about a mile north of the village.

I am indebted to Dr Macrianc, the minister of Moffat parish, for information respecting the geological sources of these springs. The learned doctor remarks the whole district lying to the great Silurian formation of the south of
Scotland. And these Silurian rocks are remarkable for the fine beds of shale into which they pass, often having beautiful silver impressions of many species of Graptolite, and one if not more bivalves, now so densely charged with bituminous matter, as to have led those who did not know better to think that coal was near.

Doubtless it is from the iron pyrites existing in these shales that we have our sulphurous waters above Arklow, and our chalybite and sulphate of iron and alumina springs at Hartfield, and other localities.

Of the two springs, only one, the upper well, can be seen, as it issues from the rock, the lower spring, the only one that is drawn is all covered in and furnished with a pipe and stop cock to draw off the water.

It is believed in Kilfady that their water is like the Healthfield one, gets stronger during wet weather. My visit to Kilfady was on the 14th March this year, it had been dry frosty weather for a week or two before, but the two days immediately preceding my visit, the frost had given way, and the snow was pretty well melted.
of the hill sides, so that from the snow-water replacing rain, I may hope I got the water in no very abnormal state.

This water has now undergone chemical examination six times. The first of these was by Mr. Matthew Mackail, in 1639, who wrote a small work on them, "The Sons Moffatensis," in which the author states that the well was discovered only six years before he wrote his book. He distinctly mentions the existence of two separate springs. His account of the source of these peculiar springs is the following:

"The complaint waters of the wells of Moffat incorporated with the sulphur sulphur of antimony, nitre, and natural sal-ammoniac, passing through the veins of the earth, and there acquire the sal-ammoniac, or salt, which cometh by coagulation from the urine of the almost innumerable birds and beasts which live in adjacent moors." It is pretty evident from Mackail's description, that he only theorized on the composition of those waters, and never made any actual examination of them.

The most considerable of these waters was
Obser. on Moffat and its Min. Rates, by I. Bar.

London, 1800.
Dr. Andrew Plummer, Prof. of Medicine in the university of Edin. His essay on these waters was published in 1747. The conclusions he arrives at after a number of apparently carefully conducted experiments are these: those medicinal waters contain a very subtle and volatile sulphur, at least some constituent parts of sulphur, some particles of copper and sal-petr or common salt.

The most writer on these waters was, Dr. Garlez of the Royal Institution, London. His analysis is as follows:†

In one wine gallon

Mineral of soda
Sulphuric acid
Nitrogen
Carbonic acid

Dr. Thomson of Glasgow in 1825, analysed this spring also. Of its results are as follows:

In one Imp. Gallon

Sulphuric acid
Sulphate of soda

21.290 cubic inches
176.569 grains
16.562

Sulphate of Lime 11.679 grs.
Sulphate of Magnesia 7.474
210.184

And lastly those 2 off-ak waters, received a very careful examination by Dr. John Macadam, late of Glasgow, in 1833.*

I here subjoin Mr. Macadam's analysis:

For an Imp. Gallon

Solid matter 8.0.869 grs.
Free sulph. hyd. gas 0.353 cub. inch.
Free and combined sulphur = 2.168 grs. of
sulph. hyd. gas,
Sulphur of Soda 1.51
Chloride of Soda 60.72
Chloride of Magnesia 7.25
Chloride of Calcium 10.02
Silicate of Soda 3.46
Carbonate of Lime 1.81
Carbonate of Magnesia 0.87
Organic Matter 2.27
Loss in analysis of sol. salts 1.37
Res. " of earthy carbonate 0.83
Free Silicic acid 0.86

Spec. grav. 1.000025. Constant temp. 69.95 Fehr.
I would only here make one observation on the labours of my predecessors, which is, that it appears strange to me that they all apparently knew of the existence of two separate springs, and yet never thought of examining the upper well, but always confined their labors to the lower one. Dr. Macadam says it is true, incidently mentions that the specific gravity of the upper well was higher than the lower, but his inquiries went no further. Had any use been made of the upper well, these might have been overlooked with little loss, but as it is the source of the mineral water used for the baths in Moffat, it does seem to me necessary to have analyzed this water as well as the drinking spring. I have attempted to supply in what follows this important deficiency.

