

XXXIX. *Continuation of an experimental Inquiry concerning the Nature of the mineral elastic Spirit, or Air, contained in the Pouhon Water, and other Acidulæ. By W. Brownrigg, M. D. F. R. S. Addressed to Sir John Pringle, Bart. F. R. S.*

TO SIR JOHN PRINGLE, BART. P. R. S.

S I R,

Redde, April 28,
1774.

YOU have often, with others of my friends, been pleased to inquire after the continuation of my experiments on the mineral water of SPA, which I promised to communicate to the Royal Society, with a view to explain “ the mode of union that exists between the
“ air of those waters, and the other principles of
“ which they are composed, together with the
“ relation which that elastic fluid bears to common
“ air, and to various other bodies (a).” Those expe-

(a) See Conclusion to an experimental Inquiry concerning the mineral elastic Spirit, or Air, contained in Spa Water, &c. Philosophical Transactions, Vol. LV.

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riments I, indeed, intended to have presented to the Royal Society, soon after my experiments on the same subject had been honoured with its approbation ; but was, at that time, prevented from putting them in due form, by other more pressing engagements ; and, afterwards, thought the publication of them the less necessary, as a similar mode of union between various absorbent earths and water, by the medium of mephitic air, had been so fully explained by the Hon. HENRY CAVENDISH, in his excellent treatise on the RATHBONE-PLACE waters (*b*) ; and the solubility of iron in water, by means of the same air, had also been demonstrated by Mr. LANE, in his valuable experiments on that subject (*c*). However, as my observations and experiments are different from those of the above-named gentlemen, and the great efficacy of this aerial solvent is by them shewn, in a variety of instances ; and, more especially, as a coagulating power in other kinds of air is also there detected ; by which, and the dissolving power of mephitic air, many great changes in bodies are daily produced, I therefore now lay these papers before you, requesting, that if, after so long an interval, I may again be allowed to resume this subject, you will do me the honour to communicate them to that most respectable body, over which you so worthily preside. I am,

S I R,

Your most obliged,
and most obedient servant,

WM. BROWNRIGG.

(*b*) Philosophical Transactions, Vol. LVII. p. 92.

(*c*) Phil. Transf. Vol. LIX.

PROPOSITION THE FIRST.

The ferruginous and absorbent earths contained in the Pouchon water are kept dissolved therein, by means of the mephitic air, to which those earths are united.

IN an Inquiry concerning the nature of the mineral and elastic spirit, or air, contained in this water, published in the Transactions of the Royal Society (a), it hath been shewn (b), that when the POUCHON water is excluded from all contact with the common air, in such manner that the mephitic air which it contains has free liberty to fly from it into an empty bladder, this air does not separate from the water by any spontaneous motion, as it would from its rare texture and elastic force, was it at liberty to exert these its qualities: but, on the contrary, in this situation, it remains united to the other ingredients of the water, when exposed to the most intense heat that we usually observe, in the open air, in this our climate.

It hath been further shewn (c), that this elastic fluid, when excluded from common air in the manner before related, is but slowly expelled from the POUCHON water by a heat of 110 degrees of *Fahrenheit's* thermometer, although such heat is sufficient to raise water (a much heavier body) in distillation:

(a) Vol. LV. p. 233.

(b) Experiment the first of the said Inquiry.

(c) Experiment the second.

and

and so closely is air united to the other ingredients of the water, that it is not wholly expelled from them by a scalding heat of 160 or 170 degrees of the scale, when exposed thereto for two hours.

Which experiments therefore prove, that this air is not detained in the *POUHON* water, by the pressure of the atmosphere, or by any other external force, as is the air with which beer, or other fermenting liquors, are often surcharged, while they are confined in bottles : but that this elastic fluid is equally mixed with the watery element, and with the other ingredients of which this mineral water is composed, and exists with them in a state of solution, or in a fixed state, being attached to the water, and to the other ingredients dissolved therein, by a force sufficient to keep them all united together in one uniform compound, while this force is not removed by some external cause.

It further appears, from the same experiments (*d*), that so long as this air continues united to the other ingredients of the *POUHON* water, its martial and absorbent earths do also remain suspended therein ; but, so soon as any part of this air is expelled by heat, those earths begin to separate from the water, which then grows white and turbid ; and when, by continuance of the heat, more of this air is expelled, more of the earthly particles also separate from the water, in the same proportion as its air is separated from it ; and while only a small portion of the air remains, some portion of the martial earth also remains dissolved in the water, as appears from its

(*d*) See Experiment the second.

giving

giving a slight tinge of the purple, when mixed with galls: but none of those earths are any longer detained in the water, than while it continues impregnated with some mephitic air; when this air is entirely separated from the water, it is wholly decomposed, having lost its distinguishing brisk and pungent taste, and its power of striking a purple colour with galls; its more volatile and elastic principles being exhaled, its metalline and absorbent earths then subside in a white flocculent sediment, and no other substance remains dissolved in the water, save only the small portion of alkaline and neutral salts, which enter its composition.

From this short recapitulation of the above-mentioned experiments, it therefore appears, that the *POUHON* water undergoes a decomposition, when its air is expelled from it by means of heat. The opposite extreme of cold is also found to produce the same effect of decomposing the *POUHON* water, when this its aëreal principle is expelled from it by means of congelation.

For having poured some of this water into open tin vessels, that were placed in the common freezing mixture of sea-salt and snow, so soon as the water began to shoot into ice at the bottom and sides of the vessels, very minute bubbles of air incessantly arose therein, and were discharged from its surface with such force, as to carry with them small particles of the water to a considerable height; and continued thus to fly off, till all the water was congealed. The ice was very white, from the minute bubbles of air, which were every where interspersed though it, and by which the frozen water

considerably increased in bulk, so as to rise at its surface into a very convex form. The water, when thawed, was white and turbid, and soon let fall its metallic and absorbent earths in a white sediment : it then had almost lost its taste ; and, being mixed with tincture of galls, only gave therewith a slight purple tinge. By a second congelation, it seemed almost entirely deprived of its air, and, with it, of the remaining part of its white earths ; and, when decanted from its sediment, no longer struck a colour with galls. From these experiments it therefore appears, that so soon as this water is deprived of its air, whether it be by heat or by cold, it is no longer capable of keeping those earths dissolved, which, while it is impregnated with this air, continue suspended therein.

In these decompositions of the POUHON water, by heat and by cold, no volatile spirit, either acid or sulphureous, nor any other subtile matter, has been found to fly from it, save only its mephitic air : while this air is present in the water, its martial and absorbent earths remain dissolved therein ; so soon as this air is separated from the water, in whole or in part, those earths, either in the whole or in part, do also separate from it, and are no longer suspended therein, than while they are united to a due proportion of this aerial solvent. From whence it appears, that this mephitic air is the medium by which the metalline and absorbent earths contained in the POUHON water are therein held in solution ; and, contrary-wise, that those earths are the medium, by which this air is more firmly united to the watery element in this compound, in which it enters as a

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principal

principal ingredient, and, by its solution in the water, and its union with these earthy substances, from a very rare volatile and elastic body, is reduced to a fixed state.

This dissolving power of mephitic air may farther be proved from the recomposition of the POUHON water, by adding thereto the air expelled from it by coction. But as Mr. CAVENDISH has already shewn, that the absorbent earths of RATHBONE-PLACE water may be redissolved by the mephitic, or fixed air, which had been extracted from that water; and as Mr. LANE has also demonstrated, that iron is rendered soluble in water, by the medium of mephitic air, I therefore shall not, at this time, detain the Society with my experiments on the same subject; but as those experiments contain some phenomena, that have not yet been noticed, I may, perhaps, offer them to the public on some future occasion.

S C H O L I A.

From the foregoing experiments, it appears that the mephitic air and martial earth, contained in the POUHON waters, strongly attract each other, and, uniting together, form a concrete soluble in water, and readily distinguished therein, by the peculiarly brisk acidulous taste, which it receives from this aerial principle, joined to a rough subastringent taste, which proceeds from the iron. This concrete, like other vitriols of iron, strikes a black colour with galls, and may well be esteemed a saline body of the neutral kind, of which the mephitic air constitutes

the spirituous solvent, and the martial earth its base. It further appears, that the mephitic air is possessed of all the properties, by which some of the chemists have distinguished those pure and simple bodies, or spirits, which by them are esteemed, in *their own nature*, and *of themselves*, saline, and which, in union with other bodies, form salts that are more compound. For this æreal solvent, in like manner with the pure acid spirits, is soluble in water, and imparts thereto its peculiar sharp and acidulous flavour: moreover, in combination with various metalline and absorbent earths, this volatile elastic spirit, like those acids, forms various saline concretes of the neutral kind; inasmuch as those metalline and absorbent earths, when united to this elastic spirit, are thereby rendered soluble in water; and, in union therewith, acquire peculiar flavours, resulting, in part, from this their spirituous principle, and, in part also, from the particular kind of earth with which it is combined. This air, therefore, considered in the relation which it bears to several earthy substances, and to water; considered also as it impresses the organs of taste, with its peculiar brisk and acidulous flavour, may justly be stiled a *mineral elastic spirit of a saline nature*, and is sufficiently distinguished from all other saline spirits, by its great rarity, and by its æreal nature. How far, and under what laws, this relation between mephitic air and various saline earths, and other bodies, may be extended, hath not yet been fully discovered: suffice it in this place to remark, that a class of saline bodies of a neutral nature are here detected, composed of various earthy bases, united to a volatile æreal spirit, all of which