**The Lower, or Drinking Well.**

This water as it comes from the stop-cock is very clear, tastes and smells very distinctly of sulphuretted hydrogen gas, though not of such a marked degree as the fumes of the gas would have led one to expect. The water does
not appear much when poured from one vessel to another.

A thermometer held for two or three minutes in the stream of water showed a temperature of 18 1/2°; the surrounding air being at 3 2°; snow was falling pretty heavy at time of visit. The water did not set either on blue or white litmus paper.

The sulphuretted hydrogen was twice determined, both trials gave the same result, namely .53 of a grain which equals 0.17 cubic inches. As I have already stated I added a solution of arsenic to another quantity of this water; the results from this determination gave .51 of a grain.

Qualitative analysis revealed the presence of the following substances:

Bases - Lime, Magnesia, Soda, traces of Alumina and Iron.

Acids - Silicic, Carbonic, Chlorine Phy. and Nitric.

The specific gravity of the water at 60° was 1.001 2.

The precipitate produced by boiling
amended to 1.69 gos in a gallon.

It consisted of:
- Carbonate of Iron: traces
- Carbonate of Lime: 4.60
- Carbonate of Magnesia: traces

Direct Results of analysis calculated in an Imperial Gallon. Amount of solid matter by experiments:

<table>
<thead>
<tr>
<th>Substance</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica</td>
<td>2.55</td>
</tr>
<tr>
<td>Organic Matter</td>
<td>5.80</td>
</tr>
<tr>
<td>Sodium</td>
<td>27.14</td>
</tr>
<tr>
<td>Magnesium</td>
<td>1.62</td>
</tr>
<tr>
<td>Calcium</td>
<td>6.51</td>
</tr>
<tr>
<td>Chlorine</td>
<td>49.42</td>
</tr>
<tr>
<td>Carbonic acid</td>
<td>2.38</td>
</tr>
<tr>
<td>Oxygen in union with</td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>6.4</td>
</tr>
</tbody>
</table>

Total: 96.06

Statement of the above as they combine with one another:

<table>
<thead>
<tr>
<th>Substance</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride of Sodium</td>
<td>41.86</td>
</tr>
<tr>
<td>Chlorine</td>
<td>27.14</td>
</tr>
<tr>
<td>Sodium</td>
<td>69.00</td>
</tr>
<tr>
<td>Chloride of Magnesium</td>
<td>4.79</td>
</tr>
<tr>
<td>Chlorine</td>
<td>1.62</td>
</tr>
<tr>
<td>Magnesium</td>
<td>6.41</td>
</tr>
</tbody>
</table>
Chloride of Calcium  2.77
Chlorine            1.93 - 7.70
Calcium             2.38
Carbonate of Lime   2.22 - 4.60
Carbonic acid       2.55
Silica              5.80
Organic Matter      96.06

Statement of the saline, and other constituents in an Imperial Gallon.

Sulphhydrated hydrogen in grains  0.53
The same in cubic inches  1.37
Free carbonic acid in grains  2.22
The same in cubic inches  4.46

The amount of solid matter in a gallon by experiment is 96.16

Carbonate of Iron
Alumina
Carbonate of Lime  4.60
Chloride of Calcium  7.70
Chloride of Magnesium  6.41
Carbonate of Magnesium
Chloride of Sodium  69.02
Sulphur, Sulphur of Soda, Sodium, Silica, Organic Matter, traces, 2.55, 5.80, 96.08.

When a well sealed bottle of this water was opened after seven days, it showed the presence of 2.55 of a grain of sulphuretted hydrogen. In this short time, therefore, it had lost one half of this valuable constituent. This result, along with the following, that when one pint of the water was boiled for 35 minutes, the whole of the sulphuretted hydrogen had been expelled with the exception of a mere trace, just appreciable and no more. This differs from an observation made by Dr. Macadam in this water, and on which he lays considerable stress, namely that five-sixths of the hydrosulphuric acid remains intact as an alkaline sulphuretted. Why this difference should be I cannot explain, all I can venture to say is that I have perfect confidence in my own statement above, for, on opening another half pint bottle that had stood two days with the cork only loosely put in
I found that without any boiling at all, the whole of the sulphurated hydrogen had disappeared. But on the whole, Dr. Macadam's numbers and my own are not very wide of one another, considering that there has been five years between our analyses, and that his samples were selected in summer, mine in winter. With regard to Dr. Thomson's analysis, I can only say, that since his enquiring the water must have changed its constitution entirely, for recently, neither Dr. Macadam nor myself could detect a trace of sulphuric acid, whereas in 1828, Dr. Thomson apparently found abundance of that substance.

The Upper Well.

As has been said, one can easily see this water, as it issues out of the rock. No great pains are taken to preserve the spring pure, as the channel in which it collects, lies exposed to the air, and is filled with a dark, red, grey deposit composed of accumulated detritus from the rock, and deposits from the water. This renders it no easy matter to collect a pure
specimen of the water. This water is not used for drinking, but is sent along with the waste of the lower spring, down a pipe to the village reservoir there to supply the baths. It is on the rocky side of the channel of this well that the stones with a sulphur-like incrustation, are met with, mentioned by Mr. Mackail and Dr. Pimm and Dr. Macadam, they were analyzed quantitatively by the latter gentlemen, and found to consist of sulphur and sesquioxide of iron. I did not examine them myself.

The water from the spring when carefully collected is quite clear, and if taken up as it comes out of the rock, is both tastes and smell distinctly of sulphuretted hydrogen.

This water was also quite neutral to test-paper. Its temperature 41°, the atmosphere being 32°.

The sulphuretted hydrogen estimated on a quantity collected just as it issued from the rock, showed the presence of 0.35 of a grain equal to 0.91 of a cubic inch of this gas in gallon. A specimen of this water lifted
out of the pool at the bottom of the channel, when the water collected contained but a trace of sulphuric hydrogen, and this result was verified by a second trial. Nevertheless it was from this pool I collected the water used in the extended analyses, for although the more volatile constituents might have escaped, the fixed are not in any way altered.

Qualitative analysis showed the presence of bases — lime, magnesia, soda, traces of copper and iron.

Acids — silicic, hydrosulphuric, sulphuric, chlorine, and only traces of carbonic.

The specific gravity of the water at 66° was 1.000. etc.

No precipitate whatever was produced by boiling in this water, no doubt, from the very small quantity of carbonic acid gas it contains.

Direct results of analysis as contained in a gallon

Solid Matter

Silica 1.01
Organic Matter
Sodium 4.70
Magnesium .39
Calcium 3.00
Sulphuric acid 2.01
Chlorine 27.09
Oxygen in union with Sodium .06

53.96

Statement of the above as they combine with one another
Chloride of Sodium
Chlorine 20.70
Sodium 13.41 - 34.11
Sulphate of Soda
Sulphuric acid 2.01
Soda 1.33 - 3.36

Chloride of Magnesium
Chlorine 1.07
Magnesium 0.39 - 1.46
Chloride of Calcium
Chlorine 5.32
Calcium 3.00 - 8.32
Silica

1.81
Organic Matter 4.70

53.96
Statement of the saline and other con.
stituents in an Imperial Gallon
Sulphureted hydrogen in grains 0.35
The same in cubic inches 0.91
Carbonic acid gas Trace

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total solid matter by experiment</td>
<td>34.60</td>
</tr>
<tr>
<td>Chloride of Calcium</td>
<td>8.32</td>
</tr>
<tr>
<td>Chloride of Magnesium</td>
<td>1.46</td>
</tr>
<tr>
<td>Chloride of Potassium</td>
<td>3.41</td>
</tr>
<tr>
<td>Sulphate of Soda</td>
<td>3.56</td>
</tr>
<tr>
<td>Silver</td>
<td>1.81</td>
</tr>
<tr>
<td>Organic Matter</td>
<td>0.70</td>
</tr>
<tr>
<td>Copper of Iron</td>
<td>Trace</td>
</tr>
<tr>
<td>Copper of Copper</td>
<td>Trace</td>
</tr>
<tr>
<td></td>
<td>3.96</td>
</tr>
</tbody>
</table>

Physical Relations
Temp. of spring at corner 71.1°
Specific gravity at 60° 1000. 746

This then concludes the notice of the Moffat sulphurous water. One feature of the analysis demands a little notice here which is, the somewhat large quantity of organic matter this water contains. What the precise nature of this organic matter
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is, I am not at present prepared to say, and I think it most likely a small quantity of some soluble bitumenous compound.