which agree in one common solvent, the mephitic air, but differ from each other, according to the nature of the base to which this air is united.

The agreement of these saline concretes with neutral salts in these essential properties, by which these last are distinguished from other more simple saline bodies, will further appear from their decomposition ; which is effected by those various ways, and under the same laws, by which all other neutral salts are decomposed ; namely, by all those different ways, by which the acid spirits, and the terrene or alkaline bases of neutral salts, can be separated from each other.

For, *first*, the æreal spirit of these saline concretes is forced, *by fire*, from its union with the earthy base, which it holds dissolved in water, in like manner as the acid spirit of other neutral salts are expelled by fire from the more fixed principles, which enter the composition of those salts. The degree of heat required to separate the acid spirit of neutral salts, from their more fixed alkaline or earthy base, varies in the decomposition of almost every different kind of salts ; and the extreme volatility and expansive force of this æreo-saline principle renders it more easily separable, by heat, from the fixed principles to which it unites, than any other kind of saline spirit.

Secondly. The saline concretes, formed with this æreal solvent (in like manner as other neutral salts), are decomposed by the *addition of stronger acids*, which more powerfully attract the terrene or metallic base of these concretes, than it is attracted by their light and subtle æreal spirit, and detaches from them the æreal solvent to which those earths were before united. All
acids,

acids, found in a liquid form, have this effect, from the light vinous acids to the most ponderous acid of vitriol; so that the affinity between these metalline and absorbent earths, and this their æreal solvent, is less than that which exists between the same earths and all the known acid spirits. In all additions of these acids to the spirituous or acidulous waters, an effervescence has been observed, not readily accounted for, by those who suppose an acid to predominate in those waters. The conflict and discharge of air here arises from the expulsion of the æreal principle from its terrene base; in like manner as the acids of sea salt and nitre are expelled, with effervescence, from their alkaline bases, by the more powerful acid of vitriol. And here, by the way, it may be proper to remark, that the vitriolic acid, when mixed with the *acidulæ* and other chalybeate waters, doth not preserve those waters from decay, as the excellent HALES, and others, after him, have supposed; but, on the contrary, destroys their texture, or decomposes them, by expelling their elastic spirit, and entering into new combinations with their earthy principles; thereby forming a new compound, less perishable indeed than the former, but also less efficacious in the cure of many diseases. When Rhenish wine is added to the *acidulæ*, the large quantity of air that flies off may, in part, proceed from the wine; but when I mixed the vitriolic acid with POUHON water, a considerable quantity of air was indeed discharged; but not the whole which that water holds in solution. I therefore conjectured, that some part of the air, contained in that water, might be imbibed by the superabundant acid, which

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I used in the experiment, and that more mephitic air might, perhaps, have been expelled from the water, had I only mixed with it the exact quantity of this acid, that was required to dissolve the earthy substances contained therein.

Thirdly. These saline concretes, contained in the POUHON water and other *acidulæ*, are subject to decomposition, not only from acids, as before related, but also from *alkalies*, whether fixed or volatile: all which more powerfully attract this subtilè aëreal principle than it is attracted by the martial and absorbent earths, to which it is united in those waters. And here again appears an exact agreement between these aëreo-saline concretes and various neutral salts, in the mode of their decomposition. For the ammoniacal salts (which are all composed of the volatile *alkali*, united to an acid spirit, either muriatic, nitrous, or of some other kind) so soon as one of the fixed *alkalies*, or quicklime, is added to any of them, the acid spirit which it contains, quitting its union with the weaker volatile *alkali*, this last is let loose; and the stronger *alkali*, or quick-lime, takes its place; between which and the acid spirit a new combination is formed. The same happens when any *aleali*, either fixed or volatile, is added to the *acidulæ*; their elastic spirit then quits the ferruginous and absorbent earths, to which it was joined, and forms a new combination with the *alkali*, by which it is more powerfully attracted than by these earthy substances. These earths, therefore, being no longer suspended in the water by the aëreal solvent, render it turbid and milky, until they have gradually subsided therein, in the form of a white sediment:

sediment: for such is the native appearance of the martial earth, as well as of all the other earths contained in these waters, as will be shewn hereafter. In these decompositions of acidulous waters, by means of alcalies, no effervescence, or discharge of air-bubbles, takes place; for here the air is all absorbed by the *alkali* added thereto, and not expelled from the water, as it is in the decomposition of the same waters, by means of stronger acids.