The Origin of the Sulphuretted Hydrogen in Sulphurous mineral Waters.

I do not mean to enter at any length into this division of my subject, as it is now very generally believed both among chemists and geologists that this gas is derived almost always from two sources, 1st either by the action of organic matter on sulphuretted solution or 2nd from the action of water on metallic sulphurets such as iron pyrites. If the sulphuretted hydrogen is produced by the first way, then it exists generally as a soluble sulphuretted as sulphuretted of sodium or potassium; if by the latter mode then the gas is more likely to be in a free state. 

But although these principles have now been established for a considerable time; it seemed to me that if it could be shown, after haburate and in what quantity the sulphuretted hydrogen was produced by their Decompositions.
I might contribute somewhat to the stability of other principles. Accordingly with this view I have performed the following experiments.

One half gallon of sea-water, which contained an abundance of sulphates, was placed in a large stoppered bottle along with a quantity of firm wood saw-dust and agitated from time to time. About thirty days afterwards I took out the stopper, no smell of sulphurated hydrogen was perceived but when a fluid of the filtered water was tested with the standard solution of Iodine and starch, it showed the presence of 0.01 grain of sulphurated hydrogen equal to 0.08 in a gallon. So remarkable was the result of this experiment that to make sure there was no source of error in it, I tested a kind of sea-water to which nothing had been added, but the very first drop of the Iodine solution gave a permanent blue color. And in addition I evaporated down some of the sea-water that had been acted on by the saw-dust and it gave a brown color with a lead test-paper. Therefore there could be no doubt that sulphurated hydrogen had been produced.
is considerable quantity. Five days afterward I again opened the bottle and tasted the water, and found the sulphuric hydrogen had increased to 0.210 of a grain in a gallon, showing that the air now excluded in the half-emptied bottle hastened the production of the gas considerably. Lastly I boiled another pint of the water for some time and found it still contained the same amount of gas, showing that it did not in reality exist as a gas but as a soluble sulphure.

At the same time that I had been going the first experiment, I also put in a similar bottle a mixture of solutions of sulphate of bismuth and sulphate of magnesia, but instead of using cow-dung I used a quantity of starch paste, choosing it as a substance containing no sulphur yet prone to change. I then examined the water of this experiment about a month afterwards but the sulphuric hydrogen produced if any at all was the mere store.

And finding it afterwards it still gave no sign of forming more abundantly seven in a half-emptied bottle. This failure is not altogether...
attributable to using starch as the organic matter. For on trying a quantity of sea-water with starch and letting it stand about the same time as the other, I then found that a part of the water took a half measure of the solution which equals 0.2 of a grain of sulphured hydrogen in a gallon. The explanation of this seems to be that in the earths the sulphates of the earths are not reduced to sulphurets so easily as the corresponding salts of the alkalies.

Next tried the action of iron pyrites on common water, and for this purpose I powdered some of the shale from which the sulphurous water at Gilsland in Cumberland, springs; but in addition to what iron pyrites this shale contained I powdered some more of that substance and added it to the powdered shale. I had only time however, to allow this experiment to stand a week in a half empty bottle, as at the end of that time, I found that about 0.04 of a grain of gas had been produced in a gallon of water.

We have then been able to apply the knowledge gained by these experiments to sulphurous...
springs, and if we suppose a large quantity of water either containing sulphates like the Dead Sea springs, lying for some time in contact with detrituous matter, or in the case of the Moffat waters containing none or a very small quantity of sulphates, yet passing across extensive beds of shale containing abundance of iron pyrites, then we have all the circumstances necessary for the production of sulfuretted hydrogen in considerable quantity.

Such then is a brief statement of the manner in which we may suppose a sulphureous spring to be formed, still it may be that after all this is not the way these springs are produced, and all that can be said for the above experiments and others that have gone before them is that they render the formation of these springs in that way at least very probable.