When the *acidulæ* are mixed with common soap, a two-fold decomposition takes place. The fixed *alkali*, quitting the unctuous substances, to which it was joined in the soap, unites itself to the æreal spirit, or mephitic air, of those waters, while this air, at the same time, deserts the earthy substances with which it was before combined. The same new combinations seem to take place, when soap is mixed with any of those waters which are usually called hard; many of which waters have been found to contain an earthy substance, dissolved by means of this subtilè æreal principle.

The above observations and experiments shew an exact agreement, in the several ways, by which the various neutral salts, and those saline concretes formed of mephitic air united to an earthy base, are decomposed. It ought, however, here to be remarked, that the saline concretes, which exist in the POUHON water, in a dissolved state, though evidently of the neutral kind, have not hitherto been obtained in a solid form; owing, perhaps, in some measure, to the great volatility of their spirituous principle; but chiefly to their being subject to decomposition, from the precipitation of their earthy
base,

base, by means of common air, during the evaporation of the water in which they are dissolved, as will be shewn hereafter.

The mephitic air of the *acidulæ*, although it is soluble in water, and imparts thereto its brisk and pungent taste, which has been usually stiled subacid; and although it produces effects exactly similar to those of acid spirits (by readily uniting to various earthy substances, which of themselves are not soluble in water, but, by their union with this aëreal fluid, are rendered soluble therein, and communicate to the water peculiar favours, and form therein saline concretes of the neutral kind; which concretes, so formed, are again separable into their component ingredients, by all those ways by which the acid and alkaline principles of other neutral salts are separable from each other) yet it differs from all acid spirits, found in a liquid form, in its rare texture and its elastic quality, and in not striking a red colour with syrup of violets, and other blue tinctures of vegetables; which change in the blue colour of those tinctures, is usually esteemed a test of the presence of an acid. Besides the trials which other gentlemen and myself have made, by mixing syrup of violets with pure water, impregnated with various kinds of mephitic air, in which no change in the colour of the syrup was observed, I have for several days suspended pieces of linen, that had been dyed blue with fresh juice of violets, in the mephitic air of SPA water, and also in that of chalk; and, when the linen was taken out of the said air, did not perceive its blue colour in any wise changed, al-

though the same pieces of dyed linen were instantly turned of a green colour, when exposed to the fumes of spirit of hartshorn. Whether therefore, and under what relations, this æreo-saline spirit may merit the title of an *acid*, I leave to the determination of others. Such, however, it has appeared to be to many philosophers, since this mephitic air is doubtless the same with the *acidum vagum fodinarum* of BOERHAAVE and others; and with the *acidum centrale perpetuum inexhaustibile* of BECHER; with the *spiritus sulphureus æreo-æthereo-elasticus* of HOFFMAN; and the *sal embrionatus* and *sal esurius* of the sagacious HELMONT, which, he says, corrodes the ore of iron, and with it forms a volatile vitriol in the POUHON water. All these, and many other philosophers, had acquired some knowledge of this subtle æreo-saline principle from contemplating its effects; but, not having obtained it in a palpable form, were unacquainted with several of its principal properties.

From considering the great subtilty of this æreo-saline principle, its power of dissolving many earthy substances, together with its property of uniting readily to water, and with it, of pervading the very minute vessels of the animal frame, without injuring them, as stronger acids do by their corrosive quality, we may from thence form some judgement of the great efficacy of this air, as a *de-obstruent* and *solvent*, in many diseases of the human body arising from preternatural concretions and obstructions thence ensuing. If to these we add the great antiseptic powers of this kind of air, which it possesses in com-

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mon with acids (and which were first detected by SIR JOHN PRINGLE, and have since been more fully explained by Mr. MACBRIDE and Dr. PRIESTLY); we then, in some measure, may account for those extraordinary effects, which this kind of air is found to produce in the cure of many obstinate diseases, with which mankind are afflicted.