The Therapeutical Action of Sulphurous Mineral Waters.

In treating of this last branch of my subject I will confine myself to the waters which have been used -
ticed in this thesis, making them serve as typi-
cal illustrations of the medicinal action of cold sulphurous springs. In adopting this plan, I shall
have the advantage of giving the actual experience
of the physicians of these places, who were kinds en-
ough to give me the results of their long experience.

There are one or two general considerations
which must be premised in treating of the med-
icinal action of springs. The first of these is,
what may be called their moral action. For
as these waters are always surrounded by the very
springs, this necessarily removes the person
for whose benefit they are prescribed, from all
worry and over work of business, from per-
haps excesses both in eating and drinking, and
especially it takes away the singularity and
inconveniences of following out a course of med-
ic treatment during ordinary business
vocations. It removes him from all these
and places him as a patient among patients,
when he will be likelier to pursue more regular
habits both as regards exercise and diet.
But in addition to all these, the watering-place
has its physical bearings on the patient, for hav
ing little else to do then to amuse himself, and
that too in weather and in climate more trac-
ing and cheerful then those he may be in
the habit of enjoying.

But although these circumstances favour
the cure of disease, yet it is not to them, in
dependence of the mineral spring that we can
ascertain many of the undoubted recoveries
that take place from year to year at all
watering-places.

But other circumstance, I should like to state
which must always render it difficult, if
not an impossible matter, ever to give any
thing like a rationale of the actions of the dif-
fert mineral springs, and this circumstance
is that none of these springs are ever pure in
their kind, one has but to look at the detail-
ed analyses already given to see that all of
them contain besides sulphurated hydrogen,
gas a great deal of salts. Nor whether is it
to the gas or the salts these waters contain
are to attribute the beneficial actions they un-
questionably have. No doubt the proper an-
drew to this question is that all the ingredi-

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Armstrong on the treatment of chronic diseases and sulphurous waters.
contribute to produce its general effects. Of a mineral water, yet one must confess that this plurality of active agents, complicates the consideration of their general medical action.

Now having promised them few sentences I will now briefly discuss those diseases in relation to their treatment by sulphurous waters. The first in importance among these is diseases of the skin; second diseases of the liver, stomach, kidney and uterus; third some diseases of the constitution as gout, rheumatism &; and lastly some forms of affection of the nervous system. A larger list than this might have been drawn up, for some authors, as I Armstrong, hold them to be especially good for all chronic congestion and inflammation, but that is certainly too wide and strong a statement.

The skin diseases that sulphurous waters have most influence upon those of the class, lepra, psoriasis, syphilis, and syphilitic eruptions, but on others also isuz em they seem to have a good influence, and if we may include scrofulous sore as a disease of the skin.
they too are quickly healed under their action. For these afections the waters are used both in baths and to drink. The first way in which they exert their influence is by the cleanliness they effect, and next by their stimulative action on the skin, they gradually return to that important organ its normal function. And by drinking the water for confirmative aches and tumours and syphilitic affections, the absorbing system is stimulated while at the same time the kidneys are powerfully acted on, and their use they eliminate at least for a time the mercurialmost of confirmations and syphilis.

Mr. Ross of Dingwall informed me that he has often noticed how rapidly confirmative aches get well by using the baths for watering. Complaints of the skin produced by abuse of Mercury are also greatly benefited by their water. This they say, Mr. Astrie, by the sulphur of the waters dissolving the insoluble compounds which are formed by alburninous matter with mineral substances such as mercury.
Our next class of diseases is that of the affections of liver, stomach, kidney, and uterus. On the first of these organs, sulphurous waters have long had a reputation of being eminently curative, and the particular affections most successfully treated by them are chronic congestion, and jaundice produced by high living or residence in hot climates. These conditions they remove by stimulating the kidneys and skin to increased action, and when the bowels are carefully regulated in addition to the drinking of the water by mild doses of experient medicine this state of plethora is soon relieved and the patient gets rapidly well. It would only be repeating these same remarks to say anything more of these stomach diseases treated by these waters, for they are mostly cases of dyspepsia depending on sluggish action of the liver and duodenum so that when these latter are put right by the stimulating action of the water the dyspepsia disappears also.

The only disease of the kidneys relieved by sulphurous waters is gravel, and this they effect
simply by dilution of the urine and increasing its quantity and so washing away the earthy matter and preventing its aggregation into calculi.

The diseases of the uterine system in which these springs are useful, are Amenorrhœa, dysmenorrhœa, and chlorosis; it is again the stimulating power of these waters that is effected in these affections, the action being exerted on the mucous membrane of the uterus, and thus by enabling this organ to regain its tonicity, its irregular or departed function, is remedied or restored. For these forms of diseases the waters are used in the warm bath, or still better by the tepid ascending douche applied at once to the affected part. It is no doubt this action of such waters that gave to the Woffard spring a reputation of curing sterility. There is no doubt however that chalybeate waters are more efficacious in those uterine affections than the sulphureous, but it might be useful in many cases to combine them, and this can be done in most cases with any difficulty so sulphureous and chalybe-
ate springs are often associated in the same district, and this holds true in Strathpeffer, Moffat, and even at St. Bernard's.

3. The next class of affecting in which these waters prove eminently useful are gout and rheumatism. It is not difficult to see how these affections are benefited by these springs, because as they depend on the presence of a mortificating matter in the blood, it is rational to suppose, that a powerful diuretic and diaphoretic agent like a sulphureous water is one of the best means we could think of employing to eliminate materials mortifici. In Moffat, Dr. Smith and Munro always order the hot mineral bath in addition to drinking the water in the above cases.

Although it is mostly chronic cases of Rheumatism that are sent to sulphur springs, yet it would seem from Dr. Ross's experience that he has been very successful in treating cases of acute Rheumatism after the more acute symptoms have abated by ordering the Strathpeffer water to be drunk.

4. These waters have also enjoyed a reputa-
tion for curing certain forms of paralysis, hemiplegia and paraplegia where these diseases depend on functional derangement and not on organic lesion. In these it is only the stimulating effect of the hot bath that is of any use. A recent writer in "Le Bulletin Généraux de Thérapéutique," Dr. Durand Pardel, denies that sulphurous water are of any avail in the treatment of paralysis, and that the only mineral waters which do good in these diseases are those containing chloride of sodium and other chlorides. He gives the results of the treatment of 3,910 cases of hemiplegia produced from apoplexy, by hot baths, 2,6 were cured, 317 relieved, 6 treated without any success and 1 died. Dr. Pardel adds he has more hope of curing cases of paraplegia than hemiplegia, as the latter is often due to a serious organic lesion while the former frequently proceeds from irritation of the spinal nerves. He prefers the thermal waters for using in such cases. Now although we have no thermal sulphurous water in Scotland and even those we have lose the gra...
or part of their sulphuric hydrogen, when heated for a bath, the Moffat waters especially which when so treated become in fact converted into a saline hot-bath. Yet this by no means unfit them according to Dr. Landells view from being used to treat cases of paralysis; indeed a hot-bath of the Moffat water seems quite suited for that purpose.

I regret that none of my correspondents have furnished me with any facts on the treatment of such cases, but in Mr. Milloy's essay already quoted he gives instances of two gentlemen who had numbness and weakness in their legs, evidently a commencing paralysis, and by the use of the hot and cold bath alternately, three times a week accompanied by drinking the mineral water, he states that one of the cases recovered completely, and the other got greatly better.

This, then is what can be justly claimed as the therapeutical action of sulphurous mineral waters, and let me only remark in concluding that it is in
Chronic diseases these waters are most frequently employed, and this feature is a cause of hope and comfort both to the physician and patient, for in those long, wearying maladies when all the medicine of the pharmacopeia has failed, let them not despair for nature has yet provided her fountain of water which literally can wash away many of the ills to which our humanity is subject and bring the far away course of health within reach of the worn-out sufferer.

Murray Thomson
Scotus.

The analyses in the foregoing thesis were executed in the laboratory of Professor George Wilson and I take this opportunity of thanking him for his great liberality in giving me every advantage for conducting this investigation.